Maritime & Coastguard Agency

MARINE GUIDANCE NOTE

MGN 654 (M+F)

Safety of Navigation: Offshore Renewable Energy Installations (OREIs) - Guidance on UK Navigational Practice, Safety and Emergency Response.

Notice to Other UK Government Departments, Offshore Renewable Energy Developers, Offshore Transmission Owners, Port Authorities, Ship owners, Masters, Ships' Officers, Fishermen and Recreational Sailors.

This notice replaces Marine Guidance Note 543 and should be read in conjunction with the following MCA documents:

- *Marine Guidance Note 372 "Offshore Renewable Energy Installations (OREIs) - Guidance to Mariners operating in the vicinity of UK OREIs", and*
- *"Methodology for Assessing the Marine Navigational Safety Risks & Emergency Response of Offshore Renewable Energy Installations".*

Note: References contained in this document can be accessed via the MCA website at www.gov.uk/guidance/offshore-renewable-energy-installations-impact-on-shipping

Other useful websites include:

- www.gov.uk/beis
- www.thecrownestate.co.uk
- www.crownestatescotland.com
- www.legislation.gov.uk
- www.gov.uk/mmo
- www.gov.scot/marine-and-fisheries/
- https://naturalresourceswales.gov.uk
- www.daera-ni.gov.uk
- https://infrastructure.planninginspectorate.gov.uk
- www.un.org/depts/los
- www.kis-orca.eu
- www.iala-aism.org

Summary

This Marine Guidance Note highlights issues that need to be taken into consideration when assessing the impact on navigational safety and emergency response (search and rescue, salvage and towing, and counter pollution) caused by offshore renewable energy installation developments (wind, wave and tidal). It applies to proposals in United Kingdom internal waters, Territorial Sea and Exclusive Economic Zone.

Key Points

- The recommendations in this guidance note should be used, primarily, by OREI developers seeking consent to undertake marine works and in developing post-consent plans and documentation.
- The MGN intends to follow the consenting process and provide guidance at each stage.
- It provides updates in accordance with current practices; and
- The revision includes a reorganisation of the annexes to incorporate existing bespoke documents into the guidance, as follows:
  - **Annex 1**: Methodology for Assessing the Marine Navigational Safety & Emergency Response Risks of Offshore Renewable Energy Installations.
  - **Annex 2**: MCA's shipping template for assessing wind farm boundary distance from shipping routes.
  - **Annex 3**: NOREL paper on under-keel clearance - Guidance to Developers in Assessing Minimum Water Depth over Tidal Devices.
  - **Annex 4**: Hydrography Guidelines for Offshore Renewable Energy Developers.
  - **Annex 5**: Search and Rescue (SAR) and emergency response matters.
  - **Annex 6**: MGN Checklist.

1. Introduction:

1.1 Offshore Renewable Energy Installations (OREI) include offshore wind farms, tidal energy converters (including tidal range devices), wave energy converters and any associated infrastructure with the potential to affect marine navigation and emergency response, proposed in United Kingdom (UK) internal waters, Territorial Sea and Exclusive Economic Zone (EEZ).

1.2 Recommendations in this guidance note should be taken into consideration by all OREI developers seeking formal consent for marine works. Failure by developers to give due regard to these recommendations may result in objections to their proposals on the grounds of navigational safety or emergency response preparedness. Additional information on the process for consenting OREIs and the regulatory framework is available from the Department for Business, Energy & Industrial Strategy (BEIS), Marine Management Organisation (MMO), Natural Resources Wales (NRW), Marine Scotland and Department of the Environment, Agriculture and Rural Affairs (DAERA) [Northern Ireland] websites.

1.3 The considerations and criteria contained in this Marine Guidance Note (MGN) and its annexes are intended to address the navigational and emergency response impacts of OREIs proposed for UK sites. Their development necessitates the establishment of clear guidance to deal with potential adverse effects. The licensing and consent regimes must take account of local factors, national requirements and international standards which could influence the establishment of an OREI.

1.4 This guidance has been developed in consultation with BEIS, the devolved Government authorities for England, Scotland, Wales and Northern Ireland, mariners in the commercial, military, fisheries and recreational sectors, relevant associations and port authority representatives, the General Lighthouse Authorities (GLA) and emergency response services.

2. Primary and Secondary Legislation with regard to OREIs and Navigation

2.1 The 2020 Energy White Paper sets out the Government's "ambition to have 40GW of offshore wind by 2030, a fourfold increase on today's installed capacity". The Energy Act 2004 (as amended) establishes a regulatory regime for OREIs beyond the Territorial Sea, in the UK's EEZ, and supplements the regime which already applies in the UK's internal and Territorial Sea. Sections 99 and 100 of the Act deal specifically with navigation and introduces a new section, 36B with the title "Duties in relation to navigation" into section 36 of the Electricity Act 1989 (as amended). Under section 36B of the Electricity Act 1989, sub-section (1), consent cannot be granted for an OREI which is likely to interfere with the use of "recognised sea lanes essential to international navigation". This expression directly refers to Article 60(7) of the United Nations Convention on the Law of the Sea, 1982 (UNCLOS) and the position is repeated in Section 2.6.161 of the National Policy Statement for Renewable Energy Infrastructure (EN-3).

2.2 The Merchant Shipping (Safety of Navigation) Regulations 2020 implements the Safety of Life at Sea (SOLAS) Convention Chapter V (Safety of Navigation). This applies to all vessels on all voyages. In some cases, areas of sea may be considered an essential area for navigation and of strategic importance for vessel operation and in accessing ports and harbours. Whilst not an IMO designated routeing measure, these might be an area of sea that is actively used by all vessel types, including large commercial and internationally trading vessels, supply routes, and ferry routes. Therefore, for the purposes of this document "sea lanes" are considered to be IMO-adopted routeing measures and potentially other sea/shipping routes transited by all vessel types[1].

2.3 Section 36B, sub-section (2) of the Electricity Act 1989 (as amended) provides that the decision to grant consent and any conditions placed on a consent must "have regard to the extent and nature of any obstruction of or danger to navigation which (without amounting to interference with the use of such sea lanes) is likely to be caused by the carrying on of the activities, or is likely to result from their having been carried on."

2.4 Shipping is recognised in the Marine Policy Statement 2011, Chapter 3.4, as "an essential and valuable economic activity in the UK" and that "increased competition for marine resources may affect the sea space available for the safe navigation of ships. Marine plan authorities and decision makers should take into account and seek to minimise any negative impacts on shipping activity, freedom of navigation and navigational safety and ensure that their decisions are in compliance with international maritime law". In addition, both the Marine and Coastal Access Act 2009, Part 4, Section 69, sub-section (1)(c) and the Marine (Scotland) Act 2010, Part 4, Section 27, sub-section (1)(a)(iii), provide for marine licence decisions to "have regard to the need to prevent interference with legitimate uses of the sea".

2.5 The MCA (through UK Technical Services Navigation) is a statutory consultee within the planning process for development consent and a primary advisor to the licensing authorities for issuing marine licences. The MCA provides advice and guidance to developers and other Government departments throughout the lifetime of an OREI on matters concerning navigational safety and emergency response.

[1] Table 10 of the Methodology document provides a list of example vessel types involved in navigation activities.

3. How and When the Recommendations Should be Used

3.1 This MGN is intended for the guidance of developers and others. Failure to accept the principles of the guidance may result in delays or objections from stakeholders within the licensing and consenting process. The recommendations should be taken into account by OREI developers and their contracted environmental and risk assessors in the preparation of Scoping Reports (SR), Navigational Risk Assessments (NRA) and resulting EIA Reports, and in any required post-consent documents.

3.2 The recommendations should be used to evaluate all navigational possibilities, which could be reasonably foreseeable, by which the siting, construction, extension, operation and de-commissioning of an OREI could cause or contribute to an obstruction of, or danger to, navigation or emergency response. They should also be used to assess possible changes to traffic patterns and the most favourable options to be adopted, including those of operational site monitoring.

3.3 In terms of navigational priority, these recommendations do not encourage a differentiation to be made between any types of seagoing watercraft, operations, or mariners.

3.4 It is recognised that all OREI projects are at varying stages of planning and development, both pre-consent and post-consent, therefore proposals on meeting the principles of this guidance for undertaking marine works will be assessed on a ‘case by case’ basis.

3.5 The recommendations contained therein apply to all sites, whether within the jurisdiction of port/harbour limits or in open sea areas. However, port/harbour authorities may require developers to comply with their own specific criteria and/or local regulations and directions. In addition, where proposals within port/harbour limits could affect navigation or emergency planning or response, the port/harbour authority will be under an obligation to review its safety management system following the issue of consent to the developer, in accordance with the Port Marine Safety Code. Evaluating the impact of OREI schemes on existing port/harbour activities should be carried out in consultation with the relevant port/harbour authority and the wider port community. Such reviews should be undertaken by the developer as part of the Environmental Impact Assessment and the outcome addressed in the resulting EIA Report.

3.6 OREI developers should evaluate the impacts of their projects and comply with the recommendations during all phases of:

- (1) planning;
- (2) construction;
- (3) operation; and,
- (4) decommissioning.

4. Planning Stage – Prior to Consent

4.1 Early engagement with MCA and relevant navigational stakeholders e.g. during the scoping stage, is key for early identification of potential areas of concern that may require close attention. Developers are required to produce a NRA in the planning stage as part of their application for development consent. The MCA’s *“Methodology for Assessing the Marine Navigational Safety & Emergency Response Risks of Offshore Renewable Energy Installations (OREI)”* (hereafter known as the ‘Methodology document’) provides guidance for producing an NRA, including a template. It is based on IMO Formal Safety Assessment and the latest version is available on the MCA's website. Any substantial changes to the project that impacts on shipping and navigation may require relevant NRA updates.

4.2 Potential navigational or communications impacts or difficulties caused to mariners or emergency response services, using the site area and its environs, should be assessed. Assessments should be made of the consequences of ships deviating from normal routes to avoid proposed sites, including smaller vessels e.g. domestic, coasters, recreational or fishing vessels, entering shipping routes with larger vessels. Special regard should be given to evaluating situations which could lead to safety of navigation being compromised e.g. an increase in 'end-on' or 'crossing' encounters, reduction in sea-room or water depth for manoeuvring, leading to choke points, etc.

4.3 Issues that could contribute to a marine casualty leading to injury, death or loss of property, either at sea or amongst the population ashore, or damage to the marine environment, should be highlighted as well as those affecting emergency response. Consultation with national search and rescue authorities should be initiated as early as possible and consideration given to the types of aircraft, vessels and equipment which might be used in emergencies. This should include the possible use of OREI structures as emergency refuges and any matters that might affect emergency response within or close to the OREI.

4.4 An MGN checklist is available on the MCA website as an aid for developers when completing and submitting their NRA to ensure all guidance has been considered and addressed.

4.5 Developers are responsible for ensuring that formally agreed co-ordinates and subsequent variations of site perimeters and individual OREI structures are made available, on request, to interested parties at relevant project stages, including application for consent, development, array variation, operation and decommissioning. This should be supplied as authoritative Geographical Information System (GIS) data, preferably in Environmental Systems Research Institute (ESRI) format. Metadata should facilitate the identification of the data creator, its date and purpose, and the geodetic datum used. For mariners' use, appropriate data should also be provided with latitude and longitude coordinates in WGS84 (ETRS89) datum.

4.6 NRA – Traffic Survey[2]

a. An up to date, traffic survey of the proposed development area concerned should be undertaken within 12 months prior to submission of the EIA Report. This should include all the vessel and craft types found in the area and total at least 28 days duration but also take account of seasonal variations and peak times in traffic patterns and fishing operations. AIS data alone will not constitute an appropriate traffic survey; radar, manual observations, other data sources (e.g. for fishing and recreation) and stakeholder consultation will ensure those vessels that are not required to carry and operate AIS are included, and it provides an appropriate representation of the base line marine traffic.

b. However, to cover seasonal variations, peak times or perceived future traffic trends, the survey period may be extended to a maximum of 24 months. For all OREI developments, subject to the planning process, the survey may be undertaken within 24 months prior to submission. If the EIA Report is not submitted within 24 months an additional 14 day continuation survey data may be required for each subsequent 12-month period. Should there be a break in the continuation surveys, a new full traffic survey may be required and the time period starts from the completion of the initial 28 day survey period.

[2] See Methodology document Annex B.

c. In the event of location specific issues being identified by the existing traffic survey and/or through consultation, additional surveys beyond the minimum outlined above may be required in order to support assessment of such issues.

d. These variations should be justified in consultation with the relevant GLA, UK Chamber of Shipping, representative recreational (e.g. RYA) and fishing vessel organisations and, where appropriate, port/harbour and navigation authorities. While recognising that site-specific factors need to be taken into consideration any such survey should include but may not be limited to an assessment of the cumulative and individual effects of the following:

i. Proposed OREI site relative to areas used by any type of marine craft.

ii. Numbers, types and sizes of vessels presently using such areas.

iii. Non-transit uses of the areas, e.g. fishing, day cruising by leisure craft, commercial passenger vessels undertaking visits to the OREI, racing, aggregate dredging, personal watercraft etc.

iv. Whether these areas contain shipping routes used by coastal, deep-draught or international scheduled vessels on passage.

v. Alignment and proximity of the site relative to adjacent shipping routes.

vi. Whether the nearby area contains prescribed routeing schemes or precautionary areas.

vii. Proximity of the site to areas used for anchorage (charted or uncharted), safe haven, port approaches and pilot boarding or landing areas.

viii. Whether the site lies within the limits of jurisdiction of a port and/or navigation authority.

ix. Proximity of the site to existing fishing grounds, or to routes used by fishing vessels to such grounds.

x. Proximity of the site to offshore firing/bombing ranges or ordnance dumping grounds and areas used for any marine military purposes either presently or in the past.

xi. Proximity of the site to existing or proposed submarine cables and pipelines, offshore oil / gas platforms, marine aggregate dredging, marine archaeological sites or wrecks, Marine Protected Area or other exploration/exploitation sites. This should include projects in the planning process, in addition to those consented.

xii. Proximity of the site to existing or proposed OREI developments, in co-operation with other relevant developers, within each round of lease awards.

xiii. Proximity of the site relative to any designated areas for the disposal of dredging spoil.

xiv. Proximity of the site to any types of aids to navigation and/or Vessel Traffic Services (VTS) in or adjacent to the area and any impact thereon.

xv. Researched opinion using appropriate computer simulation techniques with respect to the displacement of traffic and, in particular, the creation of 'choke points' in areas of high traffic density and nearby planned or consented OREI sites not yet constructed.

xvi. With reference to xv. above, the number and type of incidents to vessels which have taken place in or near to the proposed site of the OREI to assess the likelihood of such events in the future and the potential impact of such a situation.

xvii. Proximity of the site to areas used for recreation which depend on specific features of the area

e. Developers are advised to discuss their traffic survey proposals prior to making any commitments in carrying out the survey – see Section 3 of the Methodology document for further information on scope and depth of assessment.

d. A review of the Navigational Risk Assessment should be carried out post-consent and prior to construction commencing to validate the EIA Report. This may include additional traffic survey data or if there are any changes to plans that could impact navigation e.g. construction methodology.

4.7 NRA – Predicted Effect of OREI on traffic and Interactive Boundaries

a. In late 2004 the Greater Wash wind farm developers group sought guidance from the Maritime and Coastguard Agency on the inter-relationship of wind farms to shipping routes so that they could take early recognition of the factors involved when planning a turbine layout within their allocated water space. The template in Annex 2 is the result.

b. The template combines the simulated radar reception results of the North Hoyle electromagnetic trials with published ship domain theory to better interpret the inter-relationship of marine wind farms and shipping routes. The resultant template also informs the assessments made as part of the consenting process.

c. There may be opportunities for the interactive boundaries to be flexible where, again, for example, vessels may be able to distance themselves from turbines to provide more comfort without significant penalty, or where turbines could be distanced from shipping nodal points. Domains have been derived from a statistical study of ship domains based on radar simulator performance, and traffic surveys in the North Sea, but it is recognised that larger, high speed, hazardous cargo and passenger carrying vessels may have larger domains.

d. Traffic surveys would also establish any route traffic bias where mariners may naturally turn to starboard to facilitate passing encounters in accordance with the IMO International Regulations for Preventing Collisions at Sea, 1972 (COLREG). Additionally, marine traffic surveys would identify vessel type or category which may consequently require larger domains to ensure that the following factors can be taken into consideration in determining corridor widths:

i. Compliance with the best practices of seamanship and principles to be observed in keeping a navigational watch including the composition of the watch,

ii. The manoeuvrability of vessels with special reference to stopping distance and turning ability in the prevailing conditions,

iii. Provisions that may be required with mechanical failure of vessels involved and level of support services,

iv. The state of visibility, wind, sea and tidal stream, and the proximity of navigational hazards,

v. The traffic density including concentrations of fishing vessels or any other vessels,

vi. The draught in relation to the available depth of water and the existence of submarine cables and obstructions,

vii. The effect on radar detection of the sea state, weather and other OREI sources of interference.

e. In the approaches to ports and harbours this is particularly relevant. This additional information would influence where boundaries need to be established.

f. When larger developments provide corridors between sites to allow safe passage of shipping a detailed assessment will be required to establish the minimum width of the corridor. The assessment of the required sea room (corridor width) will be undertaken on a case-by-case basis and should take into account not only the requirements of the traffic survey but also the general location, sea area involved and nearby structures and installations. It will not always be possible to make a course that is planned, and experience shows that in heavy sea conditions it is much harder to stop or turn the vessel around. Deviations from track by as much as 20°, or more, are common and must be considered. This deviation is used as the baseline for calculating corridor widths contained in the windfarm shipping route template.

Clearly, marine traffic survey information is required to inform such boundaries. Where turbines appear along both sides of a shipping corridor, the width requirement will be proportional to corridor length, based on a 20-degree course deviation.

g. The following factors should be applied when considering the width of a shipping corridor through an array, between two turbine arrays or between an array and shore and how far turbines should be from an established shipping route. The assessment of the required sea room must take into account the general location and sea area involved. The bridge awareness, availability of engines for immediate manoeuvre and readiness to use anchors will all vary when the vessel is on a general sea passage, as opposed to in areas of recognised constrained operation, for example port approaches and rivers.

i. Size, manoeuvring characteristics and volume of the vessels expected to transit the proposed lanes.

(1) Standard turning circles for vessels are worked on six times the ship's length. This is a particularly good assumption when vessels on ocean or deep-sea passage will not have the same manoeuvrability as when engines and systems are prepared for port approach.

(2) Requirements for stopping in an emergency must be considered, for example following a steering gear failure a crash stop, the quickest way to stop a vessel's movement, for a large tanker may still be up to 3km.

(3) The Netherlands made an assessment of sea room requirements using data supported by the PIANC assessment for channel design and the PIANC *Interaction Between Offshore Wind Farms and Maritime Navigation* (2018) report. In general, they strive for an obstacle free, or buffer, zone of 2nm between wind farms and shipping routes.

(4) The possibility of ships overtaking cannot be excluded and should be taken into consideration. Consequently, the assumption should be that four ships should safely be able to pass each other.

(5) Between overtaking and meeting vessels, a distance of two ship's lengths is normally maintained as a minimum passing distance. This is based on the experience gained from ships' masters and deep-sea pilots operating in the North Sea and has been verified by simulation trials carried out in the Netherlands (based on 400m length vessels).

ii. Provisions for possible mechanical failure of transiting vessels, bearing in mind the availability of support services.

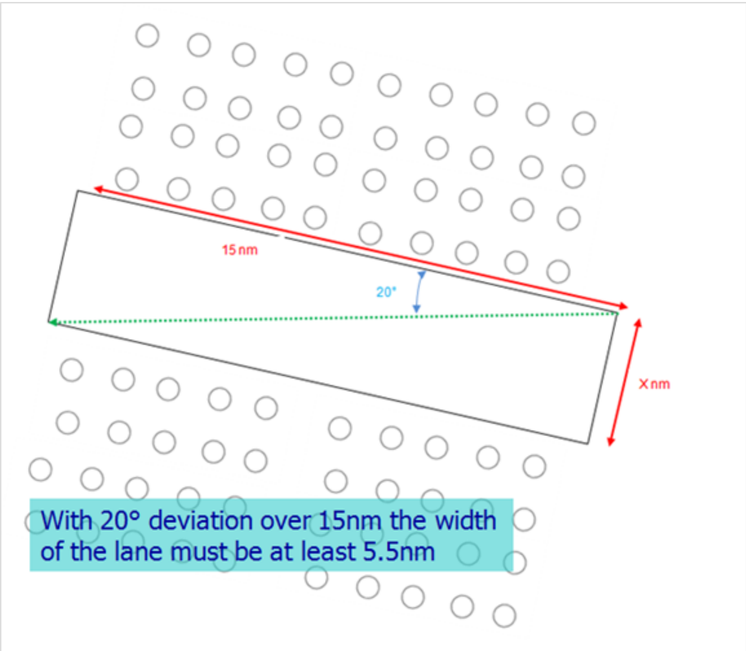
(1) Engine failure whilst using a transit lane might necessitate emergency or unplanned anchoring, restricting available sea room for other vessels.

(2) Dependant on depth of water the swinging circle of very large vessels, when anchored, must be calculated to assess the sea room required.

iii. Constraints of weather, sea and tidal conditions that may be expected in the location.

(1) Unlike inshore and estuary areas, when on passage in exposed sea areas, for example offshore in the North Sea, it will not always be possible to make good a planned course. Experience also shows that in heavy sea conditions it is much harder to turn the vessel around and may not be possible to achieve a dead stop and deviations from track are common. Therefore 20° or more, are common (as determined from the traffic assessment of the NRA) and must be considered in developing corridors through OREIs.

(2) For example:



(3) In tidal areas, the navigable width of a channel or route, for example, between an OREI and the shore, may be significantly reduced at low water.

iv. Other traffic, for example concentrations of fishing vessels, that will affect available sea-room to manoeuvre.

(1) Concentrations of fishing vessels, or leisure traffic, will create requirements for manoeuvre and course alteration by other through traffic and also restrict sea room in the shipping lane. The risk of further vessel to vessel conflict will be consequently increased.

(2) Displacing a group of traffic into space utilised by other users where available sea room is already confined, must be considered. For example, where leisure traffic is forced to use the same sea space as much larger and faster commercial vessels.

v. Existence of submarine cables and obstructions. The existence of submarine cables or other seabed obstructions may affect the ability of a vessel to anchor safely away from other traffic and this may be another consideration when assessing sea room requirements.

vi. Radar interference. Dependant on the proximity to wind turbine towers, and the location of radar scanners aboard the vessel, some vessels may experience degradation of the radar display by false echoes. It may be possible that this will reduce the ability of the bridge team to identify other vessels, including crossing vessels at the extremities of the lanes, which may require avoiding action. It is common to find that the radar instrumentation is then often adjusted to reduce the unwanted interference which can have the effect of reducing actual target acquisition.

h. IMO Routeing Measures. In some circumstances it may be requested, or necessary, to introduce, extend, expand or remove an IMO routeing measure as a result of an OREI. In this instance a proposal must be submitted in discussion with the MCA for consideration by the UK Safety of Navigation (UKSON) committee and subsequent recommendation to and approval by the IMO.

4.8 NRA - OREI Structures

a. It should be determined whether any features of the OREI, including auxiliary platforms outside the main generator site, mooring and anchoring systems, inter-device and export cabling, could pose any type of difficulty or danger to vessels underway, performing normal operations, including fishing, anchoring and emergency response. Such dangers would include air clearances of wind turbine blades above the sea surface, changes to charted depth due to tidal turbines, the burial depth of cabling, lateral movement of floating wind or tidal turbines etc.

b. Recommended minimum safe (air) clearances between sea level conditions at mean high water springs (MHWS) and rotor blades on fixed foundation wind turbines, or auxiliary platforms, stipulate that they should be suitable for the vessels types identified in the traffic survey but not less than 22 metres, unless developers are able to offer evidence that risks to any vessel type with air drafts greater than the requested minimum air drafts being provided are minimised. Depths, clearances and similar features of other OREI types which might affect marine safety should be determined on a case-by-case basis, for example, floating foundation wind turbines must allow for the degrees of motion (pitch, roll, yaw, heave, surge and sway), as appropriate.

c. There is no standard clearance figure that can be used to establish the safe clearance over underwater turbine devices. Rather, developers will need to demonstrate an evidence based, case-by-case approach which will include dynamic draught modelling in relation to charted water depth to ascertain the safe clearance over a device. The following approach should be adopted:

i. To establish a minimum clearance depth over devices, the developer needs to identify from the traffic survey and data sources the deepest draught of observed traffic. This will then require modelling to assess impacts of all external dynamic influences giving a calculated figure for dynamic draught. A 30% factor of safety for under keel clearance (UKC) should then be applied to the dynamic draught, giving an overall calculated safe clearance depth to be used in calculations.

ii. The Charted Depth reduced by safe clearance depth gives a maximum height above seabed available from which turbine design height including any design clearance requirements can be established.

iii. The MCA's "Under Keel Clearance Policy" paper (see Annex 3) should be closely followed throughout the Environmental Impact Assessment.

d. It should also be determined whether:

i. The structures could block or hinder the view of other vessels under way on any route.

ii. The structures could block or hinder the view of the coastline or of any other navigational feature such as aids to navigation, landmarks, promontories, etc.

In both cases, the impact must form part of the risk assessment.

4.9 NRA – Tides, Tidal Streams and Weather

It should be determined whether:

a. Current maritime traffic flows and operations in the general area are affected by the depth of water in which the proposed installation is situated at various states of the tide i.e. whether the installation could pose problems at high water which do not exist at low water conditions, and vice versa.

b. The set and rate of the tidal stream, at any state of the tide, has a significant effect the handling of vessels in the area of the OREI site.

c. The maximum rate tidal stream runs parallel to the major axis of the proposed OREI site layout, and if so, its effect on vessel handling and manoeuvring.

d. The set is across the major axis of the OREI layout at any time, and, if so, at what rate.

e. In general, whether engine and/or steering failure, or other circumstance could cause vessels to be set into danger by the tidal stream. This should include unpowered vessels and small low speed craft.

f. The structures themselves could cause changes in the set and rate of the tidal stream.

g. The structures in the tidal stream could be such as to produce siltation, deposition of sediment or scouring, affecting navigable water depths in the OREI area or adjacent to the area.

h. The site, in normal, bad weather, or restricted visibility conditions, could present difficulties or dangers to all vessels that might pass through or in close proximity to it.

i. The structures could create problems in the area for vessels under sail, such as wind masking, turbulence or sheer.

j. In general, taking into account the prevailing winds for the area, whether engine failure or other circumstances could cause vessels to drift into danger, particularly if in conjunction with a tidal set such as referred to above.

4.10 NRA – Access to and Navigation Within, or Close to, an OREI

It should be determined to what extent navigation would be feasible within or near to the OREI site itself by assessing whether:

a. Navigation within and /or near the site would be safe:

  i. for all vessels, or
  ii. for specified vessel types, operations and/or sizes.
  iii. in all directions or areas, or
  iv. in specified directions or areas.
  v. in specified tidal, weather or other conditions.

b. Navigation in and/or near the site should be prohibited or restricted:

  i. for specified vessels types, operations and/or sizes,
  ii. in respect of specific activities,
  iii. in all areas or directions, or
  iv. in specified areas or directions, or
  v. in specified tidal or weather conditions, or simply
  vi. recommended to be avoided.

c. Where it is not feasible for vessels to access or navigate through the site, it could cause navigational safety, emergency response or routeing problems for vessels operating in the area, e.g. by causing a vessel or vessels to follow a less than optimum route or preventing vessels from responding to calls for assistance from persons in distress (as per SOLAS obligations).

d. Guidance on the calculation of safe distances of wind farm boundaries from shipping routes can be found in Annex 2 “MCA Template for assessing distances between wind farm boundaries and shipping routes”. Advice on the safe distances of other OREI developments from shipping routes may be obtained from MCA’s Navigation Safety Branch.

4.11 NRA - Search & Rescue, Maritime Assistance Service, Counter Pollution and Salvage Incident Response

a. The MCA, through HM Coastguard, is required to provide a Search and Rescue (SAR) and emergency response service within the sea area occupied by all offshore renewable energy installations in UK waters. To ensure that such operations can be safely and effectively conducted, certain requirements must be met by developers and operators.

b. A preliminary assessment on the potential impacts to SAR and emergency response with the introduction of the OREI must be carried out and included as a chapter in the NRA. Further information can be found in Chapter 3 of the Methodology document. Information on post-consent requirements can be found in section 6.8 of this MGN.

4.12 NRA - Hydrography

a. In order to establish a baseline, confirm the safe navigable depth, monitor seabed mobility and to identify underwater hazards, detailed and accurate hydrographic surveys are required of the development at the pre-consent stage:

   i. The site of the generating assets area shall be undertaken as part of the licence and/or consent application.
   ii. All proposed cable route(s).

b. The development may result in an alteration to maritime traffic patterns as vessels seek alternative passage around the installed generating assets area. Where this is the case, it may be considered necessary that a hydrographic survey of these alternate passages and their immediate environs extending to 500m be undertaken. MCA can provide guidance here if required.

d. All hydrographic surveys listed above should fulfil the requirements of the MCA's 'Hydrography Guidelines for Offshore Developers' in Annex 4.

e. Further hydrographic surveys are required during the post-consent and decommissioning stages (see sections 6.8 and 7 below).

4.13 NRA - Communications, Radar and Positioning Systems

To provide researched opinion of a generic and, where appropriate, site specific nature concerning whether:

a. The structures could produce radio frequency interference such as shadowing, reflections or phase changes, and emissions with respect to any frequencies used for marine positioning, navigation and timing (PNT) or communications including Global Maritime Distress Safety System (GMDSS) and Automatic Identification Systems (AIS), whether ship borne, ashore or fitted to any of the proposed structures. Consideration should be given to three scenarios:

   i. Vessels operating at a safe navigational distance (see Annex 2),
   ii. Vessels by the nature of their work necessarily operating at less than the safe navigational distance to the OREI, e.g. support vessels, survey vessels, SAR assets.
   iii. Vessels by the nature of their work necessarily operating within the OREI.

   Note: *GMDSS frequencies may not be subject to harmful interference, but for other frequencies, cases (ii) and (iii) may rely on agreed special measures where necessary.*

b. The structures could produce radar reflections, blind spots, shadow areas or other adverse effects, amongst others:

   i. Vessel to/from shore;
   ii. Vessel to vessel
   iii. VTS radar to/from vessel;
   iv. Anomalous radar beacon (Racon) reception by vessel; and,
   v. Search and Rescue and maritime surveillance aircraft to/from vessels and/or OREI structures

c. The structures and generators might produce sonar interference affecting fishing, industrial or military systems used in the area.

d. The site might produce acoustic noise which could mask prescribed sound signals.

e. The generators and the seabed cabling within the site and onshore might produce electromagnetic fields affecting compasses and other navigation systems.

