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Effective Collision Risk Management for Offshore Installations

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1 EXECUTIVE SUMMARY

An offshore installation is exposed to ship collision risk from both in-field and passing vessels. Both categories of collision have occurred on the United Kingdom Continental Shelf (UKCS) and both have the potential to result in catastrophic damage to the installation, although to date only severe (not catastrophic) consequences have been observed in UK waters. World-wide, catastrophic collisions with installations have occurred resulting in significant damage to vessels and installations, leading to loss of life and environmental damage.

There are a number of Acts and Regulations governing the hazard of ship collisions with offshore installations. All ship masters are required to adhere to "The International Regulations For Preventing Collisions At Sea 1972". These regulations set out all aspects of vessel conduct in various visibility conditions. For the management of ship collision risk on installations, a number of regulations require the duty holder of an installation to demonstrate that there is an effective management system which ensures that hazards with the potential to cause a major accident (ship collision falls within this category) are identified, that risks are adequately controlled and that the organisational arrangements in place will enable the duty holder to comply with relevant health and safety legislation.

This report was developed to provide guidance on the key elements of an effective collision risk management system for offshore installations located on the UKCS.

The report provides an overview of the legal requirements relating to ship collision hazard management (Section 3). It then goes on to provide an overview of ship collision hazards and their likelihood and consequences (Sections 4 & 5).

The accident statistics show that the majority (66%) of ship collisions with installations involve supply vessels, with only 2% involving passing vessels. Figure 1.1 presents graphically, the distribution of impacts by vessel type.

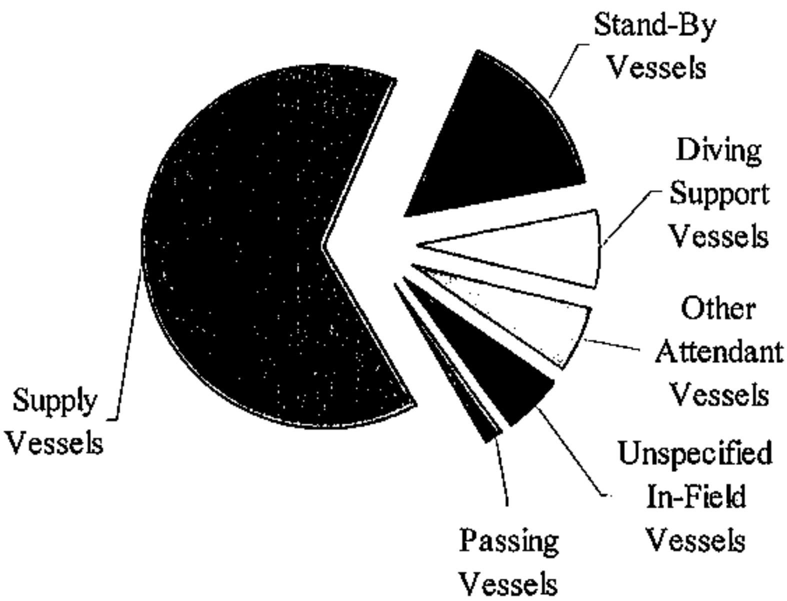

Figure 1.1

Distribution of Impacts by Vessel Category

Section 5 closes by discussing potential future trends in both the marine and offshore oil industries which may influence the likelihood and consequences of ship collisions with offshore installations.

A detailed assessment of the causes of ship impacts with installations forms part of this study (Section 6). From a large number of reference sources, the primary high level causation factors were identified and discussed for both in-field and passing vessels.

Key high level causation factors for supply vessel and alongside standby vessel collisions include:

- Lack of marine experience on the installation;
- Poor relationship/communications between installation and vessel;
- Poor or inadequate installation design (e.g. too few cranes, cranes which are badly positioned, slow, or have inadequate reach, topsides with little overhang under the crane, etc.);
- Insufficient understanding by the installation management of the implications of selecting a vessel primarily on cost;
- Insufficient manning on board the vessel;
- Reluctance of installation managers to exclude vessels from entering the 500m zone;
- Reluctance of vessel masters to call off a close proximity operation in marginal conditions due to commercial pressures, professional pride, or threat of reprimand;
- Pressures on the supply vessel company to remain competitive which leads to increased crew fatigue, increased likelihood of mechanical breakdown, and reduced level of crew training.

The use of shuttle tankers on the UKCS to export oil from offshore fields has increased significantly over recent years. Worryingly, there has been a relatively high number of collisions between shuttle tankers and the Floating, Production, Storage and Offloading (FPSO) installations which they have been visiting. This is of particular concern due to the potential for major consequential loss as a result of a shuttle tanker/FPSO collision. Based on a close proximity study that was undertaken for the HSE, the most likely causes of shuttle tanker collisions are:

- Operation and reliability of position reference system for DP shuttle tankers;
- Engine failure leading to shuttle tanker drift
- Change over from automatic to manual control during emergency situations;
- Manning levels of control spaces;
- Cultural differences;
- Training, familiarisation and competence of tanker crews;
- Fish-tailing;
- Surging;
- Operation of CPP thrusters;
- Failures of main propulsion;
- Commercial pressures in decision making in relation to off-take operations;
- Inability to accurately monitor weather and environmental conditions.
- For passing vessels, the primary causes of collisions between a passing vessel, which is underway, and an offshore installation, are:
- Ineffective watchkeeping on board the vessel, and/or
- The vessel travelling too fast for the prevailing conditions to allow for successful collision avoidance action, and/or
- Mechanical failure during a collision avoidance manoeuvre that negates the actions taken.

Following the expert panel meeting (Appendix A) and review of the relevant reference material, ineffective watchkeeping was considered the most probable cause for a passing vessel ship collision with an offshore installation. The main causes for ineffective watch keeping are:

1. Watchkeeper present on bridge but:
   a) Busy/preoccupied with other tasks;
   b) Asleep;
   c) Incapacitated due to sickness, accident or substance abuse;
2. Watchkeeper absent from the bridge;
3. Poor visibility combined with undetected radar fault.

To effectively manage ship collision risks, a duty holder needs to establish an appropriate management system to:

- Identify all potential ship collision hazards;
- Assess the risks associated with those hazards;
- Identify and implement risk reduction measures by eliminating, preventing, controlling and mitigating such hazards; and
- Address the emergency response measures required in the event of a ship collision with an installation.

Section 7 deals with the practical aspects of developing an effective ship collision risk management system based on the principles set out in the HSE publication HS(G)65 "Successful Health and Safety Management". In view of the differences between in-field and passing vessels as regards collision risks, the common elements of a Safety Management System for the management of ship collision risks are discussed first in Section 7, followed by separate, more detailed, discussions of the management of in-field and passing vessel collision risks. Finally, these sections are pulled together as an overall Safety Management System for the management of ship collision risks in total.

For both in-field and passing vessels, Section 7, systematically details and discusses the following key elements of an effective collision risk management system:

- Hazard identification;
- Risk assessment;
- Preventive measures;
- Control measures;
- Mitigation measures;
- Emergency response measures.

In the assessment of passing vessel collision risk management, reference is made to Appendix B in which there is an overview of hardware systems currently available to assist in this area.

It is recognised that operators of offshore installations are faced with difficult problems when attempting to manage ship collision risks. They have to have an effective management system to manage the risks associated with both visiting vessels, which are frequent visitors and under the management control of the duty holder, and passing vessels, over which the duty holder has little, if any, management control.

To date there have been no catastrophic ship collision incidents on the UKCS, but, based on past near misses, potential impact energies and incidents that have occurred world-wide, duty holders should not underestimate the real risk and serious consequences of ship collisions with their installations.

This report will assist duty holders to develop an effective collision risk management system.

Recommendations arising from this study are given in Section 8 of the report. An outline of the recommendations, which are intended to support industries' proactive approach towards improving collision risk management, are as follows:

- There is a lack of suitable guidance in industry for effective collision risk management, this should be improved;
- Increase hazard awareness in the marine industry in relation to offshore operations. Potential co-operation with MCA;
- Investigate the human factor aspects in ship collision management;
- Investigate better methods of sharing information on best practice between operators arising out of incidents and near misses associated with visiting and passing vessels;
- Undertake a detailed assessment of the effective management of shuttle tanker collision risk;
- Assess the implications of one-man bridge operations on visiting vessels;
- Investigate the potential for long term degradation of platform structures as a result of the accumulated effect of repetitive minor impacts from alongside vessels;
- Examine the effect on safety of contractual arrangements between installation operators and visiting vessel operators;
- Independent field trials should be carried out into different vessel detection systems being employed by operators;
- The practice of applying common collision risk management procedures, independent of installation location and field specific details, should be examined;
- Consider the introduction of a unique collision warning alarm on installations;
- Investigate methods for the effective alerting of errant vessels that are on a collision course with an offshore installation;
- Undertake a detailed investigation into the issues surrounding and the methods available for the control of drifting vessel collision risk.

To provide "expert" opinion on the available means of reducing the probability of collisions between offshore installations and passing vessels, a review meeting was conducted. This meeting highlighted a number issues relating to collision risk and its management. Further details can be found in Appendix A.

2 INTRODUCTION AND BACKGROUND

2.1 INTRODUCTION

Shipping poses a threat to all offshore installations. Under UK offshore health and safety legislation, the duty holder of an installation, the operator of a fixed installation or the owner of a mobile installation, is required to demonstrate that an effective safety management system (SMS) is in place. This SMS ensures that hazards have been identified and the risks to health, safety and welfare of personnel have been controlled so far as is reasonably practicable (ALARP). Collisions between a ship and an installation have the potential to cause major damage to the structure of the installation and, therefore, by legislation, are major accident events that require risk management.

The effective management of the threat posed by shipping, apart from being a legal requirement, should also be a high priority objective of all installation operating companies for commercial reasons. All impacts and some near miss incidents will cost the operating company dearly. The cost may be in terms of human loss, direct financial loss from repairs, installation evacuation, deferred production, environmental clean-up, or compensation, or from less tangible costs such as loss of reputation and image in the regulatory, commercial or public spheres of influence.

Following the Piper Alpha incident, considerable effort has been applied to the effective management of risks associated with on-installation hazards, such as fires and explosions. This research project has been commissioned by the Health and Safety Executive (HSE) to enhance understanding of the risks of ship collision with offshore installations and to provide guidance as to the key elements of an effective collision risk management system.

This Section presents the background to the project, the objectives and the scope of work and details of the abbreviations used throughout the report.

2.2 BACKGROUND

During the 23 years from 1975 through to 1997 there were 491 reported collisions between ships and offshore oil and gas installations located on the UK continental shelf (UKCS). Of these, 84 caused moderate or severe damage to the installation. There have been no catastrophic ship collision incidents involving offshore oil and gas installations on the UKCS to-date although a number of the reported impacts and near miss occurrences, could have resulted in such (e.g. impacts with gas export risers, drifting tankers, etc.). World wide, there have been at least 9 collisions which have resulted in the total loss of an offshore installation. There should be no doubt that such catastrophic events could occur in UK waters since the potential impact energies of most shipping in the vicinity of UK offshore installations far exceed the designed structural capacity of the installations.

Of the 491 reported collisions, only 8 involved passing vessels (i.e. vessels not operating in connection with the installation). The majority, over two thirds, of the in-field vessel collisions were with supply vessels.

In terms of collision frequency, based on 1997 figures, approximately 30 out of the 200 offshore installations on the UKCS could expect to suffer an in-field vessel impact during a year. For passing vessel collisions, again based on the 1997 installation population of approximately 200, a passing vessel collision could be expected to occur, somewhere on the UKCS, once every 2 years.

For collisions involving in-field vessels, over which it should be noted the duty holder has management control, there has been a significant fall in the number of reported collisions, with a three fold decrease, in terms of collisions reported per installation, between 1980 and 1997. Per installation, floating units (e.g. semi-submersibles, FPSOs, etc.) have recorded the highest level of in-field vessel impacts and the decreasing trend may reverse with the increased use of FPSOs and shuttle tankers. There have been at least 4 FPSO/shuttle tanker collisions reported in the last year (1997/8).

The frequency of passing vessel collisions, albeit much lower than in-field vessel impacts, shows no trends either for better or worse. They have occurred sporadically over the years.

As noted earlier, there has been a significant decrease in the frequency of in-field vessel impacts, probably due to the increased awareness of the associated hazards, the increased experience of the marine crews, and the increased demand for higher safety standards. An illustration of the commitment by the offshore and marine industries to the effective control of marine hazards within the vicinity of offshore installations is the production of Guidelines for the Safe Management of Offshore Support Vessels (Ref. 1). These guidelines, which were published by UKOOA/Chamber of Shipping in July 1998, set out what is generally regarded in the industry as good practice for avoiding and reducing the hazards and risks which affect offshore vessels and their crew in normal operations. This new guidance brings together and formalises current good practice. The influence of it on in-field vessel collisions and near misses, as well as improvements in collision risk management requires monitoring.

The UKOOA/Chamber of Shipping guidelines do not cover shuttle tanker operations which, as noted above, appear to be an operation where there is a relatively high likelihood of collision and where there is the potential for major damage, loss of life and pollution.

In terms of management of passing vessel risks, it is generally believed that as passing vessels are usually outside the direct management influence of the offshore installation operator, the effective management of the risk is limited, albeit the law requires you to do what is reasonably practicable. Nearly all offshore operators place a large responsibility for the control of passing vessel collision risk on the standby vessel. The crew of this vessel are required, in all weather conditions, to monitor traffic in the area, provide sufficient warning of potential collisions to allow the installation to take appropriate emergency response, attempt to warn off approaching errant vessels, and, if a collision occurs, provide suitable and effective casualty rescue capabilities.

It is considered possible, that with the current economic climate, there may be a negative effect on the safety of in-field vessel operations and management of passing vessel risk, as operators and contractors strive to drive down operating overheads and increase returns on their investments. Such a decrease in safety standards, should they occur, would be unacceptable.

2.3 PREVIOUS AND ONGOING RESEARCH IN THE FIELD

The major hazard of ship collisions has been recognised since the early days of the development of oil and gas fields on the UKCS. Consequently, a number of research projects were commissioned, primarily by the HSE and the Department of Energy, their predecessor as regulator of the oil and gas industry. The majority of this work was carried out in the mid 1980's. In addition to UK research into this hazard, other parts of the world (e.g. Gulf of Mexico and the Dutch & Norwegian Sectors of the North Sea) have also shown a high level of interest.

Throughout this report, references are made to relevant sources of information, much of which is contained within the above mentioned research projects. Section 9 contains a complete list of the reference material used in this study.

2.4 SCOPE OF WORK/PROJECT OBJECTIVES

The overall objective of the project is to develop further the understanding of the major hazard associated with ship collisions with offshore installations and to provide guidance on the key aspects of an effective collision risk management system. In order to meet this overall objective, a number of tasks were completed within the scope of the project. These tasks were to:

- Present an overview of the legislation relevant to the ship collision hazard (Section 3);
- Provide an overview of historical incidents that have occurred and document the likelihood and consequences of collisions taking place between in-field and passing vessels and an offshore installation, based on historical data (Sections 4 & 5);
- Present a discussion on the causes of collisions between in-field and passing vessels and offshore installations, based on historical data and research carried out in the field (Section 6);
- Undertake an expert panel review meeting to examine the effectiveness of available radar systems (Appendix A);
- Present a review in terms of the advantages and limitations of different collision control and avoidance systems (Appendix B);
- Identify and discuss the different elements and factors to be considered in order to develop an effective collision risk management system as part of the overall Safety Management System for an offshore installation (Section 7).

2.5 ABBREVIATIONS

The following abbreviations are used throughout this report:

AHT	Anchor Handling Tug
AHV	Anchor Handling Vessel
ALARP	As Low as is Reasonably Practicable
ARPA	Automatic Radar Plotting Aid
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CPA	Closest Point of Approach
CPP	Controllable Pitch Propeller
CRM	Collision Risk Management
DAMA	Databank of Marine Accidents
DARPS	Differential Absolute and Relative Positioning System
dB	Decibels
DCR	Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996
DETR	Department of the Environment, Transport and the Regions
DGPS	Differential Global Positioning System
DNV	Det Norsk Veritas
DP	Dynamic Positioning
DWR	Deep Water Route
DWT	Dead Weight Tonnage
FPSO	Floating Production, Storage and Offloading
FRC	Fast Rescue Craft
FSU	Floating Storage Unit
GJ	Gigajoule
GPS	Global Positioning System
HASAWA	Health and Safety at Work, etc. Act 1974
HLV	Heavy Lift Vessel
HSE	Health & Safety Executive
HSE OSD	Health & Safety Executive, Offshore Safety Division
IADC	International Association of Drilling Contractors
ILO	International Labour Organisation
IMO	International Maritime Organisation
ISM	International Safety Management
MAIB	Marine Accident Investigation Branch
MAPD	Major Accident Prevention Document
MAR	Offshore Installations and Pipeline Works (Management and Administration) Regulations 1995
MARS	Marine Accident Reporting System
MCA	Maritime & Coastguard Agency
MHSWR	Management of Health and Safety at Work Regulations 1992
MJ	Megajoule
MoD	Ministry of Defence
MODU	Mobile Offshore Drilling Unit
MTD	Marine Technology Directorate Limited
nm	Nautical Mile
NUI	Normally Unmanned Installation
NMD	Norwegian Maritime Directorate
NPD	Norwegian Petroleum Directorate

NUC	Not Under Command
NWECS	North Western European Continental Shelf
OIM	Offshore Installation Manager
OIR	Offshore Incident Report
PUWER	Provision and Use of Work Equipment Regulations 1992
PFEER	Offshore Installations (Prevention of Fire and Explosion, & Emergency Response) Regulations 1995
PRS	Position Reference System
PSR	Pipeline Safety Regulations 1996
RABL	Risk Assessment of Buoyancy Loss
RACON	Radar Beacon
RADAR	Radar Detecting and Ranging
REWS	Radar Early Warning System
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995
SCR	Offshore Installations (Safety Case) Regulations 1992
SBV	Standby Vessel
SI	Statutory Instrument
SMR	Standard Marine Radar
SPM	Single Point Mooring
STCW	Standards for Training, Competence and Watchkeeping Regulations 1978
TCPA	Time to Closest Point of Approach
TEMPSC	Totally Enclosed Motor Propelled Survival Craft
TLP	Tension Leg Platform
TSS	Traffic Separation Scheme
UKCS	United Kingdom Continental Shelf
UKOOA	United Kingdom Offshore Operators Association
UMS	Unmanned Machinery Space
VHF	Very High Frequency
VTS	Vessel Traffic Service
WOAD	World Offshore Accident Database

3 LEGAL REQUIREMENTS – A LEGISLATIVE OVERVIEW

3.1 INTRODUCTION

This Section identifies and summarises the key requirements of current legislation relevant to the management of ship collision risks within the offshore oil and gas industry on the UK Continental Shelf (UKCS). It does not provide a definitive interpretation of the relevant legislation, which may be found in published guidance from the Health and Safety Executive, such as their Approved Codes of Practice and Guidance to Regulations.

The following Acts and Regulations are summarised below:

- Health & Safety at Work Act 1974;
- Management of Health and Safety at Work Regulations 1992 (MHSWR);
- Provision and Use of Work Equipment Regulations 1992 (PUWER);
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR);
- Offshore Installations (Safety Case) Regulations 1992 (SCR);
- Offshore Installations and Pipeline Works (Management and Administration) Regulations 1995 (MAR);
- Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995 (PFEER);
- Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996 (DCR)
- Pipeline Safety Regulations (PSR) 1996;
- Petroleum Act 1987;
- The Offshore Installations (Safety Zones) Regulations 1987
- Coast Protection Act 1949 (as extended by S.4(1) of the Continental Shelf Act 1964 and amended by S.36 of the Merchant Shipping Act 1988).
- International Regulations for Preventing Collisions at Sea 1972 (amended 1989);

The first two Sections address the requirements of the Health and Safety at Work Act 1974 and the Management of Health and Safety at Work Regulations 1992, which apply to virtually all workplaces (though not to merchant ships). Further sections discuss the requirements of a number of complementary Regulations, which are specific to the operation of offshore installations. Finally, the Coast Protection Act and the International Regulations for Preventing Collisions at Sea are outlined.

3.2 HEALTH AND SAFETY AT WORK ACT 1974

The Health and Safety at Work Act sets out the basic principles of health and safety in general terms and places duties on employers, employees and the self-employed. General duties with regard to the safety of persons other than employees are also imposed upon employers and the self-employed and on persons having control of non-domestic premises.

The primary duties on employers and employees are all qualified by the phrase 'so far as is reasonably practicable'. The term 'reasonably practicable' is a narrower term than 'physically possible' and implies that a computation must be made in which the quantum of risk is placed in one scale and the sacrifice, whether in money, time or trouble, involved in the measures necessary to avert the risk is placed in the other; and that, if it be shown that there is a gross disproportion between them, the risk being insignificant in relation to the sacrifice, the person upon whom the duty is laid discharges the burden of proving that compliance was not reasonably practicable. This computation falls to be made at a point in time anterior to the happening of the incident.

It is the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees. The matters to which that duty extends includes in particular:

(a) the provision and maintenance of plant and systems of work that are safe and without risks to health;
(b) arrangements for ensuring safety and absence of risk to health in connection with the use, handling, storage and transport of articles and substances;
(c) the provision of information, instruction, training and supervision;
(d) the maintenance of a safe place of work and the provision and maintenance of safe means of access and egress from it;
(e) the provision and maintenance of a safe working environment which is adequate as regards facilities and arrangements for the welfare of employees at work.

Under these general provisions of the Health and Safety at Work Act, there is a duty on the operators of fixed installations and the owners of mobile installations to provide appropriate plant and equipment and safe systems of work in order to reduce the risks to employees and others from ship collision so far as is reasonably practicable.

Section 3 of the Health and Safety at Work imposes a duty on every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health and safety. If an operator employs a contractor to manage certain aspects of his undertaking, he cannot thereby shed his responsibilities under this Section of the Act. It is the responsibility of the operator to ensure, not only that he has selected a competent contractor to undertake the relevant work activities, but also to institute and implement appropriate monitoring and auditing systems so as to ensure that such activities are conducted in a manner which is safe and without risks to the health of anyone who may be affected by these work activities.

3.3 HEALTH AND SAFETY AT WORK ETC ACT (APPLICATION OUTSIDE GREAT BRITAIN) ORDER 1995

This Order applies Sections 1-59 and 80-82 of the Health and Safety at Work Act (HASAWA) 1974 within territorial waters or a designated area to and in relation to any offshore installation and any activity on it.

The above provisions of HASAWA do not apply to any activity on or from a vessel being used as a stand-by vessel or to the transporting, towing or navigating of an installation.

3.4 MANAGEMENT OF HEALTH AND SAFETY AT WORK REGULATIONS 1992

The Management of Health and Safety at Work Regulations 1992 (MHSWR) impose a duty on all employers to make a suitable and sufficient assessment of the risks to the health and safety of their employees and of non-employees affected by their work.

The general principles of risk control and health and safety management are set out in the Management of Health and Safety at Work Regulations 1992 Approved Code of Practice.

The principles of risk control involve a hierarchical approach to the management of hazards. The hierarchy entails:

(a) inherent safety through the elimination and minimisation of the hazards by design;
(b) prevention (reduction of likelihood);
(c) detection (transmission of information to control point);

(d) control (limitation of scale, intensity and duration);
(e) mitigation of consequences (protection from effects).

The various elements of this hierarchy in relation to the management of ship collision risks associated with offshore installations are examined in depth later in this document.

The MHSWR Approved Code of Practice sets out the following principles for preventive and protective measures:

(a) it is always best, if possible, to avoid a risk altogether;
(b) combat risks at source, rather than by palliative measures;
(c) wherever possible, adapt work to the individual;
(d) take advantage of technological and technical progress to improve work methods and make them safer;
(e) risk prevention measures should form part of a coherent policy and approach to reduce risks progressively that cannot be prevented or avoided altogether;
(f) give priority to measures which protect the whole workplace;
(g) make sure workers understand what they need to do;
(h) create an active health and safety culture which affects the organisation as a whole.

The application of these principles to the management of ship collision risks is discussed later in this document.

The MHSWR Approved Code of Practice also sets out the principles for health and safety management:

- Planning. Adopting a systematic approach, which identifies priorities and sets objectives. Whenever possible, risks are eliminated by the careful selection and design of facilities, equipment and processes or minimised by the use of physical control measures;
- Organisation. Putting in place the necessary structure with the aim of ensuring that there is a progressive improvement in health and safety performance;
- Control. Ensuring that the decisions for ensuring and promoting health and safety are being implemented as planned;
- Monitoring and Review. Like quality, progressive improvement in health and safety can only be achieved through the constant development of policies, approaches to implementation and techniques of risk control.

The application of these various principles to the management of ship collision risk, with respect to offshore installations, is discussed in a later section with the management of this type of risk within the context of the overall safety management system for the installation.

Regulation 6 of MHSWR requires every employer, subject to one or two caveats, to appoint one or more competent persons to assist him in undertaking the measures he needs to take to comply with the requirements and prohibitions imposed upon him by or under the relevant statutory provisions.

It is, therefore, the responsibility of the duty holder of an installation to ensure that he has available appropriate health and safety assistance with respect to all aspects of his operations. With regard to ship collision risks, he should ensure that he has access to persons competent in marine matters for the provision of appropriate health and safety advice.

3.5 PROVISION AND USE OF WORK EQUIPMENT REGULATIONS 1998

The Provision and Use of Work Equipment Regulations 1998 (PUWER) impose duties to:

- provide and maintain suitable work equipment;
- provide adequate training, information and consultation;
- restrict, to trained employees only, equipment likely to carry a risk;
- provide adequate information, instructions and training;
- protect against dangerous parts and other hazards;
- protect against high and low temperatures;
- provide visible controls to start, control, stop and emergency stop the equipment;
- provide isolation from energy sources;
- stabilise equipment;
- illumination of equipment
- protect against risks whilst maintaining equipment; and
- include safety markings and warning devices.

Although sea-going ships are not covered, the Regulations are relevant to the loading and unloading of ships and the Regulations apply to offshore installations and associated vessels and equipment with respect to these operations.

3.6 REPORTING OF INJURIES, DISEASES AND DANGEROUS OCCURRENCES REGULATIONS 1995

The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR) consolidated and simplified the law by applying a single set of reporting requirements to all work activities in Great Britain and in the offshore oil and gas industry.

Schedule 2 of RIDDOR specifies which dangerous occurrences are required to be reported to the HSE and includes:

- Any collision between a vessel and an offshore installation which results in damage to the installation or the vessel;
- Any occurrence with the potential for a collision between a vessel and an offshore installation where, had a collision occurred, it would have been liable to jeopardise the overall structural integrity of the offshore installation.

3.7 OFFSHORE INSTALLATIONS (SAFETY CASE) REGULATIONS 1992

The primary aim of the Offshore Installations (Safety Case) Regulations 1992 (SCR) is to reduce risks from major accident hazards to the health and safety of the workforce employed on offshore installations or in connected activities. The Regulations implement the central recommendation of Lord Cullen's Report on the Public Inquiry into the Piper Alpha Disaster: This stated that the operator or owner of every offshore installation should be required to prepare a Safety Case, and submit it for acceptance by the HSE.

Safety Cases are required for all fixed and mobile installations operating, or to be operated, in British waters and in UK designated areas of the Continental Shelf.

Operators of new fixed installations that are to be established offshore are required to submit a Design Safety Case at such time before completion of the design of the installation as will enable issues raised by the HSE to be taken into account in the design. There is no requirement for a Design Safety Case to be accepted by the HSE, but by considering the issues raised by the HSE during the design phase, this is likely to assist in the acceptance of a full Operational Safety Case.

For all fixed installations a full Operational Safety Case must be submitted to the HSE at least six months before commencing operations on the installation. The Operational Safety Case is subject to acceptance by the HSE before the installation can be operated.

A further submission must be made to, and accepted by, HSE before a fixed installation is decommissioned.

For mobile installations, the owner is required to submit an Operational Safety Case before moving the installation into UK waters for the purpose of operating it there. This Safety Case also requires acceptance by the HSE.

Once every three years, or as often as may be necessary to cover material changes, the Operational Safety Case must be re-submitted to HSE for acceptance before operations can continue.

Additional Safety Cases are required where fixed and mobile installations engage in combined operations, to cover the specific features of such operations.

HSE acceptance is required for all Safety Cases except those for the design of fixed installations. For the purposes of these Regulations, 'acceptance' means a written notification to the duty holder that HSE is satisfied with the case for health and safety made out in the Safety Case.

These Regulations define a 'major accident' as:

(a) fire, explosion or the release of a dangerous substance involving death or serious personal injury to persons on the installation or engaged in an activity on or in connection with it;
(b) any event involving major damage to the structure of the installation or plant affixed thereto or any loss in the stability of the installation;
(c) the collision of a helicopter with the installation;
(d) the failure of life support systems for diving operations in connection with the installation, the detachment of a diving bell used for such operations or the trapping of a diver in a diving bell or other subsea chamber used for such operations; or
(e) any other event arising from work activity involving death or serious personal injury to five or more persons on the installation or engaged in an activity in connection with it.

The definition of major accident lists a number of types of accident which involve serious injury or loss of life, or which have the potential to do so. A key feature of the Safety Case regime is the requirement in Regulation 8(1)(c) and (d) of these Regulations for duty holders to demonstrate in their Safety Case that all hazards with the potential to cause a major accident as defined have been identified, that the risks have been evaluated and that measures have been, or will be, taken to reduce the risks to people to the lowest reasonably practicable level (the ALARP principle).

With regard to part (b) of the definition, events likely to involve major damage to the structure of the installation include vessel impact from supply and standby vessels, shuttle tankers, through traffic and mobile installations.

Regulation 15A requires the duty holder of an offshore installation to establish a verification scheme for the safety critical elements of the installation. Such safety critical elements must be verified as suitable by an independent and competent person by means of a written verification scheme. The overall objective of the offshore verification scheme is to set in place independent and competent scrutiny of those parts of an installation which are 'critical to safety' referred to in these Regulations as safety critical elements (SCEs). These verification requirements apply to both fixed and mobile installations and new and existing ones.

Any structure, plant, equipment, system (including computer software) or component part whose failure could cause or contribute substantially to a major accident is safety critical, as is any which is intended to prevent or limit the effect of a major accident.

The term 'contribute substantially to a major accident' is intended to include within the category of 'safety critical element' those parts whose failure would not directly cause a major accident but would make a significant contribution to a chain of events which could result in a major accident.

Consideration of safety critical elements should include systems for the detection, control and mitigation of major accidents. Items improving reliability by providing redundancy or diversity also need to be considered.

Regulation 8(1)(a) of these Regulations requires an operator or owner to include in his Safety Case sufficient particulars to demonstrate that his management system is adequate to ensure that relevant statutory provisions will (in respect of matters within his control) be complied with in relation to the installation and any activity on or in connection with it.

Regulation 2 defines 'management system' as the organisation and arrangements established by the duty holder for managing his undertaking.

The duty holder must demonstrate that there is an effective safety management system (SMS) which ensures that hazards with the potential to cause a major accident, such as ship collision, are identified, that risks are adequately controlled and that the organisational arrangements in place will enable the duty holders to comply with relevant health and safety legislation.

The Health and Safety Executive, in their publication Assessment Principles for Offshore Safety Case (paras. 83 - 87), expect duty holders to undertake a systematic and comprehensive identification of major accident hazard risk reduction measures. Furthermore, any identified practicable measure to reduce the risk of major accidents should be implemented, unless it is clear that the measure is not reasonably practicable.

Regulation 8(1)(b) requires the duty holder to establish adequate arrangements for audit and for the production of audit reports.

Regulation 8(4) states that 'audit' means systematic assessment of the adequacy of the management system carried out by persons who are sufficiently independent of the system to ensure that such assessment is objective. The duty holder may employ the auditor(s).

Duty holders need to ensure that appropriate audits of their management system in relation to collision risk management are undertaken on a regular basis by persons who are knowledgeable of such risks and independent of the system itself.

3.8 OFFSHORE INSTALLATIONS AND PIPELINE WORKS (MANAGEMENT AND ADMINISTRATION) REGULATIONS 1995

The Offshore Installations and Pipeline Works (Management and Administration) Regulations 1995 (MAR) complement other Regulations dealing with the safe management of offshore installations, including the Offshore Installations (Safety Case) Regulations 1992 and the Management of Health and Safety at Work Regulations 1992. These Regulations apply to both fixed and mobile installations.

Regulation 8(1) of MAR requires every person to co-operate with the manager of an offshore installation, and any other person on whom any duty is placed by Regulations 5 to 19 of MAR, so far as is necessary to enable him to comply with the relevant statutory provisions.

The duty in Regulation 8(1) of MAR is without prejudice to any duty owed by a master, captain or person in charge of any vessel or aircraft.

Safety requires co-operation between everyone who has a contribution to make to ensuring health and safety on an offshore installation or in activities involving the installation. The scope of Regulation 8 of MAR is, therefore, very wide and includes operators, owners, concession owners, employers, employees, managers and people in charge of visiting vessels or aircraft.

Anyone who boards or comes close to an offshore installation must recognise the duty holder's primary responsibility for health and safety and the authority of the Offshore Installation Manager.

Regulation 12 of MAR requires the duty holder to ensure that arrangements, which are appropriate for health and safety purposes, are in place for effective communication between the offshore installation and the shore, vessels, aircraft and other installations.

Appropriate arrangements for communication may include provision of equipment, ensuring persons competent to use it are present and setting out relevant procedures. Duty holders need to determine what is appropriate depending on the communication needs of the offshore installation in relation to the operations being undertaken. Such needs in relation to the avoidance of ship collisions are discussed in greater detail in later sections.

3.9 OFFSHORE INSTALLATIONS (PREVENTION OF FIRE AND EXPLOSION AND EMERGENCY RESPONSE) REGULATIONS 1995

The Offshore Installations (Prevention of Fire and Explosion and Emergency Response) Regulations 1995 (PFEER) specify particular goals for preventive and protective measures to manage fire and explosion hazards, and to secure effective emergency response. These measures are the responsibility of a primary duty holder who is the operator in the case of a fixed installation and the owner in the case of a mobile installation. In particular, the duty holder needs to address the risk of ship collision in relation to the following Regulations.

3.9.1 General Duty (Reg. 4)

Regulation 4 imposes a general duty on the duty holder to take appropriate measures with a view to securing effective emergency response, which includes dealing with an emergency arising from a collision between a vessel and the installation. This is a broad general duty which is developed in detail in further Regulations as discussed below.

3.9.2 Assessment (Reg. 5)

Regulation 5 requires the duty holder to assess major accident hazards arising from fire and explosion and events, which may require evacuation, escape and rescue, and identify appropriate arrangements for dealing with them. Such an assessment feeds into the Safety Case for the installation.

As discussed earlier, the impact of a vessel with an offshore installation may well result in a situation that will involve the evacuation, escape and rescue arrangements for the installation. Therefore, the duty holder as part of his system for the management of ship collision risk needs to address these issues as part of his demonstration of compliance with PFEER.

Ship collision is a major accident hazard requiring assessment as defined in this Regulation. The process of assessment involves:

- Identifying ship collision hazards which may require evacuation, escape and rescue;
- Identifying the likelihood of them occurring and their consequences;
- Identifying the measures needed to meet the requirements of these Regulations in relation to the evacuation, escape and rescue in the event of a ship collision;
- Identifying performance standards to ensure effective escape, evacuation and rescue.

A performance standard is a statement, which can be expressed in qualitative or quantitative terms, of the performance required of a system, item of equipment, person or procedure, and which is used as the basis for managing the hazard, (e.g.) planning, measuring, control or audit, through the life cycle of the installation. Regulation 5 of PFEER does not specify what performance standards should be; that is for the duty holder to decide, taking into account the circumstances on the particular installation.

That part of the assessment dealing with evacuation, escape and rescue should address:

- The organisation and arrangements for the management of an emergency which might lead to evacuation, escape and rescue, including the formal command structure;
- The means of evacuation, including type, capacity and location , available for the evacuation of personnel from temporary refuge, muster areas and other parts of the installation from which access to temporary refuge is not readily available;
- Types, capacity and location of means of escape to the sea;
- The performance of the rescue and recovery facilities, including their function, capacity and availability;
- The types, numbers and location of personal survival and escape equipment.

The assessment should identify the factors which might affect the availability of the measures and arrangements. This should include the environmental and weather conditions which may limit the capacity to carry out effective evacuation, escape and rescue. Catastrophic ship collision in itself presents difficulties as discussed in Section 7.

Setting performance standards for measures is a crucial aspect of the assessment process. Performance standards should relate to the purpose of the system, item of equipment, procedure, etc. which they describe. They may be described in terms of functionality, survivability, reliability and availability and they should be measurable and auditable.

3.9.3 Preparation for Emergencies (Reg. 6)

This Regulation requires the duty holder to prepare for emergencies and identifies a number of key areas to address, including the command structure; the selection and competence of personnel to undertake emergency duties and instruction and training for everyone on the installation regarding the appropriate action to take in an emergency.

3.9.4 Emergency Response Plan (Reg. 8)

This Regulation requires the duty holder to prepare an emergency response plan, which documents the organisation and arrangements for dealing with an emergency on the installation. It also requires duty holders to consult those who may become involved in emergency response.

Organisation and arrangements include the organisational structure for handling emergencies, including the chain of command, the roles and responsibilities of key people, communication arrangements and the action to be taken in response to specific emergencies, such as ship collision.

The plan should cover the arrangements and procedures needed to respond to a ship collision. It should set out who does what, when, where, how and to what effect, in the event of a ship collision. It should describe both the offshore and onshore arrangements and ensure that they dovetail. It should cover all stages of the emergency from the time it is detected until normalisation. The plan should indicate the point at which it should be initiated and give guidance on the factors to consider in choosing particular courses of action, including the choice of external evacuation, rescue and recovery services in specific circumstances, in this case, ship collision. The plan should be concise, readable and in a format which can be used readily in real emergencies, as well as in training, exercises and drills.

3.9.5 Detection of Incidents (Reg. 10)

This Regulation requires the duty holder to take appropriate measures to detect emergencies including vessels on potential collision courses with the installation, (e.g. by the use of radar, by a standby vessel, or on the installation itself).

Such detection systems should be appropriate and should provide sufficient levels of availability and reliability to meet the demands placed upon them. Equipment should be appropriately located, taking account of the nature of ship collision risks and the capacity of the equipment to respond and relay the right information for effective control action to take place. In general, detection measures should be automatic where this is reasonably practicable as should the transmission of information from detection systems to the point at which control action can be instigated. Where detection and relay of information cannot be done automatically, adequate arrangements should be in place to detect incidents and to instigate control action.

3.9.6 Communications (Reg. 11)

This Regulation requires the duty holder to make appropriate arrangements for rapidly alerting all personnel on the installation that an emergency has occurred, or is occurring, including impending ship collision.

The Regulation requires arrangements for communications on the installation for the purpose of emergency response. This includes those responsible for the management of the emergency and those persons with specific emergency duties. It also requires arrangements for communications with persons engaged in activities in connection with the installation, such as supply vessels and heavy lift vessels and with persons not on the installation who have a role in the emergency plan, such as the standby vessel.

These arrangements need to be based on the findings of the assessment required under Regulation 5.

3.9.7 Control of Emergencies (Reg. 12)

Regulation 12 covers all types of emergency and requires duty holders to have appropriate control measures to limit escalation in the event of an emergency. Such control measures may comprise structural measures, operational and management procedures, plant and equipment and their control systems.

In relation to ship collision risks, attention needs to be paid to the likelihood and consequences of escalation involving fire, (e.g. breaching of the cargo tanks of an FPSO or the risers of a fixed installation). Appropriate control measures may involve using double hulls for FPSOs and shutting in wells or closing down process equipment on detection of an impending collision.

3.9.8 Muster Areas, etc. (Reg. 14)

This Regulation requires the duty holder to make provision for personnel on the installation to assemble safely while the emergency is assessed and control action taken. It also requires provision for personnel to access safely, means for leaving the installation if necessary.

In the event of a fire or explosion on an installation, it may be advisable to arrange for muster areas within the temporary refuge. However, in the case of a potential ship collision, it is better to muster personnel outside any accommodation in order to avoid persons being trapped within the structure. Such considerations need to be taken into account when designating muster areas on an installation.

3.9.9 Arrangements for Evacuation (Reg. 15)

Regulation 15 requires the duty holder to make suitable arrangements for all persons to leave the installation safely in the event of an emergency which requires evacuation, and to be taken to a place of safety.

Duty holders should select means of evacuation on the basis of their contribution to reducing the risks to those who might have to use them so far as is reasonably practicable. When making arrangements for evacuation, duty holders should identify and take into account any constraints on their use by weather conditions, the nature and location of the emergency and the time available to evacuate. Catastrophic ship collision is a difficult scenario with which to deal and careful thought needs to be given to the development and implementation of such arrangements for this particular risk.

3.9.10 Means of Escape (Reg. 16)

This Regulation requires the duty holder to provide means of escape so that persons may escape from the installation in the event of the failure of the evacuation system in a catastrophic incident, such as ship collision, when a planned and orderly evacuation cannot be achieved.

The provision of means of escape should be based on the findings of the assessment required under Regulation 5 and the escape arrangements should be set out in the Emergency Response Plan required under Regulation 8.

Duty holders should select means of escape on the basis of their contribution to reducing the risks to those who may have to escape from the installation so far as is reasonably practicable. This means that duty holders should give preference to means which offer some protection from the elements and avoid the need to enter the sea directly.

