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GUIDANCE ON THE ASSESSMENT OF THE IMPACT OF OFFSHORE WIND FARMS:

Methodology for Assessing the Marine Navigational Safety Risks of Offshore Wind Farms

IN ASSOCIATION WITH

mca
Maritime and Coastguard Agency

Department for Transport

GUIDANCE ON THE ASSESSMENT OF THE IMPACT OF OFFSHORE WIND FARMS:

Methodology for Assessing the Marine Navigational Safety Risks of Offshore Wind Farms

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Acknowledgements

The Department of Trade and Industry (DTI) have produced the "Methodology for Assessing the Marine Navigational Safety Risks of Offshore Wind Farms" document, in association with the Department for Transport (DFT), the Maritime and Coastguard Agency (MCA) and BMT Renewables Limited. The preparation of this guidance has been supported by a Steering Group, comprising Dr. Caroline Roberts and Angela Wratten (DTI); John Mairs and Jim Spooner (DFT); Joe Collins and Simon Gooder (MCA) and Captain Colin Brown (DTI project manager). We are indebted to the input from this Steering Group, in particular the involvement and contributions of Captain Colin Brown. Additionally, we would like to thank the many practitioners who contributed their helpful comments and ideas through attending workshops, meetings and written feedback throughout the project.

Executive Summary

The Department of Trade and Industry (DTI) have produced this document, with the co-operation of the Department for Transport (DFT), as a Methodology for Assessing the Marine Navigational Safety Risks of Offshore Wind farms.

Its purpose is to be used as a template by developers in preparing their navigation risk assessments, and for Government Departments to help in the assessment of these.

The Methodology is centred on risk controls and the feedback from risk controls into risk assessment. It requires a submission that shows that sufficient risk controls are, or will be, in place for the assessed risk to be judged as broadly acceptable or tolerable with further controls or actions.

The key features of the Methodology are that developers are to:

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 wind farm, 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 Wind Farm" level of risk based on existing densities and types of traffic, the existing marine environment and with the wind farm in place.

8. Predict the "Future Case with Wind Farm" based on future traffic densities and types, the future marine environment and with the wind farm in place.

9. Process this information into a submission including a claim that the risks associated with the wind farm are "Broadly Acceptable" or "Tolerable" on the basis of As Low As Reasonably Practicable" (ALARP) declarations.

and that Government will base their decision on assessing:

1. That the tools and techniques used in the assessments are acceptable.

2. That the claim in the submission shows that the wind farm will meet the sought after level of marine navigational safety.
3. That there is sufficient information with the submission to have confidence in the claim.

4. That there is sufficient information with the submission to have confidence that appropriate risk controls are, or will be, in place.

Methodology

1. Introduction

1.1 Development of the Methodology

This project to develop a methodology for assessing the marine navigational safety risks of offshore wind farms has been carried out by the Department of Trade and Industry (DTI). It has evolved with the close co-operation of developers, Government, its agencies, and other stakeholders in conjunction with British Maritime Technology (BMT) Renewables Ltd. Extensive consultation and research has been carried out to ensure that the methodology is robust, verified, auditable and accountable in a local, national and international context.

1.2 Risk Control Focused on the Methodology

The Methodology is focused both on risk controls and in preparing a Submission that shows that sufficient risk controls are in place for the Assessed Risk to be judged as:

- Broadly acceptable; or
- Tolerable with further controls in place or actions taken

1.3 Structure of the Methodology

The Methodology comprises three parts:

- A recommended Methodology (described in the Main Text)
- Guidance (described in the Annexes)
- Further general information and guidance (contained in Appendices A & B)

Methodology

Developers are invited to carry out Marine Navigational Safety Risk Assessments in accordance with the spirit of the methodology and to submit the results in accordance with the standard format for a submission.

Guidance

Guidance to developers in applying the methodology is provided, as are appendices illustrating various methods of doing so. 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:

Methodology	The recommended process, as described in this document, for undertaking and presenting a Marine Navigational Safety Risk Assessment to Government as part of the developer's Environmental Statement (E.S.).
Guidance	Guidance on techniques and tools that may be used in applying the Methodology.
Marine Navigational Safety Risk Assessment	The body of information produced that is used as the basis of the marine navigational safety risk assessment carried out for inclusion in the developer's E.S. 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
	• General details of Emergency Response implications

General Navigation Safety Risk Assessment	That 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.
Other Navigation Safety Risk Assessment	That 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.
Area Traffic Assessment	That part of general navigation risk assessment that assesses the wider sea area, its marine environment, traffic and the wind farm development to enable the prediction of the risk of collision, contact, grounding and stranding.
Specific Traffic Assessment	That part of 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.
Acceptable Techniques	Techniques that are acceptable to Government in assessing the marine navigational safety risks of offshore wind farms
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

Table 1 - Key Terminology

1.5 How the Methodology Was Developed

Risk Assessment

A number of risk assessment techniques may be appropriate for use in specific circumstances or in respect of a particular development.

The Maritime and Coastguard Agency (MCA) have had a major role in the development of Formal Safety Assessment (FSA) techniques since the 1992 Carver Report. An MCA introduction to Formal Safety Assessments, together with the techniques that may be used in them, is contained within **Appendix A**.

To assist BMT Renewables Ltd in developing their input to the Methodology a series of illustrative risk assessments were undertaken by them, using their proprietary computer based simulation modelling tools and their own preferred processes.

2. Use and Coverage of the Methodology

2.1 Use by Developers

The Methodology has been produced to be used as a template primarily by developers in preparing their marine navigation safety risk assessments, and hence to identify what type and level of information should be provided by the wind farm developer in an application.

Developers are recommended to carry out marine navigation safety risk assessments in accordance with the spirit of the Methodology and to submit the results in accordance with the standard format for a submission.

It is anticipated that the methodology may also be used by both developers and Government with reference to offshore wind farms and other types of offshore renewable energy installations (OREI).

2.2 Coverage of the Methodology – Risk Areas

The methodology covers the marine navigational safety risks for navigation and operations taking place within and around developments and the need for:

- Formal Safety Assessment supported by
- Navigation risk assessment, including: -
  - Search and rescue overview
  - Emergency response overview.

2.3 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 wind farm developments in the strategic wind farm area
- In-combination effects on the risk of the development with other economic developments over the operational life of the wind farm.

2.4 Relationship with the Environmental Impact Assessment

The Marine Navigational Safety Risk Assessment (produced by applying this methodology) forms part of the Environmental Impact Assessment, as follows:
- The submitted document is an Environmental Statement
- A required part of the Environmental Statement is a Marine Navigational Impact Assessment
- A marine navigational safety risk assessment, produced by applying this methodology, is required as part of the Marine Navigational Impact Assessment
- The marine navigational safety risk aspects of the navigational impact assessment are largely based on the Maritime and Coastguard Agency's Marine Guidance Note 275 (M)[1].

This guidance note is reproduced in full in **Appendix B** of this document.

[1] Marine Guidance Note 275(M) " *Proposed UK Offshore Renewable Energy Installations (OREI) – Guidance on Navigational Safety Issues.*" Maritime and Coastguard Agency, August 2004. This is available from www.mcga.gov.uk in the "Guidance and Regulations" section.

3. Scope and Depth of the Developer's 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
- Magnitude of the risks.

3.2 Judging Proportionality

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.

3.3 MCA Guidance

The MCA will:

- Give guidance if asked
- Be prepared, in principle, to accept a change in scope, depth, tools and techniques resulting from the assessed risk as the full assessment progresses.

3.4 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, 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 of 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.

3.5 Preliminary Search and Rescue Operations Assessment or Overview

The scope of a preliminary assessment or overview should be proportionate to the scale of development and the magnitude of the risks. Developers should seek guidance from MCA as to the scope to be followed.

The wind farm itself 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 that could present problems for the emergency services.

These considerations will include, but not be limited to, the detection and positioning of casualties within and near to the wind farm by other vessels, Maritime and Coastguard Agency (MCA) Maritime Rescue C-ordination Centres (MRCC) or Maritime Rescue Sub Centres (MRSC), and MCA, Royal Air Force (RAF) or Royal Navy (RN) helicopters. They should also outline the details of the proposed turbine compliance with Annex 4 of MGN 275[2], in respect of an active safety management system (ASMS) addressing individual turbine marking, lighting, rotor control, emergency refuge and communications links. These should link to the developer's own contingency plans in relation to its personnel working on turbines or operating within and close to the wind farm. Such plans should form part of the Environmental Statement submission. It is recommended that any marine safety aspects of these be discussed and agreed with MCA.

In general, since surface vessels are the most likely means of rescue from within wind farms, the assessment should give details of the Royal National Lifeboat Institution (RNLI) stations and their lifeboats near to the site, and of any appropriate training which will be given to lifeboat crews. Such training might include the methods and equipment used in boarding turbines and platforms.

Requirements for more detailed Search and Rescue Operation Assessments.

Where appropriate, i.e. in areas of high traffic density, where marine safety hazards of any type are seen to be significant, or where passenger vessel operations are common, DTI, in co-operation with DfT, may require a more detailed Search and Rescue 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.

[2] Ibid

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.

3.6 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) of which a new draft was circulated for consultation in June 2005 and will shortly be adopted.[3] Such pollution, which includes oil and a variety of hazardous substances, may result from incidents occurring within or close to offshore wind farms. The NCP takes account of the Civil Contingencies Act (CCA) of 2004 of which offshore wind farm developers should also be aware.

The preliminary assessment should determine the likelihood of any such incidents 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 wind farm 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 wind farm development, but into whose area the resulting pollution may drift.

Requirements for more detailed Emergency Response Assessments

Depending on the above assessment, DTI, in co-operation with DfT, 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 give rise for even greater concern, a full assessment may be required before consent is granted.

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

[3] At the time of publishing this document, greater detail of the National Contingency Plan is obtainable from the MCA's Counter Pollution Branch via Ms. Gail Robertson, tel. 02380 329482.

4. Marine Navigational Safety Goal

4.1 Background

The UK Government is committed to the development of offshore wind farms as part of its 2010 and 2020 targets of generating electricity from renewable energy sources. These wind farms should co-exist safely with other users of the sea with the minimum increase to the baseline level of risk during construction, operation and decommissioning.

4.2 National and International Navigation Safety Goals

The UK Government, the European Union or international bodies, such as the International Maritime Organisation, have not yet set any specific target for navigational safety in national or international waters.

4.3 Navigational Safety Goals Around Wind Farms

Similarly, no specific target has yet been set for the allowable change to navigation safety caused by the development of wind farms.

4.4 Proposed Navigation Safety Goal

Due to the lack of specified goals it is therefore prudent to consider the overarching UK principle of reducing risk to that which is "as low as reasonably practical" 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[4]. The document is aimed at explaining the decision-making process of the HSE[5] and therefore contains useful information on risk-based decision-making.

4.5 Implications of the Proposed Navigational Safety Goal

Implications prior to Consent:

The implication of the proposed navigational safety goal is that safety will have to be managed through the life of the offshore installation. Through life safety management will include:

- Keeping up to date the marine navigational safety risk assessment
    - Updating risk assessments
    - Updating risk mitigations and controls (including the provision of assets)

[4] 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
[5] RRPP page vi

- Having a safety policy
- Having a commitment to install features designed to comply with MGN 275 Annex 4 requirements.
- Running an active safety management system
- Keeping current a safety and operations plan
- Having an emergency plan
- Maintaining a safety culture
- Having a process for "Through Life Review".

Implications Post Consent

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

- Marine navigation risk assessment
  - Set in place 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 BWEA Guidelines for Health and Safety in the Wind Energy Industry
- Set in place a safety management system
- Install, operate and practice the Active Safety Management System (ASMS) described in Annex 4 of MGN 275
- Operate in accordance with a safety and operations plan
- Set up and periodically exercise an emergency plan
- Take positive action to create a safety culture including:
  - Board level responsibilities
  - Measurement and feedback of the level of compliance
- Undertake periodic risk reviews and implement the findings to keep the risk levels within the goals for the Marine Navigation Safety aspects of the wind farm 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 Goal

The key features of the Marine Navigational Safety 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 broadly acceptable (or tolerable with controls or actions), 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 and the magnitude of the risks
2	Estimate "base case" level of risk
3	Predict "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 wind farm" level of risk
7	Predict "future case with wind farm" level of risk
8	Submission

Figure 1 – Key Features of the Methodology

5.2 Appropriate Risk Assessment Techniques

There is 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. These include, amongst others:

- Hazard based risk assessment
- Hazard and operability (HAZOP) studies
- Failure modes and effects analysis (FMEA)
- Issues analysis
- Risk profile generation.

These options are explained in more detail in **Appendix A**

The techniques selected will need to be justified in the Submission by developers.

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:

- Prove that the activities (i.e. navigation, search and rescue and emergency response) remain feasible during construction, operation and decommissioning 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 Main Sections of the Submission

The main sections of the submission are:

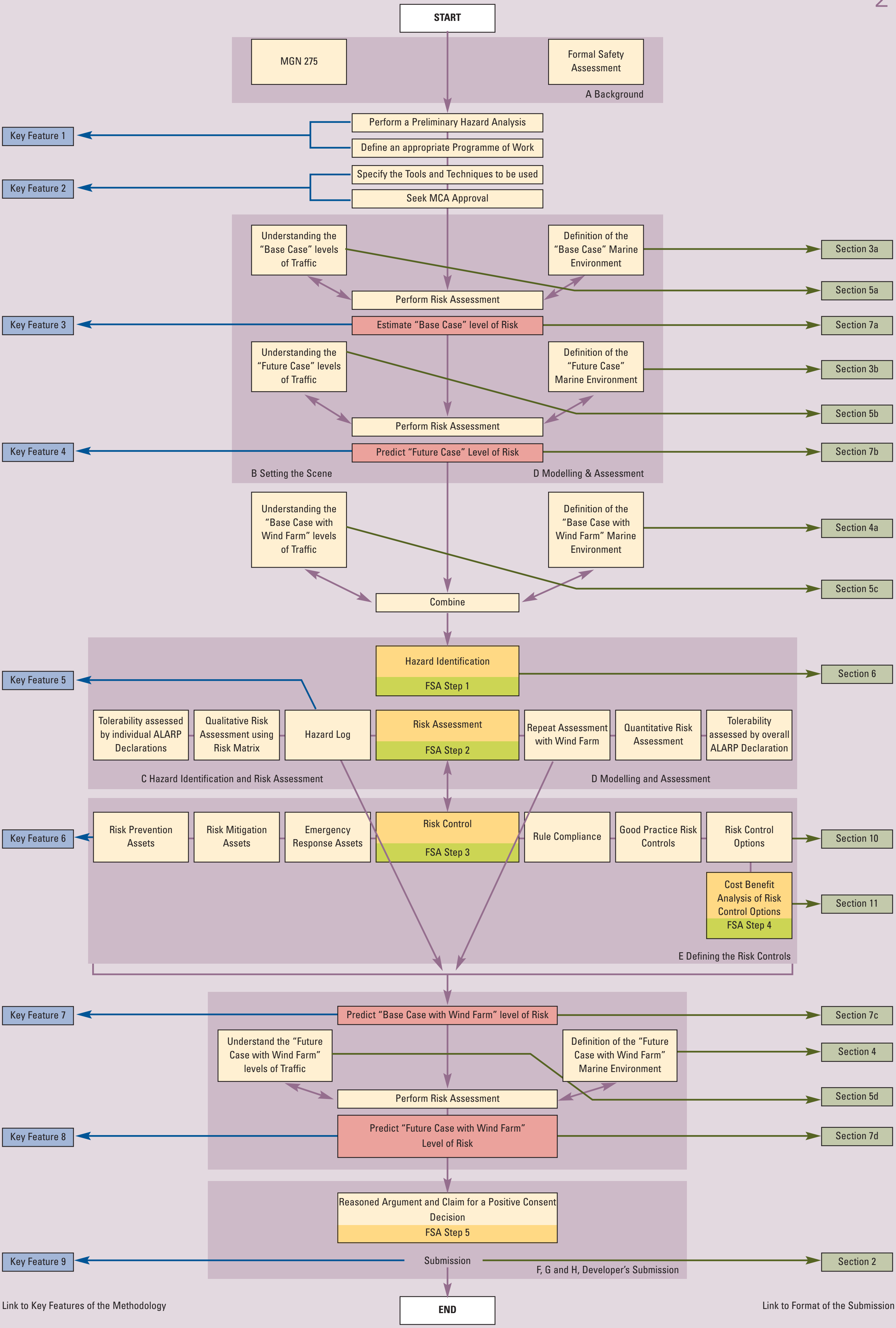
1	Summary
2	Risk claim supported by a reasoned argument and evidence
3	Description of the marine environment
4	Description of the wind farm and how it changes the marine environment
5	Analysis of marine traffic
6	Hazard log
7	Navigation risk assessment
8	Search & rescue and emergency response overviews
9	Risk control log
10	Cost benefit analysis
11	Major hazards summary
12	Statement of limitations
13	Through life safety management

Figure 2 - Main Sections of the Submission

5.5 Overview of the Process to Develop the Navigation Risk Assessments

Figure 3 - Overview of the Process to Develop Navigation Risk Assessments

Note: The links shown in the right hand column refer to section 7.1, Table 2: "Contents of a Marine Navigational Safety Risk Assessment Submission"


START
MGN 275
Formal Safety Assessment
A Background
Perform a Preliminary Hazard Analysis
Define an appropriate Programme of Work
Specify the Tools and Techniques to be used
Seek MCA Approval
Key Feature 1
Key Feature 2
Understanding the "Base Case" levels of Traffic
Definition of the "Base Case" Marine Environment
Perform Risk Assessment
Estimate "Base Case" level of Risk
Key Feature 3
Understanding the "Future Case" levels of Traffic
Definition of the "Future Case" Marine Environment
Perform Risk Assessment
Predict "Future Case" Level of Risk
Key Feature 4
B Setting the Scene
D Modelling & Assessment
Section 3a
Section 5a
Section 7a
Section 3b
Section 5b
Section 7b
Understanding the "Base Case with Wind Farm" levels of Traffic
Definition of the "Base Case with Wind Farm" Marine Environment
Combine
Section 4a
Section 5c
Hazard Identification
FSA Step 1
Section 6
Key Feature 5
Tolerability assessed by individual ALARP Declarations
Qualitative Risk Assessment using Risk Matrix
Hazard Log
Risk Assessment
FSA Step 2
Repeat Assessment with Wind Farm
Quantitative Risk Assessment
Tolerability assessed by overall ALARP Declaration
C Hazard Identification and Risk Assessment
D Modelling and Assessment
Key Feature 6
Risk Prevention Assets
Risk Mitigation Assets
Emergency Response Assets
Risk Control
FSA Step 3
Rule Compliance
Good Practice Risk Controls
Risk Control Options
Section 10
Cost Benefit Analysis of Risk Control Options
FSA Step 4
Section 11
E Defining the Risk Controls
Key Feature 7
Predict "Base Case with Wind Farm" level of Risk
Section 7c
Understand the "Future Case with Wind Farm" levels of Traffic
Definition of the "Future Case with Wind Farm" Marine Environment
Section 4
Perform Risk Assessment
Section 5d
Key Feature 8
Predict "Future Case with Wind Farm" Level of Risk
Section 7d
Reasoned Argument and Claim for a Positive Consent Decision
FSA Step 5
Key Feature 9
Submission
F, G and H, Developer's Submission
Section 2
END
Link to Key Features of the Methodology
Link to Format of the Submission

5.6 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
  - 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

- Stage 5: Other Assessments (if required by MCA)
  - 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 Satety Risk

6.1 Tolerability of Individual Risks

Risk

For each entry in the hazard log the risk shall be assessed against a risk Criticality Matrix[6]:

- There shall be no unacceptable risks (i.e. criticality 6 or 7)
- All risks in between (i.e. criticality 3 to 5) 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 quality of the evidence shall be assessed against an Evidence Matrix[7]:

- There shall be no broadly acceptable risks (i.e. criticality 1 and 2) where the evidence supporting the risk assessment is less than “Expert Opinion – Written” (i.e. category E3).

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 which is “as low as reasonably possible” (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 wind farm
  - Is assumed to be tolerable
- Base Case with Wind Farm
  - With the current traffic, existing marine environment and with the wind farm
  - The change against the base case needs to be assessed and judged against ALARP criteria

[6] See Annex C4 – Measuring the level of risk
[7] Annex C4 Fig. 23
[8] See Annex C4 – Measuring the level of risk

- Future Case
  - With the future traffic, future marine environment without the wind farm
  - Is assumed to be tolerable
- Future Case with Wind Farm
  - With the future traffic, future marine environment and with the wind farm
  - 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 a wind farm. 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 wind farm to base case risk.

7. Standard Format of a Submission

7.1 Contents of a Marine Navigational Safety Risk Assessment Submission

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

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 wind farm 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 d. 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	Annex F1
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 Wind Farm Development and how it changes the Marine Environment	This description should include: a. The proposed wind farm b. Any options c. The future environment	Annex B3
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 wind farm on current traffic densities and types d. The effect of the wind farm 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	Annex C3
7	Navigation Risk Assessment	The risk assessment should include: a. "Base Case" General Navigation Safety Risk Assessment b. "Future Case" General Navigation Safety Risk Assessment c. "Base Case with Wind Farm" General navigation risk assessment d. "Future Case with Wind Farm" General navigation risk assessment e. Future Options General navigation risk assessment f. Other Navigation Safety Risk - 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 3.5
9	Emergency Response Overview and Assessment	Assessment dependent on level agreed with the MCA.	Section 3.6
10	Status of Risk Control Log	An overview of the risk controls in the Risk Control Log	Annex E1
11	Summary of Cost Benefit Analyses used in the selection or rejection of Risk Controls	Details of any Cost Benefit Assessments completed in support of Risk Control selection	Annex E2
12	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 wind farm structures • Grounding • Contact with cables and snagging of them • Interference with communications, radar, etc.	Annexes G1, G2
13	Statement of Limitations		E3
14	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 Plus, details of • Compliance with the MCA's required Active Safety Management System as specified in MGN 275 Annex 4[9]	

Table 2 - Contents of a Marine Navigational Safety Risk Assessment Submission

[9] (Ibid)

7.2 Explanatory Annexes

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

	Annex	Commentary on 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 Log	This should include: a. Development of Specific Influences on the Level of Risk b. Hazard log Worksheets or Database
D	Results of analysis techniques and tools used	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	Risk Control Log	This should include: a. Risk Control Log Worksheets or Database
F	Lessons Learned Log	
G	Quality Checking and Verification of Evidence	This should be a statement on how the assessment has been checked and how the evidence on which it is based has been verified.
H	Self Declaration against MGN 275	

Table 3 - Annexes to a Marine Navigational Safety Risk Assessment Submission

7.3 Electronic Distribution

The submission and its annexes shall be capable of electronic circulation (e.g. PDF or similar open standard files types from file download sites, over email, etc.).

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 claim that if the planned risk controls are implemented and maintained the proposed wind farm 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:
   - The rules have been complied with
   - As a minimum standard or relevant good practice, risk controls will be put in place
   - The risks are: -
     - Broadly acceptable; or
     - Tolerable with modifications; or
     - Tolerable with additional controls; or
     - Tolerable with monitoring

   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.

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

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

1) The nature, assumptions and limitations of the submission are set out and understood

2) 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 Task Force, shortly to become the Better Regulation Commission, 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 link can be summarised as follows:

- The submission forms part of the developer's Environmental Statement based on an Environmental Impact Assessment, which is needed to support an application for the consents and licenses necessary for an offshore development (Section 36 Electricity Act 1989, Section 34 Coast Protection Act 1949 and section 5 Food and Environment Protection Act 1985)
- The Developer submits the applications as appropriate to the Electricity Development Consents Directorate (EDC) of the Department of Trade and Industry and to the Marine Consents and Environment Unit (MCEU) (which comprises DTI and the Department for Environment, Food and Rural Affairs (DEFRA))
- The DTI, on behalf of the MCEU, circulate it to:
    - Other Government Departments, including the Department for Transport and the Ministry of Defence

- A range of organisations such as, Trinity House, Chamber of Shipping, Royal Yachting Association, the port authority (if relevant), National Federation of Fishermen's Organisations, and the British Marine Aggregates Producers Association.
- In addition, DTI will also seek an opinion on the marine navigational safety risks from the Maritime and Coastguard Agency.

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

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

The advice given is likely to fall into the following categories:

- "No objection"
- "No objection" with conditions
- Holding objection, with a request for more information or analysis
- Objection with reasons

Applicants are informed of this advice and invited to respond.

9.3 Ultimate Responsibility for Consent

The aim is to involve stakeholders at all stages with the aim of achieving consensus. However, the DTI/DFT/MCA must make recommendations to Ministers where consensus is not possible, for example where different stakeholders hold opposite 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 Overview and guidance on navigational safety issues, MCA MGN 275 (M)[10]

A2 Overview of Formal Safety Assessment

A3 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 Overview of hazard identification

C2 Overview of risk assessment

C3 Guidance on creating a hazard log

C4 Measuring the level of risk

C5 The Influences on the level of risk

C6 The tolerability of residual risks

ANNEX D Appropriate Assessment Techniques & Tools

D1 Overview of modelling and other appropriate assessment techniques

D2 The selection of techniques that are acceptable to Government

D3 Guidance on demonstrating 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 techniques

ANNEX E Deciding on the Risk Controls

E1 Guidance on creating a risk control log

E2 Guidance on cost benefit assessment in risk control and mitigation selection

E3 Guidance on assessing the equity of risk controls and mitigations to stakeholders

ANNEX F Developer's Submission

F1 Guidance on tolerability of risk claims supported by reasoned arguments

ANNEX G Example Checklists

G1 Example hazard identification checklist

G2 Example risk control checklist

G3 Example MCA wind farm application check off list for MGN 275 compliance

ANNEX H

H1 Terms, abbreviations and references

Appendices Providing Further Information or Guidance

Appendix A: MCA Formal Safety Assessment notes

Appendix B: MCA Marine Guidance Note (MGN) 275 (M)

[10] (Ibid)

General Guidance and Suggested Techniques

A1 Overview and Guidance Navigational Safety Issues, MCA MGN 275 (M)

Developers will be expected to base their submissions on addressing the navigation issues arising from Marine Guidance Note 275 (M) "*Proposed UK Offshore Renewable Energy Installations (OREI) – Guidance on Navigational Safety Issues.*" [11]

MGN 275 (M) is reproduced in full in **Appendix B.**

Note that the Maritime and Coastguard Agency may amend or modify the contents of MGN 275 in accordance with continuing offshore wind farm experience.