4.14 NRA – Assessment of Risk[3]

a. The above NRA data and evidence gathering will feed into understanding the base case densities and types of traffic and estimating the level of baseline risks without the OREI in place and inherent risks associated with the introduction of the OREI. The Methodology document requires a hazard log to be developed listing the hazards caused or changed by the OREI and the predicted baseline and inherent risks associated with each hazard. The hazard log must also include residual risks to show the tolerability level of risk after risk mitigation measures have been implemented to reduce them to As Low as Reasonably Practicable (ALARP)[4].

4.15 NRA - Risk Mitigation[5]

a. Mitigation and safety measures will be applied to the OREI development appropriate to the level and type of risk determined during the Environmental Impact Assessment (EIA). The specific measures to be employed will be selected in consultation with the MCA's Navigation Safety Branch and will be listed in the developer's EIA Report. These will be consistent with international standards contained in, for example, the Safety of Life at Sea Convention, 1974 (SOLAS) - Chapter V, IMO Resolutions A.572 (14) and Resolution A.671 (16) and could include any or all of the following:

   i. Promulgation of information and warnings through notices to mariners and other appropriate maritime safety information (MSI) dissemination methods.

   ii. Continuous watch by multi-channel VHF, including Digital Selective Calling (DSC).

   iii. Safety zones of appropriate configuration, extent and application to specified vessels.

   iv. Designation of the site as an area to be avoided (ATBA).

   v. Provision of Aids to Navigation as determined by the General Lighthouse Authority.

   vi. Implementation of routeing measures within or near to the development.

   vii. Monitoring by radar, AIS, closed circuit television (CCTV) or other agreed means.

   viii. Appropriate means for OREI operators to notify, and provide evidence of, the infringement of safety zones or ATBA.

   ix. Creation of an Emergency Response Cooperation Plan with the MCA's Search and Rescue Branch for the construction phase onwards.

---

[3] See Methodology document Annex C and D.

[4] Descriptions of ALARP can be found in:
a) Health and Safety Executive (2001) 'Reducing Risks, Protecting People'
b) IMO (2018) MSC-MEPC.2/Circ.12/Rev.2 dated 9 April 2018, 'Revised Guidelines for Formal Safety Assessment (FSA) in the IMO Rule-Making Process'

[5] See Methodology document Annex E and G.

x. Use of guard vessels where appropriate.

xi. Update NRAs every two years e.g. at testing sites.

xii. Device-specific or array-specific NRAs.

xiii. Design of OREI structures to minimise risk to contacting vessels or craft.

xiv. Any other measures and procedures considered appropriate in consultation with other stakeholders.

b. The mention of the IMO/UNCLOS safety zones limited to 500 metres does not imply a direct parallel to be applied to OREIs. Section 95 of the Energy Act 2004 provides for the decision to grant safety zones around renewable energy installations. The Electricity (Offshore Generating Stations) (Safety Zones) (Application Procedures and Control of Access) Regulations 2007 (SI 2007 No. 1948) provides the regulatory framework for establishing safety zones to OREIs in the UK. It allows for 500m safety zones around wind turbines during construction, extension, major maintenance or decommissioning and 50m safety zones during operation. If developers wish to submit an application to either BEIS or the appropriate marine licensing authority where applicable, it must be accompanied with safety case and supporting evidence showing justification for the safety zone(s) and how it will be managed. The decision whether the safety zone(s) is granted will be made following a consultation with relevant stakeholders. For further guidance, please see DECC's document titled "Applying for Safety Zones Around Offshore Renewable Energy Installations".

5. Development Consent

5.1 The MCA will expect all appropriate aspects of this MGN and the Methodology document to be considered and adequately addressed through the MGN Checklist and submitted as part of the consent application. Any aspects missing or inadequately addressed to the satisfaction of MCA may result in delays or objection to an application.

5.2 In order to make an application, developers should aim to get agreement from all relevant navigation stakeholders for ensuring risks are assessed as ALARP and that risk mitigation measures are agreed.

6. Post-consent – construction and operation phases

6.1 In the UK all vessels have freedom to transit through OREIs, subject to any applied safety zones, and their own risk assessments, which should take account of factors such as vessel size, manoeuvrability, environmental factors and competency of the Master and crew. MGN 372 (or subsequent update) provides further guidance on navigation in and around OREIs.

6.2 Layout Design

a. MCA has statutory obligations to provide Search and Rescue (SAR) services in and around OREIs in UK waters, using both SAR helicopters and emergency response vessels. The MCA also has responsibilities to ensure the safety of navigation is maintained and to address the risks to mariners who may wish to transit an offshore renewable development or find themselves in the vicinity of a development in an emerging situation or in adverse weather conditions.

b. Turbine layouts of every offshore renewable energy project with floating and/or surface piercing devices and structures must be designed to allow safe transit through OREIs by SAR helicopters operating at low altitude in bad weather, and those vessels (including rescue craft) that decide to, or must, transit through them. Multiple lines of orientation provide alternative options for passage planning and for vessels and aircraft to counter the environmental effects on manoeuvring i.e. sea state, tides, currents, weather, and visibility. OREI structures (turbines, substations, platforms, and any other structure within the OREI site) that are aligned in straight rows and columns are considered the safest layout arrangement by UK navigation stakeholders and the MCA contracted SAR helicopter pilots. Developers should therefore carry out a further site-specific assessment, which builds on previous assessments, to identify the proposed locations of individual structures.

c. In compliance with safety of navigation and search and rescue requirements in the UK, developers of every offshore renewable energy project with floating and/or surface piercing devices should undertake a thorough appraisal of the safety benefits afforded by two consistent lines of orientation and, based on this, either implement such layouts or, where appropriate, consider alternatives. The MCA will not consider any layout proposals with just one line of orientation, without supporting documentation which fully justifies the proposed layout to the satisfaction of MCA. A layout with zero lines of orientation will not be acceptable to the MCA.

d. The layout assessment should start with a layout option with at least two consistent lines of orientation (which may include perimeter turbines with smaller spacing than internal turbines) and then be refined as appropriate for the project. The assessment should consider the potential impacts the proposed locations may have on navigation and SAR activities. Where a project proposed one line of orientation, this should be discussed with MCA and a safety justification must be prepared to support this reduction and submitted to the MCA for consideration.

e. The safety justification should build on work conducted as part of the Navigation Risk Assessment and the mitigations identified as part of that process. It should include a risk comparison between one and two (or more) lines of orientation, the reasons why two lines is not proposed and present sufficient information to enable the MCA to adequately understand how the risks to navigation and SAR associated with the proposed layout have been reduced to ALARP.

f. Liaison with the MCA is encouraged as early as possible following the outcome of the site-specific layout assessment, and to discuss any potential improvements which can be made to the proposed layout, where considered necessary. Where a project proposes just one line of orientation, this discussion should include any potential secondary lines, and additional risk mitigation measures that may be required as a result.

g. Micrositing should be carried out in such a way which has the least impact on the overall layout within agreed distances. Any requirement to locate structures beyond agreed distances should be discussed with MCA on a case-by-case basis.

h. Where multiple OREI sites have adjacent boundaries less than 1nm apart, including extensions to existing sites, due consideration must be given to the requirement for lines of orientation that allow a continuous passage for vessels and/or SAR helicopters through both sites, whilst still maintaining plans for at least two lines of orientation as appropriate to the site-specific nature of that site. Adjacent sites, as used in this section, will be assessed on a case-by-case basis.

i. Each layout design will be assessed on a case-by-case basis and once agreed formal acceptance will be provided collectively by both MCA's Technical Services Navigation and HM Coastguard.

6.3 Marine Navigational Marking

It should be determined:

a. How the overall site would be marked by day and by night throughout construction, operation and decommissioning phases, taking into account that there may be an ongoing requirement for marking on completion of decommissioning, depending on individual circumstances. Aids to Navigation (AtoN) will be determined (and sanctioned) by the relevant General Lighthouse Authority (GLA) (Trinity House, Northern Lighthouse Board or Commissioners of Irish Lights).

b. How individual structures and fittings on the perimeter of and within the site, both above and below the sea surface, would be marked by day and by night.

c. If the specific OREI structure would be inherently radar conspicuous from all seaward directions (and for SAR and maritime surveillance aviation purposes) or would require special radar reflectors or target enhancers.

d. If the site would be marked by additional electronic means e.g. Racons.

e. If the site would be marked by an Automatic Identification System (AIS) transceiver, and if so, the data it would transmit.

f. If the site would be fitted with audible hazard warning in accordance with IALA recommendations.

g. If the structure(s) would be fitted with aviation lighting, and, if so, how these would be screened from mariners or guarded against potential confusion with other surface navigational marks and lights (see Annex 5).

h. The proposed site and/or its individual generators must comply in general with markings for such structures, as required by the relevant GLA in consideration of IALA guidelines and recommendations. There is an expectation that working lights and the ID lighting will not interfere with Aids to Navigation or create confusion for the Mariner navigating in or near the OREI.

i. The Aids to Navigation specified by the GLAs are being maintained such that the 'availability criteria', as laid down and applied by the GLAs, is met at all times. Separate detailed guidance is available from the GLAs on this matter.

j. The procedures that need to be put in place to respond to casualties to the aids to navigation specified by the GLAs, within the timescales laid down and specified by the GLAs.

6.4 Identification Marking

a. Individual ID markings should conform to a "spreadsheet" format, e.g. lettered on the horizontal axis, and numbered on the vertical axis. The ID marking should be sequential, aligned with 'SAR lanes' (line of orientation for search and rescue purposes) and begin with the OREI name designator code, then the row/column numbering starting with the letter 'A' and then the turbine number. To avoid confusion, the letters 'O' and 'I' should not be used to avoid confusion with the numbers 0 and 1. The detail of this will depend on the shape, geographical orientation and potential future expansion of each OREI development. The ID marking must be discussed with the MCA who will advise on any specific requirements for each development, taking into account any difference between internal and periphery turbine alignment.

b. The ID marking of substations should be considered in line with the above and there should be a clear differentiation between the substation and the turbine.

c. ID numbers must be clearly readable by an observer stationed three metres above sea level at a distance of at least 150 metres from the turbine. Each ID number plate shall be illuminated by a low intensity light visible from a vessel thus enabling the structure to be detected at a suitable distance to avoid a collision. Lighting for this purpose must be hooded or baffled so as to avoid unnecessary light pollution or confusion with navigation marks.

6.5 Mooring Arrangements

a. Floating devices, including those suspended in the water column, must have suitable mooring arrangements for the environmental conditions to ensure the device(s) remains on station and does not become a navigation hazard through failure of its moorings. The Health and Safety Executive (HSE) and MCA have developed a combined guidance document that should be followed: *Regulatory expectations on moorings for floating wind and marine devices.* This is available from the MCA website and provides information on:

i. Safety Management Systems
ii. Design
iii. Hardware
iv. Installation
v. Operation
vi. Monitoring
vii. Third Party Verification

b. MCA will expect evidence of compliance with the *Regulatory expectations on moorings for floating wind and marine devices* demonstrated through the report and third-party verification.

6.6 Traffic Monitoring

a. There is a requirement for OREI operators to monitor and review the impact their activities have on the safety of navigation during the construction and operation phases.

b. The main purpose of vessel traffic monitoring is to be able to ensure the Navigation Risk Assessment (NRA) for the project is accurate for the construction and operation phase; that the predictions made in the NRA with regards to the traffic patterns are accurate, and to ensure the mitigation measures are effective and remain fit for purpose.

c. This should be carried out using AIS data and where practical, feedback should also be sought from commercial Masters, fishing vessel skippers, work boat crews and recreational sailors/users who regularly operate in and around different OREI sites to get realistic information on their experiences in different conditions.

d. The MCA would expect the opportunity to discuss any changes identified as part of this monitoring, since the submission of the NRA.

6.7 Cable Burial and Protection

a. It should be determined at what depth below the seafloor export cables are buried to ensure there are no changes to charted depths. If burial is not possible, for example due to underwater features and/or seabed ground conditions export cables should be suitably protected (e.g. by rocks or other such suitable mattress placements) to mitigate the risks to vessels. Any consented cable protection works must ensure existing and future safe navigation is not compromised. Consequently, the MCA would be willing to accept up to 5% reduction in surrounding charted depths referenced to Chart Datum, unless developers are able to demonstrate that any identified risks to any vessel type are satisfactorily mitigated.

b. Under no circumstances should depth reductions compromise safe navigation. Therefore, consideration should be given to areas of critical depths in relation to under keel clearance where any reduction in depth will increase risk to safe navigation, such as in IMO routeing measures, mobile seabed, approaches to ports etc, and developers must discuss the tolerability of any changes to depths with MCA.

6.8 Hydrography

a. In order to confirm the seabed has been returned as close to its original profile and to identify underwater hazards, namely exposed cables and any protection measures, detailed and accurate hydrographic surveys are required of the cable route(s) in the post-construction phase. This should be carried out in accordance with the guidelines in Annex 4.

6.9 Search and Rescue Requirements

a. As part of the post consent requirements, developers must address the requirements and guidance of the *Offshore Renewable Energy Installations: Requirements, Guidance and Operational Considerations for Search and Rescue (SAR) and Emergency Response* – Annex 5.

b. Based on lessons learned from OREI developments, the MCA has provided a SAR checklist for developers to record decisions made regarding the information contained in this document. The content of the SAR checklist is intended to be a live document and will apply throughout the lifecycle of the development. It will be used by the MCA to ensure actions agreed pre-consent and pre-construction, are correctly implemented. The actions will not all be completed when the checklist is agreed.

c. This SAR checklist is available to download from the MCA website and developers are expected to complete it as part of meeting their marine licence condition requirements. This is in addition to the MGN checklist required separately as part of the development consent process.

d. An agreed Hub Emergency Response Cooperation Plan (ERCoP) must be in place prior to construction commencing and a template, which includes guidance for completion, is available to download from the MCA website. The ERCoP must be updated or replaced with a new version for the operational phase of the OREI.

e. The offshore renewable energy industry is advancing and evolving, and requirements and guidance may therefore have to change in light of experience and lessons learned from emergencies and SAR incidents.

7. Decommissioning

7.1 The requirements for decommissioning offshore renewable energy installations are derived from the Energy Act 2004, Sections 105 to 114 and further guidance can be found in the BEIS publication *Decommissioning of offshore renewable energy installations under the Energy Act 2004* published in March 2019 and Marine Scotland's publication *Offshore Renewable Energy: decommissioning guidance* published in November 2019.

7.2 To minimise risks to mariners and SAR Operations there is an expectation that all infrastructure above the seabed and the sea surface will be removed. In the time between when the installation ceases to be operational and its removal, appropriate mitigation measures as per section 4.15 must be applied.

7.3 An agreed and updated ERCoP must be in place prior to the removal of any offshore infrastructure.

7.3 In order to confirm the seabed has been returned as close to its original profile once all, or some, of the infrastructure has been removed as required, a hydrographic survey is required of the cable route(s) and the installed generating assets area in accordance with the guidelines in Annex 4.

8. New and Emerging Technologies

8.1 It is recognised that the OREI industry is constantly evolving and its associated technology and procedures are developing. This means that there is an increasing demand on the UK's territorial seas and the EEZ and the MCA wishes to ensure that the increased use of those resources is managed in such a way that any risks that might impact on safety and pollution of the marine environment is kept to as low as is reasonably practicable.

8.2 The MCA continues to work with other regulators, navigation stakeholders and developers in achieving this goal. Regular meetings are held under the auspices of the Nautical and Offshore Renewable Liaison Group (NOREL) at which technical and consenting issues are discussed, and if necessary, referred to the Technical Working Group. Agreed recommendations and guidance is periodically agreed by NOREL and the MCA reserves the right to vary or modify the recommendations in this document based on experience or in accordance with internationally recognised standards in the interest of safety of life at sea and protection of the marine environment.

More Information

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Annex 1

Methodology for Assessing the Marine Navigational Safety & Emergency Response Risks of Offshore Renewable Energy Installations (OREI)

The MCA's "Methodology" document provides the recommended risk assessment methodology to use when preparing a Navigation Risk Assessment (NRA) for an OREI as part of the Shipping & Navigation chapter of a development consent application. It is based on the International Maritime Organization's Formal Safety Assessment guidelines and its principles can be applied to all OREIs of all sizes.

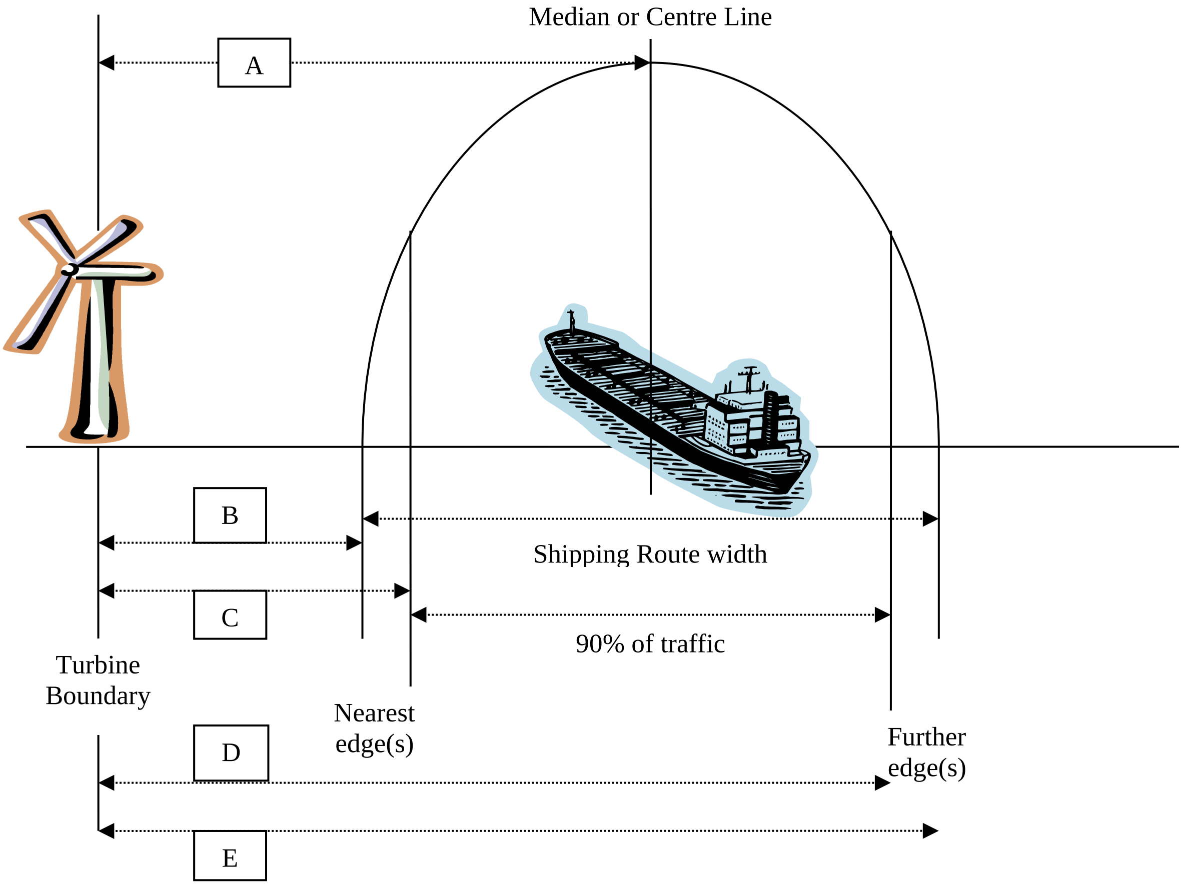
The document provides recommendations on the structure and contents of a NRA, including the identification of hazards and risk controls and a declaration that the risks associated with the OREI are As Low As Reasonably Practicable (ALARP) and tolerable.

The document is available to download from the MCA website.

Annex 2

INTERACTIVE BOUNDARIES

The below templates can be used for assessing distances between wind farm boundaries and shipping routes – see paragraph 4.7[6]



Precisely where an interactive boundary should lie requires similarly flexible definition and agreement. See diagram above where:

A = Turbine boundary to the shipping route median or centre line
B = Turbine boundary to nearest shipping route edge or IMO routeing measure boundary
C = Turbine boundary to nearest shipping 90% traffic level*
D = Turbine boundary to further shipping 90% traffic level*
E = Turbine boundary to further shipping route edge

(* = or another % to be determined)

[6] The Nautical Institute and World Ocean Council guidance document titled *The Shipping Industry and Marine Spatial Planning* may be useful to read in conjunction with this Annex: https://www.nautinst.org/uploads/assets/uploaded/299f934f-ee69-492e-8ada51abf26e8b19.pdf

WIND FARM SHIPPING ROUTE TEMPLATE

The wind farm "Shipping route" guidance template below is to be used as guidance and approval of distances between wind farm boundaries and shipping routes is on a case by case basis with MCA and relevant navigation stakeholders. It is important to recognise that the template is not a prescriptive tool but needs intelligent application and advice will be provided on a case-by-case basis.

<table>
<tr><th>Distance of turbine boundary from shipping route (90% of traffic, as per Distance C)[7]</th><th>Factors for consideration</th><th>Risk</th><th>Tolerability</th></tr>
<tr><td><0.5nm
(<926m)</td><td>X-Band radar interference Vessels may generate multiple echoes on shore-based radars</td><td>VERY HIGH</td><td>INTOLERABLE</td></tr>
<tr><td>0.5nm to <1nm
926m to <1852m</td><td>Mariners' Ship Domain (vessel size and manoeuvrability)</td><td>HIGH</td><td rowspan="3">TOLERABLE IF ALARP
Additional risk assessment and proposed mitigation measures required
* Descriptions of ALARP can be found in:
a) Health and Safety Executive (2001) 'Reducing Risks, Protecting People'
b) IMO (2018) MSC-MEPC.2/Circ.12/Rev.2 dated 9 April 2018, 'Revised Guidelines for Formal Safety Assessment (FSA) in the IMO Rule-Making Process'</td></tr>
<tr><td>1nm to <2nm
1852m to <3704m</td><td>Minimum distance to parallel an IMO routeing measure, as per Distance B.
S-Band radar interference ARPA affected (or other automatic target tracking means)</td><td>MEDIUM</td></tr>
<tr><td>2nm to 3.5nm
(3704m – 6482m)</td><td>Preferred distance to parallel boundary of an IMO routeing measure, as per Distance B[8]
Compliance with COLREG becomes less challenging</td><td>LOW</td></tr>
<tr><td>>3.5nm
(>6482m)</td><td>Minimum separation distance between turbines on opposite sides of a route</td><td>LOW</td><td>BROADLY ACCEPTABLE</td></tr>
<tr><td>>5nm
(>9260m)</td><td>Adjacent wind farm introduces cumulative effect
Minimum distance from TSS entry/exit</td><td>VERY LOW</td><td>BROADLY ACCEPTABLE</td></tr>
</table>

[7] Distance from an IMO Routeing Measure is measured from the routeing boundary i.e. Distance B.

[8] The Netherlands assessed sea room requirements using data supported by the PIANC assessment for channel design and the PIANC Interaction Between Offshore Wind Farms and Maritime Navigation (2018) report. In general, they strive for an obstacle free, or buffer, zone of 2nm between wind farms and shipping routes.

Under Keel Clearance Policy Paper, NOREL, May 2014

Guidance To Developers in Assessing Minimum Water Depth over Tidal Devices[9]

Purpose

The purpose of this paper is to provide guidance to developers in determining an appropriate margin of safety for vessels transiting over tidal devices and their associated structures.

This Paper is intended to assist discussions between developers and MCA and represents guidance only. Developers are free to deviate from the approach where they consider it necessary, can present a sound argument for doing so and/or offer mitigation measures.

Additionally, it is intended that this paper assists developers in identifying suitable locations for underwater devices when considered in the context of available water depth, vessels and craft that transit the area. However, it is not intended that this paper removes the need for developers to consult with the relevant regulator and advisors.

This UKC guidance addresses the worst case scenario, each specific development will have its own unique characteristics and will therefore be assessed on a case by case basis.

Background

Traditionally, the (minimum) under keel clearance was calculated as one of the factors required to provide safe passage for a vessel. Once known, this would allow the most viable route to be planned taking into account a vessel's size, draught and nature of cargo. Many vessel transits occur in the confined waters of ports and harbours where a minimum clearance can be defined and controlled. Many ports use whichever is the greater of a defined figure or 10% of a vessel's draught as the minimum under keel clearance.

Transits of areas of limited water depth in relation to a ship's draught and available width of navigable water are undertaken with caution, at reduced speed, with engines ready for immediate manoeuvre, watertight doors closed, bridge manning increased and in port areas, tug assistance for larger vessels. These precautions are taken because, despite the application of a minimum under keel clearance, the likelihood of grounding on immediately adjacent shallows is increased.

When calculating compliance with this requirement, the Master considers the effects of squat, heeling and other dynamic forces on the vessel. Tidal predictions will also be taken into account and transits planned to take advantage of tidal height.

Outside ports and other confined waters, the minimum under keel clearance used is at the discretion of the Master and quite often forms part of Ship Owner/Operator, Charterer or Insurer's policies/requirements.

Ensuring safe transit

In open waters, a larger minimum under keel clearance allowance will be used to account for the vessel's dynamic movement in a seaway and other external factors leading to subsequent changes in draught. Generally transits will be planned for any state of tide.

[9] This guidance can also be applied to wave energy devices.

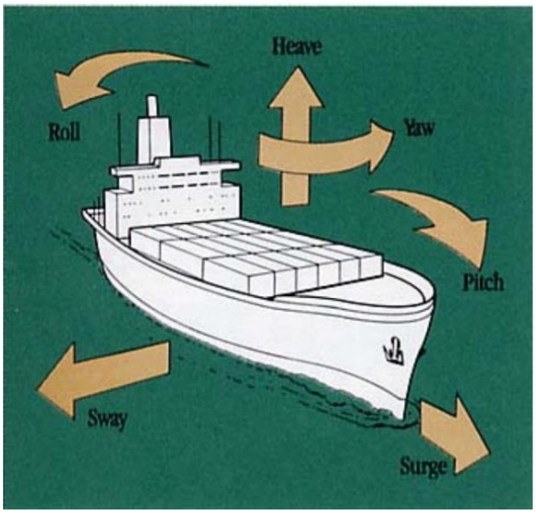


Figure 1: Vessel movements in a seaway

Available depth of water is affected by height of tide. There is a significant difference in some locations between Neap and Spring tide heights and range. Tidal heights can be affected by meteorological conditions which can on occasions mean that the actual tide height is less than the predicted height of tide.

The sea state has a significant impact with swell and sea waves causing reduced depths in the trough of a wave. Pitching and rolling along with vertical heave increases the draught of a vessel, as does the heeling of a vessel by the wind, sea and sharp rudder movements.

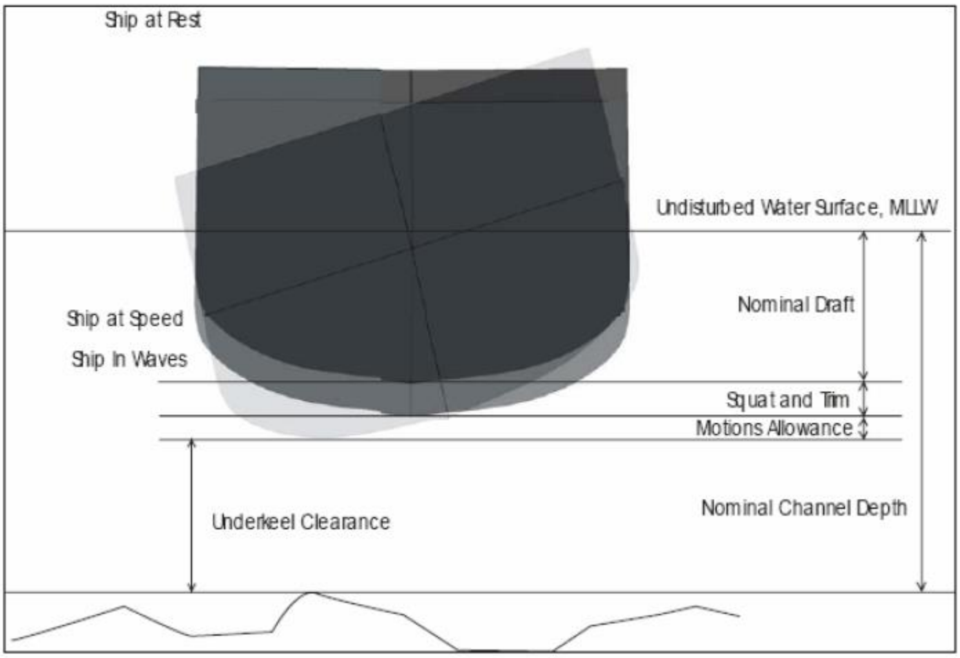


Figure 2: Effects of vessel dynamic movements on under keel clearance

Vessels create significant pressure variations around them as they pass through the body of water. These pressure variations are causal factors in vessel squat, bank effect, and interaction between vessels. The impact on these pressure variations on wave, tidal and similar devices is unknown and therefore advice from individual manufacturers should be sought.

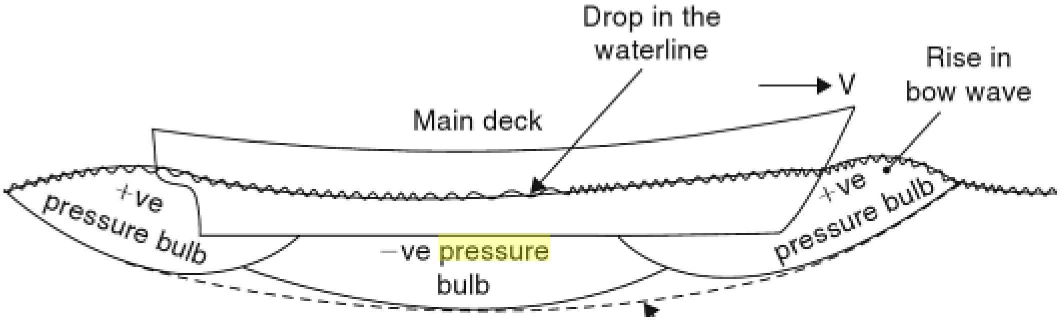


Figure 3: Vessel pressure variations (reproduced from Derret "Ship Stability for Masters and Mates")

Guidance for determining safe depth of water over wave, tidal and similar devices

Where there is no safe and reasonable deviation for marine traffic using the area, under keel clearance (UKC) over tidal turbines or other man made under water obstructions must allow for the safe transit of vessels at all states of tide.