3.9.11 Arrangements for Recovery and Rescue (Reg. 17)

Regulation 17 requires the duty holder to make effective arrangements, which include such arrangements with suitable persons beyond the installation, for:

(a) recovery of persons following their evacuation or escape from the installation; and
(b) rescue of persons near the installation; and
(c) taking such persons to a place of safety.

For the purposes of this Regulation, arrangements are regarded as being effective if they secure a good prospect of those persons being recovered, rescued, and taken to a place of safety.

The Approved Code of Practice uses the term 'reasonably foreseeable' with respect to events requiring the evacuation, escape and rescue of personnel and ship collision is specifically identified as such an event.

Regulation 17 requires rescue arrangements to be effective and it should be noted that this requirement is not qualified by the phrase 'so far as is reasonably practicable', (i.e. cost should not be taken into account). However, the Approved Code of Practice explains the term 'good prospect of being recovered, rescued, and taken to a place of safety' as meaning 'arrangements designed to give a good probability, in all but the most severe storm conditions and sea states, of rescuing, recovering and taking to a place of safety persons who have to evacuate or escape from an installation, or who fall overboard or are involved in a helicopter ditching on take-off or landing.

3.10 OFFSHORE INSTALLATIONS AND WELLS (DESIGN AND CONSTRUCTION ETC) REGULATIONS 1996

The Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996 (DCR) impose duties on the operators of fixed installations and the owners of mobile installations (the duty holder) in relation to the design and construction of offshore installations.

Regulation 4 of DCR places a general duty on the duty holder to ensure that an installation at all times possesses such integrity as is reasonably practicable.

Regulation 5(1)(a) requires the duty holder to ensure that the design to which an installation is to be, or in the event, is constructed are such that, so far as is reasonably practicable it can withstand such forces acting on it as are reasonably foreseeable. Regulation 5(1)(e) requires that in the event of reasonably foreseeable damage to the installation it will retain sufficient integrity to enable action to be taken to safeguard the health and safety of persons on or near it.

The HSE Guidance on Regulations for DCR states that reasonably foreseeable forces include those arising from the activities on or in connection with the installation such as vessel impact. Apart from any systems for the avoidance of ship collision with an installation, the duty holder must take into account potential damage from vessel impact when considering the design, construction and operation of an installation.

The requirements of the DCR Regulations need to be addressed in relation to systems involved in the detection, control and mitigation of ship collision. These are discussed in greater depth in later sections.

3.10 PIPELINES SAFETY REGULATIONS 1996

The Pipeline Safety Regulations 1996 (PSR) apply to offshore pipelines, including the risers up to the emergency shutdown valve (ESDV) if a pig trap is not fitted and including the pig trap, if one is fitted.

The risers on an offshore installation may be vulnerable to ship collision, especially if the risers run outside the jacket.

Regulation 5 of PSR requires the operator of a pipeline to ensure that it has been so designed that, so far as is reasonably practicable, it can withstand the external forces to which it may be subjected. Impact of a vessel with an installation is reasonably foreseeable and such a risk should be taken into account during the design of a pipeline including the location of the riser(s) in order to minimise any damage arising from a vessel colliding with the installation.

Offshore pipelines carrying hydrocarbons fall within the definition of major accident hazard pipelines under PSR. Under Regulation 23, the operator is required to prepare and revise and replace, as appropriate, a Major Accident Prevention Document (MAPD) for a pipeline. The MAPD should contain sufficient information to demonstrate that all hazards relating to the pipeline with the potential to cause a major accident, including the possibility of vessel impact with a riser, have been identified and the risks arising from those hazards have been evaluated. Clearly, there is overlap with some of the other offshore Regulations discussed above which need to be taken into account when considering the risk of damage arising from a vessel colliding with an installation.

3.11 THE INTERNATIONAL REGULATIONS FOR PREVENTING COLLISIONS AT SEA 1972

These Regulations incorporate The Merchant Shipping (Distress Signals and Prevention of Collisions) Regulations 1996, and Merchant Shipping Notice No. M1642/COLREG 1. They apply to all vessels upon the high seas and in all waters connected therewith navigable by seagoing vessels. Therefore, all vessels associated with the operation of an offshore installation are subject to these Rules both in and outside the 500m safety zone.

The Regulations set out, in 39 Rules, all aspects of vessel conduct in various visibility conditions, the lights and shapes to be displayed for various vessels performing various operations, and the sound and light signals to be broadcast for various warning and distress conditions.

Outlined below are details of the rules of the Regulations which are considered of particular relevance in this collision risk management study:

Rule 5: Look-out

Every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.

Rule 6: Speed

Every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions.

In determining a safe speed the following factors shall be among those taken into account:

(a) By all vessels:
 i. the state of visibility;
 ii. the traffic density including concentrations of fishing vessels or any other vessels;
 iii. the manoeuvrability of the vessel with special reference to stopping distance and turning ability in the prevailing conditions;
 iv. at night the presence of background light such as from shore lights or from back scatter of her own lights;
 v. the state of wind, sea and current, and the proximity of navigational hazards;
 vi. the draught in relation to the available depth of water.

(b) Additionally, by vessels with operational radar:
 i. the characteristics, efficiency and limitations of the radar equipment;
 ii. any constraints imposed by the radar range scale in use;
 iii. the effect on radar detection of the sea state, weather and other sources of interference;

iv. the possibility that small vessels, ice and other floating objects may not be detected by radar at an adequate range;

v. the number, location and movement of vessels detected by radar;

vi. the more exact assessment of the visibility that may be possible when radar is used to determine the range of vessels or other objects in the vicinity."

Rule 7: Risk Of Collision

(a) Every vessel shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt such risk shall be deemed to exist.

(b) Proper use shall be made of radar equipment if fitted and operational, including long-range scanning to obtain early warning of risk of collision and radar plotting or equivalent systematic observation of detected objects.

(c) Assumptions shall not be made on the basis of scanty information, especially scanty radar information.

(d) In determining if risk of collision exists the following considerations shall be among those taken into account:

i. such risk shall be deemed to exist if the compass bearing of an approaching vessel does not appreciably change;

ii. such risk may sometimes exist even when an appreciable bearing change is evident, particularly when approaching a very large vessel or a tow or when approaching a vessel at close range.

Rule 8: Action To Avoid Collision

(a) Any action taken to avoid collision shall, if the circumstances of the case admit, be positive, made in ample time and with due regard to the observance of good seamanship.

(b) Any alteration of course and/or speed to avoid collision shall, if the circumstances of the case admit, be large enough to be readily apparent to another vessel observing visually or by radar; a succession of small alterations of course and/or speed should be avoided.

(c) If there is sufficient sea-room, alteration of course alone may be the most effective action to avoid a close-quarters situation provided that it is made in good time, is substantial and does not result in another close-quarters situation.

(d) Action taken to avoid collision with another vessel shall be such as to result in passing at a safe distance. The effectiveness of the action shall be carefully checked until the other vessel is finally past and clear.

(e) If necessary to avoid collision or allow more time to assess the situation, a vessel shall slacken her speed or take all way off by stopping or reversing her means of propulsion.

(f)

i. A vessel which, by any of these Rules, is required not to impede the passage or safe passage of another vessel shall, when required by the circumstances of the case, take early action to allow sufficient sea-room for the safe passage of the other vessel.

ii. A vessel required not to impede the passage or safe passage of another vessel is not relieved of this obligation if approaching the other vessel so as to involve risk of collision and shall, when taking action, have full regard to the action which may be required by the Rules of this Part.

iii. A vessel the passage of which is not to be impeded remains fully obliged to comply with the Rules of this Part when the two vessels are approaching one another so as to involve risk of collision."

Rule 14: Head-on Situation

(a) When two power-driven vessels are meeting on reciprocal or nearly reciprocal courses so as to involve risk of collision each shall alter her course to starboard so that each shall pass on the port side of the other.

(b) Such a situation shall be deemed to exist when a vessel sees the other ahead or nearly ahead and by night she would see the mast head lights of the other in a line or nearly in a line and/or both sidelights and by day she observes the corresponding aspect of the other vessel.

(c) When a vessel is in any doubt as to whether such a situation exists she shall assume that it does exist and act accordingly.

Rule 15: Crossing Situation

When two power-driven vessels are crossing so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way and shall, if the circumstances of the case admit, avoid crossing ahead of the other vessel.

Rule 16: Action by Give-Way Vessel

Every vessel which is directed to keep out of the way of another vessel shall, so far as possible, take early and substantial action to keep well clear.

Rule 17: Action by Stand-on Vessel

(a)

i. Where one of two vessels is to keep out of the way the other shall keep her course and speed.

ii. The latter vessel may however take action to avoid collision by her manoeuvre alone, as soon as it becomes apparent to her that the vessel required to keep out of the way is not taking appropriate action in compliance with these Rules.

(b) When, from any cause, the vessel required to keep her course and speed finds herself so close that collision cannot be avoided by the action of the give-way vessel alone, she shall take such action as will best aid to avoid collision.

(c) A power-driven vessel which takes action in a crossing situation in accordance with sub-paragraph (a)(ii) of this Rule to avoid collision with another power-driven vessel shall, if the circumstances of the case admit, not alter course to port for a vessel on her own port side.

(d) This Rule does not relieve the give-way vessel of her obligation to keep out of the way.

Rule 19: Conduct of Vessels in Restricted Visibility

(a) This Rule applies to vessels not in sight of one another when navigating in or near an area of restricted visibility.

(b) Every vessel shall proceed at a safe speed adapted to the prevailing circumstances and conditions of restricted visibility. A power-driven vessel shall have her engines ready for immediate manoeuvre.

(c) Every vessel shall have due regard to the prevailing circumstances and conditions of restricted visibility when complying with the Rules of Section I of this Part.

(d) A vessel which detects by radar alone the presence of another vessel shall determine if a close-quarters situation is developing and/or risk of collision exists. If so, she shall take avoiding action in ample time, provided that when such action consists of an alteration of course, so far as possible the following shall be avoided:

i. an alteration of course to port for a vessel forward of the beam, other than for a vessel being overtaken;
ii. an alteration of course towards a vessel abeam or abaft the beam.

(e) Except where it has been determined that a risk of collision does not exist, every vessel which hears apparently forward of her beam the fog signal of another vessel, or which cannot avoid a close-quarters situation with another vessel forward of her beam, shall reduce her speed to the minimum at which she can be kept on her course. She shall if necessary take all her way off and in any event navigate with extreme caution until danger of collision is over.

If the Regulations are contravened, the owner of the vessel, the master and any person for the time being responsible for the conduct of the vessel shall each be guilty of an offence, punishable on conviction on indictment by imprisonment for a term not exceeding two years and a fine. In addition, in the case where a ship does not comply with the requirements of the Regulations, the ship is liable to be detained.

3.12 INTERNATIONAL SHIPPING CONVENTIONS

ILO Convention 147 (Merchant Shipping (Minimum Standards) Convention, 1976) requires Administrations to have effective legislation on safe manning standards, hours of work, seafarers' competency and social security. It also sets employment standards equivalent to those contained in a range of ILO instruments, including those covering training.

In 1995, the International Convention on Standards, Training, Certification and Watchkeeping for Seafarers, 1978 (STCW) was substantially revised and the amendments came into force in February 1997. In addition to establishing uniform standards of competence for seafarers, details of which are contained in the Seafarers' Training, Certification and Watchkeeping (STCW) Code, the revised Convention contains explicit new responsibilities with which shipping companies must comply.

As well as concerning the need for companies to ensure that seafarers are indeed competent and properly certificated in accordance with the Convention, new company responsibilities relate to manning, record keeping, shipboard familiarisation of crew, the ability of ships' complements to co-ordinate their activities and minimum rest periods.

In 1993, the IMO adopted the International Management Code for the Safe Operation of Ships and for Pollution Prevention (the International Safety Management (ISM) Code). The ISM Code establishes an international standard for the safe management and operation of ships by setting rules for the organisation of company management in relation to safety and pollution prevention and for the implementation of a safety management system.

Although largely derived from the ISM Code, the emphasis of the STCW on company responsibility is more precise. Whereas the ISM Code requires shipping companies to ensure that certain procedures relating to personnel are established, the STCW Convention stipulates that companies must be able to demonstrate that relevant STCW provisions have been implemented to ensure that the Convention's intentions have been brought into effect, i.e. that seafarers employed on board are competent, qualified and can indeed perform their duties safety and effectively.

3.13 THE PETROLEUM ACT 1987

The Geneva Convention of 1958 automatically provides for a 500m safety zone around any offshore installation which protrudes above the sea surface. For a sub-sea installation, notification is necessary.

The Petroleum Act 1987 defines relevant offences and penalties in relation to such safety zones. Section 23(1) of the Petroleum Act 1987 prohibits a vessel entering or remaining in a safety zone established around an installation.

The Offshore Installations (Safety Zones) Regulations 1987 states that this prohibition shall not apply to a vessel entering or remaining in the safety zone:

(a) in connection with the laying, inspection, testing, repair, alteration, renewal or removal of any submarine cable or pipeline in or near that safety zone;
(b) to provide services for, to transport persons or goods to or from, or under the authority of a government department to inspect, any installation in that safety zone;
(c) if it is a vessel belonging to a general lighthouse authority performing duties relating to the safety of navigation;
(d) in connection with the saving or attempted saving of life or property;
(e) owing to stress of weather; or
(f) when in distress.

Offshore operators should report infringements of the 500m zone to the HSE on Form OIR13 with copies to UKOOA and to the Royal Navy as detailed in HSE Offshore Safety Division Operations Notice 11, which also includes guidance on obtaining relevant evidence and completing the form.

3.14 THE COAST PROTECTION ACT 1949

The Coast Protection Act 1949 (as extended by S.4(1) of the Continental Shelf Act 1964, and amended by S.36 of the Merchant Shipping Act 1988) requires that operators obtain prior written consent from the Secretary of State for the Environment, Transport and the Regions to construct, alter or improve any works on the UK Continental Shelf where danger or obstruction to navigation is likely to result. This Act comes under the jurisdiction of the Department of the Environment, Transport and the Regions (DETR).

The DETR has a duty under the Act to assess whether any obstruction or danger that a new installation may have on navigation, is acceptable and that all appropriate risk reduction measures have been or will be, taken. As such, the DETR reviews risks from the perspective of vessels on the high seas and not those associated with the collision risk to the installation, which is the HSE's statutory duty (see Section 3.7).

The operator requires to submit sufficient location-specific information and an assessment to allow the DETR to assess:

- The shipping movements in the area;
- The likely changes in those movements resulting from an installation;
- The constraints imposed upon local navigation by the installation;
- The danger of passing vessels colliding with the installation;
- The increased danger of ships colliding with each other, or having other misfortunes, as a result of having to avoid the installation;
- If appropriate, the scope for reducing risk by taking counter measures.

Under this Act, the government has refused consent to locate drilling rigs and fixed installations at proposed sites due to the effect on navigation as being too significant.

4 OVERVIEW OF SHIP COLLISION HAZARDS

4.1 INTRODUCTION

This Section provides an overview of the different types of collision hazards that present a risk to personnel working on offshore installations, the environment and the asset. The collisions are subdivided into "In-field" and "Passing" vessel categories. Within this Section, an overview of the different types of offshore installations exposed to ship collisions is provided which highlights the different characteristics that influence collision risk. Also, discussion is presented to outline the effect of geographical location on risk. Finally, examples of incidents, which have taken place on the UKCS and in other parts of the World are presented.

4.2 IN-FIELD VESSEL COLLISIONS

There are a large variety of in-field vessels which are used to support offshore exploration and production. The different types of vessels and units, which could be operating either within the 500m safety zone or in close proximity to an installation, include:

- Standby vessels
- Multi-purpose vessels
- Supply vessels
- Mobile offshore drilling units (MODUs)
- Mobile accommodation units (flotels)
- Shuttle tankers
- Heavy lift vessels (crane barges)
- Anchor handling tugs
- Tugs
- Barges (e.g. pipelay barges)
- Diving support vessels
- Survey vessels
- Well stimulation vessels

Each of the above listed vessel types present risk of collision to the installation. Historical data has indicated that there are two distinct collision scenarios involving in-field vessels, which are:

- Powered vessel collisions;
- Drifting vessel collisions.

In the powered scenario the in-field vessel tends to impact with the installation at speed, under power, and, therefore, there is the potential for significant damage. Under a drifting scenario, the vessel has either lost power through engine failure or is not under command and drifts into the installation. These types of collision are generally regarded as having fewer consequences associated with them, given the lower vessel velocities likely to be involved.

In-field collision risks tend to be considered as high frequency, low consequence events, however experience has shown that they do have the potential to result in severe damage and tend to amount to a high proportion of an installation's repair costs. This has been confirmed by a recent study by the Marine Technology Directorate in 1994 (Ref.2), which found that vessel impacts were a major cause of damage to offshore structures.

It is clearly good practice to manage these risks effectively to ensure safety of personnel and to reduce the cost of repairs. This is amplified as more fields rely on visits from shuttle tankers and larger supply vessels, which have the potential for higher consequence impacts.

4.3 PASSING VESSEL COLLISIONS

The passing vessel category can include all vessels proceeding on the high seas and not visiting or working in the vicinity of, and in connection with, a particular offshore installation. For example, a supply or standby vessel is likely to pass a number of other offshore installations en route to a specific installation. For these installations, this vessel represents a passing vessel hazard, whilst for the installation it is visiting it will represent an in-field vessel hazard.

As with in-field vessels, the hazards presented by passing vessels can be sub-divided into two distinct categories:

- Powered Vessel Collisions;
- Drifting Vessel Collisions

These categories are discussed further in the following sub-sections:

4.3.1 Powered Collisions (Passing Vessels)

This type of collision can be defined as a collision which occurs when the vessel collides with the installation whilst moving under power. Such collisions could occur if a vessel had set a course between two way points and failed to take into account the presence of an offshore installation. This would also have to coincide with personnel on the bridge of the vessel failing to notice the installation and take corrective action to avert a collision. The causes of such incidents are presented and discussed in Section 6.

Powered passing vessel collisions are potentially the worst type of collision, as the colliding vessel can be large and travelling at a speed which could result in very large collision energies.

Table 4.1 presents examples of typical passing vessels encountered in UK waters. The Table also presents typical sizes and speeds of vessels and the impact energy if a collision occurred with an installation. The examples presented are based on a large number of traffic surveys carried out on the UKCS.

Table 4.1

Typical Passing Vessel Which Could Collide With an Offshore Installation

Vessel Type	Displacement Tonnes[1]	Speed Knots [2]	(Impact Energy MJ) [3]
Tanker	120,000	13	2952 MJ
Ferry	8,500	16	317 MJ
Merchant Container Ship	22,500	11	396 MJ
Offshore Supply Vessel	3,500	10	51 MJ
Offshore Standby Vessel	1,500	10	22 MJ
Large fishing vessel	1,000	8	9 MJ
Small Fishing Vessel	400	8	4 MJ

1 It should be noted that the sizes for the different types of vessels can range significantly and those presented in the table are examples of typical vessels (e.g. a shuttle tanker in ballast will typically be 120,000 t displacement, whilst laden may be in excess of 200,000 t).

2 The speed at which a vessel is travelling may vary depending on sea conditions, distance from port, fuel consumption, etc. The speeds presented are indicative and are based on typical speeds recorded during a large number of traffic surveys.

*3 The impact energy has been calculated based on $E = 0.5mv^2$ where m = (displacement * 1.1) to take into account the added mass of water acting with the vessel.*

Whilst this list does not attempt to define every type of vessel that can collide with an offshore installation, it gives an indication of the magnitude of the hazard should a collision occur. Under the HSE 4th Edition Guidelines for the Design and Construction of Offshore Installations, offshore installations have, generally, been designed to withstand an impact energy of the order of 11-14MJ, for larger installations in the Central and Northern North Sea, and of the order of 4MJ for smaller installations in the Southern North Sea. It can be seen from this Table that, in the event of any of these vessels (with the exception of smaller fishing vessels) colliding with an offshore installation, whilst travelling at typical operating speeds, such a vessel would present a threat to the integrity of the vast majority of installations on the UKCS. It is noted that certain types of installations, such as FPSOs and some mobile units, may, due to their inherent strength and flexible mooring, be able to withstand much higher impact energies than 11-14MJ without their overall integrity being threatened, however, this should be assessed on a case by case basis.

Passing vessels, not only pose a higher potential risk of serious structural damage than in-field vessels, the risks associated with the passing vessel hazard are much more difficult to manage, from the operators perspective. This is due to the fact that passing vessels are usually outside the direct management influence of the offshore installation operator, unlike in-field vessels. A passing vessel on a collision course with an installation would firstly require to be identified as a threat before any action to minimise risk can be initiated. Such actions would include the standby vessel challenging the incoming vessel, both by radio, light, sound and possibly but unlikely, by physical means. On the installation, measures would be taken to limit the consequences of a collision such as shutting down wells and depressurising the process systems. Personnel may also be evacuated from the threatened installation but with the likely time available, this would probably be by lifeboat rather than the preferred helicopter.

As typical times required for the shutdown, mustering and lifeboat evacuation of a large offshore installation would likely be in the order of 30-45 minutes, detection of an incoming vessel would have to be made when the vessel is 6-9 nm from the installation, assuming a speed of around 12 knots. Faster vessels would offer less time. With incoming vessels at such a distance from the installation, to initiate an installation shutdown and evacuation may be difficult since the incoming vessel may be under normal command and may alter course well in advance of the installation. But not to take action, would reduce the time available to complete a successful shutdown and evacuation.

The above demonstrates the difficult nature of management of powered passing vessel hazards and shows the need for an operator to have a comprehensive understanding of shipping risks so as to be able to develop an effective safety management system for each specific location.

4.3.2 Drifting Collisions (Passing Vessels)

This type of collision can occur when a vessel has lost propulsion and cannot maintain a course or sufficient steerage. In the event of the vessel being unable to re-establish power in time and with no effective measures available to control the course of the vessel, the possibility exists that it could collide with an installation.

The main difference between this type of collision and a powered vessel collision is that as the vessel is not under power (i.e. it is under the influence of environmental conditions such as wind, waves, current), the velocities involved tend to be much lower, in the region of 1-4 knots. In a drifting vessel scenario, given the lower drift speeds involved, there is more time available to recover the vessel from the collision course either through use of its secondary propulsion units (self-recovery) or through towage (external recovery). In addition, it is noted that the greater time assists in the decision making process on the installation in terms of identifying the optimal mitigation procedure. A number of drifting vessel scenarios have occurred in the North Sea to date with a significant proportion resulting in precautionary down manning.

4.4 DIFFERENT TYPES OF INSTALLATIONS EXPOSED TO COLLISION RISKS

It is useful to enumerate the different types of installations exposed to the risks of vessel collisions as each has a number of factors associated with them that influence the likelihood and consequences of collision. Table 4.2 provides an overview of these factors:

Table 4.1

Different Types of Installations Exposed to Collision Risks

Fixed/ Mobile	Installation type	Factors Influencing Likelihood & Consequence of Collision	
		Passing	In-Field
Fixed	Single Jacket/ Platform	• Unable to move/relocate. • Reliant on monitoring from SBV or platform radar. • Position marked on navigational chart. • Passing vessels should be well aware of installation's position over time at field. • Greater time required to muster and evacuate. • Should have good knowledge of passing vessel routing in vicinity.	• Standby vessel likely to be dedicated to installation, familiar with procedures, SMS, etc. • Supply vessel procedures likely to be well developed, based on experience. • Risers on outside of jacket on some older installations.
	Bridge Linked Complex	• Issues as for single fixed installations. • Options to evacuate to another platform in complex. • Problem in assessing which platform may be hit.	• Issues as for single, fixed installations.
	FPSO	• Some FPSOs have thrusters, which they could use to turn and present a smaller target to	• As fixed installations. • Large shuttle tankers likely to be loading in

Fixed/ Mobile	Installation type	Factors Influencing Likelihood & Consequence of Collision	
		Passing	In-Field
		oncoming vessel. • Vessels on DP could potentially disconnect depending on time. • Likely to withstand greater impacts than some platforms • Some have larger geometrical target area. • Likely to have experienced marine personnel onboard. • Other issues as for fixed installations. • Vessels yawing in extreme weather make collision alarms difficult to operate.	close proximity. • Could have tankers from "spot" market as opposed to dedicated vessels, depending on field & policy. • Movement of FPSO as well as visiting vessel.
	NUI	• Installations more at risk when in unmanned mode. Less likely to have SBV to detect & respond to rogue vessel. • Smaller target, smaller radar echo. • Limited impact energy resistance. • Easier to carry out precautionary down manning. • Less time to muster and evacuate, than large platform/complex.	• Lower impact energy resistance, small installations. • Fewer vessel visits. • Smaller vessels tend to visit. • Smaller geometrical target & radar return.
	TLP/Semi-Submersible	• Issues as for fixed installation. • Ballast system may be used to minimise criticality of impairment. • Likely to have experienced marine personnel onboard.	• Issues as for fixed installation. • Movement of installation as well as visiting vessel.
Mobile	Jack-Up	• Likely to be working at sites where there is no fixed installation, therefore, passing vessels less familiar with activity. • Less likely to have	• Vessels may be visiting a number of different installations. Large number of operations at night. • Vessels more likely to be

Fixed/ Mobile	Installation type	Factors Influencing Likelihood & Consequence of Collision	
		Passing	In-Field
		knowledge of vessel routing in vicinity. • Less time to develop procedures & synchronise with SBV. • Site not marked on charts which vessels will be carrying. • May be involved in a hazardous drilling operation which requires well to be made safe. • Short time spent at location • Three-legged design leads to greater vulnerability from toppling.	hired on "spot" market. • Vessels less familiar with procedures and limitations of installation they are visiting.
	Semi-Sub-mersible (incl. Flotels etc.)	• Issues as with Jack-Up & fixed semi-submersibles.	• Issues as with Jack-Up & fixed semi-submersibles.

4,5 EFFECT OF GEOGRAPHICAL LOCATION ON COLLISION RISK

For in-field vessels, the geographical location has an effect on the collision risk. This is mainly due to the fact that the vessels will be faced by different environmental conditions and also due to the fact that in certain areas, such as the Northern North Sea, supply vessels are larger than in the Southern North Sea.

For passing vessel collision, geographical location has a significant effect on risk. For example, an installation located in proximity to a busy port or near an established shipping lane, such as a Traffic Separation Scheme (TSS) or a Deep Water Route (DWR), will have a much higher volume of traffic passing in close proximity, compared to an installation located in a more remote area. This is highlighted by the passing vessel collision data which indicates that the majority of incidents have occurred in the busy Southern North Sea areas which are also characterised by restricted navigation as a result of shallows and high installation density.

It is noted that, in the case of the installation being in proximity to a port, shallows, TSS, or DWR, the navigation of vessels is likely to be restricted and therefore when developing a collision management system, appreciation has to be given to the Regulations governing the passing vessels and the risks presented to them. This has been evident in some areas of the North Sea from feedback from the shipping industry. A vessel passing an installation at speed under good command may be challenged by a standby vessel on an interception course which requires the passing vessel to turn towards the installation rather than away from it. Clearly, the Master of a standby vessel should be familiar with the rules of navigation and ensure that he approaches potentially errant vessels on a safe course for all concerned, including the installation.

The effects of geographical location as well as installation specifics must, therefore, be taken into account within the Collision Risk Management System.

4.5 HISTORICAL EXAMPLES OF COLLISIONS

This Section presents an overview of some collisions which have taken place on the UKCS as well as in other parts of the world, divided into passing and in-field vessel collisions. It should be noted that those presented are a limited sample of the total number which have occurred and that at least nine collisions have occurred resulting in the total loss of an installation. In addition to the incidents which have occurred, there have been numerous safety zone infringements with passing vessels illegally entering the 500m safety zone around platforms on the UKCS.

4.5.1 Collisions on UKCS (Passing Vessels)

This Section documents passing vessel collisions that have occurred on the UKCS. The primary source of this data is the HSE OSD database on ship collisions (Ref. 3).

Table 4.1

Passing Vessel Collisions on UKCS

Year	Type of Installation & Vessel	Location	Details of Incident (Where Available)
1995	NUI & fishing vessel	Southern North Sea	Fishing vessel steamed into platform. Damage and installation shutdown.
1988	Jack-Up & cargo ship	Southern North Sea	Vessel struck jack-up with vessel causing severe damage and jack-up came close to collapsing. (see Figure 4.1)
1985	NUI & offshore supply vessel.	Southern North Sea	Vessel collided with platform whilst en-route to another installation.
1983	NUI & cargo ship	Southern North Sea	Vessel collided with installation, resulting in slight damage. Thought to be

Year	Type of Installation & Vessel	Location	Details of Incident (Where Available)
			a glancing blow.
1967	Semi-Submersible & cargo ship	Southern North Sea	Vessel hit rig in fog. One leg of installation punctured.

Note: no drifting passing vessel collisions have been recorded on the UKCS to date, however, these have occurred within the Dutch sector of the North Sea.

In addition to offshore oil and gas installations, collisions have also occurred with two installations similar in design to the small NUI of the Southern North Sea. These include an installation belonging to Trinity House and one to British Aerospace.

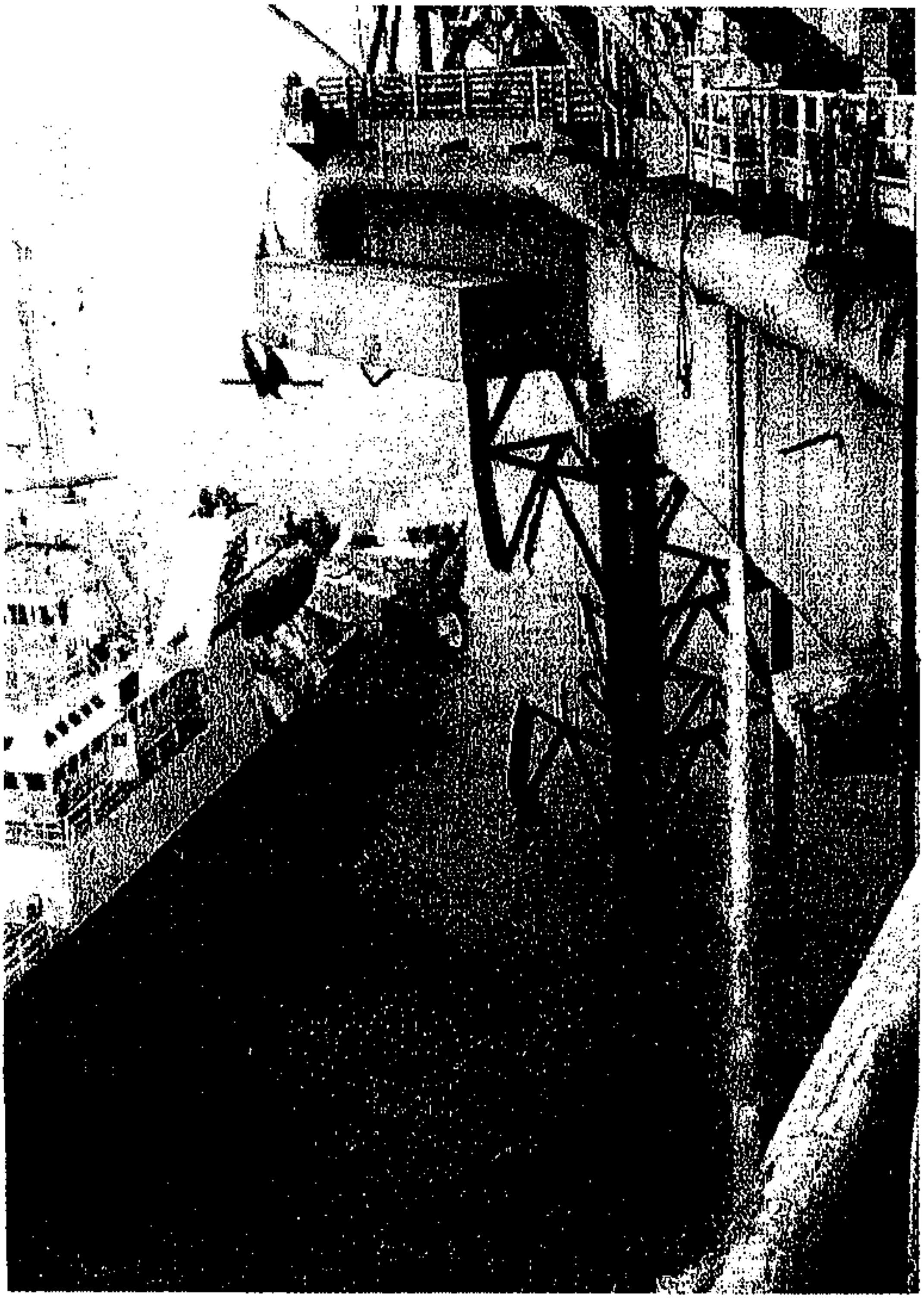

Figure 4.1

Collision Damage Sustained To A Jack-Up From A Passing Vessel Collision
(Photo courtesy of Global Marine)

4.5.2 Collisions on UKCS (In-Field Vessels)

This Section documents in-field vessel collisions which have occurred on the UKCS. The primary source of this data is the HSE OSD database on ship collisions (Ref. 3)

Table 4.1

Examples of In-Field Vessel Collisions on UKCS

Year	Type of Installation & Vessel	Location	Details of Incident (Where Available)
1997	FPSO & shuttle tanker	Central North Sea	Failure in position referencing system resulted in drive off and collision between bow of shuttle tanker & stern of FPSO.
1997	FPSO & supply vessel	Central North Sea	
1985	Semi-submersible & supply vessel	UKCS	Supply vessel collided with platform at 4 knots. Assumed to be a last minute emergency stop.
1978	Jack-Up & supply vessel	Morecambe Bay	Officer on watch fell asleep & vessel hit rig at 11 knots, mainly damaging the vessels bow.

4.5.3 Collisions Outside UKCS (Passing Vessels)

This Section documents passing vessel collisions that have occurred outside the UKCS.

Table 4.1

Examples of Passing Vessel Collisions Outside UKCS

Year	Type of Installation & Vessel	Location	Details of Incident (Where Available)
1975	Unmanned Platform and Tanker	Gulf of Mexico	Platform hit by large laden tanker, damaged cargo tank, released and ignited oil, serious damage to ship and platform. Significant loss of life.
1993	NUI and Tanker	Offshore Egypt	Fire on platform and on vessel, several crew on vessel killed.
1986	NUI and merchant vessel	Gulf of Mexico	Platform hit by passing merchant vessel, severe damage to vessel and platform.
1981	Unmanned platform and Ro-Ro vessel	Gulf of Mexico	Platform suffered severe damage.
1986	Unmanned platform and bulk carrier	Gulf of Mexico	Hit by a bulk carrier, one platform leg was damaged, part of main deck was torn away and helideck supports damaged.
1980	Unmanned Platform and Tanker	Gulf of Mexico	Platform hit by a laden tanker, bow cut through centre of jacket, impact released and ignited cargo, serious damage to ship and platform.
1995	Platform and Cargo Vessel	German Sector	Cargo ship struck platform close to the riser.

5 CONSEQUENCES AND LIKELIHOOD OF SHIP COLLISIONS

5.1 INTRODUCTION

This Section presents a discussion of the consequences and likelihood of ship collisions with offshore installations located on the UKCS. The consequences of the collisions which have taken place are discussed as well as the historical frequency of collisions based on the number of collisions and the number of years of exposure data of different types of installation. The section concludes with a discussion on future trends in the offshore marine environment and how these may affect the collision risk on all types of installations.

The main basis of this Section is the Ship/Platform Collision Incident Database which was developed/updated for the HSE in 1997 (Ref. 3). This collision incident database records details of 491 incidents in which vessels made contact with UKCS offshore oil and gas installations in the period from January 1975 to the end of April 1997 and is believed to be currently the most complete record of collisions on the UKCS. The database was compiled and cross-checked using a wide range of information sources, including information from:

- Department Of Energy Incident Reports OIR/9
- Health And Safety Executive Incident Reports OIR/9a
- National Maritime Institute Ltd. (NMI) (Refs. 4, 5)
- International Association Of Drilling Contractors (IADC) (Ref. 6)
- Advanced Mechanics and Engineering Ltd. (Ref. 7)
- Department of Transport Marine Accident Investigation Branch (MAIB) (Ref. 8)

Additional worldwide collision incident information has also been reviewed in order to provide a wider perspective to the risks associated with ship impacts on offshore installations.

The primary objective of this Section is to highlight that ship collisions with offshore installations occur on a regular basis and that the consequences of such collisions involve the offshore oil and gas industry in significant losses.

5.2 COLLISION INCIDENT OVERVIEW

During the 23 years between 1975 and 1997 there were 491 reported incidents in which a vessel made contact with an UKCS offshore oil and gas installation. Of these, 8 (1.8%) were passing vessels, the remainder associated with in-field vessels. Of the in-field vessels, 318 (66%) impacts involved supply vessels, 76 (16%) involved standby vessels, 34 (7%) involved diving support vessels, 29 (6%) involved other attendant vessels (e.g. anchor handler, tug, survey, shuttle tanker, etc.), and 26 (5%) involved unspecified vessels.

The distribution of impacts by vessel type is presented graphically in Figure 5.1.

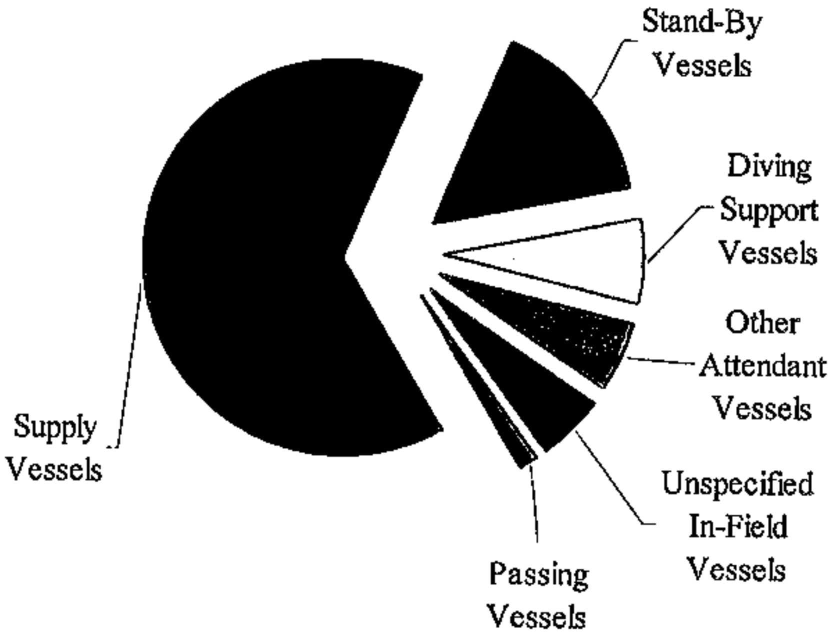

Figure 5.1

Distribution Of Impacts By Vessel Category

Figure 5.2 compares the damage sustained to offshore installations in the UKCS from in-field and passing vessel impacts. From this figure it can be seen that in the past, in-field vessels have caused considerably more damage to installations than passing vessels.

It should, however, be stressed that although there have been very few passing vessel impacts to-date on the UKCS, and those which have, have not been catastrophic, passing vessels, due to their size and speed, have the potential to cause total loss of an installation, as has occurred elsewhere in the world.

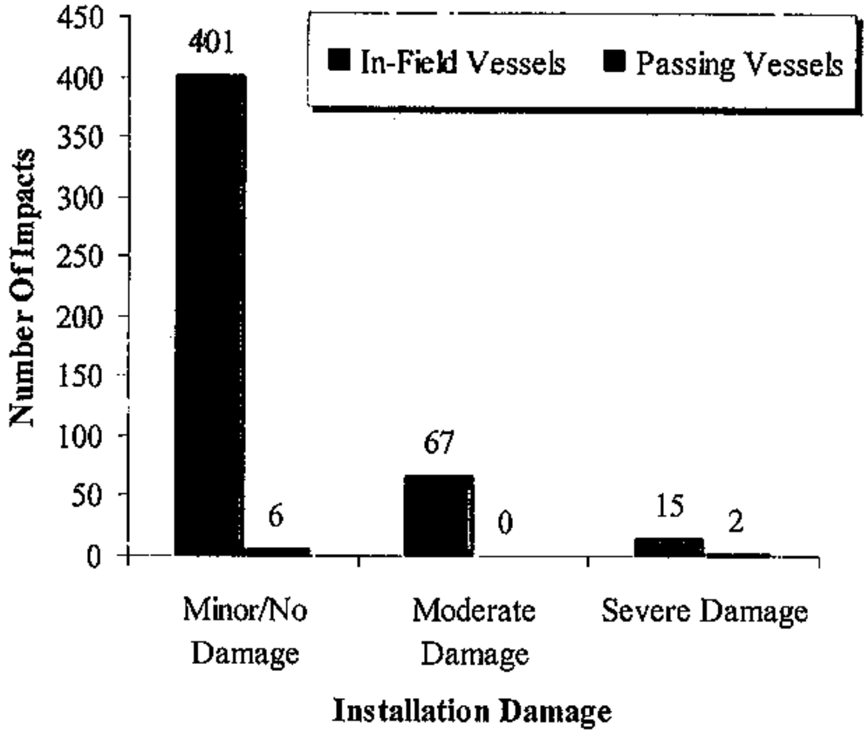

Figure 5.2

Comparison Between In-Field And Passing Vessel Impact Damage

A discussion of the consequences of vessel impacts and the likelihood of them occurring is presented in the following sections.

5.3 CONSEQUENCES OF IMPACT

5.3.1 In-Field Vessels

Figure 5.1 presents the breakdown of the levels of damage sustained by UKCS installations as a result of the reported 483 in-field vessel impacts between 1975 and 1997. The levels of damage presented are minor/no damage, moderate damage[1] and severe damage[2].