A.1.1 The Principal Features of MGN 275 relating to Marine Navigational Safety risk assessment are listed below:

MGN 275	Feature
Main Text	**Evaluation of Navigation**
Para 2.2.	Evaluate all navigational possibilities which could be reasonably foreseeable, by which the siting, construction, establishment and decommissioning of an OREI could cause or contribute to an obstruction of, or danger to, navigation or marine emergency services.
Main Text	**Assessment of Navigation**
Para 2.3.	Potential navigational or communications difficulties caused to any mariners or emergency services using the site area and its environs should be assessed.
Para 2.3.	Difficulties that could contribute to a marine casualty leading to injury, death or loss of property, either at sea of amongst the population ashore should be highlighted.
Para 2.3.	Difficulties, which could affect the emergency services, should be highlighted.
Main Text	**Assessment of Consequences**
Para 2.4.	Assessment of the consequences of ships deviating from normal routes to avoid proposed sites.
Para 2.4.	Assessment of the consequences of recreational craft entering shipping routes to avoid proposed sites.
Main Text	**Contingency Arrangements**
Para 3.4.	Contingency arrangements to deal with marine casualties in, or adjacent to, sites should be planned and practiced.
Para 3.4.	Contingency arrangements to deal with environmental pollution in, or adjacent to, sites should be planned and practiced.
Annex 1	**Site Position, Structures and Safety Zones**
Annex 1 Para 1.	Traffic Survey Up to date traffic survey leading to researched opinion using computer simulation techniques with respect to the displacement of traffic and, in particular, the creation of 'choke points' in areas of high traffic density

[11] (Ibid)

Annex 1 Para 2.	Structures Determination if structures could pose any difficulty to navigation
	Determination if structures can cause problems for emergency rescue services Determine how structures will be controlled in an emergency
Annex 1 Para 3.	Access to and Navigation Within Assessment whether navigation within the site would be safe
MGN 275 (M) Annex 1 Para 3.	Assessment whether navigation in and / or near the site should be prohibited or avoided.
MGN 275 (M) Annex 1 Para 3.	Assessment of exclusion from the site
Annex 2	**Navigation, Collision Avoidance and Communications**
Annex 2 Para 1.	The effect of tides and tidal streams
Annex 2 Para 2.	The effect of weather
Annex 2 Para 3.	The effect on visual navigation and collision avoidance
Annex 2 Para 4.	The effect on communications, radar and positioning systems
Annex 2 Para 5.	The proposal for marine navigational marking
Annex 3	**Safety and mitigation measures during construction, operation and decommissioning**
Annex 3 Para 1	Safety and mitigation measures during construction, operation and decommissioning
Annex 4	**Standards and Procedures for Shutdown**
Annex 4 Section 1	Design Requirements Emergency rotor shut-down in the event of events such as search and rescue, counter pollution or salvage operation
Annex 4 Section 2	Operational Requirements Control room functionality
Annex 4 Section 3	Operational Procedures Control room operation

Table 4 - Principal Features of MGN 275 relating to Navigational Safety Risk Assessment

A.1.2 The Merchant Shipping (Distress Signals and Prevention of Collision) Regulations

MGN 275 requires that assessment of navigation risk include the implications of the International Maritime Organisation's "*International Regulations for Preventing Collisions at Sea 1972 as amended to date*". In the UK these are defined in Merchant Shipping Notice 1781 (M + F)[12]. These are sometimes referred to simply as the "Collision Regulations" or, less formally, as the "COLREGS".
The assessment tools and techniques used in the navigational risk assessment must be such that all of the regulations are applied to the vessel types and operations that make up the traffic in the sea area under consideration. Assessments using numerical modelling and simulation tools that are not able to meet this requirement will need to be supplemented by other techniques.

The rules are listed below. Of these the assessment should particularly address Rules 1 to 19 which will not only affect the probability of collision and contact between vessels and with wind farm structures, but may also influence that of grounding when in restricted water depths. Additionally any potential interference by the

[12] Merchant Shipping Notice 1781 (M + F) "T*he Merchant Shipping (Distress Signals and Prevention of Collisions Regulations) 1996*" The Maritime and Coastguard Agency, May 2004. This is available from the MCA website: www.mcga.gov.uk in the "Guidance and Regulations" section.

development with the vessel lights and shapes or light and sound signals defined in Rules 20 to 38 should be addressed. The positioning and technical details of such lights and shapes, additional signals for fishing vessels, sound signals and distress signals are contained in Annexes I to IV of the Collision Regulations.

The Merchant Shipping (Distress Signals and Prevention of Collisions) Regulations 1996
MSN 1781 (M & F)

Part A General

• Rule 1	Application
• Rule 2	Responsibility
• Rule 3	General definitions

Part B Steering and Sailing Rules – Section I Conduct of vessels in any condition of visibility

• Rule 4	Application
• Rule 5	Look-out
• Rule 6	Safe speed
• Rule 7	Risk of collision
• Rule 8	Action to avoid collision
• Rule 9	Narrow channels
• Rule 10	Traffic separation schemes

Part B Steering and Sailing Rules – Section II Conduct of vessels in sight of one another

• Rule 11	Application
• Rule 12	Sailing Vessels
• Rule 13	Overtaking
• Rule 14	Head-on situation
• Rule 15	Crossing situation
• Rule 16	Action by give-way vessel
• Rule 17	Action by stand-on vessel
• Rule 18	Responsibilities between vessels

Part B Steering and Sailing Rules – Section III Conduct of vessels in restricted visibility

• Rule 19	Conduct of vessels in restricted visibility

Part C Lights and Shapes

• Rule 20	Application
• Rule 21	Definitions
• Rule 22	Visibility of lights
• Rule 23	Power-driven vessels underway
• Rule 24	Towing and pushing
• Rule 25	Sailing vessels underway and vessels under oars
• Rule 26	Fishing Vessels
• Rule 27	Vessels not under command or restricted in their ability to manoeuvre
• Rule 28	Vessels constrained by their draught
• Rule 29	Pilot vessels
• Rule 30	Anchored vessels and vessels aground
• Rule 31	Seaplanes

Part D Sound and Light Signals

• Rule 32	Definitions
• Rule 33	Equipment for sound signals
• Rule 34	Manoeuvring and warning signals
• Rule 35	Sound signals in restricted visibility
• Rule 36	Signals to attract attention
• Rule 37	Distress signals

Part E Exemptions

• Rule 38	Exemptions

Annexes

- I Positioning and technical details of lights and shapes
- II Additional signals for fishing vessels fishing in close proximity
- III Technical details of sound signal appliances
- IV Distress signals

A2 Overview of Formal Safety Assessment

Developers will be expected to base their submissions on a Formal Safety Assessment.

A.2.1 Overview of Formal Safety Assessment

There exists only one established methodology for international maritime risk management, the International Maritime Organisation's Formal Safety Assessment Process. 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.

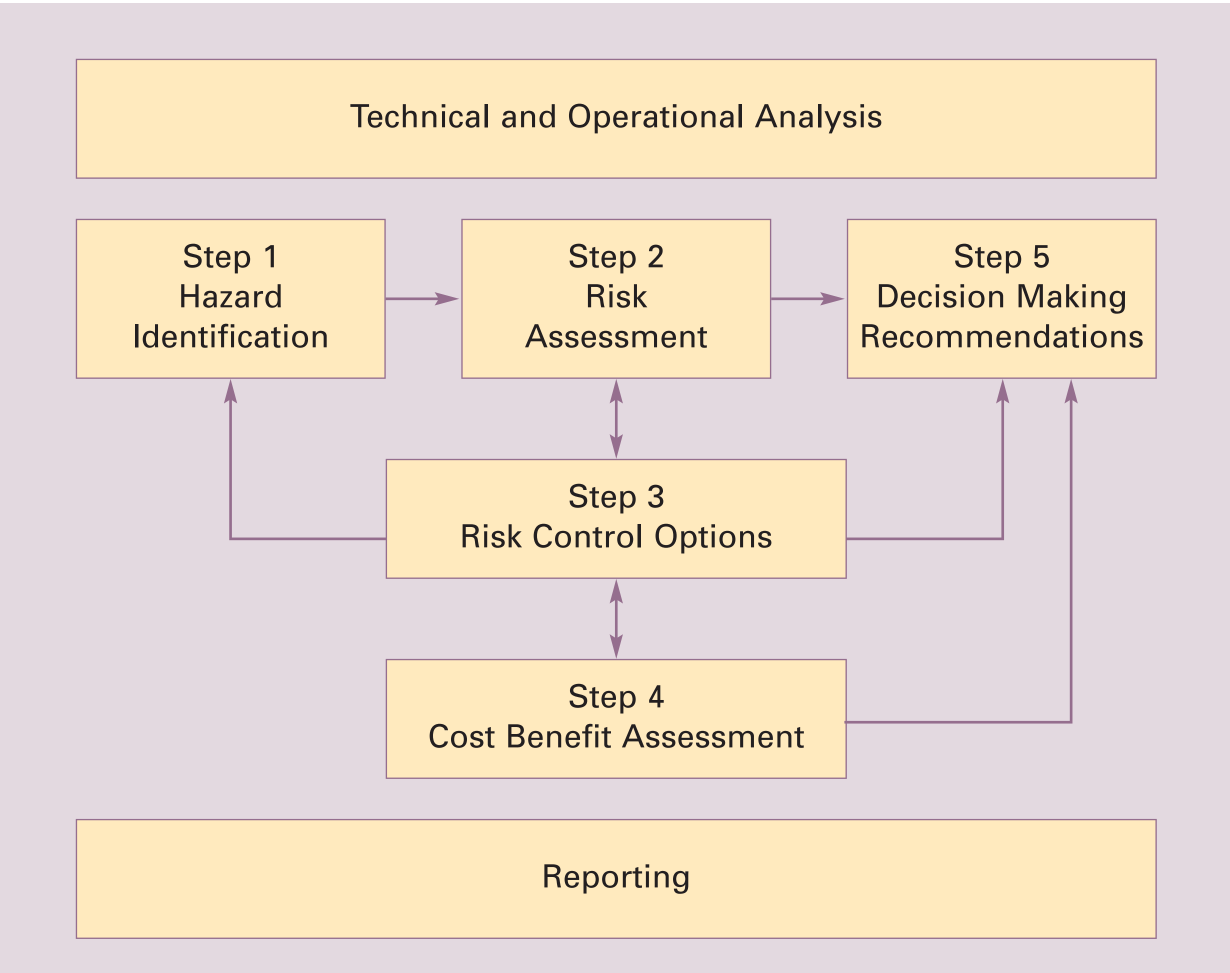


Figure 4 - Overview of Formal Safety Assessment

In addition, it introduces a framework for:

- The types of marine accident (e.g. contact, collision, etc)
- The ranges of causes (e.g. human error, hardware failure and external events)
- The safety, environmental, property and business consequences of risks
- Assessing the tolerability of risk to the stakeholders
- Assessing the equity of risk control to the stakeholders.

A key aspect of Formal Safety Assessment is that it stresses that the selection of risks needing control should be based on:

- High Risks
    - Consider frequency of occurrence together with severity of outcome
- High Probability Events
    - Consider high probability events irrespective of the severity of the outcome
- High Severity Outcomes
    - Consider high severity outcomes irrespective of the probability of the event
- Low Confidence
    - Consider risks where there is uncertainty in the risk assessment, the probability or the outcome.

The Maritime and Coastguard Agency's Risk, Analysis and Prevention Branch publishes guidance to its approved FSA methodology options on the MCA website: http://www.mcga.gov.uk/. Relevant sections from this site are included in **Appendix A** of this document.

The website also gives details of MCA contacts within the Branch.

A3 Guidance on Lessons Learned

In any industry, and especially in new industries, there is considerable benefit in the sharing of Lessons Learned. This methodology encourages the use of more formal ways of:

- Using the Lessons Learned from other wind farms
- Reporting Lessons Learned to other wind farms.

A.3.1 Lessons Learned Log

The suggested method for this is to maintain and circulate a Lessons Learned Log.

Ref	Problem	Source of Information	Root Cause(s)	Lessons Learned	How the Lesson Learned has been implemented Wind Farm XXXX

Figure 5 - Lessons Learned Log (Use of Lessons from other Wind Farms) - Example Spreadsheet Format

Ref	Problem	Source of Information	Root Cause(s)	Lessons Learned	How the Lesson Learned has been implemented Wind Farm XXXX	Potential Applicability other Wind Farm

Figure 6 - Lessons Learned Log (Reporting Lessons to other Wind Farms) - Example Spreadsheet Format

A.3.2 Sources of Lessons Learned

Prior to and during the development of this Methodology (January to August 2005), 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.

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	**Sharing the Wind - Recreational Boating in the Offshore Wind Farm Strategic Areas** Identification of recreational boating interests in the Thames Estuary, Greater Wash and North West (Liverpool Bay) The Royal Yachting Association and the Cruising Association	2004
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

Table 5 –Some Trials Reports and other Lessons Learned

B1 Guidance on Understanding the Base Case Traffic Densities and Types

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 wind farm or wind farm 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 wind farms exist in many situations, and particularly where there is a combination of high traffic levels, different vessel operations and constrained water spaces. These aspects are inter-related with respect to offshore wind farms. 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.

MGN 275 mandates a minimum 28 days month coverage over a year to characterise activity at the site. "*An up to date (generally within 12 months prior to submission of the Environmental Statement) traffic survey of the area concerned should be undertaken. This should include all vessel types and is likely to total at least four weeks duration but also taking account of seasonal variations in traffic patterns. These variations should be determined in consultation with representative recreational and fishing vessel organisations, and, where appropriate, port and navigation authorities*"

B.1.2 Extracting Information from the Data

MGN 275 does not specify detailed requirements for the traffic survey, these varying for each proposed location. However the results must provide basic traffic information for the traffic as a whole and for each class of vessel. 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 hourly traffic volume and types of vessels passing along key routes,

- Key seasonal variations in traffic activity.

B.1.3 Link to the DTI Marine Traffic Database

In this context "class of vessel" means a grouping of vessels that are of a common type, in terms of operation and / or cargo, etc., size, and navigation characteristics. Draft of each class in an assumed loaded condition will be an important parameter with respect to most UK wind farms.

The categorisation of such classes of vessels should, in general, be similar to those detailed within the DTI Marine Traffic Database[13] or as appropriate to a specific site. They will not necessarily have the same consequence of incident and the risk analysis must differentiate incidents occurring to vessels whose consequences may extend beyond the initiating cause.

B.1.4 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.

It 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, if appropriate, 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.

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 offshore wind farms unless they lie within sea areas controlled by appropriate authorities, e.g. port authorities, who would promulgate any necessary differences from the Collision Regulations.

Note: It is unlikely that such "special rules" would impinge on any UK Round 2 offshore wind farm proposals

[13] Marine Traffic Database, from a DTI project, "A Study to Identify, Obtain and Collate Data for the Development of a Marine Vessel Traffic Survey Database", available at: http://www.maritimedata.co.uk/

B2 Guidance on Predicting Future Densities and Types of Traffic

The methodology requires "Future Case" levels of risk with and without the wind farm 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 wind farm 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)
- Account should be taken of 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 – as also may speed
- Account should be taken of the future change for all marine activities, such as fishing, recreational craft, offshore exploitation, etc.

B.2.2 Techniques of Traffic Forecasting

A number of techniques may be used to forecast future traffic volume, routes and vessel types. Developer's 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., might lead to the non-viability of major traffic routes or operations due to the wind farm 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.

Step	Procedure	Objective
Analyse historic data (for each vessel class)		
1	Calculate the overall % increase from historic limit to present day	To identify the overall trend
2	Compute the geometric average of the % increase over the historic period	To calculate the average annual % increase
3	Calculate the % increase of each year during the historic period versus the prior year	To measure the uncertainty over the successive time period
4	Compute the Standard Deviation (SD) of actual annual % increase	To find the random short-term fluctuations within the long term trend
5	Obtain the Coefficient of Variation (CoV) by dividing standard deviation by overall % increase	To find the non-dimensionalised random fluctuation
Analyse predicted data (see figure below)		
6	Estimate the % increase of target year w.r.t. present year (i.e. from 2005 to 2025)	To illustrate the expected trend
7	Compute the standard error as the product of % increase and CoV	To assess the forecast that include level of trend and uncertainty
8	The forecast % increase and standard error are input into model and run for 1,000 times with Monte Carlo simulation to provide a family of results.	To identify the distribution of various forecast and the upper and lower limits of prediction

Table 6 - Steps in a Stochastic Method of Future Traffic Prediction

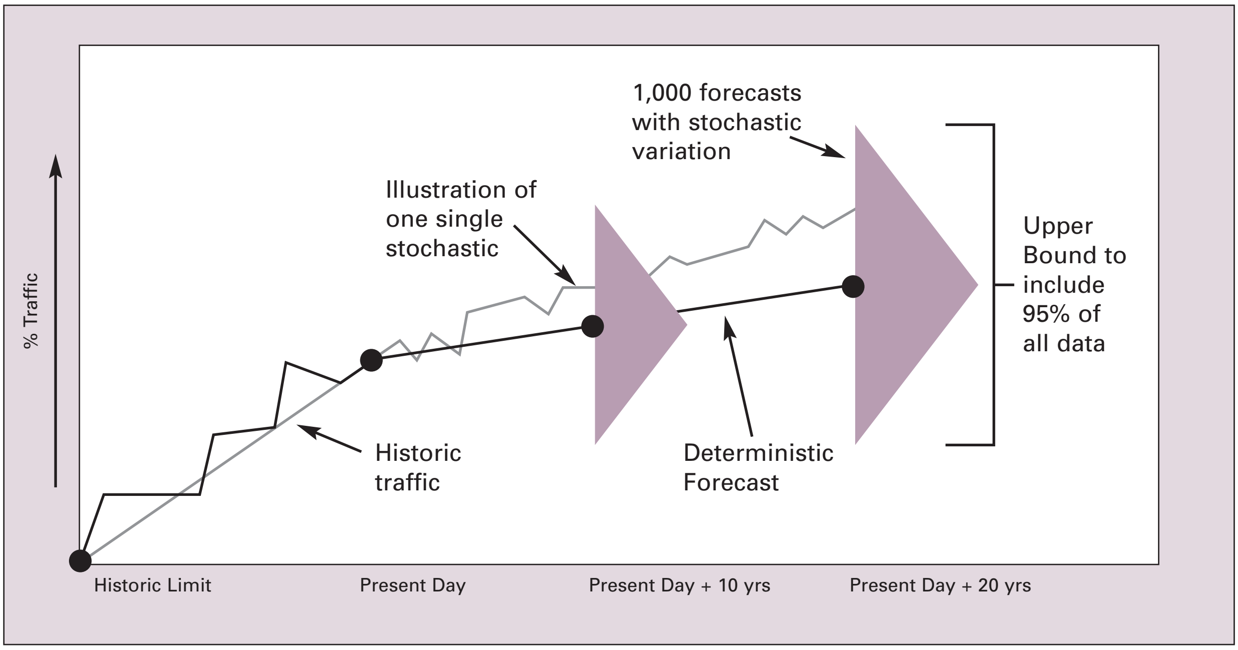


Figure 7 – A Method of Statistical Forecasting

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.

B3 Guidance on 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.

B.3.1 Description of a Technical and Operational Analysis

The developer's technical and operational analysis, and the navigational safety risk assessment will both be expected to include a description of:

1. The technical scope of the development and how this relates to maritime safety
2. The structural details of turbines, platforms and cabling.
3. The positioning, configuration and proposed structure of the development as a whole.
4. How the development will be built, commissioned, operated and decommissioned and how this relates to maritime safety.

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 wind farm 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 wind farm
3. Wind farm structures that could affect navigation activities
4. Wind farm 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.

B.3.2 Generic Technical and Operational Analysis

The following sections describe a generic technical and operational Analysis. In producing a site specific analysis developers should use this as a guide:

- Adding site specific items
- Removing (with justifications) items that are not applicable

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.3.3 Potential Accidents resulting from Navigation Activities – Example Checklist

Table 7 - Potential Accidents resulting from Navigation Activities

H1	Accident Category
	All
1	General Navigation Safety Risks
	1. Collision
	2. Contact
	3. Grounding and Stranding
2	Other Navigation Safety Risks
	1. Foundering
	2. Capsizing
	3. Fire
	4. Explosion
	5. Loss of Hull Integrity
	6. Flooding
	7. Machinery Related Accidents
	8. Payload Related Accidents
	9. Hazardous Substance Accidents
	10. Accidents to Personnel
	11. Accidents to the General Public and Shore Populations
	12. Electrocution
3	Aviation Safety Risks[14]
	1. Aviation Accidents
4	Other Safety Risks
	1. High Probability Events
	2. High Severity Outcomes
	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
	1. Overall
	2. External to Internal
	3. Internal to Internal
	4. Internal to External
	5. External to External
	6. Worst Case
6	Emergency Response
	1. Overall
	2. External to Internal
	3. Internal to Internal
	4. Internal to External
	5. External to External
	6. Worst Case

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

B.3.4 Navigation Activities affected by an Offshore Wind Farm – ExampleChecklist

H2	Navigation Activity
1	*All*
2	Navigation on Passage
	1. Navigating or operating near a wind farm
	2. Navigating or operating around a wind farm
	3. Navigating or operating through a wind farm
	4. Navigating or operating within a wind farm
	5. International traffic
	6. National traffic
	7. Coastal traffic
	8. Short sea shipping traffic
	9. Fishing vessels
	10. Recreational craft
	11. All other traffic listed in section 6 below
3	Fishing operations
	1. Single vessels
	2. Paired vessels & others fishing in close proximity
	3. Crabbing
	4. Trawling
	5. Drift Nets
4	Recreational activities
	1. Sail and power cruising
	2. Sail and power day sailing
	3. Sail and power racing
	4. Personal watercraft use (e.g. Jet Skiing)
	5. Windsurfing
	6. Kite Surfing and Kite Boarding
	7. Leisure or Sport Diving
5	Anchoring
	1. Routine Anchoring
	2. Emergency Anchoring
6	Other Marine Operations close to or within a wind farm
	1. Aggregate Dredging, Dredging or Spoil Dumping
	2. Commercial Diving
	3. Construction Operations
	4. Servicing Operations
	5. Decommissioning Operations
	6. Oil and Gas Operations
	7. Salvage Operations
	8. Cable Laying
	9. Pipeline Installation
	10. Boarding and Landing of Pilots
7	Special Events
	1. Regattas and Competitions
8	*None*

Table 8 - Navigation Activities affected by an Offshore Wind Farm

B.3.5 Wind Farm Structures that could affect Navigation Activities – Example Checklist

Table 9 – Wind Farm Structures that could affect Navigation Activities

H3	Wind Farm Structures
1	Turbines
	a. Foundation type
	b. Transition Piece
	c. Tower
	d. Nacelle
	e. Blades
	f. Platforms and superstructure fittings
2	Offshore Installations (if appropriate)
	a. Offshore Substation
	a. Offshore Service Bases
	a. Offshore Accommodation Bases
3	Cable
	a. Export Cable
	a. Inter-turbine Cabling
4	Subsea Installations, including antiscour material

B.3.6 Wind Farm Development Phases that could affect Navigation Activities – Example Checklist

Table 10 - Wind Farm Development Phases that could affect Navigation Activities

H4	Development Phase
1	*All*
2	Pre-construction
3	Construction
4	Operation
5	Maintenance
6	Decommissioning

B.3.7 Other Structures and Features that could affect Navigation Activities – Example Checklist

Table 11 - 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 Wind Farms (Existing and projected)
4	Other Offshore Renewable Energy Installations (Existing and projected)
5	Other Exclusion or Safety Zones including Areas to be avoided (ATBA)
6	Fishing Grounds
7	Dredging and Dumping Areas
8	Diving Areas

B.3.8 Vessel Types involved in Navigation Activities – Example Checklist

H6	Types of Vessel
1	*All*
2a	Large Vessels
	1. Bulk Carriers
	2. Bulk/Oil Carriers
	3. Chemical Tankers
	4. Container Vessels
	5. Cruise Vessels
	6. Liquefied Gas Carriers
	7. Oil Tankers
2b	Medium Vessels
	1. General Cargo
	2. Specialised Carriers
	3. Passenger
	4. Passenger Ferries
2c	High Speed Craft (HSC's)
	1. High speed ferries
	2. Other high speed recreational and commercial craft
3	Fishing Vessels
	1. Fish Processing
	2. Fishing Vessels (Various types and operations)
4	Recreational Vessels
	1. Sailing dinghies and Yachts
	2. Motor Boats
	3. Small Personal Watercraft
	4. Rowing boats
	5. Sports Fishing
	6. Windsurfer
	7. Kite Boards
	8. Tall Ships
	9. Recreational Submarines and dive support craft
5	Anchored Vessels
	All
6	Other Operational Vessels
	1. Barges
	2. Dredgers
	3. Dry Cargo Barge
	4. Offshore Production and Support
	5. Salvage
	6. Tank Barges
	7. Tugs and Tows
7	Military Vessels
	1. Warships
	2. Submarines
	3. Royal Fleet Auxiliaries
8	Other Vessels
	1. Seaplanes
	2. Wing-In-Ground Craft (WIG)
	3. Hovercraft

Table 12 - Vessel Types involved in Navigation Activities

B.3.9 Conditions affecting Navigation Activities – Example Checklist

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

Table 13 - Conditions affecting Navigation Activities

B.3.10 Human Actions related to Navigation Activities – Example Checklist

H8	Human Actions
1	Violation
2	Mistakes
3	Lapse
4	Slip

Table 14 - Human Actions related to Navigation Activities

(See section C.1.2)

C1 Overview of Hazard Identification

Developers will be expected to include a Hazard Identification based on analysis of the causal chain of an accident including human error.

C.1.1 Causal Chains used in Navigation Hazard Identification

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.

C.1.2 Human Element

FSA stresses the importance of the human element. It states that, "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. Figure 9 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.

The causal chain used here is:

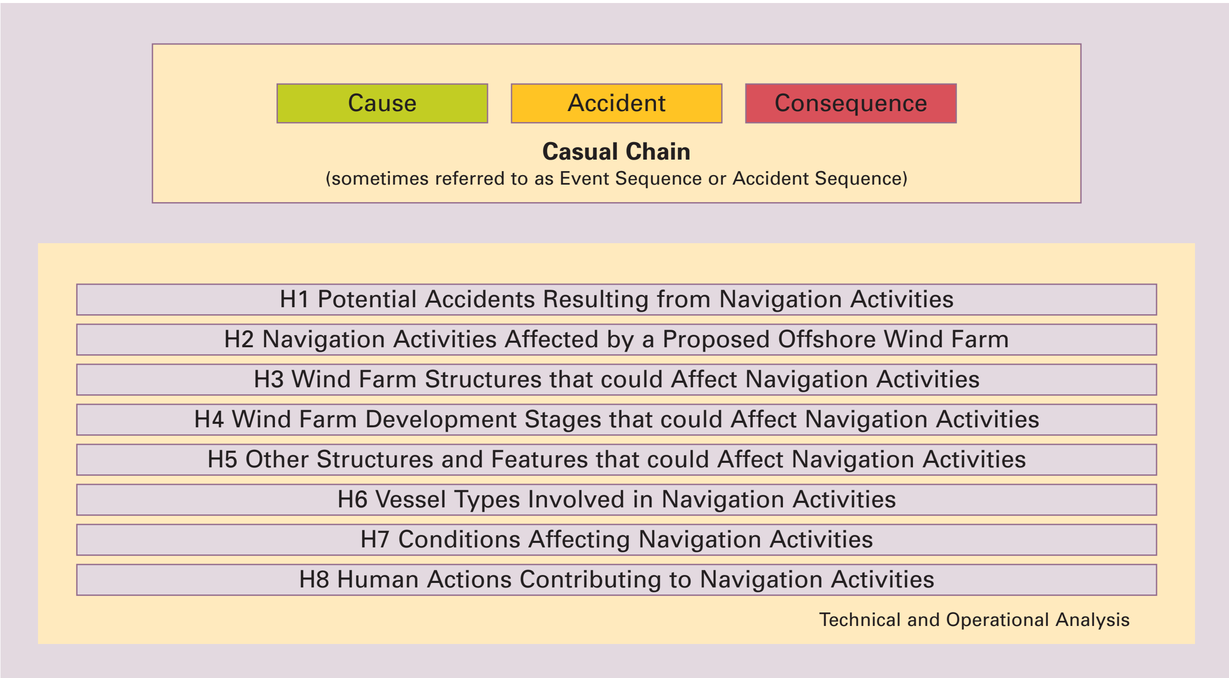


Figure 8 - Overview of Causal Chains

Note: In the above figure 'H1', 'H2', etc., are the 'Hazard' categories identified in Section B.3.2

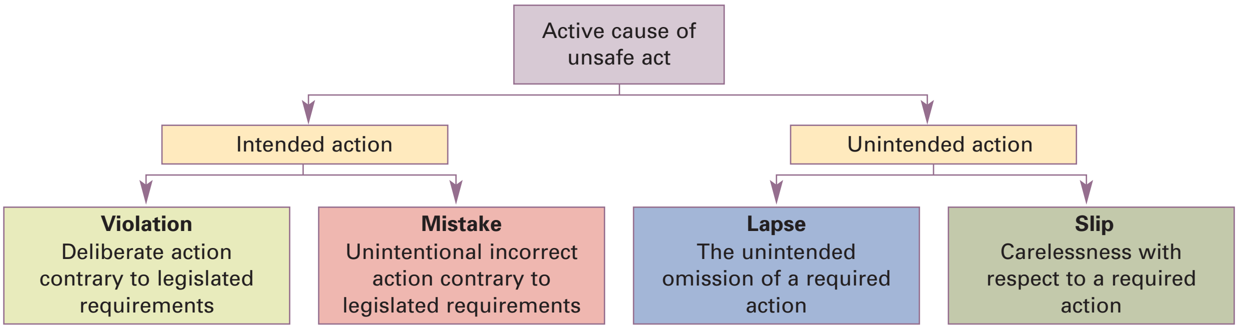


Figure 9 - Overview of the Human Element

Any analysis technique must be able to assess vessels' compliance with the steering and sailing rules (1 to 19) of the International Regulations for Preventing Collisions as Sea[15] and this sub-division of the active causes of unsafe act should be used for quantified analysis of the effect of occasional random events of not complying with them.