This transit must be safe; this means that it must protect the vessel, its crew and cargo along with the wave, tidal turbine or other under water structures associated with them.

Two key factors need to be considered in determining UKC:

(i) The height of the device including its vertical safety margin. Two aspects to be considered; the position of the sea bed in relation to chart datum (CD) and the minimum vertical safety margin (M required above the device to ensure vessel transits do not damage and/or are detrimental to the device (e.g. the effects of interaction between a vessel and the device).

(ii) The draught of vessels transiting above the device. In Figure 4 the draught (Dd) is the maximum dynamic draught of the vessel and includes suitable allowances for the factors discussed under the heading 'Ensuring safe transit'.

When considered collectively, these two factors should ensure that there is no increase in likelihood of a vessel grounding (or in this case, striking an underwater device).

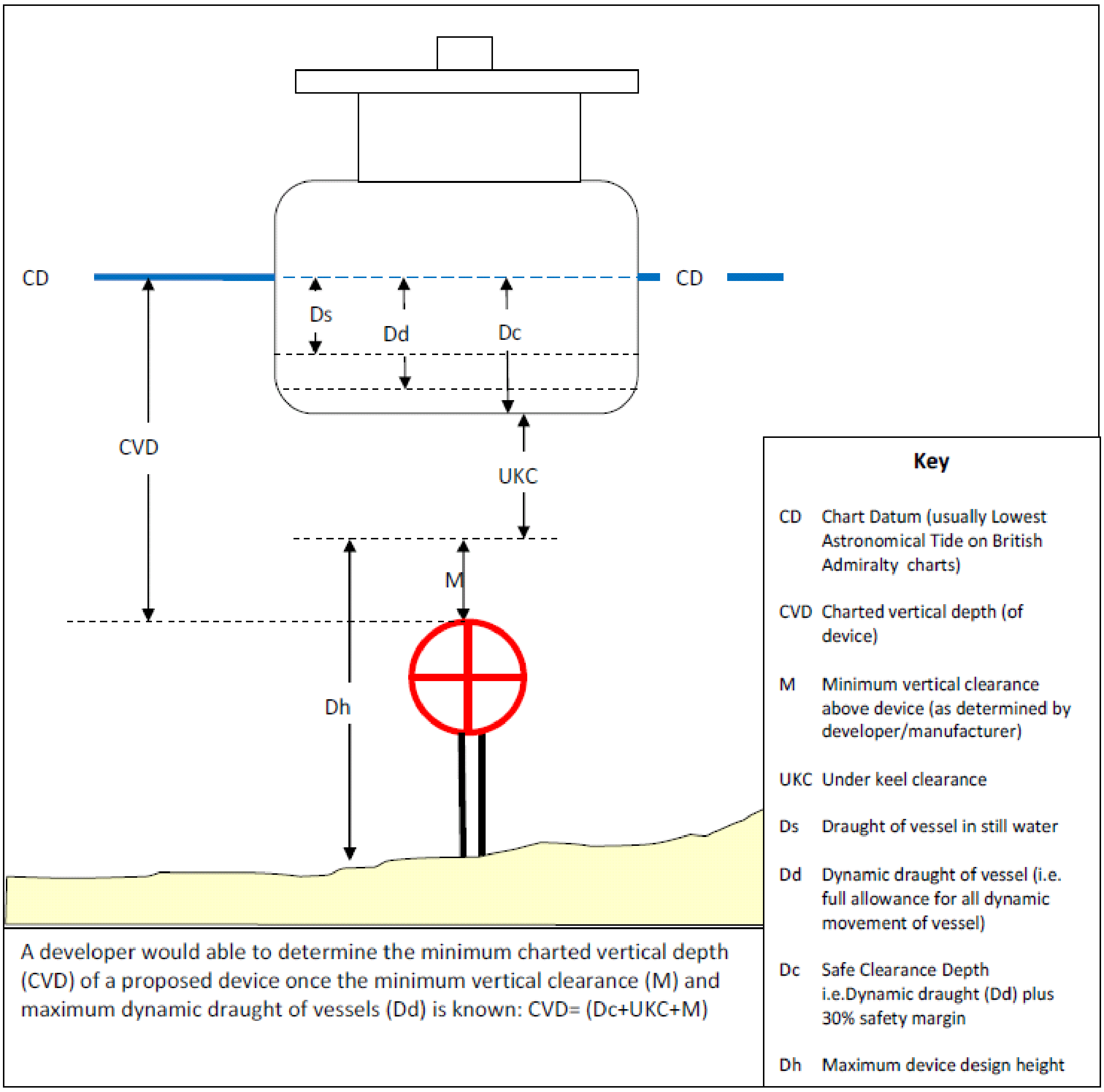


Figure 4: Illustrative view of a vessel passing over an underwater wave, tidal or similar device with the key heights and measurements

Each location will be unique and must be considered for the characteristics of sea, weather and swell. Traffic using the area must be thoroughly understood and the generic characteristic of vessels whether small, medium or large and their behaviour in expected sea states should be documented.

Based on this analysis, the maximum worst case dynamic draft can be calculated along with the least depth of available water.

OREI operators have no control over the transit time of vessels and therefore will not know what the tide state is during transit. To take account of this, their calculations should be based from chart datum and consider the worst case scenario transit at Low water (which for calculation purposes can be considered as the charted depth).

Assessment Criteria

In assessing minimum clearance depth over devices, using Figure 4 as the source data, the developer needs to establish a figure for Charted Vertical Depth (CVD) i.e. the minimum depth of water over the device, the following process should be adopted.

Establish, from traffic survey the deepest draft of observed traffic (Ds), this will require modelling to assess impacts of all external dynamic influences giving a calculated figure for dynamic draught (Dd).

A 30% factor of safety for UKC should then be applied to the dynamic draught, giving an overall safe clearance depth (Dc) to be used in calculation,

Charted Depth reduced by safe clearance depth (Dc) gives a maximum height above seabed available from which turbine design height (Dh) including any design clearance requirements (M) can be established.

This simple formula will give a minimum depth over the device against a calculated worst case scenario.

Conclusion

Taking account of the issues identified within this paper, it is clear that there is no standard figure that can be used to establish the safe clearance over underwater devices. Rather, developers will need to demonstrate an evidence based, 'case by case' approach which will include dynamic draught modelling to ascertain the safe water depth taking into consideration the guidance contained in this document.

Annex 4

Hydrography Guidelines for Offshore Developers

All hydrographic surveys should provide full seafloor coverage that meets the requirements of IHO S44ed5 Order 1a. Particular attention should be given to horizontal and vertical sounding accuracy, together with target detection requirements and, we would request that all data and reports are passed on to the UKHO for the update of the UK's nautical charts and publications.

The full details can be found in The Hydrography Guidelines for Offshore Developers and the Post Construction Hydrography Guidelines for Offshore Developers available from the MCA website.

Annex 5

Search & Rescue, Maritime Assistance Service, Counter Pollution and Salvage Incident Response

OREI developers must fulfil the requirements of the MCA's guidance document "*Offshore Renewable Energy Installations: Requirements, Advice and Guidance for Search and Rescue and Emergency Response"* which includes design, equipment and operational requirements.

A completed SAR checklist and a Hub Emergency Response Co-operation Plan (ERCoP) are required to be in place for the construction, operation and decommissioning phases of any OREI. The SAR checklist is a record of discussions regarding the requirements, recommendations and considerations outlined in the above document and should be agreed by the developer and MCA on a case-by-case basis. The content of the SAR checklist will apply throughout the life of the OREI and will be used by the MCA to ensure actions agreed pre-construction and are correctly implemented.

Templates of the SAR checklist and Hub ERCoP are available from the MCA website.

Annex 6

MGN Checklist

A checklist document has been produced as an aid for developers to confirm the guidance in this MGN has been addressed within a Navigation Risk Assessment and/or Environmental Impact Assessment as required for development consent decisions.

Full details and the template can be found on the MCA website. It should be noted a completed checklist is required to accompany the Navigation Risk Assessment and/or shipping and navigation chapter in an EIA Report.

Maritime &
Coastguard
Agency

Methodology for Assessing Marine Navigational Safety & Emergency Response Risks of Offshore Renewable Energy Installations (OREI)

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Version History	Date	Government Department
1	December 2005	Department for Trade and Industry
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3	April 2021	Maritime and Coastguard Agency, Department for Transport

Acknowledgements

In December 2005 the Department of Trade & Industry (DTI), in co-operation with the Department for Transport (DfT) and the Maritime & Coastguard Agency (MCA), produced a document entitled “*Methodology for Assessing the Marine Navigational Safety Risks of Offshore Wind Farms”.* In September 2013 the Department of Energy and Climate Change (DECC) in co-operation with the MCA, updated this edition to include data gained through operational knowledge since 2005, with Marine Guidance Notes (MGN) produced by the MCA and to enable the risk assessment of all OREI types, including the associated emergency response issues. The title was amended to *Methodology for Assessing the Marine Navigational Safety & Emergency Response Risks of Offshore Renewable Energy Installations”.*

This version was produced by MCA in co-operation with those individuals and organisations who contributed useful feedback during the consultation period through the Nautical and Offshore Renewable Energy Liaison (NOREL) group. It is not intended to be published in hard copy, but available online, along with a suite of technical support documents. A revised MGN will direct users to the on-line guidance documentation.

Note: *New guidance and MGNs together with mandatory legislation may be promulgated at any time and developers should consult the MCA website at regular intervals for such revisions or innovations.*

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GLOSSARY

AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
BEIS	Department for Business, Energy and Industrial Strategy
BMT	British Maritime Technology
CBA	Cost Benefit Analysis
CEFAS	Centre for Environment, Fisheries and aquaculture Science
CGOC	Coastguard Operations Centre
COLREG	International Regulations for the Prevention of Collisions at Sea 1972, as amended
CPA	Coast protection Act 1949
CURR	Cost per Unit Reduction of Risk
DECC	Department for Energy and Climate Change
DEFRA	Department for Environment, Food & Rural Affairs
DfT	Department for Transport
DTI	Department of Trade and Industry
ER	Emergency Response
ERCoP	Emergency Response Cooperation Plan
ETA	Event Tree Analysis
EU	European Union
FEPA	Food and Environmental Protection Act 1985
FMEA	Failure Modes and Effects Analysis
FSA	Formal Safety Assessment
FTA	Fault Tree Analysis
HAZOP	Hazard and Operability Studies
SFAIRP	So Far As Is Reasonably Practicable
HSE	Health and Safety Executive
IMO	International Maritime Organization
LOHI	Loss of Hull Integrity
MCA	Maritime and Coastguard Agency
MGN	Marine Guidance Note
MSN	Merchant Shipping Notice

OREI	Offshore Renewable Energy Installation
RCM	Risk Control Measure
RCO	Risk Control Option
RNLI	Royal National Lifeboat Institution
R2P2	HSE Document Reducing Risks, Protecting People
SAR	Search and Rescue
SFAIRP	So Far As Is Reasonably Practicable
VTS	Vessel Traffic Service

EXECUTIVE SUMMARY

This revised document has been produced by the Maritime and Coastguard Agency (MCA) with the co-operation of key stakeholders as a methodology for assessing the marine navigational safety & emergency response risks of offshore renewable energy installations. With the exception of the MCA technical guidance, it conforms closely to the original version of December 2005 and subsequent amendment in September 2013. This version was incorporated into MGN 654 as Annex 1. Developers who have produced Navigational Risk Assessments prior to the publication of this document should simply note the new guidance available and refer to it as and when appropriate.

Its purpose is to be used as guidance for developers in preparing their navigation risk and emergency response assessments and includes a suggested template in which they may produce their submission. It is centred around risk controls and the feedback from risk controls into risk assessment. It requires a submission that shows that suitable and appropriate risk controls are, or will be, in place for the assessed risk to be judged as broadly acceptable or tolerable. Although the specifics of this guidance are not mandatory, its use in carrying out marine navigational safety and emergency response risk assessments is strongly recommended. The key features of the Methodology recommend that developers:

1. Produce a submission that is proportionate to the scale of the development and the magnitude of the risks.
2. Produce a submission based on assessing risk by Formal Safety Assessment (FSA) using numerical modelling and/or other techniques and tools of assessment acceptable to Government and capable of producing results that are also acceptable to Government.
3. Estimate the “Base Case” level of risk based on existing densities and types of traffic and the existing marine environment.
4. Predict the “Future Case” level of risk based on the predicted growth in future densities and types of traffic and reasonably foreseeable future changes in the marine environment.
5. Produce a “Hazard Log” listing the hazards caused or changed by the introduction of the OREI, the risk associated with the hazard, the controls put in place and the tolerability of the residual risk.
6. Define the risk controls that will be put in place and create a Risk Control Log.
7. Predict the “Base Case with OREI” level of risk based on existing densities and types of traffic, the existing marine environment and with the OREI in place.
8. Predict the “Future Case with OREI” based on future traffic densities and types, the future marine environment and with the OREI in place.
9. Process this information into a submission including a claim that the risks associated with the OREI are Tolerable on the basis of “As Low As Reasonably Practicable” (ALARP) declarations.

It advises that Government will base their decision on assessing:

1. Whether the tools and techniques used in the assessments are acceptable.
2. Whether the claim in the submission shows that the OREI will meet the sought-after level of marine navigational safety and emergency response.
3. Whether there is sufficient information with the submission to have confidence in the claim.
4. Whether there is sufficient information with the submission to have confidence that appropriate risks controls are, or will be, in place.

1. INTRODUCTION

1.1 Development of the Methodology

The project to develop a methodology for assessing the marine navigational safety risks of offshore wind farms and other types of OREI was originally, in 2005, carried out by the Department of Trade and Industry (DTI) in conjunction with British Maritime Technology (BMT) Renewables Ltd. It has evolved with the close co-operation of developers, the Government, its agencies, and other stakeholders. Extensive consultation and research were carried out to ensure that the methodology is robust, verified, auditable and accountable in a local, national and international context. These features have been confirmed in the intervening years and were expanded in 2013 to cover emergency response issues and the document was revised in consultation with key stakeholders.

1.2 Risk Control

The Methodology is focused on risk controls and in preparing a submission which shows that sufficient risk controls are in place for the assessed risk to be judged as “tolerable”.

The primary duty in law (Health and Safety at Work Act, 1974) is to reduce risk so far as is reasonably practicable (SFAIRP). For most purposes, this is synonymous with it being reduced to as low as reasonably practicable (ALARP) used in the IMO’s Formal Safety Assessment (FSA) guidance, upon which this risk methodology is based. The mere fact that a risk falls into a ‘tolerable’ or ‘broadly acceptable’ band in a Risk Matrix (see Annex C), or is below some numerical limit, does not prove that it has been reduced SFAIRP or to ALARP. Further reduction may still be reasonably practicable, however small the risk.

1.3 Structure

This document is comprised of two parts:

- A recommended Methodology (described in the main text);
- General guidance & suggested techniques (described in the Annexes);

Methodology

Developers are invited to carry out marine navigational safety and emergency response risk assessments in accordance with the spirit of the methodology and the MCA’s Marine Guidance Note (MGN) 654 *Safety of Navigation: Offshore Renewable Energy Installations (OREIs) - Guidance on UK Navigational Practice, Safety and Emergency Response* and to submit the results in accordance with the standard format for a submission.

In carrying out these assessments, developers should address the two phases of the OREI’s life concerning construction, and operation and maintenance.
(Note: The assessment of risks during the decommissioning stage are addressed separately through the decommissioning programme.)

Guidance

Guidance to developers in applying the methodology is provided, as annexes illustrating various methods. Although the specific aspects of this guidance are not mandatory, it is strongly recommended that developers carry out risk assessments in the spirit of the detail indicated.

1.4 Key Terminology

The key terminology used in this document is:

Table 1 - Key Terminology

Acceptable Techniques	Techniques that are acceptable to Government in assessing the marine navigational safety and emergency response risks of offshore wind farms and other OREI types.
Acceptable Results	Results from applying the acceptable techniques that are themselves acceptable to Government. ***Note:*** *An "Acceptable Result" is a result where the risk has been accurately assessed. It does not necessarily mean that the risk is acceptable.*
Accident	An unintended event involving fatality or injury, property loss or damage or environmental damage.
Accident Category	A designation of accident reported according to their nature.
Area Traffic Assessment	The part of general navigation risk assessment that assesses the wider sea area, its marine environment, traffic and the OREI development to enable the prediction of the risk of collision, contact, grounding and stranding.
Consequence	The outcome of an accident.
FN Curve	The cumulative frequency (F) of an accident versus the number (N) of fatalities.
Formal Safety Assessment	A rational and systematic process for assessing the risk associated with an activity and for evaluating the costs and benefits of options for reducing these risks. FSA is recommended by the IMO in its rule-making process.
Frequency	The number of occurrences per unit time (e.g. per year).
General Navigation Safety Risk Assessment	The part of the navigation risk assessment relating to collision, contact, grounding and stranding of vessels. Generally, this assessment will be centred on a Hazard Log and other assessment techniques and appropriate tools, which may include numerical modelling and simulation.

Guidance	Guidance on techniques and tools that may be used in applying the Methodology.
Hazard	A potential to threaten human life, health, property of the environment.
Individual Risk	A direct measure of the frequency of injury and fatalities for individuals at a given location e.g. crew members, passengers and third parties.
Initiating Event	The first in a sequence of events leading to a hazardous situation or accident.
Marine Navigational Safety and Emergency Response Risk Assessment	The body of information produced that is used as the basis of the marine navigational safety and emergency response risk assessment carried out for inclusion in the developer's ES comprising: • Formal Safety Assessment (FSA) supported by: • Navigation risk assessment comprising: ○ General Navigation Safety Risk Assessment and ○ Other Navigation Safety Risk Assessment • General details of Search and Rescue implications
Methodology	The recommended process, as described in this document, for undertaking and presenting a marine navigational safety and emergency response risk assessment to Government as part of the developer's EIA Report.
Other Navigation Safety Risk Assessment	The part of the navigation risk assessment relating to the wider range of marine safety risks but excluding initial collision, contact, grounding and stranding. This assessment may be centred on a Hazard Log.
Risk	The combination of the frequency of occurrence and the severity of the consequence.
Risk Control Measure	A means of controlling a single element of risk. Usually expressed as either: a. embedded – standard or good practice measures already utilised or in place, or b. additional – in addition to embedded controls for reducing risk to ALARP
Risk Control Option	A grouping of risk control measures into a practical regulatory option.

Societal Risk	An indirect measure of the magnitude of the event taking into account public aversion to large accidents. It is average risk experienced by a group of people exposed to an accident scenario.
Specific Traffic Assessment	The part of the general navigation risk assessment that may be used, where required, to assess in detail the risk of more specific navigation issues and/or the proposed risk controls.

2. USE AND COVERAGE OF THE METHODOLOGY

2.1 Use by Developers

This Methodology has been produced to assist developers in preparing their marine navigation safety and emergency response risk assessments for all types of OREI, and to identify the type and level of information that should be provided by the OREI developer in an application. It includes a template developers may wish to follow in preparing their submission.

Developers are recommended to carry out marine navigation safety and emergency response risk assessments in accordance with the IMO's Formal Safety Assessment methodology and to submit the results in accordance with the standard format for a submission. This is shown in Section 7.

Although this methodology was originally intended for use by OREI developers, the principles can be applied to other developments below Mean High Water Spring, for example, individual structures (e.g. meteorological masts), cables (e.g. telecommunications, interconnectors), aquaculture (e.g. seaweed farms), other energy generating facilities (e.g. biomass, waste, nuclear) and more.

Note: *With respect to operations carried out on wind turbines and other OREI structures, developers are directed towards the various Health & Safety Executive (HSE) guidance and requirements, including Construction, Design and Management (CDM) regulations*[1].

2.2 Coverage of the Methodology – Physical Areas

The key risk areas to be covered by the methodology are:

- Risks associated with a development
- Cumulative risks associated with the development and the other OREI developments in the strategic OREI area
- In-combination effects on the risk of the development with other economic developments over the operational life of the OREI.

2.3 Cumulative Impacts

Consideration of cumulative and in combination effects need to be undertaken, adopting a zonal approach for large developments, which will require a detailed consideration of the 'worst case' scenario. The National Policy Statement for Renewable Energy Infrastructure (EN1) outlines the Government approach to cumulative impacts[2].

2.4 Relationship with the EIA Report

The Navigational Risk Assessment (NRA), produced by applying this Methodology, informs the Shipping and Navigation chapter of the EIA Report required for a development consent decision. The EIA Report should confirm which NRA recommendations are proposed with justification for acceptance or rejection of each. It is recommended to use the same or similar terminology in the

[1] For initial advice see : http://www.hse.gov.uk/risk/fivesteps.htm

[2] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf

EIA Report and NRA to ensure there is a clear understanding on the proposals at the application stage.

The marine navigational safety and emergency response risk aspects of the Navigational Risk Assessment are largely based on the Maritime and Coastguard Agency's Marine Guidance Note 654 (M+F), or subsequent updates. This MGN provides guidance on the technical navigation and Search and Rescue (SAR) issues needed to be considered for all stages of development, not just pre-consent to which this methodology applies.

3. SCOPE AND DEPTH OF ASSESSMENT

3.1 Proportionality

The scope and depth of the developer's assessment, together with the tools and techniques necessary to carry this out, should be proportionate to the scale of the development and magnitude of the risks. Developers are advised, prior to developing a submission to:

- Inform the MCA of their proposals and seek guidance
- Carry out a preliminary hazard analysis
- Define an appropriate programme of work
- Define the tools and techniques to be used
- Be prepared to change scope, depth, tools and techniques resulting from assessed risk as the full assessment progresses.

The MCA will consider each assessment on a case by case basis and will be prepared in principle to accept a change in scope, depth, tools and techniques resulting from the assessed risk as the full assessment progresses.

3.2 Examples of Proportionality

High Risk or Large-Scale Development

A development in an area where the potential risks are high, or a large-scale development e.g. those that qualify for an EIA, would probably require a submission based on a:

- Comprehensive Hazard Log
- Detailed and quantified Navigation Risk Assessment
- Preliminary search and rescue assessment or overview to agreed MCA requirements
- Preliminary emergency response assessment or overview to agreed MCA requirements
- Comprehensive Risk control log.

Low Risk or Small-Scale Development

A development in an area where the potential risks are lower, or a small-scale development, might only require a submission based on a:

- Hazard list
- Navigation Risk Assessment based on qualitative techniques such as "expert judgement"
- Search and Rescue overview, to agreed MCA requirements
- Emergency response overview, to agreed MCA requirements
- Risk Control List.

3.3 Preliminary Search and Rescue Operations Assessment or Overview

The OREI may present risks to marine safety that generate the need for search and rescue operations or may hinder search and rescue operations not connected to the development itself.

Therefore, the preliminary assessment should firstly consider all those features of the proposal which could present problems for the emergency services.

These considerations will include, but not be limited to, the detection, location and rescue of casualties[3] and safe operation of rescue assets within and near to the OREI by: other vessels, MCA Coastguard Operations Centres (CGOCs), MCA SAR helicopters and RNLI lifeboats or other rescue assets. They will subsequently feed into the details of the proposed turbine compliance with respect of an Emergency Response Cooperation Plan (ERCoP) addressing individual turbine marking, lighting, rotor and nacelle control, emergency refuge and communications links. These should link to the developer's own contingency plans and safety management system, developed in conjunction with the Health & Safety Executive (HSE) in relation to its personnel working on turbines or operating within and close to the OREI. It is recommended that any marine safety aspects of these be discussed and agreed with MCA. In particular, note should be taken of any recommendations made by the Nautical & Offshore Renewable Energy Liaison (NOREL) group with respect to helicopter operations within and around OREI, and to the requirements of the Civil Aviation Authority (CAA).

Due to the differences in designs and layouts, the physiological demands and safety risks of OREI structures, the rescue of personnel from OREI structures is not part of the training or mission of search and rescue helicopter or lifeboat personnel. To ensure rapid and effective rescue of injured or ill persons from within OREIs, it is recommended that developers and operators create in-field Technical Rescue teams or capabilities. Such teams could be comprised of technicians or other employees who have received relevant training and qualification in technical rescue and immediate medical aid techniques and procedures. These teams would form the primary response to extract an injured or ill person from within an OREI and deliver them to an accessible area for onward evacuation by SAR unit. This would most likely be from a helicopter winching area or vessel.

Emergency trials and exercises have taken place at a variety of UK windfarms since an initial one at North Hoyle in 2005, including 'Guardex', a major multi-agency exercise at London Array in 2012. HM Coastguard SAR helicopters have also conducted a series of exercises at Hornsea 1, where crews were able to simulate bad weather flying prior to the windfarm being fully constructed. These have all proved invaluable to evaluate SOPs and ensure operations within and in the vicinity of OREIs is fully understood and refined.

Since surface vessels will, in some circumstances, often be the most appropriate means of rescue from within wind farms or close to other OREI, the assessment should give details of the nearest RNLI, or other lifeboat service, stations near to the site.

Such a full assessment may, if deemed appropriate by MCA, include:

- Resource planning assessment
- Response planning assessment

The MCA will inform developers of their specific requirements in this respect.

[3] Casualty is a generic term used by the Coastguard to describe persons, vessels or aircraft in distress or danger at sea.

3.4 Preliminary Assessment or Overview of the Required Emergency Response to the spills of Hazardous and Polluting Substances

Developers should become familiar with the Government's "National Contingency Plan for Marine Pollution from Shipping and Offshore Installations" (NCP)[4]. Such pollution, which includes oil and a variety of hazardous substances, may result from incidents occurring within or close to an OREI.

The preliminary assessment should determine the likelihood of any such incident occurring, such assessment to be based on the general navigation risk assessment and the types of vessel expected to be found in the vicinity. The potential consequences of such an incident, with respect to seafarers, the environment, and the shore population should be considered.

Any circumstance created by the OREI development which may adversely affect counter pollution operations undertaken by the appropriate authorities should be specified. These circumstances should include counter pollution operations relating to incidents not caused by the development itself, but into whose area the resulting pollution may drift.

3.5 Requirements for more detailed Emergency Response Assessments

Depending on the above assessment MCA may require a more detailed emergency response assessment to be undertaken later as a condition of a granted consent. However, where the frequency or the consequences of such incidents gives rise for even greater concern, a full assessment may be required before consent is granted. Developers of specified OREIs may be required to develop individual Marine Pollution Contingency Plans (MPCP) broadly following the structures set out in the NCP.

[4] Details of changes to the NCP, and other information on its content can be obtained from the MCA's Counter Pollution Branch.

4. MARINE NAVIGATIONAL SAFETY GOAL

4.1 Proposed Navigation Safety Principles

Due to the lack of specified goals for navigational safety in national or international waters, it is prudent to consider the overarching principle of reducing risk to that which is "as low as reasonably practicable" (ALARP) and that relevant good practice risk controls are in place.

This overarching principle is based on the UK Health and Safety Executive (HSE) document "Reducing Risks Protecting People", which is a guide to the HSE's decision-making process[5]. The document is aimed at explaining the decision-making process of the HSE[6] and therefore contains much useful information on risk-based decision making.

4.2 Implications of the Proposed Navigational Approach

The implication of the proposed navigational safety approach is that safety will have to be managed through the lifetime of an OREI. Through life safety management will include:

- Keeping up to date the marine navigational safety and emergency response risk assessment
- Updating other risk assessments
- Updating risk mitigations and controls (including the provision of assets)
- Having a safety policy
- Having a commitment to comply with latest MGN guidance.
- Meeting the requirements for lighting and marking in accordance with IALA O-139
- Running an effective ERCoP
- Keeping current a safety and operations plan
- Having an emergency plan
- Maintaining a safety culture
- Having a process for "Through Life Review".

As much of this will involve work after the consent period is granted, at the consent application stage the developer's navigational safety and emergency response risk assessment must make a commitment to:

- Marine navigation risk assessment
- Enact the risk mitigations and controls (including the provision of assets) listed in the application
- Undertake any required post consent search and rescue and emergency response assessments.
- Define a safety policy
- Follow the RenewableUK Guidelines for Health and Safety in the wind energy and other OREI industries[7]
- Introduce a safety management system
- Install, operate and practice the Emergency Response Cooperation Plan (ERCOP)
- Operate in accordance with a safety and operations plan

[5] Reducing Risks Protecting People (RRPP or R2P2), ISBN 0 7176 2151 0, available as a download from www.hse.gov.uk/risk/theory/r2p2.htm

[6] RRPP page vi

[7] See "Health & Safety" at www.renewableuk.com

- Set up and periodically exercise an emergency plan
- Take positive action to create a safety culture including Board level responsibilities and Measurement with feedback of the level of compliance
- Undertake periodic risk reviews and implement the findings to keep the risk levels within the goals for the navigation safety aspects of the OREI as part of their overall approach to safety.

5. OVERVIEW OF THE METHODOLOGY

5.1 Key Features of the Methodology to achieve the Marine Navigational Safety Objectives

The key features of the Navigational Risk Assessment methodology are risk assessment (supported by appropriate techniques and tools), creating a hazard log, defining the risk controls in a Risk Control Log required to achieve a level of risk that is tolerable, and preparing a submission that includes a claim, based on a reasoned argument, for a positive consent decision.

To produce a submission based on Formal Safety Assessment:	
1	**Define a Scope & Depth of the submission proportionate to the scale of the development & the magnitude of the risks**
2	**Estimate the "base case" level of risk**
3	**Predict the "future case" level of risk**
4	**Create a hazard log**
5	**Define risk controls and create a risk control log**
6	**Predict "base case with OREI" level of risk**
7	**Predict "future case with OREI" level of risk**
8	**Submission**

Figure 1- Key Features of the Methodology

5.2 Appropriate Risk Assessment Techniques

There are a wide range of risk assessment techniques available and the selection of the techniques should be:

- Proportionate to the scale of the development and the magnitude of the risk
- Acceptable to Government.

Techniques and tools appropriate to aspects of specific developments include:

- No action
- Expert judgement
- Qualitative assessment
- Quantitative calculations
- Simulations
- Trials
- Analysis of the real-world situation.

Various approaches to risk assessment, using the above techniques and tools, can be utilised and the techniques selected will need to be justified in the submission (see Annex D2).

5.3 Integrity of Risk Assessment

It is important that risk assessment should be of high integrity and not just a quoted risk number. Risk assessment should be used to:

- Show that the activities (i.e. navigation, search and rescue and emergency response) will remain feasible during construction and operation of the development.
- Produce an intelligent comparative value of the change in risk associated with the activity caused by the development
- Assess the sensitivity of the risk to changes
- Identify, evaluate and decide on appropriate risk controls.

In addition, the discipline of risk assessment is to be used to identify issues that need to be considered in the:

- Hazard log
- Selection of Risk Control Options.