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[1] Moderate damage being damage requiring repair in the medium (up to 6 months) or longer term (over 6 months).

[2] Severe damage being damage affecting the integrity of an installation sufficient to require repair in the immediate or short term (up to 1 month).

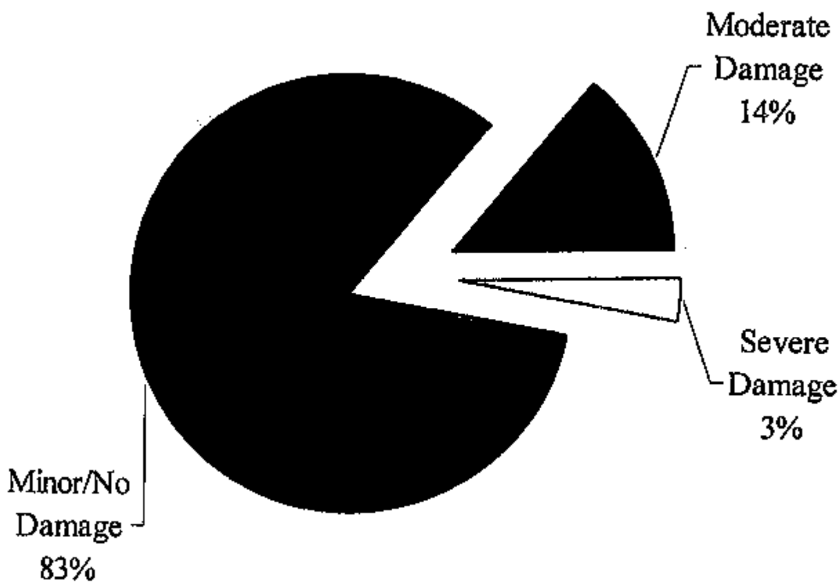

Figure 5.1

Installation Damage From In-Field Vessel Impacts

From Figure 5.1, it is clear that the majority of in-field vessel impacts cause little or no significant structural damage to the installation. However, even though the structural integrity of the installation is not compromised in the majority of in-field impacts, the impact area will normally still require to be inspected and the protective coatings on structural members repaired, if damaged. Whilst such repair should be straightforward, the location of the damage near sea level can increase the costs of repairs several fold.

It should also be borne in mind that it is unlikely that the complete costs associated with repair of impact damage will be covered by insurance. In some circumstances, operators may be unwilling to make insurance claims for what can be relatively frequent, albeit minor (in terms of the underwritten costs of an installation), incidents. The costs to industry from in-field collisions are, therefore, likely to be paid for from OPEX budgets.

The above discussion relates to the observed damage sustained as a result of ship impacts. It does not cover any accumulated effect of repetitive minor impacts on a structure such as work hardening, reduced fatigue life, and reduced static and dynamic strength. Such long term degradation, if it occurs, would probably be detected later in the life of an installation and would undoubtedly result in much higher repair costs.

To substantiate the claim that vessel impacts are a major cause of damage to offshore installations, the results of a MTD (Maritime Technology Directorate Ltd.) study can be cited (Ref. 2). This study, which was sponsored and steered by installation operators and the HSE, reviewed the repairs to offshore structures located on the North West European Continental Shelf (NWECS) during the period 1965-91. Of the 172 incidents in which repair was required to either steel or concrete offshore structures due to damage sustained, 37 (22%) were due to vessel impacts. The breakdown of installation damage causes is presented graphically in Figure 5.4

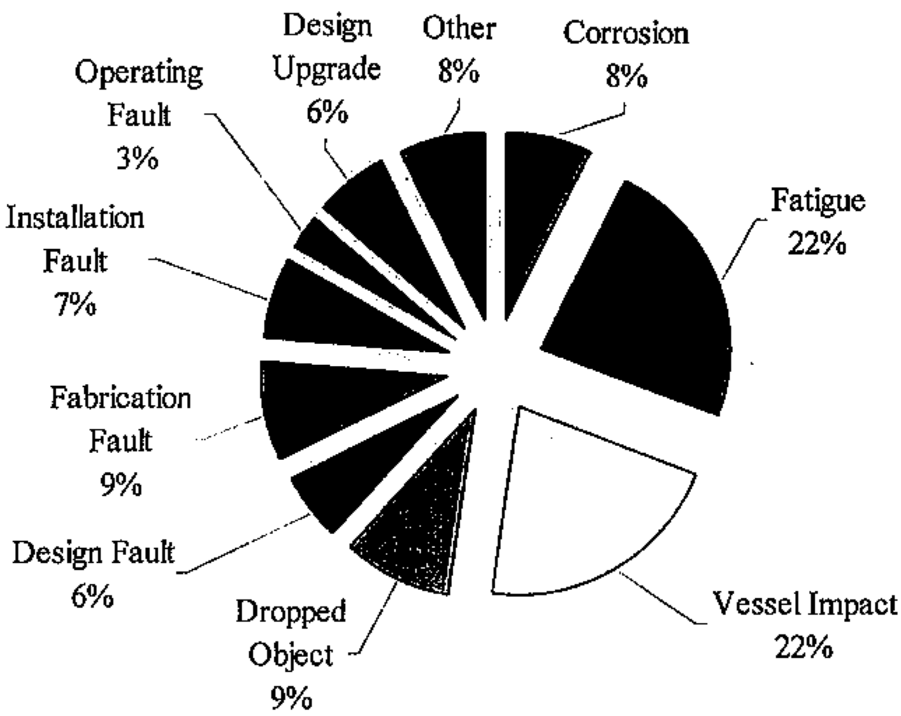

Figure 5.4

Causes Of Installation Damage On The NWECS During 1965-91

Figure 5.5 presents a breakdown of the in-field vessel impacts which caused either moderate or severe damage to the installation.

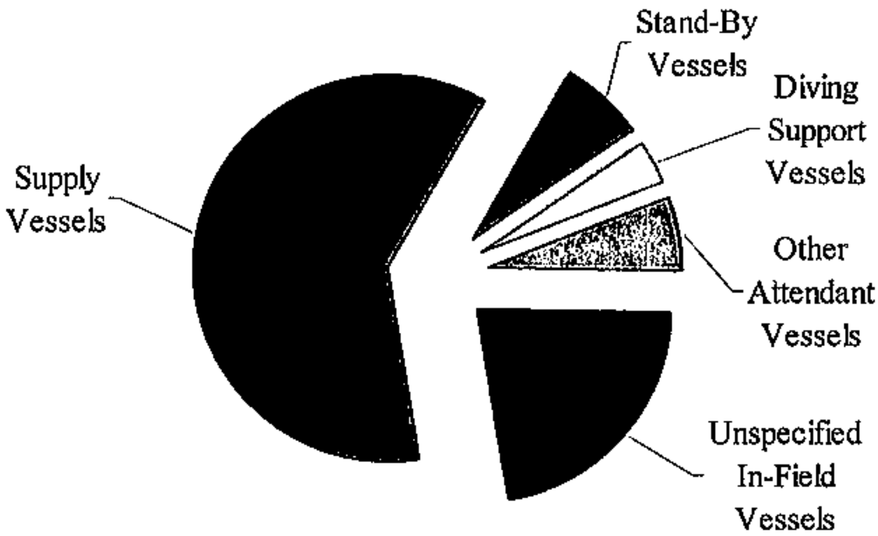

Figure 5.5

Distribution Of Moderate/Severe Impacts By In-Field Vessel Category

It is clear that for the 23 year period under consideration, supply vessels caused the highest proportion of damage requiring repair on installations on the UKCS. The main reasons for this are primarily a combination of:

- the requirement for the vessel to come close to the installation during cargo transfer operations,
- the relatively high number of supply vessels visits per year, and

- the requirement for the supply vessel to maintain position for extended periods usually by use of engines and thrusters to counteract the effects of environmental forces.

Of the reported 483 in-field vessel impacts between 1975 and 1997 for UKCS installations, 4 were between an installation and a merchant tanker (i.e. a shuttle tanker). Impacts between the tanker and a loading buoy were the most common type of impact, accounting for 3 of the collisions, the remaining one was with a fixed steel jacket platform in the Northern North Sea.

All of the reported impacts with shuttle tankers prior to 1997 resulted in only minor damage to the installation. However, since 1997 there have been a number of collisions between FPSOs and attendant shuttle tankers which have caused significant damage to the stern of the FPSO and some damage to process and utility systems on board the FPSO.

On most conventional, tanker-based (or shaped) FPSO's, the most probable locations for ship-to-ship collision impacts will be:

- The bow for drifting vessels;
- The stern for offloading tankers;
- The side for supply vessels and passing powered vessels.

For collisions to the bow or stern of a conventionally shaped FPSO there should be a significant element of structural protection against damage occurring to the process equipment which is usually mounted amidships. For collisions against the side of the FPSO, the combination of the height of the FPSO's side, the side ballast tanks, and the strength of the longitudinal structural members, should offer significant impact resistance and energy absorption, again minimising damage to process equipment.

Having an effective "crumple zone" around the process systems, in most circumstances, prevents installation collision damage from being exacerbated, or escalated, by adding process damage (with the resultant hazards of hydrocarbon loss of containment, possible fire, and so forth). Collision damage to the FPSO may be severe, but in the event of an offloading tanker collision (a predictable/relatively frequent, potentially high energy visiting vessel) it is unlikely to be catastrophic in most instances, as the speed, and hence impact energy, is most likely to be modest, as a result of in-field manoeuvring being done at a lower velocity than open water passage making.

Hence, it is considered likely that the FPSO will usually be able to survive the event, and if the ships storage tanks are ruptured, the oil lost will be "dead crude", which is de-gassed for storage, and is hence very much less likely to ignite or burn than "live" process fluids.

In considering alternative FPSO types or layouts, the most likely impact location of ship impact needs to be assessed for the predictable consequences in terms of damage to the process equipment. If the process equipment is near to the vessel edges, overhung, or relatively low above the water line, then the risk of damage is obviously far greater, and if process equipment is damaged, then the risk of fire or explosion is also far greater, due to the probability that gas or pressurised oil will be released.

5.3.2 Passing Vessels

In terms of the consequences of passing vessel impacts, 2 (25%) of the 8 passing vessel collisions resulted in severe damage to the installation, with the remainder causing only minor or no damage. Of the 6 impacts which caused only minor damage, 5 involved fishing vessels.

These statistics may be read as indicating that the consequences of a passing vessel impact with an installation will probably not be catastrophic and will most likely result in minimal damage. However, one of the severe damage incidents, which occurred in 1988 involved the 6616 gross tonne cargo vessel *Irving Forest* and the jack-up *Glomar Labrador 1*, and, reportedly, came close to causing collapse of the installation. In another passing vessel impact which occurred in the Southern North Sea between a port bound supply vessel and a British Aerospace radar tracking platform [1], the platform sustained approximately £6m worth of damage and was out of full operation for 15 months. In addition, a review of the World Offshore Accident Database (WOAD, Ref. 9) showed that of the 40 offshore related vessel collision incidents which occurred during the period 1971-97, 5 collisions resulted in the total loss of the installation.

It should also be noted that the magnitude of costs incurred should an installation suffer total loss (or any damage where there is significant loss of life and/or environmental damage), whether it is as a result of a fire or ship collision, will be extremely high. Insurance underwriters would probably cover some of the resulting losses but past experience shows that the uninsured losses to the installation's operator (e.g. Occidental's withdrawal from the North Sea following the Piper Alpha disaster), and also to the offshore oil and gas industry as a whole, would be very significant.

There have been no reported collisions between submarines and UKCS installations, but such impacts do occur. In 1990, a 450 tonne German submarine ran into the Oseberg platform at an estimated speed of 9 knots. Significant damage was sustained to both the installation and submarine, although it is understood that no lives were lost.

5.4 LIKELIHOOD OF IMPACTS

5.4.1 Overview

Figure 5.6 presents a comparison of the average number of installations in each year between 1975 and 1996 [2] with the number of reported vessel impacts for the corresponding period.

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[1] *As the BAe platform was not an offshore oil and gas platform, it was not included in the HSE's database (Ref. 3).*

[2] *1997 has been excluded since the database contains only up to the end of April 1997.*

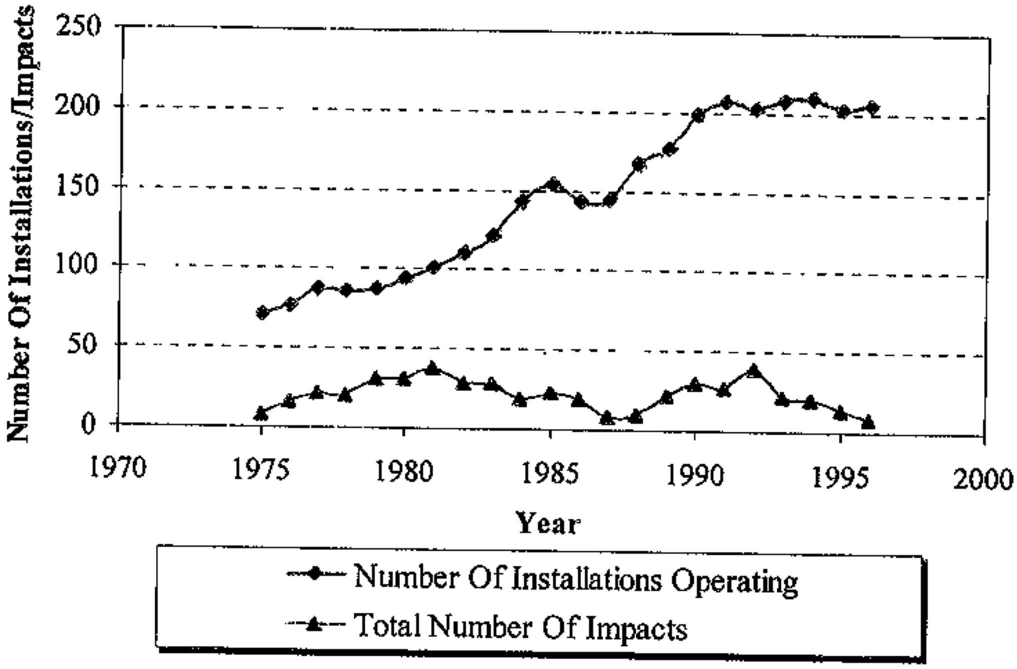

Figure 5.6

Comparison Between Number Of Installations And Number Of Impacts

Whereas the number of installations operating within the UKCS has risen from 70 in 1975 to over 200 in the 1990s, the number of vessel impacts has stayed fairly constant at around 20 per year.

To highlight the variance between the number of passing vessel impacts and in-field vessel impacts, Figure 5.7 presents the numbers of incidents for the years from 1975 to 1997.

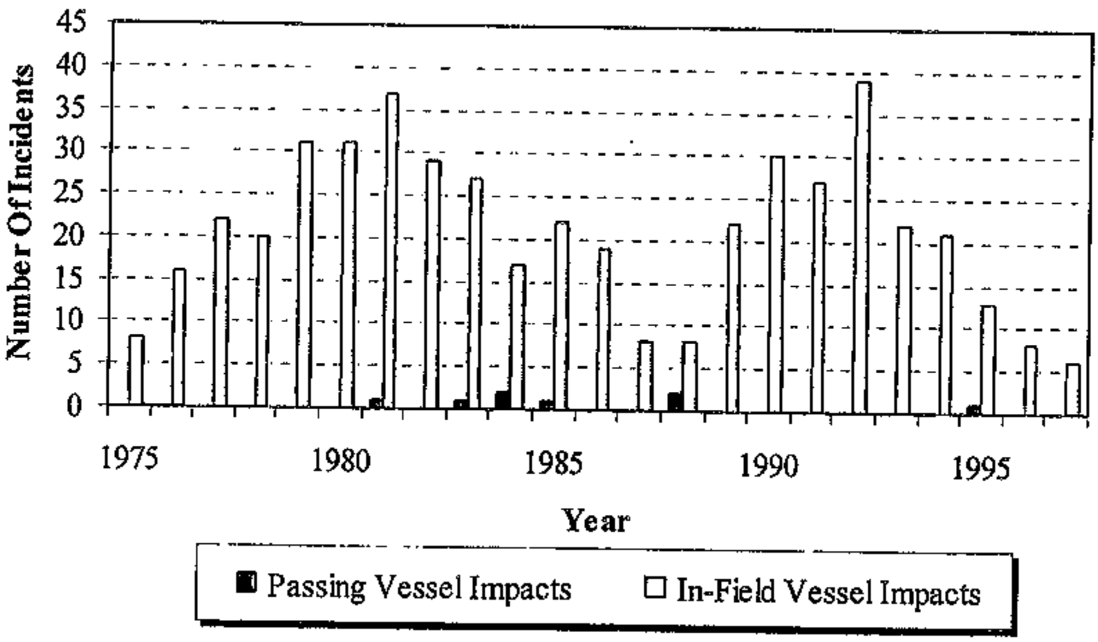

Figure 5.7

Number Of Passing And In-Field Vessel Impacts

Figure 5.8 presents the cumulative annual frequency of impacts, based on the number of installations within the UKCS for each year under consideration (see Figure 5.6) for both in-field vessels and passing vessels.

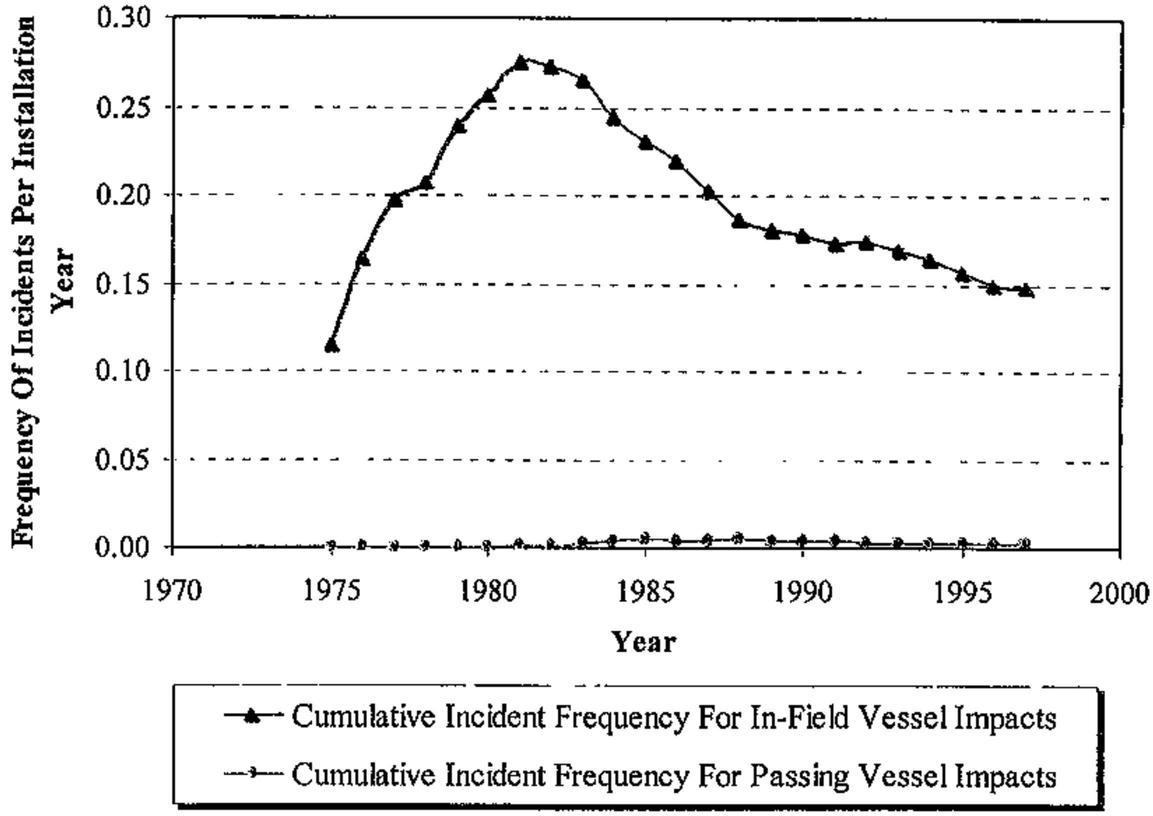

Figure 5.8

Frequency Of Reported Incidents Per Year

For in-field vessels, the final cumulative incident frequency is 0.15 per year. Based on this, it would be expected that with an UKCS installation population of 201 (i.e. 1997 level), there would be approximately 30 installations experiencing an impact during a year. Alternatively, an installation with a design life of 25 years would be expected to suffer an in-field vessel impact between 3 and 4 times during its life.

The frequencies presented in Figure 5.8 are considered to be optimistic (i.e. lower than actual) since although it is known through interviewing operators that minor vessel impacts are very frequent, they are rarely recorded.

The final cumulative incident frequency for passing vessel impacts is 0.0025 per year. With an installation population of 201, this is equivalent to expecting one of the installations to suffer a passing vessel impact every 2 years.

5.4.2 In-Field Vessels

In the previous Section, Figure 5.8 presented the cumulative incident frequency for all in-field vessel impacts for all types of offshore installation but, as noted previously, minor damage impacts are believed to be under reported and, therefore, the predicted frequencies for all levels of impact will be optimistic.

Figure 5.9 presents the cumulative incident frequencies for all in-field vessel impacts that caused moderate or severe damage, along with the frequencies subdivided by installation type. The years from 1975-80 are not presented for clarity due to the large fluctuations caused by the low level of installation experience in the early years of North Sea development.

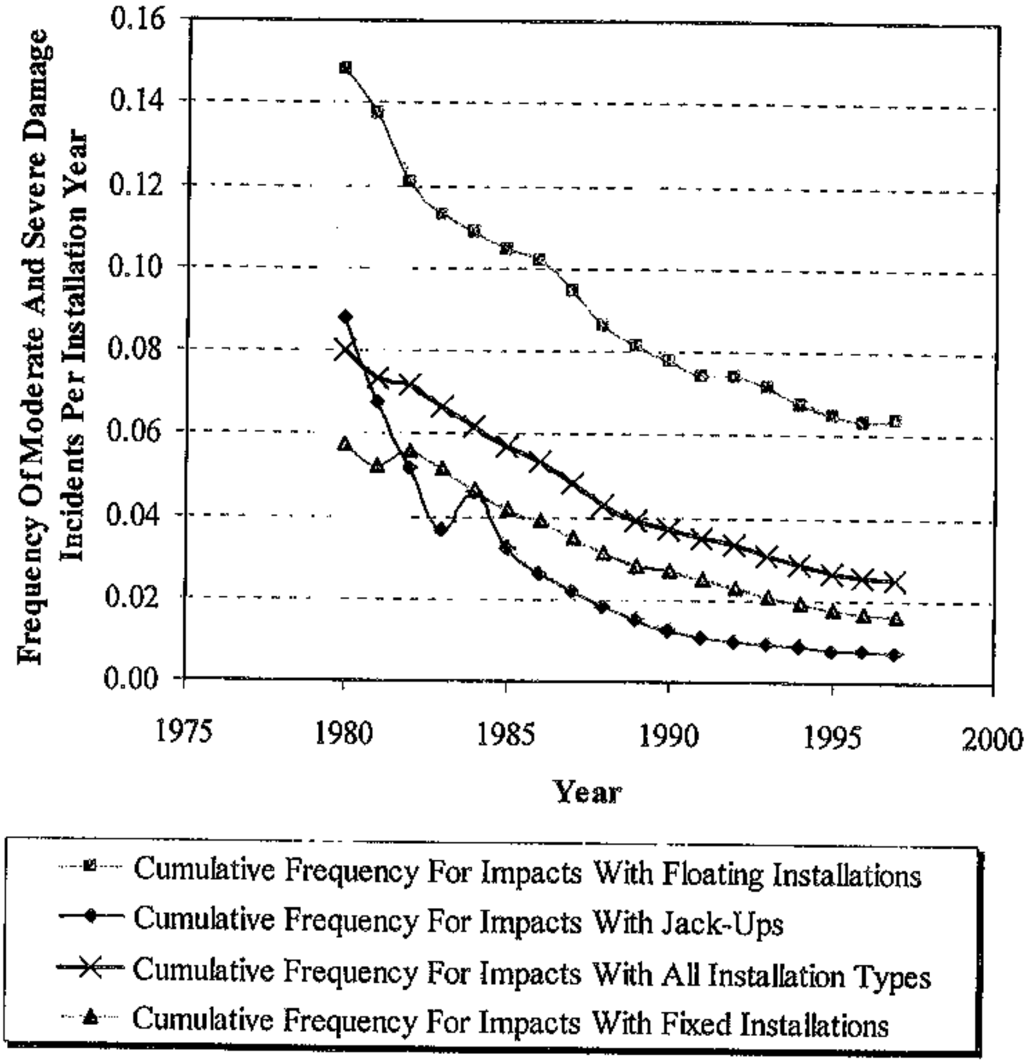

Figure 5.9

Frequency Of Reported Mod./Severe Incidents Per Year By Installation Type

It can be clearly seen that the frequency of in-field vessel impacts which cause damage requiring repair has significantly reduced from 1980 to 1997 for each installation type considered. It should also be noted that in all cases the improvements in collision frequency reduction diminished towards the end of the reported period.

Floating installations, which in all reported cases in the survey period are semi-submersible units (i.e. drilling, production, support or accommodation units), have significantly higher annual collision frequencies than either fixed or jack-up installations. It is considered that the most probable reasons for this are:

1. The number of supply vessel visits was higher for the semi-submersible units due to the large number of drilling units operating;
2. The supply vessels had to hold location closer to the semi-submersible structure due to the minimal overhang of a semi-submersible compared to the larger overhangs on fixed platforms and jack-up units;
3. Semi-submersibles move under environmental forces and, therefore, do not offer a fixed reference for the master of the alongside vessel.

Figure 5.10 presents a breakdown for each of the installation types considered, of the type of in-field vessel which caused the moderate or severe damage.

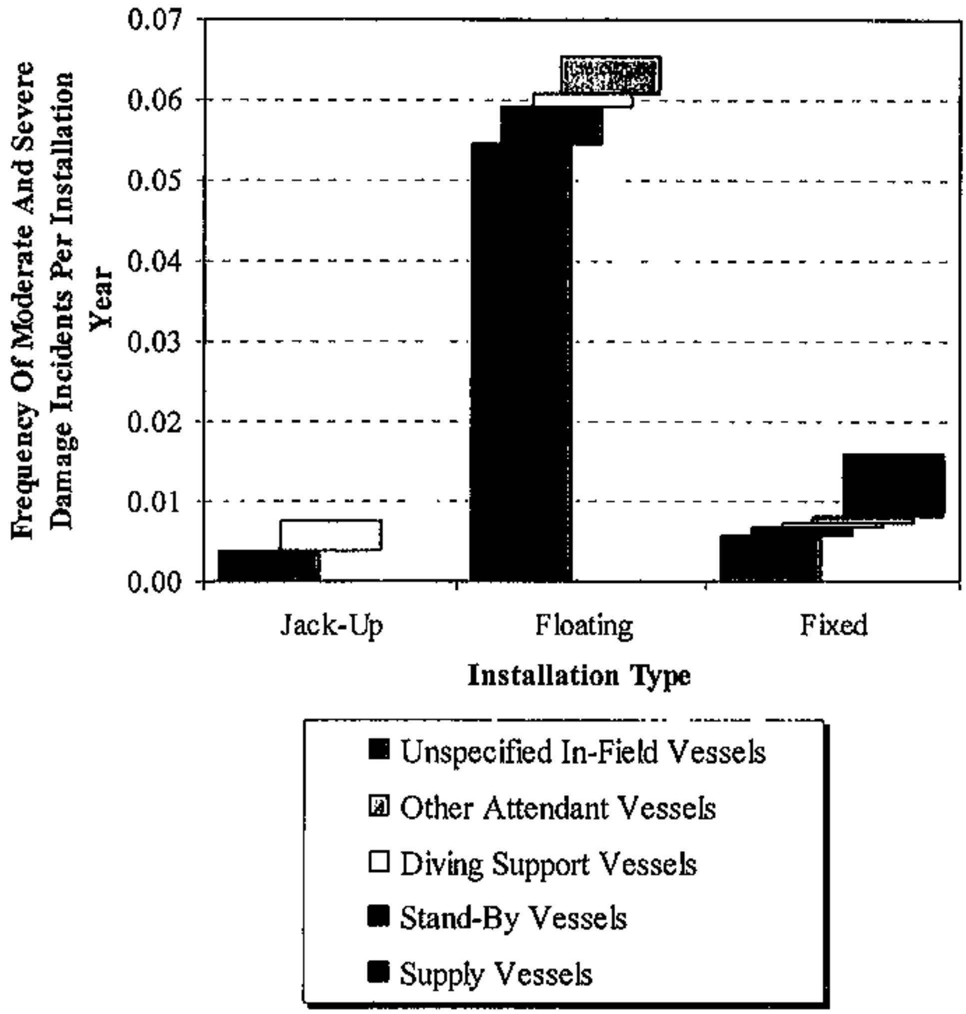

Figure 5.10

Breakdown Of In-Field Vessel Impact Types By Installation Type

It can be seen that, based on past accidents, supply vessels pose the greatest risk of causing damage by collision, to installations on the UKCS. This conclusion is only valid if, on an annual basis, current installations have a similar exposure to in-field vessels as in the past (i.e. the number of visits to installations today is comparable to that during the survey period).

As detailed in Section 5.3.1 there were only 4 reported collisions between an installation and its attendant shuttle tanker, and, of these, 3 were associated with operations at an SPM loading buoy. Since 1997, there have been a number of shuttle tanker impacts which have resulted in significant denting to the hulls of FPSOs (Ref. 10).

In a study commissioned by the HSE to examine the collision risks associated with shuttle tankers when in close proximity to offshore installations (Ref. 11), the results of statistical calculations, carried out as part of the safety case requirement, was presented. An annual frequency for shuttle tanker impacts which caused only slight damage to the installation was cited as 2×10^{-3} whereas the frequency of severe damage impacts was 5.4×10^{-4} per year. Obviously as the assumptions, parameters, control measures, etc. used during the calculation of these frequencies are not known, straight comparison with the other frequencies presented in this Section should be made with caution.

5.4.3 Passing Vessels

As detailed in the previous Section, the cumulative incident frequency for passing vessel impacts is 0.0025 per year. This is based on a total of 8 passing vessel collisions, but of these only 2 were categorised as causing serious damage requiring urgent structural repair. Therefore, the historical frequency of serious passing vessel impacts for installations on the UKCS is 0.0006 per year or, based on an installation population of 201 (1997), a serious passing vessel collision would be expected every 8 years.

Again, it should be stressed that a large proportion of ships navigating the UKCS waters have the potential, should they collide with an offshore installation, to impart impact energies far in excess of the installation's design criteria. For example, a 10,000 tonne cargo vessel travelling at 15 knots has a kinetic energy of around 330 MJ whereas a fully laden tanker of 150,000 tonnes travelling at the same speed has a kinetic energy of nearly 5 GJ.

As detailed in Section 5.3.2, there have been no reported collisions between submarines and UKCS installations although such collisions have occurred. The frequency of submarine impacts with installations cannot, therefore, be accurately predicted.

5.5 FUTURE TRENDS

5.5.1 Introduction

This Section presents and discusses potential future trends in the offshore installation and marine industries which will influence the risks associated with ship collisions with offshore oil and gas installations. It should be noted that many of the identified trends are interrelated and should be taken into account when reading this Section.

For clarity, the future trends for in-field vessels have been discussed separately from those that relate to passing vessels. However, as in-field vessels will be passing vessels on their way to or from a particular installation, there will be some level of interrelation between the subsections.

5.5.2 In-Field Vessels

The following bullets provide an outline of main areas which are considered to affect collision risk assessment and management. A short discussion on each point is provided to assist the reader in assessing the likely effect of each for each specific location:

- Increased use of FPSOs. This will result in increased use of shuttle tankers which will increase both visiting and passing vessel risks.
- Increased use of smaller FPSO designs. This may increase the risks associated with in-field vessel impacts due to the more dynamic nature of the FPSO (e.g. leading to impacts due to sudden FPSO movement, extended alongside exposure due to difficulties transferring loads, crew fatigue due to inadequate rest) and due to the reduced "crumple zone" around the hydrocarbon carrying storage tanks and systems.
- Larger supply vessels. With increased size, the potential for damage is increased due to the increased kinetic energy.

- Reduced day rates for supply vessels. Reduced overheads and increased vessel utilisation may lead to reduced manning, a shortage of experienced junior officers, increased levels of crew fatigue, increased number of night time operations, working close to environmental limits, and, due to the minimal time to perform maintenance, more mechanical breakdowns.
- Operators reducing costs by placing an increased onus, during vessel/contractor selection, on bottom line price, and less on the safety record and regime of the vessel/contractor.
- Increased use of spot market contracts for all attendant vessels, particularly supply vessels.
- Increased use of shared standby vessels and multi-role standby vessels. This may lead to crew fatigue or crew taking short cuts.
- Increased use of position transponders to track/identify in-field vessels.
- Increased operation within harsh environments.
- Increased FPSO development West of Shetland where the long period swells and strong currents cause shuttle tankers to surge and fish-tail.
- Increased demand on bridge crew (e.g. paperwork following a safety zone infringement or during surveying). This is compounded by minimal manning regimes.
- Ageing population of Masters.
- Minimal and process orientated manning on installations which will probably result in the absence of marine experienced personnel to assist in the decision making concerning attendant vessels.
- The availability of simulator training which should decrease risks offshore.
- The increased use of smaller, budget, installations (e.g. integrated deck structures, mono-towers, etc.) which may be more susceptible to severe/critical damage and will probably have minimal structural overhangs under the crane, inadequately located and insufficient laydown areas, and cranes which are of insufficient number, poorly located, slow, low capacity, and with insufficient reach.

5.5.3 Passing Vessels

The following bullets provide an outline of main areas which are considered to affect collision risk assessment and management. A short discussion on each point is provided to assist the reader in assessing the likely effect of each for each specific location:

- Increased use of platform based radars which should provide an increased range and therefore warning time.
- Increased dependency on unmanned, automatic, radar target tracking systems.
- Increased use of DGPS. Groundings are occurring where officer's have implicitly believed the GPS long after the data from it should have been ignored. This is a "human factor" discovered and mirrored in aviation during the eighties. Thus, GPS aided navigational errors are occurring more regularly. If this is linked to poor lookout practices, which are not uncommon, (in contravention of the International Regulations For Preventing Collisions At Sea [Reg. 5]) there is a foreseeable increased risk of collision.
- More installations possibly leading to narrower routes through the offshore fields.
- More use of subsea developments so that the presence of surface installations is not continual and may/will not be shown on charts.
- Larger more automated and comfortable bridged vessels which may lead

to watchkeepers falling asleep or suffering from hypovigilance which is the state just before sleep where the "lights are on but nobody is home".

- More shuttle tankers servicing the increased number of FPSOs
- Increased use of moored installations possibly increasing the likelihood of submarine impact to mooring spreads.
- Increased size of fishing vessels.
- Increased pressure to fish right up to the 500m zone.
- Increased use of shared standby vessels and Mother/daughter arrangements.
- Privatising and competition of ports results in alternative routes and changing hazard.
- Higher speed craft.
- Skeleton manning levels on commercial shipping.
- Introduction of ISM code.
- Increased use of electronic charts and navigational systems
- Ageing installations which have problems with Nav Aid maintenance.

6 CAUSES OF SHIP IMPACTS WITH INSTALLATIONS

6.1 INTRODUCTION

This Section identifies and discusses the primary causation factors of ship impacts with offshore installations.[1] Knowledge of the causes of ship impacts helps to improve understanding of the hazard as well as identify the key features which should be included within an effective Collision Risk Management System (CRMS).

The Section examines the causes of impacts (or near misses) between installations and:

(a) In-field vessels
(b) Passing vessels

Details of ship impacts (or near misses) referenced within this Section have been obtained from a large number of different databases and research studies including:

- COLLIDE and RABL collision data (Ref. 12)
- HSE ship/platform collision data (Ref. 3)
- Marine Accident Report Scheme (MARS)
- Prevention through People (US Coast Guard, Ref. 13)
- Database of Vessel Collisions for Gulf of Mexico (MMS, Ref. 14)
- Boat Impact Phase 1 (NPD, Ref. 15)
- Database for Marine Accidents (DAMA)
- Marine Accident Investigation Branch (MAIB)
- National Offshore Safety Advisory Committee (NOSAC)
- Close Proximity Study, (HSE, Ref. 11)
- Protection Of Offshore Installations Against Impact (Department of Energy, Ref. 16)

In addition, to ensure that input to this study was obtained from as wide a range of sources as possible, an expert panel was convened to evaluate the different measures available for ship/installation collision control and avoidance, and interviews were conducted with installation operators and support vessel operators. Details of the expert panel review of a number of typical collision scenarios are included in Appendix A.

6.2 GENERAL OVERVIEW

In Section 5, it was noted that impacts between offshore installations occur on a regular basis. In fact, based on incident data for the UKCS during the period 1975 – 1997, the annual frequency of vessel/installation impacts is approximately 0.15, or around 30 impacts per year assuming a UKCS installation population of 200 [2]. It should, however, be noted that this frequency is based on reported impact incidents, and as minor impacts which result in only minor damage are believed to be rarely recorded, this frequency is considered optimistic (i.e. lower than actual).

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[1] *The causes of impacts with hydrocarbon carrying subsea pipelines is not discussed as this is outside the scope of this study.*

[2] *The UKCS installation population for 1997 was 201.*

Of the reported impacts, over 98% were with in-field vessels. In the majority (83%) of in-field vessel incidents, the damage sustained by the installation was categorised as minor or none, and in the cases where repair was required, only 3% were of a severity which required urgent repair (i.e. within 1 month).

For the recorded passing vessel collisions on the UKCS, 25% resulted in severe damage with the remainder causing only minor or no damage. Fishing vessels contributed 62% of all passing vessel impacts, with damage sustained by the installation from such impacts being minor in every case.

To determine the reasons why collisions with offshore installations continue to occur, in-field and passing vessels must be divided since the former are required to operate close to an installation whilst the latter should, by international law, pass well clear of all installations (i.e. at a minimum distance of 500m from the installation).

In-field vessels range significantly in size, shape and operating regime. Some are required to "sweep" past the installations as in the case of survey vessels whilst others, like supply vessels, diving support vessels, flotels and anchor handling vessels, are required to hold location very close to the supporting structure of an installation. Shuttle tankers, which are being employed more frequently in the North Sea in the support of FPSOs, are both large and require to manoeuvre close to moored installations. The always present standby vessel is usually relatively small and maintains station in the vicinity of an installation or group of installations. Although the standby vessel usually sails well clear of an installation, it is sometimes required to provide close support during, for example, overside working periods on the installation. Some installations, particularly in the shallower Southern North Sea, require periodic visits from a drilling or workover jack-up drilling unit, which manoeuvres very close to an installation before its legs are lowered to the seabed.

All in-field vessels are required to seek and obtain permission from the installation's OIM prior to entering the safety zone. Therefore, provided a collision is not connected with the "approach to field" phase of the visit, the master of the in-field vessel will be fully aware that his vessel is going to get close to the installation. If a collision occurs, it must, therefore, be as a result of, or combination of:

- Human error (e.g. poor judgement or ship handling, inattention, fatigue or workload); and/or,
- Mechanical or systems failure on board the vessel; or,
- Freak or unplanned for environmental conditions.

This conclusion is supported by a number of accident review assessments, including the recent HSE Ship/Platform Collision Incident Database (Ref. 3), which cites the following proportional breakdown for the primary causes of in-field vessel collisions, 45% human error, 33% equipment failure, and 22% external factors.

All vessels upon the high seas are required to comply with the International Regulations for Preventing Collisions at Sea (Ref. 17). Rule 5 of these Regulations requires that every vessel maintains "... a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision." Whereas Rule 6 requires every vessel at all times to "... proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions."

In addition, a dedicated (i.e. with no other duties) look-out must be posted on the bridge at night in addition to the Officer of the Watch, in accordance with the Standards for Training, Competence and Watchkeeping (STCW) 1978 Regulations. During daylight, the STCW Regulations allow for the dedicated look-out to be dispensed with provided that it has been assessed as being safe to do so.

It is worth noting at this point that the Department of Transport's Marine Accident Investigation Branch (MAIB) have "substantial evidence to indicate that many ships, especially short sea traders, operate with only one person on the bridge at night" (Ref.18).

By maintaining an effective look-out and travelling at a safe speed, the probability of a collision between a passing vessel and what are very conspicuous, fixed obstructions should be extremely low, much lower than that predicted on the basis of past incidents.

In a detailed US Coastguard assessment of the causes of marine accidents (Ref. 13), human error was found to be a major cause of ship collisions, accounting for between 89% and 96% of such incidents. The assessment classified the predominant human errors into five groups:

Management	This error category deals with shipboard, waterway, and company policies and procedures and includes items such as "insufficient manning", "inadequate communications or co-ordination", and "faulty standards, regulations, policies, or practices". It includes the influence of company culture; on board, vessel/installation and vessel/shore synergy; management style (autocratic, laissez faire or self centred); lack of standard operational procedures.
Operator Status	Errors attributable to operator status, which characterise mariner attributes, including items such as: fatigue; inattention; carelessness; recklessness; boredom; vision deficit; workload; and other pitfalls of cognitive (mental) operation, such as: loss of situational awareness; representation error; limitations of short term memory; accessing long term memory, not using professional language; national cultural/language differences when different nationalities are employed on a vessel; confidence not matched to competence; stress; over and under loaded.
Working Environment	This category describes errors caused by the natural and onboard working environments, and includes items such as "hazardous natural environment", "poor human factors equipment design", "poor maintenance", and "inadequate aids to navigation, markers, or information".
Knowledge	Knowledge errors deal with the mariner's knowledge and experience and includes items such as "inadequate general technical knowledge", "inadequate knowledge of own ship shiphandling", "inadequate knowledge of own ship procedures and operations", and "unaware of role/task responsibility".
Decision-Making	Decision making includes items such as "faulty understanding of current situation", "decision based on inadequate information", "not prudent seamanship", "decision making biases" and the "weighing up of internal and external risk".