The analysis should also take into account any effects which the wind farm 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.1.3 Special Cases of the Causal Chain

Some causal chains may be wider than the wind farm itself or even the cumulative and in-combination effects of wind farm groups. Certain events may originate in any sea or coastal area and yet impinge on the wind farm under consideration.
These might consist, for example, of vessels not under command, oil pollution, chemical hazard, or casualties requiring search and rescue operations, being set or drifting from, into or through the wind farm, perhaps from a considerable distance, as indicated in the Figure below:

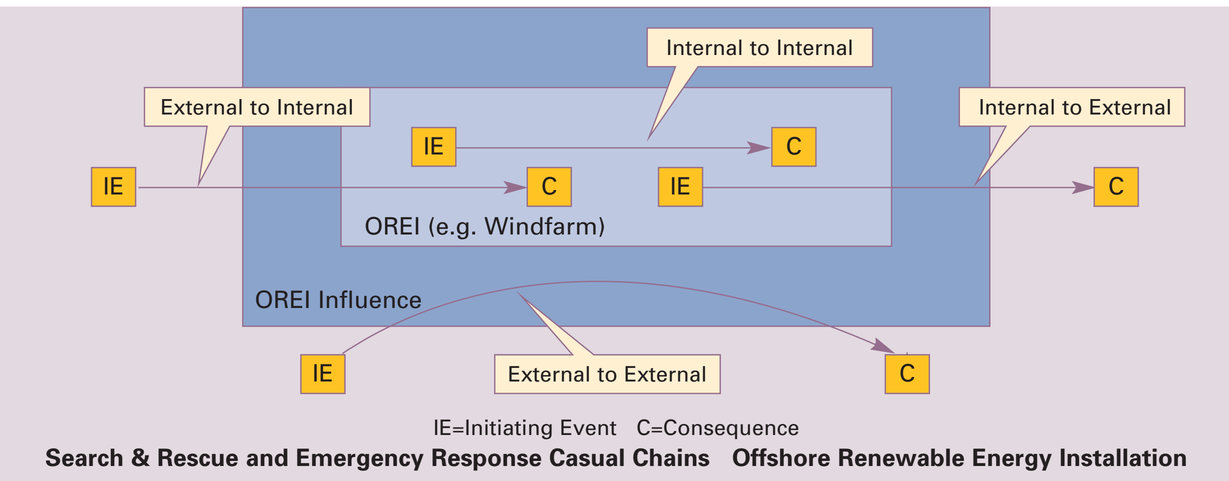


Figure 10 - Example of a casual chain of events impinging on an offshore wind farm

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

C2 Overview of Risk Assessment

FSA summarises risk as the classic definition, i.e. a combination of probability and consequence.

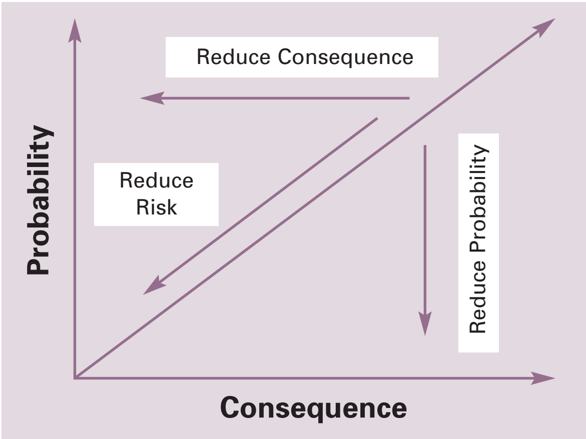


Figure 11 - Classic Definition of Risk

Linking this to the Causal Chain (used in Hazard Identification) requires an assessment to be made of the probability of the cause and the magnitude of the consequence.

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

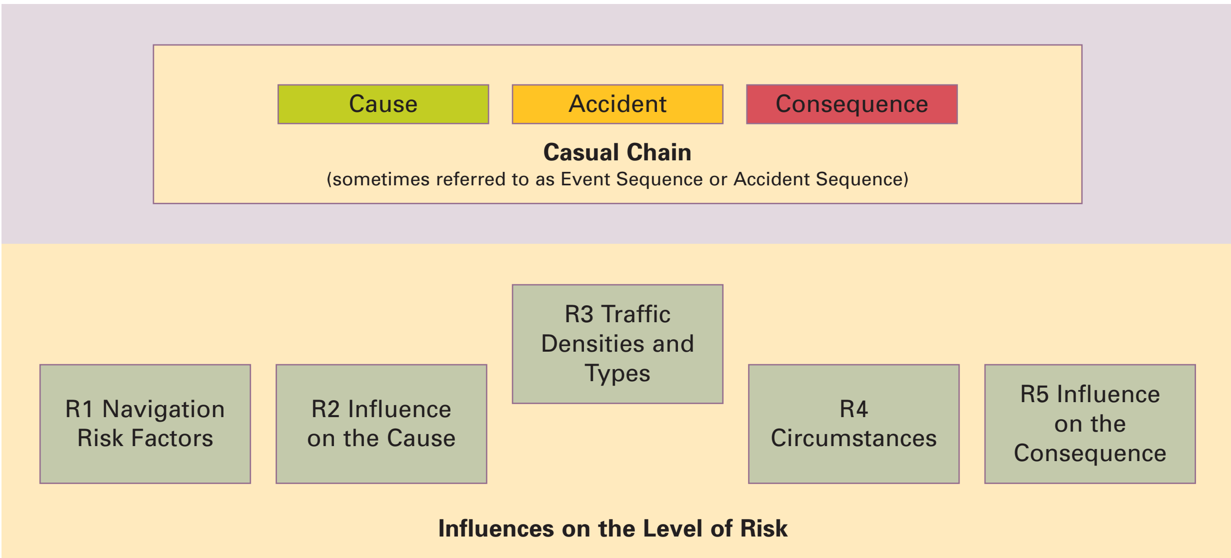


Figure 12 - Overview of Influences on the Level of Risk

C3 Guidance on Creating a Hazard Log

This annex gives guidance on

- The definition of a hazard log
- Suggested process for creating a hazard log
- Closing the hazard log.

C.3.1 Definition of a Hazard Log

There are many different terminologies for what is referred to here as a "hazard log". These terminologies include:

- Risk Register
- Hazard Identification and Risk Assessment (HIRA) process.

However the general principles are much the same.

In this methodology the Hazard Log is a process covering:

- Hazard Identification
- Risk Assessment
- Confidence Assessment
- Risk Control Assessment
- Tolerability Assessment
- Closure.

C.3.2 Suggested Process for Creating a Hazard Log

The suggested process for creating a hazard log is:

Hazard Identification

- Identify all the relevant hazards and describe them as Causal Chains (also referred to as Event Sequences or Accident Sequences). Techniques for this include:
    - Hazard Identification brainstorming, checklists, etc. (HAZID)
    - Hazard and Operability Studies (HAZOP)
    - Failure Modes and Effects Analysis (FMECA)
      (See also Appendix A "MCA Formal Safety Assessment Notes")
  - Group the causal chains identified into risk groups. Suggested risk groups are:
    - General navigation safety
    - Other navigation safety
  - Aviation safety aspects related to navigation safety
    - Other safety including overviews of:
      - Search and rescue
      - Emergency response
  - Analyse each causal chain against marine environment lists (from the Technical and Operational Analysis) to understand it in detail and allow it to be risk assessed, adding extra causal chains as required. Suggested marine environment lists are:
    - Accident category
    - Navigation activity
    - Wind farm structures
    - Phase of development
    - Structures and features
    - Vessel types
    - Conditions
    - Human actions.

Hazard Identification– Example of Spreadsheet Format

Description					Hazard Identification							
Ref				Description of Casual Chain (Event sequence) (Accident sequence)	Accident	Navigation Activities	Wind Farm Structures	Phase of Development	Structures and Features	Vessel Type	Conditions	Human Activities
					Checklist H1	Checklist H2	Checklist H3	Checklist H4	Checklist H5	Checklist H6	Checklist H7	Checklist H8
1				**Navigation Safety**								
1	**2**			Collision								
1	2	01	a	Vessel navigating near a wind farm collides with another vessel that is navigating near a wind farm								

Figure 13 – Example Hazard Log - Hazard Identification

Note: In the above figure 'H1', 'H2', etc., are the 'Hazard' categories identified in Section B.3.2

Risk Assessment

- Analyse each causal chain against influences on the level of risks (from the influence analysis) to understand it in detail and allow it to be risk assessed, adding extra causal chains as required. Suggested influence lists are:
    - Navigation risk factors
    - Influence on causes
    - Traffic types, densities and operations (referred to in fig. 14 as traffic "levels")
    - Circumstances
    - Influences on consequences
- Assign a probability and consequence to each causal chain
- It is sometimes also useful at this stage to identify the non-marine navigational safety consequences, as these can be useful in deciding on risk controls (for example an asset to control a safety risk might not be justified by ALARP arguments but when combined with environmental, property or business arguments the asset may be justified).

Risk Assessment – Example of Spreadsheet Format

Description					Risk Assessment													
					Without Wind Farm				With Wind Farm									
Ref				Description of Casual Chain (Event sequence) (Accident sequence)	Frequency	"Typical" Consequence	Criticality	"Worst Credible" Consequence	Frequency	"Typical" Consequence	Criticality	"Worst Credible" Consequence	Navigation Risk Factors	Influences on Cause	Traffic Levels	Circumstance	Influences on Consequence	Non safety Navigation Consequence
					F	C	CR	C	F	C	CR	C	Checklist R1	Checklist R2	Checklist R3	Checklist R4	Checklist R5	Checklist R6
1				**Navigation Safety**														
1	**2**			Collision														
1	2	01	a	Vessel navigating near a wind farm collides with another vessel that is navigating near a wind farm														

Figure 14 – Example Hazard Log – Risk Assessment

Note: In the above figure 'R1', 'R2', etc., are the 'Risk Factor' categories identified in Section C.5

Confidence Assessment

- List the evidence supporting the risk assessment
- Assess the quality of the evidence.

Confidence Assessment – Example of Spreadsheet Format

Description					Confidence	
Ref				Description of Casual Chain (Event sequence) (Accident sequence)	Evidence Supporting Risk Assessment	Evidence Quality
1				**Navigation Safety**		
1	**2**			Collision		
1	2	01	a	Vessel navigating near a wind farm collides with another vessel that is navigating near a wind farm		

Figure 15 – Example Hazard Log – Confidence Assessment

Risk Control Assessment

- List the risk controls that are included in the risk assessment. Suggested categories for controls are:
  - Assets
  - Rules
  - Good practices
- List the risk control options still under consideration
- Link the risk controls to the risk control log.

Risk Control Assessment – Example of Spreadsheet Format

Description					Risk Control			
Ref				Description of Casual Chain (Event sequence) (Accident sequence)	Assets	Rules	Risk Controls	Risk Controls Options
1				**Navigation Safety**				
1	**2**			Collision				
1	2	01	a	Vessel navigating near a wind farm collides with another vessel that is navigating near a wind farm				

Figure 16 – Example Hazard Log – Risk Control Assessment

Risk Tolerability Assessment

- Assess the risk tolerability. Suggested outcomes are:
  - Broadly acceptable
  - Tolerable with monitoring
  - Tolerable with additional controls
  - Tolerable with modifications
  - Unacceptable.

Risk Tolerability Assessment – Example of Spreadsheet Format

Description					Tolerability
Ref				Description of Casual Chain (Event sequence) (Accident sequence)	Risk Tolerability
					T
1				**Navigation Safety**	
1	**2**			Collision	
1	2	01	a	Vessel navigating near a wind farm collides with another vessel that is navigating near a wind farm	

Figure 17 – Example Hazard Log – Risk Tolerability

C.3.3 Closing the Hazard Log

Closure of Hazard Log

Closing the hazard log is based on the individual closure of each hazard log entry.

Closure of Hazard Log Entry

Closing each hazard log entry is based on a judgement on the "Tolerability of the Risk":

- A justification that the risk has been adequately assessed, risk controls defined and/or put in place and that further risk control is grossly disproportionate

- A declaration by a nominated and accountable person that they agree with the each justification.

Closure – Example of Spreadsheet Format

Description					Closure	
Ref				Description of Casual Chain (Event sequence) (Accident sequence)	ALARP Justification	ALARP Declaration
1				**Navigation Safety**		
1	**2**			Collision		
1	2	01	a	Vessel navigating near a wind farm collides with another vessel that is navigating near a wind farm		

Figure 18 – Example Hazard Log – Closure

C4 Guidance on Measuring the Level of Risk

C.4.1 Introduction

This guidance is in two parts:

- Measures of individual risk
- Measures of societal concern

C.4.2 Measures of Individual Risk

Qualitative risk assessment should be made on the basis of:

- Frequency bands
- Consequence bands
- Criticality matrix
- Tolerability matrix
- Evidence matrix

C.4.3 Selection of an Appropriate Criticality Matrix

There is no generally accepted standard for a criticality matrix. However, a reasonably common numerical foundation is a matrix where both the frequency and probability are banded in decades.

Example Criticality Matrix – Decade Based

Figure 19 – Example Criticality Matrix - Decade Based

Probability/Frequency (per year)									
100									
10									
1									
1/10									
1/100									
1/1,000									
1/10,000									
1/100,000									
1/1,000,000									
Consequence (Fatalities)	minor injuries	major injuries	1	10	100	1,000	10,000	100,000	

Note: In Figures 19, 20 and 21 "minor" and "major" refer to consequential injuries as precursors to consequential fatalities

This type of matrix has the advantage that it can be used for both numerical and specifically defined risk criticality ranking.

Example Criticality Matrix – Numerically Ranked

A numerical risk criticality ranking is based on multiplying probability and consequence as shown below:

Figure 20 – Example Criticality Matrix - Numerically Ranked

The advantage of this approach is that it can be fed directly into an FN curve, (See section C.4.6 for an explanation of FN Curves, where "N" relates to the number of casualties per accident and "F" is the potential frequency per year of these occurring).

The disadvantage is that it does not cope with aversion, 1,000 accidents killing 1 person are treated the same as 1 accident killing 1,000 and there much evidence that the public does not accept this equivalence.

Probability/Frequency (per year)	minor injuries	major injuries	1	10	100	1,000	10,000	100,000
100	0	1	2	3	4	5	6	7
10	-1	0	1	2	3	4	5	6
1	-2	-1	0	1	2	3	4	5
1/10	-3	-2	-1	0	1	2	3	4
1/100	-4	0	0	-1	0	1	2	3
1/1,000	-5	-4	-3	-2	-1	0	1	2
1/10,000	-6	-5	-4	-3	-2	-1	0	1
1/100,000	-7	-6	-5	-4	-3	-2	-1	0
1/1,000,000	-8	-7	-6	-5	-4	-3	-2	-1

Consequence (Fatalities)

Example Criticality Matrix – Specifically Defined

A specifically defined ranking can be anything the assessor needs it to be. An arbitrary example is shown below:

Figure 21 – Example Criticality Matrix - Selected Ranking

Probability/Frequency (per year)	minor injuries	major injuries	1	10	100	1,000	10,000	100,000
100	6	6	7	7	8	8	9	9
10	5	6	6	7	7	8	8	9
1	5	5	6	6	7	7	8	8
1/10	4	5	5	6	6	7	7	8
1/100	3	4	5	5	6	6	7	7
1/1,000	3	3	4	5	5	6	6	7
1/10,000	2	3	3	4	5	5	6	6
1/100,000	1	2	3	3	4	5	5	6
1/1,000,000	1	1	2	3	3	4	5	5

Consequence (Fatalities)

The disadvantage is that it cannot be fed into an FN curve.

The advantage is that it can cope with aversion.

Criticality Matrix – Selection

The disadvantage of both approaches is that people prefer to judge:

- Risk in a more qualitative way
- From fewer probability bands (often 5).

Therefore, what is suggested is that the assessment is based on a criticality matrix that developers believe is appropriate for their needs, but that a mapping is made to a decade based risk matrix to allow a FN curve to be generated.

The following is an example of this based on a 4x4 IMO matrix.

IMO Style Frequency Bands

Frequency	Frequent	Likely to happen (to a wind farm) yearly or more frequently.
	Reasonably Probable	Likely to happen during the licence period of a wind farm (nominally 20 years).
	Remote	Unlikely (but not exceptional) to happen during the licence period.
	Extremely Remote	Only likely to happen in exceptional circumstances.

Table 15 – IMO Style Frequency Bands (F)

IMO Style Consequence Bands

No significant harm to people	Injury to vessels crew Injury to turbine installation or maintenance crew Injury on the shore	Loss of a vessel crew member(s) (1 to 3) Loss of a turbine installation or maintenance crew member(s) (1 to 3) Fatality(ies) on the shore (1 to 3)	Total loss of a vessels crew Total loss of a turbine installation or maintenance crew Multiple fatalities on the shore
Insignificant	Minor	Major	Catastropic
Consequence to People			

Table 16 – IMO Style Consequence Band – People (C)

IMO Style Criticality Matrix

Frequency		Insignificant	Minor	Major	Catastropic
Frequency	Frequent	4	5	6	7
	Reasonably Probable	3	4	5	6
	Remote	2	3	4	5
	Extremely Remote	1	2	3	4
		Consequence			

Table 17 – IMO Style Criticality Matrix (CR)

C.4.4 Tolerability Matrix

There is no generally accepted standard for a tolerability assessment. However, the following example, using the criticality band 1 to 7 in Table 17, is based on both Reducing Risk Protecting People and parallel transport risk experience.

Table 18 – Example Risk Tolerability Matrix (T)

Risk Criticality		Condition	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	with a commitment to further risk reduction before construction	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	with a commitment to further risk reduction before operation	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	with a commitment to risk monitoring and reduction during operation	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

C.4.5 Evidence Matrix

Development in risk assessment techniques, since the IMO developed Formal Safety Assessment, have included defining risk as not just a combination of probability and consequence but as a combination of probability, consequence and uncertainty in the assessment of probability and consequence as shown in the Figure below (*See also Appendix A "MCA Formal Safety Assessment Notes" for an explanation of this concept*).

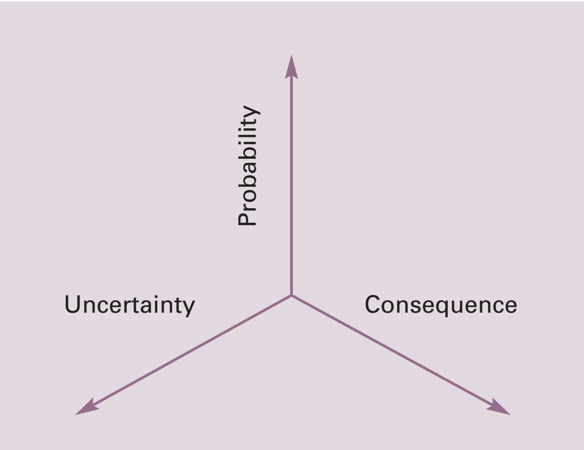


Figure 22 - Definition of Risk Including Uncertainty

The purpose is to make sure that risks ranked as "low" are scrutinised to check that this assessment is valid.

This has been interpreted as a need to assess the quality of the evidence used to support a probability and consequence assessment. An example of a guide to assessing confidence for particular risks, in a particular wind farm and in a particular scenario is shown in figure 23. This indicates how evidence quality, for this particular development or scenario, may be assessed in an Evidence Matrix.

However, This example matrix should not be taken as a guide to the order of best evidence for all risks, in all wind farms and all scenarios. Advice on appropriate evidence for a particular development may be sought during initial discussions with MCA.

Figure 23 – Example Evidence Matrix

C.4.6 Measures of Societal Concern

A measure of societal concern is to assess the overall level of risk based on an FN curve. An example of a curve (with dummy values for a wind farm) is shown below. The area under the graph is the aggregate potential loss of life for the all the hazards in the wind farm itself and of those in the sea area that may result from an incident within or close to the wind farm.

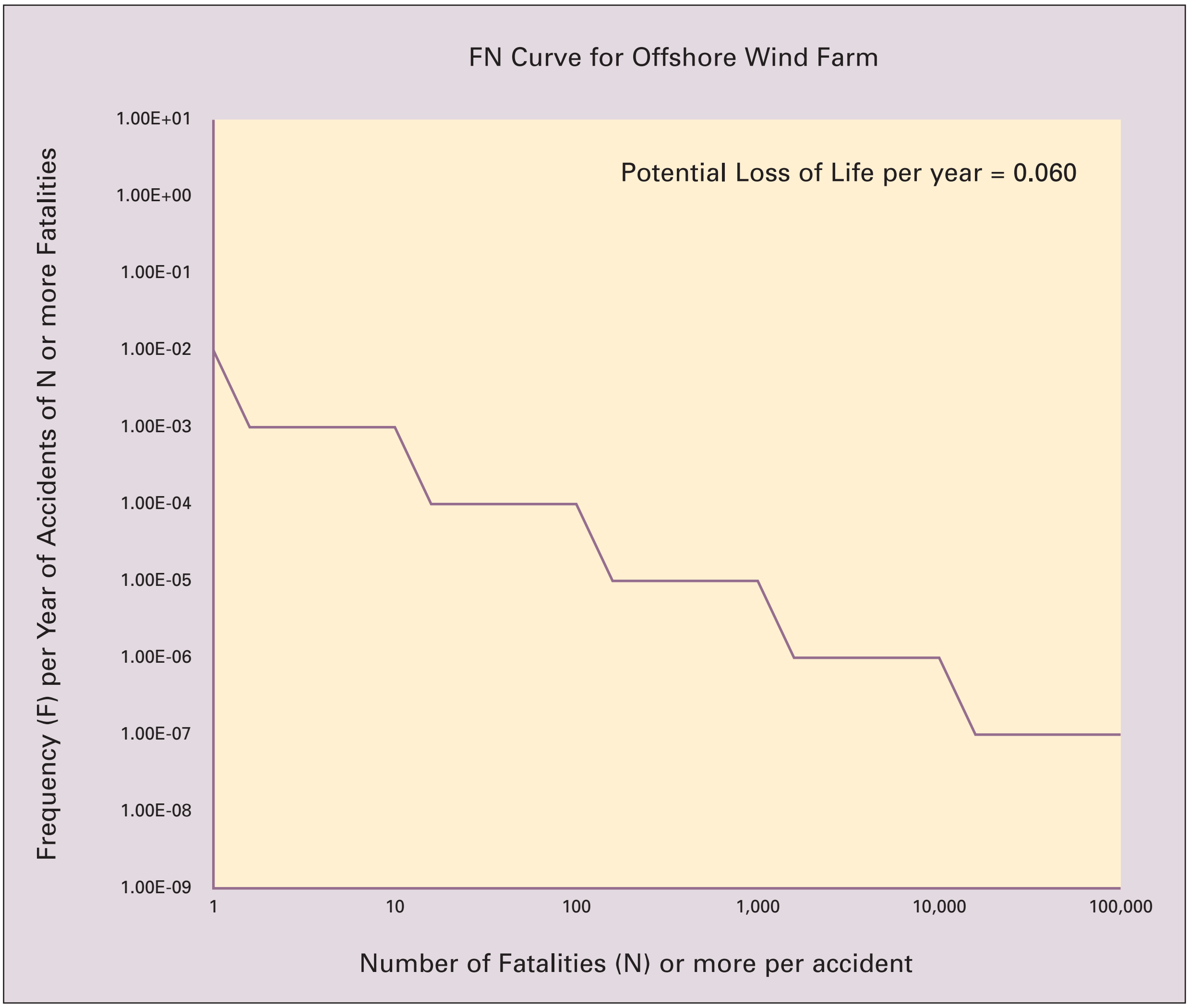


Figure 24 - Example FN Curve

C5 Guidance on 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.5.1 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.

R1	Risk Factors
1	**Site**
	1. Location of wind farm.
	2. Alignment of wind farm.
	3. Layout of wind farm. (E.g. grid, scattered or other layouts)
2	**Traffic**
	1. Traffic routes, density, type and operations.
	2. Potential growth or decline in traffic.
	3. Seasonal variation in traffic.
	4. Special traffic, e.g. dangerous goods, etc.
3	**Interrelations Between Vessels**
	1. Blocking of escape routes or bad weather refuges
	2. Bunching
	3. Increase in “crossing” encounters
	4. Increase in “end-on” encounters
	5. Increase in “overtaking” encounters
	6. Increase in traffic volumes
	7. Loss of recreational cruising routes
	8. Pinching
	9. Reduction in sea room for manoeuvring
	10. Reduction in water depth for manoeuvring
	11. Blocking of routes to safe havens and inshore anchorages
	12. Redirection of recreational craft and fishing vessels into routes used by other vessels, particularly larger and faster vessels.
4	**Navigator Behaviour**
	1. Lengthened navigation routes for leisure craft increase navigator fatigue (and hence error) and increase the criticality of weather windows.
	2. Enhanced navigational complexity and need for navigational awareness increase fatigue (and hence error)
5	**Other single vessel factors**
	1. Collision with wind farm structures
	2. Fouling or contact with cables
	3. Grounding

Table 19 - Risk Factors – Example Checklist

C.5.3 Influences on Causes – Example Checklist for a particular development (See also following example check lists.)