5.4 Progressive Development of the Submission

It is recommended that the submission is developed in stages as the scope and depth of each stage is dependent on the findings of the previous stage. The suggested stages are:

Stage 1: Obtain MCA approval for approach to be taken

- Preliminary Hazard Analysis
- Define an appropriate Programme of Work

- Specify the tools and techniques to be used

Stage 2: Traffic Survey (see MGN 654 Section 4.6)

- Understanding the Base Case densities and types of traffic
- Understanding the future densities and types of traffic

Stage 3: Navigation risk assessment

- Area traffic assessment
- Specific traffic assessment (if appropriate)

Stage 4: Formal Safety Assessment comprising

- Hazard identification
- Risk assessment
- Hazard log
- Risk control log
- Cost-Benefit Analysis, if appropriate.

Stage 5: Other Assessments

- Appropriate search and rescue assessment or overview
- Appropriate emergency response assessment or overview

Stage 6: Final Assessments and Submission Preparation.

6. MECHANISM FOR ASSESSING TOLERABILITY OF MARINE NAVIGATIONAL SAFETY AND EMERGENCY RESPONSE RISK

6.1 Tolerability of Individual Risks

Developers should aim to achieve agreement with stakeholders that risks in the hazard log are reduced to a level that is as low as reasonably practicable (ALARP). Failure to reach agreement may result in delays or objections from stakeholders within the licensing and consenting process.

Risk

For each entry in the hazard log the risk shall be assessed against a risk matrix. Annex C provides examples of risk scoring from the IMO and HSE. Other risk scoring systems may be used by developers.

- There shall be no unacceptable risks
(***Note***: *The rating of risk may, with suitable justification, be determined by those undertaking the assessment. "Unacceptable" risks are normally those with a score of 6 or 7, in the HSE example*)

- All risks assessed as Tolerable with 'x' (e.g. scores 3 to 5, *in the HSE example*) shall be subject to an assessment of rule compliance and proposed risk controls. Further risk control options must be considered to the point where further risk control is grossly disproportionate (i.e. the ALARP principle) and an ALARP justification and declaration made.

Evidence

For each entry in the hazard log the sources of evidence shall be listed e.g. expert judgement, quantitative calculations.

Risk Controls

For each entry in the hazard log the risk controls shall be listed.

6.2 Tolerability of Societal Concerns

It is unlikely that reducing all risks in the hazard log to a level that is ALARP will be sufficient to give confidence that societal concerns are broadly acceptable. This is because many of the risks are interrelated in both cause and consequence and also the affected stakeholders may have different perspectives of perceived risks. Therefore, as a minimum, an overall assessment of societal risk will need to be made as:

- An aggregate of all entries in the risk register; and for
- Major risks such as collision, contact, grounding and stranding

The level of risk can, if appropriate, be determined in the form of an FN curve[8] and:

Base Case

- With the current traffic, existing marine environment without the OREI
- Is assumed to be tolerable

Base Case with OREI

- With the current traffic, existing marine environment and with the OREI
- The change against the base case needs to be assessed and judged against ALARP criteria

Future Case

- With the future traffic, future marine environment without the OREI
- Is assumed to be tolerable

Future Case with OREI

- With the future traffic, future marine environment and with the OREI
- The change against the future case needs to be assessed and judged against ALARP criteria

These calculations and their results shall both be based on techniques that are acceptable to Government.

Note: *These values of change and their tolerability are likely to be dependent on a number of variables used in the assessment of an OREI. These will include the size of the water space, its bathymetry and hence the sea room available for manoeuvring, and the variations in the marine operations taking place in the water space. The larger the space the lower the ratio of the OREI to base case risk.*

[8] See Annex C4 – Measuring the level of risk

7. STANDARD FORMAT OF A SUBMISSION

7.1 Contents of a marine navigational safety and emergency response risk assessment Submission

Developers are invited to submit their assessments in the following format:

Table 2 - Contents of a marine navigational safety and emergency response risk assessment submission

Sect.	Contents	Commentary on the Contents	Supporting information
1	**Summary**		
2	**Risk Claim supported by a Reasoned Argument and Evidence**	This should be written in such a way so that, if read separately from the rest of the document, the reader can understand: • If the developer is claiming that the OREI will achieve the sought for level of marine navigational safety • the reasoning and evidence on which that claim is made It should include: a. Navigational Safety Claim b. Supporting Reasoned Argument c. Overview of the Evidence obtained Detailed description of the tools and techniques used, describing in detail, and demonstrating where necessary, the tools and techniques used and their rationale. This will be necessary for gaining "acceptance" of tools and techniques by Government	
3	**Description of the Marine Environment**	This description should include the: a. Current marine environment b. Future marine environment	**Annex B3**
4	**Description of the OREI Development and how it changes the Marine Environment**	This description should include: a. The proposed OREI b. Any options c. The future environment	**Annex B3**

Sect.	Contents	Commentary on the Contents	Supporting information
5	**Analysis of the Marine Traffic**	This analysis should include: a. Current traffic densities and types b. Predicted future traffic densities and types c. The effect of the OREI on current traffic densities and types d. The effect of the OREI on future traffic densities and types	**Annexes** **B1** **B2**
6	**Status of the Hazard Log**	This should include: a. Summary of Tolerable, ALARP and Intolerable Risks b. Graphical representation of all risks on a matrix	**Annexes** **C3** **C4** **C5**
7	**Navigation Risk Assessment**	The risk assessment should include: a. Base Case b. Future Case c. Base Case with OREI d. Future Case with OREI e. Future Options f. A summary of the other navigation safety risks from the hazard log and the risk controls put in place to manage them	**Annex** **D1**
8	**Search and Rescue Overview and Assessment**	Assessment dependent on level agreed with the MCA. In high risk developments this may include, prior to or post consent: • Resource Planning • Prevention Strategy • Response Plan Assessment	**Section** **3.3**
9	**Emergency Response Overview and Assessment**	Assessment dependent on level agreed with the MCA.	**Sections** **3.4** **3.5**
10	**Status of Risk Control Log**	An overview of the risk controls in the Risk Control Log	**Annex** **E1**

Sect.	Contents	Commentary on the Contents	Supporting information
11	**Major Hazards Summary**	A summary of the major hazards, how they have been assessed, how they will be controlled and what trials have been undertaken to develop the assessment or controls. Likely “Major Hazards” to be summarised are: • Collision and contact with other vessels and with OREI structures • Grounding • Contact with cables and snagging • Interference with communications, radar, etc.	**Annexes** **F1** **F2**
12	**Statement of Limitations**		**Annex E2**
13	**Through Life Safety Management**	An indication of, or a commitment to, the planned through life safety management including: • Updating risk assessments • Filling gaps in assessment • Safety Policy • Safety Management System • Safety and Operations Plan • Emergency Plan • Through Life Review • Emergency Response Cooperation Plan[9]	

7.2 Explanatory Annexes

Explanatory annexes may be included if appropriate to expand on the information given in the submission:

[9] Marine Guidance Note 654 (M+F) *“Offshore Renewable Energy Installations (OREIs) – Guidance on UK Navigational Practice, Safety and Emergency Response Issues.”* Maritime and Coastguard Agency, August 2021. Available from the MCA website.

Table 3 - Annexes to a marine navigational safety and emergency response risk assessment submission

	Annex	Commentary of the Annex
A	**Background Information**	
B	**Setting the Scene**	This should include: a. Base Case densities and types of traffic b. Predicted Future Level of Traffic c. The Marine Environment – development of a Specific Technical and Operational Analysis
C	**Hazard Identification and Risk Assessment**	This should include: a. Development of Specific Influences on the Level of Risk b. Hazard log Worksheets or Database
D	**Appropriate Assessment Techniques and Tools**	This should include: a. Navigation risk assessment b. Appropriate search & rescue overview & assessment c. Appropriate emergency response overview & assessment d. Selection of techniques that are acceptable to Government e. Demonstration that results from the techniques are acceptable to Government
E	**Deciding on the Risk Controls**	This should include: a. Risk Control Log Worksheets or Database

7.3 Electronic Distribution

The submission and its annexes must be capable of electronic circulation e.g. PDF, similar open standard files types from file download sites, over email, etc. or by other means in agreement with MCA e.g. digital submissions.

8. INDICATIVE PROCESS FOLLOWED BY GOVERNMENT DEPARTMENTS AND AGENCIES IN ASSESSING A DEVELOPER'S SUBMISSION

8.1 Introduction

This section gives an indication of the process that will be followed by Government in assessing submissions.

8.2 Principle of the Process

The principle behind the process followed by government departments is that they will seek the following in a developer's submission:

- A supported claim that if the planned risk controls are implemented and maintained the proposed OREI will achieve the sought for level of marine navigational safety
- Sufficient information for government departments, their agencies and other stakeholders to have confidence in the claim
- A declaration that the risk controls will be implemented.

8.3 Assessment of Information Supplied in the Submission

Government departments will assess if the submission includes information showing that:

1. The marine navigational safety requirements have been correctly identified based on Formal Safety Assessment
2. The submission makes a claim against the safety requirements that:
   a. The rules have been complied with
   b. As a minimum standard or relevant good practice, risk controls will be put in place
   c. The risks are broadly acceptable; or
      i. Tolerable with modifications; or
      ii. Tolerable with additional controls; or
      iii. Tolerable with monitoring
   d. That further risk control is grossly disproportionate
3. The claim is backed up by a reasoned argument
4. The reasoned argument is built on the use of evidence and appropriate risk assessment tools and techniques
5. The evidence is quality checked
6. Techniques selected are acceptable to Government
7. The results from applying the techniques are acceptable to Government, such as calibration against known data.
8. MGN checklist has been completed

8.4 Assessment of the Limitations of the Information Supplied in the submission

Government departments will assess if the submission includes information showing that:

- The nature, assumptions and limitations of the submission are set out and understood
- The "absence of evidence of risk" is not taken as "evidence of absence of risk".

9. INDICATIVE PROCESS FOLLOWED BY GOVERNMENT DEPARTMENTS IN RESPONDING TO A DEVELOPER'S SUBMISSION

9.1 Background to the Response Process

In defining the response process the broadly stated principles of good regulation, published by the Better Regulation Executive will be applied. These require:

- The targeting of action: focussing on the most serious risks or where the hazards need greater controls
- Consistency: adopting a similar approach in similar circumstances to achieve similar ends
- Proportionality: requiring action that is commensurate to the risks
- Transparency: being open on how decisions were arrived at and what their implications are
- Accountability: making clear, for all to see, who are accountable when things go wrong.

9.2 How the Response Process links to the Consent Application Process

The submission forms part of the developer's EIA Report based on an Environmental Impact Assessment, which is needed to support an application for the consents and licenses necessary for an offshore development In England and Wales through the Planning Inspectorate (The Infrastructure Planning Regulations 2009 Section 36, Electricity Act 1989, Section 56 Planning Act 2008). In Scotland the same NRA approach is adopted, and applications are made to Marine Scotland, whilst in Northern Ireland applications are made to the Department of Agriculture, Environment and Rural Affairs (DAERA). In reviewing the NRA, a number of bodies will be consulted including:

- Other Government departments including the MCA, DfT and the Ministry of Defence.
- A range of organisations such as the General Lighthouse Authority, Chamber of Shipping, Royal Yachting Association, ports and harbour authorities (if relevant), fishing associations, the British Marine Aggregates Producers Association, shipping companies and Maritime Administrations of neighbouring states (if relevant).

The relevant organisations are invited to advise on the potential marine navigational safety and emergency response risk impacts of the:

- Development itself
- Development in-combination with other planned developments
- Effect of these on other future developments.

9.3 Ultimate Responsibility for consent

The aim is to involve stakeholders at all stages of development with the aim of achieving consensus. However, Government departments (namely The Planning Inspectorate, BEIS, Marine Scotland, Natural Resources Wales, Marine Management Organisation, Department of Agriculture, Environment and Rural Affairs or DfT/MCA) must make recommendations to Ministers where consensus is not possible, for example because different stakeholders hold opposing views based on deep-rooted beliefs.

10. GUIDANCE TO DEVELOPERS IN APPLYING THE METHODOLOGY

The guidance is given in the following Annexes:

ANNEX A: BACKGROUND INFORMATION

A1 Reference Sources - Lessons Learned

ANNEX B: SETTING THE SCENE

B1 Understanding the base case traffic densities and types
B2 Predicting future densities and types of traffic
B3 Describing the marine environment

ANNEX C: HAZARD IDENTIFICATION AND RISK ASSESSMENT

C1 Hazard identification in the marine environment
C2 Risk assessment in the marine environment
C3 Influences on the level of risk
C4 Tolerability of risk
C5 Risk Matrix

ANNEX D: APPROPRIATE ASSESSMENT TECHNIQUES & TOOLS

D1 Overview of appropriate assessment techniques
D2 The selection of techniques that are acceptable to Government
D3 Demonstration that the results from the techniques are acceptable to Government
D4 Navigation risk assessment – area traffic assessment techniques
D5 Navigation risk assessment – specific traffic assessment technique

ANNEX E: DECIDING ON THE RISK CONTROLS

E1 Creating a risk control log
E2 Marine stakeholders and stakeholder organisations

ANNEX F: EXAMPLE CHECKLISTS

F1 Example hazard identification checklist
F2 Example risk control checklist

ANNEX G:

G1 Categories, Terms and References

ANNEX A Background Information

A1 Overview of Formal Safety Assessment

Developers are expected to base their submissions on a Formal Safety Assessment[10] and addressing the navigation issues arising from the Marine Guidance Note *Safety of Navigation: Offshore Renewable Energy Installations (OREI) – Guidance on UK Navigational Practice, Safety and Emergency Response*.

The IMO methodology was developed for use in the IMO rule making process for ships involved in international trade but since its development it has proved successful in more general marine applications, including the navigation risk assessment of ports. Formal Safety Assessment is a five-step process aimed at producing decision-making recommendations:

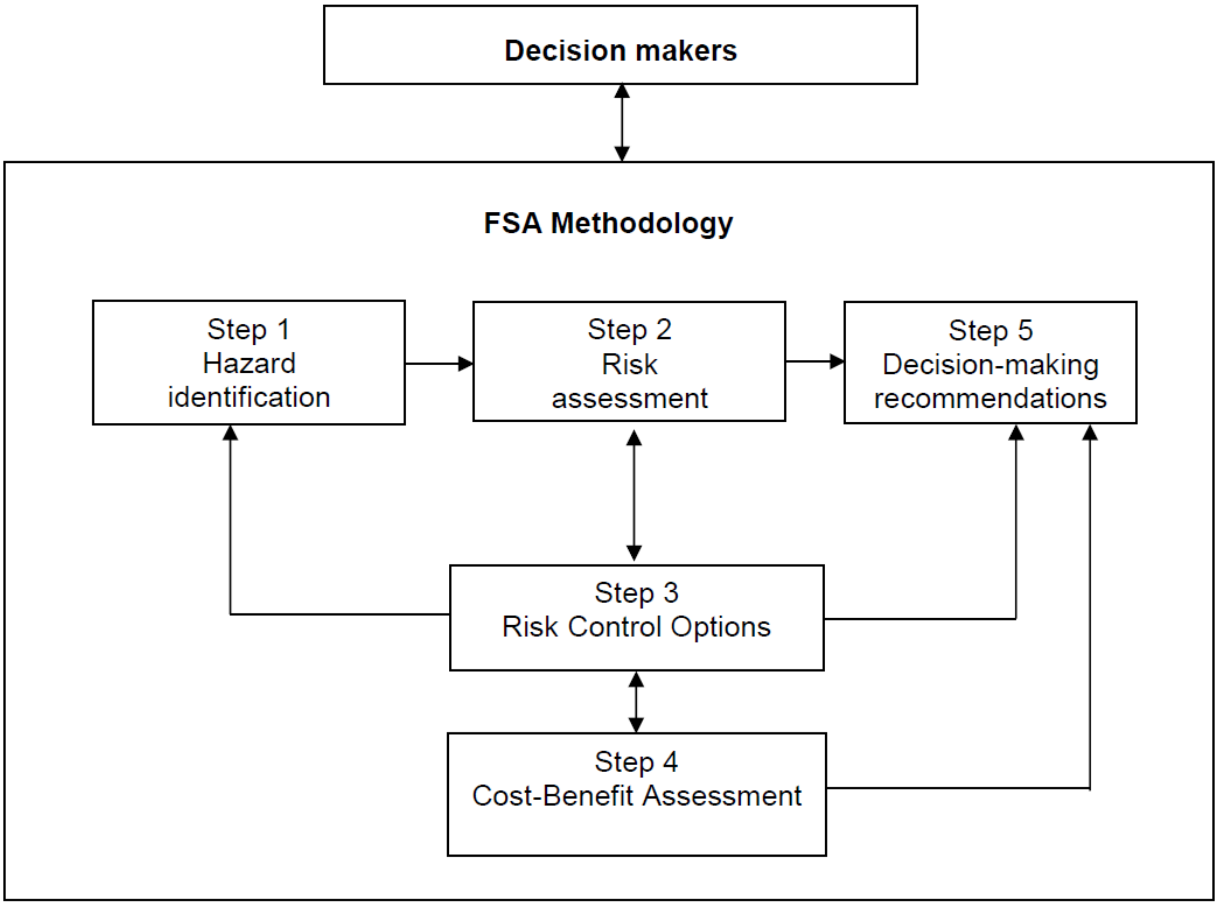


Figure 2 Flow Chart of the FSA Methodology

[10] See International Maritime Organization guidelines for FSA for use in the IMO-rule making process (MSC-MEPC.2/Circ.12/Rev.2)

A2 Reference Sources - Lessons Learned

Prior to and during the development of this methodology (January to August 2005, updated 2013 and 2021) a number of desktop and laboratory investigations and, where feasible, field trials in early UK wind farm developments, were carried out. Some of these trials, reports and other documents with Lessons Learned are listed below.

Table 4 - Some Trials Reports and other Lessons Learned

Ref	Title	Date
1	**Assessing the Navigational Impact of Offshore Wind Farm Proposed for UK Sites – Guidance for Developers** Maritime and Coastguard Agency Project MSA 10/6/200, May 2002	2002
2	**Wind Energy and Aviation Issues - Interim Guidance** Wind Energy, Defence & Civil Aviation Interests Working Group ETSU W/14/00626/REP	2002
3	**UK Atlas of Recreational Boating** A compilation of the cruising routes, general sailing & racing areas used by recreational sailing craft around the UK coast. The Royal Yachting Association	2008
4	**Results of the electromagnetic investigations and assessments of marine radar, communications and positioning systems undertaken at the North Hoyle wind farm by QinetiQ and the Maritime and Coastguard Agency** QINETIQ/03/00297/1.1 MCA MNA 53/10/366	2004
5	**Guidelines for Health & Safety in the Wind Energy Industry** British Wind Energy Association	2005
6	**Offshore Wind Farm Helicopter Search and Rescue - Trials Undertaken at the North Hoyle Wind Farm** Report of helicopter SAR trials undertaken with Royal Air Force Valley 'C' Flight 22 Squadron on March 22nd 2005 Maritime and Coastguard Agency Project MSA 10/6/239, May 2005	2005
7	**Interference to radar imagery from offshore wind farms** A Report compiled by the Port of London Authority based on experience of the Kentish Flats Wind Farm Development 2nd NOREL WP4	2005

8	**Investigation of Technical and Operational Effects on Marine Radar close to Kentish Flats Offshore Wind Farm** [11] Investigation of Technical and Operational Effects on Marine Radar close to Kentish Flats Offshore Wind Farm – Report by the BWEA (British Wind Energy Association) April 2007	2007
9	**MCA report following aviation trials and exercises in relation to offshore windfarms** A summary of findings, lessons learned and corroboration of published MCA guidance following helicopter SAR exercises, trials and discussions undertaken between 2015 and 2019. Maritime and Coastguard Agency, January 2019	2019
10	**MCA report following aviation trials at Hornsea Project 1 windfarm** A report on helicopter SAR trials undertaken within a large wind farm to test the various systems on the aircraft Maritime and Coastguard Agency, November 2019	2019
11	**Regulatory Expectations for Emergency Response Arrangements for the Offshore Renewable Energy Industry** A document setting out the principles to be adopted to ensure compliance with relevant legislation. Health and Safety Executive and Maritime and Coastguard Agency, August 2019	2019

Note: *Various trials and research projects are continuously being undertaken with respect to all offshore renewable energy installations. These include work on wind turbine effects on marine and military radars, the resolving of incompatibilities between marine navigation and aviation lighting, etc. Developers are advised to contact the Maritime & Coastguard Agency's Navigation Safety Branch if they have any queries relating to navigational safety or emergency response issues.*

[11] Investigation of Technical and Operational Effects on Marine Radar close to Kentish Flats Offshore Wind Farm. BWEA (British Wind Energy Association) April 2007 report. This is available from www.dft.gov.uk/mca/kentish_flats_radar.pdf

ANNEX B Setting the Scene

B1 Understanding the Base Case Traffic Densities and Types

This section should be read in conjunction with MGN 654 Section 4.

The risk assessment needs to be based on a sound knowledge of the traffic densities and types. This is one of the key inputs to assessing proportionality.

Survey Area

The boundary of the Survey Area should be constituted at a position so that further extension of the boundary would not appreciably impact the results of the assessment, i.e. boundary effects are minimised. A general guideline could be applied that the area of direct interest adjacent to the OREI or OREI groups, should lie within the centre 1/4 to 1/3 of the Survey Area. However, it is the responsibility of the analyst to demonstrate that the Survey Area is appropriate.

B.1.1 Traffic Data Requirements

Marine navigation safety issues within and close to offshore OREI exist in many situations, and particularly where there is a combination of high traffic levels, different vessel operations and constrained water spaces, cumulative impacts and weather routing being key considerations. These aspects are inter-related with respect to offshore OREI. The risk is also dependent upon the type, size and nature of the vessels and their operations within the survey area. As such the classification of the traffic density, types, operations, sizes, drafts, speeds and routes, is key to the accurate representation of the present safety regime, and future impacts.

MCA traffic survey requirements contained in MGN 654 Section 4.6 should be followed.

B.1.2 Extracting Information from the Data

The results of the traffic survey should provide traffic information for the traffic as a whole and for each class of vessel with the data available. AIS data alone will not capture all vessel sizes therefore data from appropriate additional sources such as radar should be collected. The type of data required may vary with the type of modelling or other appropriate technique used in the risk assessment but may include such parameters as, for example:

- the centrelines and excursion limits of representative routes and operations through and within the Study Area
- the average traffic volume of vessels passing along key routes
- key seasonal variations in traffic activity.

B.1.3 Design Traffic Densities and Types

A key issue following collection and collation of data is the accurate representation of “Design Traffic Densities and Types” in the risk assessment. This raises the issue over whether average, peak or some intermediate values should be used as the base case and of the traffic limits appropriate to the assessment. In some cases, it might be appropriate to identify an average of the daily traffic densities and types for these routes or operations and for the survey area as a whole.

Routes and operational areas associated with and used by leisure craft, fishing vessels, aggregate dredging and other marine activities, should be identified. The seasonal variation of such traffic should be closely examined, and the data used to assess the specific risks relevant to these vessel types together with their interaction with larger vessels which might be navigating on through routes.

Developers should be aware that the traffic survey and assessment requirements cover all vessel and craft types and sizes. Many smaller vessels will not be equipped with the Automatic Identification System (AIS) and therefore will not be detected using that system alone. Similarly, if radar surveys are made from shore locations, account should be taken of the operational range of such radars based on antenna height and target vessel size. Where small vessels cannot be detected visually or by either of these two methods, alternative arrangements should be made to fairly assess traffic types, routes and operations within the whole of the area under survey. Consultation with organisations representing such vessels or craft may be useful in establishing how data can be obtained and establishing confidence level information on detection of non-AIS vessels and craft.

Additionally, it should be noted that there are differences in the levels of training, equipment & manoeuvrability amongst the various vessel categories – for which see Table 10, section B.3.7.

B1.4 Human Element

For risk assessments where the scale of development and/or the magnitude of the risk has led to a risk assessment supported by simulation modelling then the typical behaviour of vessels in complying with the "Collision Regulations" should be extracted from available data and included in the assessment algorithms. Where appropriate the algorithms should include the results of Rule violations, mistakes, lapses or slips, these categories being transparent and variable amongst the simulation algorithms.

This should not be taken to indicate that the Maritime and Coastguard Agency sanctions any departure from the Collision Regulations or "special rules". No such "special rules" will apply to areas around OREI unless they lie within sea areas controlled by appropriate authorities, e.g. port authorities, who would promulgate any necessary differences from the Collision Regulations. It is unlikely that such "special rules" would impinge on any UK offshore wind farm proposals.

B2 Predicting Future Densities and Types of Traffic

The methodology requires "Future Case" levels of Risk with and without the OREI to be assessed. Therefore, a prediction needs to be made of the future densities and types of traffic.

B.2.1 Traffic Forecasting

A forecast of future traffic activity at 10-year intervals over the expected life of the OREI should be made, dependent on:

- macro drivers (national/regional marine growth predictions) and local conditions (reasonably foreseeable developments, i.e. port & marine growth plans, etc)
- changes in vessel size anticipated over the forecast period. For example, if a local container port is set to improve its throughput by 50% in the next 20 years, but the vessels serving this facility will grow at a similar rate the traffic volumes will stay the same, although the vessel size, displacement and draft will increase.
- future change in all marine activities, such as fishing, recreational craft, offshore exploitation, other OREIs etc.

B.2.2 Techniques of Traffic Forecasting

A number of techniques may be used to forecast future traffic volume, routes and vessel types. Developers' proposals for appropriate techniques for predicting future densities and types of traffic should be discussed with MCA at the commencement of the risk assessment.

Vessel types, routes and operational areas

Various techniques may be used in assessing prime considerations such as whether the growth of traffic densities, or of vessel types, size, draft, etc., and construction of other OREIs, might lead to the non-viability of major traffic routes or operations due to the OREI location.

Local knowledge, together with that of international trade, fishing operations and all other activities potentially affecting the sea area will be vitally important in traffic forecasting. Together with sample assessments using stepped traffic growths of 20%, 40%, etc., such knowledge may be used to determine whether or not non-viability of major traffic routes is a credible possibility. It should be remembered that traffic within a particular area may reduce as well as increase due to a variety of controlling circumstances.

B.2.3 Stochastic Forecasting

In addition to the stepped change techniques mentioned above, some techniques may use a stochastic, or probabilistic, approach. This method, which may be appropriate for some development sites, reviews prior historic traffic trends for the previous ten years or more and identifies the variability of relevant factors. The forecast model then creates various viable future scenarios.

Stochastic forecast techniques review prior historic growth trends (preferably for a time span of the previous 10 years or more) from a specific end point against the key economic/transport drivers and identify the variability of these factors. This variability is then introduced into the forecast model to create a range of viable future scenarios. Those carrying out stochastic forecasting should bear in mind the limitations of traffic data obtained from the Automatic Identification System (AIS).[12]

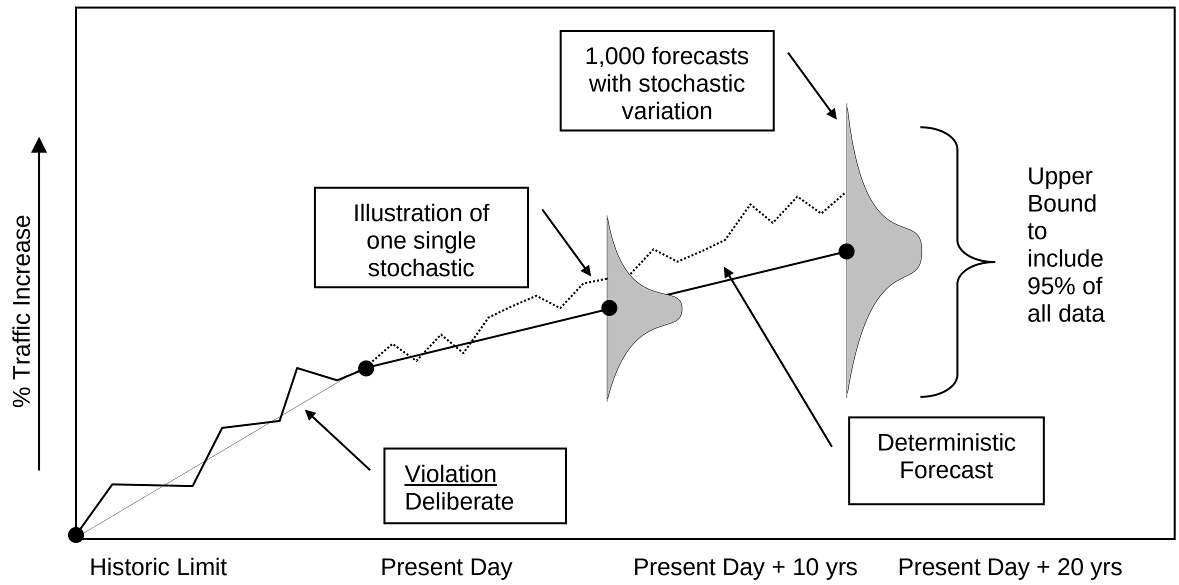


Figure 3 – A Method of Statistical Forecasting

If statistical forecasting is used, the adoption of a Design Traffic Level at the 95% confidence level is suggested, i.e. that only 5% of the future growth scenarios develop traffic above that predicted. This exercise may be conducted for each class and the traffic levels combined.

[12] See IMO requirements in: http://www.imo.org/Safety/mainframe.asp?topic_id=754

B3 Describing the Marine Environment

Developers should use the following analysis as a starting point for a site specific technical and operational analysis including any extra site-specific information and excluding (with a justification) information that is not applicable.

This section should be read in conjunction with MGN 654 Section 4.

B.3.1 Description of a Technical and Operational Analysis

The developer's analysis will be expected to cover navigational risks which will include appropriate search and rescue and emergency response overviews and how these will be assessed and managed over all phases of the OREI development.

The developer's analysis will be expected to include a systematic identification of:

1. Potential accidents resulting from navigation activities
2. Navigation activities affected by their proposed offshore OREI
3. OREI structures that could affect navigation activities
4. OREI development phases that could affect navigation activities
5. Other structures and features that could affect navigation activities
6. Vessel types involved in navigation activities
7. Conditions affecting navigation activities
8. Human actions related to navigation activities for use in hazard identification.

Note: *In this context "Navigation" includes the marine operations undertaken by vessels of all types and sizes. Examples of such operations include fishing, aggregate dredging, recreational activities, etc. Where military vessel activity takes place on a regular basis in a particular area, such activity should be taken into account.*

The following sections describe a generic technical and operational analysis. In producing a site-specific analysis, developers should use this as a guide and add or remove site specific items, as appropriate and with justifications.