It was noted in the assessment that as only two of the above listed human error categories, operator status and decision-making, represent what is commonly thought of as "human error", more than half of the errors are, therefore, attributable to other factors.

The assessment identified the following reasons why casualties persist in maritime operations, despite historical efforts to increase maritime safety:

- Lack of root cause investigations of marine casualties, so that specific human error problems that cause casualties cannot be identified;
- Lack of identification and systematic analysis of high risk operations;
- Lack of identification, development, and implementation of effective measures to prevent the specific human error problems that dominate casualties;

- Lack of effort by the collective marine industry to analyse problems, and share analyses and lessons learned.

The assessment concluded that the three largest specific problems present throughout the entire maritime industry were fatigue, inadequate pilot-bridge crew co-ordination, and inadequate technical knowledge, especially of radar.

6.3 CAUSES OF IN-FIELD COLLISIONS WITH INSTALLATIONS

6.3.1 Introduction

As detailed in Section 5, approximately 98% of all reported ship impacts with installations have been with in-field vessels, and even though the impact energies of this category of ship collision are generally low, there is the potential for an in-field vessel impact to be catastrophic. To illustrate this, there have been a number of in-field vessel impacts with installation risers. Although none caused a loss of containment, damage to risers did result and in one incident a gas export riser was displaced 225mm.

Detailed in the following subsections is discussion of the primary causation factors of collisions between installations and the following types of in-field vessel:

- Standby vessels
- Multi-purpose vessels
- Supply vessels
- Anchor handling vessels
- Tugs
- Survey vessels
- Shuttle tankers
- Diving support vessels
- Other large units (e.g. MODUs, heavy lift vessels, flotels, barges, etc.)

6.3.2 Standby Vessels / Multi-Purpose Vessels

When manned, offshore installations normally require a standby vessel, since in many circumstances this is the only means of providing effective arrangements for recovery and rescue of installation personnel should an escape or evacuation situation occur, or if a helicopter crashes close to the installation.

An installation's standby vessel may be shared with other installations provided that this does not compromise the objective of providing a "good prospect" of recovery and rescue. In addition, some offshore installations are served by multi-purpose vessels which are capable of not only performing standby duties but also cargo handling. Reference should, therefore, be made to Section 6.3.3 where the causes of collisions involving vessels performing cargo operations are discussed. The remainder of this Section covers the causes of impacts between standby vessels and installations during standby operations.

It is normal for a standby vessel to be an integral part of the Safety Management System (SMS) of an installation in so far as it can provide measures for the prevention, control and mitigation of ship collision risk and provide rapid emergency response in times of emergency. It should, however, be noted that the presence of a standby vessel in the vicinity of an installation also creates a risk of collision.

Standby vessels spend the majority of their time slowly patrolling the sea area around the installation(s)[1]. The distance and bearing from the installation(s) will be determined by many factors including:

- Prevailing weather, sea state and currents;
- Activities being performed on or near the installation; and,
- Character of the passing shipping in the area.

During periods of general patrolling, the standby vessel will keep out of the installation(s) safety zone(s).

If requested by the installation to provide close support, during, for example, periods of overside work on the installation, the standby vessel will move in towards the installation to hold location where it can best monitor and, if required, provide rescue assistance to the at risk installation personnel.

Not withstanding a multi-role standby vessel performing cargo handling operations, it will be in exceptional circumstances, that a standby vessel will come alongside an installation. This is usually so that equipment and/or personnel can be transferred between the installation and the standby vessel. Such circumstances would, for example, follow an accident on the standby vessel where one of its crew is injured and required transfer to hospital, or following a machinery breakdown on the standby vessel and for repair it requires an urgent delivery of a spare part.

The standby vessel could also come alongside the installation in times of emergency on board the installation to provide assistance.

It is not generally acceptable, in the offshore oil industry, to perform routine transfers of mail and/or papers to the standby vessel from the installation by bringing the standby vessel alongside the installation. Instead, such non-essential transfers are now performed by the standby vessel's fast rescue craft (FRC).

In all but emergency situations, the standby vessel will enter the safety zone of an installation only after prior approval has been obtained from the installation's OIM.

With reference to the latest statistics on ship impacts with UKCS installations (Ref. 3), of the 71 reported impacts which occurred between 1975 and 1997, involving standby vessels and installations, 1 resulted in severe damage, 5 in moderate damage, and the remainder little or no damage. Figure 6.1 presents a breakdown of the operation that the standby vessel was undertaking at the time of impact.

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[1] If the standby vessel is being shared between installations, its patrol area will be in the vicinity of all of the installations which it is assigned to cover.

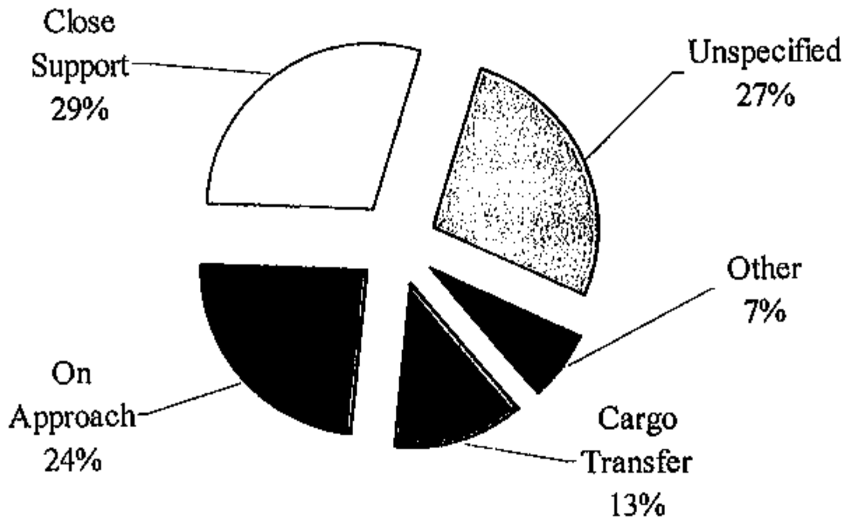

Figure 6.1

Breakdown Of Standby Vessel Operation When Impact Occurred

From Figure 6.1 it can be seen that of the specified standby vessel operations, it is during close support when most impacts occur, although impacts on approach to the installation are also very significant. It is worth noting that it was during an installation approach that the only severe damage collision occurred and the reported causation of this impact was misjudgement.

There was only one reported collision between a standby vessel and an installation during a period when the standby vessel was performing its normal patrolling duties. In this case, the officer on watch was distracted, and the vessel drifted into the installation.

In order to obtain an appreciation of the causation of standby vessel impacts and how this varies by operation, Figure 6.2 presents a proportional breakdown of the reported impacts by operation and reported causation.

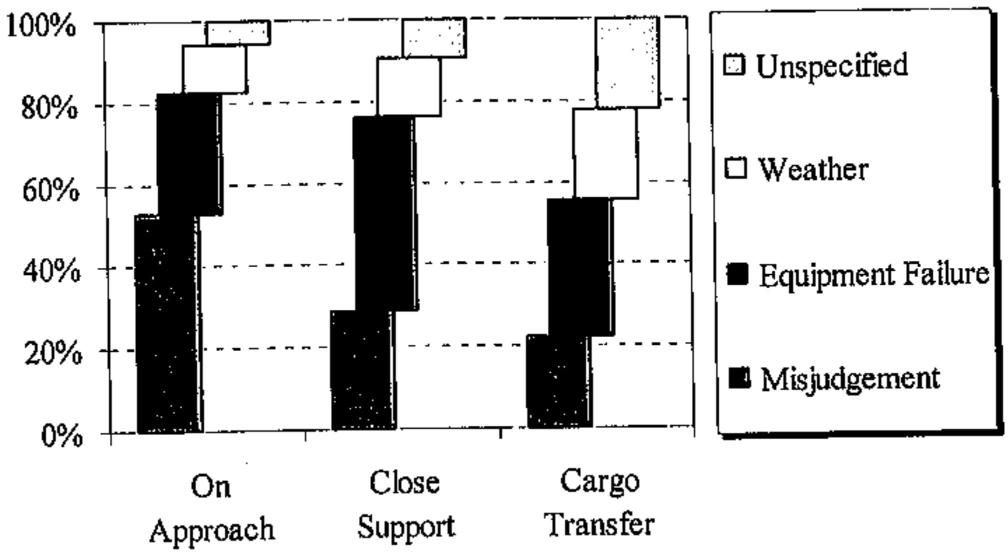

Figure 6.2

Proportional Breakdown Of Reported Cause By Operation

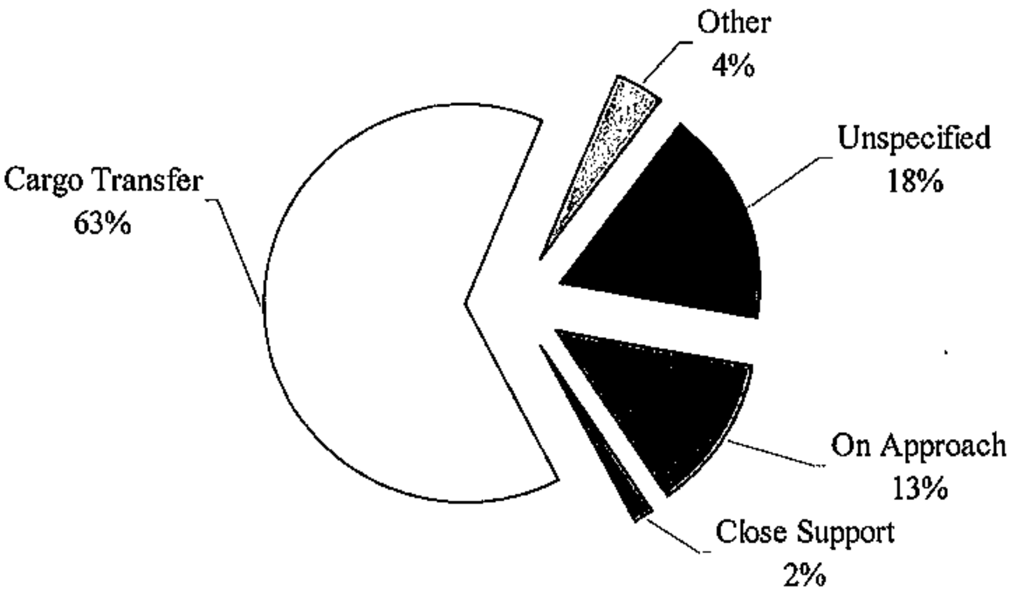

Figure 6.1

Breakdown Of Supply Vessel Operation When Impact Occurred

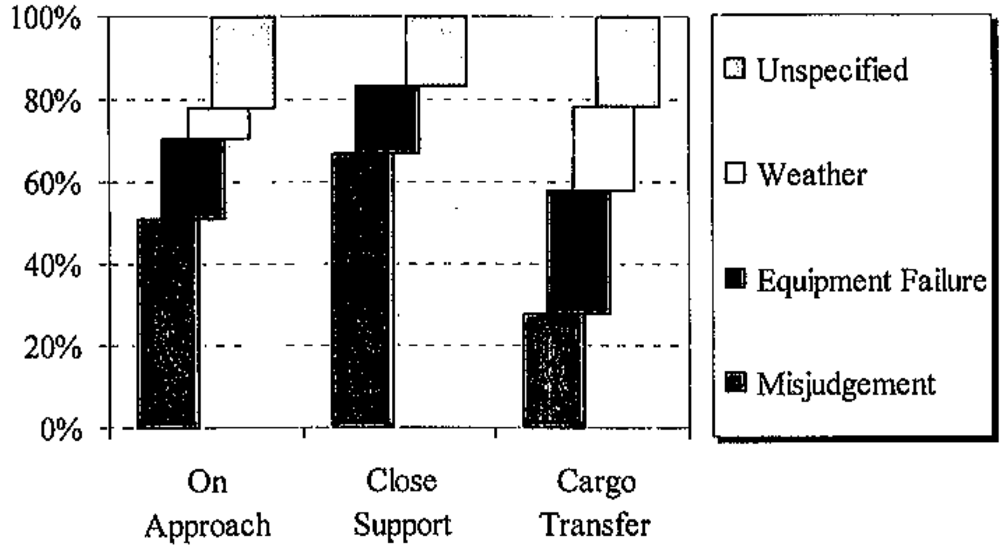

Figure 6.4

Proportional Breakdown Of Reported Cause By Operation

Analysis of the HSE ship collision database indicates that, as with standby vessels, the majority of incidents involving supply vessels have a primary cause linked to some form of control failure, be it either human or mechanical. In addition, again as discussed under the standby vessel section, the reported impacts which were supposedly caused by external factors, such as poor visibility and other weather conditions, should more probably fall within the human control failure category and perhaps the operations should have been aborted or postponed if conditions were inappropriate.

Supply vessels do, however, pose a significantly higher risk to an installation than standby vessels, since:

From Figure 6.2, it can be concluded:

- During approach to an installation (which must occur after approval from the installation) over 50% of impacts were categorised as being as a result of misjudgement;
- Misjudgement during close support and cargo transfer operations ranges between 20% and 30%;
- Equipment failure, whilst the vessel is close to the installation, is the cause of between 30% and 50% of impacts;
- Impacts blamed on the weather contribute between 10% and 20% of the total.

It should, however, be noted that a significant proportion of the impacts attributed to equipment failure, particularly during installation approach, will have an underlying cause of poor seamanship. For a collision to occur, the standby vessel must either be set on a collision course with the installation, or be required to be manoeuvring in a location up-weather of the installation. In this case, if equipment failure occurs, the standby vessel may drift into the installation. It is considered unlikely that the 5 equipment failure impacts on approach, (i.e. 3 steering failures and 2 propulsion failures), would have resulted in an impact, if the approach had been slower and to an offset position not up-weather of the installation.

In one collision incident reported by the MAIB (Ref. 19), a standby vessel, in poor visibility, repeatedly headed directly towards its installation, to a point 370m from the installation, in order to report visibility to the installation so that they would know when to turn on their fog horns. After a number of these manoeuvres, the vessel failed to respond to the helm and subsequently ran into the installation. The MAIB report stated that it was probable that the auto-pilot was engaged when approaching the installation and as a result, manual helm control would have no effect. Due to the sanitisation of the MAIB report it is not possible to positively identify the event in the HSE database and thereby determine what causation category was assigned but it is considered likely, based on review of past incidents, that a cause of auto-pilot failure may have been assigned to the incident.

By assessing the MAIB report, whilst the auto-pilot was a contributing factor, the primary cause of the accident was clearly human error on the part of the officer on watch of the standby vessel, since:

- There was no requirement to enter the 500m safety zone since fog horns should be used when visibility drops to below 2 miles;
- Standing orders (and good seamanship particularly in poor visibility) prevented the vessel approaching the installation directly;
- The auto-pilot should never be used whilst manoeuvring at low speed and in limited sea room.

The reported causation of weather is also considered to hide poor safety management, and/or poor seamanship. The fact that a vessel collides with an installation because the weather forces a vessel movement which cannot be controlled before an impact occurs, can on first examination be blamed on the weather. However, the underlying cause may be that the vessel was too close to the installation for the prevailing weather conditions.

A further discussion of the higher level causation factors, primarily associated with vessels alongside an installation but which have some relevance to standby vessel operations, is provided within Section 6.3.3.

6.3.3 Supply Vessels

Figure 6.1 and Figure 6.4 presents a breakdown of supply vessel operations and the reported causation factors for the impacts based on the HSE database of UKCS collisions between 1975 and 1997.

- The frequency of impacts is much higher due to the much higher exposure to close proximity operations;
- Supply vessels are normally much larger and, therefore, have higher kinetic energy;
- Supply vessels, particularly in the region of their stern roller, are generally stiffer and therefore more impact energy is transferred to the installation;
- Supply vessels can approach an installation from outside the field and therefore there is the potential for a transit speed, head-on impact caused by a watchkeeping failure (see Section 6.4 for details on ineffective watchkeeping causation factors);

Detailed below are the high level causation factors which are considered to be behind a large proportion of supply vessel impacts which cause damage requiring repair:

- Lack of marine experience on the installation so that marine issues and concerns (e.g. requesting a supply vessel to come alongside in marginal conditions) can be fully understood by the OIM before and during operations which require the supply vessel to be very close to the installation;
- Poor relationship/communications between installation and vessel (i.e. lack of synergy and/or autocratic management style on the installation) which fails to promote openness, suggestions, querying of instructions, early warning of potential problems, effective planning, and generally has a negative influence on the safe management of the installation;
- Poor or inadequate installation design which increases the risks associated with in-field vessel collision, such as:
  - Cranes which due to their design and/or age have insufficient reach and/or rate of operation so that vessels are required to come overly close to the installation and remain there for a prolonged period;
  - Insufficient number of, or inappropriately positioned, cranes so that vessels require to hold location up weather of the installation, or in an orientation which is not ideal (e.g. diagonally on rather than stern on or side on);
  - Minimal overhang under the crane so that vessels require to hold position close to the installation structure. FPSOs and some integrated deck platforms have little or no overhang;
  - Installation overboard lines which cause the alongside vessel to be sprayed/engulfed in liquids or bulk powders;
  - Insufficient provision of fixed access platforms so that there is an increased requirement for overside work;
  - Insufficient illumination of installation structure near sea level;
  - Lack of effective visual references on the installation to assist the master of a vessel monitor and control his relative position alongside the installation;
  - Inadequate fendering and other structural protection of key structural and hydrocarbon carrying systems.
- Too long or too short bulk hoses;
- Insufficient knowledge on the vessel of the motion characteristics of floating installations and in particular the potential for relatively rapid installation movement due to thruster operation;
- Insufficient, inappropriate and/or ineffective marine and other standing orders which do not minimise the probability of collision, and, if a collision occurs, the consequences;
- Insufficient understanding by the installation management of the implications of selecting a vessel primarily on cost (e.g. low cost vessels may be cheap due to minimal expenditure on training, manning, maintenance, vessel specification, and other areas, detailed below, which increase the risks associated with ship collision with a very expensive structure, the installation);
- Lack of vessel management control of the training, competency and on board conduct of the master and other responsible crew members;

- Lack of location/installation specific knowledge on board the vessel;
- Insufficient knowledge/understanding by marine crews of relevant installation issues;
- Insufficient manning on board the vessel which results in:
  - Inadequate rest periods leading to crew fatigue;
  - Multi-tasking which leads to operator distraction and fatigue;
  - Minimal manning levels on the bridge;
  - Less effective emergency response;
- Insufficient account taken of the effects that the motion characteristics of the vessel have on:
  - Crew rest;
  - Crew workload;
  - Vessel manoeuvrability;
- Insufficient account taken of site specific factors such as strong currents, prevalent choppy or long period seas, limited sea room, etc., when contracting a vessel;
- Poor forward planning which may lead to a vessel master performing operations which require high levels of concentration (e.g. manoeuvring close to the installation) whilst he is exhausted (e.g. at the end of a shift);
- Reluctance of installation managers to exclude vessels from entering the 500m zone if competency of vessel crew, or the capability or reliability of the vessel systems, is doubted.
- Reluctance of vessel master to call off a close proximity operation in marginal conditions due to commercial pressures, professional pride, or threat of reprimand.

In the current economic climate there is a further causation factor which is one of remaining competitive in the marketplace by driving down operating costs. For the supply vessel operators this requires a decrease in operating overheads coupled with an increase in vessel utilisation. This leads to increased demands on both the vessel and her crew.

Examples of how the striving to remain competitive in a depressed market may lead to an increase in the risks associated with supply vessel impacts include:

- Fatigue of bridge crew due to:
  - Minimum manning;
  - Increasing the number of installations visited between port visits;
  - Extending the duration of alongside operations to maximise deck space utilisation;
  - Multi-tasking of personnel;
  - Increased pressure to undertake bulk discharge operations simultaneously with crane operations;
  - Increased night time operations;
  - Reduced time spent in port;
  - Reduced time spend standing off a platform;
  - Increased likelihood of starting/continuing operations in marginal environmental conditions due to implicit or explicit pressure on the master to get in and get the job done and once there, to keep going until complete. This can be exacerbated by the fact that on some installations there are no mariners on board to apply good seamanship practice and stand the boat down;
  - Reluctance to complain;
- Increased likelihood of mechanical breakdown due to minimising maintenance time whilst increasing vessel operational exposure;
- Reduced level of crew training such as job shadowing, or simulator courses.

6.3.4 Anchor Handling Vessels and Tugs

Anchor handling vessels and tugs fall into the same category, namely specialist vessels which infrequently visit the installation but, when they do, they usually require to get very close in to the installation.

Of the 16 impacts reported in the HSE database, 3 (19%) were reportedly due to misjudgement, 4 (25%) to equipment failure, 1 (6%) to weather, and the remaining 8 (50%) were unspecified. Only one of the events caused severe damage to an installation, as a result of misjudgement.

Due to the low frequency of such events it is difficult to draw conclusions from the database, but it is believed that the high level causation factors, detailed in Section 6.3.2 are all applicable to this category of in-field vessel.

6.3.5 Survey Vessels

There were only 2 recorded incidents of a survey vessel colliding with an installation during the period 1975 – 1997. On both occasions, impact was as a result of a failure in the propulsion control system (i.e. engine control and DP control).

Equipment failure as the prime cause for survey vessel impact is considered reasonable since:

- Surveying requires a high level of bridge crew skill and attention and, therefore, collisions due to distraction or other watchkeeper failure modes should not occur;
- Survey vessels do not require to come alongside an installation, in fact in order not to damage their streamers, the vessel usually requires to keep well clear of the installation. The vessel may, however, require to head directly towards an installation so as to survey around the installation;
- Surveying is not performed in bad weather.

The high level causation factors detailed in Sections 6.3.2 and 6.3.3 regarding increased risk of collisions due to the strains placed on vessel operators and crew in a drive to reduce costs by increasing utilisation, and the implications associated with installation operators basing contractual decisions on low cost, are considered to be applicable to survey vessel operations.

6.3.6 Shuttle Tankers

With the exploitation of marginal fields in the North Sea, the use of shuttle tankers to export the oil is increasing. In the HSE's ship collision database for the years 1975 – 1997 there were 5 reported collisions involving in-field tankers, however, during 1997/98 there have been at least 4 incidents when a shuttle tanker has come into contact with the FPSO installation during close proximity operations.

As noted in Section 5.3, due to the size of the shuttle tanker, there is a high potential for significant damage to the installation and for environmental pollution. As a result, obtaining a full understanding of the potential causes of shuttle tanker collisions is very important.

Of the 5 reported cases, all but one were associated with loading buoys rather than with floating storage units (FSUs) or floating production, storage and offloading (FPSO) vessels, 2 were reportedly due to misjudgement, 2 due to equipment failure and the remainder unspecified. Full details of the recent cases involving collisions with FPSO vessels, are not currently available.

A detailed assessment of the risks of collision during close proximity operations involving shuttle tankers at offshore locations was commissioned by the HSE (Ref. 11). This close proximity study investigated the following:

- The factors that influence and control the separation between shuttle tanker and installation during offtake operations;
- The types and characteristics of offshore export systems;
- The types and characteristics of offshore shuttle tankers;
- Operational procedures;
- Emergency procedures and contingency plans;
- Safety management elements of operators and tanker owners and managers, including training, competence, reliability/technical studies and risk assessments;
- Offshore shuttle tanker selection and design criteria.

The close proximity study was conducted with the co-operation of a wide range of companies actively involved in offshore shuttle tanker operations.

Table 6.1 presents a summary of the reported concerns which where expressed by offshore operators and shuttle tanker owners.

Table 6.1

Categorisation Of Areas Of Perceived Hazard

Category	Comments	Criticality Rating
Tanker Positioning and Control	1. Operation and reliability of position reference systems for DP shuttle tankers 2. Drift movement of not under command (NUC) tankers following all power loss 3. Change over from auto to manual control in emergency situations	6
Tanker Human Factors	4. Manning of control spaces, inc. DP control locations, engine room 5. Cultural differences 6. Training, familiarisation and competence of tanker crews	5
Dynamic Interaction	7. "Fish-tailing" 8. "Surging"	4
Tanker Propulsion	9. Operation of CPP thrusters and failure modes that may result in a thruster failing to maximum thrust 10. Potential failures of main propulsion	2
Operation Management	11. Commercial pressure in decision making in relation to offtake operations, especially in adverse environmental conditions	2
Environmental Preparation	12. Weather and environmental monitoring, in particular accurate measurement of significant wave height and surface currents, especially in recent development areas, such as the Atlantic Frontier	2
Support Vessel	13. Support vessel operations and training and familiarisation of support vessel crews	1
Tanker Power Generation	14. Use of heavy fuel oil in main engine and power generation plant on DP shuttle tankers	1

From Table 6.1 it can be seen that there were 14 reported concerns, of varying assessed criticality, which have been identified as being associated with shuttle tanker operations. Each is discussed briefly in the following sub-sections since they offer a clear indication of the potential causes for shuttle tanker impacts.

1. Operation and Reliability of Position Reference Systems for DP Shuttle Tankers

As most shuttle tankers being used today employ DP to hold station whilst performing export operations, failure of this system is considered the most likely cause of the shuttle tanker to move off location and possibly impact with the FSU or FPSO.

Experience of DP failure incidents indicate that failure of the position reference system (PRS) is the cause of most DP incidents. It is normal practice during critical operations on other types of DP vessel (e.g. diving from a DSV), for a minimum of three PRSs to be on-line so that if one PRS drops out, the DP will remain stable and the vessel remains on location. On DP shuttle tankers, however, it is more common to operate with two or even one PRS. Operating with this number of PRSs means that the reliability and accuracy of the on-line systems must be adequate, since there is little or no redundancy. This has proved to be a problem in the past for DP shuttle tanker operations.

The most reliable PRS and the one which has the greatest confidence rating in the DP sector, is vertical taut wire. Taut wire PRS is, however, unsuitable for DP shuttle tankers since they are required to remain on location in relation to both environmental forces and a point that is not fixed in space, normally the stern of a weathervaning FSU or FPSO. Therefore, the positioning of the DP shuttle tanker is based on relative positioning rather than absolute positioning. This adds to the complexity of the PRS and its vulnerability to failure.

The PRS that are commonly used on DP shuttle tankers are:

- Differential absolute and relative positioning system (DARPS);
- Artemis;
- Fanbeam Laser.

Although these systems are of proven capability and reliability for most DP operations, each have known problems when used during shuttle tanker loading operations which may cause the system to drop out, poorly perform, or generate a sudden position "jump". This, in combination with the generally low level of redundancy in shuttle tanker positioning systems (see above), increases the probability of the shuttle tanker losing position during a close proximity operation.

2. Drift Movement of Not Under Command (NUC) Tankers Following All Power Loss

Systems failure which result in the total loss of the shuttle tanker propulsion will increase the risk of impact between the shuttle tanker and the FSU or FPSO, or with an adjacent field installation, should the shuttle tanker break loose from the FSU or FPSO.

With the increase use of DP, the likelihood of a complete power loss has been significantly reduced since these vessels usually have enhanced levels of redundancy, such as twin engine and twin main propulsion systems.

3. Change Over from Auto to Manual Control in Emergency Situations

A shuttle tanker, during export operations, is usually maintained between 40m and 120m from the stern of the FSU or FPSO. In an emergency situation, for example when the DP system drives the shuttle tanker ahead or astern, or when a CPP (controllable pitch propeller) fails to full thrust, the momentum build up of the shuttle tanker can be considerable. In such circumstances, the normal emergency procedure for other types of DP ship of assuming manual control and attempting to manoeuvre the ship away from the installation may not be appropriate. If the shuttle tanker is going full ahead, applying full astern is unlikely to halt the forward motion in time to avert a collision, whereas immediate hard over rudder movement, although not likely to prevent a collision, should help to limit the damage. If the shuttle tanker is driving astern and the manual action is to stop propulsion, a collision with the FSU or FPSO is still considered likely since when the hawser becomes taut, it could well catapult the tanker back in towards the FSU or FPSO.

The manual actions taken to try to avert a collision during an emergency can, therefore, contribute to the consequences associated with any subsequent collision.

4. Manning of Control Locations

Since they are classed as deep sea trading vessels a number of DP shuttle tankers operate in line with deep sea manning standards which are less stringent than for other types of ship operating in close proximity to offshore installations. This is an area of concern since the risks associated with a DP shuttle tanker, which might be only 50m away from the FSU or FPSO could be several orders of magnitude higher than those associated with, for example, a survey vessel operating within the 500m safety zone.

Particular areas where lower manning levels on shuttle tankers are of concern include the engine room and the DP console since delays in responding to system failures in these areas could increase the likelihood of collision.

5. Cultural Differences

There are various manifestations of the cultural differences that exist between DP shuttle tanker operations and other types of DP operations. A number have been raised in the preceding paragraphs, in particular the manning of control locations. The cultural differences are not restricted to shipboard operational situations but extend to the overall management and control of the DP shuttle tanker sector. For example, the standards of verification, testing and trials required by the DP shuttle tanker sector are generally thought to be less comprehensive than for other types of DP ships.

6. Training, Familiarisation and Competence of Tanker Crews

Although some training centres are now offering courses which are specific to DP shuttle tanker operations, the majority are still believed to offer general DP courses, catering best for the majority, and that means DP operators of diving support vessels, drilling rigs, cable layers, and the like.

Another area of concern is associated with DP shuttle tanker bridge management. It is a common feature of DP shuttle tanker operations that the master does not delegate DP operational control to other officers and that, frequently, he remains on watch and in charge of the DP console throughout the entire offtake operation, lasting typically from 18 – 36 hours. This is obviously inherently hazardous as it does not give the master adequate rest. It also goes against recent marine legislation which addresses hours of works as well as against the provisions of STCW 95 (Standard of Training Certification and Watchkeping).

7. & 8. Fish-Tailing and Surging

One of the major influencing factors in any close proximity situation is the separation distance. As noted earlier, typical separation distances for shuttle tanker operations in the North Sea are 40m – 120m. At such distances there can be significant dynamic interaction between two large vessels. Two interactions which cause particular hazard during offtake operations are fish-tailing and surging.

The typical control mode for DP shuttle tankers during offtake is to weathervane which utilises the stability effect of the wind and wave forces on the tanker's hull. In this mode the DP control system seeks to find the tanker heading that offers the minimum sideways force. The tanker's propulsion is then used to maintain the separation distance between the shuttle tanker and the FSU or FPSO.

Typically the preferred close proximity tanker-FSU/FPSO alignment is for the bow of the shuttle tanker to point directly towards the stern of the FSU/FPSO. Where the FSU/FPSO is in loaded condition, with substantial draft, then it is normal for the surface current force to be dominant and for the FSU/FPSO to be current rode (i.e. influenced to a greater extent by the surface currents than the wind). However, where the shuttle tanker is in ballast condition, with reasonably shallow draft, then the tanker will normally be more responsive to wind forces than to surface current forces. The tanker in this condition is, therefore, more likely to be wind rode (i.e. influenced to a greater extent by the wind than surface currents).

Fish-tailing (the alternate heading change of the vessel from one side to another) generally occurs when the environmental forces are reasonably low in magnitude. It is also principally a phenomenon that occurs when there is considerable dissimilarity in hydrodynamic characteristics between tanker and FSU or FPSO. As a result, the variable factors that contribute towards fish-tailing are continuously changing. During the course of the offtake operation, the FSU/FPSO becomes lighter and is subject to influence by a different combination of hydrodynamic forces, becoming more under the influence of wind than wave or current. Similarly, the shuttle tanker's condition changes, becoming heavier, tending to be more under the influence of wave and current than wind.

Additional complications arise when the environmental forces change in direction during the course of an offtake. The tidal cycle is a predictable change in environmental force but wind is not so predictable.

Surge is a well known problem during offtake operations. It is caused by long period waves in excess of 15s frequency which can result in large alongships oscillations, if the fore and aft propulsion is unable to dampen the motions adequately. While the tanker is subjected to such surface influenced fore and aft movement the FSU/FPSO, being secured to the seabed, generally by a chain and wire mooring arrangement, is subjected to different hydrodynamic forces and at different levels. As a result, the fore and aft motions of the shuttle tanker may be significantly different from the fore and aft motions of the FSU/FPSO, resulting in asynchronous movement. The worse case scenario is where the FSU/FPSO moves astern at the same time as the shuttle tanker moves ahead, thus reducing the separation distance. In addition to environmental induced surging, the recoil effect of a tight hawser and the reactive forces from the DP systems, can add to the problem.

As surging is a problem associated particularly with long swells, it is geographical area sensitive. In the North Sea, swells with a 15s frequency are not common, but in the Atlantic Frontier area, West of Shetland, swells of this length are much more prevalent.

9. Operation of CPP Thrusters and Failure Modes

Controllable pitch propeller (CPP) systems are known to have a failure mode that results in the propulsion system either going into full ahead or full astern, which has obvious potential consequences during a close proximity operation.

10. Potential Failures of Main Propulsion

The effects of loss of the main propulsion system on the shuttle tanker would lead to the vessel potentially drifting into the stern of the FSU/FPSO.

11. Pressure to Continue Production

Although commercial considerations should not be the pre-eminent factor in the operational decision making process, it is nevertheless apparent that there are occasions when additional commercial pressures are brought to bear on the senior personnel involved in the operation.

For example, in marginal environmental conditions, a shuttle tanker may be asked to approach, connect up and load only a part-load, as this would relieve the pressure on the installation and provide sufficient ullage to enable full production to continue for a few more days by which time the environmental conditions should have improved. This realistic scenario would give rise to both the OIM and shuttle tanker master feeling under pressure to attempt an operation in conditions that are perhaps marginal and deteriorating.

12. Environmental Preparation

Whilst parts of the North Sea are relatively sheltered, other areas particularly in Northern waters and West of Shetland are more exposed and will increase the problems associated with shuttle tanker operations such as, fish-tailing, surging, and pressures to continue operations in marginal conditions.

13. Support Vessel Operations, Training and Familiarisation of Support Vessel Crews

It is generally accepted that a support vessel is in attendance for the duration of the offtake. Apart from a few exceptions, its assistance is invariably required at the connection phase and the support vessel remains in relative close proximity to the shuttle tanker during the course of the offtake. The support vessel is normally on standby to undertake emergency towing duties in the event of a major problem with the tanker.

For many duty holders, the close attendance of the support vessel is considered as a major risk reduction measure. However, not only does the support vessel itself pose a ship collision threat but the ability of the support vessel to fulfil its emergency role may be called into question because of a number of factors including:

1. The suitability of the support vessel to undertake emergency towing operations in adverse environmental conditions;
2. The training and capability of the crews of the support vessel to carry out such activities
3. The time required to fasten a tow line and take control of a drifting vessel;
4. The legal (e.g. salvage) implications of giving/accepting a tow.

14. Use of Heavy Fuel Oil

Whereas other DP ship types have, to a large extent, replaced heavy fuel oil with diesel oil, most DP shuttle tankers still use heavy oil. It is believed that a failure in a heavy oil system is more liable to result in subsequent failure of standby machinery to start, principally because of the additional heating requirements of heavy oil, compared with diesel oil.

6.3.7 Diving Support Vessels

Diving support vessels are required to hold station, for significant periods of time, in very close proximity to installations. There is, therefore, an obvious risk of collision. This, coupled with the fact that the vessel deploys divers, who are very vulnerable to sudden movements of the vessel, forces the requirement for very high standards for vessel management, positioning systems and crew competence.

Based on the HSE's database on collisions between 1975 – 1997, there have been 32 incidents where a DSV has come into contact with an installation. Figure 6.5 presents a breakdown of the nature of the DSV operation when impact with an installation occurred.

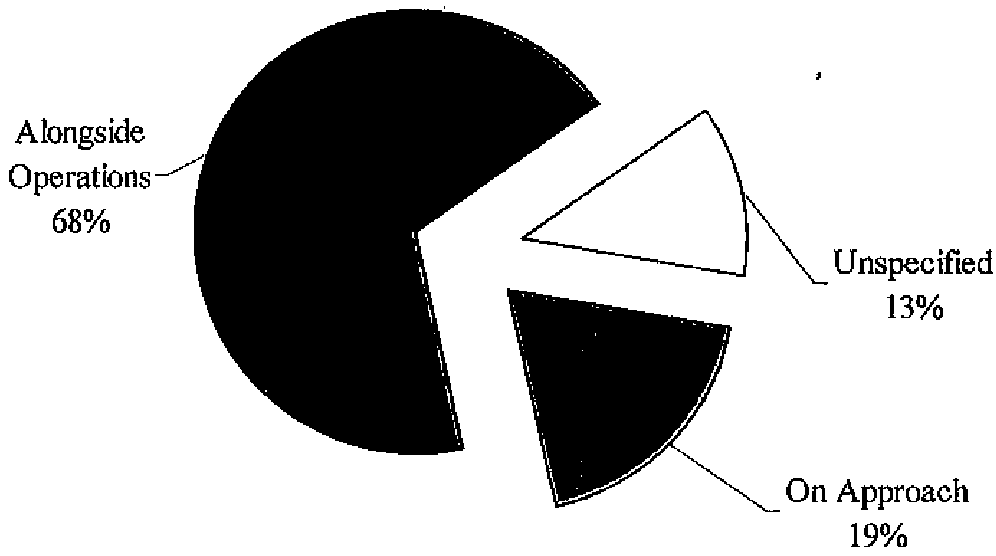

Figure 6.5

Breakdown Of DSV Operation When Impact Occurred

From Figure 6.5 it can be seen that the majority of impact incidents occur when the DSV is alongside the installation. Figure 6.6 presents a proportional breakdown of the reported causation factors for each of the operation categories when impact occurred.

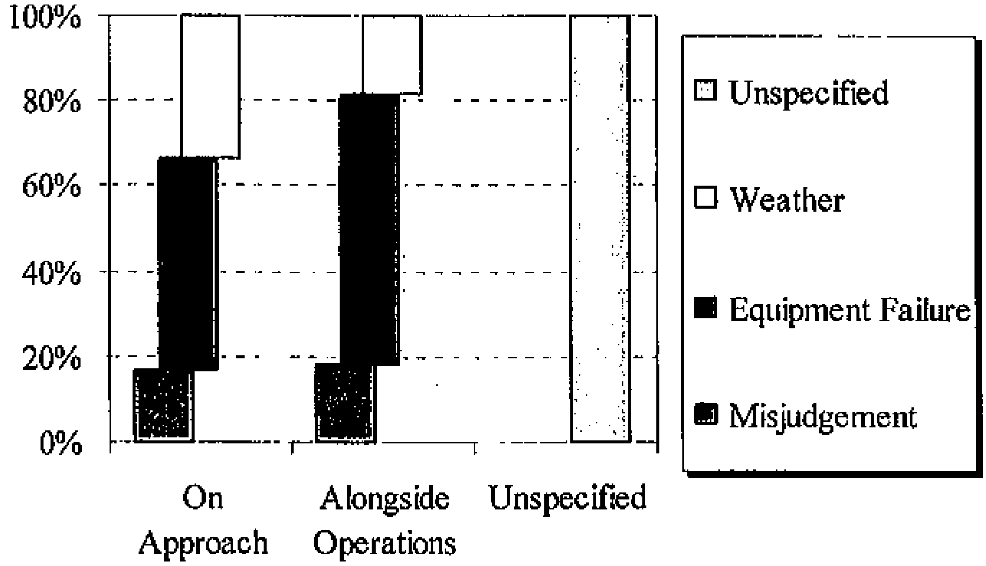

Figure 6.6

Proportional Breakdown Of Reported Cause By Operation

From Figure 6.6, equipment failure is the cause of the majority of impacts between DSVs and installations, accounting for 61% of all specified incidents. It can be further concluded, that the equipment, which should it fail, would be most likely to cause a collision incident, is the vessel's positioning system. Loss of power to this system could lead to the vessel drifting into the installation, whilst loss of system control could lead to the DSV being powered into the installation.

In Section 6.3.6, the failure modes of DP systems and other identified ship collision causation factors were considered in relation to shuttle tanker operations, with a number of references being made to the enhanced capability of diving support vessel systems (e.g. DP system, power system, etc.), manning levels and culture, and management control.

Of particular note is the much more stringent requirement for reliable and effective DP on DSVs. As most DSVs are required to operate close to a fixed installation, absolute position referencing systems such as taut wire, differential global positioning system (DGPS), and hydroacoustic position reference (HPR) systems can be used in addition to the relative position referencing systems detailed in the shuttle tanker section. The redundancy built into the positioning system is also required to be high so that single point failures will not cause failure of the positioning system.

One cultural difference which was not identified in the shuttle tanker discussion is that associated with the risks to the DSV's divers should the DSV suddenly move off location. As the divers form part of a tight knit community on board the DSV, with the lives of known individuals being directly held by the actions of others, the bridge crew of the DSV and in particular, the DP operators, are fully aware that human error on their part, can not only cause a ship collision but also cost lives. This affiliation with the lives of the divers will increase the focus of the DSV's bridge crew, thus making them more vigilant to the potential for human or equipment failure, and more prepared to take appropriate action, should such a failure occur.