R2	Influence on Causes
1	**Vessel Traffic Management**
	1. Availability of Vessel Traffic Services (VTS).
	2. Availability of Pilot services.
2	**Aids to Navigation**
	1. Compliance with requirements for Aids to Navigation. (site and vessel)
	2. Failure (or non availability) of Aids to Navigation & other systems
	3. 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.)
	4. AIS (Automatic Identification System) failure or not required to fit.
	5. Marking on charts of wind farm 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.
	8. Electromagnetic interference from turbine generators, transformers 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 interpreted as a vessel contact
5	**Future Technical Change**
	1. Application of Radar Absorbing Material to towers and blades, etc.

Table 20 - Influences on Causes – Example Checklist

C.5.4 Traffic Densities and types – Example Checklist

Table 21 - Traffic Levels – Example Checklist

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. 20 years)

C.5.5 Circumstances – Example Checklist

Table 22 – Circumstances – Example Checklist

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

C.5.6 Influences on Consequences – Example Checklist

Table 23 - Influences on Consequences – Example Checklist

R5	Influence on Consequence
1	**Wind Turbine Design**
	1. Strength and robustness of wind turbine structure.
	2. Collapse mode of impacted turbines after collision
2	**Vessels**
	1. Vessel size.
	2. Vessel cargo. (E.g. polluting cargoes, hazardous cargoes, etc.)
3	**Search and Rescue**
	1. Adequacy of Search and Rescue provision. (E.g. equipment, equipment location, communication, etc.)
	2. Availability of Search and Rescue resources. (E.g. currently in commercial use, multiple SAR operations, etc).
	3. 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**
	1. Adequacy of Emergency Response provision. (E.g. tugs, oil spill equipment, communications, etc.)
	2. Availability of Emergency Response resources. (E.g. currently in commercial use, multiple ER operations, etc).
	3. Ability to deploy Emergency Response resources. (E.g. state of contingency planning)

C6 Guidance on the Tolerability of Residual Risks

This annex gives guidance on

- Targets for safety
- Interpretation of "broadly acceptable" in an ALARP Justification
- The tolerability of risk.

C.6.1 Targets for Safety

The UK Government does not itself set targets for safety. Effectively, these are set by criminal and civil case law after accidents. However, this section sets out some guidelines that can be used in assessing tolerability.

C.6.2 Interpretation Of "Broadly Acceptable" in an ALARP Justification

The regulatory background to the Navigation Safety Goal is based on the UK Health and Safety Executive document "Reducing Risks Protecting People" (RRPP), a guide to the HSE's decision-making process[16]. The document is aimed at explaining the decision-making process of the HSE[17] and therefore contains much useful information on risk-based decision-making. It is a large document (80 pages) covering:

- Part 1: Overview of risk and risk management issues
- Part 2: Review of developments that have influenced the HSE's decision-making approach
- Part 3: Approach to reaching decisions on risk
- Appendix 1: Some of the conventions adopted for undertaking risk assessments
- Appendix 2: Identifying and considering options for new regulations, Approved Codes of Practice and guidance
- Appendix 3: Some issues relevant to assessing risk reduction options
- Appendix 4: Some statistics for comparing risks from different hazards.

The purpose of this section is to extract the key points of the document that are applicable to offshore renewable energy installations.

C.6.3 Tolerability of Risk

At its heart RRPP sets out to provide a mechanism for a regulator to "satisfy the public that industry, in taking advantage of technological advances and in responding to economic pressures, will not be allowed to impose intolerable risks on people"[18]. In doing so it sets out the framework for decision-making based "Tolerability of Risk"[19] and defines bands of unacceptable, tolerable and broadly acceptable.

It then expands on this framework by defining what is expected when deciding on whether a risk is:

[16] 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
[17] RRPP page vi [18] RRPP page 1 [19] RRPP page 3

- Unacceptable; or
- Tolerable; or
- Broadly acceptable.

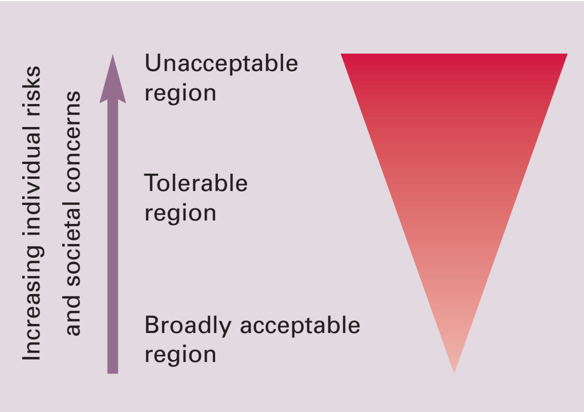


Figure 25 - HSE Framework for the Tolerability of Risk

This is summarised as:

- The level of individual risk and the societal concerns must be taken into account
- The actions taken are inherently precautionary
- Risk assessment is required to determine the risk control measures
- Suitable controls are in place
    - Controls, as a minimum, must achieve the standard of relevant good practice precautions
    - Some risks are unacceptable and the activity ruled out unless modifications can be made
    - As controls are introduced the residual risks may fall so low that additional measures to reduce them further are likely to be grossly disproportionate to the risk reduction achieved
    - Control measures should be monitored in case risks change over time.

From this three main issues emerge:

- At what point does a risk become "Broadly Acceptable"?
- What is included in "Relevant Good Practice"?
- What is "Grossly Disproportionate"?

Defining what is Broadly Acceptable

In defining "broadly acceptable", the RRPP notes that "the way we all treat risks depends on our perception of how they relate to us and the things we value" and that for man-made hazards on "how well we see the process (giving rise to the hazard) is understood, how equitable the danger is distributed, how well individuals can control their exposure and whether the risk is assumed voluntarily"[20].

The RRPP states that the "*HSE believes that an individual risk of death of one in a million per annum for both workers and the public corresponds to a very low level of risk and should be used as a guideline for the boundary between the broadly acceptable and tolerable regions*"[21].

It then notes that this level is "*extremely small when compared to the background level of risk*".

Defining Relevant Good Practice

RRPP defines relevant good practice. It considers as authoritative sources "*those enshrined in prescriptive legislation, approved codes of practice and guidance produced by Government*". It also considers including as other sources of good practice "*standards produced by Standards-making organisations (e.g. BS, CEN, CENELEC, ISO, IEC, ICRP) and guidance agreed by a body representing an industrial or occupational sector (e.g. trade federation, professional institution, sports governing body)*"[22].

[20] RRPP page 11 para 20
[21] RRPP page 45 para 130
[22] RRPP page 50 para 142

RRPP then goes on to say that experience suggests that, "*in most cases adopting good practice ensures that the risks are effectively controlled*"[23]. It then immediately qualifies this by stating that there will be cases where existing best practice was either "*not identified*" or has been found to "*result in inadequate control of risk*"[24].

RRPP also makes a distinction between good practice and best practice[25]. In effect, good practice is mandatory, but best practice is voluntary, unless complying with best practice is used as part of a tolerability argument.

In wind farm marine navigational safety terms this raises the issue that existing good practice risk measures have been extended to cover wind farms and are not yet validated by either experience or simulation and therefore may require retrospective revision.

There are gaps in good practice and as a result new practices will be developing and may require retrospective application.

Defining Grossly Disproportionate

RRPP also defines "Grossly Disproportionate" and its associated "Reasonably Practical" which are driven by case law and it is "*ultimately a matter for the courts to decide*". An analysis of case law shows that the courts "will look at all relevant circumstances, on a case by case basis, when reaching decisions on the appropriateness of action taken"[26]. Therefore all RRPP does is give a structure to possible Reasonably Practical and Grossly Disproportionate arguments.

It suggests that the starting point should be the present situation (or if this is not possible an option which is known to be reasonably practical). Risk and Risk Control Options should then be considered against this starting point to determine if the "reasonably foreseeable"[27] risks have reduced to that which is As Low As Reasonably Practical (the ALARP test). Further options should be considered to determine if there is a gross disproportion between the cost of the option and the reduction in risk (the Gross Disproportion test[28]).

The Gross Disproportion Test

As a guide to making ALARP and Gross Disproportion assessments, it gives guidance on both valuing the benefits and assessing the costs. Where the benefit is the prevention of death it defines a Value of Preventing a Fatality[29] (VPF) and adopts a benchmark value of £1,000,000 (2001 prices).

In assessing costs, case law groups them as money, time and trouble[30] though does not give a mechanism for comparing cost time and money. The cost of the measures required can be assessed to derive a Cost of Preventing a Fatality[31] (CPF). The cost has to be made up of those that are incurred unavoidably by health and safety measure less any gains made from the same measure[32]. The ability to afford a control measure is not a legitimate factor in the assessment of costs[33].

It then goes on to say that comparison of the CPF with the VPF may "well reveal a difference between them[34]" but does not define Gross Disproportion in any numerical way.

[23] RRPP page 50 para 143 [24] RRPP page 50 para 145 [25] RRPP page 36 para 101 bullet 2 [26] RRPP page 62 para 3 [27] RRPP page 63 para 6 [28] RRPP page 63 para 5
[29] RRPP page 65 para 13 [30] RRPP page 62 para 4 [31] RRPP page 65 para 15 [32] RRPP page 66 para 19 [33] RRPP page 67 para 19 bullet 3 sub-bullet 4
[34] RRPP page 65 para 15

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 could also be extended to cover some aspects of search and rescue and emergency response if this is required by MCA.

This Annex gives an overview of the:

- Purpose of the appropriate assessment in a Developer's assessment and submission.
- Types of appropriate assessment, for example modelling, sought for in a Developer's assessment and submission.
- Hierarchy of assessment techniques appropriate to a Developer's assessment and submission.
- 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 3.5 and 3.6 of this document.

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 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.

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
- Develop the risk control log.

D.1.4 Types of appropriate assessment

Depending on the 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 3.5 & 3.6.

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

The various hazards 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 of the situations 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:

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

Increasing Human Involvement

Table 24 – A Possible Hierarchy of Assessment and Trials in support of Navigation Risk Assessment

Definition 1 – Area Traffic Assessment

Area Traffic Assessment assesses the marine environment, the traffic and the wind farm 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 mariners in the navigation and operation of their vessels within and close to wind farms. 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 wind farm 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 must be capable of simulating all the navigational effects and phenomena relevant to, or peculiar to, offshore wind farms. These include, for example, the effects of wind farm 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 to date ("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 wind farm 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 wind farm 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;
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, including the DTI Marine Traffic Database, from a combination of radar surveys, Automatic Identification System (AIS) data and historical records;
e) Model or assess typical fishing and recreational activities within and close to the wind farm site, as in (d) above and their interaction with other vessel types navigating near and within the wind farm. 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 a wind farm;
h) Examine the effects of the wind farm 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 wind farm (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 wind farm 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 "COLREGS") (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, aggregate dredging, other offshore installations etc., within the proximity of the given site, given the traffic data by developers and the DTI Marine Traffic Database;

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 wind farm together with suitable researched allowances for human error;

o) Include the effects of the wind farm 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 wind farm effects 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 wind farm 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) Suggest a possible safety zone to be applied to specific or all vessel types within and around the wind farm;

v) Recommend minimum separation distances of the specific wind farm boundaries from established navigational routes, from port approaches, from routeing schemes, from other wind farms and from other offshore operations (see the MCA website for initial guidance);

w) Make navigational risk recommendations with respect to the construction and decommissioning phases of the development;

x) Include an overview of potential search and rescue activities and difficulties within and close to the wind farm.

D.2. Guidance on the 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
  - Extent of the process
  - Activities required
  - 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 Wind Farm Tools and Assessment Techniques

"Approved Wind Farm Tools and Assessment Techniques" are those which are granted approval, by the MCA, for use with wind farms, and which will subsequently join the list of those having previously having 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[35] 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 wind farms (Type D1)
- Widely and publicly used maritime tools and assessment techniques (Type D2)

[35] 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)

- Specialist maritime tools and assessment techniques (Type D3)
- 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)

These are either:

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

Definitions

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 wind farms 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 wind farms 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 either:

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

The development of new modelling tools and assessment techniques (type D5) is to be encouraged. However, by their nature they will require more evidence of verification.

D.2.4Specific 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 wind-farm assessment task. State how assumptions inherent in the tool affect the application to the wind farm 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:

	Stage	Demonstration	Statement of Tool Applicability	Clarification of Conceptual Model	Documented Model / Commented Code	Peer / Expert Review	Comparison with Real World Experience
D1	Maritime Modelling Tools and Techniques Approved for Application to Offshore Wind Farms	●	●				
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	●	●	●	●	●	●

Table 25 – Self-Declaration Information

Depth of Information

The depth of information required is dependent on the level of:

- Risk the tool or technique is assessing.
- 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 uses 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 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
    - Which wind farm or wind farm area
- Description of the modelling tool concept
- Description of prior use of the tool
    - In wind farm, 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.

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	

Table 26 - Example of Technique or Tool Description

D.3. Guidance on the 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[36] 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 presents 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.

Example Format of 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	

Figure 26 - Example Format for a Validation Statement

[36] 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)

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
- 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.

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

HM Coastguard

HM Coastguard (HMCG) keeps records of incidents where they have been involved in the co-ordination of search & rescue activities. As HMCG is responsible for coordinating maritime emergency calls & responses in the UK Search and Rescue region, this should be a comprehensive dataset for incidents where the Coastguard has been alerted. It is possible that some incidents are handled by other individuals/organisations and therefore not included in this data, but this is thought to be a small proportion when considering the sea areas potentially affected by wind farms.

HMCG database records include incident date, location, vessel type & incident type. Some data will be freely available.

Contact: Risk Analysis & Prevention Branch, tel. 02380 329323 / 329206 Additionally, for specific areas, HM Coastguard Maritime Rescue Co-ordination Centres or Maritime Rescue Sub Centres (MRCC / MRSC) may be able to help with local knowledge.

Note: HM Coastguard centres should not however be invited to offer formal opinions on navigational risk assessments. Such opinions should be sought only from MCA's Southampton Headquarters, Navigation Safety Branch.

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 (SI 2005/881)", 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

Lloyd's Register-Fairplay

LR-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.lrfairplay.com/

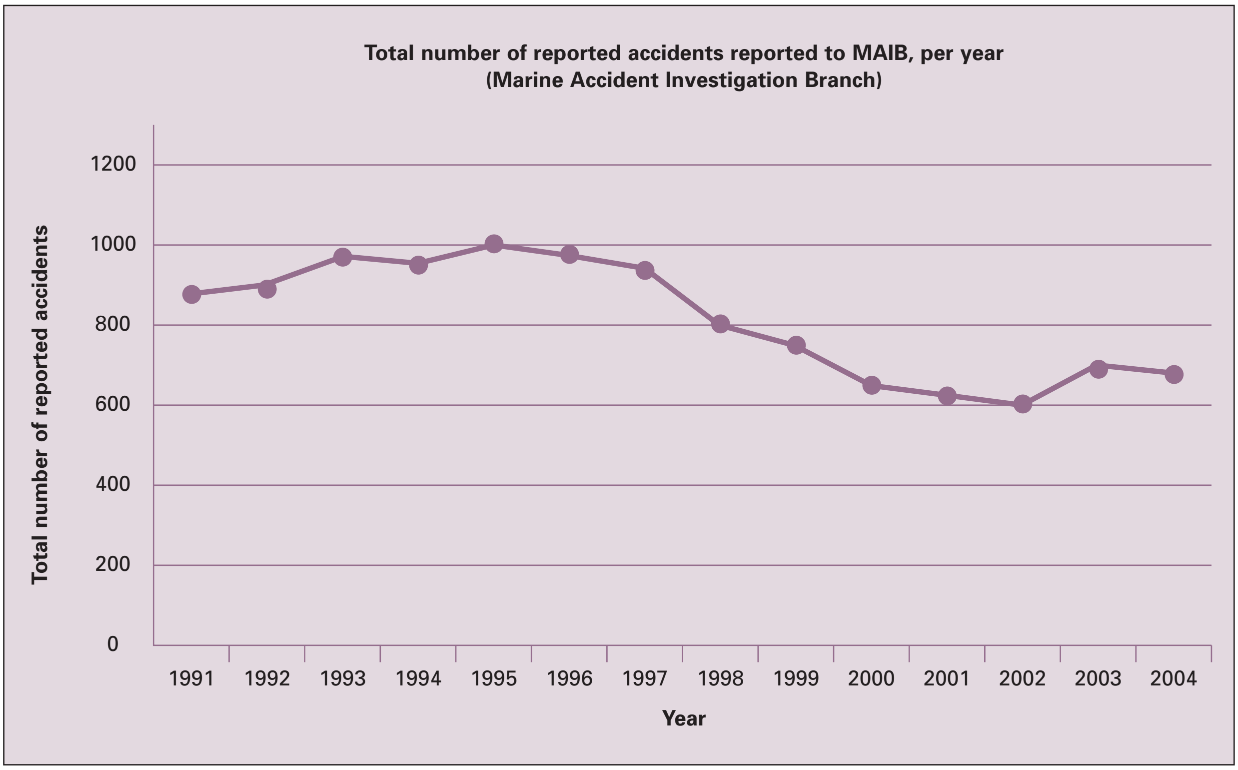


Figure 27 – Number of Marine Accidents (1991 / 2004)

D.4 Guidance on 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 wind farm on the ability of vessels to navigate and operate in the waters adjacent to and through the wind farm 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 wind farm area (if appropriate for the particular development) and the wind farm area itself.
  Assesses the movement of vessels through the water in a way that is representative of vessel navigation and activity.
  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
- 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
- Is used to calculate: -
    - As a minimum the frequency and density of interaction between vessels, vessels and shallow water, and vessels and wind farm 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 wind farm on the marine traffic and
    - The navigational risks associated with a development
    - The cumulative navigation risks associated with the development and the other wind farm developments and other types of marine activity in the Strategic Wind Farm Area.
    - The in-combination effects on the navigation risk of the development with other economic developments over the operational life of the wind farm.
- The need to evaluate the specific impact of the Wind Farm due to the presence of specific marine traffic activity that may be present, or is planned, in close proximity to the Wind Farm.
- 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 wind farm area and used to evaluate potential effects such as the introduction of separation schemes, safety and /or exclusion zones, etc. near to and within the wind farm.

Guidance on the size of the wind farm 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 (See figure 1).

Key Feature	Scenario	Objective
2	Present day "Base Case"	Provide assessment of present risk level for validation with historic data
3	"Future Case" based on: • Traffic types and densities mid way through the operational life (e.g. 10 yrs) • Traffic types and densities at end of the operational life (e.g. 20 yrs)	Future assessment of study area risks with no wind farm present
6	"Base Case with Wind Farm"	Provide analysis of wind farm(s) impacts only, unrelated to traffic increases or reductions
7	"Future Case with Wind Farm" based on: • Traffic types and densities mid way through the operational life (e.g. 10 yrs) • Traffic types and densities at end of the operational life (e.g. 20 yrs)	

Figure 28 - Scenarios Requiring Area Traffic Assessment

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 waterspace or channel, adjacent or close to wind farm developments is best developed with respect to the meteorological and oceanographic data collated above, and guidance on vessel navigation requirements.

Note: Although some Round 1 applications developers quoted the PIANC/IAPH guidelines "*Approach Channels – A Guide to Design*" their relevance to offshore wind farms was, in most instances, not accepted by MCA's Navigation Safety Branch. These guidelines were compiled to address port approach channels, which have very different parameters to routes close to and through offshore wind farms. A primary driver of the "route" widths to be applied to offshore wind farms where nearby navigable waterspace is limited will be the MCA shipping routes template, which is currently under development[37]

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.

[37] "Shipping Routes - Wind Farm Template" MCA: www.mcga.gov.uk Safety info / Navigation Safety / Offshore Renewable Energy Information

Risk

The risk associated with wind farm navigation 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 wind farm 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 Wind Farm" scenario develops broadly acceptable risk when judged against the present traffic environment, the "Future Case" (no Wind Farm(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 could be posed and answered:

- Where are the areas of increased risk?
- What are the magnitude of collision, contact, grounding and other hazard increases?
- Which vessels types 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?

Clearly 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 C5 Guidance on the Influences on the Level of Risk.

These include, but are not limited to:

- ***Adjacent wind farms*** - These scenarios may require one or more analysis for each future year to address the impact of adjacent wind farm 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 Routing Assumptions*** – Variations may be made in the routing of traffic adjacent to and within wind farm(s) 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 wind farm.
- ***Variation in Tidal Level*** – 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".
- ***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 a wind farm, or lack of AIS data. Vessel interaction is 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 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 configurations
- Possible safety zones
- Recommended minimum separation distances of the specific wind farm 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 wind farm development.

The output should inform the operator and reviewer of the quantitative and / or qualitative changes in marine risk as a result of the wind farm, 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.

Future Developments

The EU Safety@Sea project is investigating a shared format for the interchange of geospatial marine risk information and this format should be considered when available.

D.4.6 Critical Parameters within the Assessment

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

Critical Parameters Table

Ref:	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.
	Wind Farm Location	Positioning and size of wind farm, 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 the wind farm and other means of vessel detection and tracking

Table 27 – Area Traffic Assessment – Critical Parameters

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

Ref:	Critical Parameter	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 simulation.
	2D model	Many area traffic assessment techniques are 2D models. Greater consideration of risk issues, and perception of navigation challenges might be developed if the user was able to enter the model and review the simulation from the model ship's perspective.

Table 28 – Area Traffic Assessment - Limitations of Assessment

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 are 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.

Ref:	Performance Standard	Comment	Importance H/M/L
1	**MGN 275 Requirements**		
1.01	Simulation	Computer simulation techniques are suggested by MGN 275 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**		
2.01	Bathymetry	Critical parameter for boundaries of safe navigation, and route development	H
2.02	Visibility (radar blind and shadow sectors around Wind Farm)	Key impact on vessel interaction adjacent to and within wind farms	H
3	**Navigation Activities Traffic**		
3.01	Route Geometry (where relevant)	Key driver for simulation	H
3.02	Traffic distribution across routes (Where relevant)	Significant impact from traffic spread across routes	H
3.03	Variation of Vessel Types	Key driver for derivation of risk and water space impacts	H
3.04	24 Hour traffic Variation	Significant impact, particularly for scheduled traffic, fishing and tidal dependency.	H
3.05	Speed profile	Major driver of dwell time and risk	H
3.06	Vessel Length	Consistent with vessel type represented	H
3.07	Vessel Length Variation	Consistent with vessel type represented and survey data	H
3.07	Vessel domains	Consistent with vessel type represented	H
3.09	Vessel draughts	Consistent with vessel type represented and loaded state.	H
4	**Navigation Activities - Simulation Rules for the Movement of Vessels**		
4.01	Ship types	Capable of modelling all the vessel types expected in the wind farm	H
4.02	Vessels dynamics - vessel to vessel and vessel to structure manoeuvring	Consistent with vessel type represented	M
4.03	Vessels dynamics - turning, manoeuvring	Significant dependent upon available sea room, etc.	L
4.04	Vessel acceleration / deceleration	Low order if consistent validation applied.	L
5	**Navigation Activities - Simulation Rules for the Behaviour of Mariners**		
5.01	Collision Regulations	Vessel responses in accordance with all Collision Regulations including those relating to reduced visibility.	H
5.02	Collision Regulations - Human Error	Vessel responses not in accordance with Collision Regulations	H
5.03	Collision Regulations - Violation	Vessel responses in violation of the Collision Regulations	H
6	**Navigation Activities - Simulation Rules for Manoeuvring in restricted waterways**		
6.01	Vessel recognition	Recognition of turbines, shallow water and other obstructions	H
6.02	Vessel type	Different rules for vessels of different types	H

Ref:	Critical Parameter	Explanation	Ref:
6.03	Tides and Tidal Streams	In accordance with predictions in the area	M
7	**Scenario Flexibility**		
7.01	Traffic growth or reduction scenarios	Account needed of GDP growth, port developments, fishing and other activities.	H
7.02	Multiple simulations	Models with "typical" daily activity and statistical traffic variation require multiple runs for stable result reporting	H
7.03	Multiple Wind Farms	Critical ability for cumulative impact assessments	H
7.04	Vessel Routing Options & Control measures, i.e. safety zone	Development of alternate route structures	H
8	**Results Assessment**		
8.01	Visualisation	Ability to place the instructor / assessor within the simulation	H
8.02	Display - Route and Activity Structures	Ability to show the Route and Activity Structures on a GIS map or ENC chart	H
8.03	Display - Route and Activity Details	Ability to show the details for each route and activity (e.g. speed, hourly rate, course variations, etc.)	H
8.04	Display - Risk Map	Ability to display Risk as coloured areas on a GIS map or ENC chart	H
8.05	Display - Historical incidents	Ability to overlay historical incident on the Risk map	H
8.06	Encounter Frequency	Ability to calculate and display encounter frequencies	H
8.07	Collision probability	Derived from validated encounter frequency	H
8.08	Contact probability	Derived from validated encounter frequency	H
8.09	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

Figure 29 - Area Traffic Assessment – Performance Standards

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 wind farm area from the up to date traffic survey (MGN 275 requirement)
  - Traffic in the wider strategic wind farm area from the DTI Marine Vessel Traffic Survey Database[38]
- 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

[38] How to obtain and distribute traffic data. For information see the DTI Traffic Database on www.maritimedata.co.uk

Environment – Description of the wind farm Development and how it changes the Marine Environment

The bathymetry of the Study Area should be identified using data derived from Electronic Navigational Charts (ENCs) 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 routing and operations of vessels within, around and through wind farms. Particular attention should be paid to identifying those areas of shallow water that may, due to the diversion of traffic around a wind farm, 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.

The Canadian Coastguard consider that the following [39] limits possess the potential to impose navigation constraint in reduced sea room, and increase the risk of grounding or poor vessel response during collision avoidance.

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'	140' - 200'	Ocean-going Tanker, Ore and Bulk Carrier	3	2
800 - 1000	30,000 - 100,000	95' - 175'	95' - 175'	Ocean-going Tanker, Ore and Bulk Carrier	3	2
630 - 800	10,000 - 60,000	60' - 140'	60' - 140'	Tanker, Ore and Bulk Carrier, General Cargo	7	3
550 - 630	8,000 - 30,000	55' - 105'	55' - 105'	Tanker, Ore and Bulk Carrier, General Cargo	7	3
300 - 550	2,500 - 20,000	43' - 105'	43' - 105'	Tanker, Ore and Bulk Carrier, General Cargo	7	3
300 - 600	2,500 - 13,000	56' - 90'	56' - 90'	Car Ferry	7	3
200 - 300	10 - 1,500	12' - 70'	12' - 70'	Car Ferry	6	4
200 - 300	2,000 - 3,500	23' - 65'	23' - 65'	Tanker, Bulk Freighter, Self Unloader, Fish Factory	7	3
200 - 250	2,000 - 3,000	40' - 60'	40' - 60'	Small Tanker, General Cargo, Fishing (Long Liner)	6	3
150 - 200	1,500 - 2,500	30' - 50'	30' - 50'	Small Tanker, General Cargo, Fishing (Long Liner)	6	2
90 - 150	200 - 800	12' - 50'	12' - 50'	Small Tanker, General Cargo, Fishing (Dragger, Long Liner)	4	2
65 - 100	40 - 250	13' - 28'	13' - 28'	Tugs, Small Draggers, Long Liners, Pleasure Craft	4	2
45 - 65	20 - 160	9' - 16'	9' - 16'	Tugs, Work Boats, Small Draggers, Inshore Long Liners, Pleasure Craft	4	2
32 - 45	8 - 50	4' - 14'	4' - 14'	Tugs, Work Boats, Fishing (Cape Islanders, Trollers), Pleasure Craft	4	3
25 - 35	4 - 20	4' - 11'	4' - 11'	Tugs, Work Boats, Fishing Trollers, Pleasure Craft	5	4
12 - 25	1 - 7	3' - 8'	3' - 8'	Tugs, Work Boats, Inshore Fishing, Pleasure Craft	5	5

Figure 30 – Tidal Streams and Currents with the Potential to Impose a Navigation Constraint

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

Following the development of the traffic routing, 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 wind farm 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

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.