Note*: The tables are labelled H1, H2, etc. as the main use of the technical and operational analysis is in the identification of hazards.*

B.3.2 Potential Accidents resulting from Navigation Activities – Examples

Table 5 - Potential Accidents resulting from Navigation Activities

H1	Accident Category
	All
1	General Navigation Safety Risks
	a. Collision
	b. Allision/Contact
	c. Grounding and Stranding
2	Other Navigation Safety Risks
	a. Foundering

H1	Accident Category
	b. Capsizing
	c. Fire
	d. Explosion
	e. Loss of Hull Integrity
	f. Flooding
	g. Machinery Related Accidents
	h. Payload Related Accidents
	i. Hazardous Substance Accidents
	j. Accidents to Personnel
	k. Accidents to the General Public and Shore Populations
	l. Electrocution
3	Aviation Safety Risks[13]
	a. Aviation Accidents
4	Other Safety Risks
	a. High Probability Events
	b. High Severity Outcomes
	c. Low Confidence / High Uncertainty Events
	Note: *Although not "accident categories" themselves the following search and rescue and emergency response activities may result from one or more of the above incident categories*
5	Search and Rescue (see Annex F Table 28 Example Hazard Identification)
	a. Overall
	b. External to Internal
	c. Internal to Internal
	d. Internal to External
	e. External to External
	f. Worst Case
6	Emergency Response
	a. Overall
	b. External to Internal
	c. Internal to Internal
	d. Internal to External
	e. External to External
	f. Worst Case

[13] Aviation Safety Risks are included in potential accidents list as a reminder that marine navigation and aviation risks interact, for example required marine lights vs. aviation lights and potential effects on search and rescue or dispersant spraying.

B.3.3 Navigation Activities affected by an OREI – Examples

Table 6 - Navigation Activities affected by an OREI

H2	Navigation Activity
1	*All*
2	Navigation on Passage
	Navigating or operating near, around or through an OREI
	Navigating or operating within an OREI
	International traffic
	National traffic
	Coastal traffic
	Short sea shipping traffic
	Fishing vessels
	Recreational craft
	All other traffic listed in section H6 below
3	Fishing operations
	Single vessels
	Paired vessels & others fishing in close proximity
	Static e.g. pots, long lines
	Mobile e.g. trawling
	Drift Nets
4	Recreational activities
	Sail and power day sailing, cruising and racing
	Personal watercraft use (e.g. Jet Skiing, Canoeing, Kayaking, Paddleboards)
	Windsurfing
	Kite surfing and kite boarding
	Leisure or sport diving
5	Anchoring
	Routine Anchoring
	Emergency Anchoring
6	Other Marine Operations close to or within an OREI
	Aggregate Dredging, Dredging or Spoil Dumping
	Commercial Diving
	Construction Operations
	Servicing Operations
	Decommissioning Operations
	Oil and Gas Operations
	Salvage Operations
	Cable Laying
	Pipeline Installation
	Boarding and Landing of Pilots
7	Special Events
	Regattas and Competitions

B.3.4 OREI Structures that could affect Navigation Activities – Examples

Table 7 – OREI Structures that could affect Navigation Activities

H3	Structures
1	Wind Turbines (floating or fixed)
	a. Foundation type or mooring arrangements)
	b. Transition Piece
	c. Tower
	d. Nacelle
	e. Blades
	f. Platforms and superstructure fittings
2	Floating and fixed wave energy devices
	a. Seabed mounted
	b. Floating – horizontal or vertical
	c. Foundation type
3	Floating and fixed tidal energy devices
	a. Seabed mounted
	b. Suspended mid-water
	c. Floating - horizontal or vertical
	d. Foundation type
	e. Blades – exposed or enclosed
4	Offshore Installations
	a. Substation
	b. Accommodation
5	Cable
	a. Export cable
	b. Inter-array cabling
	c. Electrical hub
6	Subsea Installations, including anti-scour material
7	Moorings
	a. Foundations
	b. Lines

B.3.5 OREI Development Phases that could affect Navigation Activities – Examples

Table 8 - OREI Development Phases that could affect Navigation Activities

H4	Development Phase
1	*All*
2	Pre-construction

H4	Development Phase
3	Construction
4	Operation
5	Maintenance
6	Decommissioning

B.3.6 Other Structures and Features that could affect Navigation Activities – Examples

Table 9 - Other Structures and Features that could affect Navigation Activities

H5	Other Structures and Features
1	Wrecks
2	Oil & Gas Installations (Existing and projected)
3	Other OREI (Existing and projected)
4	Other Exclusion or Safety Zones
5	Fishing Grounds
6	Dredging and Dumping Areas
7	Diving Areas

B.3.7 Vessel Types involved in Navigation Activities – Examples

Table 10 - Vessel Types involved in Navigation Activities

H6	Types of Vessel
1	*All*
2a	Cargo Vessels
	a. General Cargo
	b. Specialised Carriers
	c. Bulk Carriers
	d. Bulk/Oil Carriers
	e. Chemical Tankers
	f. Container Vessels
	g. Cruise Vessels
	h. Liquefied Gas Carriers
	i. Oil Tankers
2b	Passenger Vessels
	a. Passenger
	b. Passenger Ferries
2c	High Speed Craft (HSCs)
	a. High speed ferries

H6	Types of Vessel
	b. Other high speed recreational and commercial craft
3	Fishing Vessels
	a. Fish Processing
	b. Fishing Vessels (Various types and operations)
4	Recreational Vessels
	a. Sailing dinghies and yachts
	b. Motorboats
	c. Small Personal Watercraft
	d. Rowing boats
	e. Sports Fishing
	f. Windsurfer
	g. Kite Boards
	h. Tall Ships
	i. Recreational Submarines and dive support craft
5	Anchored Vessels
	a. All
6	Other Operational Vessels
	a. Barges
	b. Dredgers
	c. Dry Cargo Barge
	d. Offshore Production and Support
	e. Salvage
	f. Tank Barges
	g. Tugs and Tows
7	Military Vessels
	a. Surface warships
	b. Submarines
	c. Royal Fleet Auxiliaries
8	Other Vessels
	a. Seaplanes
	b. Wing-In-Ground Craft (WIG)
	c. Hovercraft

B.3.8 Conditions affecting Navigation Activities – Examples

Table 11 - Conditions affecting Navigation Activities

H7	Conditions
1	*All*
1	Weather
	a. Restricted visibility (Fog, mist, haze, precipitation)
	b. Wind strength and direction
	c. Sea state
	d. Icing
	e. Light conditions
2	Tides and local currents
	a. Local currents
	b. Tidal streams and heights
3	Time of Day
	a. Night
	b. Dawn
	c. Day
	d. Dusk
3	Circumstances
	a. Planning access to shelter
	b. Vessel constrained by her draft
	c. Vessel engaged in fishing
	d. Vessel not under command
	e. Vessel restricted in her ability to manoeuvre
	f. Scheduled/Shuttling vessels
4	Electronics
	a. Vessels underway with no AIS (i.e. non SOLAS craft) or with AIS switched off
	b. Interference to marine radar, navigation and communications
5	Other
	a. Overfalls and other local conditions

ANNEX C HAZARD IDENTIFICATION AND RISK ASSESSMENT

C1 Hazard Identification in the Marine Environment

Marine accidents tend to be the result of a chain of events rather than a single cause and often involve human error, either in the cause of the accident or in the response to it.

The Hazard Log construction and population would largely depend on the geospatial and other complexities of a particular OREI with regard to the navigational risks and any consequential emergency responses. It should include a suitable set of incident scenarios with potential causes and outcomes, to formulate objective evidence which is empirically reproducible where possible.

The Hazard Log should, therefore, contain constructs which could:

- produce quantitively and qualitatively verifiable hazard scenarios; and
- provide data detailed enough for the next step of evaluation of risk factors.

C.1.1 Causal Chains

The IMO FSA encourages the use of causal chains in risk assessment as it recognises that many risks will be the result of complex chains of events, with a diversity of causes and a range of consequences.

The causal chain used here is:

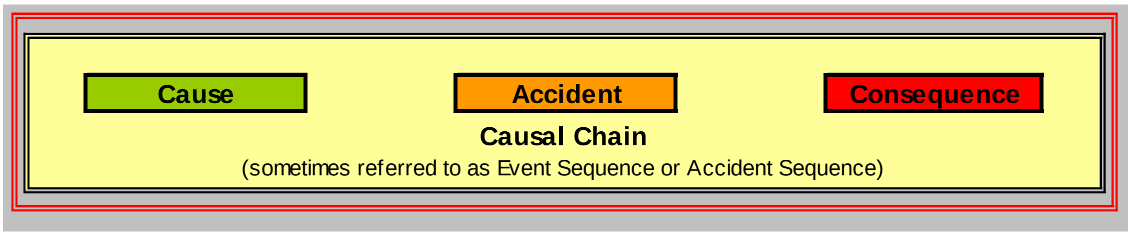


Figure 4 - Overview of Causal Chains

C.1.2 Human Element

FSA stresses the importance of the human element. It states “The human element is one of the most contributory aspects to the causation and avoidance of accidents. Human element issues should be systematically treated within the FSA framework”. The following diagram lists the principle causes of “Human Error”, here defined as examples of the active cause of an unsafe act recognising that some acts are intentional while others are not.

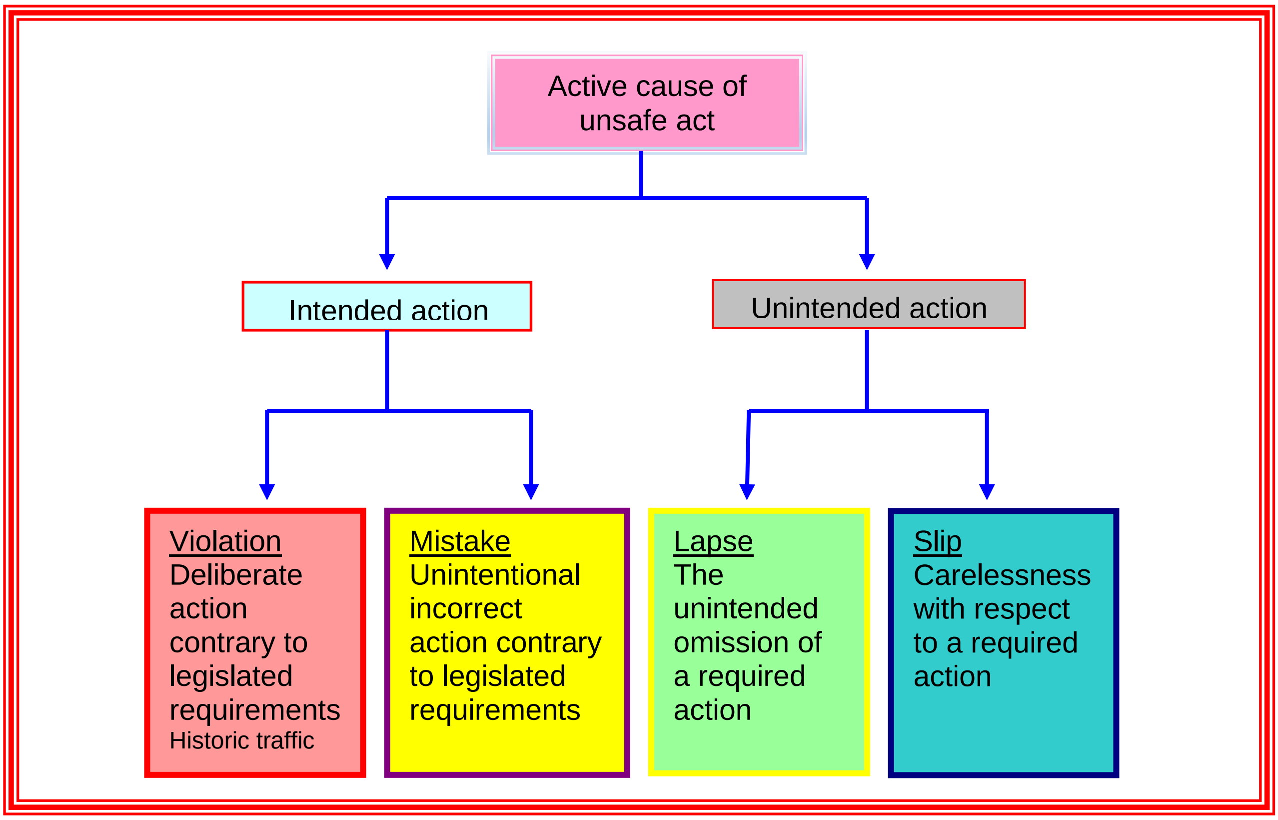


Figure 5 - Overview of the Human Element

C.1.3 Compliance with the Collision Regulations[14]

The Hazard Identification should clearly identify and investigate where the OREI may make it more likely that vessels will deviate from the International Regulations for the Prevention of Collisions at Sea 1972, as amended (IRPCS, known as COLREG), either as an intended or unintended action.

This may include any effects which the OREI might make on the lights and shapes to be carried by vessels (e.g. interference to the visibility of navigation lights), on navigation marks ashore and at sea and to the light and sound signals made by vessels and navigational aids in particular circumstances.

C.1.4 Effect of Non-Compliance with the Collision Regulations

Vessels do not always follow the COLREG. The Hazard Identification should include any reasonably foreseeable compliance with them.

Annex F Table 27 provides a list of example hazard identification.

[14] Merchant Shipping Notice MSN 1781 Amendment 2 (M+F) The Merchant Shipping (Distress Signals and Prevention of Collisions) Regulations 1996

C2 Risk Assessment in the Marine Environment

FSA uses the classic definition of risk as a combination of probability and consequence.

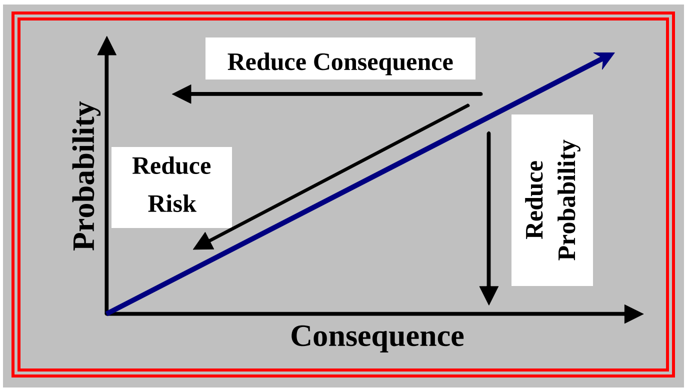


Figure 6 Classic Definition of Risk

Hazard Identification therefore requires an assessment to be made of the:

- probability of the cause
- magnitude of the consequence.

FSA also encourages the consideration of the influences on the causal chain of an accident as well as any direct causes and consequences. This is done because in many marine accident sequences these influences not only affect the probability of the cause but also the magnitude of the consequence in the same accident sequence.

Weather is a typical factor that affects both cause and consequence. It is often a major factor, as are human error and remoteness.

C3 Influences on the Level of Risk

Developers are invited to use the following analysis as a starting point for a site-specific Influence Analysis including any extra site-specific influences and excluding (with a justification) influences that are not applicable.

C.3.1 Influence Analysis

The following sections describe a generic identification of the influences on the level of risk. In producing a site-specific analysis, developers should use this as a guide:

- adding site specific influences
- removing (with justifications) influences that are not applicable

Note: *The tables are labelled R1, R2, etc. as the main use of the Influence Analysis is on the assessment or risk.*

C.3.2 Risk Factors – Examples

Table 12 - Risk Factors – Examples

R1	Risk Factors
1	Site
	a. Location of OREI.
	b. Type of OREI
	c. Alignment of OREI.
	d. Layout of OREI. (e.g. grid, scattered or other layouts)
	e. Proximity of other OREI
2	Traffic
	a. Traffic routes, density, type and operations.
	b. Potential growth or decline in traffic.
	c. Seasonal variation in traffic.
	d. Special traffic, e.g. dangerous goods, etc.
3	Interrelations Between Vessels
	a. Blocking of escape routes or bad weather refuges
	b. Bunching
	c. Increase in “crossing” encounters
	d. Increase in “end-on” encounters
	e. Increase in “overtaking” encounters
	f. Increase in traffic volumes
	g. Loss of recreational cruising routes
	h. Pinching
	i. Reduction in sea room for manoeuvring
	j. Reduction in water depth for manoeuvring
	k. Blocking of routes to safe havens and inshore anchorages
	l. Redirection of recreational craft and fishing vessels into routes used by other vessels, particularly larger and faster vessels.

R1	Risk Factors
4	**Navigator Behaviour**
	a. Lengthened navigation routes for leisure craft increase navigator fatigue (and hence error) and increase the criticality of weather windows.
	b. Enhanced navigational complexity and need for navigational awareness increase fatigue (and hence error)
5	**Other single vessel factors**
	a. Collision with OREI structures
	b. Fouling or contact with cables
	c. Grounding

C.3.3 Influences on Causes – Examples

Table 13 - Influences on Causes – Examples

R2	Influence on Causes
1	**Vessel Traffic Management**
	1. Availability of Vessel Traffic Services (VTS).
	2. Availability of Pilot services.
2	**Aids to Navigation**
	3. Compliance with requirements for Aids to Navigation (site and vessel)
	4. Failure (or non-availability) of Aids to Navigation & other systems
	5. Site specific effects on aids to navigation e.g. masking by background lights, masking by structures and the effects of rotating blades, control responsibility for foghorns, etc.)
	6. AIS (Automatic Identification System) failure or not required to fit.
	7. Marking on charts of OREI structures and associated navigation aids
3	**Bathymetry**
	1. Accuracy of and changes to bathymetry (e.g. navigable channels, shifting sandbanks, anti-scour material, seabed mobility, etc.)
4	**Interference**
	1. Interference with vessel-based communications.
	2. Interference with shore-based communications.
	3. Interference with vessel-based navigation. (e.g. GPS, radar, compasses etc.).
	4. Interference to ship-based radar e.g. shadowing and blind sectors and false echoes.
	5. Interference with shore-based navigation. (e.g. VTS services, MRCC services, etc.)
	6. Interference to shore based radar e.g. shadowing and blind sectors and false echoes.
	7. Similar interference to helicopter and fixed wing aircraft radar used in SAR and emergency response.

R2	Influence on Causes
	8. Electromagnetic interference from turbine generators, transformers, other structures or cables.
	9. Acoustic interference to sonar, diver communications, echo sounders, fish finders and acoustic release systems.
	10. Helicopter radar contact in a wind farm or other OREI interpreted as a vessel contact.
5	Future Technical Change
	1. Application of radar absorbing material to towers and blades, etc.

C.3.4 Traffic Densities and types – Examples

Table 14 - Traffic Levels – Examples

R3	Traffic Levels
1	Hindcast – ½ consent period (e.g. 10 years)
2	Current
3	Forecast – ½ consent period (e.g. 10 years)
4	Forecast – full consent period (e.g. 25 years)

C.3.5 Circumstances – Examples

Table 15 – Circumstances – Examples

R4	Circumstance
1	Intentional Navigation
	a. Intentionally navigating within a wind farm or other OREI site en route or to carry out activities.
2	Accidental Navigation
	a. Unintentionally navigating within a wind farm or other OREI site or being forced to do so to avoid collision with another vessel, carried by the tide, etc.
3	Emergency Navigation
	a. Wind farm or other OREI site blocking passage to port of refuge, safe haven, inshore anchorage or inshore routes.
	b. Wind farm or other OREI site restricting anchoring.
4	Forced Navigation
	a. Wind farm or other OREI site forcing passage in more dangerous waters.
	b. Wind farm or other OREI site forcing passage in more congested water.

C.3.6 Influences on Consequences – Examples

Table 16 - Influences on Consequences – Examples

R5	Influence on Consequence
1	**OREI Design**
	a. Strength and robustness of turbines or other OREI structure.
	b. Collapse mode of impacted turbines or other OREI structure after contact/allision
	c. Design of turbines or other OREI structure to minimise entrapment of vessels, craft or persons in the water
2	**Vessels**
	a. Vessel size.
	b. Vessel cargo. (e.g. polluting cargoes, hazardous cargoes, etc.)
3	**Search and Rescue**
	a. Adequacy of Search and Rescue provision (e.g. equipment, equipment location, communication, etc.).
	b. Availability of Search and Rescue resources (e.g. currently in commercial use, multiple SAR operations, etc).
	c. Ability to deploy Search and Rescue resources (e.g. helicopter operations affected by blade rotation, aircraft operations affected by search height restrictions, etc.).
4	**Emergency Response**
	a. Adequacy of Emergency Response provision (e.g. tugs, oil spill equipment, communications, etc.).
	b. Availability of Emergency Response resources (e.g. currently in commercial use, multiple ER operations, etc).
	c. Ability to deploy Emergency Response resources (e.g. state of contingency planning).

C4 Tolerability of Risk

Determining whether the predicted level of risk from an OREI development is tolerable or not is, in the first instance, a matter of asking the following questions:

a. is the risk below any unacceptable limit that has been established?
b. if so, has it also been reduced to as low as reasonably practicable (ALARP)?

The risk is only tolerable if the answer to both these questions can be demonstrated to be 'Yes'.

Brief guidance on addressing these two questions is given below.

Question (a): is the risk below any unacceptable limit?

The HSE has suggested that, as a very broad indication, an individual risk of death of 1 in 1000 per annum should *"…represent the dividing line between what could be just tolerable for any substantial category of workers for any large part of a working life, and what is unacceptable for any but fairly exceptional groups"*. For members of the public who have a risk imposed on them in the wider interest of society *"this limit is judged to be an order of magnitude lower –1 in 10,000 per annum"*.

It is very important to note that these limits were originally proposed in the context of considering the tolerability of risks from onshore hazardous installations, such as nuclear or chemical plant. For such installations, it is relatively clear that the groups of people most exposed, who need to be considered as the limiting case, are workers at the site and/ or people living or spending a large proportion of their time in the vicinity. For an OREI development, identifying the most exposed groups is not easy. People on board passing vessels not associated with the OREI will in general only be exposed for a small proportion of time. Even those most involved with the development, e.g. service technicians using offshore accommodation between visits to OREI(s), may only be exposed to navigational risks for relatively short periods. This might suggest that the HSE's suggested limits could be relaxed. But such groups are already exposed to other risks at other times. For example, wind farm technicians are also exposed to risks from work at height, electricity and many other hazards. The navigational risk associated with OREIs cannot be allowed to 'use up' the entire risk 'budget'. Developers should therefore give very careful consideration to the question of who is exposed to risk and hence what limits may be appropriate.

It is also essential to note that the HSE's limits were intended to be applied to the total risk to a worker as a result of their occupation, or to a member of the public from a hazardous installation which poses a risk to them. As in the paragraph above, navigational risk is itself only one component of the risk to people, and the HSE limits cannot not be applied to it, or indeed to any further subdivision into components of the navigational risk, such as those vessel-vessel collision, vessel-OREI collisions, grounding, fouling of cables and so on. The IMO (Ref. MSC-MEPC.2/Circ.12/Rev.2) recognises this, stating: *"… risk acceptance criteria always refer to the total risk to the individual and/or group of persons. Total risk means the sum of all risks that e.g. a person on board a ship is exposed to. The total risk therefore would contain risks from hazards such as fire, collision, etc. There is no criterion available to determine the acceptability of specific hazards….".* In the context of risk assessment for an OREI, total risk means the sum of all risks arising from the presence of the OREI.

The HSE is careful to note that any quantitative 'unacceptable' limits must be used with great caution. The concepts used in establishing them are complex, and the quantitative predictions that might be compared against them are fraught with uncertainty. It may not be helpful to attempt to define quantitative limits, and developers should consider whether there are other ways to define what is unacceptable. The HSE guidance document *Reducing Risks Protecting People* (R2P2) notes that what is unacceptable *"…is often spelled out or implied in legislation, ACOPs, guidance, etc or reflected in what constitutes good practice"* such that there is no need to set an explicit quantitative boundary. Developers should therefore carefully justify any unacceptable limits they propose.

Question (b): has the risk been reduced to as low as reasonably practicable (ALARP)?

A primary duty on employers with regarding to health and safety in UK law (under the Health and Safety at Work etc Act, 1974) is to reduce risk 'so far as is reasonably practicable' (SFAIRP). For most purposes, this is synonymous with its being reduced ALARP. Establishing what is reasonably practicable involves considering whether further risk control measures are called for. This must be considered in terms of:

- whether the cost of further measures would be grossly disproportionate to the value of the benefit obtained and
- whether relevant good practice has been followed.

Further guidance on the concepts of gross disproportion and relevant good practice can be found in R2P2 and elsewhere on the HSE website. It is important to note that good practice is relevant to the situation; what is good practice for a wind farm may not be good practice for a tidal array, and what is good practice for commercial shipping may not be relevant to recreational vessels and/or personal watercraft. For OREIs that are novel in type or scale there may be no established good practice.

Wider considerations

These two questions are 'pure safety' ones. In question (a), risk is considered in relation to what has been tolerated in other contexts and in question (b), it is weighed against the cost of reducing it further. Other considerations are likely to be taken into account in the final claim or decision about whether or not, taking account of risk, a development should be consented. Risk will be weighed together with other effects, positive and negative, of the proposed development. Nevertheless, the two questions provide a useful framework for looking at risk 'in its own terms'.

C5 Risk Matrix

There is no generally accepted standard for a risk matrix therefore developers will be expected to define the following as appropriate to the OREI development:

- likelihood/frequency of incident scenarios
- severity/consequence of incident scenarios
- risk matrix
- tolerability matrix scores

The below IMO examples are based on ship-board scenarios and will require intelligent application for navigational risk posed by Offshore Renewable Energy Installations. It is suggested the assessment is based on a matrix that developers believe is appropriate for the needs of their development.

C.5.1 IMO Example of Likelihood/Frequency Index

Frequency Index			
Frequency	7	Frequent	Once per month on one ship
	5	Reasonably Probable	Once a year in a fleet of 10 ships
	3	Remote	Once a year in a fleet of 1000 ships
	1	Extremely Remote	Once in 20 years of a fleet of 5000 ships

C.5.2 IMO Example of Severity/Consequence Index

(Note: this example does not consider severity/consequence to property)

Severity Index			
Severity	4	Catastrophic	Multiple fatalities
	3	Severe	Single fatality of multiple severe injuries
	2	Significant	Multiple of severe injuries
	1	Minor	Single of minor injuries

C.5.3 IMO Example of Risk Matrix

Risk Matrix					
	FREQUENCY	SEVERITY			
		1	2	3	4

		Minor	Significant	Severe	Catastrophic
4	Frequent	**8**	**9**	**10**	**11**
		7	**8**	**9**	**10**
3	Reasonably Probable	**6**	**7**	**8**	**9**
		5	**6**	**7**	**8**
2	Remote	**4**	**5**	**6**	**7**
		3	**4**	**5**	**6**
1	Extremely Remote	**2**	**3**	**4**	**5**

C.5.4 HSE Example of Tolerability Matrix[15]

Risk Matrix Score	**Tolerability**	**Explanation**
7	Unacceptable	Risk must be mitigated with design modification and/or engineering control to a Risk Class of 5 or lower before consent
6	Unacceptable	Risk must be mitigated with design modification and/or engineering control to a Risk Class of 5 or lower before consent
5	Tolerable with Modifications	Risk should be mitigated with design modification, engineering and/or administrative control to a Risk Class of 4 or below before construction
4	Tolerable with Additional Controls	Risk should be mitigated with design modification, engineering and/or administrative control to a Risk Class 3 or below before operation
3	Tolerable with Monitoring	Risk must be mitigated with engineering and/or administrative controls. Must verify that procedures and controls cited are in place and periodically checked
2	Broadly Acceptable	Technical review is required to confirm the risk assessment is reasonable. No further action is required.
1	Broadly Acceptable	Technical review is required to confirm the risk assessment is reasonable. No further action is required

[15] HSE R2P2 document.

ANNEX D APPROPRIATE ASSESSMENT TECHNIQUES & TOOLS

D1 Overview of Appropriate Risk Assessment

D.1.1 Introduction

In their assessments and submissions developers will be expected to undertake appropriate assessment in support of their navigation risk assessment. This can be extended to cover some aspects of search and rescue (SAR) and emergency response.

This Annex gives an overview of:

- the purpose of the appropriate assessment in a developer's assessment and submission;
- the types of appropriate assessment, for example modelling, sought for in a developer's assessment and submission;
- the hierarchy of appropriate assessment techniques appropriate to a developer's assessment and submission;
- the concept of a scenario to control the scope and depth of the appropriate assessment.

The Annex then includes:

- Guidance on Navigation Risk Assessment
- Area Traffic Assessment
- Specific Traffic Assessment

Note: *Guidance on appropriate search and rescue overview and appropriate emergency response overview can be found in Sections 3.3, 3.4 and 3.5.*

D.1.2 Purpose of an Appropriate Assessment Technique in Risk Assessment

The purpose of the appropriate assessment is to:

- Prove Feasibility
  Demonstrate that the navigation activities (or search and rescue and emergency response activities) are feasible, with the wind farm or other OREI structures in place, during the phase of development, for the vessel types and with the conditions

- Quantify Risk
  Produce a quantitative or qualitative value, acceptable to Government, of the change in risk caused by the development to the base risk associated with the activity and how this risk varies across vessel types

- Assess Sensitivity
  Determine the sensitivity of the risk to the conditions and the risk factors

- Decide on risk controls
  Identify, evaluate and decide on appropriate risk controls to reduce risk to ALARP.

D.1.3 Purpose of the Appropriate Assessment in Hazard Log Closure

In addition, the discipline of the appropriate assessment technique is to be used to identify issues that need to be considered:

- to close the hazard log
- to develop the risk control log.

D.1.4 Types of appropriate assessment

Depending on proportionality judgement leading to the scope and depth of the submission the following types of other appropriate assessment, for example numerical modelling, may be needed:

- In support of navigation risk assessment
- Area traffic assessment
- Specific traffic assessment
- For search and rescue and emergency responses assessments see Sections 3.3, 3.4 & 3.5.

D.1.5 Concept of the Scenario to Control the Scope and Depth of the appropriate assessment

The various hazard identifications will generate a large number of situations that require further investigation.

The concept of the scenario is to set up a model (or assessment), that while it is not necessarily an exact representation an exact situation being assessed is sufficiently:

- widely defined to cover a range of situations in a single scenario
- applicable to generate reasonable estimations of feasibility, risk, sensitivity and the effect of controls.