Detailed below are factors pertinent to diving support vessels that could cause a DSV ship collision with an installation:

- Requirement to hold a geostationary position whilst alongside a FPSO which may suddenly rotate around its mooring system or move laterally;
- Displacement of taut wire by subsea activity (e.g. ROV, diving cage, etc.) which results in the DSV suddenly moving off location;
- Pressures to start, continue and complete alongside operations during environmental conditions which may be marginal for the operation.

6.3.8 Other Large Units (e.g. MODUs, Heavy Lift Vessels, Flotels, Barges, Etc.)

There have been very few collisions between installations and large attendant vessels. The main reasons for this are believed to be due to the relatively low number of alongside operations, the detailed planning associated with such operations, and the physical controls that are in place during the approach and close proximity periods.

The following are considered to be the main causes of collision between an installation and a large attendant vessel such as a MODU or flotel:

- Mooring failure in bad weather;
- Too close to the installation during periods of marginal environmental conditions;
- Being up weather of the installation during marginal environmental conditions;
- Towing line failures during positioning operations;
- Human error during the planning and execution of the in-field operation.

6.4 CAUSES OF PASSING VESSEL IMPACTS WITH INSTALLATIONS

6.4.1 Introduction

Passing vessels, with respect to any particular offshore installation, include all vessels proceeding on the high seas which are not visiting or working in the vicinity of, or in connection with, the particular installation.

Passing vessel collision risk can be divided into two categories dependent upon whether the vessel is under power (and steerage) at the time of impact, or if it is drifting under the influence of environmental forces. Powered collisions pose the higher risk to persons both on board the installation and on the vessel due to the vessel's higher speed, which results in higher impact energies and shorter warning times.

The causes of powered and drifting passing vessel collisions are presented in the sub-sections below.

6.4.2 Powered Passing Vessel Collisions

6.4.2.1 Introduction

For a passing vessel, not suffering from propulsion or steerage problems, to collide with an offshore platform, the following three conditions must occur:

1. The ship needs to be on a collision course with the installation;
2. The navigator/watchkeeper must be unaware of the collision course sufficiently long for the ship to reach the installation;
3. The platform/standby vessel crew be unaware of the situation or unable to warn the vessel or otherwise "normalise" the situation.

Before discussing the causes of passing vessel collisions, it is necessary to obtain an understanding of how a responsible navigator on a vessel plans and navigates a voyage. Summarised below are the key steps that such a navigator would take so as to avoid a collision with an installation (or other fixed obstruction):

- The first step in the "navigation process" is to plan the proposed vessel route in advance. During the planning, the navigator may or may not become aware of a particular installation. For example, if the installation is not marked on the current revision of his chart it is reasonable for him to assume that there is open sea at its location. In addition, the navigator may or may not undertake a detailed plan of his voyage.

  Navigators who do not undertake a detailed plan of their voyage accept that the wind and waves will probably take them off their proposed route and, therefore, to plan more detail than a coarse route with few waypoints, which may take them close to an installation, would not be worthwhile. Instead, they set out following their coarse route plan, detecting all installations and other obstructions in their way, and if the actual vessel course takes them closer to an installation than is considered comfortable, the vessel heading would be altered to create a considered safe passing distance.

  Navigators who undertake a detailed plan of a voyage and find that an installation is close to their preferred straight line will either plan to avoid the installation by, if required, moving their course so as to pass the installation at a comfortable safe distance, or, less commonly, move their course towards the installation so as to allow a "position fix" to be taken. In both cases they will plan to pass the installation at a considered minimum safe distance of around 1 – 4 nm, depending upon vessel size, navigation practice and sea room.

- Once the voyage has started, there will probably be no new information on the location of a particular installation until the vessel gets close enough to observe it. Information on the location of a newly installed mobile unit may be broadcast as a radio warning or NAVTEX message but for established structures there will be no such warnings. The observation distance will vary considerably, but for radar equipped vessels it should be at least 12 nm but this will be dependent upon radar type, scanner elevation and weather conditions (e.g. snow or heavy rain will cause a significant reduction in the performance of an "X" band radar but will have minimal effect on an "S" band type). Once within the observation distance, all vessels will have access to the same "information", in that all navigators with a properly working radar now have the opportunity to discover the platform.

- Actions taken within the observation range to avoid a collision will depend on many factors, including the speed of the vessel, the manoeuvrability of the vessel, the sea room between installations, the prevailing weather conditions, and more generally, on the experience and demeanour of the vessel's master or navigator.

- Vessel Captains questioned during the completion of the assessment of collision risk for the COLLIDE ship collision risk model (Ref. 12) indicated that upon discovering that they were heading for an installation they would change their course before their vessel came within 3 – 5 nm of the installation. This distance equates to around 20 minutes before impact for a vessel travelling at 12 knots.

- Again, as discussed above, some navigators on vessels prefer to verify their position with visual observations of installations and, therefore, adjust their course to pass close enough to an installation (albeit at a safe distance) so that the platform can be identified and a position fix taken.

- During the last 20 minutes before the vessel reaches the installation, there will still be time to perform collision avoidance manoeuvres. It is at this stage that installation initiated action, mainly by use of the installation's stand-by vessel, can be taken to try to warn the approaching vessel of the potential dangers.

- Some mariners have noted that the action taken by a stand-by vessel can actually increase the likelihood of collision. This is due to the collision avoidance action that the passing vessel may be required to adopt under the International Regulations for Preventing Collisions at Sea (Ref. 17). If, for example, the stand-by vessel approaches the passing vessel head-on, the passing vessel is required (as well as the stand-by vessel) to alter course to starboard (Rule 14) which could force the passing vessel towards the installation.

It can, therefore, be concluded that it is within "normal" navigational practices that:

1. Vessel voyages are planned to pass "through" or very close to, an installation if:
   (a) The navigator is unaware that the installation exists.
   (b) The navigator is aware of the installation but accepts that he may pass close to it (depending on vessel drift due to wind and waves) and if he does he may consider taking avoiding action when he "sees" the installation.
2. When within the observation range and the bridge crew of the vessel "sees" that the current vessel course will bring the vessel uncomfortably close to an installation, a course adjustment will be made but sometimes not until about 20 minutes before a potential collision. This time could be less in bad weather when the "observation" range may be reduced.

3. There is only a limited time for the installation to identify and respond to an approaching vessel which is not following "normal" navigational practices and is going to pass uncomfortably close to the installation.
4. A vessel which maintains a collision course with an installation when there is less than about 20 minutes to impact (and there is adequate sea room) will probably not be aware of the installation.

Following on, it can be seen that the primary causes for a collision between a passing vessel, which is underway, and an offshore installation, are:

- Ineffective watchkeeping on board the vessel, and/or
- The vessel is travelling too fast for the prevailing conditions to allow for successful collision avoidance action, and/or
- There is a mechanical failure during a collision avoidance manoeuvre which negates the actions taken.

The fact that the navigator and hence other personnel on the passing vessel are unaware of the installation is an important complementary factor since being forewarned of a potential obstruction should emphasise the requirement for effective watchkeeping and possibly a reduction in speed.

It should also be noted that there is a legal requirement, under the Coast Protection Act 1949 (See Section 3.14) for prior written consent to be given by the Secretary of State for Environment, Transport and the Regions before an offshore oil and gas installation can be located on the UKCS. Consent to locate an installation is only given once the potential impact on navigation has been evaluated and it is deemed that the installation, along with any proposed risk reduction measures, will not pose an undue obstruction or endangerment to navigation. It can, therefore, be concluded that an offshore installation, which does not have increased collision risk reduction measures, is unlikely to be located in a deep water route, a traffic separation scheme or any other location which is either heavily trafficked or has restricted sea room.

The following subsections further examine the reasons for mariners being unaware of an installation, why there may be ineffective watchkeeping on board passing vessels within the "observation range", why a vessel may be travelling at unsafe speeds, and the probability of a mechanical failure during a collision avoidance manoeuvre.

6.4.2.2 Mariners Unaware of Installation

The proportion of traffic that is aware of an installation is considered to be dependent on the time the installation has been installed. Distribution of information essential to the safety of navigation is done by issue of radio navigational warning, NAVTEX messages, Notices to Mariners and eventually publication of updated charts. Some time will elapse from when the first announcement is made until most vessels have had a chance to receive the information and updated their charts. There will, therefore, be a transition period when the knowledge of a newly installed installation increases. Obviously, vessels which use certain routes on a regular basis will quickly become aware of a new installation in the vicinity of its route but other vessels, which rarely cross through a sea area, will be much less likely to know of an installation unless it is on the chart that it is using for navigation. It is, therefore, unrealistic to expect all vessels navigating within a sea area to know of an installation located within it, even after a considerable length of time.

According to navigation officers (Ref. 12), Notices To Mariners, which are published weekly, are essential for information about changes in installation locations. There is, however, normally a delay, often of a couple of months, before this information reaches the officers. Another problem is that vessels which rarely visit ports often have limited access to mail although the use of telex and other modern communication systems should help minimise this problem. It was also noted that to update the charts on the basis of the

Notices To Mariners, particularly in areas of high offshore development activity (e.g. the North Sea) is rather time consuming and the navigators' ability to update their charts is reduced due to lower manning levels and other pressures of work.

6.4.2.3 Ineffective Watchkeeping

Once the vessel, which is on a collision course with an installation, gets within its "observation range", the watchkeeper on the vessel has the means to see the potential danger and take collision avoidance actions. The time available to take these actions will be the time duration between the initial "observation range" position, and the position, much closer to the installation, where the vessel will be physically unable to respond fast enough to avoid a collision.

The "observation range" for a vessel equipped with an operating radar, will be the effective range of the radar, which is approximately line of sight but this can be decreased or increased by abnormal conditions. For large vessels, which will have a high mounted radar antenna, the effective range would be in excess of 20 nm but for smaller vessels with lower mounted antenna the effective radar distance will be significantly less. It is considered that for vessels which have the potential to cause a significant risk to an installation (e.g. not small pleasure craft, small fishing vessels, etc.) the minimum effective range of their radar will be in excess of 10 nm. For vessels without radar, the "observation range" will be limited to the prevailing visibility which would be in the range from over 15 nm in ideal conditions to near zero visibility in thick fog or heavy snow.

The position where it will be physically impossible to avert a collision will be dependent upon the manoeuvrability of the vessel at the speed that it is moving. For example, a small vessel travelling slowly will generally be able to change course within a much shorter distance than a large vessel travelling quickly.

Following the expert panel meeting (Appendix A) and review of the data sources listed in Section 6, the following causes of ineffective watchkeeping were identified:

1. Watchkeeper present on bridge but:
   (a) Busy/preoccupied with other tasks;
   (b) Asleep;
   (c) Incapacitated due to sickness, accident or substance abuse;
2. Watchkeeper absent from the bridge;
3. Poor visibility combined with undetected radar fault.

Each of these causation factors is discussed further below:

Watchkeeper Busy or Distracted

Whilst on the bridge, a watchkeeper may have numerous tasks to perform such as position fixing, navigating the course of the vessel, and recording weather data. In addition to this, there is also the likelihood that he could be distracted by conversation with either another person on the bridge or on the radio or be busy undertaking other tasks such as chart plotting. As a result of this, it is considered that there is a probability of a collision scenario developing due to the watchkeeper being busy or distracted, particularly if he is the sole person on the bridge (Ref. 18). However, the duration of the task or distraction would have to be long enough for the vessel to be unable to recover from a collision course. The main factors considered to contribute to this failure are:

- Lack of management commitment and enforcement of IMO Regulations particularly with regard to bridge manning;
- Bridge management;
- Workload of watchkeeper. This can be underload as well as overload. Underload can induce hypovigilance which is the state just before sleep where the "lights are on but nobody is home". This is a recognised human factor danger and in low

trafficked areas such as the Northern North Sea or West of Shetland this is probably a much bigger danger than overload, made worse by minimal bridge manning at night;

- Competency of watchkeeper;
- Training and experience of watchkeeper;
- Layout of bridge to enable effective watchkeeping;
- Level of navigational automation on vessel;
- Level of equipment/systems maintenance;
- Lack of attention through over-reliance upon autopilot, and/or the anti-collision facility of a modern ARPA radar;
- Lack of awareness of potential obstruction (e.g. due to uncorrected charts);
- Level of other vessel activity or offshore field activity in area;
- Absence of an effective watch alarm.

An example of a collision which occurred as a result of the watchkeeper being sufficiently distracted not to see a platform occurred in the Southern North Sea. The collision occurred in day light, in good weather and clear visibility, with an offshore supply vessel which was well equipped, and with a crew which were very familiar with the North Sea offshore environment. The vessel hit the British Aerospace platform, which was unmanned and, therefore, was not guarded by a standby vessel, at an estimated 10 knots whilst still under power. The impact halted and entrapped the supply vessel, with the installation sustaining damage to all three of its legs (see Figure 6.1). The estimated cost of platform repair was of the order of £6 million and took 15 months to repair although BAe was able to operate after 4 months in a reduced capacity. It is alleged that the bridge of the supply vessel was manned at the time of impact with a watchkeeper and 2 other crew members.

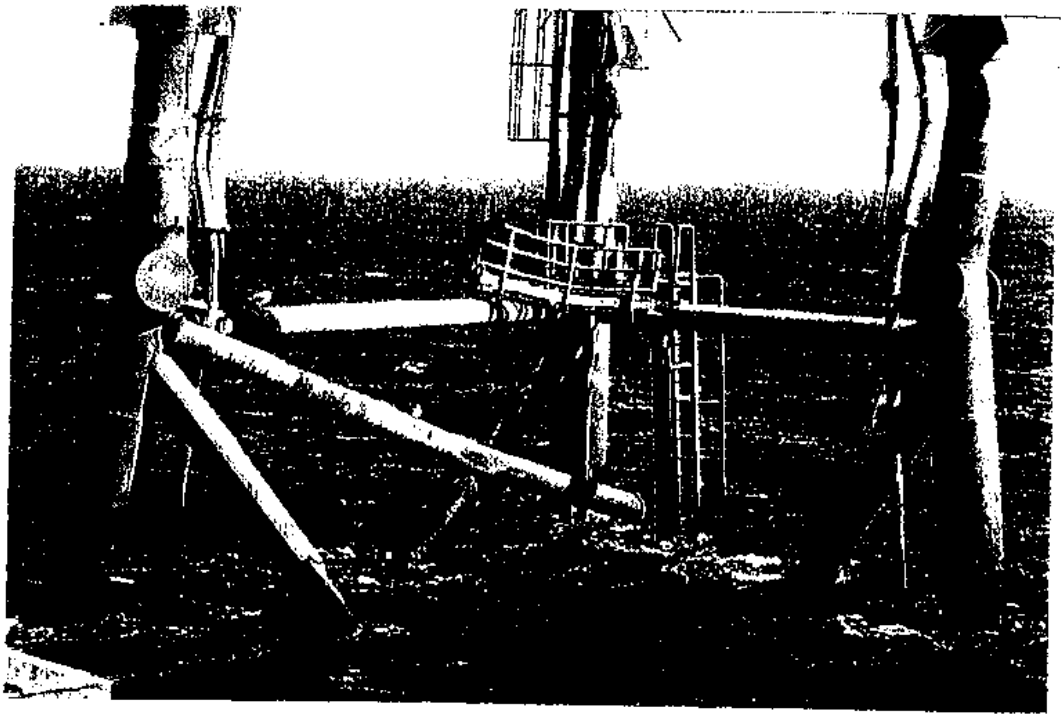

Figure 6.1

Damage Sustained To The BAe Platform Due To Collision With A "Passing" Supply Vessel
(Photo courtesy of British Aerospace)

Watchkeeper Asleep

Due to the long and irregular hours which characterise working time on a vessel there is the possibility of the watchkeeper falling asleep on the bridge. As mentioned earlier, hypovigilance, caused by underload, can cause a watchkeeper to miss, or not respond to, a potentially dangerous situation.

The problem of watchkeepers falling asleep during their on-duty period is backed up by the MAIB who regularly receive reports of bridge watchkeepers falling asleep while on watch (Ref. 18). During this period of sleep it is considered that there is, in effect, no attentive watchkeeping which, therefore, constitutes a failure. The main factors contributing to or affecting the probability of a watchkeeper falling asleep are considered to be:

- Lack of management commitment and enforcement of IMO Regulations particularly with regard to bridge manning;
- Failure of the Master and watchkeeper to ensure the latter is adequately rested and fit for duty;
- Training and experience of watchkeeper;
- Time of day;
- Time into the watch;
- Level of stimulation (e.g. bridge activity, other vessel activity, etc.);
- Duration of journey;
- Weather conditions;
- Level of navigational automation on vessel;
- Comfort level on bridge;
- Lack of awareness of potential obstruction (e.g. due to uncorrected charts);
- Absence of an effective watch alarm.

As discussed previously the duration of the sleep will have to be sufficient for the rogue vessel to be unable to recover from a collision course.

Incapacitated Due to Sickness (or Death)

A watchkeeper suddenly becoming ill is also identified as having the potential to lead to a rapid reduction in watchkeeper performance, unconsciousness or even death, due to illnesses such as a myocardial infarct (i.e. heart attack), brain haemorrhage, asthma attack, etc. The severity of the illness would have to be such that the watchkeeper was unable to pre-warn other personnel of his condition, although there will be cases when the sick person will be reluctant to request assistance due to illness in case his employment is jeopardised.

As with the other factors discussed, for illness to result in collision the duration of incapacity will have to be such that recovery of the vessel from a collision course is not possible. The main factors contributing to this are:

- Lack of management commitment and enforcement of IMO Regulations particularly with regard to bridge manning;
- Lack of management commitment to good health and monitoring of such;
- Fatigue or workload levels of watchkeeper;
- Age and general health of watchkeeper;
- Traffic density in area;
- Duration of journey;
- Weather conditions;
- Level of navigational automation on vessel;
- Comfort level on bridge;
- Hygiene levels on board;

- Proximity to port (e.g. where food poisoning may have been contracted);
- Absence of an effective watch alarm.

Incapacitated Due to Accident

There are a variety of accidents which characterise working on a ship. The MAIB holds data from accident reports received under The Merchant Shipping (Accident Investigation) Regulations 1989 and The Merchant Shipping (Safety Officials and Reporting of Accidents and Dangerous Occurrences) Regulations 1982. From this data source, slips, trips and falls were the most likely accident type (30%) followed by manual handling, and machinery use.

From the accident distribution stored by MAIB, it is considered that slips, trips and falls are the main potential causation of watchkeeper failure due to accident. Manual handling and machinery use are less appropriate for bridge accident assessment. With regard to this study, the severity of the accident would have to be such that the casualty would have to be incapacitated to a level that prevented a request for assistance and this situation would have to persist for a period of time that would render the vessel irrecoverable from a collision course. This is considered to be less likely, but could not be assessed from the data source. The main factors considered to affect the likelihood of accident are:

- Lack of management commitment and enforcement of IMO Regulations particularly with regard to bridge manning;
- Ergonomics of bridge;
- Weather conditions;
- Motion characteristics of vessel;
- Bad weather procedures;
- Time of day;
- Fatigue due to lack of adequate rest;
- Absence of an effective watch alarm.

Incapacitated Due to Substance Abuse

In this failure mode it is assumed that the level of substance abuse, which most probably would be alcohol consumption by the watchkeeper, is such that he loses consciousness, falls asleep or is unable to perform his task effectively. The substance abuse resulting in this failure can either be consumed onboard the vessel or prior to departure. The main factors contributing to this failure are recognised to be:

- Lack of management commitment and enforcement of IMO Regulations particularly with regard to bridge manning;
- Lack of management regime on use of substances which may impair performance;
- Failure of the Master and watchkeeper to ensure latter is fit for duty;
- Failure of the previous watchkeeper to alert the Master that the on duty watchkeeper is unfit for duty;
- Manning level on bridge;
- Training and experience of watchkeeper;
- Availability of substances;
- Proximity to port;
- Absence of an effective watch alarm.

Watchkeeper Absent from the Bridge

Whilst on duty, there is the probability that the watchkeeper may be absent for a number of reasons such as: toilet, refreshment, calling a relief, etc. As a result of this, it is considered that there could be a watchkeeping failure. The main factors contributing to this failure mode are considered to be:

- Lack of management commitment and enforcement of IMO Regulations particularly with regard to bridge manning;

- Training and experience of watchkeeper;
- Condition, age and level of effective maintenance of vessel;
- Time of day;
- Time into the watch;
- Level of navigational automation on vessel;
- Lack of awareness of potential obstruction (e.g. due to uncorrected charts);
- Layout of bridge deck (e.g. proximity of toilet, refreshments, etc. to the bridge);
- Absence of an effective watch alarm.

As noted earlier, the duration of the absence from the bridge will have to be significant enough for the vessel to be unable to recover from a collision course.

Poor Visibility Combined With Undetected Radar Fault

This failure mode is considered less likely due to the fact that it is a combination of events as opposed to a singular event. In this scenario, there has to be both poor visibility, so as to make visual watchkeeping not possible, and an undetected radar fault. The undetected radar fault, may be due to component failure or to maladjustment of the radar and would provide the watchkeeper with the impression that there are no immediate hazards ahead of the vessel and, therefore, no action required to be taken to avert a collision situation. It should be noted that in instances where vessels are travelling in bad visibility with more emphasis on the use of the radar, it is likely that the watchkeeper will be continually adjusting the system to optimise it's performance and, therefore, if trained properly this is an unlikely cause of failure.

The main factors influencing this failure mode are:

- Lack of management commitment and enforcement of IMO Regulations particularly with regard to bridge manning;
- Lack of management procedures to ensure that radars and navigational systems are checked and calibrated where possible throughout a voyage (e.g. by cross referencing the output of navigation systems with visual sightings of known positions such as lighthouses, installations, racons, radio beacons, stars, etc.);
- Maintenance of radar equipment;
- Reliability of radar equipment;
- Usability of radar equipment;
- Error tolerance of radar equipment to user adjustment;
- Availability of independent reference equipment to allow cross referencing of the main radar system;
- Operators experience with equipment;
- Training and experience of watchkeeper to realise radar inaccuracy;
- Lack of awareness of potential obstruction (e.g. due to uncorrected charts);
- Traffic density in area;
- Wave clutter.

General Discussion

In the preceding sections, 7 failure modes for effective watchkeeping were discussed. Based on the expert panel review it is considered that the most likely causes of ineffective watchkeeping, on passing vessels, were due to the watchkeeper either falling asleep on the bridge, or being absent from the bridge for whatever reason. The expert panel also considered that it was likely that the watchkeeper could have periods of distraction which could impair his watchkeeping abilities.

For ineffective watchkeeping to result in a ship collision with an installation, the duration of failure must be sufficient for the vessel to cover the distance between the "observation range" and the point that a collision cannot be avoided due to vessel response characteristics. This critical time will be dependent upon:

1. Distance available in which to complete successful collision avoidance action;
2. Speed of the vessel

Obviously, the slower a vessel is travelling and the larger the distance from which an obstruction can be seen, either by radar or visually, the greater the available time to alter course and avert a collision. Figure 6.2 presents a comparison between available distance and vessel speed in terms of the time available to avert the collision.

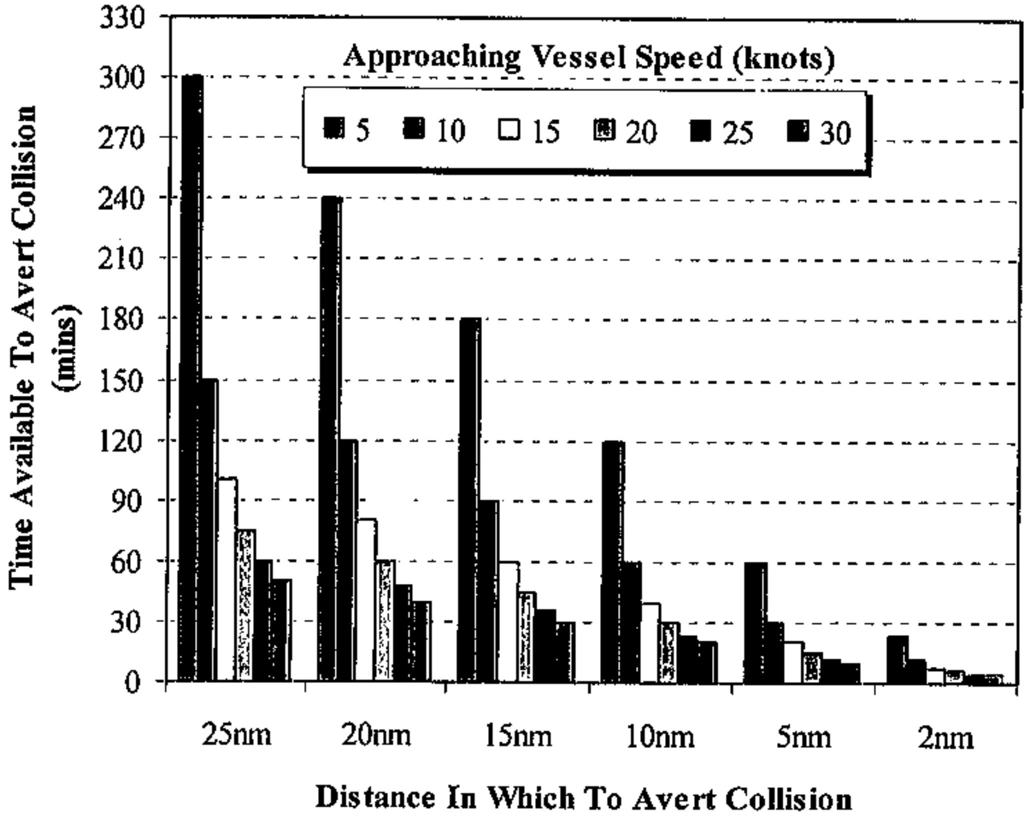

Figure 6.2

Time To Avert A Collision

Figure 6.2 gives an indication of the period that a watchkeeper must be ineffective before this failure could lead to a collision. The figure highlights the necessity of very effective watchkeeping on high speed vessels, particularly in poor visibility. For example, a vessel travelling on a collision course with an installation, at a speed of 15 knots with a radar capable of identifying an installation at 10nm, would only have around 40 minutes in which to identify the danger and take avoiding action. This time, whilst being ample for an effective watchkeeper to see the danger, plan a course alteration, and then smoothly execute the vessel manoeuvre, could easily be consumed if a watchkeeper is asleep, or heavily distracted.

Based on previous discussion of potential causes of ineffective watchkeeping, the following causation factors are highlighted as being of particular importance:

- Lack of management commitment and enforcement of IMO Regulations particularly with regard to bridge manning and bridge management;
- Failure of the Master and watchkeeper to ensure latter is adequately rested and fit for duty;

- Poor bridge ergonomics and systems design which increase the likelihood of the watchkeeper falling asleep, being distracted, being ineffective, or becoming overloaded and/or fatigued;
- Poor upkeep of navigational information resulting in a lack of awareness of potential obstructions during route planning and watchkeeping;
- Lack of management procedures and navigational crew competence to ensure that radars and navigational systems are checked and calibrated where possible throughout a voyage (e.g. by cross referencing the output of navigation systems with visual sightings of known positions such as lighthouses, installations, racons, radio beacons, stars, etc.). Cross referencing of navigational systems is recommended navigational practice and should be taught formally in all navigational schools;
- Failure to employ an effective watch alarm which is tamperproof, requires the watchkeeper to physically move to cancel it, and if not cancelled, will alarm elsewhere in the vessel where it can be heard by a competent person.

6.4.2.4 Excessive Speed

A large number of factors will influence the speed of a vessel as it navigates the high seas, including:

- Management procedures and other control measures;
- Experience and demeanour of Master;
- Ability of other bridge officers to question Master's decisions;
- Physical capabilities of vessel (e.g. engine power, length, breadth, displacement, manoeuvrability, stopping distance, etc.);
- Schedule and consequences of arriving late or early;
- Vessel motion characteristics;
- Cargo/passenger tolerance to vessel motions;
- Fuel consumption;
- Fuel on board;
- Ballast condition;
- Sea conditions;
- Wind strength and direction;
- Visibility;
- Perceived capability of radar and radar operator;
- Time of day;
- Weather forecast;
- Tidal movement;
- Density of traffic in area;
- Sea room;
- Draught in relation to the available depth of water;
- Known navigational hazards in proximity of vessel.

The Master of the vessel is, however, legally bound under Rule 6 of the International Regulations for Preventing Collisions at Sea (Ref. 17) to ensure that his vessel is at all times proceeding at a safe speed so that proper and effective action can be taken to avoid collision and stop the vessel within a distance appropriate to the prevailing circumstances and conditions.

Therefore, providing there is effective watchkeeping and no mechanical failure, should a navigational hazard appear or occur and the vessel cannot take avoiding action by changing course or slowing down or stopping, within the time available to avert a collision, the vessel will be deemed to be travelling at an unsafe speed.

It was raised during the expert panel review of collision risk (see Appendix A) that mariners may not have a full appreciation of the risks associated with a collision with an offshore installation, and that they may not realise the implications that their actions have for the operation of an offshore installation. For example, an installation may be shut down with all personnel taking to the lifeboats if a vessel is seen to pose a threat of collision. Without an understanding of the risks, both to themselves and those on board the installation, navigators may set an excessive speed whilst navigating in the vicinity of offshore developments.

6.4.2.5 Mechanical Failure During Collision Avoidance

A final cause of a collision between a powered passing vessel and an installation is related to technical failure onboard the vessel. If the vessel is on collision course and the steering gear fails, a collision may occur. This is an unlikely scenario since it requires the vessel to either be quite close to the platform before diverting from the collision course, or be unable to stop the vessel because of failure in control of the propulsion system.

A mechanical failure which leads to a collision scenario after a period of drift is discussed in Section 6.4.3.

6.4.3 Drifting Vessel Collisions

In order to enable a systematic identification of drifting vessel collision causes, it is possible to structure the problem in a similar manner to that identified in Section 6.4.2.1. For a drifting vessel collision to occur, four conditions need to be fulfilled:

1. The ship needs to be drifting on a collision course with the platform;
2. The navigator be unaware of the situation sufficiently long for the ship to reach the installation or be unable to recover the vessel from a collision course;
3. The platform/standby vessel crew be unaware of the situation or unable to "normalise" the situation;
4. External resources such as the Coastguard or nearby vessels unable to "normalise" the situation.

In a drifting vessel scenario it is considered that there is sufficient time for the navigator of the vessel to assess the drift course relative to nearby platforms. Furthermore, as watchkeeping has not failed and the crew are likely to be aware that the vessel is drifting, a warning will be sounded which is likely to be picked up by the SBV or installation. As a result of this, it is considered that the normal "failures" which will result in a drifting vessel collision are:

- The delayed response of the Master or owner of the drifting vessel to request assistance;
- The inability to get a tow line on board;
- Insufficient capacity of the SBV or other attendant vessel to tow the drifting vessel away from the installation;
- The delayed response of the Coastguard to alert nearby vessels, which have the capability to attach a tow line and tow the drifting vessel.

It is noted that environmental conditions have a significant influence on the probability of recovering a drifting vessel and also on the consequences of collision, should one occur.

Further discussions on the complex legal aspects and possible liabilities associated with towing of drifting vessels have not been included in this report but note should be taken in this section that these issues are likely to have a very strong influence on whether and when an attempt would be made to prevent a drifting vessel collision by physical actions.

Based on the previous discussion, it is considered that the benefit of installation collision control and avoidance systems will be limited in a drifting vessel scenario and that the effectiveness of collision control and avoidance systems will not be dependent on the causation factors leading to the vessel drifting.

7 KEY ELEMENTS OF A COLLISION RISK MANAGEMENT SYSTEM

7.1 INTRODUCTION

An offshore installation is exposed to ship collision risk from both in-field and passing vessels. From the review of historical data presented in Section 5.4 it was observed that both scenarios have occurred and that both have the potential to result in catastrophic damage to the installation, although to date only severe (not catastrophic) consequences have been observed in UK waters.

There are a number of Regulations governing this hazard which have already been discussed in detail under Section 3. In summary, the Regulations state that the duty holder must demonstrate that there is an effective management system which ensures that hazards with the potential to cause a major accident (ship collision falls within this category) are identified, that risks are adequately controlled and that the organisational arrangements in place will enable the duty holder to comply with relevant health and safety legislation.

This Section deals with the practical aspects of developing a collision risk management system, which will enable a duty holder to comply with the legislative requirements.

In view of the different aspects of collision risks between in-field and passing vessels, the common elements of a Safety Management System (SMS) for the management of ship collision risks are discussed first, followed by separate, more detailed, discussions of the management of in-field and passing vessel collision risks. Finally, these sections are pulled together as an overall SMS for the management of ship collision risks. An overview of the hardware systems currently available is given in Appendix B of this document.

To aid interpretation, it is recommended that the legislation outlined in Section 3 is read in conjunction with this section.

7.2 PRINCIPLES OF SUCCESSFUL HEALTH AND SAFETY MANAGEMENT

HSE's publication HS(G)65 "Successful Health and Safety Management" sets out the principles for successful health and safety management based on the practices of those organisations with effective management systems and low accident rates, see Figure 7.1.

The following elements have been identified as critical to the establishment of an effective safety management system and are briefly described before setting out in more depth how these elements and appropriate sub-elements can be applied to the management of ship collision risks.

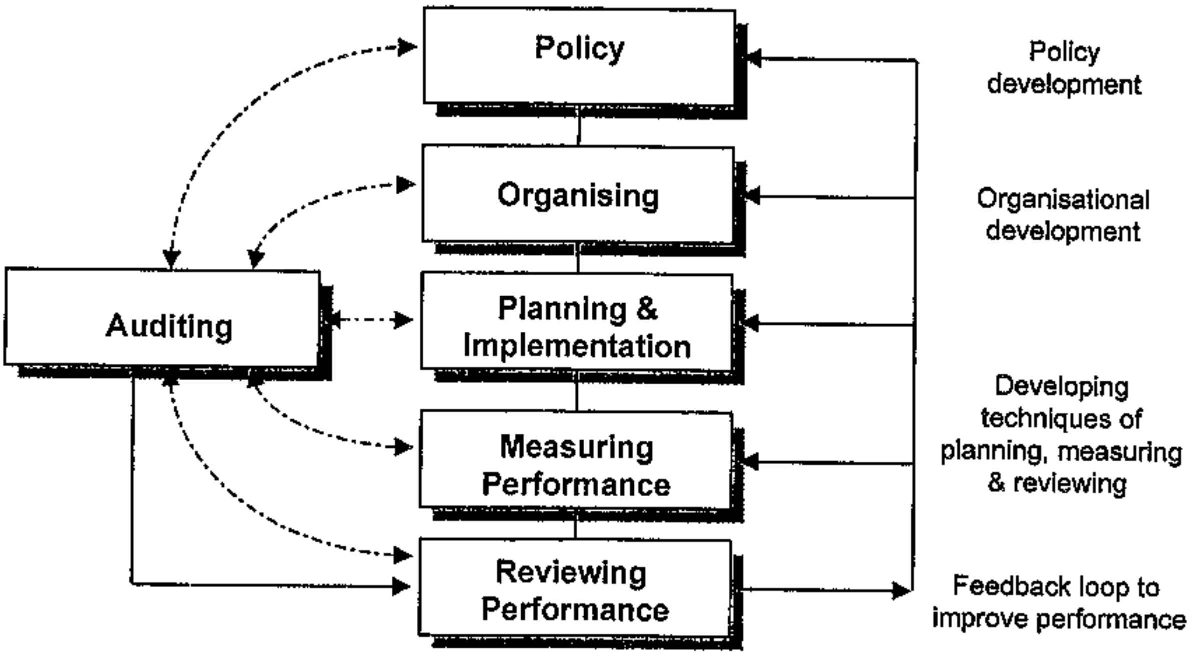

Figure 7.1

Safety Management System Model (taken from HS(G)65)

7.2.1 Policy

Organisations, which achieve high standards of health and safety, have health and safety policies which contribute to their business performance, while meeting their responsibilities to people and the environment in a way which achieves full compliance with legislative requirements. Their policies are cost effective and aimed at achieving the preservation and development of physical and human resources and reductions in financial losses and liabilities. Their health and safety policies influence all their activities and decisions, including those to do with the selection of resources and information, the design and operation of working systems, the design and delivery of products and services, and the control and disposal of waste.

7.2.2 Organising

Organisations, which achieve high health and safety standards, are structured and operated so as to put their health and safety policies into effective practice. This is helped by the creation of a positive culture which secures involvement and participation at all levels. It is sustained by effective communications and the promotion of competence which enables all employees to make a responsible and informed contribution to the health and safety effort.

7.2.3 Planning

Successful organisations adopt a planned and systematic approach to the implementation of their policies. Their aim is to minimise the risks created by work activities, products and services. They use risk assessment techniques to decide priorities and set objectives for the elimination of hazards and the reduction of risks. Performance standards are established and performance is measured against them. Wherever possible, risks are eliminated by the careful selection and design of facilities, equipment and processes or minimised by the use of physical control measures. Where this is not possible, systems of work and personal protective equipment are used to control risks.

7.2.4 Measuring Performance

Health and safety performance in organisations which manage health and safety successfully, is measured against pre-determined standards. This reveals when and where action is needed to improve performance. The success of action taken to control risks is assessed through active self-monitoring, involving a range of techniques. Failures of control are assessed through reactive monitoring which requires the thorough investigation of any accidents, ill health, and incidents with the potential to cause harm or loss. In both active and reactive monitoring, the objectives are not only to determine the immediate causes of sub-standard performance but, more importantly, to identify the underlying causes and the implications for the design and operation of the health and safety management system.

7.2.5 Auditing And Reviewing Performance

Learning from all relevant experience and applying the lessons learned are important elements in effective health and safety management. This needs to be done systematically through regular reviews of performance based on data both from monitoring activities and from independent audits of the whole health and safety management system. Commitment to continuous improvement involves the constant development of policies, approaches to implementation and techniques of risk control. Organisations, which achieve high standards of health and safety, assess their health and safety performance by internal reference to key performance indicators and by external comparison with the performance of other organisations within their business sector.

7.3 ELEMENTS OF A COLLISION RISK MANAGEMENT SYSTEM

In order to develop an effective collision risk management system based on the principles of successful health and safety management outlined above, it is necessary to consider various aspects of these elements in more detail and a suggested approach is set out below. The approach is shown in Figure 7.1, and relates it back to the principles of successful health and safety management outlined previously.

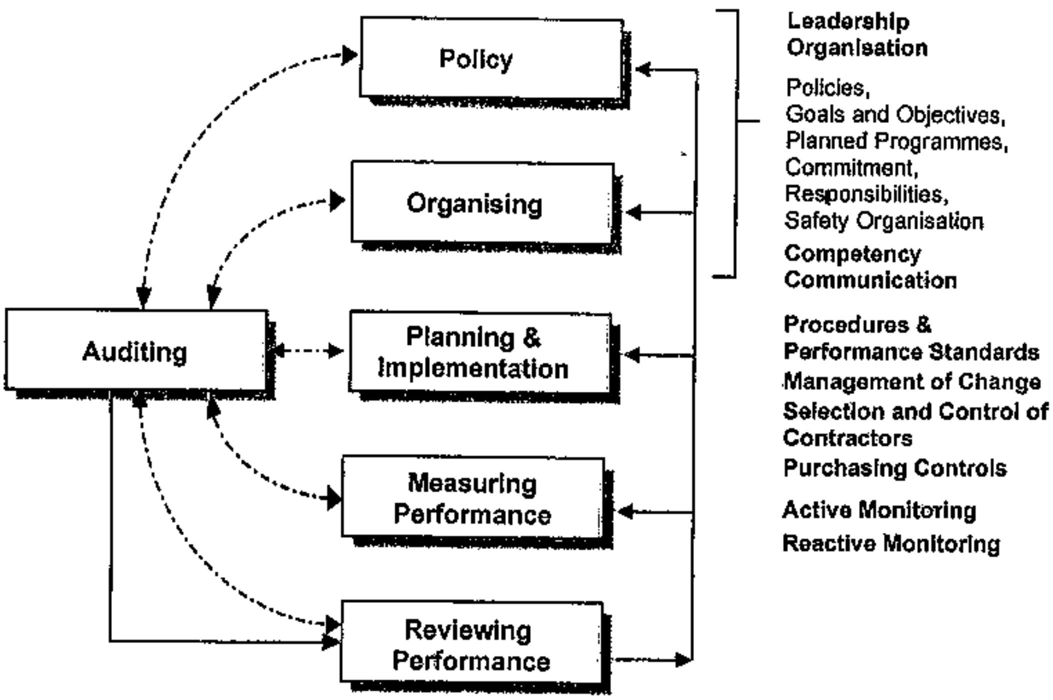

Figure 7.1

Elements Of A Collision Risk Management System

7.3.1 Leadership And Organisation

7.3.1.1 Policies

Senior management should promulgate a clear corporate policy with respect to the management of ship collision risks which includes a commitment to the identification and assessment of such risks and the establishment of appropriate measures to control them. Such a policy should also clearly address the issue of resources by senior management making a commitment to the provision of adequate monetary and labour resources, including those of specialists.

For each installation, a policy with respect to the management of ship collision risks should be prepared, which is specific to that installation, its location and facilities.

Both the corporate and installation specific policies will need to be referred to in the Operations Safety Case required under the Offshore Installations (Safety Case) Installations Regulations 1992. As with all such policies, they should be reviewed and revised on a regular basis or when necessitated by major changes.

7.3.1.2 Goals and Objectives

Senior management should establish clear goals and objectives in relation to the management of ship collision risks via corporate level performance standards such as that of a zero collision target, together with the development of a programme of hazard identification, risk assessment and preparation of appropriate procedures.