MTM 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:

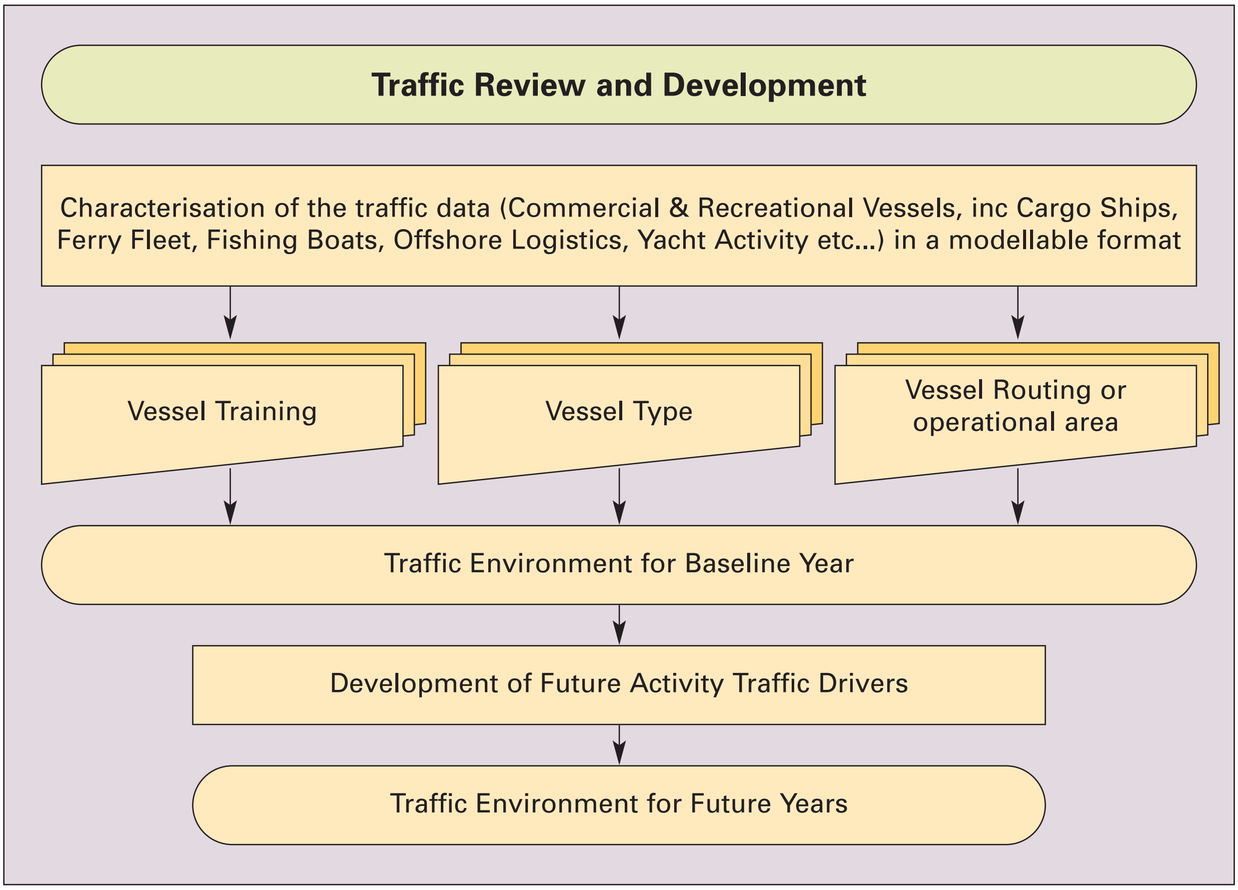


Figure 31 – Area Traffic Assessment Illustrative Example - Traffic Review and Development Flow Chart

- 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, routings 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 95% of all traffic transiting each route. It is noted that this process will result is 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 wind farm 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 routings 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"). 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").

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 wind farms. Vessel movement timings, types and routings 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 or the DTI Marine Vessel Traffic Database 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.

MTM 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 wind farm area and the wind farm 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.

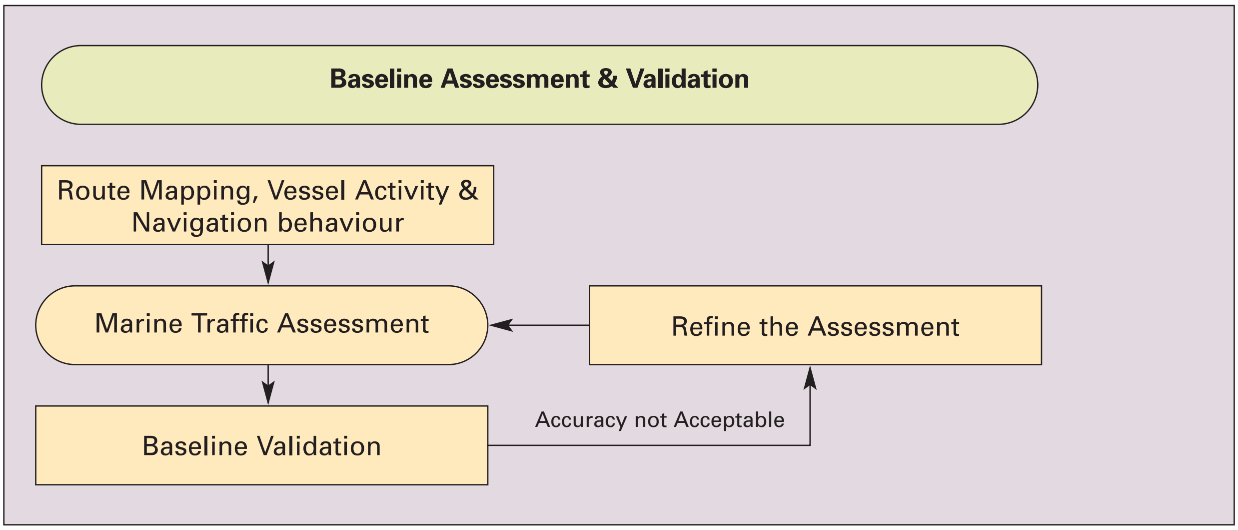


Figure 32 – Area Traffic Assessment Illustrative Example - Baseline Assessment and Validation Flow Chart

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.

MTM Step 3 – Forecasting using the model or other appropriate technique

This step uses the model or other technique to assess:

- Future case without wind farm
- Base case with wind farm
- Future case with wind farms.

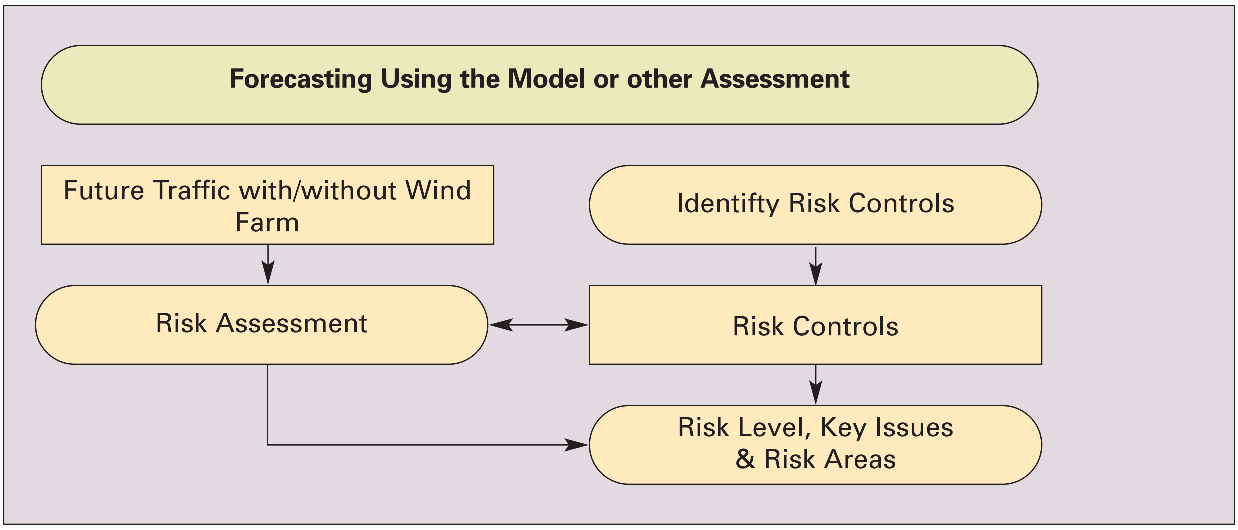


Figure 33 – Area Traffic Assessment Illustrative Example - Forecasting using the Model or other Assessment Technique Flow Chart

- Step 3.1 –Future Case without Wind Farm
  - Review forecast data
  - 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 are, 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 represent hazards to vessels not previously encountered should be taken into account.
  - This case should be reviewed against the Baseline and identifies the impact of traffic increases alone on the local risk environment.

- Step 3.2 - Base Case with Wind Farm
  - Review routes impacted by wind farms
  - Elicit, or make judgement where appropriate, regarding the relocation and distribution of routes. For those cases where 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

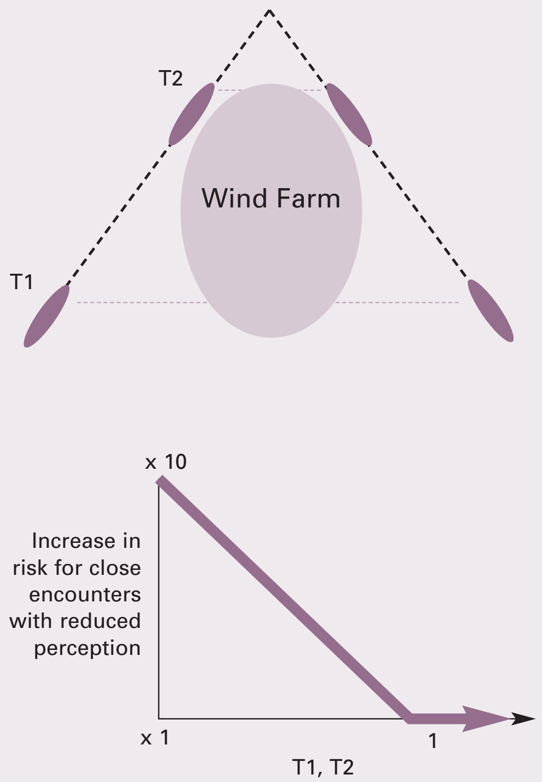
traffic, navigable water space and the presence of other obstructions.
- Determine a minimum anticipated vessel clearance, for all anticipated types of vessel, as they pass a wind farm boundary. In this element guidance may be taken from the initial MCA recommendations on boundary clearance distances from shipping routes [40]
- The width of the original route at the closest point of approach to the wind farm 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 wind farm 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 farms alone on the local risk environment.

- Step 3.3 –Future Case with wind farm
  - 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 on the local risk environment.
  - This will identify the cumulative impact of changes in the traffic volumes and wind farm 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.

[40] “Shipping Routes - Wind Farm Template” MCA : www.mcga.gov.uk Safety info / Navigation Safety / Offshore Renewable Energy Information

Example Treatment of Limited Visibility due to Wind Farms and Impact on Collision Risk



For this example it is assumed that the position at which a vessel would have normally made sighting and avoiding action occurs at T1. In this case this coincides with the boundary of the wind farm, however this may not necessarily be always 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 T2. A collision risk multiplier of some determined value (not necessarily that shown to the left) 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.

Note: Only large wind farms would be likely to completely blank the visual or radar detection in of vessels in this way, but others would certainly affect detection by both means. AIS operation – for those vessels so fitted - should normally be unaffected.

Figure 34 – Area Traffic Assessment Illustrative Example - Treatment of Limited Visibility

D.5 Guidance on 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 a wind farm. 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
- The need to evaluate the policy on safety zones
- 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 a wind farm.

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

Source of the Situations

The situations that 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 evaluate a safety zone.
- 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 effecting bathymetry
- Concerns of stakeholders
    - E.g. Visual and radar obstruction or spurious effects caused by the development
    - Some of the specific concerns of MGN 275

Need for Assessment

The need for assessment of these situations comes from MGN 275 (M). In particular paragraph 2.2, which requires 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.

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 wind farm 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 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 that will include:

- The ENC charts of the wind farm location or site specific bathymetric surveys
- Modifications to the ENC chart with details of the wind farm configurations
- The characteristics of the subject vessel or vessels.

Analysis based on Annex B3 ("Guidance on Defining the Marine Environment") and Annex C5 ("Influences on the Level of Risk") should be used as the source of information for the use in the scenario.

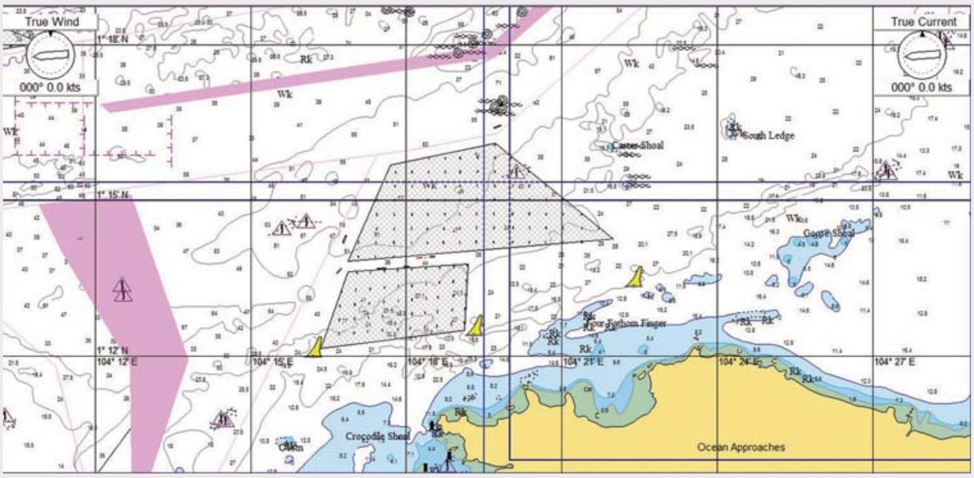
The details of the wind farm that need to be added to the ENC chart, include:

- Shape and configuration
    - Size (number and type of structure, spacing)
    - Location
    - Orientation

- Associated structures
  - Ancillary platforms
  - Transformers
  - Meteorological towers
- Development Status
  - Proposed
  - Part constructed
  - Completed and operational
  - Being decommissioned
- Marking
  - Navigation lights
  - Aviation lights
  - ASMS lights

Figure 35 - Example of an Electronic Navigational Chart modified with a wind farm but with required General Lighthouse Authority (GLA) marking and lighting omitted.

Example of an Electronic Navigational Chart modified with a Wind Farm



Scenario Planning

The particular scenario that has been defined will then drive the definition of site-specific parameters that 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.

Use of Scenarios to Evaluate the Absence of, or the Need for, Safety Zones

Suitable scenarios may be required to justify a chosen policy towards safety zones. In line with UNCLOS rules a safety zone cannot exceed 500 metres around an installation without IMO approval. Scenarios will have to be developed to justify that:

- A safety zone is necessary; and
- The suggested safety zone is effective.

Repeated iterations of the scenario may need to be assessed with:

- Different dimensions of the safety zone to then determine its optimum size for the range of parameters examined.
- Different size, location or orientation of the wind farm.
- Combinations of the above.

The basic process for assessing possible requirements for a safety zone should be to identify:

- The vessel types who should not be permitted to enter or remain in the safety zone by assessing the risk to them
- The vessel types that are capable of transiting through or operating within the specific site.
- With reasons, the activities which should not be permitted within the safety zone.

Developers should recognise that safety zones are established primarily to ensure the safety of navigation thereby safeguarding people such as mariners, a secondary justification being the protection of installations offshore.
The Government's position in relation to safety zones for offshore wind farms is that a case must be made for the establishment of such zones, based on safety grounds. Compelling risk assessed arguments would be required for the establishment of a safety zone, which excludes all vessels from the wind farm area, particularly in the case of smaller vessels.

In addition, it should be noted that whilst the navigational risk assessment should consider the necessity for a safety zone the information provided in the assessment does not constitute a formal application to Government for any recommended safety zone. A formal application under the Energy Act 2004 should be made separately at a later stage. DTI's Electricity Development Consent Directorate can provide further advice.

Minimum Clearance Distances of Wind Farm Boundaries from Shipping Routes

Figure 37 provides preliminary guidance, from the Maritime and Coastguard Agency, to developers in setting the distance of a wind farm boundary from a recognised shipping route. (See MCA website: www.mcga.gov.uk safety info /navigation safety/ OREI/ "Shipping Routes W.F. Template")

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 ("Collision Regulations" or "COLREGS"). 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.

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. 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.

Distance From	Factors	Likely Process	
Individual Wind Farm (Turbine) Boundary	700m inter-turbine spacing = small craft only recommended	NO GO If turbines this close to recognised shipping route	
500 m	X band radar Interference intense		
	IMO/UNCLOS Safety Zone		
800m	Vessels generate multiple echoes on shore based radar	VERY CLOSE & CRITICAL SCRUTINY Mitigation needed	ALARP
0.5nm (926m)	Mariners' high traffic density domain		
0.8nm (1481m)	Mariners' ship domain		
1nm (1852m)	Minimum distance to parallel boundary or TSS		
1.5nm (2778m)	S band radar interference commences ARPA affected		
2nm (3704m)	Compliance with Collision Regulations becoming less challenging	CLOSE SCRUTINY BUT BECOMING TOLERABLE	
>2nm (3704m)	But not near TSS	TOLERABLE	
5nm (9260m)	Adjacent wind farm introduces cumulative effect Distance from TSS entry/exit	VERY CLOSE & CRITICAL SCRUTINY	
10nm (18520m)	No other wind farms	TOLERABLE	

Figure 36 – Initial MCA Guidance on Boundary Clearance Distances from Shipping Routes

D.5.4 Simulator Specifications for Training Mariners Operating within or Close to Offshore Wind Farms or for Assessing an Appropriate Scenario

If a navigational simulator is to be used to train mariners operating within or close to offshore wind farms or for assessing an appropriate scenario using subject mariners then this will require a technique that can accurately represent and apply the various parameters to the base case. Such a tool can range from a "desk top" exercise to a Full Mission Simulator System, the choice of tool and its parameters having been discussed with MCA. Suitably experienced and qualified instructors / assessors and Mariners are required, particularly when the "man in the loop" (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 Code.

The mariner's domain and general approach to navigating close to offshore wind farm structures will be directly related to the relevant subject, his skill and experience, the size and type of his 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 controls
- Information on the Environment
    - E.g. ENC Chart derived information
    - Meteorological and sea conditions
    - Interactive traffic
- Information Display to the subjects
    - 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.

E.1 Guidance on Creating a Risk Control Log

The concept of an offshore wind farm is accepted and therefore developers will be expected to manage risk by the identification, application and proven worth of risk controls.

E.1.1 Background

Wind farms 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 Goal:

- Appropriate assets have to 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 have to 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 have to 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 need to be put in place and exercised.

E.1.3 Assets supporting Navigation Activities

Assets are of three main types 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 is the effect of control (prevention, mitigation and/or emergency response).

Risk Control Description – Example of Spreadsheet Format

Description			Risk Control Type				Risk Control Effect		
C1			Assets	Rule	Good Practice	Option	Prevention	Mitigation	Emergency Response
1		*All*							
2	**Vessel Assets**								
	1	Emergency Response - Requistioned Vessels	–						–

Figure 37 – 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 - Requistioned Vessels			

Figure 38 – Example Risk Control Log - Consultation, Approval & Implementation

Implementation Options

- Identify the possible project phases for implementation (i.e. during pre-construction, construction, operation, maintenance and/or decommissioning 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			Risk Control Type				
C1			Pre-Construction	Construction	Operation	Maintenance	Decommissioning
1		*All*					
2	**Vessel Assets**						
	1	Emergency Response - Requistioned Vessels			0		

Figure 39 – 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 - Requistioned Vessels	

Figure 40 – Example Risk Control Log - Implementation Plan

E.2. Guidance on Cost Benefit Assessment in Risk Control and Mitigation Selection

Where cost benefit assessments are used in support of ALARP justifications the following may be used for comparative risk control option selection.

E.2.1 Introduction

The FSA Guidelines require a process of Cost Benefit Assessment (CBA) to rank proposed risk control options in terms of risk benefit related to life cycle costs. There is no unique way of doing this but the following are some of the techniques commonly used in marine analysis.

- Cost per Unit Reduction in Risk (CURR)
- Gross Cost of Averting a Fatality (GCAF)
- Net Cost of Averting a Fatality (NCAF).

E.2.2 Cost per Unit Reduction of Risk

Source: CURR was the measure used in the UK Formal Safety Assessments submissions to the IMO for High Speed Catamaran Ferries and Bulk Carriers.

Cost per Unit Reduction of Risk (CURR) is an effective measure of the cost/benefit of a Risk Control Option. It is derived by calculating the difference between the financial costs and financial benefits of implementing a Risk Control Option and the predicted risk reduction achieved.

CURR can be calculated as:

$$\frac{\textit{Cost of the RCO - Savings in [environmental loss + property loss + business loss]}}{\textit{Change in Potential Loss of Life (PLL)}}$$

E.2.3 Gross Cost of Averting a Fatality

Source: GCAF is defined in the International Association of Classification Societies (IACS) Glossary of Terms (www.iacs.org.uk/fsa/wp5/fsaglossary.htm).

A cost effectiveness measure in terms of ratio of marginal (additional) cost of the risk control option to the reduction in risk to personnel in terms of the fatalities averted.
GCAF can be calculated as:

$$\frac{\Delta \textit{Cost}}{\Delta \textit{Risk}}$$

(Where ∆ (Delta) indicates the change in the variable)

E.2.3 Net Cost of Averting a Fatality

Source: NCAF is defined in the International Association of Classification Societies (IACS) Glossary of Terms (www.iacs.org.uk/fsa/wp5/fsaglossary.htm).

A cost effectiveness measure in terms of ratio of marginal (additional) cost, accounting for the economic benefits of the risk control option to the reduction in risk to personnel in terms of the fatalities averted.

NCAF can be defined as:

$$\frac{\Delta \textit{Cost} - \Delta \textit{Economic Benefit}}{\Delta \textit{Risk}}$$

Which is also:

$$\frac{\textit{GCAF} - \Delta \textit{Economic Benefit}}{\Delta \textit{Risk}}$$

E.2.4 Change in Risk

∆ Risk can be defined in a number of ways including:

- Change in Potential Loss of Life (PLL) for the overall level of risk (for a Risk Control that affects multiple risks)
- Change in Probability x Consequence (for a Risk Control that affects an individual, or small group of individual risks).

E.3. Guidance on Assessing the Equity of Risk Controls and Mitigations to Stakeholders

E.3.1 Stakeholders Types

There are a variety of types of Stakeholder:

- Risk Imposer is whose actions or policies result in risk and need action
- Risk Taker is whose action or inaction results in a risk
- Risk Beneficiary benefits from imposing or taking the risk
- Risk Payer pays for the management of the risk
- Risk Sufferer suffers the consequence of a risk
- Risk Observer is aware of the risk but it does not affect them directly.

E.3.2 Stakeholders Types – Example Checklist

	Stakeholders	Imposer	Taker	Beneficiary	Payer	Sufferer	Observer
1	**Human Stakeholders**						
1.1	Mariners					●	
1.2	Sailors					●	
1.3	Fishermen					●	
1.4	Crew					●	
1.5	Passengers					●	
1.6	General Public			●		●	
2	**Navigation Stakeholders**						
2.1	Commercial shipping		●				
2.2	Fishing		●				
2.3	Recreational Mariners		●				
2.4	Port Authorities		●		●		
2.5	Offshore Oil and Gas Industry		●				
2.6	Ministry of Defence		●				
3	**Navigation Support Stakeholders**						
3.1	Search and Rescue Services				●		
3.2	Salvors			●			
3.3	Maritime and Coastguard Agency				●		
4	**Wind Farm Stakeholders**						
4.1	Developer	●		●			
4.2	Owner	●		●			

	Stakeholders	Imposer	Taker	Beneficiary	Payer	Sufferer	Observer
4.3	Operator			●			
4.4	Construction			●			
4.5	Maintainers			●			
4.6	Installers			●			
5	**Wind Farm Insurance Stakeholders**						
5.1	Turbine Insurers			●			
5.2	Warranty Insurers			●			
5.3	Liability Insurers			●			
6	**Society Stakeholders**						
6.1	Shore Populations			●		●	
6.2	General Population			●			
7	**Shipping Stakeholders**						
7.1	Owner, Operator or Manager		●				
7.2	Master		●			●	
7.3	Crew					●	
7.4	Crew Agency						●
7.5	Trade Unions						●
7.6	Families					●	
8	**Shipping Insurance Stakeholders**						
8.1	Hull Underwriters			●			
8.2	Cargo Underwriters			●			
8.3	P & I Clubs			●			
9	**Ship Operations Stakeholders**						
9.1	Cargo Owners						●
9.2	Charterer						●
9.3	Terminal Operators						●
9.4	Stevedores						●
10	**Shipbuilding Stakeholders**						
10.1	Designers, Ship-builders & Repairers						●
10.2	Equipment Makers						●
10.3	Commercial Services (e.g. ship chandlery)						●
11	**Regulatory Stakeholders**						
11.1	International Maritime Organisation						●
11.2	Flag State						●
11.3	Coast State				●		
11.4	International Association of Lighthouse Authorities						●
11.5	General Lighthouse Authority						●
11.6	Maritime and Coastguard Agency				●		
12	**Other Stakeholders**						
12.1	Professional Bodies						●
12.2	Training Establishments						●
12.3	Legal Services				●		
12.4	Marine Consultants				●		
12.5	Media				●		
12.6	Environment and Pressure Groups						●

Table 29 – Example of Stakeholder Types

E.3.3 Organisations Representing Stakeholders

Stakeholders are represented by Stakeholder Organisations who take different roles including:

- Proposers who are proposing the development
- Approvers who are responsible for giving a development its consent
- Advisors who are formally consulted by the approvers
- Commentators who are not formally consulted by the approvers but who may provide input to them
- Observers.

E.3.4 Organisations Representing Stakeholders – Example Checklist

Stakeholders Organisations	Proposers	Approvers	Advisors	Commentators	Observers
Association of British Insurance					●
Banks					●
British Ports Association				●	
BWEA (including developers)	●				
CEFAS or SEAFISH				●	
Chamber of Shipping			●		
The Crown Estate		●			
DEFRA			●		
Developer	●				
Developer's Legal Teams			●		
DFT		●			
DTI		●			
MCA			●		
MoD			●		
National Federation of Fishermen's Organisations			●		
Nautical Institute					●
Royal Institute of Navigation					●
Representatives of Other Countries					●
Representatives of UK Regions				●	
Representatives of three strategic areas				●	
RNLI			●		
Royal Yachting Association			●		
Trinity House			●		
UK Harbour Masters Association					●
UK Hydrographic Office				●	
UK Major Ports Group					●
UK Offshore Aggregate Dredging Association				●	
UKOOA				●	

Table 30 – Example of Organisations Representing Stakeholders

F.1. Guidance on Tolerability of Risk Claims Supported by a Reasoned Argument

F.1.1 Background to the concept of Claims and Reasoned Arguments

The concept of a claim supported by a reasoned argument is a development of the new technique used in reliability risk management.