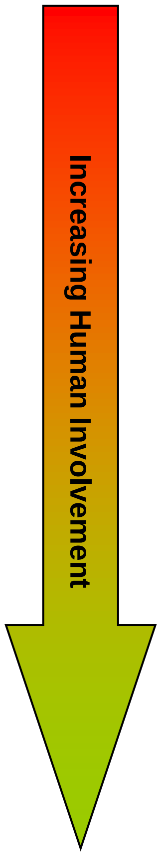
D.1.6 Hierarchy of the appropriate assessment in support of Navigation Risk Assessment

The concept of the methodology is of a hierarchy of appropriate assessment, including numerical modelling, which starts at the area level and the results used to define, if necessary, more specific issues to be investigated.

For example, the process followed to support the navigation risk assessment of a particular proposal might be:

Table 17 - A Possible Hierarchy of Assessment and Trials in support of Navigation Risk Assessment

1a	Area Traffic Assessment of the Strategic Area
	leading to:
1b	Area Traffic Assessment of the OREI Area
	leading to, where necessary:
2a	Specific Traffic Assessment in and around the OREI Area
	leading to (where necessary and appropriate to the development proposal):
2b	Specific Traffic Simulation in and around the OREI Area
	leading to (where necessary and appropriate to the development proposal):
3	Specific Traffic Bridge Control Simulation in and around the OREI Area for training and research purposes
	leading to (where necessary and appropriate to the development proposal):
4	Site Specific Trials



Definition 1 – Area Traffic Assessment

Area Traffic Assessment assesses the marine environment, the traffic and the OREI development to predict the risk of collision, contact, grounding and stranding now and in the future. If appropriate it may need to be statistical in nature, in any case based on assessing the vessel traffic and the behaviour of vessels with relation to steering rules, speed changes, the route they wish to follow, etc., and the multiple interrelationships with a large number of vessels, of different types, navigating in the same environment over a long time and involved in a variety of operations which will each interact.

Definition 2 - Specific Traffic Assessment

Specific Traffic Assessment might be used to assess in detail the risk of more specific navigation issues, and proposed risk controls, that could require a higher quality assessment and representation of:

- the manoeuvring capabilities of the vessels, including such parameters as their stopping distances and turning circles
- changes which may result in the mariners' domain size as manoeuvring sea room reduces
- details of the bathymetry.

It may also be of value to use a Navigation Simulator to train appropriate mariners in the navigation and operation of their vessels within and close to wind farms or other OREIs. Research could also be carried out, by driving the ship in real time, in conjunction with other instructor/assessor-controlled target vessels in encounter situations, to assess the feasibility and level of risk. This might include the risk of grounding or collision or contact with other vessels and structures within the OREI area or in nearby restricted water navigable channels. Such training or research should also include the ability for mariners to navigate in all circumstances using simulated radar and ARPA displays, as appropriate to their vessel types, integrated with the vessel control simulator and other simulated navigation and communication systems.

Simulators used to assess navigational risk in and near to offshore wind farms or other OREI must be capable of simulating all the navigational effects and phenomena relevant to, or peculiar to those specific OREI structures. These include, for example, the effects of such structures on vessel and shore-based radar systems.

Any simulators used should comply with Section A- I/12 ("*Standards governing the use of simulators")* of the International Convention on Standards of Training, Certification and Watchkeeping, 1978 as amended in 1995 and 2010 ("STCW Convention", IMO).

Note*: The Instructors and Assessors operating the simulator/s should be qualified and experienced as specified in Section A-I/12 Part 2 subsection 9 of that Convention ("Qualifications of instructors and assessors").*

For non-critical assessments MCA may grant permission for systems and personnel not reaching these standards and qualifications to operate acceptable proprietary systems in mutually agreed scenarios. Such permission should be sought from MCA by developers before the assessment takes place.

Some of the parameters worked out in this way may then be used in the definition of "rules" in the Area Traffic Modelling/Assessment.

Definition 3 - Specific Traffic Full Bridge Control Simulation

For critical risks or significant investment decisions on risk control options it may be necessary to extend the assessment to simulation using full bridge simulators. A number of UK marine training and research establishments, together with some universities, have such systems.

Definition 4 – Site Specific Assessment

Any numerical modelling, navigation simulator systems or other assessment techniques used in the risk assessment of a specific development will, singly or in combination with other tools and techniques, be required to fully:

a. include bathymetric and other site features data for the area using an Electronic Navigational Chart (ENC) base map or as determined by a site-specific survey. In particular, depth contours and navigation channels relevant to various vessel types, sizes and operations should be taken into account with respect to the potential for colliding with other vessels or OREI structures and for grounding due to the limitations of water space or whilst avoiding a collision.

b. model or assess the effects of tide and tidal streams in the OREI area, plus any local currents so as to determine their effects on normal manoeuvring and operations and on vessels not under command, SAR, pollution control, etc. Where tidal streams may be significantly affected by an OREI, such as tidal turbines, the effects should be modelled or assessed, covering the OREI itself and, as necessary, the surrounding area;
c. model or assess the effects on navigation and marine operations of various weather conditions such as wind, sea state and visibility;
d. use the survey traffic data supplied by the developers and other sources from a combination of radar surveys, Automatic Identification System (AIS) data, observational and historical records;
e. model or assess typical fishing and recreational activities within and close to the OREI area, as in (d) above and their interaction with other vessel types navigating near and within that area. Such requisite background data to be supplied from the developers and other sources;
f. model or assess each vessel type with suitable draughts, dynamics and domains or equivalent parameters;
g. establish a baseline of marine activity without an OREI;
h. examine the effects of the OREI on this marine activity and traffic if no re-routeing is recommended;
i. model or assess the chain of navigational events as vessels pass within or close to the OREI (i.e. where an alteration of course or speed made in an encounter with a turbine or other vessel produces a further encounter or encounters, including the avoidance of grounding in confined channels and shallow water effects);
j. model or assess the effect of the OREI on the necessary compliance of various vessel types to all of the International Regulations for the Prevention of Collisions at Sea 1972, as amended, (The Collision Regulations or “COLREG”) (e.g. power to sail, sail to fishing vessel, overtaking vessels, etc.) and to any local rules if the site lies within the area of an appropriate local authority;
k. examine the cumulative effects of all wind farms and other OREI, aggregate dredging, other offshore installations etc., within the proximity of the given site, given the traffic data by developers;
l. recommend optimum routes based on the foregoing assessments if these are seen to be required;
m. determine, on request, the increased passage distances produced by re-routeing of specific vessels;
n. allow for power and steering failures within and close to the OREI together with suitable researched allowances for human error and the effects of metocean conditions. Note that incidents such as capsizing may be part of normal operations for recreational craft that may result in them being unable to manoeuvre to avoid OREI structures;
o. Include the effects of the OREI on the detection of other vessels within or on the far side of it, such effects to include visual blind areas and radar effects such as shadow and blind sectors, spurious echoes and other effects, etc., using the typical beam widths, pulse lengths and powers of the vessel type radars involved;
p. model all vessel types’ compliance with Collision Regulations Rule 19 in relation to sub para (o) above;
q. apply such effects to relevant port and Vessel Traffic Services (VTS) radar sites;
r. If required by MCA, investigate the effects of the OREI on helicopter SAR and fixed wing aircraft dispersal operations, etc., particularly any radar or thermal imaging effects;
s. examine the hazards and the consequences of major incidents within or close to the OREI including wreck, collision involving large passenger vessels, etc.;
t. include data and an overview of the consequences and control of oil and other pollutant spills;

u. recommend minimum separation distances of the specific wind farm or other OREI boundaries from established navigational routes, from port approaches, from routeing schemes, from existing recreational areas, from other OREI and from other offshore operations (see the MCA website for initial guidance);
v. make navigational risk recommendations with respect to the construction and operation phases of the development;
w. include an overview of potential search and rescue activities and difficulties within and close to the OREI

Note: *In the post-construction phase there is a requirement for OREI operators to monitor & review the impact which their activities are having on navigation and its safety. Where practical, feedback should also be obtained from commercial Masters, fishing vessel skippers, work boat crews and recreational sailors who regularly operate in and around different wind farm sites to get realistic information on their experiences in different conditions.*

D2 Selection of Techniques that are Acceptable to Government

The purpose of this annex is to give guidance on how to select modelling tools or other assessment techniques that are, or will be, acceptable to Government.

This Annex describes:

- the process of selection of assessment techniques
- how to obtain MCA approval including:
  - the self-declaration process
  - the extent of the process
  - the activities required
  - the information required
- the method of describing in the submission the techniques and tools used.

D.2.1 Process of Selection of Assessment Techniques and tools

The Assessment Techniques and tools used shall have been submitted to the MCA for approval including a self-declaration.

Whichever technique or tool is selected, the user is strongly recommended to consult with the MCA prior to its use in a specific assessment.

D.2.2 Approved OREI Tools and Assessment Techniques

"Approved OREI Tools and Assessment Techniques" are those which are granted approval by the MCA for use with OREI, and which will subsequently join the list of those having previously obtained such approval.

D.2.3 How to Obtain MCA Approval for Tools and Assessment Techniques

The process of gaining MCA approval may consist simply of a self-declaration of the Verification[16] of the Tools and Assessment Methods.

Extent of Self Declaration

The extent of this process will depend on the development status of each tool and assessment method. This status is categorised as:

- approved maritime tools and assessment techniques designed or modified specifically for assessing navigational risk within and near to OREI (Type D1)
- Widely and publicly used maritime tools and assessment techniques (Type D2)
- Specialist maritime tools and assessment techniques (Type D3)

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[16] Verification: Confirmation through the provision of objective evidence, such as examination by or demonstration to the verifier, that specified requirements have been fulfilled. In software development, verification is the process of evaluating the (software) products of a given phase, or segment of work, to ensure correctness and consistency with respect to the products and standards provided as input to that stage. (ISO 9000:2000 TickIT guide 5.5 Revised 2007)

- Non marine tools and assessment techniques (Type D4)
- New tools and assessment techniques (Type D5).

List of Approved Maritime Tools and Assessment Methods (Type D1) are either:

Tools and assessment techniques designed or modified specifically for assessing navigational risk within and near to OREI approved by the MCA for use with the maritime environment.

or

Tools and assessment techniques designed or modified specifically for assessing navigational risk within and near to OREI and approved by third party bodies acceptable to MCA for use with the maritime environment.

Widely and publicly used maritime modelling tools and assessment techniques (Type D2) are either:

Maritime modelling tools or assessment techniques that are commercially available, quality controlled, with a proven track record and a large user base, but not necessarily with reference to offshore OREIs or other offshore structures.

or

Maritime modelling tools or assessment techniques that are not commercially available but are quality controlled, have a proven track record and have been used on a large number of applications or projects, but not necessarily with reference to offshore OREIs or other offshore structures.

Specialist maritime modelling tools and assessment techniques (Type D3) are:

Maritime modelling tools and assessment techniques that have been built up by a single user (or small group) and have been used on other specialist projects.

Non-maritime modelling tools and assessment techniques (Type D4) are:

Modelling Tools and Assessment Techniques that are commercially available and quality controlled but are capable of being used in a new way or domain.

or

Modelling Tools and Assessment Techniques that are not commercially available but are quality controlled but are capable of being used in a new way.

New modelling tools and assessment techniques (Type D5)

The development of new modelling tools and assessment techniques is to be encouraged, however, by their nature they will require more evidence of verification.

D.2.4 Specific Activities to Obtain Approval of Tools and Techniques

Depending on the status of the tools and techniques the activities to obtain approval shall include reasoned arguments and evidence for some, or all of, the following stages:

- statement of tool applicability
- clarification of conceptual model
- documented model/commented code
- demonstration of abilities
- peer/expert review
- comparison with real-world experience.

Statement of Tool Applicability

Explain how the tool is applied to the specific OREI assessment task. State how assumptions inherent in the tool affect the application to the OREI task.

Clarification of Conceptual Model

Document the conceptual model. This documentation should include:

- Objective(s)
- System structure/configuration
- Detailed description of the tool, and, if using numerical techniques, its algorithms.
- Logical rules & flow charts
- Input data sources.

Documented Model / Commented Code

Provide evidence that computer modelling tool code is sufficiently documented to enable another competent person to see how it corresponds to the conceptual model.

Demonstration of Abilities

If required, demonstrate to Government departments and agencies the capabilities of the modelling tool or other assessment technique.

Peer / Expert review

Provide evidence that the modelling tools or other assessment techniques have been peer reviewed by government approved person or persons.

Comparison with Real-World Experience

Provide evidence that the modelling tools or other assessment techniques have been compared to real-world experience in similar applications.

D.2.5 Specific Information Required to Obtain Approval of Modelling Tools or other Assessment Techniques

The scope of information that should be included with the Self Declaration:

Table 18 – Self Declaration Information

	Stage	Demonstration	Statement of Tool Applicability	Clarification of Conceptual Model	Documented Model / Commented Code	Peer / Expert Review	Comparison with Real World
D1	Maritime Modelling Tools and Techniques Approved for Application to OREI	✓	✓	-	-	-	-
D2	Widely and Publicly Used Maritime Modelling Tools and Assessment Techniques	✓	✓			✓	
D3	Specialist Maritime Modelling Tools and Assessment Techniques	✓	✓	✓	✓	✓	✓
D4	Non-Marine Modelling Tools and Assessment Techniques	✓	✓	✓	✓	✓	✓
D5	New Modelling Tools and Assessment Techniques	✓	✓	✓	✓	✓	✓

Depth of Information

The Depth of Information required is dependent on:

- the level of risk the tool or technique is assessing
- the level of control (if any) the tool or technique has on the Risk.
- Level of risk and control is likely to range

From:

Highest

- Navigation tools used in real time navigation monitoring and management (also, if appropriate, SAR Tools used in real time search planning)

High

- Specific navigation situation tools used to evaluate high risk conditions and advise on important controls (also, if appropriate, SAR tools used in advance search planning)

To:

Medium

- Specific navigation tools used to evaluate medium risk conditions
- Marine traffic assessment tools used to assess marine risk

Low

- Marine traffic assessment tools used to assess the economic impact of changed shipping routes.

It is up to the tool user to assess the level of risk and the level of control and provide an appropriate depth of information. IEC61508 [17] may be used as a guide.

D.2.6 Specific Information Required when Describing the Tools and Assessment Techniques Used

The description of the modelling tools and other assessment techniques used (or proposed to be used) should include:

- the modelling tool name including the version number of the software
- the application that the tool or assessment technique is supporting e.g. supporting marine traffic assessment, specific navigation situation assessment, SAR resource planning, SAR response planning, oil spill assessment, tidal resource and streams
- which OREI or OREI area
- description of the modelling tool concept
- a description of prior use of the tool in OREI, marine and other applications
- any pre or post processing software
- the hardware the modelling tool will be run on
- the approval status including reference to 3rd party certificates
- the self-declaration status

D.2.7 Specific Information Required when Describing the Assessment Methods Used

The following is an example of an assessment method description form.

Table 19 - Example of Technique or Tool Description

Assessment Method	Description
Name of Method	
Use of Method	
Method Type (D1 to D5)	
Concept of Method	
Prior Use of Method	
Pre or post Processing	
Other relevant information	

[17] International Standard IEC 61508 "Functional safety of electrical / electronic / programmable electronic safety-related systems (E/E/PES)" International Electrotechnical Commission

D3 Demonstration that the Results from the Techniques are Acceptable to Government

The purpose of this annex is to give guidance on how to demonstrate that the result from applying the selected techniques are, or will be, acceptable to Government.

This Annex describes:

- the process for self-declaration of validated [18] results
- self-declaration activities
- sources of real-world information.

D.3.1 Process for Self-declaration of Validated Results

The submission shall include a self-declaration that the results have been validated.

For each validation activity on the results, a declaration should be made that present the results and findings, together with a clear statement. An example format of a validation statement is given below. One statement can be made to cover a multiple set of results.

Table 20 - Example Format for a Validation Statement

Heading	Description
Validation activity	
Results produced by (staff member)	
Results produced on (date)	
Pre or post Processing	
Simulation parameter settings (if relevant)	
Comparison data (where relevant) description & source	
Validation Conclusion	

D.3.2 Self Declaration - Activities

For all results presented, the documentation of results validation shall include reasoned arguments and evidence for the following:

- tuning of parameters
- consistency checks
- behavioural reasonableness
- sensitivity analyses

[18] Validation: Confirmation or ratification through the provision of objective evidence that the requirements for a specific intended use or application have been fulfilled. (ISO 9000:2000 TickIT guide) Revised 2007

- comparison with real-world experience.

Tuning of Parameters

The submission should provide evidence that the modelling or other form of assessment has been carried out appropriately. Different methods have different parameters so the tuning required will differ. However, three key components, applicable in most models, are:

- choice of mathematical routines; choice of appropriate integration algorithms & statistical estimators
- convergence; increasing the resolution in a control dimension until changes of results are within satisfactory magnitude;
- mathematical formulae fitted to data should have some measure of goodness-of-fit calculated.

Consistency Checks

The submission should provide evidence that at key points (typically at the end), values of all parameters should be output & demonstrated that they are correct/consistent with the input. This checks that no inadvertent changes happened in the coding or running.

Similarly, variable distributions used should be checked.

Behavioural Reasonableness

The submission should provide evidence that the assessment has been exercised under a range of conditions and demonstrate that the results were reasonable.

- this is mainly a qualitative exercise, but it should be checked that variables stay within their bounds. For example, key values of variables such as vessel speed, as simulated, should be compared with the input data;
- the conditions simulated should include some extreme events; more severe than the events to be simulated for real. Reasonable behaviour under extreme conditions gives good confidence in the results for less severe conditions.

Sensitivity Analyses

The submission should provide evidence that the key input parameters have been varied by small amounts to determine the sensitivity of the results to changes in these inputs, and that the sensitivity has been examined for reasonableness.

- this sensitivity analysis is especially important for input parameters where there is uncertainty around the correct value to use.

Comparison with Real-World Experience

The submission should provide evidence that results have been compared with real-word experience.

- real-world experience may be in the form of data from controlled experiments (e.g. trial manoeuvring of a ship) or data from natural experiments (e.g. statistics on marine accidents)

- wherever real world experience is presented, it shall include estimates of uncertainty (data validity)
- care should be taken in calibrating to fit results to real-world experience: While calibration improves the comparison with a specific case, it reduces the generality
- state all calibrations applied to the model during validation.
- validation against real-world experience must be specific to the situation modelled.

If comparison with real-world experience is not possible, the developer shall justify why this is so.

- This model-to-model validation is not as thorough as model-to-real-world validation (both models may be wrong) but may be acceptable. The greater the difference in the two types of models compared, the greater the confidence in the result if they agree. A good example would be comparison between a computer simulation & a physical (test tank) model.

D.3.3 Sources of Real-World Information

Marine Accident Investigation Branch (MAIB)

The Marine Accident Investigation Branch (MAIB) issue statistical reports on marine accidents (freely available via the web page, below) and can also provide, on request, statistics broken down to date, location, vessel type & accident type. Some data will be freely available. Contact: http://www.maib.gov.uk/

MAIB data covers all accidents required to be reported under "The Merchant Shipping (accident reporting & Investigation) regulations 2005", available at: http://www.maib.gov.uk/resources/index.cfm. This is, broadly, all UK commercial vessels plus all foreign vessels in UK waters taking passengers to or from UK ports. This is thus useful but not exhaustive. Furthermore, incidents recorded in the MAIB database should all be included within HM Coastguard data. However, MAIB perform detailed investigative work on causes of accidents, which may be useful for understanding accident patterns or specific events. For example, the number of marine accidents reported to MAIB per year has varied quite widely.

Royal National Lifeboat Institution (RNLI)

The RNLI statistician keeps records of all their lifeboat launches, including incident date, incident type & type of vessels involved. This will not be exhaustive (RNLI are not called out to all incidents) but does show detailed information on the range of incidents in an area.
Contact: http://www.rnli.org.uk

IHS FAIRPLAY

IHS-Fairplay can provide, commercially, information on all global marine accidents involving vessels of 100 GRT & over, including vessel type, accident type & location.
Contact: http://www.fairplay.co.uk/

Port and Harbour Authorities

Port and Harbour Authorities keep records of vessel traffic within their limits and can be a source of information for the local area.

D4 Navigation Risk Assessment – Area Traffic Assessment Techniques

D.4.1 Use of Area Traffic Assessment Techniques

Area Traffic Assessment will be required when there is uncertainty over the effect of the OREI on the ability of vessels to navigate and operate in the waters adjacent to and through the wind farm or other OREI area without suffering an increase in risk. Such risk will include amongst others the risks of contact, collision, grounding and stranding.

Fundamental Requirements of Area Traffic Assessment

The fundamental requirements of Area Traffic Assessment include:

- that it assesses all traffic in both the strategic OREI area (if appropriate for the particular development) and the OREI area itself
- that it assesses the movement of vessels through the water in a way that is representative of vessel navigation and activity
- that it assesses the real-world behaviour of the vessels to the Collision Regulations including:
    - the effect of reduced visibility on compliance with the Collision Regulations coupled with the expected effects on vessel and shore-based radars
    - a representative rate of human error in applying the Collision Regulations
    - a representative rate of deliberate non-compliance with the Collision Regulations
- that it assesses the effect of manoeuvring in restricted waterways (defined from bathymetric data developed from Electronic Navigation Charts or from site specific surveys) including action by vessels to avoid shallow water
- that it is used to calculate:
    - as a minimum the frequency and density of interaction between vessels, vessels and shallow water, and vessels and OREI structures, to gain statistically significant information to assess the effect of the fundamental Risk Control Options of location, alignment, size and layout
    - the probability of collision, contact, and grounding
    - for specific vessel types the risk and tolerability of the risk.

D.4.2 How to select the Situations Requiring Area Traffic Assessment

Source of the Situations

The situations requiring assessment will come from:

- the need to evaluate the general effect of the OREI on the marine traffic and the navigational risks associated with a development
- the cumulative navigation risks associated with the development and the other OREI developments and other types of marine activity in the Strategic OREI Area
- the in-combination effects on the navigation risk of the development with other economic developments over the operational life of the OREI
- the need to evaluate the specific impact of the OREI due to the presence of specific marine traffic activity that may be present, or is planned, in close proximity to the OREI
- the hazard log
- the risk control log.

Study Area

It is anticipated that at least two study areas will be required.

- Study area 1 should be representative of an appropriate sea area which could be the full strategic area and used for evaluating cumulative and in-combination effects.
- Study area 2 should be representative of the OREI area and used to evaluate potential effects such as the introduction of separation schemes, safety zones, etc., near to and within the OREI.

Guidance on the size of the OREI study area is provided in Annex B1 – "Understanding the Base Case Densities and Types of Traffic". Having developed an appropriate area, it is then necessary to identify the significance of key meteorological and oceanographic parameters, and the nature and distribution of marine traffic passing within the study area.

D.4.3 How to Define Scenarios for Assessment

The assessment should include, as a minimum, the following scenarios which have been proposed to assess the cumulative impact but ensure the key drivers of increased marine traffic levels and navigation constraints can be isolated and identified.

Table 21 - Scenarios Requiring Area Traffic Assessment

Item	Scenario	Objective
1	Present day Base Case	Provide assessment of present risk level for validation with historic data
2	Future Case based on: • Traffic types and densities mid-way through the consent period (e.g. 10 yrs) • Traffic types and densities at end of the consent period (e.g. 20 yrs)	Future assessment of study area risks with no OREI present
3	Base Case with OREI	Provide analysis of OREI(s) impacts only, unrelated to traffic increases or reductions
4	Future Case with OREI based on: • Traffic types and densities mid-way through the consent period (e.g. 10 yrs) • Traffic types and densities at end of the consent period (e.g. 25 yrs)	

D.4.4 Requirements for Assessing a Scenario

Each of the Scenarios should be assessed to determine:

- Feasibility
- Risk

- Sensitivity
- Controls.

Feasibility

The feasibility of shipping operations through a particular water space or channel, adjacent or close to OREI developments is best developed with respect to the meteorological and oceanographic data collated above, and guidance on vessel navigation requirements.

Some aspects of the feasibility and desirability of navigation within channels might also be identified with reference to graphic outputs developed by simulation models which have the capability to place the instructor/assessor within an area traffic simulation. These tools may be used to assist in reviewing the relative sea room, and the navigation interactions within the Study Area.

Risk

The risk associated with navigation within or close to wind farms and other OREI should be related to frequency and consequence. The analysis results should inform the key changes in risk of collision, contact and grounding/stranding as a result of the OREI development, with consequences being fed into SAR and counter pollution assessment. The assessment output should be tailored to identify:

- the quantitative risk level;
- if the "Future Case with OREI" scenario develops broadly acceptable risk when judged against the present traffic environment, the "Future Case" (no OREI(s)), or are:
    - tolerable with modifications
    - tolerable with additional controls
    - tolerable with monitoring
- that further risk control is grossly disproportionate.

The output must provide specific data on collision potential between all vessel types routes and operations within the Study Area. The output should be in a format that the following key questions can be posed and answered:

- where are the areas of increased risk?
- what is the magnitude of collision, contact, grounding and other hazard increases?
- which vessel type's routes and operations are most impacted, and where do these incidents occur?
- is the marine traffic assessment covering all the elements of navigation and other marine activities associated with key incidents, or should these scenarios be specifically addressed - perhaps within navigation simulations - to better encompass meteorological, oceanographic, navigation and human response factors?
- what SAR and counter pollution overview data may be generated from the key incidents?

The selection and identification of key incidents will be site specific, however the following threshold is recommended:

All locations where vessel types and/or routes see an increase in risk of over 50% should be reviewed independently to identify further potential impacts from meteorological and oceanographic factors, or the applicability of mitigation measures.

Sensitivity

Each of the principal scenarios defined above may be subject to sensitivity tests to examine the impact of key drivers. The sensitivities to be examined should be determined from the Influence Analysis. See Annex C3 Guidance on the Influences on the Level of Risk.

These include, but are not limited to:

- ***Adjacent wind farms and other OREI*** - These scenarios may require one or more analysis for each future year to address the impact of adjacent OREI developments.
- ***Variation in Traffic Mix*** – Key assumptions may have been made on port/terminal/marina developments and other types of marine activity that generate traffic within the Study Area. It may be appropriate to conduct sensitivity tests on the presence or absence of this associated traffic to evaluate its impact on the risk profile.
- ***Variation in Traffic Routeing Assumptions*** – Variations may be made in the routeing of traffic adjacent to and within wind farm(s) and other OREI to review the risk control measures available, and/or the sensitivity of risk to changes in these issues. This may include the minimum separation/exclusion from the OREI.
- ***Variation in Tidal Level*** and Streams – Channel widths and available sea room may be significantly impacted by changes in tidal level. Navigation and various marine operations may also be affected by tidal stream rates and directions. If these are key issues for the Study Area their impact should be addressed within sensitivity testing.
- ***Variation in Assessment Parameters*** – Should the techniques and tools adopted be particularly sensitive to variations in their parameters these features should be sensitivity tested. Examples include the perception distances adopted within the simulation, and the assessment of vessel "domains".
- ***Weather routeing, bad weather impacts on short sea services*** – Impacts on short sea crossings, scope to allow weather routing, seeking minimising violent ship movement and vessel stress.
- ***Visibility and Vessel or Structure Detection*** – The principal scenarios may have been performed with base assumptions on the change in risk as functions of such limitations as loss of visibility or radar detection due to the presence of an OREI, or lack of AIS data. Vessel interaction is particularly considered to increase as two vessels (who might be considered as completely blind to each other's presence) approach on either side of, close to, or within a wind farm. The layout of the wind farm will contribute to changes in this base profile. Key assumptions associated with this issue, and those associated with other OREI types, may be tested in a series of sensitivity analyses.

Area traffic simulations are frequently subject to variation in output between representative days due to random generation of traffic within the model. If a simulation approach is selected, then the models should be run for sufficient time to create stable average results. Where comparison between scenarios is required these should be made on the basis of stable scenario results.

Effectiveness of Controls

Where feasible the quantitative impact of modifications, controls, and monitoring should be identified. These may, but not necessarily, include:

- realignment of development boundaries and/or turbine/platform or other structure configurations
- possible safety zones
- recommended minimum separation distances of the specific OREI boundaries, and
- established navigational routes

- mandatory routeing schemes

D.4.5 Analysis and Presentation of Results

Presentation of results should be clear and concise and in a form that can be understood by both experts and non-experts alike. This could take the form of graphical presentation supported by text and numerical data. Where large datasets are used and required for presentation these are best referenced in an annex from the main text. The presentation should include:

- the assessment technique used e.g. background, validation, references and methodology
- data inputs
- the results
- any assumptions and deviations to mainstream methodology used in the calculations
- conclusions on the impact of the assessment results with regards to OREI development.

The output should inform the operator and reviewer of the quantitative and/or qualitative changes in marine risk as a result of the OREI, and future activity. This should be set against the marine environment that has been mapped for the Study Area. The assessment should, as a minimum:

- predict the vessel to vessel and vessel to structure encounters and grounding potential
- predict the contact/collision/grounding frequency distribution
- link to vessel types to predict contact and collision risk
- assist in the evaluation of the effectiveness of controls.

D.4.6 Critical Parameters within the Assessment

The following are identified as critical parameters within area traffic assessment.

Critical Parameters Table

Table 22 – Area Traffic Assessment – Critical Parameters

Critical Parameter	Explanation
Traffic Distribution	Positioning and width of vessel routes and operations
Traffic Density & Type	Total densities and types of traffic in the assessment and potential for vessel interaction.
OREI Location	Positioning and size of OREI, also orientation with respect to traffic streams and other vessel operations
Route Relocation	Assumptions adopted in impacting the original traffic distribution
Visibility	Assumptions adopted with respect to visibility through and close to the OREI and other means of vessel detection and tracking

D.4.7 Limitations of Assessment Techniques

All assessment techniques will have limitations, the extent to which these affect the results will be depend upon the scenario, the data used, and, in the case of simulation, the algorithms used. It will be necessary to discuss the limitations of the specific assessment techniques to be used with the Maritime and Coastguard Agency or, in the case of developments within port limits, other competent navigation authority, before assessment work is completed.

From illustrative risk assessments the following were identified as potential limitations of area traffic assessment techniques.

Limitations Table

Table 23 - Area Traffic Assessment - Limitations of Assessment

Limitation	Explanation
Validation on Vessel Class-by-Class basis	The quality of validation is a key issue, and where data exists the validation should be performed on a vessel by vessel basis.
Perception Issues	Validation supports the adoption of the domain and Collision Regulations assumptions adopted in the Baseline case. However severe compression of routes and increases in traffic may bring about situations beyond the scope of the original validation requiring it to be reassessed.
Near, Mid & Far Field perception	At present many assessment techniques conduct near field collision / grounding avoidance and middle and far field route following. The boundaries between local and far field navigation may be less distinct and assessment techniques with greater control and autonomy to "goal seek" will improve the veracity of the assessment.
2D model	Many area traffic assessment techniques are 2D models. Greater consideration of risk issues and perception of navigation challenges be developed if the user was able to enter the model and review the simulation from the model ship's perspective.