7.3.1.3 Planned Programmes

In order to achieve such goals and objectives, it is necessary to plan appropriate programmes and to regularly monitor compliance with these programmes through audits, etc. One key objectives of these programmes should be effective training to increase the awareness and familiarity with procedures and the roles and responsibilities of personnel.

7.3.1.4 Commitment

Senior management's commitment to the management of ship collision risks should be visibly demonstrated, ensuring that their policy is raised and discussed at appropriate meetings, whether on or offshore and by appropriate reference to such policies and their commitment within company literature.

7.3.1.5 Responsibilities

The organisational structure for the management of ship collision risks should be clearly defined together with the roles, responsibilities, accountabilities and authorities of the personnel responsible. Such roles, responsibilities, accountabilities and authorities apply to everyone involved in the management of ship collision risks and extend beyond the employees of the duty holder to those of contractors, such as the master of a standby vessel or a visiting supply vessel.

7.3.1.6 Safety Organisation

Regulation 6 of the Management of Health and Safety at Work Regulations 1992 requires every employer to appoint one or more competent persons to assist him in undertaking the measures he needs to take to comply with the legislative requirements placed upon him. Senior management should ensure that they have access to a person who is competent in the sphere of ship collision risk management by virtue of his training, experience, knowledge and other qualities.

7.3.2 Procedures And Performance Standards

In order to manage ship collision risks, a duty holder needs to establish appropriate procedures and performance standards for:

- The structured identification of all potential hazards;
- The systematic process for the assessment of identified hazards;
- The identification and implementation of risk reduction measures by employing a hierarchical approach for the elimination, prevention, control and mitigation of the hazards; and,
- Emergency response measures, in the event of a collision which results in the need for evacuation or escape from the installation and for recovery of personnel to a place of safety, are effective to ensure "good prospect" of survival.

7.3.3 Competency

If all personnel are to make a maximum contribution to the management of ship collision risks, there must be effective arrangements in place to ensure that they are competent. Competency means more than simply training. Experience of applying skills and knowledge is another important ingredient and needs to be gained under adequate supervision. Managers need to be fully aware of legislation relevant to the management of ship collision risks. Employees will need to be competent to play their appropriate roles in order to implement the ship collision risk management system. Similarly, the personnel of any contractors involved (e.g. crews of in-field vessels), also need to be competent and familiar with any systems of work relevant to their operations within the 500m zone.

In addressing the issue of competency, the following points need to be considered:

- Recruitment and placement procedures which ensure that employees have the necessary physical and mental abilities to do their jobs or can acquire them through training and experience;
- Systems to identify health and safety training needs in connection with ship collision risk management;
- The need to maintain or enhance competence by refresher training;
- The conduct of appropriate emergency drills and exercises at suitable intervals;
- Systems and resources to provide the information, instruction, training and supporting communications effort to meet these needs;
- Arrangements to ensure competent cover for staff absences.

7.3.4 Communication

Communication is probably the most important element within any safety management system. Without clear and effective communication it is virtually impossible for an organisation to fully achieve its goals and objectives whether they be business or health and safety ones.

Personnel at all levels within the organisation will be involved in the management of ship collision risks. Also, personnel beyond the installation (e.g. the crew of a standby vessel), will require to be involved. All of these personnel, either individually or in groups will need to be involved in the setting of performance standards, devising operating and emergency systems, procedures and instructions for risk control. A culture of talking to, not at, contracting companies (e.g. supply boat companies and others), to establish common agreement on the risks and how best to reduce them to ALARP, must be created.

Apart from setting up clear lines of communication in terms of establishing and implementing appropriate polices and procedures, effective physical communication systems and procedures need to be in place for communication between the installation and vessels either operating within the 500m zone or encroaching within it.

7.3.5 Management Of Change

Change whether minor or major is a hazard which needs to be effectively managed and failure to do so has often been a contributing factor in many accidents both minor and major. In terms of ship collision risks, changes may occur quite frequently (e.g. standby vessels, supply vessels or shuttle tankers may change or members of their crews may change or passing vessel traffic patterns may change).

Whatever form change may take, whether in terms of plant and equipment, processes, procedures, personnel or contractors, the organisation should have in place appropriate systems to assess the implications and plan and manage the changes effectively.

7.3.6 Selection And Control Of Contractors

Whilst a duty holder has no control over passing vessels which may threaten the installation, he does have control of those vessels which enter the safety zone on legitimate business.

The collision risk management system should address this issue by the establishment of appropriate policies, standards and procedures for the assessment of contractors prior to the award of a contract which involves vessels approaching the installation. Such an assessment will need to consider the vessel itself in terms of its main systems such as propulsion, mooring, dynamic positioning and navigation. Apart from ensuring that the vessel itself is fit for purpose, such an assessment should also consider manning levels and the competence of the crew in relationship to this type of risk.

Selecting a competent contractor is not in itself sufficient to discharge the responsibilities imposed on an operator under the Health and Safety at Work Act 1974. Appropriate arrangements must be instituted and implemented to monitor, on a regular basis, the performance of the contractor. In order to do this effectively, the operator should identify appropriate items to measure and establish and agree with the contractor suitable performance standards. Furthermore, in the event of failure to achieve these performance standards, there should be a mechanism for agreeing and tracking necessary corrective actions.

7.3.7 Purchasing Controls

The duty holder will need to purchase equipment, materials and services in relation to the management of ship collision risks (e.g. radar systems) and should have in place appropriate procurement policies, standards and procedures.

7.3.8 Measuring Performance

Duty holders need to measure what they are doing to implement their collision risk management system, to assess how effectively they are controlling ship collision risks and how well they are developing a positive safety culture in relation to this risk. A low accident rate is no guarantee that risks are being effectively controlled and this is particularly true where there is a low probability of accidents but where major hazards are present as in the offshore oil and gas industry.

Like planning, monitoring health and safety performance against pre-determined plans and standards should be a line management responsibility. Monitoring also reinforces management's commitment to health and safety objectives in general and helps in developing a positive health and safety culture by rewarding positive work done to control risk. Two types of system are required; active and reactive.

7.3.8.1 Active Monitoring

Active monitoring involves monitoring the achievement of plans and the extent of compliance with standards. It gives an organisation feedback on performance before an accident or incident. It includes monitoring the achievement of specific plans and objectives, the operation of the collision risk management system and compliance with performance standards. This provides a firm basis for decisions about improvements in collision risk control.

The following are examples of active monitoring:

- Operational and emergency procedures monitored against pre-determined standards;
- Standby vessel radio contacts with vessels logged and reported to the OIM;
- Monitoring of the awareness of relevant procedures by attending vessels;
- Checking that traffic data reports are kept up to date and readily available;
- Assessing the performance of the radar systems in relation to the procedural requirements.
- Monitoring of records of personnel training programmes;
- Assessment of familiarity of installation and in-field craft personnel with procedures and equipment;
- Recording timings during drills and exercises for comparison against pre-determined performance standards;
- Analysis of operational experience of both equipment and personnel;
- Monitoring of shipping traffic patterns and density;
- Assessment of the effects of adverse weather;
- Monitoring of the availability of the standby vessel to act as a guard vessel;
- Monitoring of the availability of radar systems;
- Monitoring of the distribution of information to the workforce and an assessment of its effectiveness;
- Promptly reporting safety zone infringements (This is a legal requirement and should be in accordance with the HSE OIR13 report form);
- Analysis of near miss incidents to determine "lessons learnt";
- Reviewing pertinent industry-wide accident and near miss incident reports and other information sources (e.g. forum meetings, conferences, UKOOA meetings, etc.) to determine if installation specific lessons can be taken on board;
- Monitoring technological improvements in the field of collision risk management;
- Setting up a system for the implementation and tracking of prioritised actions arising from active monitoring with responsibilities and targets for completion clearly defined.

7.3.8.2 Reactive Monitoring

Reactive systems, by definition, are triggered after an event and include identifying and reporting:

- Near Misses;
- Injuries;
- Other losses, such as damage to property;
- Incidents, including those with the potential to cause injury or loss;
- Hazards;
- Weakness or omissions in performance standards.

Each of the above provide opportunities for the duty holder to check performance, learn from mistakes and improve the performance of the collision risk management system.

Everyone involved in the collision risk management system, including supply and other visiting vessels, should be encouraged to report all of the above.

Suitably qualified personnel should undertake investigations of such reports with the objective of:

- Identifying reasons for sub-standard performance;
- Identifying underlying failures in the collision risk management system;
- Learning from the events;
- Preventing recurrences, and
- Satisfying legal and reporting requirements.

An appropriate system also needs to be in place for the implementation and tracking of prioritised actions arising from accident and incident investigations with responsibilities and targets clearly defined.

A recording system is also necessary in order to:

- Collect information accurately and present it in a consistent form;
- Enable analysis to identify common causes, features and trends which may not be apparent from the investigation of an individual event;
- Record information which might be needed in the foreseeable future;
- Alert others to the lessons to be learnt from a single or series of events.

7.3.9 Audit

Organisations can maintain and improve their ability to manage risks by learning from experience through the use of audits and performance reviews. They constitute the "feedback loop" which enables an organisation to reinforce, maintain and develop its ability to reduce risks to the fullest extent and to ensure the continued effectiveness of the health and safety management system overall and the collision risk management system in this particular context.

Regulation 8(4)(a) of the Offshore Installations (Safety Case) Regulations 1992 defines audit as the "systematic assessment of the adequacy of the management system to achieve its purpose carried out by persons who are sufficiently independent of the system (but who may be employed by the duty holder) to ensure that such assessment is objective".

All control systems tend to deteriorate over time or to become obsolete as a result of change. Auditing supports monitoring by providing managers with information on how effectively plans and the components of the collision risk management system are being implemented.

The collision risk management system should be subject to periodic audit by an auditor(s) knowledgeable of this type of management system. The audit methodology should address all the elements of the collision risk management system. An appropriate system also needs to be in place for the implementation and tracking of prioritised actions arising from such audits with responsibilities and targets for completion clearly defined.

7.3.10 Performance Review

Reviewing is the process of making judgements about the adequacy of performance and taking decisions about the nature and timing of the actions necessary to remedy deficiencies. The collision risk management system should be subject to regular review at all levels. A periodic review of the collision risks associated with an installation should be undertaken in order to reassess the risks, review safety zone infringement reports, evaluate the impact of new technology, review the experience of other duty holders and any legislative developments.

Again, an appropriate system needs to be in place for the implementation and tracking of prioritised actions arising from such reviews with responsibilities and targets for completion clearly defined.

7.4 MANAGEMENT OF IN-FIELD SHIP COLLISION RISKS

As discussed in Section 3 – Legislative Requirements, the principles of risk control, as set out in the Management of Health and Safety at Work Regulations 1992 Approved Code of Practice, involve a hierarchical approach to the management of hazards. The hierarchy entails:

(a) Inherent safety through the elimination and minimisation of the hazards by design;
(b) Prevention (reduction of likelihood);
(c) Detection (transmission of information to control point);
(d) Control (limitation of scale, intensity and duration);
(e) Mitigation of consequences (protection from effects).

This hierarchy is discussed below in relation to the management of ship collision risk with respect to in-field vessels.

7.4.1 Hazard Identification (In-Field Vessels)

In order to manage any risk effectively, it is necessary first of all to identify all relevant hazards. With respect to in-field vessels, the hazard of ship collision may arise from any one or more of the following:

- Standby vessels;
- Supply vessels;
- Multi-purpose vessels;
- Mobile drilling units (MODUs) both semi-submersible and jack-up;
- Mobile accommodation units (flotels);
- Shuttle tankers;
- Heavy lift vessels;
- Anchor handling vessels;
- Tugs;
- Barges;
- Diving support vessels;
- Survey vessels;
- Well stimulation vessels;
- Pipelay barges.

Some of these vessels may be present within the 500m zone of an installation on a regular basis, (e.g. standby and supply vessels), whilst others may be present very occasionally. However, each one needs to be recognised as a potential collision hazard to the installation and taken into account when developing a collision risk management system.

In order to identify all reasonably foreseeable collision hazards associated with in-field vessels, a systematic approach, which is appropriate to the magnitude of the hazards involved, must be taken. For example, the hazard identification exercise associated with the frequent visits of supply vessels, should generally be more rigorous than that required for a tug being used to manoeuvre a drilling unit into a location some 400m from the installation once every, say, 4 years.

7.4.2 Risk Assessment (In-Field Vessels)

Having identified all potential collision hazards, the risks (i.e. the likelihood and the scale of potential consequences) of a collision between the vessels and the installation) need to be assessed. In the case of vessels which regularly visit an installation, such risks need to be addressed in detail in the Operations Safety Case for the installation. The risks associated with vessels which visit only occasionally will need to be addressed on a case by case basis. In some instances, such risks will need to be addressed in a Combined Operations Safety Case, (e.g. when a MODU is working alongside a production platform).

The assessment of collision risk should be specific to the particular installation, its environment and the vessels involved. Clearly, the likelihood of collision may be influenced by the integrity of its operational systems, and the competence of its crew. Also, the likely consequences will be dependent on the size of the vessel, its speed at impact, which may well be influenced by the nature of the operations in which it is involved, and the structural response of the installation. It should also be noted that the consequence assessment should take into account longer term effects which may occur as a result of repetitive low energy impacts/repairs (e.g. work hardening of steel, reduced fatigue life, reduced static or dynamic load capacities, etc.).

In all cases, the risk assessment of ship collision hazards should be clear, systematic and be of sufficient detail for a full understanding of the risks. It should also be of sufficient detail to allow the benefits of proposed remedial measures to be assessed and ultimately demonstrate that collision risks have been reduced to ALARP.

Factors considered pertinent to the assessment of these risks include:

- Industry experience of the causes and consequences of visiting vessel impacts;
- Visiting vessel company standards and performance, encompassing manning level and training philosophy, vessel specification and maintenance, vessel/crew utilisation limits, etc.;
- Installation and other marine procedures;
- The visit frequency, size, duration of visits, closeness of position keeping, operating requirements and characteristics of in-field vessels;
- Vessel course and speed of approach;
- Environmental factors;
- Likely impact zones;
- The probable impact energies and the structural response of both the vessel and the installation;
- The progressive and residual effects of multiple low energy impacts;
- The likely effectiveness of emergency response;
- The effect of human factors;
- The performance and criticality of equipment for the prevention, control and mitigation of ship collision risk;
- The criticality of tasks to determine the demands on personnel in terms of perception, decision-making and appropriate action;
- Conducting HAZOP's to increase awareness of risks and aid communication between the different groups involved in the activity.

7.4.3 Preventive Measures (In-Field Vessels)

When managing any risk, the first step is to consider ways of eliminating it totally. In the case of in-field vessel operations this approach may not be available. However, it may still be possible to eliminate the need for a vessel to visit the installation. For example, during the design stage of an installation, if offloading is to be via a shuttle tanker, consideration should be given to dispensing with the tanker altogether if it is practicable to tie in to an existing pipeline.

Such an option may not be available and a shuttle tanker may be the only practicable solution. In such an event, consideration needs to be given to the details of the offloading system, for example, from an FPSO is it to be via stern offloading or via a buoy and at what distance and heading from the installation should the buoy be located.

In relation to any occasional visiting vessel, the question should be asked "Is this visit necessary?" The same question can be asked of regular visiting vessels, particularly supply boats. The greater the number of visits of a supply vessel to an installation, the greater the likelihood of a collision. Therefore, reducing the number of visits of supply vessels to an installation, by, for example, improved planning and management of logistics, should lead to a reduction in collision risk.

The benefits in terms of risk reduction of preventive measures, should take the whole risk picture into account. For example, the illustration presented in the previous paragraph regarding reducing the frequency of supply vessel visits could actually increase the risks associated with supply vessel collisions, if its implementation forced an increase in supply vessel size and duration alongside or increased pressure to get it alongside when it does come even in marginal conditions.

Other possible ways of preventing in-field collisions by design, procedural change or controls include:

- Minimising the requirement for a flotel by:
  - Reducing the requirement for persons to go offshore by, for example, increasing automation, enabling remote monitoring and control, and reducing maintenance demand by using long-life, highly reliable, modular systems;
  - Minimising the requirement for offshore hook-up and commissioning by undertaking more of this work in the construction yard prior to sail-away;
  - Installing a separate accommodation platform;
  - Increasing the available accommodation on the installation.
- Minimising the requirement for a MODU by installing drilling/workover facilities on the installation;
- Minimising the requirement for pipelaying vessels, heavy lift vessels, MODUs, etc., by completing the subsea infrastructure prior to installation of the platform;
- Minimising the requirement for a diving support vessel by having a dive spread on the installation.

Again it should be stressed that whilst the above examples may reduce the risks associated with ship collision impacts, they may increase the overall risks to personnel (e.g. accommodating personnel on the installation and not on a flotel reduces their distance from platform events). Assessment of this is required on a case by case basis.

It should also be noted that during the selection of risk reducing measures, which will often involve the use of cost benefit analysis, the costs should be based on both up-front design and construction costs, and probable life-time operational costs (i.e. both CAPEX and OPEX).

7.4.4 Control Measures (In-Field Vessels)

Having reduced the risk of ship collision as far as reasonably practicable by eliminating the need for vessels to approach within the 500m zone, the next level of the hierarchy involves the design and implementation of appropriate measures to control the risk.

The duty holder and the OIM of the installation have control of which vessels may be allowed within the 500m zone. Therefore, they can ensure that any visiting vessel is "fit for purpose" through various means, including contractual specification, onshore audits, on and offshore vessel inspections and the use of an installation checklist completed via radio communication prior to the vessel entering the 500m zone. When letting any contract for whatever type of visiting vessel, the duty holder, by appropriate pre-contract assessments and auditing, should ensure that:

1. The operating envelope of the vessel is suitable for the specific location of the installation in relation to station keeping and the likely meteorological and oceanic conditions;
2. The vessel is adequately maintained;
3. It is crewed by competent personnel;
4. The number of crew is appropriate for the operations to be undertaken, (e.g. in the case of a supply vessel, a master and a master/mate may be necessary if the vessel is being used intensively in order to allow sufficient rest periods);
5. Suitable and sufficient procedures are in placed for the safe operation of the vessel, (e.g. requiring in-field craft to conduct their final approaches at slow speed and making use of a "dog leg" when approaching the installation to ensure that vessels do not steer directly for installations at high speed);
6. The owner/operator of the vessel has in place an effective safety management system, which includes appropriate provision for monitoring and auditing the system;

In connection with marine operations around the platform, the duty holder should ensure that:

1. There are sufficient and appropriate performance standards covering the use of in-field vessels. Shuttle tanker operations, in particular, require to be covered by effective performance standards since these operations have the potential to create significant risk and are currently undertaken by vessels and crews of differing standards;
2. There is sufficient marine experience on the installation, or at least in the locality, so that marine issues and concerns (e.g. requesting a supply vessel to come alongside in marginal conditions) can be fully understood by the OIM before and during a close proximity vessel operation;
3. There will be a good relationship/communications between installation and vessel crane which promotes openness, suggestions, querying of instructions, early warning of potential problems, effective planning, and generally has a positive influence on the safe management of the installation;
4. With respect to new installations, the layout and design is such that supply vessels can be worked safely. For example, selection and siting of a sufficient number of cranes, and provision of sufficient lay down areas, in terms of size and location, to:
   (a) Avoid the requirement for a vessels to operate close to risers and also to maximise clearance between the vessel and installation;
   (b) Remove blind spots;
   (c) Load/unload from the lee side of an installation and come in on the best heading for the local meteorological and oceanic conditions;
   (d) Perform the operation from a vessel orientation that will minimise the damage to the installation if a collision does occur (e.g. side-on loading versus stern-on loading).

   In all new build or conversion projects, the inclusion of persons with marine and crane operating experience, who have specific responsibilities for the examination and minimisation of the risks associated with alongside vessel impacts, would be very beneficial. In the past such experience and responsibility has apparently been lacking based on the poor provision and capabilities of cranes and laydown areas on many installations.
5. The hydrocarbon carrying systems are designed to withstand shock loads from ship impacts;

6. The design of the installation structure takes into account the degrading effects of repetitive minor ship impacts coupled, on occasion, with ad hoc structural repairs;
7. Likely contact areas are effectively protected from supply vessel impacts and that the protection scheme utilised can be repaired without undue personnel risk or cost;
8. Vulnerable areas of the installation (e.g. risers) are identified and if required protected from ship impacts;
9. Suitable and sufficient equipment is provided and maintained on board the installation for the safe handling of any vessel. Where material is transferred by bulk hose it is important that the hoses are of an appropriate length in order that the supply vessel can maintain a safe distance from the installation during unloading/back loading operations;
10. The installation is adequately illuminated, in particular in the near-sea area, and that there are sufficient and effective visual reference points on the installation, particularly FPSOs, to assist the master of an alongside vessel hold station;
11. Installation overboard lines should be designed so that they cannot cause the alongside vessel to be sprayed or engulfed in liquids or bulk powders;
12. Sufficient competent personnel are available at all times to work a vessel, (e.g. to avoid having to wake members of a deck crew to work a supply vessel during the night after completing a full day shift);
13. Suitable and sufficient procedures are in place for the safe operation of the vessel close to the installation, (e.g. bringing a heavy lift vessel in close to an installation on its anchors or anchoring a flotel or rig next to an installation);
14. Effective communication arrangements are established between the vessel and the installation and shore bases. These arrangements should ensure that during certain high concentration periods on the part of the bridge crew of the alongside vessel (e.g. during vessel set up) only high priority communications should occur, thus keeping distractions to a minimum;
15. The visiting vessel has sufficient location/installation specific knowledge. In particular for floating installations, particularly FPSOs that knowledge is passed to the visiting vessel of the motion characteristics of installation and in particular the potential for relatively rapid installation movement due to thruster operation;
16. A clear policy is established with respect to the cessation of marine operations in relation to adverse environmental conditions and that no undue pressure can be brought to bear on the master of the visiting vessel to start and/or continue operations if he considers it unsafe to do so;
17. That there are no incentive schemes which encourage potentially risk increasing activities (e.g. incentives for supply vessels to remain as long as possible alongside an installation);
18. A clear policy and procedure is in place for the reporting of any collisions, however minor, and situations which could have resulted in a collision (i.e. a near miss);
19. A procedure is in place for the timely investigation of any such incidents;
20. Suitable and sufficient monitoring and auditing arrangements are in place and undertaken by people familiar with the relevant marine operations, (e.g. a knowledge of dynamic positioning systems and their operations will be essential for many operations).

UKOOA in association with the British Chamber of Shipping has published guidance for the UK offshore industry in relation to support vessels in their "Guidelines for the Safe Management and Operation of Offshore Support Vessels" (Ref. 1). UKOOA has also published guidance in relation to standby vessels in their "Guidelines for the Operation of Vessels Standing By Offshore Installations" (Ref. 20). These documents provide useful information on the selection and operation of these types of vessel.

7.4.5 Mitigation Measures (In-Field Vessels)

In the event of a collision between a visiting vessel and an installation, the mitigation of any damage relates to the strength and layout of the installation itself and the minimisation of impact energies, (e.g. location of vulnerable and critical elements such as risers).

The strength of the installation will be based on site specific meteorological and oceanic conditions and the likely impact energies in relation to collisions with passing vessels, which are generally much higher than in-field craft. However, certain visiting vessels, (e.g. MODUs and heavy lift vessels) may be of a considerable size and capable of quite high impact energies, even at low speeds.

With regard to regular visiting vessels, such as supply boats, speeds of approach need to be reduced in order to minimise any damage in the event of an impact. As indicated in Section 5.3, even minor collisions can prove expensive in terms of inspection and repair.

The provision of suitable and sufficient PPE (e.g. lifejackets and personal locator beacons) particularly for personnel most likely to be affected by an impact (e.g. deck crew on the supply vessel, anchor handling vessel, etc.) would also help reduce the level of risk.

7.4.6 Emergency Response Measures (In-Field Vessels)

With effective preventive, control and mitigating measures in place it is considered very unlikely that a collision between a visiting vessel and the installation will lead to the evacuation of the installation. The exceptions to this statement would be high speed impacts due to the vessel being errant on approach or lower velocity impact which result in riser damage, flooding of void spaces or widespread loss of containment of process inventories due to shock loads. In these situations it has to be recognised in the emergency response planning that time to evacuate may be very limited as there is likely to be minimal warning time available to the installation OIM and crew.

In the event of a collision between a visiting vessel and the installation, appropriate emergency response measures need to be in place and need to be exercised and tested on a regular basis by the use of appropriate drills and exercises.

7.5 MANAGEMENT OF PASSING VESSEL COLLISION RISKS

Whereas the duty holder has control of vessels visiting the installation, he has no control of passing vessels and is dealing with an unpredictable hazard. It is unlikely that the crew of an installation would know anything about a passing vessel on a collision course until literally minutes before impact. Vessels may pass the installation regularly, with no signs that they are anything but under full control, however, very occasionally a vessel, often without any form of warning will present itself as a significant threat to the installation. As discussed earlier, the consequences will vary depending on a number of factors.

In the light of such a threat, duty holders may well contemplate what defensive action can realistically be taken to counter it. The following substantial problems face a duty holder when considering how to deal with such collision risks:

- Time – there is often insufficient time to allow the installation to react effectively;
- Awareness – there are often no lookouts or watchkeepers on offshore installations;
- Reliance on third parties – most installations rely on standby vessels to maintain watch;
- Inertia – there may be reluctance to shut in wells and close down a process until it's too late, partly because of such action presenting other hazards in starting up again.

However, as discussed below, there are a number of measures which a duty holder can take to reduce the risk of collision with passing vessels and to mitigate the effects in the event of such a threat materialising. It is noted that the information has been presented in a high level manner, to assist in the development of an effective collision management system for all locations in UK waters. It has been observed that there is a tendency to copy and implement which significant review, collision risk SMS's from one location to another. Such practice is not generally acceptable due to the different shipping characteristics around the UK. Some reasons for this can be borne out from the following text.

7.5.1 Hazard Identification (Passing Vessels)

Any offshore installation, whether fixed or anchored to the seabed, wherever it is located is exposed to the potential hazard of a passing ship collision. However, the degree of hazard will be dependent on traffic density and other shipping characteristics for the area. The main type of vessels likely to be considered within this hazard identification process include:

- Merchant traffic
- Shuttle tankers
- Ferries
- Offshore vessels
- Fishing boats
- Naval craft including submarines
- Pleasure craft

The degree of importance of each of these vessels will vary depending on the location of the installation. For example, a structure in proximity to an area characterised by ferries and high merchant craft activity will have to place more importance on these hazards compared to a site in a more remote location trafficked mainly be fishing craft.

There are a number of data sources available to assess the likely level of activity for any area within UK waters. For fishing vessel information, UKOOA have sponsored the development of Fisheries Sensitivity Maps in British Waters in co-operation with FRS, CEFAS, NFFO and SFF. This data set provides information on fishing activity to assist in the understanding of the potential for interaction between the fishing and offshore oil and gas industries. Maps are presented under five headings:

- Individual species spawning areas
- Individual species nursery areas
- Monthly seismic restriction areas
- Fishing effort maps
- Relative value maps

For information on merchant vessel, ferry, shuttle tanker and offshore support vessel activity there is the COAST database that was developed under sponsorship of HSE, UKOOA and DETR. The database holds information on over 200 North Sea traffic surveys, with a further 20 to 30 being added each year. The information held in the system provides an overview of plotted vessel tracks, the types of vessels, their sizes and speeds, passing distances to various sites, which can be accessed by the operator for any specified area. In 1998, the COAST system became the recommended database for preparation for Consent to Locate applications within UK waters (as specified by the Coastal Protection Act 1949). Hence, for new developments the majority of Operators will have access to information on the shipping characteristics in advance of developing a collision risk management strategy.

It is noted that when using each of the databases an estimation of the level of confidence is required and where data collection is sparse site specific surveys can be performed to provide more reliable information to use as input to the development of a collision risk management strategy. The COAST database has been set up to assist with this function when manual surveys are required. Under this initiative, COAST will provide a UKOOA developed standardised survey form and procedure to ensure the essential information is collated. For areas not already surveyed the funds will also be allocated to analyse the information for the Operator at no cost to assist in the development of the collision avoidance strategy and the further development of COAST. Typical plots from COAST showing raw survey data and calculated mean routes, are presented in Figure7.1 and Figure 7.2, respectively.

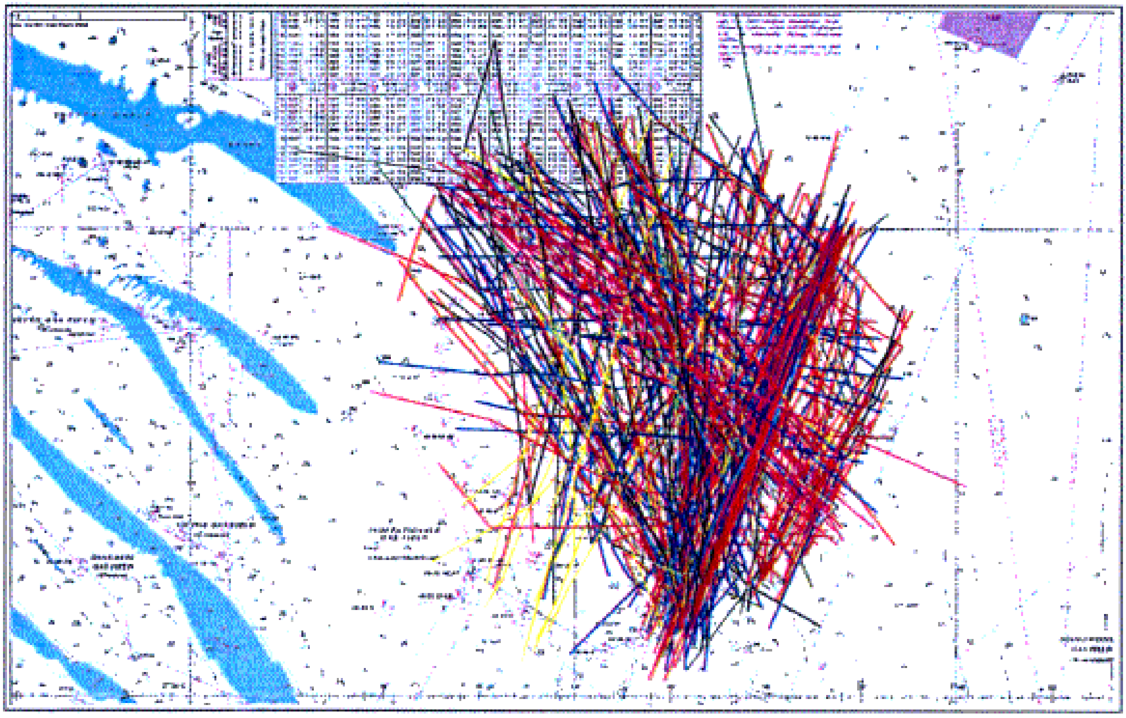

Figure 7.1

Typical Raw Data Plot from the COAST Database

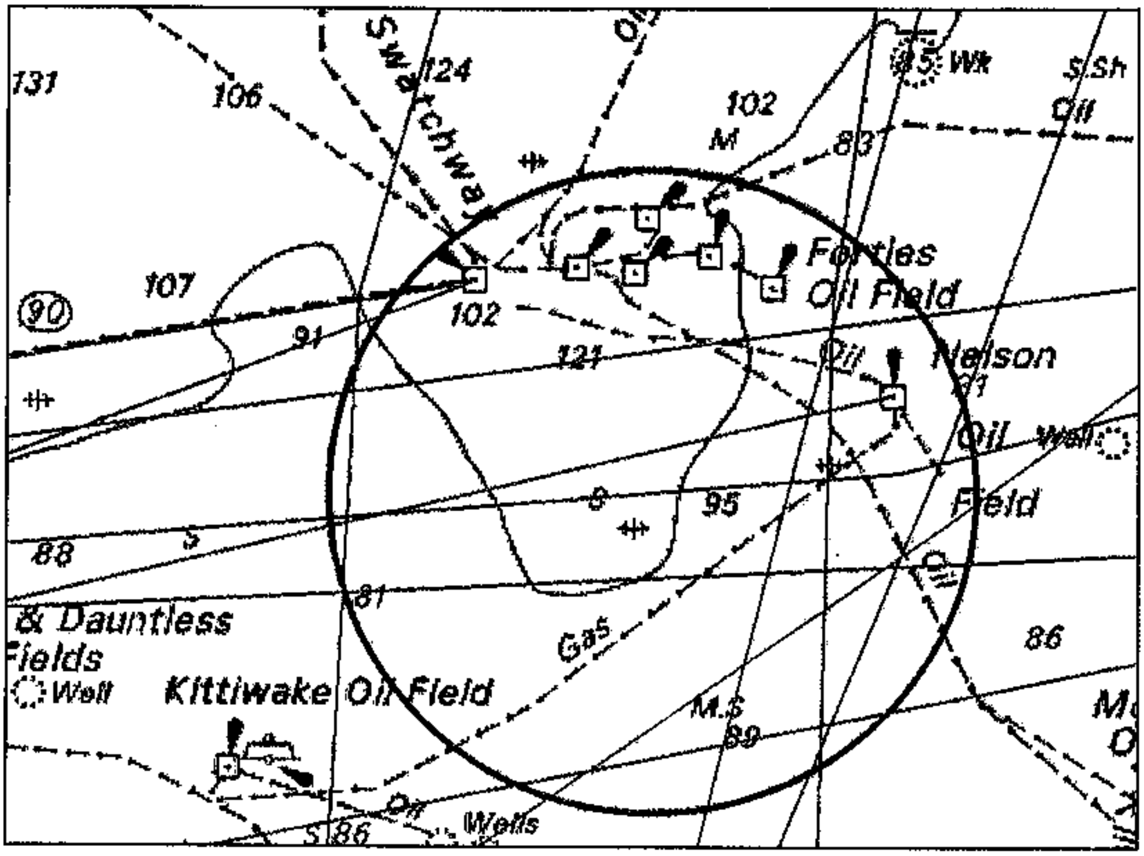

Figure 7.2

Typical Mean Route Plot from the COAST Database

There is limited information available on naval and pleasure craft, however, this can be overcome through communications with MoD and port authorities in the area.

7.5.2 Risk Assessment (Passing Vessels)

The assessment of the collision risk on installations should properly reflect the level of risk at its specific location and give credit for the primary risk reducing measures anticipated to be in place at the field, (e.g. dedicated/shared SBV, long range automated radar, etc.,).

To assist in the assessment of collision risk, there are a number of industry recognised computer tools available (e.g. COLLIDE, MANS, CRASH). These tools can be used to estimate the collision frequency and impact energy for both powered and drifting vessel collisions. It is important during the selection and application of a collision risk computer tool that the tool has been calibrated for use in the area of interest and that most reliable and location-appropriate shipping data is used (e.g. traffic surveys, COAST data, etc.).

The collision frequency and impact energy assessment provides useful input to the overall assessment of personal risk. This assessment should give consideration to the likely warning times that will be available to the OIM, and should realistically assess when mitigation actions are likely to be initiated on the installation and their effectiveness in various conditions. Having assessed the risk to people, the proportion of risk produced by passing vessels compared to other hazards can be assessed and also to the collision risks associated with other installations in UK waters. These comparisons are useful for the interpretation of the risk level and the determination of whether other control and mitigation measures are required to reduce the collision risks to ALARP.

It is noted that within this risk assessment it is imperative that the quantitative results are only used as part of the input to the control and mitigation strategy. To ensure effective management of the risks a high level of marine experience is required to assess the hazard qualitatively and in a practical manner.

7.5.3 Preventive Measures (Passing Vessels)

The first priority is to eliminate the risk, or at least reduce the consequences, of ship collision, if at all possible. For a new installation, in the light of the risk assessment, it may be possible to locate the installation so as to minimise its vulnerability to collision risks. This may mean forsaking some locations and choosing alternatives nearby or using natural defences such as shoals and reefs, where available.

The requirement for operators to apply for and receive Consent to Locate from the DETR prior to locating any structure on the seabed (for drilling or production) goes some way in the early identification of collision risks. It should be noted that in this application process, the DETR are primarily concerned with the risks to navigation and not the risks to the installation. The submission to the HSE, in which installation risks are required to be ALARP, comes much later when there is little opportunity to move the installation to a lower risk location or examine various installation configurations and options. Therefore, an earlier quantification of installation risks, albeit coarse, undertaken in parallel with the DETR's Consent to Locate application would offer greater opportunity for minimising installation risks.

The prevailing environment of commercial marine activity in the region of the installation should be taken into account in the design of the installation. Duty holders are well advised to gain an understanding of the total marine environment around their installations, including such information as:

- The nature of the merchant vessels that pass near their installation;
- Which traffic is regular and which random;
- Types of cargo carried;
- Names and details of owners and management.

Apart from locating the installation as far away as possible from recognised shipping routes, it is important to ensure that the location of the installation is made as widely known as possible through:

- The standard process of Notices to Mariners;
- The use of radio and NAVTEX for recent movements;
- High visibility paint;
- Suitable and sufficient lighting;
- Contacting of regular traffic passing the installations.

7.5.4 Control Measures (Passing Vessels)

Unlike in-field vessels, which are known to be in the vicinity and under the direction of the installation, passing vessels on potential collision courses need to be detected before any further control measures can be instigated.

Although visual sighting of vessels plays a part in the detection process, the detection of vessels on a collision course is usually undertaken by the use of radar. Such systems range from a simple, relatively low cost standard ship's radar to comprehensive field-wide integrated systems. The latter systems use the output from one or more platform-mounted scanners to automatically identify, track and then down load information to remote locations such as standby vessels, installations, other rescue craft and, if required, the duty holder's office onshore. Current systems can display the radar image on electronic charts and arrange for alarms to be placed in relation to installations, pipelines, buoys, sub-sea wellheads, etc. An overview of detection systems is provided in Appendix B.

When assessing the optimal detection system for any site an appropriate level of consideration needs to be given to factors that may influence the performance which can be covered in four general areas:

- Requirement of the installation in terms of warning time;
- Requirement of the SBV in terms of control procedures;
- Alarm zone setting;
- Review of alarm setting and procedure.

Each of the above are discussed further in the following subsections:

Requirement of the Installation

The time required by the installation, needs to be assessed. This is to ensure that any detection procedures developed are aimed at providing sufficient time for the OIM to assess the situation, make a decision regarding the best course of action and then to implement the action, which may involve shutting down wells, depressurising process systems, followed by full evacuation. These issues are discussed under Sections 7.5.5 and 7.5.6.

Requirement of the SBV

Following assessment of the time required by the installation, the proposed actions of the SBV following identification of the hazard require assessment to ensure the vessel is provided sufficient time to undertake their control procedure and still provide sufficient warning time to the installation. The following paragraphs provide information on some factors for consideration when establishing SBV control procedures.

Navigational Practice

Whilst, initially, it might be thought that the earlier the detection the better, this is not necessarily the case as incoming vessels may wait until they have identified the installation before altering course. Therefore a vessel may appear to be on a collision course and pose 'threat' to the installation but may be under good command and plan to pass the installation at a safe distance. This issue needs to be addressed on a case by case basis as some areas within the UKCS are trafficked by high traffic volumes which due to the location of installations or shallows may result in a high number of 'safe' but close passing vessels. An overview of common navigational practices within the shipping industry, which may influence the SBV procedure, are presented in Figure 7.1.

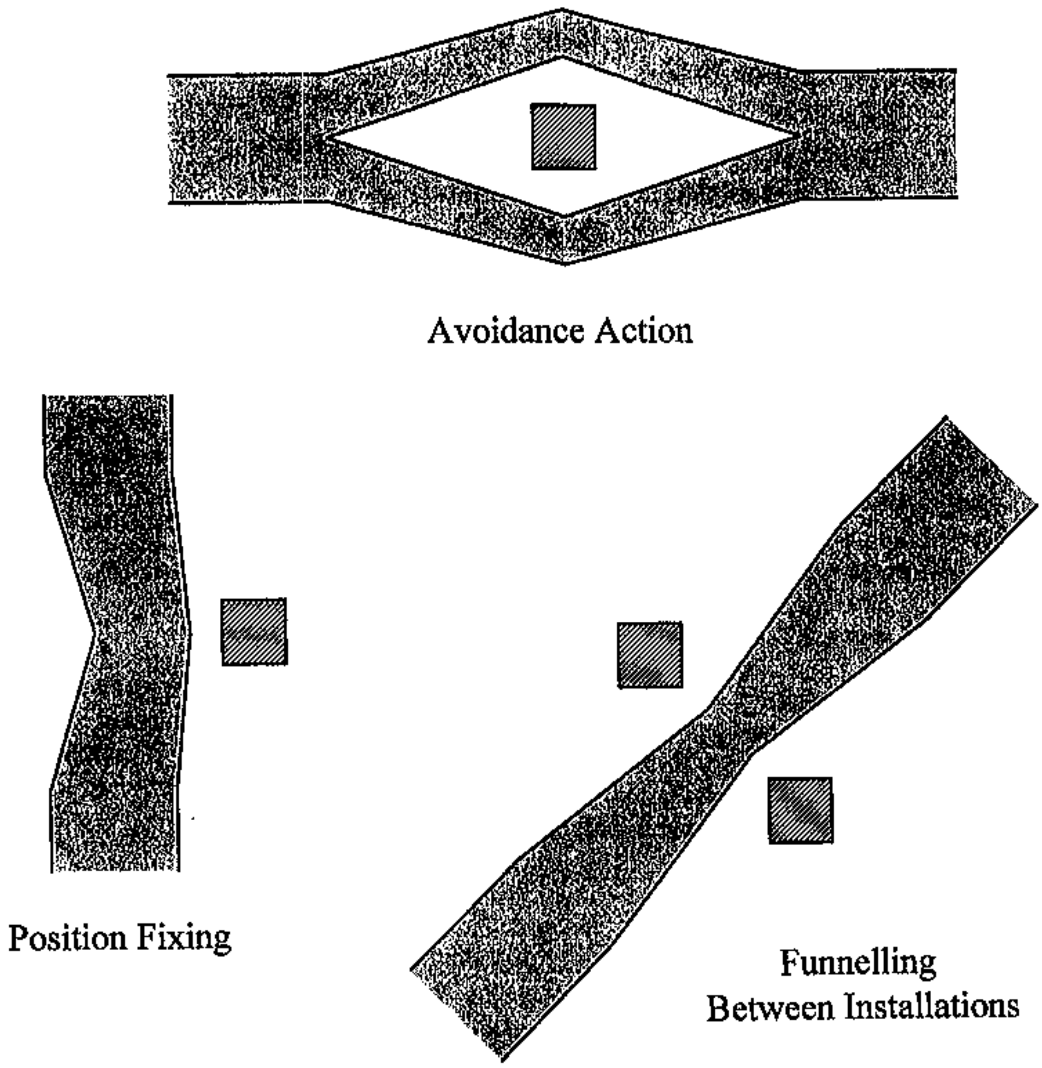

Figure 7.1

Navigational Practices in Proximity to Offshore Installations

Alerting Rogue Vessel

Having identified a vessel on a potential collision course with the installation, the next step is to alert the threatening vessel. Until the last few moments, it is noted that it is the crew of the incoming vessel who can most affect the situation by altering course away from danger however standby vessels obviously present the possibility to improve the likelihood of this recovery.