F.1.2 Purpose of the Claim

The purpose of the Claim and Reasoned Argument is to:

- Make a clear statement that is understandable to an informed, but non risk specialist, reader what the risks are and what is being done to make them broadly acceptable/tolerable i.e.:
  - To avoid specialist risk terminology
  - To avoid implicit risk or risk tolerability information being buried in the text of a risk assessment
- Through the discipline of producing a clear concise statement make sure that the producer of the submission has convinced themselves that the risks have been identified, assessed in a thorough way, controls developed and the risks broadly acceptable in a way that would stand up in “the court of informed opinion” if presented to a “judge” and challenged by “the defence”.

F.1.3 Developing the Claim

Developers should build up assessments and modelling to make a reasoned argument for a positive consent decision based on a claim that the risks are broadly acceptable or tolerable with further controls.

The reasoned argument is central to a marine navigational safety risk assessment. It is “a reasoned, auditable argument created to support the contention that a defined wind farm satisfies the requirements”.

The reasoned argument, together with the supporting evidence, should be written in a structured way forming a logical flowing argument that can be read as a “mini story”.

It should link the requirements and assumptions to the evidence, the science, the environment and the operations to produce a reliability claim. This is shown in concept below:

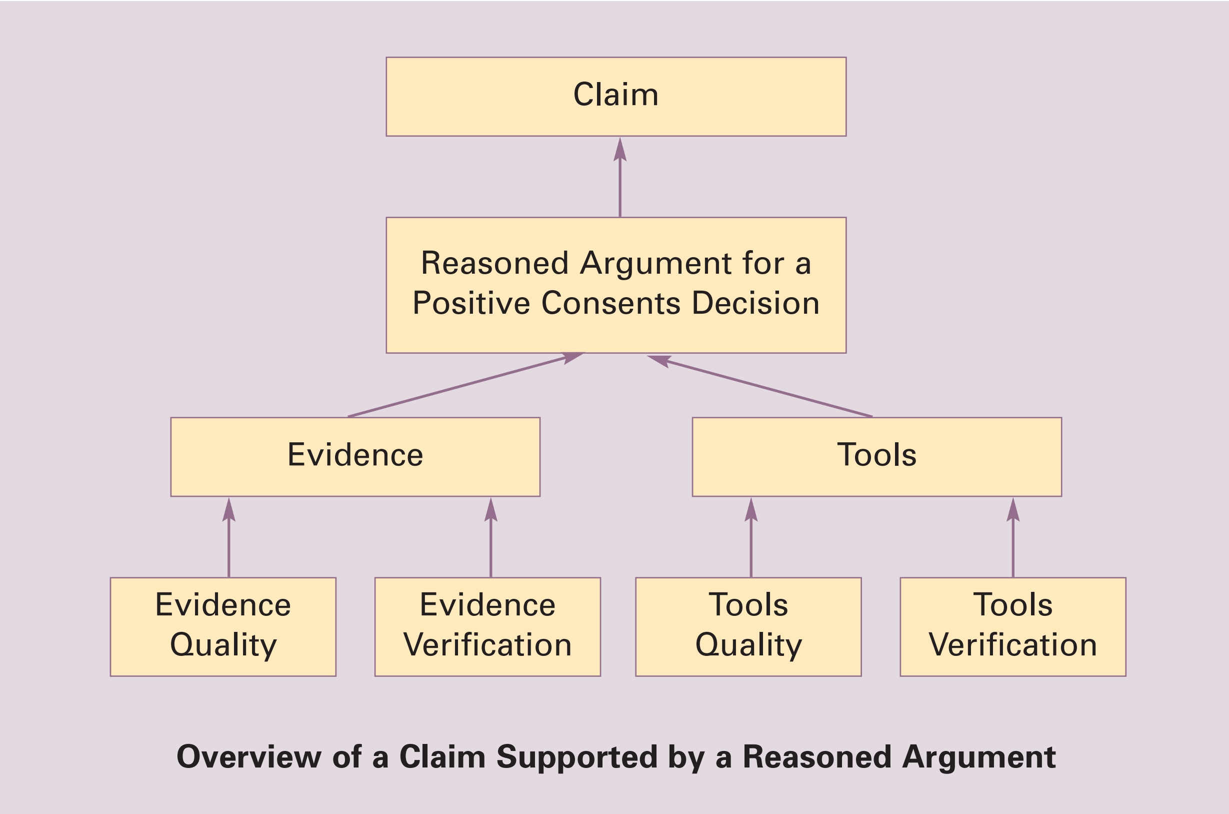


Figure 41 - Concept of a Claim Supported by a Reasoned Argument

G.1. Example Hazard Identification Checklist

Description				
Ref				Description of Casual Chain (Event Sequence) (Accident Sequence)
1				**General Navigation Safety**
1	**2**			**Collision**
1	2	01	a	Vessel navigating near a wind farm collides with another vessel that is navigating near a wind farm
1	2	01	b	Vessel navigating near a wind farm collides with another vessel navigating around a wind farm.
1	2	01	c	Vessel navigating around a wind farm collides with another vessel that is navigating around a wind farm.
1	2	01	d	Vessel navigating around a wind farm collides with another vessel that is navigating through a wind farm.
1	2	01	e	Vessel navigating through a wind farm collides with another vessel that is navigating through a wind farm.
1	2	02	a	Fishing vessel collides with another navigating vessel navigating near, around or through a wind farm
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 a wind farm
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 a wind farm
1	2	04	b	Presence of anchored vessels causes collision between other navigating vessels.
1	2	05	a	Vessel engaged in operations collides with another navigating vessel navigating near, around or through a wind farm
1	2	05	b	Presence of vessels engaged in operations causes collision between other navigating vessels.
1	2	06	a	Vessels engaged in servicing a wind turbine (e.g. a mother and daughter vessel arrangement) collide with each other
1	2	06	b	Vessels engaged in servicing a wind turbine (e.g. a mother and daughter vessel arrangement) collide with another navigating vessel navigating near, around or through a wind farm
1	2	06	c	Presence of vessels engaged in servicing a wind turbine (e.g. a mother and daughter vessel arrangement) causes collision with other navigating vessels
1	2	07	a	Vessel engaged in a special event collides with another navigating vessel navigating near, around or through a wind farm
1	2	07	b	Presence of vessels engaged in a special event causes collision between other vessels.
1	**3**			**Contact**
1	3	01	a	Vessel under control makes contact with a wind turbine
1	3	01	b	Vessel servicing a wind turbine makes contact with a wind turbine. (Special case of 3.01a)
1	3	01	c	Vessel not under command makes contact with a wind turbine
1	3	01	d	Drifting vessel makes contact with a wind turbine.
1	3	02	a	Vessel under control makes contact with an offshore sub-station
1	3	02	b	Vessel not under command makes contact with an offshore sub-station
1	3	02	c	Drifting vessel makes contact with an offshore sub-station.
1	3	03	a	Vessel under control makes contact with an offshore service base
1	3	03	b	Vessel not under command makes contact with an offshore service base
1	3	03	c	Drifting vessel makes contact with an offshore service base
1	3	04	a	Vessel under control makes contact with an offshore accommodation platform
1	3	04	b	Vessel not under command makes contact with an offshore accommodation platform
1	3	04	c	Drifting vessel makes contact with an offshore accommodation platform
1	3	05	a	Vessel under control makes contact with a wind turbine blade.
1	3	05	b	Vessel servicing a wind turbine makes contact with a wind turbine blade. (Special case of 3.02a)
1	3	06	a	Vessel not under command makes contact with a wind turbine blade
1	3	06	b	Drifting vessel makes contact with a wind turbine blade (Special case of above)
1	3	07	a	Vessel under control makes contact with a fixed structure associated with a wind farm (e.g. transformer platform)
1	3	07	b	Vessel servicing a wind farm makes contact with a fixed structure associated with a wind farm
1	3	07	a	Vessel not under command makes contact with a fixed structure associated with a wind farm
1	3	07	b	Drifting vessel makes contact with a fixed structure associated with a wind farm (Special case of above)
1	**8**			**Grounding and Stranding**
1	8	01	a	Vessel under control grounds or becomes stranded on a foundation structure and/or anti scour material.
1	8	01	b	Vessel servicing a wind turbine grounds on a foundation structure and/or anti scour material. (Special case of the above)
1	8	02		Vessel under control grounds or becomes stranded on a collapsed wind turbine

Description				
Ref				**Description of Casual Chain (Event Sequence) (Accident Sequence)**
1	8	03	a	Vessel not under command grounds or becomes stranded on a foundation structure and/or anti scour material
1	8	03	b	Drifting vessel grounds or becomes stranded on a foundation structure and/or anti scour material (Special case of the above)
1	8	04		Due to restricted manoeuvring a vessel navigating near a wind farm grounds or becomes stranded.
1	8	05		Due to restricted manoeuvring a vessel navigating around a wind farm grounds or becomes stranded.
1	8	06		Due to restricted manoeuvring a vessel navigating through a wind farm grounds or becomes stranded.
1	8	07	a	Due to naturally shifting sand banks a vessel navigating near a wind farm grounds or becomes stranded.
1	8	07	b	Due to naturally shifting sand banks a vessel navigating around a wind farm grounds or becomes stranded.
1	8	07	c	Due to naturally shifting sand banks a vessel navigating through a wind farm grounds or becomes stranded.
1	8	08	a	Due to the effect of scour a vessel navigating near a wind farm grounds or becomes stranded.
1	8	08	b	Due to the effect of scour a vessel navigating around a wind farm grounds or becomes stranded.
1	8	08	c	Due to the effect of scour a vessel navigating through a wind farm grounds or becomes stranded.
2				**Other Navigation Safety**
2	**1**			**Foundering and Capsizing**
2	1	01	a	Subsea obstacle snags fishing equipment heeling vessel and causing it to founder or capsize.
2	1	01	b	Subsea cable snags fishing equipment heeling vessel and causing it to founder or capsize.
2	1	01	c	Subsea fallen over turbine snags fishing equipment heeling vessel and causing it to founder or capsize
2	1	02	a	Subsea obstacle snags anchor heeling vessel and causing it to founder or capsize.
2	1	02	b	Subsea cable snags anchor heeling vessel and causing it to founder or capsize.
2	1	02	c	Subsea fallen over turbine snags anchor heeling vessel and causing it to founder or capsize.
2	**4**			**Fire**
2	4	01		Wind turbine fire requires emergency rescue of servicing staff
2	4	02		Wind turbine fire requires repair of burnt out turbine (and therefore deployment of support vessels) which may affect routing of vessels and the establishment of a wider safety zone
2	4	03		Release of fire suppression (real or spurious triggers) releases inert gases into the air intakes of supporting helicopters
2	4	04		*No reasonably foreseeable accident has been identified where a wind farm can cause a fire on a vessel (or vice versa) other than a consequence of a collision, contact, grounding or a stranding*
2	**5**			**Explosion**
2	5	01		Leaking gas (e.g. from an underground gas field or from batteries) builds up in tower and explodes resulting in abandoned remains of a wind turbine and increased risk of contact
2	5	02		*No other reasonably foreseeable cause of a wind turbine explosion has been identified other than by terrorism which is excluded from Formal Safety Assessment.*
2	5	03		*No reasonably foreseeable accident has been identified where a wind farm can cause an explosion on a vessel other than as a consequence of a collision, contact, grounding or a stranding.*
2	**6**			**Loss of Hull Integrity**
2	6	01		*No reasonably foreseeable accident has been identified where a wind farm can cause a loss of hull integrity on a vessel (or vice versa) other than as a consequence of a collision, contact, grounding or a stranding.*
2	**7**			**Flooding**
2	7	01		*No reasonably foreseeable accident has been identified where a wind farm can cause flooding on a vessel (or vice versa) other than as a consequence of a collision, contact, grounding or a stranding.*
2	**10**			**Machinery Related Accidents**
2	10	01		Wind turbine machinery accident requires emergency rescue of servicing staff.
2	10	02		Blade failure results in the blade (or parts of the blade) hitting a navigating vessel or a person on the vessel
2	10	03		Ice on blade comes off hitting a navigating vessel or a person on the vessel
2	10	04		Dropped object from a maintenance or installation operation hits a navigating vessel or a person on the vessel
2	10	05		Blade failure results in a floating blade entering the seaways
2	10	06		Turbine control failure results in a failure of turbine navigation aids (e.g. lighting) resulting in non detection of wind farm and increase risk of powered contact
2	10	07		*No reasonably foreseeable accident has been identified where a wind farm can cause a machinery related accident on a vessel (or vice versa) other than as a consequence of a collision, contact, grounding or a stranding.*
2	**11**			**Payload Related Accidents**
2	11	01		*No reasonably foreseeable accident has been identified where a wind farm can cause a machinery related accident on a vessel other than as a consequence of a collision, contact, grounding or a stranding.*
2	**12**			**Hazardous Substance Accident**
2	12	01		No reasonably foreseeable accident has been identified where a wind farm can cause a machinery related *accident on a vessel other than as a consequence of a collision, contact, grounding or a stranding.*
2	13			**Accidents to personnel**
2	13	01		Accidents caused by Transfer to/from servicing vessel (or helicopter) to a wind turbine
2	13	02		Accidents caused by Transfer between servicing vessels
2	13	03		Accidents within the turbine requiring rescue of personnel.
2	13	04		Toxic fume build up in the turbine from electrical fluids or batteries (or asphyxiation from fire suppression) requiring rescue of personnel.
2	13	05		Person in water (unaided, in floatation device, life raft or life boat) requires rescue
2	13	06		Bad weather (or other event) preventing egress from a wind turbine resulting in marooning and requiring rescue.
2	**14**			**Accidents to the General Public**

Description				
Ref				Description of Casual Chain (Event Sequence) (Accident Sequence)
2	14	01		Wind farm causes vessel with hazardous substance on board to be routed closer to areas of habitation.
2	14	02		*No reasonably foreseeable accident has been identified where a wind farm can cause an accident to the general public other than as a consequence of a collision, contact, grounding or a stranding.*
2	**16**			**Electrocution**
2	16	01		Vessel hits turbine structure sufficiently hard to pierce J tube and breach cable insulation
2	16	02		Anchoring vessel drags up export cable and shorts cable to the anchor
2	16	03		Servicing (or SAR) helicopter operations case an electric discharge between the helicopter and the wind turbine
3				**Aviation Safety**
3	**17**			**Aviation Accidents**
3	17	01		Helicopter flying to a turbine, 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 or tower and crashes
4				**Other Safety**
4	**20**			**High Probability Events**
4	20	01		Contact between a service vessel and a wind turbine when transferring personnel
4	20	02		Injury of service personnel when transferring to/from a wind turbine
4	20	03		Man overboard of service personnel when transferring to/from a wind turbine
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 the wind farm 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 a wind farm and the presence of wind farm inhibits search and rescue.
5	**32**			**Internal to Internal**
5	32	01		Activities within a wind farm both generate an increased need for search and rescue and the presence of the wind farm inhibits search and rescue.
5	**33**			**Internal to External**
5	33	01		Activities within a wind farm generate an increased need for search and rescue in the areas surrounding the wind farm
5	**34**			**External to External**
5	35	01		Person or vessel requiring search and rescue drifts through a wind farm and the presence of wind farm 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 wind farm increases need for emergency response from Foundering, Capsizing, Collision, Grounding or Stranding.
6	30	02		Presence of wind farm inhibits ability to provide emergency response.
6	**31**			**External to Internal**
6	31	01		Pollution outside wind farm drifts into wind farm and presence of wind farm inhibits clean up
6	**32**			**Internal to Internal**
6	32	01		Activities within a wind farm both generate an increased risk of pollution and the presence of the wind farm inhibits clean up.
6	**33**			**Internal to External**
6	33	01		Activities within a wind farm generate an increased risk of pollution in the areas surrounding the wind farm.
6	**34**			**External to External**
6	34	01		Pollution from outside a wind farm drifts through a wind farm and the presence of wind farm inhibits clean up during the transit stage.
6	34	02		Routing 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

Table 31 - Example Hazard Identification Checklist

G.2 Example Risk Control Checklist

		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	●						●
	2	Search and Rescue - Inshore	●						●
	3	Search and Rescue - Lifeboats	●						●
	4	Search and Rescue Requisitioned Vessels	●						●
	5	Tugs	●						●
	6	GLA Tenders	●						●
	7	Wind Farm Support Vessels	●						●
3		**Aviation Assets**							
	1	Search and Rescue - Helicopter	●						●
	2	Oil Spill Dispersant - Aircraft	●						
4		**Wind Farm Assets**							
	1	AIS Base Station on / depicting wind farm	●						
	2	VTS Radar on wind farm	●						
	3	Marks and Lights	●				●		
	4	Sound Signals	●				●		
	5	CCTV	●						
5		**Wind Farm Control Room Assets**							
	1	AIS monitoring	●				●		
6		**Coast State Shore-based Assets**							
	1	Marine Radar, Navigation and Communications Systems	●				●		
	2	Marine Rescue Coordination Centres	●						●
	3	Vessel Traffic Service	●				●		
	4	Shore Radar	●				●		
	5	Lighthouses	●				●		
7		**Coast State Marine Assets**							
	1	Buoys	●				●		
	2	Marks and Lights	●				●		
	3	External Assets	●						
	4	GPS and Galileo	●				●		
8		**Other Assets**							
	1	Pilot Services	●				●		
	2	Charts	●				●		
1		**Consent**							
	1	Deny consent to the wind farm				●	●		
2		**Configuration and Design**							
	1	Optimise location, alignment, size and layout			●		●		
	2	Minimum safe (air) clearances [MGN 275 (M) Annex 1 Para 2]					●		
3		**Site Designation**							
	1	Designation of the site as an area to be avoided (ATBA) [MGN 275 (M)]				●	●		
	2	Safety zones of appropriate configuration, extent and application to specified vessels [MGN 275 (M)]				●	●		
	3	Marine traffic safety zone.				●	●		
4		**Routeing and Routeing Management**							
	1	Implementation of routeing measures within or near the development [MGN 275 (M)]				●	●		
	2a	Manage traffic through VTS from Wind Farm Control Centre				●	●		
	2b	Manage traffic through VTS from MCA Control Centre				●	●		
	3a	Alert traffic via AIS tracking in Wind Farm Control Centre			●				

Description			Risk Control Type				Risk Control Effect		
C1			Asset	Rule	Good Practice	Option	Prevention	Mitigation	Emergency Response
	3b	Alert traffic via AIS tracking in MCA Control Centre			●				
	4a	Continuous watch by multi-channel VHF, including Digital Selective Calling (DSC) from Wind Farm Control Centre [MGN 275 (M)]			●		●		
	4b	Continuous watch by multi-channel VHF, including Digital Selective Calling (DSC) from MCA control centre [MGN 275 (M)]			●		●		
	5a	Monitoring by radar, AIS and/or closed circuit television (CCTV) from wind farm Control Centre [MGN 275 (M)]				●	●		
	5b	Monitoring by radar, AIS and/or closed circuit television (CCTV) from MCA Control Centre [MGN 275 (M)]				●	●		
	6	Remote radar (and AIS) sensing by pilot for remote pilotage							
	7	Appropriate means to notify and provide evidence of the infringement of ATBA's, or safety zones [MGN 275 (M)]				●	●		
	8	Speed limits to control wash			●		●		
	9	VHF broadcast messages by transiting ships				●	●		
5		**Marking**							
	1	External Marking of Offshore wind farms		●			●		
		[GLA Requirements. Based on IALA Recommendation O-117 On The Marking of Offshore wind farms Edition 2]							
	2	Internal Marking of Offshore wind farms		●			●		
	3	Marking of Individual Structures		●			●		
		[MGN 275 Annex 4 Section 1.1]							
	4	Marking of Groups of Structures (Wind Farm)		●			●		
	5	Other navigational aids				●	●		
6		**Communication and Training**							
	1	Promulgation of information and warnings through notices to mariners and other appropriate media. [MGN 275 (M)] MCA website "Navigation Safety" info.		●	●		●		
	2	Marking on Navigation Charts		●			●		
	3	Adding wind farm navigation training to mariner training syllabuses				●			
7		**Removing need for Navigation**							
	1	Turbine integrity reducing need for maintenance.				●	●		
	2	Strength of foundation design.				●	●		
8		**Safety Management**							
	1	Operator's Safety Management System			●			●	
	2	Operators Safety and Operations Plan			●			●	
	3	Operators Emergency Plan			●			●	
	4	Local and National Emergency Plans			●			●	
	5	Contingency plan if GPS switched off/failed							
	6	Active Safety Management System (MGN 275 Annex 4)	●				●	●	●
9		**Regulatory**							
	1	Application of the principles of the Port Marine Safety Code to wind farms				●			
	2	Mandatory switching on of AIS in and around wind farms				●			
	3	Mandatory fishing boat tracking systems switched on in and around wind farms				●			
	4	Mandatory leisure craft "AIS" switched on in and around wind farms				●			
10		**Search and Rescue**							
	1	SAR response planning.			●			●	
	2	SAR asset provision planning.			●			●	
	3	Turbine mast design (e.g. including safe refuge).		●			●	●	
		Standards and procedures for wind turbine generator shutdown [MGN 275 (M) Annex 4]		●					
11		**Emergency Planning**							
	1	Salvage response planning.			●			●	
	2	Salvage asset provision planning.			●			●	
	3	Oil Spill response planning			●			●	
	4	Oil Spill asset provision planning			●			●	

Table 32 - Example Risk Control Checklist

G.3 Example of MCA Wind Farm Application Check Off List for MGN 275 Compliance

It is suggested that developers prepare, as part of their submission, a self-declaration against the MCA's MGN 275 checklist.

In considering an application the MCA will check to ensure that all aspects of MGN 275 have been considered, and addressed or discounted, where necessary or appropriate. This check off list assures such compliance. Applicants that fail to demonstrate compliance with MGN 275, or discount inapplicable elements, risk prejudicing the timely consideration of their applications since it may then be necessary to seek amplifying information to substantiate arguments or assumptions.

	MGN 275 Reference		Yes	No	Remarks
	Annex 1 - Considerations on Site Position, Structures and Safety Zones				
1	**Traffic Survey**				
		All vessel types			
		four weeks duration, within 12 months prior to submission of the Environmental Statement			
		Seasonal variations			
		Recreational and fishing vessel organisations			
		Port and navigation authorities			
	a.	Proposed OREI site relative to areas used by any type of marine craft.			
	b.	Numbers, types and sizes of vessels presently using such areas			
	c.	Non-transit uses of the areas, e.g. fishing, day cruising of leisure craft, racing, aggregate dredging, etc.			
	d.	Whether these areas contain transit routes used by coastal or deep-draught vessels on passage.			
	e.	Alignment and proximity of the site relative to adjacent shipping lanes			
	f.	Whether the nearby area contains prescribed routeing schemes or precautionary areas			
	g.	Whether the site lies on or near a prescribed or conventionally accepted separation zone between two opposing routes			
	h.	Proximity of the site to areas used for anchorage, safe haven, port approaches and pilot boarding or landing areas.			
	i.	Whether the site lies within the limits of jurisdiction of a port and/or navigation authority.			
	j.	Proximity of the site to existing fishing grounds, or to routes used by fishing vessels to such grounds.			
	k.	Proximity of the site to offshore firing/bombing ranges and areas used for any marine military purposes.			
	l.	Proximity of the site to existing or proposed offshore oil / gas platform, marine aggregate dredging, marine archaeological sites or wrecks, or other exploration/exploitation sites			
	m.	Proximity of the site relative to any designated areas for the disposal of dredging spoil			
	n.	Proximity of the site to aids to navigation and/or Vessel Traffic Services (VTS) in or adjacent to the area and any impact thereon.			
	o.	Researched opinion using computer simulation techniques with respect to the displacement of traffic and, in particular, the creation of 'choke points' in areas of high traffic density.			