Key limitations should be presented within any submission, and the significance of the limitations identified.

D.4.8 Verification of Modelling Tools or Appropriate Assessment Techniques Used

General Guidance

General guidance is given in Annex D2, Guidance on the Selection of Techniques that is Acceptable to Government.

Specific Guidance

For assessment based on modelling verification of the modelling tools used for the scenarios should include:

- Copies of the electronic model run files
- Paper copies (where possible) of the data used
- Paper copies of the results as graphics and text
- Functional description of the model
- Technical description of the model.

It is strongly advised that quality assurance procedures accompany the operation and management of the modelling process.

D.4.9 Guidance on how to Validate the Assessment Results

General Guidance

General guidance is given in Annex D3, Guidance on the Demonstration that the Results from the Techniques are Acceptable to Government.

Specific Guidance

Validation of the results can be achieved with the acquisition of reference data with known results – an intrinsic role of the Baseline scenario.

D.4.10 Performance Standards Sought for in the Modelling Tool or Assessment Technique Performance Standards Table

The following table is an indication of the performance standard required from assessment techniques and tools used.

Table 24 - Area Traffic Assessment – Performance Standards

Ref	Performance Standard	Comment	Importance H/M/L
1	**MGN Requirements**		
1.1	Simulation	Computer simulation techniques are suggested to be used, where appropriate, with respect to the displacement of traffic and, in particular, the creation of “choke points” in areas of high traffic density.	H
2	**Meteorological and Oceanographic Parameters**		
2.1	Bathymetry	Critical parameter for boundaries of safe navigation, and route development.	H
2.2	Visibility (radar blind and shadow sectors around Wind Farms and other OREI)	Key impact on vessel interaction adjacent to and within OREI.	H
2.3	Tides and Tidal steams	Key to understanding the effects of wave and tidal energy devices on navigation	H
3	**Navigation Activities Traffic**		
3.1	Route Geometry (where relevant)	Key driver for simulation	H
3.2	Traffic distribution across routes (where relevant)	Significant impact from traffic spread across routes.	H
3.3	Variation of Vessel Types	Key driver for derivation of risk and water space impacts.	H

Ref	Performance Standard	Comment	Importance H/M/L
3.4	24 Hour traffic Variation	Significant impact, particularly for scheduled traffic, fishing and tidal dependency.	H
3.5	Speed profile	Major driver of dwell time and risk.	H
3.6	Vessel Length	Consistent with vessel type represented.	H
3.7	Vessel Length Variation	Consistent with vessel type represented and survey data.	H
3.7	Vessel domains	Consistent with vessel type represented.	H
3.9	Vessel draughts	Consistent with vessel type represented and loaded state.	H
4	**Navigation Activities – Simulation Rules for the Movement of Vessels**		
4.1	Vessel types	Capable of modelling all the vessel types expected in and close to the OREI.	H
4.2	Vessels dynamics – vessel to vessel and vessel to structure manoeuvring	Consistent with vessel type represented	M
4.3	Vessels dynamics – turning, manoeuvring	Significant dependent upon available sea room, etc.	L
4.4	Vessel acceleration / deceleration	Low order if consistent validation applied.	L
5	**Navigation Activities – Simulation Rules for the Behaviour of Mariners**		
5.1	Collision Regulations	Vessel responses in accordance with all Collision Regulations including those relating to reduced visibility.	H
5.2	Collision Regulations – Human Error	Vessel responses not in accordance with Collision Regulations.	H
5.3	Collision Regulations - Violation	Vessel responses in violation of the Collision Regulations.	H
6	**Navigation Activities – Simulation Rules for Manoeuvring in restricted waterways**		
6.1	Vessel recognition	Recognition of turbines, shallow water and other obstructions.	H
6.2	Vessel type	Different rules for vessels of different types.	H
6.3	Tides and Tidal Streams	In accordance with predictions in the area, as modified by the OREI (where applicable).	M
7	**Scenario Flexibility**		
7.1	Traffic growth or reduction scenarios	Account needed of GDP growth, port developments, fishing and other activities.	H

Ref	Performance Standard	Comment	Importance H/M/L
7.2	Multiple simulations	Models with "typical" daily activity and statistical traffic variation require multiple runs for stable result reporting.	H
7.3	Multiple OREI	Critical ability for cumulative impact assessments.	H
7.4	Vessel Routeing Options & Control measures, i.e. safety zone	Development of alternate route structures.	H
8	**Results Assessment**		
8.1	Visualisation	Ability to place the instructor / assessor within the simulation.	H
8.2	Display – Route and Activity Structures	Ability to show the Route and Activity Structures on a GIS map or ENC chart.	H
8.3	Display – Route and Activity Details	Ability to show the details for each route and activity (e.g. speed, hourly rate, course variations, etc.).	H
8.4	Display – Risk Map	Ability to display Risk as coloured areas on a GIS map or ENC chart.	H
8.5	Display – Historical incidents	Ability to overlay historical incident on the Risk map.	H
8.6	Encounter Frequency	Ability to calculate and display encounter frequencies.	H
8.7	Collision probability	Derived from validated encounter frequency	H
8.8	Contact probability	Derived from validated encounter frequency.	H
8.9	Grounding probability	Derived from validated encounter frequency.	H
8.10	Vessel Types and Routes Analysis	Ability to break down risk, encounters and probabilities into vessel types and routes.	H
8.11	Vessel Specific Risk Controls	Focus and identify key classes featuring increased risk to focus detailed assessment & risk control.	H

D.4.11 Illustrative Example of an Area Traffic Modelling Process

Starting Point

The starting point for the marine traffic assessment process is:

- obtain Traffic Survey Data traffic in the OREI area from the up to date traffic survey (MGN requirement) as well as the traffic in the wider strategic OREI area
- define the Baseline meteorological and oceanographic conditions.

Baseline meteorological and oceanographic conditions

The techniques used should assess the significant features identified by the Technical and Operational Analysis. See Annex B3 – Defining the Marine Environment – Description of the OREI Development and how it changes the Marine Environment.

The bathymetry of the Study Area should be identified using data derived from Electronic Navigational Charts (ENC) or site-specific surveys. The key areas of shallow water and the vessel types potentially impacted by these areas (at the limits of the tidal range) should be identified. This constraint should be adopted when examining the potential routeing and operations of vessels within, around and through OREI. Particular attention should be paid to identifying those areas of shallow water which may, due to the diversion of traffic around an OREI, be a potential grounding hazard.

Tidal streams may affect the safety of navigation and, in certain areas local currents may also do so. Regions within the Study Area should be mapped that possess tidal stream or current speeds over 1, 2, 3 …etc … knots. Regions of particularly high rates should be identified, and their potential impact on the navigation of vessels highlighted. Where the OREI may change tidal stream rates, directions, timings, or tidal levels, uncertainty in the predicted effects must be taken into account e.g. by sensitivity studies.

As a guide the Canadian Coast Guard consider that following[19] limits possess the potential to impose navigation constraints in reduced sea room and increase the risk of grounding or poor vessel response during collision avoidance.

Table 25 - Tidal Streams and Currents with the Potential to Impose a Navigation Constraint

LENGTH (feet)	GROSS TONNAGE	BEAM (feet)	DRAUGHT (feet)	Vessel Types	Significant Tidal Stream or local Current Speed (knots)	
					Along Track	Across Track
1000 +	80,000 - 300,000	140' - 200'	54' - 80'	Ocean-going Tanker, Ore and Bulk Carrier	3	2
800 - 1000	30,000 - 100,000	95' - 175'	26' - 64'	Ocean-going Tanker, Ore and Bulk Carrier	3	2
630 - 800	10,000 - 60,000	60' - 140'	20' - 54'	Tanker, Ore and Bulk Carrier, General Cargo	7	3
550 – 630	8,000 - 30,000	55' - 105'	20' - 42'	Tanker, Ore and Bulk Carrier, General Cargo	7	3
300 - 550	2,500 - 20,000	43' - 105'	16' - 38'	Tanker, Ore and Bulk Carrier, General Cargo	7	3
300 – 600	2,500 - 13,000	56' - 90'	13' - 20'	Car Ferry	7	3
200 – 300	10 - 1,500	12' - 70'	2' - 9'	Car Ferry	6	4

[19] *Source: Canadian Coastguard "Preliminary Threat Rating"*

200 – 300	2,000 - 3,500	23' - 65'	9' - 20'	Tanker, Bulk Freighter, Self-Unloader, Fish Factory	7	3
200 – 250	2,000 - 3,000	40' - 60'	8' - 20'	Small Tanker, General Cargo, Fishing (Long Liner)	6	3
150 – 200	1,500 - 2,500	30' - 50'	6' - 15'	Small Tanker, General Cargo, Fishing (Long Liner)	6	2
90 – 150	200 - 800	12' - 50'	4' - 15'	Small Tanker, General Cargo, Fishing (Dragger, Long Liner)	4	2
65 – 100	40 - 250	13' - 28'	5' - 15'	Tugs, Small Draggers, Long Liners, Pleasure Craft	4	2
45 - 65	20 - 160	9' - 16'	4' - 15'	Tugs, Work Boats, Small Draggers, Inshore Long Liners, Pleasure Craft	4	2
32 - 45	8 - 50	4' - 14'	3' - 9'	Tugs, Work Boats, Fishing (Cape Islanders, Trollers), Pleasure Craft	4	3
25 - 35	4 - 20	4' - 11'	3' - 5'	Tugs, Work Boats, Fishing Trollers, Pleasure Craft	5	4
12 - 25	1 - 7	3' - 8'	2' - 4'	Tugs, Work Boats, Inshore Fishing, Pleasure Craft	5	5
15-20	*< 1*	*2'*	*< 1'*	*Additional Craft Type: Canoes, Kayaks, Paddleboards*	*2*	*2*

Following the development of the traffic routeing, areas where vessels are subjected to tidal stream or local current rates that exceed their potential limits should be identified. This identification would then be taken forward during the review of results to identify if high marine traffic risk areas also coincide with areas of significant rates that may further increase the local risk profile. These areas of potential constraint should be re-reviewed when examining the distribution of collision potential developed from a marine traffic model, as an aid to identifying whether more detailed navigation assessment is required.

The prevailing winds in the Study Area should be identified and presented. Sea areas upwind of OREI developments should be highlighted and the traffic volume passing through these areas reviewed.

The visibility within the Study Area should be identified and presented. Particular attention should be paid to the presentation of periods of reduced visibility.

Note: *Where visibility lies below 1,000 metres the term “fog” is used & where between 1,000 and 2,000 metres the terms “mist” or “haze” are used.*

Marine Traffic Modelling (MTM)

Where marine traffic modelling is appropriate it consists of a three-step process of:

- building the traffic model within a suitable simulation modelling tool
- baseline assessment and validation of the model
- forecasting using the model.

Step 1 – Building the Model

The principle steps of building the model will be dependent on the modelling tool used but the key steps are likely to be:

- Traffic Review and Development
- Set up Simulation Rules for the movement of vessels
- Set up Simulation Rules for the behaviour of mariners
- Set up Simulation Rules for manoeuvring in restricted waterways.

The key elements associated with Traffic Review and Development are illustrated below:

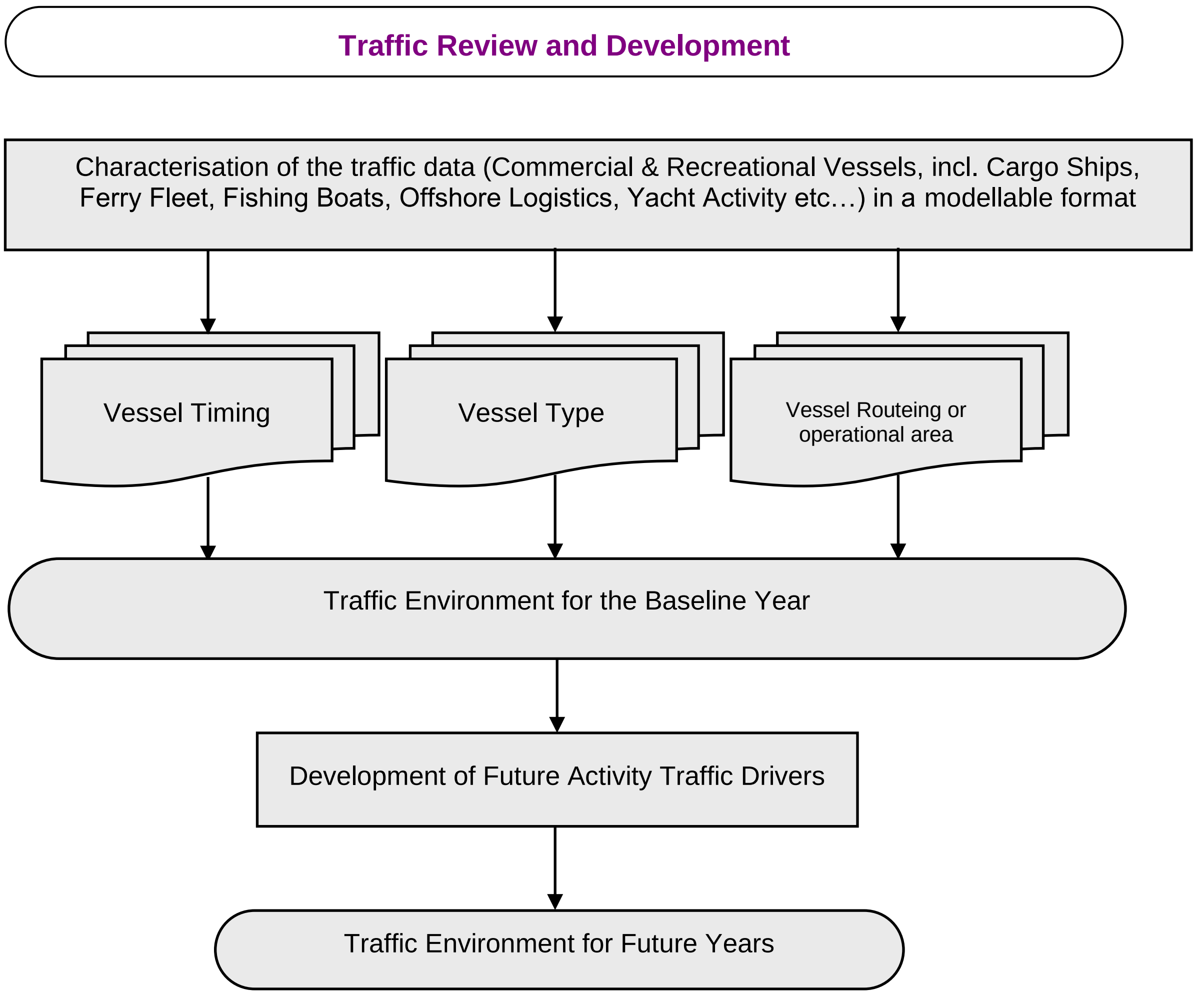

Figure 7 – Area Traffic Assessment Illustrative Example – Traffic Review and Development Flow Chart

Step 1.1 - Traffic Review and Development including

- Characterisation of the traffic data in a format capable of being assessed
- Analysis and capture of vessel timings, vessel types, routeings and operational areas. The route or operational area should be identified by geometric boundaries consistent with those identified from field surveys, and directly related to the traffic distribution mapped in the field surveys. It is suggested that, where appropriate, route widths should encompass the lateral deviation associated with +/-2 standard deviations of the

displacement of the traffic associated with movement between two locations. As a minimum the route width should accommodate 90% of all traffic transiting each route. It is noted that this process will result in variable route widths (dependent upon the sampled traffic activity).

Note: *In this context a "Route" is taken to be a track along which a significant number of vessels can be shown to navigate on largely parallel courses. "Operational areas" are those where fishing operations, recreational sailing and other marine activities take place and in which courses and speeds may vary considerably and frequently. Those interactions between vessels on routes and vessels engaged in activities in operational areas should be fully assessed as should those of all vessels with OREI structures.*

- Definition of no-route based vessel activity or operation. Where any traffic activities not consistent with point-to-point traffic are identified (i.e. recreational day sailing or fishing), the volume of this traffic should be identified, and distributions developed that best fit the available data.
- Recognition of traffic complexity. It should be emphasised that the route structure collected from survey data should capture the distribution of the full range of vessels active in the Study Area. For example, if there are a variety of vessels (coastal vessels, deep sea vessels, fishing, day sailing, high speed ferries, etc.) associated with marine traffic in the Study Area, all of these may have separate traffic distributions, time histories and vessel characteristics. All these elements and the associated complexity should be sampled and represented to as high a degree of fidelity as is feasible.
- Map routeings and operations onto a geospatial map of the area extracted from ENC charts or from site specific surveys.
- Define traffic in baseline year (See Annex B1 -Understanding the Base Case densities and types of traffic for further information). The traffic variation along routes and in operational areas should be representative of that identified from field surveys and should mimic the hourly variation in activity identified for "typical" daily conditions.
- Define traffic in future years (See Annex B2 – Predicting Future densities and types of traffic for further information).

The aim of the traffic review and development is to develop a comprehensive representation of present and future marine traffic in offshore waters, within the vicinity of the OREI. Vessel movement timings, types and routeings must be identified to develop a statistically representative sample of activity. This data may, if appropriate, allow the development of diverse vessel tracks into key characteristic routes to map present activity.

Step 1.2 – Set up Rules for the movement of vessels through the water including:

- The navigation manoeuvring characteristics of the vessels
- Realistic routes with appropriate traffic volumes, route widths, and speed profiles. The speed profile of vessels moving along a route should be representative of data identified from field surveys. This should identify vessel speeds, including average vessels speeds, together with changes in speed along routes as vessels pass across the Study Area. (Similar rules apply to vessels engaged in activities within operational areas.)

The aim of the rules for movement is to set up credible vessel behaviour; however it is recognised that the complexity of modelling this behaviour for multiple vessels within a traffic simulation may require a simplification of the navigation characteristics and thus numerical modelling may not be the appropriate technique for particular scenarios.

Step 1.3 – Set up Rules for the behaviour of mariners including:

- how they respond to the Collision Regulations (in both single and multiple encounter situations) and in all conditions of visibility.
- human error and deliberate violation in applying the Collision Regulations.

The aim of the rules for behaviour is to set up credible mariner behaviour. A key part of the representation of vessel interactions will also be to identify how vessels may interact following actions by one or more vessels which deviate from those required by the Collision Regulations. Analysis of the traffic survey data may provide this information. Failing that a credible estimate must be made.

Step 1.4 – Set up Rules for manoeuvring in restricted waterways including:

- differing behaviour for different classes of vessel
- different behaviour for different tides
- different behaviour for different tidal streams

The aim of the simulation rules for restricted waterways is to set up credible vessel and mariner behaviour appropriate to potential hazards.

Step 2 – Baseline Assessment and Validation of the Technique or Tool

This step is crucial; if the technique or tool cannot be validated for the base case year then it cannot be used to predict future years. Maritime incident data for the Strategic OREI Area and the actual OREI Area should be sought, analysed and mapped to both the encounter frequencies and frequency density and the collision, contact, grounding and stranding probabilities and probability densities.

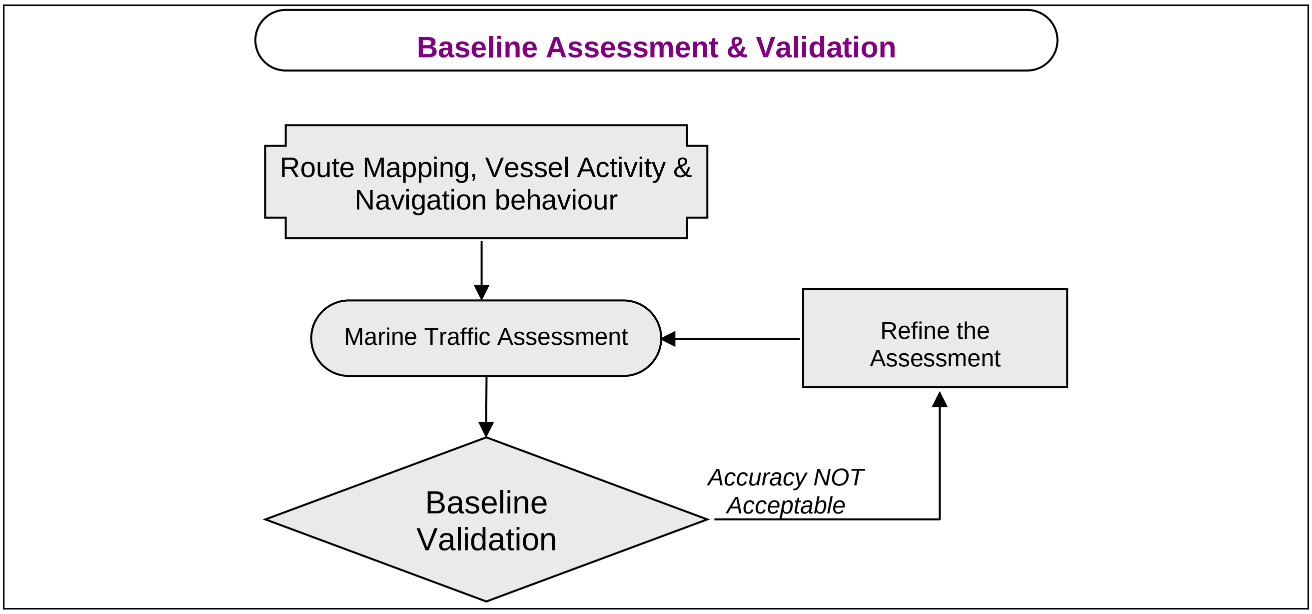

Figure 8 – Area Traffic Assessment Illustrative Example - Baseline Assessment and Validation Flow Chart

The principle steps of building a numerical model would encompass:

- Running the baseline model
- Interpreting the results
- Development of causation factors
- Model acceptance/refinement.

Step 2.1 – Running the Baseline model including:

- Multiple simulations of characteristic daily activity (for cases where the simulation develops random vessels to target frequencies)
- Review of simulations to ensure stable average activity is being presented.

Step 2.2 – Interpreting the results

- Review of boundary conditions and assessment of Study Area for validation
- Spatial mapping of model output ("encounters" or "domain violations"), this may be done on a global basis or in greater detail for different vessel types.

Step 2.3 – Development of Causation Factors

- Mapping of historic incident data in Study Area
- Identification of causation factor (Incidents from historic record/model output) for collisions and groundings. Where no site-specific data is available analysis by Fuji adopted in IALA Waterway Risk Assessment Program may be adopted if appropriate, this program being devised largely for use in closed boundary waterways such as rivers and canals.

Step 2.4 – Model Acceptance / Refinement

- Review of model incident distribution accuracy
- Adoption of model if distribution of incidents accurately represented, else investigation of key model parameters and reassessment.

The validation of the model allows the quantitative assessment of collision and contact risk to be conducted, rather than purely representing the risks as qualitative increases in hazard.

Step 3 – Forecasting using the model or other appropriate technique

This step uses the model or other technique to assess:

- future case without OREI
- base case with OREI
- future case with wind OREI

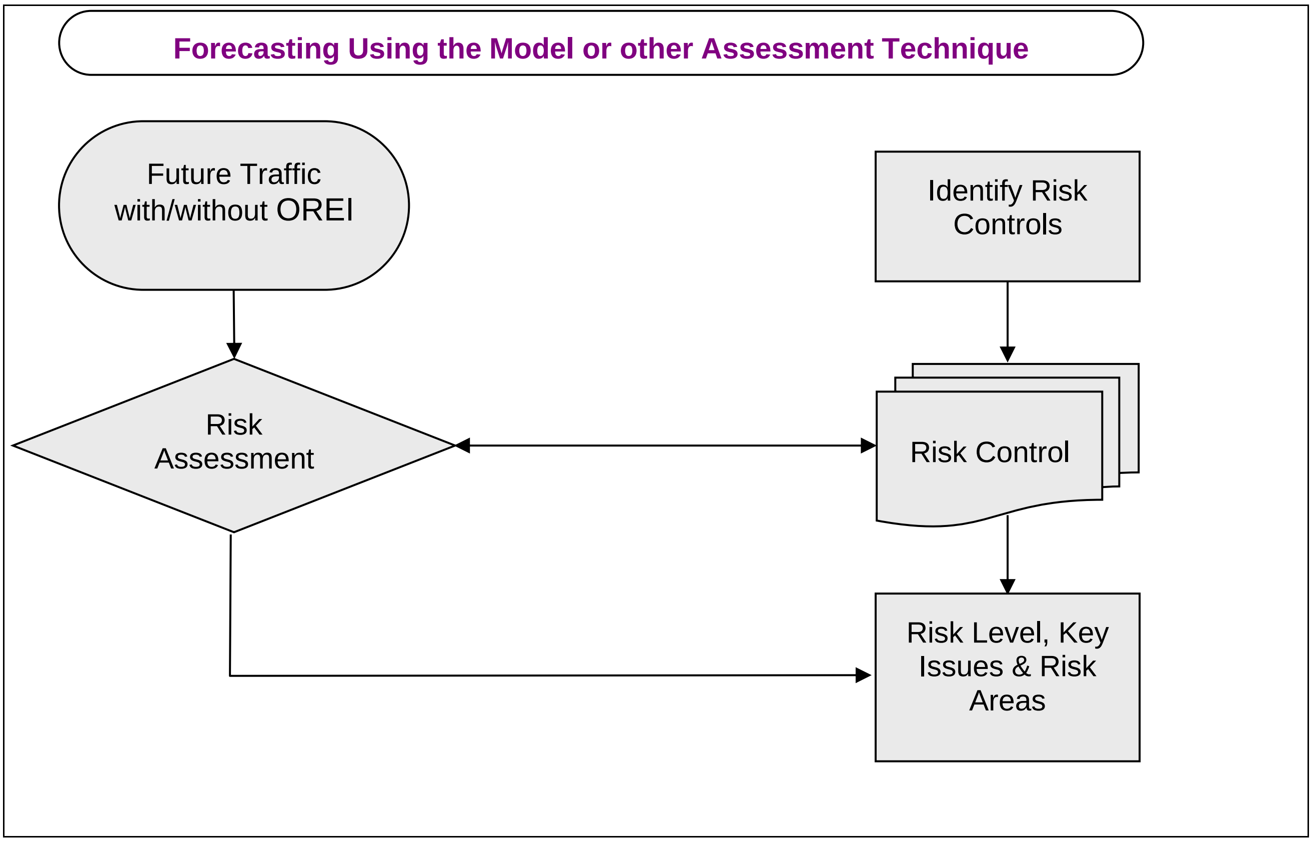

Figure 9 – Area Traffic Assessment Illustrative Example - Forecasting using the Model or other Assessment Technique Flow Chart

Step 3.1 – Future Case without OREI

- Review forecast traffic predictions
- Identify distinct vessel type, operation or route, traffic increase allocations
- Apply vessel type, operation or route, traffic increase allocations
- Represent future vessel size increases where appropriate
- Where appropriate run model, develop collision/grounding/ contact distribution
- Assess collision, contact, grounding and stranding distribution, for all vessels, and specific areas/vessels/ routes/operations identified as suffering significant increases in collision/grounding/contact risk.
- Identify Risk Regime Environment. It is recognised that the safety of marine operations is, in general, improving. Although predicted incident magnitudes and distributions may be factored to account for this improvement if supported by a review of historic incident frequency, the proviso that large area, multi-structure Round 2 wind farms and other OREI represent hazards to vessels not previously encountered should be taken into account.

This case should be reviewed against the Baseline and identify the impact of traffic increases alone on the local risk environment.

Step 3.2 – Base Case with OREI

- Review routes impacted by OREI

- Elicit, or make judgement where appropriate, regarding the relocation and distribution of routes. For those cases where, for example, a route bisects a wind farm it is necessary to make judgements of whether to pass through the wind farm, as smaller vessels might be expected to do, or, in the case of larger vessels, to normally leave it to port or starboard. These should be reviewed with respect to the origin and destination of the traffic, navigable water space and the presence of other obstructions.
- Determine a minimum anticipated vessel clearance, for all anticipated types of vessel, as they pass an OREI boundary. In this element guidance may be taken from the initial MCA recommendations on boundary clearance distances from shipping routes[20].
- The width of the original route at the closest point of approach to the OREI must be developed. As a first guide a width 50% that of the original route width at this location to mimic the compression of traffic expected as the OREI perimeter could be adopted as a virtual way mark. Again, the initial MCA guidance on boundary clearance distances from shipping routes should be taken into account.
- Assess collision/grounding/ contact distribution, for all vessel types, and specific areas/vessels/routes/ operational areas identified as suffering significant increases in collision/grounding/contact risk.
- Impact of limited visibility. A key aspect of the wind farm case is the inclusion of loss of visibility and vessel detection capability due to the presence of wind farms. One approach would be to identify the increase in collision risk as a result of limited visibility and apply this increase in risk to all traffic encounters between two or more vessels. Potentially unable to detect each other because of the wind farm.

This case should be reviewed against the baseline and identifies the impact of the wind farm or other OREI alone on the local risk environment.

Step 3.3 –Future Case with OREI

Adopt traffic density and type allocation as per Step 3.1

- Adopt route and area of operation structures as per Step 3.2.
- Assess collision/grounding/contact distribution, for all vessels, and specific areas/vessels/routes/operations identified as suffering significant increases in collision/ grounding/contact risk.
- This case should be reviewed against the Baseline and identifies the impact of the future traffic changes and wind farms or other OREI on the local risk environment.
- This will identify the cumulative impact of changes in the traffic volumes and OREI placement and should be used as the basis for risk assessment and contingency planning.
- The acceptability level may, if appropriate, be plotted on an F-N curve of the risks within the Study Area should be examined.

Key risk areas identified in the marine traffic simulation should be scrutinised and reviewed with respect to the local marine environment and specific navigation simulations.