Initially, VHF radio will usually be used to bring the situation to the attention of the incoming vessel's crew. This may not be enough since a vessel, which is keeping a radio watch, is also likely to be keeping a visual lookout. In addition, the incoming vessel itself may not consider the situation to be an emergency and may therefore not consider it necessary to make communication. A number of North Sea trials have indicated that this is an important issue since response rates can sometimes be as low as 50-60% for vessel passing within 0-1 nm of the installation (see Figure 7.2)

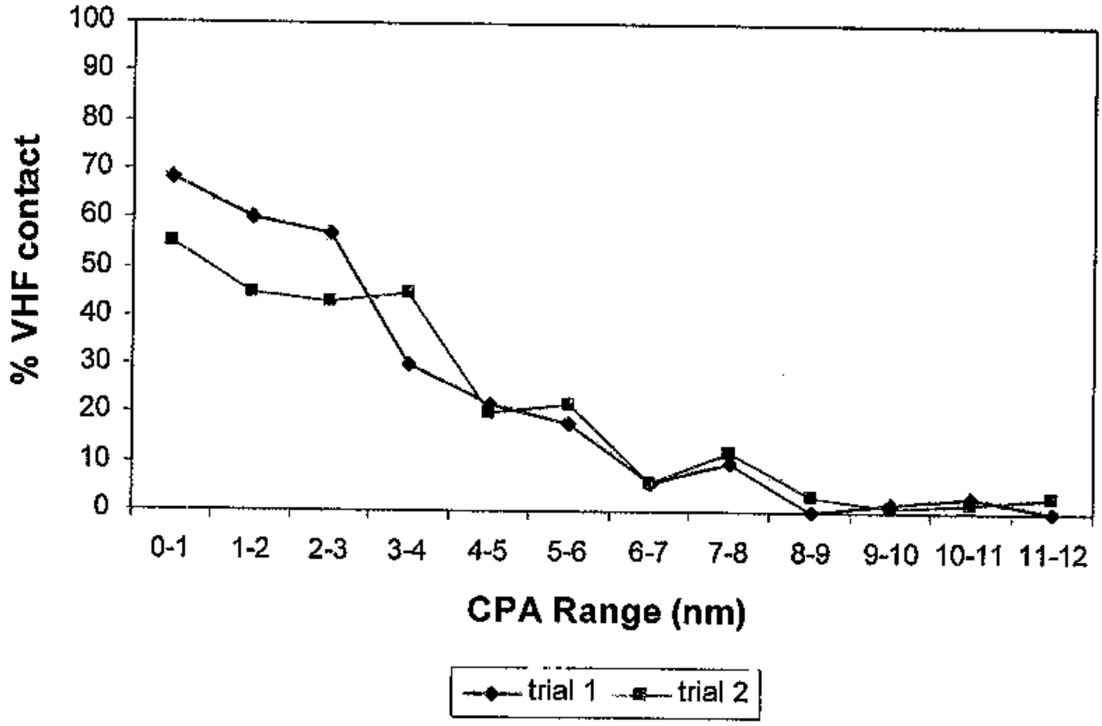

Figure 7.2

VHF Response Rate – North Sea Trials

In addition to VHF, the SBV can also use the Aldis lamp to assist in alerting the incoming vessel of the potential danger of the installation. The use of the Aldis lamp is recognised marine practice.

Having failed to alert the in-coming vessel through VHF or lamp, "maroons" or "thunder flashes" have much to recommend them. They are fast, loud and will almost certainly elicit a reaction and they compensate for the relatively slow speed of the standby vessel. Again when identifying the situation when these systems are used, consideration should be given to the fact that the incoming vessel may be on safe navigation, but may not consider it necessary to respond to radio calls or to alter course. An overview of some alerting systems is presented in Appendix B.

Intervention of Rogue Vessel

Other forms of intervention by a standby vessel are less likely to succeed. Physically approaching a vessel on a collision course, which is probably larger and faster, is difficult and may not even be possible. Such an action contravenes the Prevention of Collision Regulations and may actually increase the risks of collision by forcing the incoming vessel towards the installation if it acts under the aforementioned Regulations. Also, the standby vessel may be some distance away and unable to intercept in the time available. Even if it does get close, the most it can probably do is sound its horn.

It should also be noted that a primary responsibility of the standby vessel is to provide rescue provision for the installation. Therefore, prior to a major collision impact, the standby vessel should be taking up a position where it can offer effective rescue cover, which in most cases will be just down-weather of the installation.

Other forms of direct physical action, such as close quarter manoeuvring or "nudging", are fraught with great danger to the crew of the standby vessel and have serious legal implications. As mentioned earlier, the alerting process should be phased and based on time not distance. Modern radar systems can readily provide relevant information for use by the

Master of the standby vessel and the OIM in conjunction with appropriate mitigating measures.

In the case of a drifting vessel on a collision course, the standby vessel may be of greater value, especially if it is capable of getting a line on the drifting vessel so that the drifting vessel's course can at least be influenced. Particular consideration may need to be given to this point for installations involving the use of shuttle tankers where, in the event of loss of power, the tanker may present a considerable threat to the installation. When preparing the specification for a standby vessel for such an installation, the duty holder may wish to take such operations into account. If a standby vessel is to be used in this way, appropriate exercises will need to be undertaken to ensure that it is capable of performing such a function, if required.

All operators of offshore installations who are exposed to the risk of drifting vessel collision should be familiar with the complex legal, liability and salvage issues which surround the provision of assistance to a stricken vessel on the high seas. Such issues may prevent offering or accepting assistance in as timely a manner as would be thought reasonable.

Alarm Zone Setting

Having defined the critical time for initiation of SBV procedure and warning, installation alarm zones are required. Focus should be placed on making these time-based rather than distance-based. Good practice is to establish a number of settings at which various actions are to be initiated, (e.g. green – monitor vessel and attempt radio contact, amber – approach incoming vessel and contact installation to initiate muster, red – evacuate installation).

Review of Alarm Setting and Procedure

Having established the alarm zone settings it is then important that these be assessed with reference to the shipping pattern in the area. This is a useful review process that facilitates assessment of the watchkeeper workload on the SBV. For example, in an area characterised by a high volume of traffic which, under normal navigation, passes in close proximity to the installation being guarded the required alarm zone setting may not be practical to attain with a 'normal' SBV and further assessment may be required to identify improvements. This may involve investigating the possibilities of increased manning on the SBV, system automation or means of reducing the time required by the SBV or the installation in terms of performing their procedure. It is noted that within this review procedure consideration should be given to the effects of weather, the SBV being occupied in other duties, and also the consequences of failure of critical equipment.

The flow diagram presented in Figure 7.3 provides a summary of the previously discussed method used for establishing control procedures for an SBV.

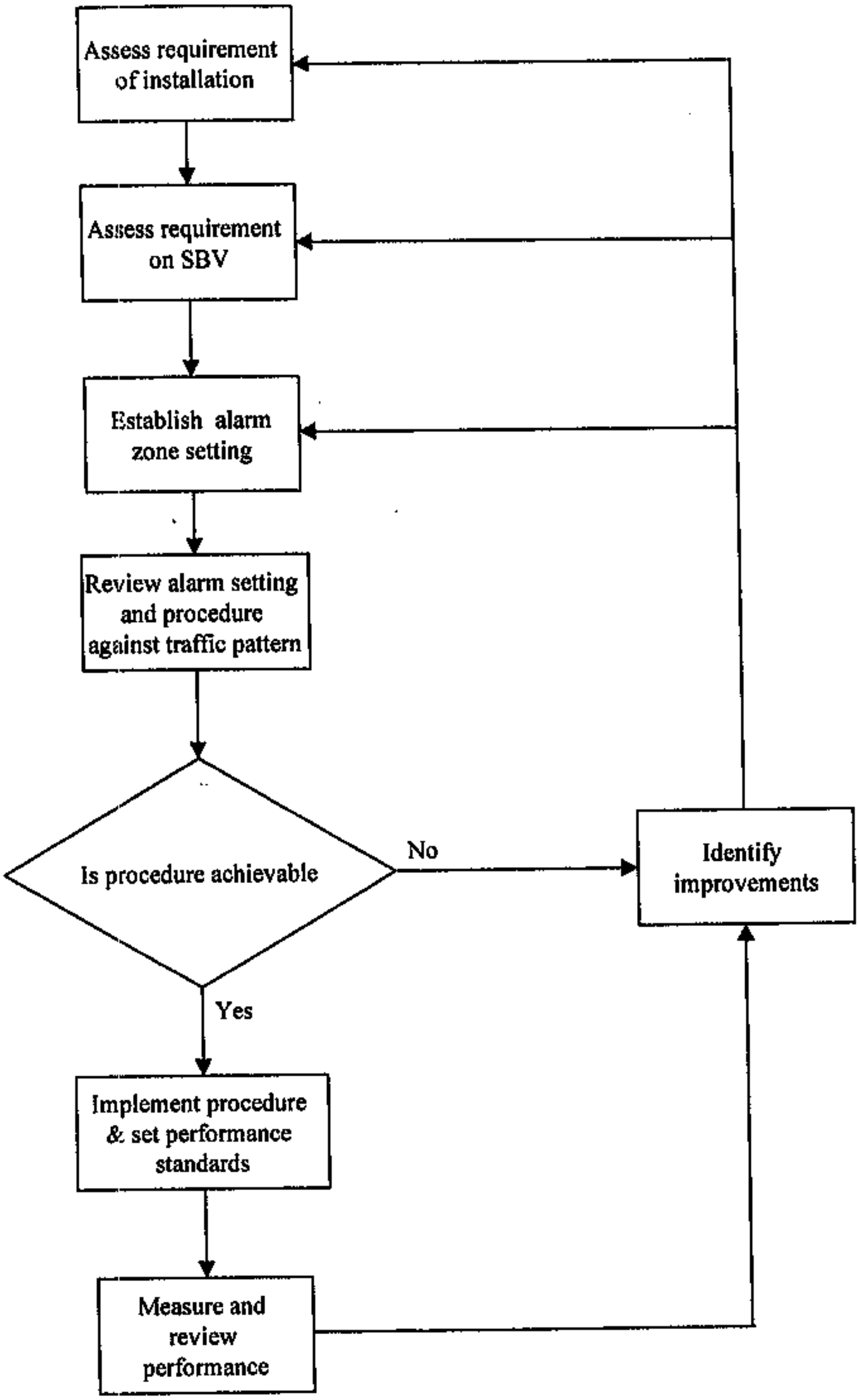

Figure 7.3

Method for Establishing Control Procedure for Management of Ship Collision

7.5.5 Mitigation Measures (Passing Vessels)

In the event of a collision between a passing vessel and an installation, the mitigation of any damage relates to the strength and layout of the installation itself and the minimisation of impact energies, (e.g. location of vulnerable and critical elements such as risers). In view of the potentially large impact energies associated with certain classes of passing vessels (see Table 4.1) most installations would not be able to withstand or deflect such a collision and mitigation measures will have to depend on appropriate procedures as discussed below.

Apart from the design and layout of the installation, other mitigation measures involve appropriate procedures. The collision risk management system needs to address the special peculiarities of an emergency situation involving vessel collisions. Due to the nature of catastrophic collision risks, there may be a need for personnel to leave enclosed accommodation areas as quickly as possible in order to avoid becoming trapped inside should the structure collapse. The collision risk management system needs to address the issue of how to inform personnel of an imminent collision and where they should muster. In such circumstances, having everyone muster inside an enclosed temporary refuge may well not be the safest option. Consideration should, therefore, be given to having a unique alarm for impending collisions and the designation of appropriate muster areas outside the accommodation.

The collision risk management system will need to be tailored to the specific circumstances of each installation. The arrangements on bridge linked platforms will differ from those on an FPSO as will those on an installation with only a small complement as opposed to one with two or three hundred.

The following factors and points need to be taken into consideration when establishing appropriate mitigation measures for dealing with ship collision risks:

1. The location of alternative muster points, taking into account possible points of impact, position of risers, location of escape routes and TEMPSC(s);
2. The provision of lifejackets, abandonment suits, liferafts and other relevant PPE;
3. The need to be able to determine the point of impact;
4. The need to assess the likely energy of the impact and whether the installation is likely to survive or not;
5. The ability, in the case of semi-submersibles and FPSOs, to maintain stability;
6. The development of appropriately succinct operational plans;
7. The need to ensure that key personnel are trained in appropriate and effective command and control techniques;
8. Ensuring that well/process control and personnel muster times are adequate;
9. The need to establish optimal positions for SBV in terms of personnel pick-up;
10. The need to establish the effect of weather on the decision to evacuate;
11. The need to ascertain the effectiveness of the mitigation measures and to ensure that suitable and sufficient exercises and drills are undertaken to maintain that effectiveness.

7.5.6 Emergency Response Measures (Passing Vessels)

As discussed in Section 3.9, the Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1992 place a number of responsibilities on the duty holder in relation to the provision of appropriate measures for the evacuation, escape and rescue of personnel from an offshore installation.

Catastrophic ship collision events can occur with little warning and give rise to mass escape events, which are probably the most difficult evacuation, escape and rescue scenarios which a duty holder has to address.

With regard to certain ship collision scenarios, there may not be time to arrange an orderly evacuation of the installation before impact occurs. In such circumstances, some personnel may be able to make their escape to the sea but many may well be pitched into the sea as a result of the impact. Provided personnel have sufficient time to muster, they should, at least, be equipped with a lifejacket. However, in some circumstances, a large number of personnel may be thrown into the sea before they even have time to don lifejackets.

Regulation 17 of PFEER requires the duty holder to ensure that effective arrangements are made, including arrangements with suitable persons beyond the installation for:

1. Recovery of persons following their evacuation or escape from the installation; and
2. Rescue of persons near the installation; and
3. Taking such persons to a place of safety.

For the purposes of this Regulation arrangements are regarded as being effective if they secure a "good prospect" of those persons being recovered, rescued and taken to a place of safety.

Regulation 17 is not subject to the principle of "as low as reasonably practicable". Effective arrangements are required to respond to all "reasonably foreseeable" events. The HSE Guidance to PFEER states that "reasonably foreseeable" events include catastrophic events such as a helicopter ditching near the installation and ship collision. The associated Approved Code of Practice states that rescue and recovery arrangements should be appropriate to cope with all "reasonably foreseeable" events likely to lead to the need for evacuation, escape and rescue. The requirement to provide effective arrangements for all "reasonably foreseeable" events goes beyond what would be required solely from a consideration of overall risk to an individual and the need to reduce that risk to as low as reasonably practicable.

A catastrophic ship collision scenario presents a duty holder with considerable difficulties in providing effective arrangements for rescue and recovery. This is so for moderate weather conditions; however, as conditions worsen, it becomes increasingly difficult for a duty holder to meet the performance standards necessary to achieve a "good prospect" of recovery and rescue.

In developing and implementing the overall emergency response plan and arrangements for evacuation, escape and rescue, the duty holder must take full cognisance of these difficulties for each installation, taking into account its specific design, function and location.

The emergency response plan and procedures should be exercised on a regular basis and should involve the standby vessel and other agencies using realistic scenarios, including catastrophic ship collision.

7.6 AN INTEGRATED COLLISION RISK MANAGEMENT SYSTEM

In view of the differences in detail between the management of in-field and passing vessel collision risks, these risks have been examined separately. However, a duty holder needs to prepare an integrated collision risk management system which addresses **all** aspects of all ship collision risks. Within such an integrated management system, many of the elements will be applicable to both in-field and passing vessels risks. However, within some of the various elements, there will be a need to develop specific policies and procedures to deal separately with in-field and passing vessels but within an overall coherent strategy for the management of the risks.

Operators of offshore installations are faced with difficult problems when attempting to manage ship collision risks. Collisions between vessels and offshore installations occur reasonably frequently, however, the majority cause little damage to the installation and often involve supply vessels which are under the management control of the duty holder.

Catastrophic collisions, on the other hand, occur much less frequently and are usually of a different nature and present the greatest threat to an installation. Such collisions are more likely to involve passing vessels over which the duty holder has little, if any, management control.

In view of the potential for catastrophic loss of an installation and, possibly, a large proportion of its crew, it is essential that all duty holders develop an effective collision risk management system along the lines discussed in this document.

In conclusion, duty holders should not underestimate the real risk and serious consequences of ship collisions with their installations.

8 RECOMMENDATIONS

8.1 STUDY RECOMMENDATIONS

8.1.1 Introduction

This report was developed to provide guidance on the key elements of an effective collision risk management system for offshore installations. During completion of this report, recommendations were identified in areas where further detailed consideration is required, which would, it is believed, be beneficial in the effective management of collision risk.

The identified recommendations have been divided for reasons of clarity into the following three areas:

- Recommendations associated with the overall management of collision risk at offshore installations.
- Recommendations associated with the management of in-field vessel collision risk.
- Recommendations associated with the management of passing vessel collision risk.

8.1.2 Overall Collision Risk Management

The following recommendations are submitted with the aim of improving the overall effectiveness of collision risk management at offshore installations:

1. Suitable guidance in the subject area of effective collision management requires to be developed by, and disseminated within, the offshore and associated marine industries.
2. Further research should be conducted by the marine industry to investigate the human factor aspects in ship collision management both on the installation and on the approaching ship.

8.1.3 Collision Risk Management of In-Field Vessels

The following recommendations are submitted with the aim of improving the effectiveness of in-field vessel collision risk management:

1. A reporting system requires to be developed by industry to:
   (a) Provide an industry-accepted means of recording collision incidents, near misses and other relevant hazardous occurrences.
   (b) Examine, review and statistically analyses the incident data received.
   (c) Freely share the findings, trends and identified best practices with the offshore and marine industries, and the legislative bodies such as the MCA and HSE.
2. The effective management of shuttle tanker collision risk requires urgent examination.
3. The implications of one-man bridge operations on the risks associated with vessels working alongside offshore installations should be assessed.
4. The potential for long term degradation of a platform as a result of the accumulated effect of repetitive minor impacts on the support structure, particularly in light of the current trend for larger supply vessels, requires further investigation.
5. Industry should review the contractual arrangements and their subsequent effect on safety.

8.1.4 Collision Risk Management Of Passing Vessels

The following recommendations are submitted with the aim of improving the effectiveness of passing vessel collision risk management:

1. Consideration should be given by the offshore industry to having a unique installation alarm to provide clear warning to personnel of an impending ship collision.
2. There currently exists no research-based guidance to assist duty holders in the development of an effective collision averting strategy. Such guidance requires urgently to be developed.
3. To ensure an effective and rapid response to a drifting vessel incident, industry should develop guidance to summarise the legal and commercial issues that need to be resolved before measures can be taken to manage the risks associated with such vessels.
4. Experience from near misses and incidents has shown that emergency response to ship collision is not well understood/developed compared to other major hazards. Industry should examine the effective response to a passing vessel collision threat and develop guidance to assist duty holders.

8.2 EXPERT PANEL CONCLUSIONS

To provide "expert" opinion on the available means of reducing the probability of collisions between offshore installations and passing vessels, a review meeting was conducted. This meeting highlighted a number issues relating to collision risk and its management. Further details can be found in Appendix A.

9 REFERENCES

1 UKOOA/Chamber of Shipping, "Guidelines for the Safe Management and Operation of Offshore Support Vessels", Issue 2, July 1998.

2 Marine Technology Directorate: "Review of Repairs to Offshore Structures & Pipelines", Publication 94/102, 1994.

3 HSE Offshore Safety Division: "Ship/Platform Collision Incident Database", Prepared by MaTSU, Report No.: MaTR 0447, November 1997.

4 National Maritime Institute Ltd.: "Collision of Attendant Vessels with Offshore Installations, Part 1 General Description and Principal Results", Offshore Technology report OTH 84 208, 1995.

5 National Maritime Institute Ltd.: "Collision of Attendant Vessels with Offshore Installations, Part 2 Detailed Calculations", Offshore Technology report OTH 84 209, 1995.

6 International Association Of Drilling Contractors: "IADC MODI Accident Survey Boat Collisions in the North Sea", May 1984.

7 HSE: "Revision of Offshore Collision Incident Database", Prepared by Advanced Mechanics and Engineering Ltd., 1992.

8 Marine Accident Investigation Branch: "Marine Accident Database", Department of Transport, 1998.

9 Veritec: "Worldwide Offshore Accident Databank (WOAD)".

10 Lloyds List daily publication.

11 HSE: "Close Proximity Study", Offshore Technology Report – OTO 97 055, October 1997.

12 Siktec as: "COLLIDE Reference Manual", Report No.: ST-89-RF-006-01, July 1989.

13 US Coast Guard: "Prevention through People"

14 Database of Vessel Collisions for Gulf of Mexico (MMS),

15 Boat Impact Phase 1 (NPD)

16 Department Of Energy: "Protection of Offshore Installations Against Impact – Background Report", OTI 88 535, 1988.

17 The Trustees of the Rivers Wye and Lugg Navigation: "The International Regulations For Preventing Collisions At Sea 1972", with amendments adopted from November 1989.

18 Marine Accident Investigation Branch (MAIB): "Safety Digest 2/97: Part 1-9, Report No. 9"

19 Marine Accident Investigation Branch: "Safety Digest 2/97: Part 1 – 13".

20 UKOOA: "Guidelines for Operation of Vessels Standing By Offshore Installations", Issue No. 2, May 1997.

APPENDIX A

Expert Panel Evaluation

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A1 INTRODUCTION

This Appendix describes the work of an expert panel convened to discuss and evaluate possible means of reducing the probability of collisions between offshore installations and passing vessels. The objectives of the panel included:

a) The identification of prime accident causation factors;

b) Evaluation of systems currently used to identify the potential threat posed by shipping to an installation;

c) Consideration of how a collision avoidance system might intervene on detection of a potential collision path; and

d) Identification of the key elements of an effective collision avoidance and control system.

A total of eight different powered and one drifting vessel collision scenarios were identified and evaluated in order to 'visualise' the possible effect of different collision avoidance measures.

The expert panel identified a number of important points:

e) Ship collision risks need to be managed by the adoption of appropriate polices, organisation, arrangements and procedures based on suitable risk assessments;

f) In order to obtain optimal performance from radar systems, they should be sited on the installation to obtain the best possible coverage with monitoring of a remote slave screen on the standby vessel;

g) A common approach should be agreed and adopted by installation duty holders with respect to the means of attracting the attention of errant vessels;

h) Human factor aspects of ship collision avoidance appear to have been neglected and further work is required in the area;

i) Standby vessel crews need to be integrated more closely with those of the installations;

j) Greater consideration needs to be given to the role of the installation itself in the management of ship collision risks.

A2 THE EXPERT PANEL

The members of the expert panel were carefully selected so as to provide a wide knowledge base. Table 0.1 presents the members of the panel, their company or organisation, and their area of expertise.

Table 0.1
Expert Panel Members

Name	Company/Institution	Comments
Lars H. Katteland	Dovre Safetec	Collision Risk (causes, contingency measures) and navigational aspects
Alasdair MacDonald	Dovre Safetec	Collision Risk
Michael Cain	Dovre Safetec	Collision Risk
Dr. Joe Gray	Dovre Safetec	Chairman of the Expert Panel, (SMS)
Dr. Emil Dahle	DNV	Collision Risk. Navigation
Professor Malek Pourzanjani	Southampton Maritime Research Centre	Human Factors Specialist
Capt. Bill Dineley	John Moores University, Liverpool	Radar Specialist/Master Mariner
Bob Miles	HSE	Observer Day 1
Capt. Dave Forsyth	HSE	Navigation. Master Mariner. Former OIM.
Capt. Denis Rudd	Inchmarlo Marine Management	Navigation
David Vaughan	MaTSU	Observer Day 1

A2.1

A3 METHODOLOGY

INTRODUCTION

The primary aim of the expert panel was to discuss and evaluate possible means of reducing the probability of collisions between offshore installations and passing vessels.

In order to achieve a systematic identification of collision causes, it is necessary to identify the prime conditions which need to be fulfilled for a collision to occur. For a collision to occur between a powered passing vessel and an installation:

- The ship needs to be on a collision course with the installation
- The navigator must be unaware of the situation sufficiently long for the ship to reach the installation
- The installation/standby vessel crew must be unaware of the situation or unable to warn the vessel or otherwise 'normalise' the situation.

The initiating 'failures' in this chain of events are the first two items which both involve the ship and its operation. A ship on a collision course is in itself not a critical situation; only when the ship comes close to the installation and is still on a collision course is this potentially critical. The primary causes of collisions lie within the second item above, namely that the navigator is unaware of being on a collision course. Table 0.1 below identifies the causes of ineffective watchkeeping and lists some key factors which affect the probability of this occurring. Further details of the causes of ineffective watchkeeping is presented in Section 6 of the main report.

Table 0.1
Watchkeeper Failure Modes

No.	Cause	Important factors
1	Navigator busy/preoccupied with other tasks	Workload of navigator/Manning level Traffic density/Other activity in the area
2	No-one present on the bridge	Manning level Traffic density/Other activity in the area
3	Navigator asleep	Manning level Time of day Traffic density/Other activity in the area
4	Navigator drunk	Proximity to port Availability of alcohol on board
5	Navigator has had an accident	Ergonomics of bridge Weather conditions/movement of ship
6	Navigator ill	Health of crew Age of crew Manning level
7	Non-detected radar failure combined with poor visibility	Maintenance of radar equipment Availability of back-up equipment Operators experience with equipment
8	Radar maladjustment combined with poor visibility	Inadequate training/competence of crew Poor ergonomics/usability of equipment

A3.1

REPRESENTATIVE SCENARIOS AND AVOIDANCE MEASURES

A total of 8 different powered vessel collision scenarios were identified and evaluated in order to 'visualise'. the possible effect of different collision avoidance measures. The scenarios and avoidance measures considered are as follows:

Scenarios:

1. Platform in low platform density, low traffic density area with good weather and visibility. Merchant vessel speed 12 knots.
2. Platform in high traffic density area, the rest as in 2.
3. Platform in high traffic density area, vessel speed of 20 knots, the rest as in 2.
4. Platform in high traffic density area, poor visibility (fog) vessel speed of 12 knots.
5. Platform in high traffic density area, bad weather with rain.
6. Platform in low traffic density area, vessel speed of 20 knots.
7. Platform in low traffic density area, poor visibility.
8. Platform in low traffic density area, bad weather.

Following these eight scenarios, a drifting vessel Drifting vessel collision scenario was reviewed.

Avoidance Measures:

1. Marine Radar on Standby Vessel
2. Marine Radar on Installation
3. ARPA Radar on Standby Vessel
4. ARPA Radar on Installation
5. Vessel Traffic System (VTS)
6. Radar Early Warning System (REWS)

A3.2 CATEGORISATION OF COLLISION AVOIDANCE SUCCESS

Each scenario was discussed in detail and the following elements relevant to collision avoidance evaluated:

1. The probability of detection of the vessel on collision course.
2. The probability of the avoidance measures being initiated on detection.
3. The probability of the collision avoidance measures being successful.

Each of these probabilities was assessed by the Expert Panel and an estimate made of the probability band for each using the bands presented in Table 0.1.

Table 0.1
Probability Bands

Probability Band	< 10%	10-25%	25-50%	50-75%	75-90%	>90%
Code	A	B	C	D	E	F

The collision avoidance performance was evaluated from the point of view of the different failure modes for watchkeeping, with the effect of each of the Standby Vessels actions being assessed for each failure mode. With respect to the prevention performance results it is noted that these are presented based on a 12 nm first sighting. In instances where the incoming vessel is sighted at a reduced distances, which for certain radar systems is highly probable, the prevention performance of the SBV will reduce. The level of reduction was identified to be dependent on two main factors :

- The performance reduction due to the decreased time available to make radio contact and approach the vessel.

- The performance reduction due to the fact that insufficient time is available to go alongside the vessel and sound alarms etc.

It was agreed by the panel that the first of these is likely to result in a limited reduction in performance whereas in the latter case the level of reduction is highlighted to be more significant.

A4 SCENARIO EVALUATION

As mentioned in Section 0, 8 scenarios were developed to ensure that the advantages and disadvantages associated with each of the systems were highlighted. For each of the scenarios the following methodology was adopted:

1. Present Scenario
2. Discuss scenario and highlight key factors
3. Evaluate each of the systems in terms of detection, initiation of avoidance measures, effectiveness of avoidance measures

The following subsections present a summary of the outcomes of these assessments for each scenario. Before presenting details of the results of the 8 scenarios however, a discussion of a North Sea ship/platform collision occurring in 1995 is presented

A4.1 RECENT COLLISION INCIDENT INVOLVING M/S REINT AND H7 PLATFORM

A4.1.1 Description

The characteristics of an actual collision incident which occurred in the North Sea are summarised in Table 0.1.

Table 0.1
Details Of H7 Collision

Parameter	Description
Vessel type	Small Cargo Vessel
Vessel Size	273 tonnes
Vessel Speed	8 knots
Wind	3.0 m/s
Wave height	4-5 metres
Visibility	Daylight, good visibility

This example was used as a starting point for the discussion of the eight scenarios.

In this encounter, it was noted that it proved impossible to attract the attention of the crew of the errant vessel prior to the collision occurring. The main factor influencing this "failure" was identified to be the late time at which the SBV initiated actions to recover the rogue vessel from its collision course. As a result, the main measure used to attract the attention of the crew on the incoming vessel was radio as insufficient time was available to approach the vessel and utilise other measures. The actual point of impact was one of the legs of the platform and relatively little damage was incurred. A metre or so to one side and the vessel would have become wedged within the installations jacket, a metre or so the other side and the vessel would have struck the protection frame for the external risers and might well have had enough energy to damage not only the riser protection frame but the risers themselves.

Interestingly, some of the crew of the installation were involved in an exercise on the helideck and, although they spotted the ship at some 1500 m from the installation, apparently did not realise that the ship was on a collision course until it was quite close to the platform and, therefore, did not react as early as they might have done. It was suggested that failure to perceive the errant vessel as a threat is related to the fact that the threat is external to the platform and, although ship collision is probably on a par with fire and explosion in terms of frequency of occurrence, it is seen as remote, never going to happen and something over which they have no control. On the other hand, fire and explosion is seen by the crew of the installation as an immediate threat and one which they can understand and have some feeling that they can influence the threat.

Consideration of this event prompted some discussion within the panel on the best course of action for the crew of the installation to take in these circumstances. In the event of a potential ship collision, clearly it is important to get personnel mustered. Shutting in the platform was considered to be an important action, however, it was recognised that some platforms can take 20 minutes or more to shut in and, therefore, the decision to shut in needs to be taken whilst a vessel on a potential collision course is still some distance from the installation. This leads to the possibility of shutting in platforms unnecessarily due to the difficulty in identifying actual collision scenarios, assuming that the vessel fails to respond to attempts to attract their attention until close to the installation. It was suggested that the crew of the installation could take to the lifeboats and abandon the installation. In the event of the threat not materialising, in addition to the problem of getting back on to the installation this, action has risk associated with it.

Discussion of this event illustrated several of the problems associated with ship collision avoidance in terms of contacting an errant vessel effectively and in a timely manner together with those of the actions available to the crew of an installation faced with the threat of a potential collision. It was clear that the first priority must be to attract the attention of the crew of the errant vessel since, in practice, the crew of the installation have a relatively small number of courses of action open to them.

A4.2 SCENARIO 1 - BASE CASE

A4.2.1 Description

The characteristics of scenario 1 are summarised in Table 0.1

Table 0.1
Scenario 1 - Base Case

Parameter	Description
Location	The installation is situated in a low traffic density area.
Vessel Type	Cargo Vessel
Vessel Size	5000 tonnes
Vessel Speed	12 knots
Wind	5 m/s
Wave height	2 metres
Visibility	Daylight, good visibility

A4.2.2 Discussion

This scenario was used as a base case during which there was considerable discussion of all aspects of the problem and other scenarios were subsequently discussed as variations of the main points which arose. Set out below are key points of discussion relevant to the base case and all the other scenarios discussed. Other key points, relevant to particular scenarios are discussed below the summary tables for each particular scenario.

For the initial detection of a vessel on a potential collision course, 12 nm was considered to be the optimum threshold, as beyond this range it was suggested by the panel that little action would be initiated by the SBV with respect to collision avoidance. For the purpose of this study detection was defined as :

- the theoretical detection by the radar hardware.

- the detection of the target by the watchkeeper.
- the correct interpretation of the targets movements and identification of the collision scenario.

The panel agreed that both the Standard Marine Radar and ARPA on the SBV offered a high level of detection performance as there were likely to be a high standard of radar watches on the SBV, whereas for installation based marine radar and ARPA, it was considered that detection performance would be less effective at this range, even if they were switched on, because it would be unlikely that a full watch would be maintained.

Discussion of this point led into the question of the competence of watchkeepers both on the SBV and the installation, particularly with respect to their involvement in other tasks which would clearly degrade their performance in detecting vessels on a potential collision course at an early stage. With marine radar, which has no capability for automatic plotting, there might well be problems in monitoring a vessel on a collision course in any case.

The panel also highlighted that there is the possibility to set up alarm zones with most ARPA systems which sound an alarm on identification of a vessel crossing the designated alarm zone which can be set as a range from the installation. From a human factors perspective, for this system, it was established that, provided that personnel were in the vicinity of the ARPA alarm, there would be a very high probability of detecting the incoming vessels. It was noted that the radar had to register the vessel crossing the alarm zone and that a small vessel, which does not return an echo until it is within the alarm zone setting, will not trigger the alarm. The settings of this alarm "range" were also discussed briefly to determine the main factors which should be considered when assessing a suitable range. The main factors suggested included evacuation times, vessel speeds, and the traffic density associated with the location.

Overall, the consensus of the panel was that placing ARPA (with alarm zones set appropriately for location) on the installation with a slave on the SBV was the best arrangement for obtaining the optimum performance from radar equipment since the SBV should be better able to maintain a continuous radar watch. Responsibility for the monitoring of the radar should rest with the SBV crew and the set on the installation should only be used to monitor the situation once a scenario had developed. However, with this arrangement, if the SBV is changed, the appropriate equipment may need to be reinstalled on another vessel unless arrangements are made to equip all the potential standby vessels for that particular installation or group of installations.

It was agreed that the SBV would need to plot the path of an errant vessel throughout the course of an incident, partly for practicable reasons and partly for evidence for potential legal proceedings for infringement of the 500 m zone.

It was also suggested that, once an installation is warned of a vessel on a potential collision course, the installation should visually plot the path of the oncoming vessel. This would require identified vantage points on the installation and suitably trained personnel to undertake the plotting. For incidents occurring at night, night binoculars would need to be supplied.

If an errant vessel failed to respond to radio calls, various other methods of attracting the attention of the crew of the vessel were discussed, including light and sound signals, water cannon and for the SBV to present itself bow on to the rogue vessel to encourage it to alter course away from the installation. As a final resort the ultimate option of the SBV was highlighted to be an attempt to push the errant vessel off course.

Light signals would include signal lamps to signal U - standing into danger, flares, which would need to be white to comply with the relevant collision avoidance regulations. Clearly, flares would need to be fired across the bows of the errant vessel rather than on to the vessel since the latter could be potentially hazardous. Sound signals would include use of the fog horn and a sound gun. In all these cases, consideration should be given to the use of these methods not only on the SBV but also on the installation at an appropriate range.

Use of a water cannon on the hull of an errant vessel, if the SBV could get alongside, was considered to be an effective method of attracting attention since the sound would permeate the whole ship. Again, care would be needed to ensure that the water jet did not impinge on the bridge or other vulnerable areas with potentially hazardous consequences.

Presenting the bow of the SBV to the rogue vessel to "stand into danger" was recognised as a practice which was often practised by SBV's, however, the legality of the action was questioned with respect to the International Regulations for Preventing Collisions at Sea.

Attempting to push the errant vessel off course was considered as a last resort but would depend on the size of the SBV in relation to the oncoming vessel. It was also recognised that it is a potentially very hazardous operation and of doubtful legality, even if it was practicable.

SBV crews and offshore installation crews typically come from different backgrounds, marine in the former and process in the latter, and often do not appreciate each other's profession. Also, because the SBV crew have little or no direct contact with the crew of the installation, they are not seen as part of the overall team. This can lead to problems such as the SBV Captain being reluctant to contact an OIM until he is absolutely sure that a vessel is on a collision course because he is unsure of the reception he will receive. The installation crew, on the other hand, do not perceive ship collision as being a major problem due to its remoteness and, in many cases, it is suggested that they are unaware of the relatively short timescale involved between detecting a vessel on a potential collision course and it colliding with the installation.

For optimum performance, the interfaces between the installation and the SBV need to be clear and steps need to be taken to ensure that they understand each others roles and act as one team. In order to achieve this, procedures should be developed for dealing with ship collisions, including when to inform the installation. Such procedures should be based on time rather than distance since the time available to decide on a course of action will be inversely proportional to speed of the errant vessel. The procedures will need to take into account the likely speed distributions of vessels in the area, limitations on where the SBV may be located and the possible utilisation of daughter craft or FRCs for intercepting higher speed vessels. The approach to collision avoidance management requires an approach based on PFEER, i.e. based on risk assessment and the appropriate policies and procedures prepared on the basis of the risk for that individual installation and properly drafted and implemented. Steps also need to be taken to develop the relationship between the installation and SBV crews.

Mobile drilling units by their nature work for relatively short periods of time in many different locations. Therefore, it is very important that collision avoidance procedures are drawn up and agreed between the rig and the SBV prior to rig mobilisation to ensure a common understanding as well as developing a working relationship between them.

A4.2.3 Evaluation

Table 0.1 and Table 0.2 present details of the results of this assessment performed for Scenario 1. The tables provide details for detection and prevention performance respectively. For ARPA an alarm zone set at 8nm has been assumed due to the fact that the location is not busy.

Table 0.1
Detection Performance - Scenario 1

Radar Type	Range from Installation (nm)						
	12	10	8	6	4	2	1
Marine Radar on SBV	A	B	C	D/E	E/F	F	F
Marine Radar on Installation	A	A	A	A/B	B	C	C/D
ARPA on SBV	D/E	E	E/F	F	F	F	F
ARPA on Installation	A	A/B	C	C	C/D	C/D	D
REWS	E/F	F	F	F	F	F	F
VTS	F	F	F	F	F	F	F

Table 0.2
Prevention Performance - Scenario 1 (Based on 12nm Detection)

Prevention Performance					
Dist/Time	Actions	Effect on Causation			
12 nm - 60'	Vessel Detected	1	-	5	-
		2	-	6	-
		3	-	7	-
		4	-	8	-
10 nm - 50'	Vessel Contacted by VHF radio (low probability of contact,	1	A/B	5	A
	e.g PPCoN - H-7). Platform should be given early warning;	2	A	6	A
	procedures should include specific instructions since	3	A	7	A/B
	watchkeeper on SBV may be reluctant to contact OIM. OIM	4	A	8	A/B
	may need time to shut in platform and arrange evacuation. SBV prepares to move towards vessel.				
8 nm - 40'	Attempts to contact vessel by VHF radio continue. SBV	1	B	5	A/B
	moves towards incoming vessel. SBV uses light signals	2	A/B	6	A/B
	(signals U with signal lamp). SBV is assumed to be able to	3	A/B	7	B
	make approximately 12 knots	4	A	8	B
6 nm - 30'	SBV continues to try to make contact with radio, continues to	1	C/D	5	C
	use light signals and also sound, e.g. foghorn. If available the	2	C	6	C
	use of sound gun, i.e. a maroon, and pyrotechnics should be	3	C	7	D
	attempted. OIM informed of the situation.	4	B	8	D
4 nm - 20'	SBV is now alongside the rogue vessel and continues to use	1	F	5	E/F
	lights, sound (horn and maroon) and VHF radio.	2	E/F	6	E/F
		3	E/F	7	F
		4	E	8	F
2 nm - 10	If there is no response by this stage, something is seriously	1	F	5	E/F
	wrong. Attempts to make contact continue. The SBV must	2	E/F	6	E/F
	decide whether to stand-off or "nudge" the incoming vessel	3	E/F	7	F
	off collision course With respect to the latter action however,	4	E/F	8	F
	the expert panel raised questions with regard to the legality of "nudging" a vessel as well as the risks to the SBV crew which are associated with this action.				
1 nm - 5'	SBV proceeds to either "nudge" vessel off collision course or	1	F	5	E/F
	makes ready to accept survivors	2	E/F	6	E/F
		3	E/F	7	F
		4	E/F	8	F

A4.3 SCENARIO 2 - AS FOR 1 BUT HIGH TRAFFIC DENSITY

A4.3.1 Description

The characteristics of scenario 2 are summarised in Table 0.1.