	MGN 275 Reference	Yes	No	Remarks
2	**OREI Structures**			
	a. Whether any features of the OREI, including auxiliary platforms outside the main generator site and cabling to the shore, could pose any type of difficulty or danger to vessels underway, performing normal operations, or anchoring			
	• Clearances of wind turbine blades above the sea surface not less than 22 metres			
	• Least depth of current turbine blades			
	• The burial depth of cabling			
	b. Whether any feature of the installation could create problems for emergency rescue services, including the use of lifeboats, helicopters and emergency towing vessels (ETVs)			
	c. How rotor blade rotation and power transmission, etc., will be controlled by the designated services when this is required in an emergency.			
3	**Assessment of Access to and Navigation Within, or Close to, an OREI**			
	To determine the extent to which navigation would be feasible within the OREI site itself by assessing whether:			
	a. Navigation within the site would be safe:			
	i. by all vessels, or			
	ii. by 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:			
	i. prohibited by specified vessels types, operations and/or sizes. ii. prohibited in respect of specific activities, iii. prohibited in all areas or directions, or iv. prohibited in specified areas or directions, or v. prohibited in specified tidal or weather conditions, or simply vi. recommended to be avoided.			
	c. Exclusion from the site could cause navigational, safety or routeing problems for vessels operating in the area.			
	Note: Relevant information concerning a decision to seek a "safety zone" for a particular site during any point in its construction, operation or decommissioning must be presented.			
	Annex 2 - Navigation, collision avoidance and communications			
1	**The Effect of Tides and Tidal Streams :**			
	It should be determined whether or not:			
	i. 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.			
	ii. Set and rate of the tidal stream, at any state of the tide, has a significant affect on vessels in the area of the OREI site.			
	iii. Maximum rate tidal stream runs parallel to the major axis of the proposed site layout, and, if so, its effect.			
	iv. The set is across the major axis of the layout at any time, and, if so, at what rate.			
	v. In general, whether engine failure or other circumstance could cause vessels to be set into danger by the tidal stream.			
	vi. Structures themselves could cause changes in the set and rate of the tidal stream.			
	vii. Structures in the tidal stream could be such as to produce siltation, deposition of sediment or scouring, affecting navigable water depths in the wind farm area or adjacent to the area			
	Note: A hydrographic survey of the site and its immediate environs has been undertaken to establish a baseline. Such a survey should be undertaken to at least International Hydrographic Organization (IHO) Order 1 standard multibeam bathymetry, with final data being supplied as a digital full density data set, and erroneous soundings flagged as deleted but included in the data set.			
2	**Weather:**			
	To determine if:			
	i. The site, in normal, bad weather, or restricted visibility conditions, could present difficulties or dangers to craft, including sailing vessels, which might pass in close proximity to it.			
	ii The structures could create problems in the area for vessels under sail, such as wind masking, turbulence or sheer.			
3	**Visual Navigation and Collision Avoidance:**			
	To assess the extent to which:			
	i. Structures could block or hinder the view of other vessels under way on any route.			
	ii. Structures could block or hinder the view of the coastline or of any other navigational feature such as aids to navigation, landmarks, promontories, etc			

	MGN 275 Reference	Yes	No	Remarks
4	**Communications, Radar and Positioning Systems:**			
	To provide researched opinion of a generic and, where appropriate, site specific nature concerning whether or not			
	i. Structures could produce radio interference such as shadowing, reflections or phase changes, with respect to any frequencies used for marine positioning, navigation or communications, including Automatic Identification Systems (AIS), whether ship borne, ashore or fitted to any of the proposed structures.			
	ii. Structures could produce radar reflections, blind spots, shadow areas or other adverse effects:			
	a. Vessel to vessel			
	b. Vessel to shore;			
	c. VTS radar to vessel;			
	d. Racon to/from vessel.			
	iii. OREI, in general, would comply with current recommendations concerning electromagnetic interference.			
	iv. Structures and generators might produce sonar interference affecting fishing, industrial or military systems used in the area.			
	v. Site might produce acoustic noise which could mask prescribed sound signals.			
	vi. Generators and the seabed cabling within the site and onshore might produce electro-magnetic fields affecting compasses and other navigation systems.			
5	**Marine Navigational Marking:**			
	To determine:			
	i. How the overall site would be marked by day and by night taking into account that there may be an ongoing requirement for marking on completion of decommissioning, depending on individual circumstances.			
	ii. How individual structures on the perimeter of and within the site, both above and below the sea surface, would be marked by day and by night.			
	iii. If the site would be marked by one or more racons and/ or,			
	iv. If the site would be marked by an Automatic Identification System (AIS) transceiver, and if so, the data it would transmit.			
	v. If the site would be fitted with a sound signal, and where the signal or signals would be sited			
	vi. Whether the proposed site and/or its individual generators would comply in general with markings for such structures, as required by the relevant General Lighthouse Authority (GLA) or recommended by the Maritime and Coastguard Agency, respectively.			
	vii. 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.			
	viii. 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.			
	Annex 3 - Safety and mitigation measures recommended for OREI during construction, operation and decommissioning.			
	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 Maritime and Coastguard Agency and will be listed in the developer's Environmental Statement (ES). These will be consistent with international standards contained in, for example, the Safety of Life at Sea (SOLAS) Convention - Chapter V, IMO Resolution A.572 (14)3 and Resolution A.671(16)4 and could include any or all of the following:			
	i. Promulgation of information and warnings through notices to mariners and other appropriate media.			
	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. Implementation of routeing measures within or near to the development.			
	vi. Monitoring by radar, AIS and/or closed circuit television (CCTV).			
	vii. Appropriate means to notify and provide evidence of the infringement of safety zones or ATBA's.			
	viii. Any other measures and procedures considered appropriate in consultation with other stakeholders.			
	Annex 4 - Standards and procedures for wind turbine generator shutdown in the event of a search and rescue, counter pollution or salvage incident in or around a wind farm			
1	**Design Requirements**			
	The wind farm should be designed and constructed to satisfy the following design requirements for emergency rotor shut-down in the event of a search and rescue (SAR), counter pollution or salvage operation in or around a wind farm:			

	MGN 275 Reference	Yes	No	Remarks
	i. All wind turbine generators (WTGs) will be marked with clearly visible unique identification characters. The identification characters shall each 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 contact with it. The size of the identification characters in combination with the lighting should be such that, under normal conditions of visibility and all known tidal conditions, they are clearly readable by an observer, stationed 3 metres above sea levels, and at a distance of at least 150 metres from the turbine. It is recommended that lighting for this purpose be hooded or baffled so as to avoid unnecessary light pollution or confusion with navigation marks. (Precise dimensions to be determined by the height of lights and necessary range of visibility of the identification numbers).			
	ii. All WTGs should be equipped with control mechanisms that can be operated from the Central Control Room of the wind farm.			
	iii. Throughout the design process for a wind farm, appropriate assessments and methods for safe shutdown should be established and agreed, through consultation with MCA and other emergency support services.			
	iv. The WTG control mechanisms should allow the Control Room Operator to fix and maintain the position of the WTG blades as determined by the Maritime Rescue Co-ordination Centre or Maritime Rescue Sub Centre (MRCC/SC).			
	v. Nacelle hatches should be capable of being opened from the outside. This will allow rescuers (e.g. helicopter winch-man) to gain access to the tower if tower occupants are unable to assist and when sea-borne approach is not possible.			
	vi. Access ladders, although designed for entry by trained personnel using specialised equipment and procedures for turbine maintenance in calm weather, could conceivably be used, in an emergency situation, to provide refuge on the turbine structure for distressed mariners. This scenario should therefore be considered when identifying the optimum position of such ladders and take into account the prevailing wind, wave and tidal conditions.			
2	**Operational Requirements**			
	i. The Central Control Room should be manned 24 hours a day.			
	ii. The Central Control Room operator should have a chart indicating the Global Positioning System (GPS) position and unique identification numbers of each of the WTGs in the wind farm.			
	iii. All MRCC/SCs will be advised of the contact telephone number of the Central Control Room.			
	iv. All MRCC/SCs will have a chart indicating the GPS position and unique identification number of each of the WTGs in all wind farms.			
3	**Operational Procedures**			
	i. Upon receiving a distress call or other emergency alert from a vessel which is concerned about a possible contact with a WTG or is already close to or within the wind farm, the MRCC/SC will establish the position of the vessel and the identification numbers of any WTGs which are visible to the vessel. The position of the vessel and identification numbers of the WTGs will be passed immediately to the Central Control Room by the MRCC/SC.			
	ii. The control room operator should immediately initiate the shut-down procedure for those WTGs as requested by the MRCC/SC, and maintain the WTG in the appropriate shut-down position, again as requested by the MRCC/SC, until receiving notification from the MRCC/SC that it is safe to restart the WTG.			
	iii. Communication and shutdown procedures should be tested satisfactorily at least twice a year			

Table 33 - MCA Wind Farm Application Check Off List for MGN 275 Compliance

H1 Terms, Abbreviations & References

H.1.1 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	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
4	Fire	Fire is defined as the uncontrolled process of combustion characterised by heat or smoke or flame or any combination of these.
5	Explosion	An explosion is defined as an uncontrolled release of energy which causes a pressure discontinuity or blast wave.
6	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.
7	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.
8	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.
9	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).
10	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.
11	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.
12	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.
13	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.
14	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.[41]
15	Capsizing	The overturning of a vessel after attaining negative stability

Table 34 - Marine Accident Categories

[41] This definition is interpreted from MGN 275 rather that a generally recognised marine accident category.

H.1.2 Risk Terms used in this Methodology

Term	Definition
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.
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.
Frequency	The number of occurrences per unit time (e.g. per year).
Hazard	A potential to threaten human life, health, property of the environment.
Individual Risk	A direct measure of the frequency of fatalities for individuals.
Initiating Event	The first in a sequence of events leading to a hazardous situation or accident.
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.
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.

Table 35 - Risk Terms used in this Methodology

H.1.3 Abbreviations used in this Methodology

	Full Name
AIS	Automatic Identification System
BMT	British Maritime Technology
CBA	Cost Benefit Analysis
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CPA	Coast Protection Act 1949
CURR	Cost per Unit Reduction of Risk
DEFRA	Department for Environment, Food & Rural Affairs
DFT	Department for Transport (in the UK)
DTI	Department of Trade and Industry (in the UK)
DTLR	Department of Transport, Local Government and the Regions
ER	Emergency Response
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
GCAF	Gross Cost of Averting a Fatality
HAZOP	Hazard and Operability Studies
HSE	Health and Safety Executive
IMO	International Maritime Organisation
LOHI	Loss of Hull Integrity
MCA	Maritime and Coastguard Agency
MGN	Marine Guidance Note
MRCC	Maritime Rescue Co-ordination Centre
MRSC	Maritime Rescue Sub Centre
MSN	Merchant Shipping Notice
NCAF	Net Cost of Averting a Fatality
NCP	National Contingency Plan
OSIS	Oil Spill Information System
PLL	Potential Loss of Life
RAF	Royal Air Force
RCM	Risk Control Measure
RCO	Risk Control Option
RNLI	Royal National Lifeboat Institution
RPPP	HSE Document Reducing Risks, Protecting People
RZPZ	HSE Document Reducing Risks, Protecting People
SAR	Search and Rescue
SARIS	Search and Rescue Information System
SRMD	Search and Rescue Methodology Database
VTS	Vessel Traffic System

Table 36 - Abbreviations Used in this Methodology

H.1.4 References

Ref	Title
1	Project FRCA/005/000/12P "Methodology for Assessing the Marine Navigational Safety Risks of Offshore Wind Farms. DTI 29th November 2005
2	MGN 275: Marine Guidance Note 275(M) "Proposed UK Offshore Renewable Energy Installations (OREI) – Guidance on Navigational Safety Issues." Maritime and Coastguard Agency, August 2004. This is available from http://www.mcga.gov.uk/in the "Guidance and Regulations" section.
3	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
8	Merchant Shipping Notice 1781 (M + F) "The Merchant Shipping (Distress Signals and Prevention of Collisions Regulations) 1996" The Maritime and Coastguard Agency, May 2004. This is available from www.mcga.gov.uk in the "Guidance and Regulations" section.
11	Merchant Shipping Notice MSN 1781 (M + F) The Merchant Shipping (Distress Signals and Prevention of Collisions) Regulations 1996. (From www. mcga.gov.uk, Guidance and Regulations, Merchant Shipping Notices)
31	ISO 9000:2000 TickIT Guide
Various	"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" MCA website: www.mcga.gov.uk, hence Safety Information / Navigation Safety, OREI.

Table 37 –Some References used in this Methodology

Appendix A

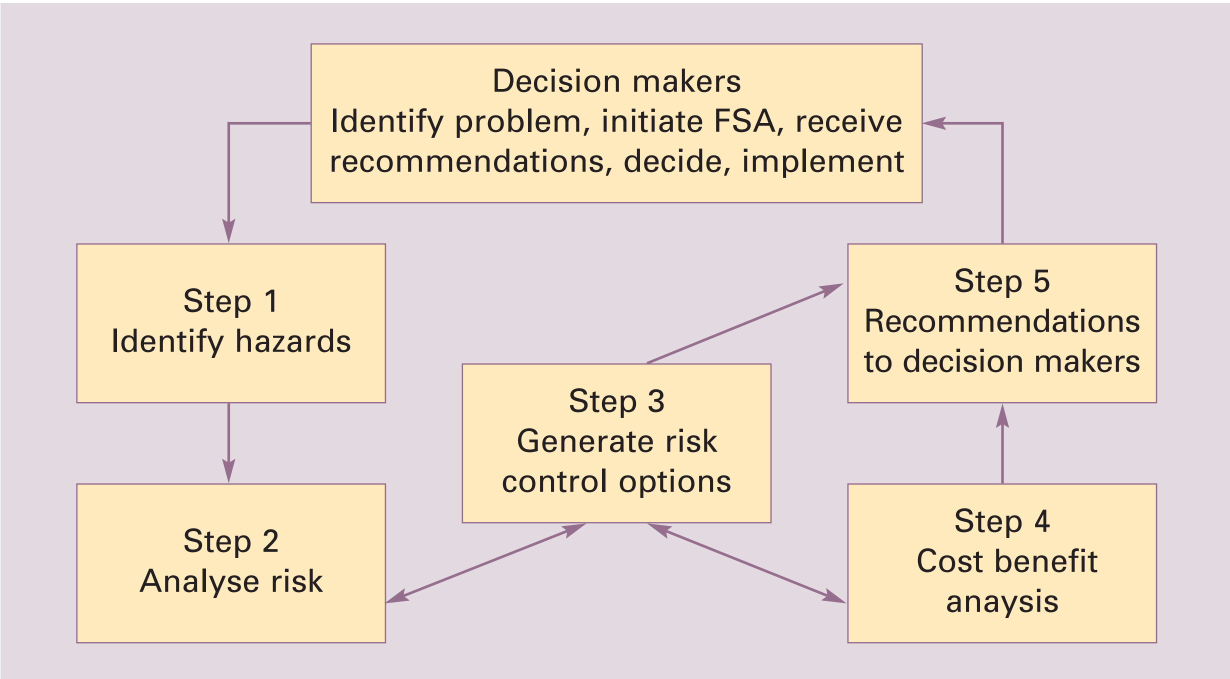
Formal Safety Assessment (FSA) Notes

The following information is taken from the data posted on the Maritime and Coastguard Agency's web site by its Risk, Analysis and Prevention Branch. The full documents can be obtained by accessing www.mcga.gov.uk, thence "Safety Information" and "FSA" The sections that follow have been selected as appropriate for offshore wind farm use.

About the FSA

Formal Safety Assessment is a structured, systematic five-step methodology, aimed at enhancing maritime safety including the protection of life, health, the marine environment and property using risk analysis, cost benefit analysis and regulatory influence diagrams to facilitate decision making.

The FSA Methodology



FSA evaluates not only that a particular measure will improve maritime safety or pollution prevention but also by how much and at what cost. FSA also ensures that safety measures are equitable by identifying who carries the risk, who benefits from the reduction in risk and who bears the cost.

FSA comprises of five steps, as follows:

- Identification of hazards.
- Assessment of the risks associated with those hazards.
- Consideration of alternative ways of managing those risks.
- Cost benefit assessment of alternative risk management options.
- Decisions on which option to select.

Objectives

The objective of this paper is to outline a systematic and robust methodology for Step 2 of FSA, i.e. for assessing the risks arising from the hazards to which vessels are exposed. The methodology is generic in character, encompassing and evaluating in a consistent way risks arising from different sources and allows their relative significance to be assessed. It is important to be able to trace these various sources of risk to their more fundamental underlying causes such that appropriate regulations can be found.
The work carried out within the Formal Safety Assessment Branch can be applied to all aspects of the MCA and maritime industry and environmental issues to facilitate achieving the organisations' key targets and business activities.

Representation of Uncertainty in Step 2 Methodology

Background

Uncertainty is inherent in all risk assessment. It is important to assess the magnitude of the uncertainty to ensure that the input of the results into cost benefit analysis is realistic. This section describes how the areas of uncertainty arise in Step 2 in relation to:

- Uncertainty in the estimation of base case risk levels;
- Uncertainty in quantification of risk reduction measures; and
- The effects of uncertainty on the results.
- Additionally, a method for representing uncertainty in the results is given.

Uncertainty in Estimation of Base Case Risk Levels

The base case risk is quantified from historical data. This allows some confidence that the predicted risk levels are reasonable, and that they give an accurate indication of the areas of high risk. It is thus considered that there is likely to be less uncertainty associated with this methodology at this stage than with other possible methodologies. However there remains a number of areas of uncertainty in the analysis, such as:

- The applicability of historical data to the current situation; and
- Uncertainty in the completeness of the data

The applicability of historical data to the current situation

Over a period of time there are likely to be changes to the risks associated with a system. This might be due to older equipment being replaced by modern items, degradation of existing equipment and structures, changes in management systems, changes in operating conditions etc. These will tend to move the actual risk levels away from the average historical levels, so that the present-day risk is different from the risk used as a basis for calculation. The net result is often a lowering of the risk over a period of time.

However such changes are usually very slow to occur and often have a minimal impact on accident statistics over, say, a ten year period. In the shipping industry in particular there is unlikely to be a sudden step-change in overall risk levels as vessels are likely to trade for over 20 years and practices evolve rather than being replaced by entirely novel methods. It is thus expected that this will have a small impact on the uncertainty inherent in the analysis.

Uncertainty in the completeness of the data

It is extremely unlikely that every accident will be reported. This will lead to an historical risk level that is lower than the risk in reality. This is expected to be the major cause of uncertainty in the estimation of the base case risk levels. The shipping industry is very diverse, and there is no central body to which all accidents must be reported.

However, there are a number of organisations that collect shipping accident data and it is very likely that major accidents, particularly those involving loss of life, or major pollution will be known by those organisations. It is thus expected that, whilst there will be some uncertainty in the results, the high-risk areas will have been adequately identified.

Uncertainty in Quantification of Risk Reduction Measures

The results of the assessment of risk reduction measures will be subject to some uncertainty. The key areas of the analysis where uncertainty is expected to be the greatest are:

- The quantification of the effects of human factors;
- The use of engineering judgement; and
- The necessity for simplifying assumptions.

Risk reduction measures are evaluated by considering the change in factors that influence the magnitude, progression and initiating of an event. These factors are quantified in terms of their change from the average level, and hence if no change from the average is expected then no change to the risk is modelled. The exclusion of a factor from consideration thus implies that an average level is assumed. Hence the omission of possible influences on risk is likely to have a much smaller effect on the results than with other methodologies.

The Effects of Uncertainty on the Results

Each item of data will have an upper and lower band of uncertainty associated with it. The combined effects of all the uncertainties are to place a range on the results. The inputs to the risk assessment can be varied, and error bands can be put on the results, between which it is expected that the risk lie. Thus, the overall FN curve will have three lines on it:

- The maximum likely risk level;
- A best estimate of the risk; and
- The minimum likely risk level.

It is unlikely that all estimates will over-predict the risk, and it is equally unlikely that all will under-predict the risk. Indeed, some will over-predict and some will under-predict, with the errors partially counterbalancing each other and leading to results which are a cautious best estimate of risk.

It is therefore sensible to vary a few key assumptions, or items of data, in order to examine which are the most important. The item that most increases the risk, should be varied to its maximum limit to obtain the maximum likely risk level, and similarly the item which most decreases the risk should be varied to its minimum limit to obtain the minimum likely risk level.

When passing on results to other steps in the methodology, it is important that the uncertainty bounds are passed also, along with information on the key areas of uncertainty and what effect they might have on the risk levels.

Calculational Requirements

The application of the Step 2 methodology does not require any specialised software, although some of the many available fault tree analysis packages may prove useful in assisting the development of the progression trees. However, in common with the majority of current risk assessment methods, there would need to be a heavy reliance on the use of spreadsheets with overall structures, or macros, pre-programmed within them.

All the calculations involved in the process are relatively simple multiplication/division and addition/subtraction, however there are potentially a very large number of these to perform. In addition there is a need to “tag” different influences so that their effect on the complete picture, or only parts of it, can be accurately represented. So, for example the effect of improved training regimes on the overall risk could be assessed whether this may be on the initiation of an event, its progression, or the severity of the accident in terms of loss of life. Similarly, the relative contributions to these various areas of risk could be assessed and the principal intermediate causes or actions quantified. For example does the effect of training on improving inspection and housekeeping, produce a bigger risk reduction than improved fire-fighting or improved evacuation of passengers? What are the key assumptions/influences in driving these results? How sensitive are they to the assumptions, and was there a great divergence of opinion at the group session that set the value of the influences?

The spreadsheet structure would need to be devised as a result of the structuring of the risk contribution tree, the influence diagrams and the progression and magnitude trees, with the calculational interdependencies defined. Not all routes through the structure would of course be used for all events of interest, some would be unused by having null values. This spreadsheet would need to be developed by an experienced risk analyst with a mathematical bias, and would inevitably be refined as the process progressed.

Options for Step 2

Background to Development

A number of options can be considered in the application of the Step 2 FSA methodology. These are, amongst others:

- Hazard based risk assessment
- Hazard and operability (HAZOP) studies
- Failure modes and effects analysis (FMEA)
- Issues analysis
- Risk profile generation.
- Each of these options is considered in turn below.

Hazard Based Risk Assessment

This is the 'traditional' approach to risk assessment, and is based upon the following sequence of activities:
Define the system being studied.
Identify the hazards associated with that system.

- Assess the likelihood of the hazards occurring.
- Identify how each hazard might progress to various outcomes.
- Assess the likelihood of progression to each outcome.
- Assess the consequences associated with each outcome.
- Multiply likelihood and consequence to obtain the risk associated with each outcome.

Sum the risks associated with the outcomes to produce an overall risk

This is a very robust and systematic approach, and has been used for many years to assess risks in a large number of diverse industries, including the shipping industry. In addition, these eight steps listed above could be said to comprise a generic methodology for assessing risks and, as such, warrants consideration as an approach for the application of a FSA methodology. The above approach has several advantages, namely:

- It is a generic technique;
- It is very thorough;
- It easily leads to the identification of incident progression pathways;
- It attempts to recreate reality (i.e. hazards lead to accidents, which in turn have consequences).

The main disadvantage to this approach is that, although the sequence of steps is generic for all risk assessments, the analysis does not lead to a generic answer. This is due to the necessity to rigorously define the system being studied in order to identify the hazards associated with that system. Although such an approach is ideal when considering a specific vessel, the shipping industry is by nature a very diverse industry. Even so-called 'sister' ships often vary in ways that significantly affect the way in which it is operated or in the way that a hazard might progress to cause an accident. Thus, for this approach to be able to produce a realistic estimate of the risk to an entire class of vessels, a very large number of separate arrangements of hardware (engines, bulkheads, fuel systems, fire extinguishing systems, etc) and software (procedures) must be evaluated. Attempts to evaluate the overall risk levels by defining a 'typical' vessel will at best lead to a poor estimation of overall risks, and at worst divert attention from the real issues and lead to a net risk increase.

In addition, there are several other areas of difficulty and complexity associated with this approach:

- Often insufficient data exists on the likelihood of failures and on the potential for those failures to escalate e.g. the likelihood of a fuel leak in an engine room igniting or the proportion of steering gear failures that lead to a collision).
- All mitigating measures must be considered explicitly in order to examine the progress of the event.
- It is difficult for future updates to the analysis to incorporate novel risk reduction measures or changes to the system description. Typically, a large proportion of the analysis must be re-worked.

The approach is not easy to audit. Many fault trees and/or event trees are generally required to perform the analysis, and these are difficult to check.

HAZOP Studies

A HAZOP study is a generic methodology for formally identifying the hazards associated with a system. It can be combined with a risk assessment exercise (either ranking by experts or by more rigorous quantification) in order to assess the risk associated with that system.

A HAZOP study relies on several key items:

- A rigorously defined system to study;
- The use of appropriate keywords and guide-words;
- An experienced HAZOP team with complementary areas of knowledge.

As with the hazard-based risk assessment technique, this approach is generic and systematic. It has also been used for several years in many industries, and has proven its worth for hazard identification and, when combined with risk ranking, for simple risk assessment.

In order to utilise this technique for FSA purposes it is necessary to:

- Define appropriate keywords and guidewords;
- Define an appropriate level of risk assessment.

The lack of the above definition does not detract from the potential usefulness of this tool. The advantages of this approach are that it is:

- A generic technique;
- Very thorough;

- A visible process (i.e. it is possible to identify exactly which events have been considered);
  - Requires little knowledge of risk assessment techniques.

However, as previously discussed, techniques that rely on a very rigorous definition of the system being studied have several inherent disadvantages. In addition, other disadvantages are that:

- It does not lead easily to an explicit quantification of overall risk;
- The team members are limited by their personal experience;
- It is difficult to update the analysis over time;

FMEA

The FMEA technique is very similar to a HAZOP study, in that a defined system is considered in some detail, following a formalised procedure. Faults at the part/component level are identified and, using failure rates for the appropriate operating conditions, their effect on the system level is determined. Each part is considered in turn as having failed in each possible mode. The effect of each of these failures at various system levels is noted and a failure rate assigned from available data. Each system level failure mode will be seen to result from various possible component failures, and these can be grouped together for the purpose of calculating the system failure rate. Again, this approach is generic and systematic, and is a widely accepted technique for assessing the reliability of a system. The advantages to this approach are that it:

- Is a generic technique;
- Is very thorough;
- Easily leads to the identification of incident progression pathways.

Again, however, a detailed system definition is required. It suffers from the same disadvantages as the hazard-based approach. In addition it does not quantify the effects of failures, and so further work is required in order to estimate risk levels.

Issues Analysis

Issue analysis is a systematic approach to ensure that all key issues are identified with a lower chance of oversight. There are four tasks in the process:

- The first task requires that the overall over-riding issue should be identified.
- The second task breaks down the overall issue into issues and sub-issues in terms of simple statements of requirements; these must have yes or no answers as to whether they are correct or complied with or "not confirmed".
- The third task develops hypotheses from these sub-issues.
- The fourth task develops conclusions and recommendations.

This approach is very good for analysing a non-numerical problem in a logical and systematic way. It does not rely on a detailed system description, and can very quickly develop a logical basis from which decisions can be made or attention focused. The approach is highly visible, as a logical structure can be drawn showing the relationship between the issues and sub-issues, facilitating auditability. The disadvantage is that this method does not readily facilitate the analysing of a numerical problem, as the answers are all in terms of 'Yes/No'.

Risk Profile Generation

This approach is generic methodology for determining the risk profile of a type of vessel, system or function and for identifying the underlying causes which make up that risk profile. The first task is to classify the various causes of accidents. This allows the classification of risks into categories (e.g. 'Collision') and subcategories (eg. 'Collision caused by watch-keeping failure'). Secondly, the risk profile for a typical vessel of the type being considered is generated in the form of a logic tree structure, here called "the risk contribution tree". This process performed from the top down, as follows:

- The top-level risks are initially quantified (from historical data for established ship types).
- The second level risks are assigned by determining their contribution to the top-level risks.
- Similarly, any third or further level risks are assigned by determining their contribution to t he first level risks.
- This process is repeated until all risks have been quantified.

Once the risk profile has been generated, the underlying causes of the bottom level risks are determined. These are evaluated separately for factors that influence the frequency of an event occurring, factors that influence the progression of an event to cause loss and factors that influence the magnitude of the loss.

A logical structure is then developed showing the relationship between the various factors. In the initial base case, all the influencing factors are set at a value of 1.0, i.e. they neither raise nor lower the risk away from the historically observed value for an average vessel of that type. Once risk reduction measures are proposed, these factors are evaluated in terms of their influence on average risk levels, with a value of 1.2 indicating a 20% increase in the risk and a value of 0.8 indicating a 20% reduction in the risk.

Approach Adopted in this Paper

It is this latter approach of risk profile generation that has been adopted as the central methodology in this step. The risk profile process may be illustrated diagrammatically as a risk contribution tree. The purpose of the risk contribution tree is to structure the causes of accidents and apportion the contribution they make to the frequency of loss of life (as derived from the F-N, frequency - number of fatality curves).

The traditional approaches to risk assessment discussed above, and used in other industries are ideally suited to situations where the large accidents are rare events that cannot be reliably predicted, and where there is a need to reflect precise differences in design and operation of each individual plant or platform. In the case of shipping, however, there is a wealth of data on the major losses that have occurred and their immediate causes. The situation is different therefore from that in which Quantified Risk Assessment (QRA) techniques are normally used. In addition, the need in this case to generate a generic methodology precludes the approach of other industries as this is necessarily tailored to specific installations or operation by means of event trees which vary in structure.

The approach to apply is therefore one in which the risk to a typical vessel is determined (from historical data), and then broken down by various hazardous outcomes; multiplying factors (which may raise or lower risk for those outcomes away from the norm) are quantified.

The key elements of the methodology are therefore that it will:

- Minimise the use of complex event trees;
- Concentrate on "high level" issues and avoid the consideration of ship-specific aspects;
- Be modular, in order to allow future improvements to be slotted in or taken out as appropriate;
- Be flexible, in order to incorporate results and requirements from other projects running concurrently;
- Account for the possibility that risk reduction measures may raise some risks whilst lowering others.

The identification of three categories of influencing factors is consistent with the main components of risk, which are:

- Frequency
- Consequence
- Magnitude of impact.

Often consequence and impact are combined and termed "severity", however it is important to distinguish between them in the consideration of risk reduction. Clearly an accident can be a serious event in terms of damage to the ship without necessarily affecting the safety of people. At the extreme this may be because there are no people present, however in practice what is meant is the rapid removal of people from the incident or their effective protection from its effects. Therefore in this methodology, these three components have been addressed separately by using likelihood, progression, and magnitude factors. The quantification of the effect of different risk control options on these factors may be achieved in many different ways, using one of several techniques. One particularly useful method in this context however is that of the influence diagram approach which is a method of modelling the network of influences. These influences link failures at the operational level with their direct causes, and with the underlying organisational and regulatory influences.