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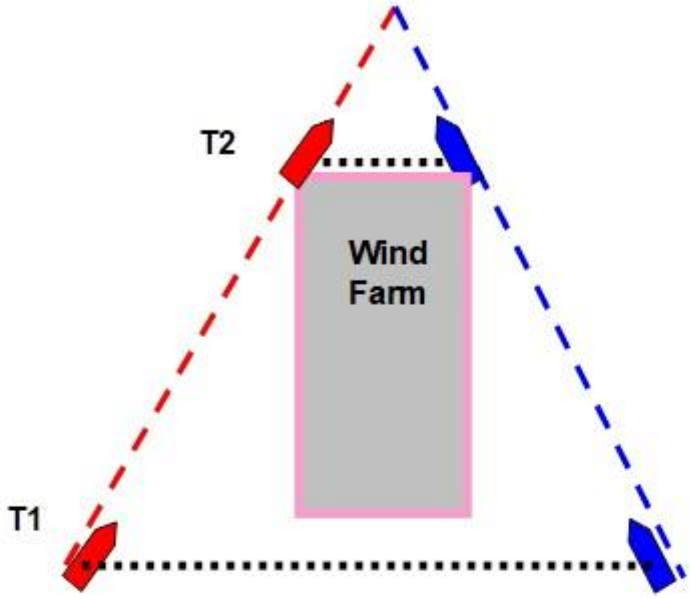
[20] "Shipping Routes – Wind Farm Template MCA: www.dft.gov.uk/mca Safety info / Navigation Safety / Offshore Renewable Energy Information



For this example it is assumed that the position at which a vessel would have normally made sighting and avoiding action occurs at T_1. In this case this coincides with the boundary of the wind farm; however this may not necessarily always be the case. Assuming neither vessel is aware of the other as they pass the wind farm, the vessels finally may have clear visibility of each other at T_2. A collision risk multiplier of some determined value (not necessarily that shown above) could then be applied for decreases in the perception distance at which acquisition is made. This may be applied for each and every vessel to vessel encounter.

Figure 10 – Area Traffic Assessment Illustrative Example - Treatment of Limited Visibility

D5 Navigation Risk Assessment – Specific Traffic Assessment Techniques

D.5.1 Use of Specific Navigation Assessment Techniques

Specific Traffic Assessment may be required to answer detailed questions about the feasibility and risk associated with specific navigation activities in or around an OREI. Typically, such assessment could be performed in response to:

- areas of "High Risk" identified by the Area Traffic Assessment
- the need for an "ALARP declaration" in the hazard log
- the need to evaluate the effectiveness of a Risk Control in the risk control log
- a request to evaluate the ability for SAR operations and for emergency response vessels (e.g. emergency towing vessels) to render assistance to vessels, in and around an OREI.

D.5.2 How to Select the Situations Requiring Specific Traffic Assessment

The situations which may require Specific Traffic Assessment could come from:

- the navigation risk assessment - Area Traffic Assessment results
  - e.g. problems identified in the Area Traffic Assessment results and not able to be assessed by this method. With respect, for example, to such factors as the creation of "choke points" including the identification of vessel types affected and potential influential parameters
- the hazard log
- the risk control log
- a need to give an overview of the Emergency Response Operations
- a need to evaluate the track of a vessel with engine (or other) failure

Other Sources

It is important the selection also takes into account the following as evaluation may be important to gain consent irrespective of the risk estimate:

- local knowledge e.g. sand waves or scouring on spring tides affecting bathymetry
- concerns of stakeholders e.g. visual and radar obstruction or spurious effects caused by the development
- some of the specific concerns of the technical guidance

Need for Assessment

The need for assessment of these situations comes from MGN guidance. An evaluation of all navigational possibilities which could be reasonably foreseeable, by which the siting, construction, establishment and de-commissioning of an OREI could cause or contribute to an obstruction of or danger to navigation or marine emergency services is required.

Specific traffic assessment may therefore be required to assess the risk of more specific navigational issues where the actual manoeuvring capabilities of the specific vessels involved in relationship to:

- the bathymetry

- the environmental conditions
- other traffic
- human action, inaction and error
- the OREI development structures

are, or may be, critical to comply with the Collision Regulations and avoid incident.

Type of Assessment

Once identified, these situations may need to be converted to scenarios that are capable of being examined and risk assessed using suitable tools. These tools include real and fast time manoeuvring and ship handling simulators. The basic scenario can then be subjected to parametric variation to investigate the hazard, the risk associated with the hazard and the effectiveness of any risk control measures.

Feedback from the results can be used to drive the parametric variation or modify the scenario based on emergent findings and thus test the appropriateness of any risk controls. It may identify further situations to be assessed or alternative risk controls to be evaluated.

D.5.3 Safety Zones

Safety zones for construction, maintenance and decommissioning will be applied for routinely through the appropriate authority e.g. BEIS, Marine Scotland, MMO, Welsh Government.

The Government's position in relation to operational safety zones for OREI is that a case must be made for the establishment of such zones. Compelling risk assessed arguments would be required for the establishment of a safety zone which excludes all vessels from the OREI area.

The IMO/UNCLOS safety zone at 500 metres considered with respect to other types of offshore structure does not imply that a direct parallel can be applied to wind farms or other types of OREI. It is used to illustrate an existing limitation but where the personnel expected to be found on structures and the potential for environmental damage are primary considerations.

D.5.4 How to Define Scenarios for Assessment

Once a situation has been selected, a scenario or numbers of scenarios may need to be defined to fully explore the situation. It is important that the scenario definition is robust, i.e. that it is capable of broad interpretation and not narrowly focused on a unique situation.

Each scenario requires a core or base starting point which will include:

- the ENC charts of the OREI location or site-specific bathymetric surveys
- modifications to the ENC chart with details of the OREI configurations
- the characteristics of the subject vessel or vessels.

Analysis based on Annex B3 (Guidance on Defining the Marine Environment) and Annex C3 (Influences on the Level of Risk) should be used as the source of information for the use in the scenario.

The details of the OREI that need to be added to the ENC chart include:

Shape and configuration

- size (number and type of structure, spacing)
- location
- orientation

Associated structures

- ancillary platforms
- floating structures
- transformers
- meteorological towers

Development Status

- proposed
- part constructed
- completed and operational

Marking

- navigation lights
- aviation lights
- AIS marks

Example of an Electronic Navigational Chart modified with a Wind Farm

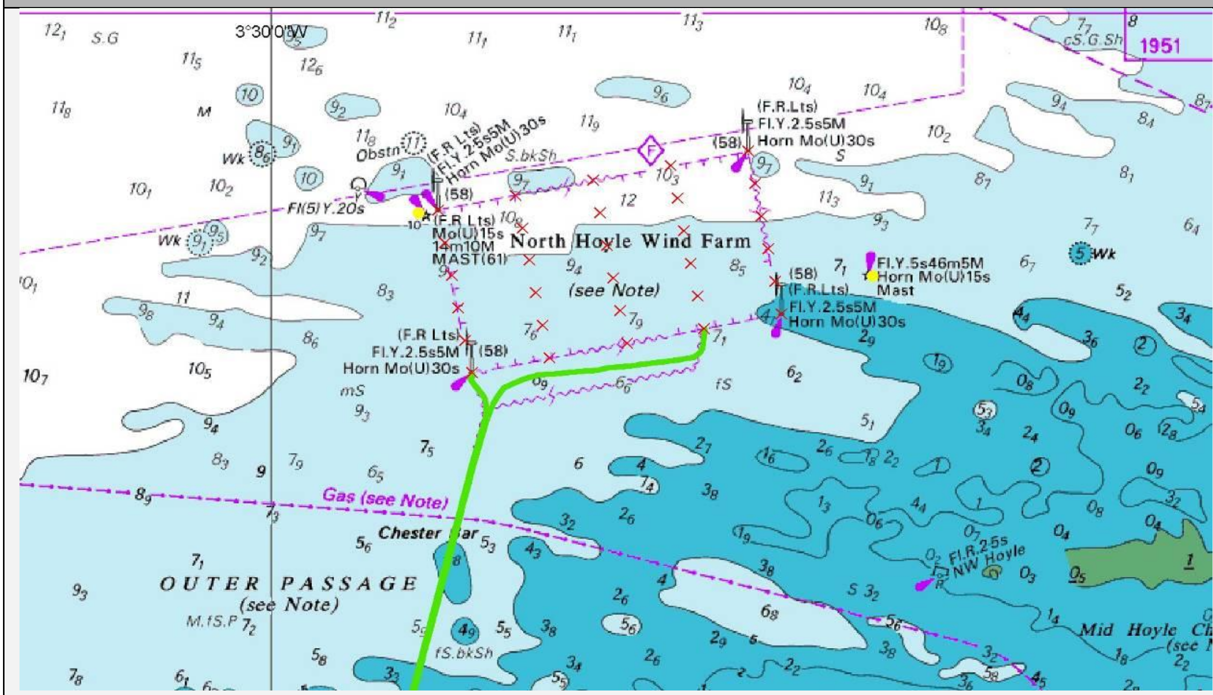


Figure 11 - Example of an Electronic Navigational Chart modified with a wind farm

Scenario Planning

The particular scenario which has been defined will then drive the definition of site-specific parameters which need to be defined and investigated.

Each scenario needs to be defined by the base case plus the relevant parameters selected for parametric variation.

This can be extended as necessary to include all relevant parameters and levels of parametric variation. Control measures may form part of the original scenario or may be derived from the results in which case new control measures can then be used to redefine the base scenarios.

Minimum Clearance Distances of Wind Farm Boundaries from Shipping Routes

MCA provides preliminary guidance in the form of a shipping route template to developers in setting the distance of a wind farm boundary from a recognised shipping route. The template combines the results of researched ship domain theory with those of radar and detection trials carried out at wind farm sites, to indicate the inter-relationship between shipping routes, offshore wind farms and the avoidance of collision between vessels and contact with wind farm structures. The template indicates the process by which consent applications may be considered by Government.

The template is not a prescriptive tool but needs intelligent application. For example, there may be opportunities for the interactive boundaries to be flexible where vessels are able to set themselves greater clearance distances from turbines, providing more reassurance without significant penalty and, conversely, at shipping route nodal points greater clearances from turbines may have to be set. The template, however, takes no account of the sea area bathymetry or of other hazards to navigation.

The positioning of an interactive boundary will be site specific and will require interpretative flexibility but is to be evidence based. The marine traffic survey information will inform such boundaries. Traffic surveys should establish any route traffic bias where mariners may naturally offset themselves to starboard to facilitate passing encounters in accordance with the International Regulations for the Prevention of Collision at Sea (COLREG). Additionally, the marine traffic surveys should identify vessel type or category or operation which may consequently require larger domains. In the approaches to ports this is particularly relevant. UK Hydrographic Charts and/or site-specific surveys will supply the necessary bathymetric data. All this additional information will influence where boundaries need to be established.

D.5.5 Simulator Specifications for Training Mariners Operating within or Close to OREI or for Assessing an Appropriate Scenario

If a navigational simulator exercise is to be used to train mariners operating within or close to offshore wind farms and other OREI developments or for assessing an appropriate scenario using subject mariners then this will require a technique which can accurately represent and apply the various parameters to the base case. Such a tool can range from a “desktop” exercise to a Full Mission Simulator System, the choice of tool and its parameters having been discussed with MCA. Suitability experienced and qualified instructors/assessors and mariners are required, particularly when the mariner is an important element in the scenario. Occasionally, however, non-mariners may be required as control groups. The required qualifications of instructors and assessors are those detailed in Section A-I/12 subsection 9 of the IMO’s STCW Convention.

The mariner's domain and general approach to navigating close to any offshore development structures will be directly related to the relevant subject, their skill and experience, the size and type of the vessel and crucial to the relevance of the results.

Implementing the Scenario in a Modelling Tool

If simulation modelling is selected as the assessment technique the modelling tool will need to be set up to include the following attributes:

- the manoeuvring characteristics of the Vessel
- interface with the Mariners / subjects e.g. vessel steering and power cuts
- information on the Environment e.g.:
    - ENC Chart derived information
    - Meteorological and sea conditions
    - Interactive traffic
- information display to the subjects e.g.:
    - 3-D Views e.g. bridge, bridge wing, etc.
    - Integrated radar simulation and other navigation information
    - Ship dimensions, draft, type and loading Information
- the parameters of the scenario.

ANNEX E DECIDING ON THE RISK CONTROLS

E1 Creating a Risk Control Log

The concept of offshore renewable installations (OREI) and potential risk is accepted and therefore developers will be expected to manage risk by the identification, application and proven worth of risk controls.

Annex G Table 28 provides a list of example risk controls (see also MGN 654 Section 4.15

E.1.1 Background

OREIs are in an environment where there are already considerable controls and mitigations (comprising rules, risk controls, risk mitigations and emergency plans) in place to manage risk. The developer is responsible for:

- interfacing with these existing controls and mitigations
- implementing new controls and mitigations for new risks (or change in level of existing risks).

E.1.2 Risk Control and Mitigation

To meet the Marine Navigational Safety Objectives:

- appropriate assets must be identified, consultations with appropriate stakeholder bodies held, agreement with the competent body reached, and the assets have to be put in place by the responsible body.
- applicable rules must be identified, consultations with appropriate stakeholder bodies held, agreement with the competent body reached, and the rules have to be implemented by the responsible body.
- standard or relevant good practice risk controls must be identified, consultations with appropriate stakeholder bodies held, agreement with the competent body reached, and the risk controls have to be implemented by the responsible body.
- risk control options have to be identified, consultations with appropriate stakeholder bodies held, agreement with a competent body reached, on risk controls that are capable of reducing risk to that which is As Low As Reasonably Practical and are assessed by risk assessment and the assessment used to decide if they will be incorporated
- emergency and contingency plans must be put in place and exercised.

E.1.3 Assets supporting Navigation Activities

Assets are of three main type functions:

- to reduce probability of an accident (typically called risk prevention assets)
- to reduce the consequence of an accident (typically called risk mitigation assets)
- emergency response.

Any given asset may be involved in all three.

E.1.4 Suggested Process for Creating a Risk Control Log

The suggested process for creating a risk control log is:

Risk Control Description

- identify all the relevant risk controls
- define the type of control (asset, rule, good practice and/or option)
- define what effect of control (prevention, mitigation and/or emergency response).

Risk Control Description – Example of Spreadsheet Format

DESCRIPTION			RISK CONTROL TYPE				RISK CONTROL EFFECT		
C1			Asset	Rule	Good Practice	Option	Prevention	Mitigation	Emergency Response
1		*All*							
2		**Vessel Assets**							
	1	Emergency Response - Requisitioned Vessels	√						√

Figure 12 – Example Risk Control Log - Risk Control Description

Consultation, Approval & Implementation

- identify appropriate stakeholder bodies for consultation
- identify the competent body for approval
- identify the responsible body for implementation.

Consultation, Approval & Implementation – Example Spreadsheet Format

DESCRIPTION			CONSULTATION, APPROVAL & IMPLEMENTATION		
C1			Appropriate Stakeholder Bodies for Consultation	Competent Body for Approval	Responsible Body for Implementation
1		*All*			
2		**Vessel Assets**			
	1	Emergency Response - Requisitioned Vessels			

Figure 13 – Example Risk Control Log - Consultation, Approval & Implementation

Implementation Options

- identify the possible project phases for implementation (i.e. during pre-construction, construction, operation and maintenance phases)
- identify the best phase for implementation (e.g. O = Optimum, P = Possible, C = Costly, N = Not Feasible).

Implementation Options - Example of Spreadsheet Format

DESCRIPTION			IMPLEMENTATION OPTIONS				
C1			Pre-Construction	Construction	Operation	Maintenance	Decommissioning
1		*All*					
2		**Vessel Assets**					
	1	Emergency Response - Requisitioned Vessels			**O**		

Figure 14 – Example Risk Control Log - Implementation Options

Implementation Plan

- describe the chosen plan for implementation
- highlight risk controls that are controlling major risks that are not being implemented by the developer.

Implementation Plan – Example of Spreadsheet Format

DESCRIPTION			IMPLEMENTATION PLAN
C1			
1		*All*	
2		**Vessel Assets**	
	1	Emergency Response - Requisitioned Vessels	

Figure 15 – Example Risk Control Log - Implementation Plan

E2 Navigation and SAR Stakeholders and Stakeholder Organisations

There are a large number of stakeholders who will have an interest in the effect on navigation of the OREI and it is important that their views are recognised, and they are consulted through the appropriate stakeholder organisation.

This section gives an indicative list of stakeholders and stakeholder organisations.

E.2.1 Stakeholders and Organisations

Table 26 - Example Stakeholders

Navigation Stakeholders
Commercial shipping owners, operators and associations
Fishing industry – individuals, groups and associations
Recreational mariners, groups and organisations
Port/Harbour Authorities and representatives of groups and associations
Other ports e.g. not a Statutory Harbour Authority
Offshore Oil and Gas Industry
Ministry of Defence
Chamber of Shipping
Mariners – Masters, sailors, crew
Search and Rescue Stakeholders
RNLI
HM Coastguard
Wind Farm Stakeholders
Developer
Owner
Operator
Regulatory Stakeholders
UK Hydrographic Office
Flag State of neighbouring countries
MAIB
DfT
General Lighthouse Authority
Maritime and Coastguard Agency
Civil Aviation Authority
Health and Safety Executive
Other Stakeholders
The Crown Estate
The Crown Estate Scotland
Legal Services
Marine Consultants
Marine licensing authorities

ANNEX F EXAMPLE HAZARD IDENTIFICATION

Table 27 - Example Hazard Identification

DESCRIPTION				
Ref				Description of Causal Chain (Event Sequence) (Accident Sequence)
1				**General Navigation Safety**
1	**2**			**Collision**
1	2	01	a	Merchant vessel [broken down by type] navigating near or around an OREI collides with another vessel that is navigating near or around an OREI
1	2	01	e	Merchant vessel [broken down by type] navigating through an OREI collides with another vessel that is navigating through an OREI.
1	2	02	a	Fishing vessel collides with another vessel navigating near, around or through an OREI
1	2	02	b	Presence of fishing vessels causes collision between other navigating vessels.
1	2	03	a	Recreational vessel collides with another navigating vessel navigating near, around or through an OREI
1	2	03	b	Presence of recreational vessels causes collision between other navigating vessels.
1	2	04	a	Anchored vessel collides with another navigating vessel navigating near, around or through an OREI
1	2	04	b	Presence of anchored vessels causes collision between other navigating vessels.
1	2	05	a	Vessel engaged in servicing an OREI collides with another navigating vessel navigating near, around or through an OREI
1	2	05	b	Presence of vessels engaged in servicing an OREI causes collision between other navigating vessels.
1	2	06	a	Vessels engaged in servicing an OREI (e.g. a mother and daughter vessel arrangement) collide with each other
1	2	06	b	Vessels engaged in servicing an OREI (e.g. a mother and daughter vessel arrangement) collide with another navigating vessel navigating near, around or through an OREI
1	2	06	c	Presence of vessels engaged in servicing an OREI (e.g. a mother and daughter vessel arrangement) causes collision with other navigating vessels
1	**3**			**Contact**
1	3	01	a	Vessel [broken down by type, inc personal watercraft] under control makes contact with a floating or fixed OREI structure e.g. foundation, platform, transition piece, blade, substation, accommodation platform
1	3	01	b	Vessel servicing an OREI structure makes contact with an OREI structure
1	3	01	c	Vessel not under command makes contact with an OREI structure
1	**8**			**Grounding and Stranding**
1	8	01	a	Vessel under control grounds or becomes stranded on an OREI structure e.g. foundation, transition piece, collapsed wind turbine.
1	8	01	b	Vessel servicing an OREI structure grounds on an OREI structure
1	8	03	a	Vessel not under command grounds or becomes stranded on an OREI structure
1	8	04		Due to restricted manoeuvring a vessel navigating near, around or through an OREI grounds or becomes stranded.
1	8	07	a	Due to naturally shifting sand banks a vessel navigating near, around or through an OREI grounds or becomes stranded.
1	8	08	a	Due to the effect of scour a vessel navigating near, around or through an OREI grounds or becomes stranded.
2				**Other Navigation Safety**
2	**1**			**Foundering and Capsizing**

DESCRIPTION				
Ref				Description of Causal Chain (Event Sequence) (Accident Sequence)
2	1	02	a	Subsea obstacle e.g. cable, fallen structure snags anchor heeling vessel and causing it to founder or capsize.
2	**4**			**Fire**
2	4	01		Wind turbine or other OREI structure fire requires emergency rescue of servicing staff
2	4	03		Release of fire suppression (real or spurious triggers) releases inert gases into the air intakes of supporting helicopters
3				**SAR Aviation Safety**
3	**17**			**Aviation Accidents**
3	17	01		Helicopter flying to a turbine, OREI structure, sub-station, service base or accommodation base hits blades or tower and crashes
3	17	02		Helicopter flying to a nearby installation or in transit hits blades, tower or other OREI structure and crashes
4				**Other Safety**
4	**20**			**High Probability Events**
4	20	01		Contact between a service vessel and an OREI structure when transferring personnel
4	20	02		Injury of service personnel when transferring to/from an OREI structure
4	20	03		Man overboard of service personnel when transferring to/from an OREI structure
4	20	04		Navigation in potential safety zones
4	**21**			**High Severity Outcomes**
4	21	01		A major incident with a large Cruise Vessel or Passenger Ferry leading to a major search and rescue event
4	21	02		Emergency response operations following a major incident with a large oil tanker leading to large scale pollution
4	21	03		Emergency response operations following a major incident with a Liquefied Gas Tanker close to a major centre of population resulting in a large-scale explosion risk
4	**22**			**Low Confidence/High Uncertainty**
4	22	01		No risks have been identified where there is significant uncertainty in the assessment, the probability or of the outcome
5				**Search and Rescue**
5	**30**			**Overall**
5	30	01		Presence of an OREI increases the risk of an accident (e.g. collision, contact, stranding or grounding) and also inhibits search and rescue.
5	**31**			**External to Internal**
5	31	01		Person or vessel requiring search and rescue drifts into an OREI and the presence of the OREI restricts search and rescue.
5	**32**			**Internal to Internal**
5	32	01		Activities within an OREI both generate an increased need for search and rescue and the presence of the OREI inhibits search and rescue.
5	**33**			**Internal to External**
5	33	01		Activities within a an OREI generate an increased need for search and rescue in the areas surrounding the OREI
5	**34**			**External to External**
5	35	01		Person or vessel requiring search and rescue drifts through an OREI and the presence of the OREI inhibits search and rescue during the transit stage.
5	**35**			**Worst Case**
5	35	01		Search and Rescue operations following a major incident with a large Cruise Vessel or Passenger Ferry
6				**Emergency Response**
6	**30**			**Overall**
6	30	01		Presence of an OREI increases need for emergency response from Foundering, Capsizing, Collision, Grounding or Stranding.

DESCRIPTION				
Ref				Description of Causal Chain (Event Sequence) (Accident Sequence)
6	30	02		Present an OREI ce of inhibits ability to provide emergency response.
6	**31**			**External to Internal**
6	31	01		Pollution outside an OREI drifts into the OREI and presence of the OREI inhibits clean up
6	**32**			**Internal to Internal**
6	32	01		Activities within an OREI both generate an increased risk of pollution and the presence of the OREI inhibits clean up.
6	**33**			**Internal to External**
6	33	01		Activities within an OREI generate an increased risk of pollution in the areas surrounding the OREI
6	**34**			**External to External**
6	34	01		Pollution from outside an OREI drifts through the OREI and the presence of the OREI inhibits clean up during the transit stage.
6	34	02		Routeing of vessels (or post collision, contact or grounded vessel) results in hazardous cargoes closer to areas of population
6	**35**			**Worst Case**
6	35	01		Emergency response operations following a major incident with a large oil tanker
6	35	02		Emergency response operations following a major incident with a Liquefied Gas Tanker close to a major centre of population

ANNEX G EXAMPLE RISK CONTROLS

Table 28 - Example risk controls for developer and navigation stakeholders

DESCRIPTION			RISK CONTROL TYPE				RISK CONTROL EFFECT		
			Asset	Rule	Good Practice	Option	Prevention	Mitigation	Emergency Response
1		**Vessel Assets**							
	1	Emergency Response - Requisitioned Vessels	✓						✓
	2	Search and Rescue – Inshore	✓						✓
	3	Search and Rescue - Lifeboats	✓						✓
	4	Search and Rescue Requisitioned Vessels	✓						✓
	5	Tugs	✓						✓
	6	GLA Tenders	✓						✓
	7	OREI Support Vessels	✓						✓
2		**Aviation Assets**							
	1	Search and Rescue - Helicopter	✓						✓
	2	Oil Spill Dispersant - Aircraft	✓						
3		**OREI Assets**							
	1	AIS Base Station on / depicting OREI	✓						
	2	VTS Radar on OREI	✓						
	3	Marks and Lights	✓				✓		
	4	Sound Signals	✓				✓		
	5	CCTV	✓						
	6	Design specifications e.g. to aid SAR	✓					✓	✓
4		**OREI Control Room Assets**							
	1	AIS monitoring	✓				✓		
5		**Shore-based Assets**							
	1	Marine Radar, Navigation and Communications Systems	✓				✓		
	2	Marine Rescue Coordination Centres	✓						✓
	3	Vessel Traffic Service	✓				✓		
	4	Shore Radar	✓				✓		
6		**Other Assets**							
	1	Pilot Services	✓				✓		
	2	Charts	✓				✓		
7		**Consent**							
	1	Deny consent to the OREI				✓	✓		
8		**Configuration and Design**							
	1	Optimise location, alignment, size and layout			✓		✓		

DESCRIPTION			RISK CONTROL TYPE				RISK CONTROL EFFECT		
			Asset	Rule	Good Practice	Option	Prevention	Mitigation	Emergency Response
	2	Minimum safe (air) clearances		✓			✓		
9		**Site Designation**							
	1	Safety zones of appropriate configuration and extent during construction, operation and decommissioning phases.				✓	✓		
10		**Routeing and Routeing Management**							
	1	Implementation of IMO routeing measures within or near the development e.g. Traffic Separation Scheme, Recommended Route, Area to be Avoided etc.				✓	✓		
	2a	Manage traffic through VTS from OREI Control Centre				✓	✓		
	2b	Manage traffic through VTS from MCA Control Centre				✓	✓		
	3	Continuous watch by multi-channel VHF, including Digital Selective Calling (DSC) from OREI Control Centre			✓		✓		
	4	Monitoring by radar, AIS and/or closed-circuit television (CCTV) from OREI Control Centre				✓	✓		
	8	Speed limits to control wash			✓		✓		
11		**Navigational Marking**							
	1	External Marking of OREI to GLA requirements based on IALA recommendations		✓			✓		
	2	Internal Marking of OREI to GLA requirements		✓			✓		
	3	ID Marking of Individual Structures		✓			✓		
	4	Aids to Navigation to GLA requirements		✓			✓		
12		**Communication and Training**							
	1	Promulgation of information and warnings through notices to mariners and other appropriate media		✓	✓		✓		
	2	Marking on Navigation Charts		✓			✓		
13		**Safety Management**							
	1	Operator's Safety Management System			✓			✓	
	2	Operators Safety and Operations Plan			✓			✓	
	3	Operators Emergency Plan			✓			✓	
	4	Contingency plan if GPS switched off/failed			✓				

DESCRIPTION			RISK CONTROL TYPE				RISK CONTROL EFFECT		
			Asset	Rule	Good Practice	Option	Prevention	Mitigation	Emergency Response
	5	Emergency Response Plan	✓				✓	✓	✓
14		**Regulatory**							
	1	Application of the principles of the Port Marine Safety Code to OREI				✓			
15		**Search and Rescue**							
	1	SAR response planning			✓				✓
	2	SAR asset provision planning			✓				✓
	3	Turbine mast design (e.g. including safe refuge).		✓				✓	
	4	Standards and procedures for wind turbine generator shutdown		✓			✓		
	5	Aviation lighting and ID marking of external and internal structures		✓					✓
	6	Emergency Response Cooperation Plan		✓					✓
16		**Emergency Planning**							
	1	Salvage response planning			✓			✓	
	2	Salvage asset provision planning			✓			✓	
	3	Oil Spill response planning			✓			✓	
	4	Oil Spill asset provision planning			✓			✓	

ANNEX H CATEGORIES, TERMS AND REFERENCES

H1.1 Marine Accident Categories

Table 29 - Marine Accident Categories

	Category	Description
1	Foundering	To sink below the surface of the water.
2	Collision	Collision is defined as a vessel striking, or being struck, by another vessel, regardless of whether either vessel is under way, anchored or moored; but excludes hitting underwater wrecks.
3	Allision	Defined as a violent contact between a vessel and a fixed structure.
4	Contact	Contact is defined as a vessel striking, or being struck, by an external object that is not another vessel or the sea bottom. Sometimes referred to as Impact
5	Fire	Fire is defined as the uncontrolled process of combustion characterised by heat or smoke or flame or any combination of these.
6	Explosion	An explosion is defined as an uncontrolled release of energy which causes a pressure discontinuity or blast wave.
7	Loss of Hull Integrity	Loss of Hull Integrity (LOHI) is defined as the consequence of certain initiating events that result in damage to the external hull, or to internal structure and sub-division, such that any compartment or space within the hull is opened to the sea or to any other compartment or space.
8	Flooding	Flooding is defined as sea water, or water ballast, entering a space, from which it should be excluded, in such a quantity that there is a possibility of loss of stability leading to capsizing or sinking of the vessel.
9	Grounding	Grounding is defined as the ship coming to rest on, or riding across underwater features or objects, but where the vessel can be freed from the obstruction by lightening and/or assistance from another vessel (e.g. tug) or by floating off on the next tide.
10	Stranding	Stranding is defined as being a greater hazard than grounding and is defined as the ship becoming fixed on an underwater feature or object such that the vessel cannot readily be moved by lightening, floating off or with assistance from other vessels (e.g. tugs).
11	Machinery Related Accidents	Machinery related accidents are defined as any failure of equipment, plant and associated systems which prevents, or could prevent if circumstances dictate, the ship from manoeuvring or being propelled or controlling its stability.

	Category	Description
12	**Payload Related Accidents**	**Payload related accidents include loss of stability due to cargo shifting and damage to the vessel's structure resulting from the method employed for loading or discharging the cargo. This category does not include incidents which can be categorised as Hazardous Substance, Fires, Explosions, Loss of Hull Integrity, Flooding accidents etc.**
13	**Hazardous Substance Accidents**	**Hazardous substance accidents are defined as any substance which, if generated as a result of a fire, accidental release, human error, failure of process equipment, loss of containment, or overheating of electrical equipment; can cause impairment of the health and/or functioning of people or damage to the vessel. These materials may be toxic or flammable gases, vapours, liquids, dusts or solid substances.**
14	**Accidents to Personnel**	**Accidents to personnel are defined as those accidents which cause harm to any person on board the vessel e.g. crew, passengers, stevedores; which do not arise as a result of one of the other accident categories. Essentially, it refers to accidents to individuals, though this does not preclude multiple human casualties as a result of the same hazard, and typically includes harm caused by the movement of the vessel when underway, slips, trips, falls, electrocution and confined space accidents, food poisoning incidents, etc.**
15	**Accidents to the General Public**	**Accidents to personnel are defined as those accidents which lead to injury, death or loss of property amongst the population ashore resulting from one of the other ship accident categories.**[21]
16	**Capsizing**	**The overturning of a vessel after attaining negative stability**

[21] This definition is interpreted from MGN 654 rather that a generally recognised marine accident category.

H1.2 References

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