Performance influencing factors represent the effect of underlying causes by operating on the direct causes. In addition to providing a qualitative tool for understanding the nature of these influences, the influence diagram can also be used as a predictive tool. Although the influence diagram approach has been developed in the context of human factors and failures it can also be applied to accidents primarily due to hardware failures or external events (e.g. extreme weather). It is also necessary to consider other causal influences introduced through the state of knowledge inherent in design approaches, material selection, construction technology and the operating environment to which ships are subjected. This knowledge is embedded in rules and regulations and supporting design, construction and operational practice.

This largely top down analysis also make the best use of the relatively good data available at the major accident level. This does not, however, imply that the methodology will only address accidents that have happened in a reactive way. The essential feature of the methodology is the generation of a generic risk profile for a vessel type where the factors that may affect this risk, whether in terms of likelihood, progression or magnitude of fatalities, are explicit and may be varied to reflect changes in operation, design or safety measures aided by appropriate influence diagrams. By trying to understand the underlying causes, therefore, the method becomes a proactive tool rather than reactive. This top down approach has been successfully used in a number of other applications:

- In the railway industry to determine the causes of fatalities at level crossings, and also to determine the necessity for ATP (Automatic Train Protection) systems.
- In the nuclear industry to determine the likelihood of degraded cores from loss of coolant accidents.
- In the offshore industry in two ways; to evaluate events which can cause impairment of safety functions in the Norwegian concept safety evaluation and, on a Liverpool Bay Oil storage barge to modify tanker fire and explosion data for the enhanced operational and human factors situation.

Appendix B

MARINE GUIDANCE NOTE
MGN 275 (M)

Proposed UK Offshore Renewable Energy Installations (OREI) - Guidance on Navigational Safety Issues.

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

Summary

This guidance note highlights issues that need to be taken into consideration when assessing the impact on navigational safety from offshore renewable energy developments, proposed for United Kingdom internal waters, territorial sea or in a Renewable Energy Zone, when established, beyond the territorial sea.

Key Points

- The recommendations in this guidance note should be used, primarily, by offshore renewable energy installation developers, seeking consent to undertake marine works.
- Specific annexes address issues covering; site position, structures and safety zones (Annex 1), developments, navigation, collision avoidance and communications (Annex 2), safety and mitigation measures recommended for OREI during construction, operation and decommissioning (Annex 3), search and rescue matters (Annex 4), Section 36 of the Electricity Act 1989, as amended by the Energy Act 2004 (Annex 5) and Article 60 of the United Nations Convention on the Law of the Sea (UNCLOS) (Annex 6).

1 Introduction:

1.1 Offshore Renewable Energy Installations (OREI) include off s h o re wind farms, marine current turbines, wave generators and any other installation, with the potential to affect marine navigation and safety, proposed for United Kingdom (UK) internal waters, territorial sea or in a Renewable Energy Zone (REZ), when established, beyond the territorial sea.

1.2 Recommendations in this guidance note should be taken into account by 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. Additional information on the process for consenting off shore windfarms and the regulatory framework is available from the Offshore Renewables Consents Unit of Department for Trade and Industry (DTI)[1]. It should be noted, however, that DTI is not responsible for consenting projects in Northern Ireland internal and territorial waters.

1.3 The considerations and criteria contained in the attached annexes are intended to address the navigational impact of OREI proposed for UK sites. Their development necessitates the establishment of a clear consents process to deal with potential detrimental effects. The consent regime must take account of local factors, national standards and international aspects which could influence the establishment of an OREI. Under the regime, consents will not be granted if OREIs are likely to interfere with the use of recognised sea lanes essential to international navigation.

1.4 The Energy Act 2004 establishes a regulatory regime for OREI beyond territorial waters, in the UK's REZ, and supplements the regime which already applies in Great Britain's internal and territorial waters. Section 99 of the Act deals 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. The text of section 36, as amended by the Energy Act, is attached at Annex 5. Under 36B(1) a consent cannot be granted for an OREI which is likely to interfere with the use of recognised sea lanes essential to international navigation. This term is married at 36B(7) to Article 60(7) of the United Nations Convention on the Law of the Sea. The text of Article 60 is attached at Annex 6. 36B(2) consolidates into section 36 the provisions of section 34 of the Coast Protection Act 1949

1.5 The recommendations have been developed in consultation with DTI, the devolved government authorities for 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 support services such as the Royal National Lifeboat Institution (RNLI).

2. How and when the recommendations should be used.

2.1 This Guidance Note, as the name implies, is intended for the guidance of developers and others. Whilst non mandatory, failure to heed the guidance may result in delaying the consents 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), Environmental Impact Assessments (EIA) and resulting Environmental Statements (ES).

2.2 These should evaluate all navigational possibilities, which could be reasonably foreseeable, by which the siting, construction, establishment

[1] www.dti.gov.uk/energy/leg_and_reg/consents/guidance.pdf

and decommissioning of an OREI could cause or contribute to an obstruction of, or danger to, navigation or marine emergency services. They should also be used to assess the most favourable options to be adopted.

2.3 Potential navigational or communications difficulties caused to any mariners or emergency services using the site area and its environs should be assessed. Those difficulties which could contribute to a marine casualty leading to injury, death or loss of property, either at sea or amongst the population ashore, should be highlighted as well as those affecting emergency services. Consultation with local and national search and rescue authorities should be initiated and consideration given to the types of vessels and equipment which might be used in emergencies. This should include the possible use of OREI structures as emergency refuges.

2.4 Assessments should be made of the consequences of ships deviating from normal routes or recreational craft entering shipping routes in order to avoid proposed sites. 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 etc.

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

3. Annexes:

3.1 The recommendations contained there in apply to all sites, whether within the jurisdiction of port limits or in open sea areas. However, port authorities may require developers to comply with their own specific criteria. In addition, where proposals within port limits could affect navigation or emergency planning, the port authorities will be under an obligation to review its safety management system, in accordance with the Port Marine Safety Code. Such reviews should be undertaken in parallel with the OREI developer's Environmental Impact Assessment and the outcome addressed in the resulting Environmental Statement.

3.2 OREI developers should comply with the recommendations during all phases of their planning, construction, operation and decommissioning.

3.3 Information concerning their navigational impact during these four phases should be promulgated in ample time to all relevant mariners, organisations and authorities.

3.4 Contingency arrangements to deal with marine casualties in, or adjacent to sites, including responses to environmental pollution, should be planned, and practised to test their efficiency.

3.5 The following annexes contain recommendations on:

Annex 1: Considerations on site position and structure.

Annex 2: Navigation, collision avoidance and communications.

Annex 3: Safety and mitigation measures recommended for OREI during construction, operation and decommissioning.

Annex 4: S tandards and procedures for wind turbine generator shutdown in the event of a search and rescue, counter pollution or salvage incident in or around a wind farm.

3.6 The following annexes contain regulatory extracts:

Annex 5: Section 36 of the Electricity Act 1989 (as amended by the Energy Act 2004).

Annex 6: Article 60 of the United Nations Convention on the Law of the Sea (UNCLOS), relating to artificial islands, installations and structures in the exclusive economic zone.

3.7 **Note:** *The Maritime and Coastguard Agency (MCA) reserves the right to vary or modify these recommendations on the basis of experience or in accordance with internationally recognised standards in the interest of safety of life at sea and protection of the marine environment. As other types of offshore renewable energy installations are developed, new annexes to this document will be introduced and a revision of this Marine Guidance Note will be issued.*

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Annex 1. Considerations on Site Position, Structures and Safety Zones

1. Traffic Survey

An up to date[2] traffic survey of the area concerned should be undertaken. This should include all vessel types and is likely to total at least four weeks duration but also taking account of seasonal variations in traffic patterns. These variations should be determined in consultation with representative recreational and fishing vessel organisations, and, where appropriate, port and navigation authorities. Whilst recognising that site-specific factors need to be taken into consideration, any such survey should, in general, assess:

a. Proposed OREI site relative to areas used by any type of marine craft.
b. Numbers, types and sizes of vessels presently using such areas.
c. Non-transit uses of the areas, e.g. fishing, day cruising of leisure craft, racing, aggregate dredging, etc.
d. Whether these areas contain transit routes used by coastal or deep-draught vessels on passage.
e. Alignment and proximity of the site relative to adjacent shipping lanes.
f. Whether the nearby area contains prescribed routeing schemes or precautionary areas.
g. Whether the site lies on or near a prescribed or conventionally accepted separation zone between two opposing routes.
h. Proximity of the site to areas used for anchorage, safe haven, port approaches and pilot boarding or landing areas.
i. Whether the site lies within the limits of jurisdiction of a port and/or navigation authority.
j. Proximity of the site to existing fishing grounds, or to routes used by fishing vessels to such grounds.
k. Proximity of the site to offshore firing/bombing ranges and areas used for any marine military purposes.
l. Proximity of the site to existing or proposed offshore oil / gas platform, marine aggregate dredging, marine archaeological sites or wrecks, or other exploration/exploitation sites.
m. Proximity of the site relative to any designated areas for the disposal of dredging spoil.
n. Proximity of the site to aids to navigation and/or Vessel Traffic Services (VTS) in or adjacent to the area and any impact thereon.
o. Researched opinion using computer simulation techniques with respect to the displacement of traffic and, in particular, the creation of 'choke points' in areas of high traffic density.

2. OREI Structures

It should be determined:

a. Whether any features of the OREI, including auxiliary platforms outside the main generator site and cabling to the shore, could pose any type of difficulty or danger to vessels underway, performing normal operations, or anchoring.

   Such dangers would include clearances of wind turbine blades above the sea surface, the least depth of current turbine blades, the burial depth of cabling, etc.

[2] Within 12 months prior to the submission of the Environmental Statement

Note: Recommended minimum safe (air) clearances between sea level conditions at mean high water springs (MHWS) and wind turbine rotors are that they should be suitable for the vessels types identified in the traffic survey but generally not less than 22 metres. Depths, clearances and similar features of other OREI types which might affect marine safety should be determined on a case by case basis.

b. Whether any feature of the installation could create problems for emergency rescue services, including the use of lifeboats, helicopters and emergency towing vessels (ETVs)
c. How rotor blade rotation and power transmission, etc., will be controlled by the designated services when this is required in an emergency.

Note: Annex 4 of this document details HM Coastguard recommended standards and procedures for the use of an Active Safety Management System (ASMS) in the event of an incident in or around an offshore wind farm.

3. Assessment of Access to and Navigation Within, or Close to, an OREI

To determine the extent to which navigation would be feasible within the OREI site itself by assessing whether:

a. Navigation within the site would be safe :
i. by all vessels, or
ii. by 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 :
i. prohibited by specified vessels types, operations and/or sizes.
ii. ii. prohibited in respect of specific activities,
iii. prohibited in all areas or directions, or
iv. prohibited in specified areas or directions, or
v. prohibited in specified tidal or weather conditions, or simply
vi. recommended to be avoided.
c. Exclusion from the site could cause navigational, safety or routeing problems for vessels operating in the area.

Note : Relevant information concerning a decision to seek a “safety zone” for a particular site during any point in its construction, operation or decommissioning, should be promulgated to MCA and other interested parties without delay.

Annex 2. Navigation, collision avoidance and communications

1. The Effect of Tides and Tidal Streams:

It should be determined whether or not:

i. 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.

ii. Set and rate of the tidal stream, at any state of the tide, has a significant affect on vessels in the area of the OREI site.
iii. Maximum rate tidal stream runs parallel to the major axis of the proposed site layout, and, if so, its effect.
iv. The set is across the major axis of the layout at any time, and, if so, at what rate.
v. In general, whether engine failure or other circumstance could cause vessels to be set into danger by the tidal stream.
vi. Structures themselves could cause changes in the set and rate of the tidal stream.
vii. Structures in the tidal stream could be such as to produce siltation, deposition of sediment or scouring, affecting navigable water depths in the windfarm area or adjacent to the area.

Note: In relation to Sub Paragraph vii above, it is considered necessary that a hydrographic survey of the site and its immediate environs be undertaken to establish a baseline. Such a survey should be undertaken to at least International Hydrographic Organization (IHO) Order 1 standard multibeam bathymetry , with final data being supplied as a digital full density data set, and erroneous soundings flagged as deleted but included in the data set.

2. Weather:

To determine if:

i. The site, in normal, bad weather, or restricted visibility conditions, could present difficulties or dangers to craft, including sailing vessels, which might pass in close proximity to it.
ii. The structures could create problems in the area for vessels under sail, such as wind masking, turbulence or sheer.

3. Visual Navigation and Collision Avoidance:

To assess the extent to which:

i. Structures could block or hinder the view of other vessels under way on any route.
ii. Structures could block or hinder the view of the coastline or of any other navigational feature such as aids to navigation, landmarks, promontories, etc.

4. Communications, Radar and Positioning Systems:

To provide researched opinion of a generic and, where appropriate, site specific nature concerning whether or not:

i. Structures could produce radio interference such as shadowing, reflections or phase changes, with respect to any frequencies used for marine positioning, navigation or communications, including Automatic Identification Systems (AIS), whether ship borne, ashore or fitted to any of the proposed structures.
ii. Structures could produce radar reflections, blind spots, shadow areas or other adverse effects:
    a. Vessel to vessel;
    b. Vessel to shore;
    c. VTS radar to vessel;
    d. Racon to/from vessel.

iii. OREI, in general, would comply with current recommendations concerning electromagnetic interference.
iv. Structures and generators might produce sonar interference affecting fishing, industrial or military systems used in the area.
v. Site might produce acoustic noise which could mask prescribed sound signals.
vi. Generators and the seabed cabling within the site and onshore might produce electro-magnetic fields affecting compasses and other navigation systems.

5. Marine Navigational Marking:

To determine:

i. How the overall site would be marked by day and by night taking into account that there may be an ongoing requirement for marking on completion of decommissioning, depending on individual circumstances.
ii. How individual structures on the perimeter of and within the site, both above and below the sea surface, would be marked by day and by night.
iii. If the site would be marked by one or more racons and/ or,
iv. If the site would be marked by an Automatic Identification System (AIS) transceiver, and if so, the data it would transmit.
v. If the site would be fitted with a sound signal, and where the signal or signals would be sited.
vi. Whether the proposed site and/or its individual generators would comply in general with markings for such structures, as required by the relevant General Lighthouse Authority (GLA) or recommended by the Maritime and Coastguard Agency, respectively.
vii. 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.
viii. 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.

Annex 3. Safety and mitigation measures recommended for OREI during construction, operation and decommissioning.

3.1 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 Maritime and Coastguard Agency and will be listed in the developer's Environmental Statement (ES). These will be consistent with international standards contained in, for example, the Safety of Life at Sea (SOLAS) Convention - Chapter V, IMO Resolution A.572 (14)[3] and Resolution A.671(16)[4] and could include any or all of the following:

i. Promulgation of information and warnings through notices to mariners and other appropriate media.
ii. Continuous watch by multi-channel VHF, including Digital Selective Calling (DSC).

[3] "General Provisions on Ships' Routeing", adopted on 20 November 1985
[4] "Safety Zones and Safety of Navigation around Offshore Installations and Structures", adopted 19 October 1989.

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. Implementation of routeing measures within or near to the development.
vi. Monitoring by radar, AIS and/or closed circuit television (CCTV).
vii. Appropriate means to notify and provide evidence of the infringement of safety zones or ATBA's.
viii. Any other measures and procedures considered appropriate in consultation with other stakeholders.

Annex 4. Standards and procedures for wind turbine generator shutdown in the event of a search and rescue, counter pollution or salvage incident in or around a wind farm.

1. Design Requirements

The wind farm should be designed and constructed to satisfy the following design requirements for emergency rotor shut-down in the event of a search and rescue (SAR), counter pollution or salvage operation in or around a wind farm:

i. All wind turbine generators (WTGs) will be marked with clearly visible unique identification characters. The identification characters shall each 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 with it. The size of the identification characters in combination with the lighting should be such that, under normal conditions of visibility and all known tidal conditions, they are clearly readable by an observer, stationed 3 metres above sea levels, and at a distance of at least 150 metres from the turbine. It is recommended that lighting for this purpose be hooded or baffled so as to avoid unnecessary light pollution or confusion with navigation marks. (Precise dimensions to be determined by the height of lights and necessary range of visibility of the identification numbers).
ii. All WTGs should be equipped with control mechanisms that can be operated from the Central Control Room of the wind farm.
iii. Throughout the design process for a wind farm, appropriate assessments and methods for safe shutdown should be established and agreed, through consultation with MCAand other emergency support services.
iv. The WTG control mechanisms should allow the Control Room Operator to fix and maintain the position of the WTG blades as determined by the Maritime Rescue Co-ordination Centre or Maritime Rescue Sub Centre (MRCC/SC).
v. Nacelle hatches should be capable of being opened from the outside. This will allow rescuers (e.g. helicopter winch-man) to gain access to the tower if tower occupants are unable to assist and when sea-borne approach is not possible.
vi. Access ladders, although designed for entry by trained personnel using specialised

equipment and procedures for turbine maintenance in calm weather, could conceivably be used, in an emergency situation, to provide refuge on the turbine structure for distressed mariners. This scenario should therefore be considered when identifying the optimum position of such ladders and take into account the prevailing wind, wave and tidal conditions.

2. Operational Requirements

i. The Central Control Room should be manned 24 hours a day.
ii. The Central Control Room operator should have a chart indicating the Global Positioning System (GPS) position and unique identification numbers of each of the WTGs in the wind farm.
iii. All MRCC/SCs will be advised of the contact telephone number of the Central Control Room.
iv. All MRCC/SCs will have a chart indicating the GPS position and unique identification number of each of the WTGs in all wind farms.

3. Operational Procedures

i. Upon receiving a distress call or other emergency alert from a vessel which is concerned about a possible collision with a WTG or is already close to or within the wind farm, the MRCC/SC will establish the position of the vessel and the identification numbers of any WTGs which are visible to the vessel. The position of the vessel and identification numbers of the WTGs will be passed immediately to the Central Control Room by the MRCC/SC.
ii. The control room operator should immediately initiate the shut-down procedure for those WTGs as requested by the MRCC/SC, and maintain the WTG in the appropriate shut-down position, again as requested by the MRCC/SC, until receiving notification from the MRCC/SC that it is safe to restart the WTG.
iii. Communication and shutdown procedures should be tested satisfactorily at least twice a year

Note: Other types, designs and configurations of OREI will be similarly evaluated and procedures laid down by the Maritime and Coastguard Agency, in consultation with appropriate stakeholders, during the Scoping and Environmental Impact Assessment processes.

Annex 5. Section 36 of the Electricity Act 1989 (as amended by the Energy Act 2004)

36 Consent required for construction etc of generating stations

(1) Subject to subsections (2) and (4) below, a generating station shall not be constructed at a relevant place (within the meaning of section 4), and a generating station at such a place shall not be extended or operated except in accordance with a consent granted by the Secretary of State.

(2) Subsection (1) above shall not apply to a generating station whose capacity –
  (a) does not exceed the permitted capacity, that is to say, 50 megawatts; and

(b) in the case of a generating station which is to be constructed or extended, will not exceed the permitted capacity when it is constructed or extended; and an order under this subsection may make different provision for generating stations of different classes or descriptions.

(3) The Secretary of State may by order provide that subsection (2) above shall have effect as if for the permitted capacity mentioned in paragraph (a) there were substituted such other capacity as may be specified in the order.

(4) The Secretary of State may by order direct that subsection (1) above shall not apply to generating stations of a particular class or description, either generally or for such purposes as may be specified in the order.

(5) A consent under this subsection –
(a) may include such conditions (including conditions as to the ownership or operation of the station) as appear to the Secretary of State to be appropriate; and
(b) shall continue in force for such a period as may be specified in or determined by or under the consent.

(6) Any person who without reasonable excuse contravenes the provisions of this section shall be liable on summary conviction to a fine not exceeding level 5 on the standard scale.

(7) No proceedings shall be instituted in England and Wales in respect of an offence under this section except by or on behalf of the Secretary of State.

(8) The provisions of Schedule 8 of the Act (which relates to consents under this section and section 37 below) shall have effect.

(9) In this Part "extension", in relation to a generating station, includes the use by the person operating the station of any kind (wherever situated) for a purpose directly related to the generation of electricity by that station and "extend" shall be construed accordingly.

36A Declarations extinguishing etc. public rights of navigation

(1) Where a consent is granted by the Secretary of State or the Scottish Ministers in relation to –
(a) the construction or operation of a generating station that comprises or is to comprise (in whole or in part) renewable energy installations situated at places in relevant waters, or
(b) an extension that is to comprise (in whole or in part) renewable energy installations situated at places in relevant waters or an extension of such an installation, he or (as the case may be) they may, at the same time, make a declaration under this section as respects rights of navigation so far as they pass through some or all of those places.

(2) The Secretary of State or the Scottish Ministers may make a declaration only if the applicant for the consent made an application for such a declaration when making his application for the consent.

(3) A declaration under this section is one declaring that the rights of navigation specified or described in it -
   (a) are extinguished;
   (b) are suspended for a period that is specified in the declaration;
   (c) are suspended until such time as may be determined in accordance with provision contained in the declaration; or
   (d) are to be exercisable subject to such restrictions or conditions, or both, as are set out in the declaration.

(4) A declaration under this section –
   (a) has effect, in relation to the rights specified or described in it, from the time at which it comes into force; and
   (b) continues in force for such a period as may be specified in the declaration or as may be determined in accordance with provision contained in it.

(5) A declaration under this section –
   (a) must identify the renewable energy installations, or proposed renewable energy installations, by reference to which it is made;
   (b) must specify the date on which it is to come into force, or the means by which that date is to be determined;
   (c) may modify or revoke a previous such declaration, or a declaration under section 101 of the Energy Act 2004; and
   (d) may make different provision in relation to different means of exercising a right of navigation.

(6) Where a declaration is made under this section by the Secretary of State or the Scottish Ministers, or a determination is made by him or them for the purposes of a provision contained in such a declaration, he or (as the case may be) they must either -
   (a) publish the declaration or determination in such a manner as appears to him or them to be appropriate for bringing it, as soon as is reasonably practicable, to the attention of persons likely to be affected by it; or
   (b) secure that it is published in that manner by the applicant for the declaration.

(7) In this section –

"consent" means a consent under section 36 above;

"extension", in relation to a renewable energy installation, has the same meaning as in Chapter 2 of Part 3 of the Energy Act 2004

"relevant waters" means waters in or adjacent to Great Britain which are between the mean low water mark and the seaward limits of the territorial sea.

36B Duties in relation to navigation

(1) Neither the Secretary of State nor the Scottish Ministers may grant a consent in relation to any particular offshore generating activities if he considers, or (as the case may be) they consider, that interference with the use of recognised sea lanes essential to international navigation:
   (a) is likely to be caused by the carrying on of those activities; or
   (b) is likely to result from their having been carried on.

(2) It shall be the duty both of the Secretary of State and of the Scottish Ministers, in determining:
   (a) whether to give a consent for any particular offshore generating activities, and
   (b) what conditions to include in such a consent, to 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.

(3) In determining for the purposes of this section what interference, obstruction or danger is likely and its extent and nature, the Secretary of State or (as the case may be) the Scottish Ministers must have re g a rd to the likely effect (both while being carried on and subsequently) of -
   (a) the activities in question; and
   (b) such other offshore generating activities as are either already the subject of consents or are activities in respect of which it appears likely that consents will be granted.

(4) For the purposes of this section the effects of offshore generating activities include:
   (a) how, in relation to those activities, the Secretary of State and the Scottish Ministers have exercised or will exercise their powers under section 36A above and section 101 of the Energy Act 2004 (extinguishment of public rights of navigation); and
   (b) how, in relation to those activities, the Secretary of State has exercised or will exercise his powers under sections 94 and 95 and Chapter 3 of Part 2 of that Act (safety zones and decommissioning).

(5) If the person who has granted a consent in relation to any offshore generating activities thinks it appropriate to do so in the interests of the safety of navigation, he may at any time vary conditions of the consent so as to modify in relation to any of the following matters the obligations imposed by those conditions –
   (a) the provision of aids to navigation (including, in particular, lights and signals);
   (b) the stationing of guard ships in the vicinity of the place where the activities are being or are to be carried on; or

(c) the taking of other measures for the purposes of, or in connection with, the control of the movement of vessels in that vicinity.

(6) A modification in exercise of the power under subsection (5) must be set out in a notice given by the person who granted the consent to the person whose obligations are modified.

(7) In this section –

'consent' means a consent under section 36 above;

'offshore generating activities' means –

(a) the construction or operation of a generating station that is to comprise or comprises (in whole or in part) renewable energy installations; or

(b) an extension of a generating station that is to comprise (in whole or in part) renewable energy installations or an extension of such an installations;

'the use of recognised sea lanes essential to international navigation' means –

(a) anything that constitutes the use of such a sea lane for the purposes of Article 60 (7) of the United Nations Convention on the Law of the Sea 1082 (Cmnd 8941); or

(b) any use of waters in the territorial sea adjacent to Great Britain that would fall within paragraph (a) if the waters were in a Renewable Energy Zone.

(8) In subsection (7) 'extension', in relation to a renewable energy installation, has the same meaning as in Chapter 2 of Part 2 of the Energy Act 2004.

Annex 6. Article 60 UNCLOS - Artificial islands, installations and structures in the exclusive economic zone

1. In the exclusive economic zone, the coastal State shall have the exclusive right to construct and to authorize and regulate the construction, operation and use of:
   a. artificial islands;
   b. installations and structures for the purposes provided for in article 56 and other economic purposes;
   c. installations and structures which may interfere with the exercise of the rights of the coastal State in the zone.

2. The coastal State shall have exclusive jurisdiction over such artificial islands installations and structures, including jurisdiction with regard to customs fiscal health, safety and immigration laws and regulations.

3. Due notice must be given of the construction of such artificial islands, installations or structures, and permanent means for giving warning of their presence must be maintained. Any installations or structures which are abandoned or disused shall be removed to ensure safety of navigation, taking into account any generally accepted international standards

established in this regard by the competent international organization. Such removal shall also have due regard to fishing, the protection of the marine environment and the rights and duties of other States. Appropriate publicity shall be given to the depth, position and dimensions of any installations or structures not entirely removed.

4. The coastal State may, where necessary, establish reasonable safety zones around such artificial islands, installations and structures in which it may take appropriate measures to ensure the safety both of navigation and of the artificial islands, installations and structures.

5. The breadth of the safety zones shall be determined by the coastal State taking into account applicable international standards. Such zones shall be designed to ensure that they are reasonably related to the nature and function of the artificial islands, installations or structures, and shall not exceed a distance of 500 metres around them, measured from each point of their outer edge, except as authorized by generally accepted international standards or as recommended by the competent international organization. Due notice shall be given of the extent of safety zones.

6. All ships must respect these safety zones and shall comply with generally accepted international standards regarding navigation in the vicinity of artificial islands, installations, structures and safety zones.

7. Artificial islands, installations and structures and the safety zones around them may not be established where interference may be caused to the use of recognized sea lanes essential to international navigation.

8. Artificial islands, installations and structures do not possess the status of islands. They have no territorial sea of their own, and their presence does not affect the delimitation of the territorial sea, the exclusive economic zone or the continental shelf.

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