Table 0.1
Scenario 2

Parameter	Description
Location	The installation is situated in a high traffic density area.
Vessel Type	Cargo Vessel
Vessel Size	5000 tonnes
Vessel Speed	12 knots
Wind	5 m/s
Wave height	2 metres
Visibility	Daylight, good visibility

A4.3.2 Discussion

In high traffic density areas, it is possible that the installation will be used as a way point and the navigating officer will be well aware of the presence of the installation and, at a certain point, possibly quite close to it, will alter course and pass clear outside the 500 m zone. The problem for the SBV is in deciding whether the vessel is on a collision course but has every intention of changing course or is on a collision course but unaware of the fact. Depending on the circumstances, attempts to contact a vessel on the radio may be made at different times, e.g. if the vessel is on a known route on which the installation is used as a way point, it would be done later whereas if the apparently errant vessel was approaching from an unusual quarter contact would be attempted much earlier.

Benefits have been noted from SBVs carrying out traffic surveys in that the SBV crew become aware of the vessels which are passing regularly in the vicinity and the routes which they expect the vessels to be on. This has led to an increase in awareness of the crews aboard the SBVs.

In high traffic density areas, greater vigilance will be required on the part of the SBV crew in terms of radar watch. The effectiveness of procedures and their implementation will be more critical and the role of the SBV as detector will be more important. It is also noted that it is less desirable for the SBV to leave the location and approach the incoming vessel due to the fact that there is considerably more traffic to monitor which may also present a collision threat.

A4.3.3 Evaluation

Table 0.1 and Table 0.2 present details of the results of this assessment performed for Scenario 2. The tables provide details for detection and prevention performance respectively. For ARPA an alarm zone setting of 6nm has been assumed based on the fact that the location is busy.

Table 0.1
Detection Performance - Scenario 2

Radar Type	Range from Installation (nm)						
	12	10	8	6	4	2	1
Marine Radar on SBV	A	A/B	B	C/D	D/E	E/F	E/F
Marine Radar on Installation	A	A	A	A/B	B	B/C	C
ARPA on SBV	D/E	D/E	E	E/F	F	F	F
ARPA on Installation	A	A/B	A/B	C	C	C/D	C/D
REWS	E/F	F	F	F	F	F	F
VTS	F	F	F	F	F	F	F

Table 0.2
Prevention Performance - Scenario 2 (Based on 12nm Detection)

Prevention Performance						
Dist/Time	Actions	Effect on Causation				
12 nm; 60'	Vessel Detected	1	-	5	-
		2	-	6	-
		3	-	7	-
		4	-	8	-
10 n. 50'	Vessel Contacted by VHF radio (low probability of contact,	1	A/B	5	A
	e.g PPCoN - H-7). Platform should be given early warning;	2	A	6	A
	procedures should include specific instructions since	3	A	7	A/B
	watchkeeper on SBV may be reluctant to contact OIM. Vessel	4	A	8	A/B
	prepares to move towards incoming vessel. SBV should be aware of high traffic and therefore should also keep watch for other vessels passing though area				
8 [illegible]0'	Attempts to contact vessel by VHF radio continue. SBV	1	B	5	A/B
	moves towards incoming vessel to take position at	2	A/B	6	A/B
	approximately 1000m from installation between the rogue	3	A/B	7	B
	vessel and installation. SBV warning lamp utilised as signal.	4	A	8	B
	Global traffic watch maintained.				
6[illegible]	Attempt to make radio contact is continued. Vessel maintains	1	C	5	B/C
	1000m position and presents itself to encourage change of	2	B	6	B/C
	course of incoming vessel. SBV continues to use signal	3	B	7	C
	lamp and also sound, e.g. foghorn. If available the use of	4	A/B	8	C
	sound gun, i.e. a maroon, and pyrotechnics should be attempted. OIM is informed of situation.				
4[illegible]	SBV continues to use radio, sound and lights as well as	1	D/E	5	D
	pyrotechnics to attract attention of crew onboard rogue vessel.	2	D	6	D
		3	D	7	D/E
		4	C/D	8	D/E
2 [illegible]0	At this point there if there is no response from the incoming	1	E/F	5	D/E
	vessel the SBV must decide whether to stand off and make	2	D/E	6	D/E
	ready for survivors or to nudge the incoming vessel off its	3	D/E	7	F
	course.	4	D	8	F
1 n5'	SBV proceeds to either "nudge" vessel off collision course or	1	E/F	5	D/E
	stand-off	2	D/E	6	D/E
		3	D/E	7	F
		4	D	8	F

A4.4 SCENARIO 3 - AS IN 1 BUT HIGH TRAFFIC DENSITY & HIGH SPEED VESSEL

A4.4.1 Description

The characteristics of scenario 3 are summarised in Table 0.1.

Table 0.1
Scenario 3

Parameter	Description
Installation	The installation is situated in a high traffic density area.
Vessel Type	Cargo Vessel
Vessel Size	5000 tonnes
Vessel Speed	20 knots
Wind	5 m/s
Wave height	2 metres
Visibility	Daylight, good visibility

A4.4.2 Discussion

In this type of scenario, everything happens much faster and the energy involved in any collision will be that much greater with a corresponding increase in the damage likely to be sustained. In the time taken to detect that a high speed vessel is on a collision course, it will have travelled that much further so the proportion of vessels detected in each range is reduced from those in the base case. It will be even more important to have clearly defined procedures for both the installation and the SBV since the thinking time available is much reduced.

Since the SBV will be slower than the errant vessel, the former does not have the option of drawing alongside but would only have the option of identifying a course to intercept the errant vessel, assuming no response is obtained on the radio. In effect, the SBV would have of the order of two attempts to contact the errant vessel by light and/or sound, i.e. at say 2 nm between the vessels and at the intercept point.

A4.4.3 Evaluation

Table 0.1and Table 0.2 present details of the results of this assessment performed for Scenario 3. The tables provide details for detection and prevention performance respectively.

Table 0.1
Detection Performance - Scenario 3

Radar Type	Range from Installation (nm)						
	12	10	8	6	4	2	1
Marine Radar on SBV	A	A	A/B	B/C	D	D/E	D/E
Marine Radar on Installation	A	A	A	A	A/B	B	B/C
ARPA on SBV	C/D	D	D	D/E	E	E	E/F
ARPA on Installation	A	A	A/B	C	C	C/D	C/D
REWS	E/F	E/F	F	F	F	F	F
VTS	E/F	F	F	F	F	F	F

* *ARPA alarm zone set at 6nm based on the fact that the location is busy*

Table 0.2
Prevention Performance - Scenario 3 (Based on 12nm Detection)

Prevention Performance						
Dist/Time	Actions	Effect on Causation				
12 nm - 36'	Vessel Detected	1	-	5	-
		2	-	6	-
		3	-	7	-
		4	-	8	-
10 nm - 30'	Vessel Contacted by VHF radio (low probability of contact,	1	A/B	5	A
	e.g PPCoN - H-7. Platform should be given early warning;	2	A	6	A
	procedures should include specific instructions since	3	A	7	A/B
	watchkeeper on SBV may be reluctant to contact OIM. OIM	4	A	8	A/B
	may need time to shut in platform and arrange evacuation. SBV prepares to move towards vessel.				
8 nm - 24'	Attempts to contact vessel by VHF continue. SBV moves	1	B	5	A/B
	towards incoming vessel at speed. Light signals and sound	2	A/B	6	A/B
	are used to attract attention. Pyrotechnics also fired off..	3	A/B	7	B
		4	A	8	B
6 nm - 18'	VHF contact continued. Lights, Sound and Pyrotechnics	1	C	5	B
	utilised to attract attention of incoming vessel. Due to the	2	B	6	B
	rapid development of the hazard the OIM should be informed	3	B	7	C/D
	of situation at regular intervals.	4	A/B	8	C/D
4 nm - 12'	Vessels approximately 2nm apart. SBV uses sound and lights	1	C/D	5	C
	as well as pyrotechnics and radio to attract attention of crew	2	C	6	C
	onboard rogue vessel.	3	C	7	D
		4	B	8	D
2 nm - 6	SBV at intercept point of vessel. If there is no change in	1	D/E	5	D
	course SBV must make way to the fast vessel and take	2	D	6	D
	position to recover personnel	3	D	7	E
	.	4	C	8	E
1 nm - 3'	SBV holds best position to recover survivors.	1	D/E	5	D
		2	D	6	D
		3	D	7	E
		4	C	8	E

A4.5

SCENARIO 4 - HIGH TRAFFIC DENSITY & POOR VISIBILITY (FOG)

A4.5.1 Description

The characteristics of scenario 4 are summarised in
Table 0.1.

Table 0.1
Scenario 4

Parameter	Description
Installation	The installation is situated in a high traffic density area.
Vessel Type	Cargo Vessel
Vessel Size	5000 tonnes
Vessel Speed	12 knots
Wind	Calm
Wave height	2 metres
Visibility	Poor Visibility (Fog)

A4.5.2 Discussion

Fog adds to the problems of detecting vessels on potential collision courses. Although plotting via radar is unaffected, visual identification and tracking becomes much less effective. This will primarily effect the SBV detection systems which have the most benefit of visual look-out compared to the installation based systems which have limited visual observation. Usually in fog, the sea state is reasonable so that the performance of the radar is less likely to be impaired by clutter from waves. On the other hand, in fog it is reasonable to assume that vessels are maintaining a higher level of vigilance as indicated by the International Regulations for Preventing Collisions at Sea.

Also, in these conditions, the installation procedures should require cessation of work, such as over the side, which requires the SBV to operate in close standby, thereby compromising the performance of the SBV.

The efficiency of light signals will be significantly reduced in fog and in addition it is noted there will also be reduced benefit from sound signals. In fog, it will be dangerous for the SBV to approach too close to an errant vessel. The duty holder should specify the capabilities of SBV performance in fog and other conditions.

A4.5.3 Evaluation

Table 0.1 and Table 0.2 present details of the results of this assessment performed for Scenario 4. The tables provide details for detection and prevention performance respectively.

Table 0.1
Detection Performance - Scenario 4

Radar Type	Range from Installation (nm)						
	12	10	8	6	4	2	1
Marine Radar on SBV	A	A	B	C	D	E	E
Marine Radar on Installation	A	A	A	A/B	B	B/C	C
ARPA on SBV	D/E	D/E	E	E/F	F	F	F
ARPA on Installation	A	A/B	B	C	C/D	C/D	D
REWS	E/F	F	F	F	F	F	F
VTS	F	F	F	F	F	F	F

* *ARPA alarm zone set at 6nm based on the fact that the location is busy*

Table 0.2
Prevention Performance - Scenario 4 (Based on 12nm Detection)

Dist/Time	Prevention Performance: Actions	Effect on Causation			
12 nm - 60'	Vessel Detected	1	-	5	-
		2	-	6	-
		3	-	7	-
		4	-	8	-
10 nm - 50'	Vessel Contacted by VHF radio (low probability of contact,	1	A/B	5	A
	e.g. PPCoN - H-7). Platform should be given early warning;	2	A	6	A
	procedures should include specific instructions since	3	A	7	A/B
	watchkeeper on SBV may be reluctant to contact OIM. Vessel	4	A	8	A/B
	prepares to move towards incoming vessel. SBV should be aware of high traffic and therefore should also keep watch for other vessels passing though area				
8 nm - 40'	Attempts to contact vessel by VHF radio continue. SBV	1	B	5	A/B
	moves towards incoming vessel to take position at	2	A/B	6	A/B
	approximately 1000m from installation between the rogue	3	A/B	7	B
	vessel and installation. Global traffic watch maintained.	4	A	8	B
6 nm - 30'	Attempt to make radio contact is continued. Vessel maintains	1	B/C	5	B
	1000m position and presents itself to encourage change of	2	B	6	B
	course of incoming vessel. SBV uses sound signals, e.g..	3	B	7	B/C
	foghorn , sound gun, i.e. a maroon. pyrotechnics should	4	A/B	8	B/C
	be attempted. OIM is informed of situation.				
4 nm - 20'	SBV uses sound and lights as well as pyrotechnics	1	C/D	5	C

	and radio				
	to attract attention of crew onboard rogue vessel. Full	2	C	6	C
	consideration should be given to the environmental condition	3	C	7	C/D
	and the dangers these present with respect to approaching vessels	4	B/C	8	C/D
2 nm - 10	At this point if there is no response from the incoming	1	D	5	C/D
	vessel the SBV must decide whether to stand off and make	2	C/D	6	C/D
	ready for survivors or to "nudge" the incoming vessel off its	3	C/D	7	D
	course.	4	C	8	D
1 nm - 5'	SBV proceeds to either "nudge" vessel off collision course or	1	D	5	C/D
	stand-off and make ready to collect survivors.	2	C/D	6	C/D
		3	C/D	7	D
		4	C	8	D

A4.6 SCENARIO 5 - HIGH TRAFFIC DENSITY & POOR VISIBILITY (PRECIPITATION)

A4.6.1 Description

The characteristics of scenario 5 are summarised in Table 0.1.

Table 0.1
Scenario 5

Parameter	Description
Installation	The installation is situated in a high traffic density area.
Vessel Type	Cargo Vessel
Vessel Size	5000 tonnes
Vessel Speed	12 knots
Wind	5 m/s
Wave height	2 metres
Visibility	Poor Visibility (Rain, Hail, Snow)

A4.6.2 Discussion

These are probably the worst conditions and most demanding on human and hardware performance. As in fog, visual bearings cannot be taken of the course of errant vessels. Again, in such conditions, the SBV is less able to approach very close to an errant vessel.

A4.6.3 Evaluation

Table 0.1 and Table 0.2 present details of the results of this assessment performed for Scenario 5. The tables provide details for detection and prevention performance respectively.

Table 0.1
Detection Performance - Scenario 5

Radar Type	Range from Installation (nm)						
	12	10	8	6	4	2	1
Marine Radar on SBV	A	A	A/B	B	C	D	D
Marine Radar on Installation	A	A	A	A	A/B	B/C	B/C
ARPA on SBV	C	C	C/D	D	D/E	E	E
ARPA on Installation	A	A/B	B	C	C	C/D	C/D
REWS	D	D/E	E	E/F	F	F	F
VTS	E/F	E/F	F	F	F	F	F

- *ARPA alarm zone set at 6nm based on the fact that the location is busy*

Table 0.2
Prevention Performance - Scenario 5 (Based on 12nm Detection)

Prevention Performance					
Dist/Time	Actions	Effect on Causation			
12 nm - 60'	Vessel Detected	1	-	5	-
		2	-	6	-
		3	-	7	-
		4	-	8	-
10 nm - 50'	Vessel Contacted by VHF radio (low probability of contact,	1	A/B	5	A
	e.g. PPCoN - H-7. Platform should be given early warning;	2	A	6	A
	procedures should include specific instructions since	3	A	7	A/B
	watchkeeper on SBV may be reluctant to contact OIM. Vessel	4	A	8	A/B
	prepares to move towards incoming vessel. SBV should be aware of high traffic and therefore should also keep watch for other vessels passing though area				
8 nm - 40'	Attempts to contact vessel by VHF radio continue. SBV	1	B	5	A/B
	moves towards incoming vessel to take position at	2	A/B	6	A/B
	approximately 1000m from installation between the rogue	3	A/B	7	B
	vessel and installation. SBV warning lamp utilised as signal.	4	A	8	B
	Global traffic watch maintained.				
6 nm - 30'	Attempt to make radio contact is continued. Vessel maintains	1	B/C	5	B
	1000m position and presents itself to encourage change of	2	B	6	B
	course of incoming vessel. SBV continues to use signal	3	B	7	B/C
	lamp and also sound, e.g. foghorn. If available the use of	4	A/B	8	B/C
	sound gun, i.e. a maroon, or pyrotechnics should be attempted. OIM is				

	informed of situation.				
4 nm - 20'	SBV uses sound and lights as well as pyrotechnics and radio	1	C/D	5	C
	to attract attention of crew onboard rogue vessel. Full	2	C	6	C
	consideration should be given to the environmental condition	3	C	7	C/D
	and the dangers these present with respect to approaching vessels.	4	B/C	8	C/D
2 nm - 10	At this point there if there is no response from the incoming	1	D	5	C/D
	vessel the SBV must decide whether to stand off and make	2	C/D	6	C/D
	ready for survivors or to nudge the incoming vessel off its	3	C/D	7	D
	course.	4	C	8	D
1 nm - 5'	SBV proceeds to either "nudge" vessel off collision course or	1	D	5	C/D
	stand-off to accept survivors.	2	C/D	6	C/D
		3	C/D	7	D
		4	C	8	D

A4.7 SCENARIO 6 - LOW TRAFFIC DENSITY & HIGH SPEED VESSEL

A4.7.1 Description

The characteristics of scenario 6 are summarised in Table 0.1.

Table 0.1
Scenario 6

Parameter	Description
Installation	The installation is situated in a low traffic density area.
Vessel type	Cargo Vessel
Vessel Size	5000 tonnes
Vessel Speed	20 knots
Wind	5 m/s
Wave height	2 metres
Visibility	Daylight, good visibility

A4.7.2 Discussion

In a low traffic density area, the detection of an errant high speed vessel may occur earlier due to the lower number of vessels compared with Scenario 3. Otherwise, the scenario unfolds much as for Scenario 3.

A4.7.3 Evaluation

Table 0.1 and Table 0.1 present details of the results of this assessment performed for Scenario 6. The tables provide details for detection and prevention performance respectively.

Table 0.1
Detection Performance - Scenario 6

Radar Type	Range from Installation (nm)						
	12	10	8	6	4	2	1
Marine Radar on SBV	A	A/B	B	C	D/E	E/F	F
Marine Radar on Installation	A	A	A	A/B	A/B	B	C
ARPA on SBV	D	D/E	E/F	F	F	F	F
ARPA on Installation	A	A	C	C	C/D	C/D	D
REWS	E	E/F	F	F	F	F	F
VTS	F	F	F	F	F	F	F

* *ARPA alarm zone set at 8nm based on the fact that the location is not busy.*

Table 0.2
Prevention Performance - Scenario 6 (Based on 12nm Detection)

Prevention Performance					
Dist/Time	**Actions**	**Effect on Causation**			
12 nm - 36'	Vessel Detected	1	-	5	-
		2	-	6	-
		3	-	7	-
		4	-	8	-
10 nm - 30'	Vessel Contacted by VHF radio (low probability of contact,	1	A/B	5	A
	e.g. PPCoN - H-7. Platform should be given early warning;	2	A	6	A
	procedures should include specific instructions since	3	A	7	A/B
	watchkeeper on SBV may be reluctant to contact OIM. OIM	4	A	8	A/B
	may need time to shut in platform and arrange evacuation. SBV prepares to move towards vessel.				
8 nm - 24'	Attempts to contact vessel by VHF continue. SBV moves	1	B	5	A/B
	towards incoming vessel at speed. Light signals and sound	2	A/B	6	A/B
	are used to attract attention. Pyrotechnics also fired off.	3	A/B	7	B
		4	A	8	B
6 nm - 18'	VHF contact continued. Lights, Sound and Pyrotechnics	1	C	5	B/C
	utilised to attract attention of incoming vessel. Due to the	2	B/C	6	B/C
	rapid development of the hazard the OIM should be informed	3	B/C	7	C
	of situation at regular intervals.	4	A/B	8	C
4 nm - 12'	Vessels approximately 2nm apart. SBV uses sound and lights	1	D	5	C/D
	as well as pyrotechnics and radio to attract attention of crew	2	C/D	6	C/D
	onboard rogue vessel.	3	C/D	7	D
		4	C	8	D
2 nm - 6	SBV at intercept point of vessel. If there is no change in	1	E	5	D/E
	course SBV must make way to the fast vessel and take	2	D/E	6	D/E
	position to recover personnel	3	D/E	7	E
		4	D	8	E
1 nm - 3'	SBV holds best position to recover survivors.	1	E	5	D/E
		2	D/E	6	D/E
		3	D/E	7	E
		4	D	8	E

A4.8

SCENARIO 7 - LOW TRAFFIC DENSITY & POOR VISIBILITY (FOG)

A4.8.1 Description

The characteristics of scenario 7 are summarised in Table 0.1.

Table 0.1
Scenario 7

Parameter	Description
Installation	The installation is situated in a low traffic density area.
Vessel type	Cargo Vessel
Vessel Size	5000 tonnes
Vessel Speed	12 knots
Wind	Calm
Wave height	2 metres
Visibility	Poor Visibility (Fog)

A4.8.2 Discussion

This Scenario unfolds much as for Scenario 4, except that with lower traffic density, detection of potential collision courses should be a little easier. In addition it is noted that the SBV is more likely to move off location to intercept the vessel at an earlier stage of the event as there is less additional traffic to monitor.

A4.8.3 Evaluation

Table 0.1 and Table 0.2 present details of the results of this assessment performed for Scenario 7. The tables provide details for detection and prevention performance respectively.

Table 0.1
Detection Performance - Scenario 7

Radar Type	Range from Installation (nm)						
	12	10	8	6	4	2	1
Marine Radar on SBV	A	A/B	B/C	D	D/E	E	E/F
Marine Radar on Installation	A	A	A	A/B	B	C	C/D
ARPA on SBV	D/E	E	E/F	F	F	F	F
ARPA on Installation	A	A/B	C	C	C/D	C/D	D
REWS	E/F	F	F	F	F	F	F
VTS	F	F	F	F	F	F	F

* *ARPA alarm zone set at 8nm based on the fact that the location is not busy*

Table 0.2
Prevention Performance - Scenario 7 (Based on 12nm Detection)

Prevention Performance					
Dist/Time	Actions	Effect on Causation			
12 nm - 60'	Vessel Detected	1	-	5	-
		2	-	6	-
		3	-	7	-
		4	-	8	-
10 nm - 50'	Vessel Contacted by VHF radio (low probability of contact, e.g. PPCoN - H-7). Platform should be given early warning; procedures should include specific instructions since watchkeeper on SBV may be reluctant to contact OIM. OIM may need time to shut in platform and arrange evacuation. SBV prepares to move towards vessel.	1	A/B	5	A
		2	A	6	A
		3	A	7	A/B
		4	A	8	A/B
8 nm - 40'	Attempts to contact vessel by VHF radio continue. SBV moves towards incoming vessel. SBV uses light signals (signals U with signal lamp). SBV is assumed to be able to make approximately 12 knots	1	B	5	A
		2	A/B	6	A
		3	A/B	7	A/B
		4	A	8	A/B
6 nm - 30'	SBV continues to try to make contact with radio, continues to use light signals and also sound, e.g. foghorn. If available the use of sound gun, i.e. a maroon, and pyrotechnics should be attempted. OIM informed of situation.	1	C	5	B/C
		2	B/C	6	B/C
		3	B/C	7	C
		4	B	8	C
4 nm - 20'	SBV is now approaching rogue vessel but should keep safe distance considering the environmental conditions. SBV continues to use lights, sound (horn and maroon) and VHF radio.	1	D	5	C/D
		2	C/D	6	C/D
		3	C/D	7	D
		4	C	8	D
2 nm - 10	If there is no response by this stage, something is seriously wrong. Attempts to make contact continue. The SBV must decide whether to stand-off or nudge the incoming vessel off collision course With respect to the latter action however, the expert panel raised questions with regard to the legality of nudging a vessel as well as the hazard exposure of the SBV crew.	1	D/E	5	D
		2	D	6	D
		3	D	7	D/E
		4	C/D	8	D/E
1 nm - 5'	SBV proceeds to either "nudge" vessel off course or make ready to accept survivors.	1	D/E	5	D
		2	D	6	D
		3	D	7	D/E
		4	C/D	8	D/E

A4.9 SCENARIO 8 - LOW TRAFFIC DENSITY & BAD WEATHER (WAVES)

A4.9.1 Description

The characteristics of scenario 8 are summarised in Table 0.1.

Table 0.1
Scenario 8

Parameter	Description
Installation	The installation is situated in a low traffic density area.
Vessel type	Cargo Vessel
Vessel Size	5000 tonnes
Vessel Speed	12 knots
Wind	10 m/s
Wave height	5 metres
Visibility	Daylight, good visibility

A4.9.2 Discussion

In these conditions the range of radar is adversely affected with a consequent reduction in the ability of the SBV to detect actual collision courses. Again, taking visual bearings will be more difficult in these circumstances.

Sound signals will be less effective in windy conditions and the SBV will approach any errant vessel on the lee side since it would take longer to reach it from the windward side. It was also noted that the speed at which the SBV can approach the rogue vessel will be affected by the sea-state.

In these circumstances, the competence of the radar operator is extremely important. As part of the policies and arrangements for collision avoidance management the skill level of radar observance for the SBV crew should be defined.

A4.9.3 Evaluation

Table 0.1 and Table 0.2 present details of the results of this assessment performed for Scenario 8. The tables provide details for detection and prevention performance respectively.

Table 0.1
Detection Performance - Scenario 8

Radar Type	Range from Installation (nm)						
	12	10	8	6	4	2	1
Marine Radar on SBV	A	A	A/B	B	C	D	D
Marine Radar on Installation	A	A	A	A	A/B	B/C	B/C
ARPA on SBV	C	C	C/D	D	D/E	E	E
ARPA on Installation	A	A/B	B	C	C	C/D	C/D
REWS	D	D/E	E	E/F	F	F	F
VTS	E/F	E/F	F	F	F	F	F

* *ARPA alarm zone set at 8nm based on the fact that the location is not busy*

Table 0.2
Prevention Performance - Scenario 8 (Based on 12nm Detection)

Prevention Performance						
Dist/Time	Actions	Effect on Causation				
12 nm - 60'	Vessel Detected	1	-	5	-
		2	-	6	-
		3	-	7	-
		4	-	8	-
10 nm - 50'	Vessel Contacted by VHF radio (low probability of contact,	1	A/B	5	A
	e.g. PPCoN - H-7). Platform should be given early warning;	2	A	6	A
	procedures should include specific instructions since	3	A	7	A/B
	watchkeeper on SBV may be reluctant to contact OIM. OIM	4	A	8	A/B
	may need time to shut in platform and arrange evacuation. SBV prepares to move towards vessel.				
8 nm - 40'	Attempts to contact vessel by VHF radio continue. SBV	1	B	5	A
	moves towards incoming vessel. SBV uses light signals	2	A/B	6	A
	(signals U with signal lamp). SBV is assumed to be able to	3	A/B	7	A/B
	make approximately 12 knots	4	A	8	A/B
6 nm - 30'	SBV continues to try to make contact with radio, continues to	1	C	5	B/C
	use light signals and also sound, e.g. foghorn. If available the	2	B/C	6	B/C
	use of sound gun, i.e. a maroon, and pyrotechnics should be	3	B/C	7	C
	attempted. OIM informed of situation.	4	B	8	C
4 nm - 20'	SBV is now approaching rogue vessel but should keep safe	1	D	5	C/D
	distance considering the environmental conditions. SBV	2	C/D	6	C/D
	continues to use lights, sound (horn and maroon) and VHF	3	C/D	7	D
	radio.	4	C	8	D
2 nm - 10	If there is no response by this stage, something is seriously	1	D/E	5	D
	wrong. Attempts to make contact continue.	2	D	6	D
		3	D	7	D/E
		4	C/D	8	D/E
1 nm - 5'	SBV stands off and makes ready to accept survivors	1	D/E	5	D
		2	D	6	D
		3	D	7	D/E
		4	C/D	8	D/E

A4.10

DRIFTING VESSEL SCENARIO

A4.10.1 Description

The characteristics of this scenario are summarised in Table 0.1.

Table 0.1
Drifting Vessel Scenario

Parameter	Description
Installation	The installation is situated in a low traffic density area.
Vessel type	Tanker (Drifting)
Vessel Size	50000 tonnes
Vessel Speed	2 knots
Wind	5 m/s
Wave height	2 metres
Visibility	Good visibility

A4.10.2 Discussion

This type of scenario develops slowly and there is plenty of thinking time available. Predicting potential collision courses is more problematical due to factors such as wind and current.

It was suggested that SBVs might be equipped with towing capability but this may raise other issues such as salvage rights and in the event of an SBV taking a drifting vessel in tow, it will not be in a position to undertake any other duties for which it is responsible.

A4.10.3 Evaluation

Detection of such a vessel was not identified to present a problem for either detection system being considered due to the fact that the crew aboard the drifting vessel will be aware they are drifting and will therefore tend to be more vigilant and radio responsive. It was noted that at 10 nm there will be in the order of 5 hrs to collision. It was also noted that with respect to detection range and time in some instances vessel owners are unwilling to declare themselves as drifting and therefore there may be a slight probability that the warning time will be less.

With respect to prevention it was identified that a different approach was required as the watchkeeping failure modes were not applicable to drifting vessel scenarios which usually resulted from steering gear or propulsion failure. Based on this, a general discussion took place between the panel members which highlighted that the main factors which would influence the probability of initiating recovery of the vessels were, the availability of tugs to assist in the towing of the tanker, the willingness of the Captain aboard the drifting vessel to accept liability and a tow line, the environmental conditions and the ease of which a tow line could be attached, and the ability of the tug to tow the tanker to safety. It was highlighted that as the effectiveness of these actions is independent of the radar systems previously considered and is more location specific being dependent on tug availability and weather conditions, etc. As a result of this no further assessment of this scenario was carried out.

A5 KEY POINTS ARISING FROM THE EXPERT PANEL

Detailed below are the main points which were raised during the Expert Panel review of the representative collision scenarios:

1. Ship collision avoidance needs to be managed in the same way as any other hazard threatening an installation. Appropriate policies, organisation, arrangements and procedures need to be in place. These should be based on a suitable risk assessment of the potential for ship collision in relation to the site of the installation, traffic density, environmental conditions, etc. and should take into account SBV capability, etc. and ensure that appropriate performance standards are devised and implemented.
2. In order to obtain the optimal performance from radar systems, the optimum arrangement would appear to be citing the system on the installation to obtain best possible coverage. It was noted that this system would require a dedicated and trained watchkeeper to be effective as well as well structured training of communication between the installation and SBV. Due to these limitations the most practical system was identified to be the radar system on the installation but with the SBV monitoring a slave on the SBV since they will be most effective in maintaining radar watch and acting upon the information. It is also noted that this latter system would require for the SBV to be able to tune the radar system to the environmental conditions.
3. The various means of attracting the attention of errant vessels should be reviewed and a common approach agreed and implemented by members of UKOOA and disseminated as far as possible to shipping companies themselves.
4. The human factor aspects of ship collision avoidance is an important area which appears to have been neglected. Crews of installations without marine backgrounds tend not to perceive collision as being a serious hazard due to its remoteness and their potential inability to do very much about it. It is suggested that further work should be done in this area.
5. SBV crews should be integrated more with that of the installation so that they feel and are treated more as members of the same team.
6. Greater consideration should be given to the role of the installation itself in ship collision avoidance such as being involved in visual plotting of potential collision courses after being alerted by the SBV and using light and sound signals themselves to attract the attention of errant vessels.
7. Because the VTS system is constantly manned by experienced personnel it can be optimally set in all condition to ensure the vast majority of vessels are picked up. For the REWS systems this is not he case and therefore, in a similar manner to the radars located on the installation their performance may reduce in bad weather. For the radar systems installed on the SBV's it is noted that the crew of this vessel have a great deal more experience in using radar than the majority of installation control personnel and therefore the control settings can be optimised to suit the prevailing conditions. It is noted that some REWS systems claim to offer automatic tuning but no performance specification was available.

APPENDIX B

Ship Collision Detection and Alerting Systems

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B1 INTRODUCTION

This appendix provides an overview of a selection of hardware systems currently available to assist in the management of passing vessel collision risks.

The first step in controlling the threat posed by passing vessels is to identify the potential threat (i.e. determine if a vessel is on a collision course with the installation). Section 0 of this appendix provides an overview of the detection systems that are currently available. The section also provides discussion on the main aspects that should be considered when assessing the suitability of a system to a particular operational requirement.

Section 0 then provides information on the alerting systems that could be used to warn-off an approaching ship that has been detected as posing a threat to the installation.

The information presented in this appendix is based on a number of studies and trials performed by Safetec which were carried out to assess performance levels and identify optimal system layouts for managing collision risks at offshore fields. In addition to this, visits were made to a number of system providers to ensure that the information presented was current at the time of this report.

B2 DETECTION SYSTEMS

B2.1 INTRODUCTION

The first step in the process of controlling the threat posed by passing vessels is to identify if a vessel is on a collision course with the installation. The way this is usually performed by a combination of optical and radar observation to determine the passing vessel's projected Closest Point of Approach (CPA) and Time to Closest Point of Approach (TCPA).

More sophisticated radar systems are now being introduced with the aim of improving the efficiency of errant vessel detection. The efficiency improvements being measured, not only in terms of detection performance and reliability when compared with older systems, but also in terms of cost per unit area of (acceptable) detection coverage.

To achieve improvements in detection efficiency, radar systems are increasingly being mounted on fixed installations with, in some cases, automatic detection and remote monitoring.

Within the process of establishing an effective detection capability for a specific installation or field, there are a number of issues that require to be addressed so as to ensure that the detection system meets the performance standard required. It should be noted that there are two basic requirements of a detection system, these being:

1. It should provide sufficient time for the alerting procedures and installation emergency procedures to be enacted;
2. It should have a high degree of reliability (both operationally and in performance) under all reasonably foreseeable conditions (weather, traffic density, etc.).

When selecting a detection system, the location specific conditions and environment in which it must adequately perform, must be fully considered, and, as in the selection of other risk management measures, the cost versus achieved benefit must form part of the selection process. For example, a relatively high cost sophisticated detection system may be required of a highly trafficked sea area whereas a low cost system may suffice in a sea area with only a single vessel passing per day.

The following section provides information on what are the key performance factors which affect the performance of detection systems. An overview is then provided of the strengths and limitations of the various types of detection systems that are currently available.

B2.2 DETECTION PERFORMANCE FACTORS

The performance of a detection system, be it a purely human system (i.e. by a person scanning the horizon for approaching ships) or a sophisticated radar based system, will be significantly influenced by the following:

- The aspect, material, surface textures, colour, shape and size of the target;
- The prevailing atmospheric conditions;
- The sea and precipitation conditions;
- The location of the detection device (e.g. the eye level, radar antenna, etc.).

All of the above, with exception of the last are outside the control of the installation management. The location of the detection device is, however, under the management control of the installation and has, by trial and experience, been found to have a significant influence on the performance of a detection system although it is noted that in certain cases the extended coverage is not always required.

There are currently two locations that are commonly used for the siting of the detection system, these being on the installation's standby vessel, and on the installation itself. The use of the former location is widespread throughout the offshore industry since it employs the use of the standby vessel's radar and watchkeeper, two "assets" which are already available and paid for. The use of installation or platform based detection systems is less common since it usually incurs an added cost penalty although this can be offset by greater effective coverage.

In the following discussion on available detection means, the achievable benefits of a platform based system or a standby vessel based system will be highlighted.

B2.3 VISUAL OBSERVATION

Rule 5 of the International Regulations for Preventing Collisions at Sea (collision regulations) states that every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means in the prevailing circumstances and conditions. Past accidents have, however, shown that failure to comply with this rule is the cause of a significant number of ship collisions.

Standby vessels attending an offshore installation are required to obey the same regulations and therefore should always have someone on the bridge keeping look-out for the vessel. This look-out also provides a very important function to the installation and is an invaluable component of a collision risk management strategy in terms of interpreting the situation based on all information available, (e.g. level of VHF response, navigational behaviour of vessel in water, etc.). Hence, a person with marine training generally best carries out this role.

It is noted that in addition to having a watchkeeper on the SBV, which is required under the collision regulations, there is potential to have a watchkeeper on the installation, (e.g. due to the extended range offered). This should be assessed on a case by case basis. The main characteristics of a visual look-out when considering its ability to satisfy the requirements of a collision avoidance strategy are summarised in Table 0.1.

Table 0.1
Characteristics of Visual Observation

Visual Observation	
Advantages	**Limitations**
Sensitive to colour.	Poor at assessing distance (Worse at Night).
Can assess aspect of vessel.	Subject to night adaptation.
Can positively identify targets.	Degradation through glare.
Can see light configurations.	Can get fatigued.
Can identify conspicuous marks.	Binoculars needed for early identification.
Can identify flashing lights.	Limited use in bad visibility.
Can see changing weather patterns.	Cannot accurately determine speed
Can see effect of sea on vessel.	Cannot accurately determine course
Can combine visual observation and audio communication through VHF.	Cannot reliable estimate Closest Point of Approach
Has potential to move to eliminate blind sectors and/or get a better view.	

From the preceding table it can be seen that visual observation will form a key element of any collision management systems mainly based on its ability to:

- Provide additional, more subtle information on the incoming vessel than can be made available from a radar system;
- Assess combined additional inputs with detection to generate a greater understanding of the situation, (e.g. VHF communication, lights on vessels, etc.);

Visual detection, as the sole means of detection does have limitations but these are usually minimised by training, experience and management. The use of radar as an additional means of detection is now the recognised standard and this overcomes, to a large extent, the limitations associated with the weather. Radar detection is discussed further in the next section.

With respect to the location of the observer, an observer on a platform will be both higher (than one on a standby vessel) and therefore able to theoretically see further, and will not be affected by vessel motions. In addition, if the observer is on the installation that is being protected, he will be able to see more clearly if the vessel is heading straight for the installation. An observer on a standby vessel does have the advantage that he is usually free to move (the standby vessel) to obtain a better view or perspective of an approaching ship.

In terms of cost, to have a 24 hour visual watch on an installation would be relatively expensive whereas if there is already a standby vessel in attendance, a watch is already being performed as part of the collision regulations. In addition, on an SBV someone with marine experience would perform the watch whereas on the installation this may not be the case. This marine experience is important in the assessment of the situation and the prediction of the likely actions that an incoming vessel may take.

B2.4 RADAR DETECTION

B2.4.1 Standard Marine Radar

Standard Marine Radar (SMR) as used within the marine industry is defined as a navigational radar which complies with IMO performance Standards A222(VII), A278(VII) and A477(XII). The main components of the system are:

- Power supply
- Scanner/aerial
- Transceiver
- Display

SMR is currently key to the majority of systems in operation in the North Sea although more are being fitted with ARPA devices to improve performance (See Section 0). SMR can be sighted either on the standby vessel or on the installation for longer-range coverage, although it is noted that there can be blind sectors with an installation mounted system which requires consideration. Blind sectors on a standby vessel system is of less importance provided the standby vessel is constantly "roaming" around the installation.

Ranges of detection for radar systems can be selected from 0.5 nm to in excess of 48 nm however the majority of systems in use offshore have good weather ranges in the region of 12-24 nm although it is noted that this is influenced by the factors listed in Section 0.

Currently, there is limited information on the overall effects of each of these factors on the performance of the radar. Therefore, when used for the management of ship collision it is recommended that the performance of each system be assessed through trials to ensure that it meets the required standard in all environmental conditions likely to be encountered at the specific location of the installation.

As with most radar, this system detects vessels by receiving, amplifying and processing the return of a transmitted radio signal, (i.e. uses the echo principle). The electronic data is then presented to the operator on a display screen which must be interpreted to identify which echo's correspond to vessels and which are representative of the surrounding environment, (e.g. installation, buoys, shore, rain, waves, snow, etc.).

To assist in this, radar has a number of features that can be used to enhance the effectiveness of the system such as watch alarms, which ensure that the operator is monitoring the system regularly, and tools to reduce noise, sea clutter around own ship and reflections from rain, snow and hail. These tools can be manually selected and tuned, pre-set and stored for conditions regularly experienced or automatically optimised by the system itself. In addition, most radar's provide the operator with a suite of tools which allow him to determine the course, speed and passing distance of a target to the installation. It is noted that on standard marine radar these feature are manually operated and therefore can lead to high work load if traffic monitoring is required in busy locations or if passing traffic has to be referenced to a number of installations.

High levels of manual operation can become a greater problem if the radar is set up without a gyrostabiliser. Without this, manual plotting becomes more complex, as both the target vessel and the standby vessel course and speed must be utilised to determine the target vessels passing distance, bearing and velocity. This is therefore more likely to lead to delays in hazard identification or interpolation errors if adequate training is not provided and/or the operators work load is high.

As a result of this workload and susceptibility to human error a number of add-on systems to radar are available which assist the operator in assessing the situation. The main add-on systems are ARPA and PC based systems. Both are discussed below.

B2.4.2 ARPA (Automatic Radar Plotting Aid)

An ARPA is a plotting aid which complies with IMO performance standards A422(XI) and can be considered as an 'add-on' to standard marine radar (SMR). Therefore, ARPA will not improve the likelihood of theoretical detection over SMR, however its additional features, which present additional and more accurate information about objects and vessels being tracked, will assist the watchkeeper when interpreting the situation.

One of the main features of ARPA is that it allows targets to be manually or automatically selected on the radar display and then automatically tracked as they pass through the radar range. In addition, the system presents vectors on each track to indicate the course and speed of the passing vessel. This provides useful and immediate information to the watchkeeper to assist the interpretation of the situation. In busy locations, or when a number of installations are being guarded, this feature is of considerable benefit to the operator.

It is noted that ARPA can also present details on each target in terms of CPA and TCPA. This is usually set with reference to the scanner location but can, in the case of some systems, be set to establish the installation (multi-installation with some systems) as the reference so that all targets are displayed with respect to the offshore structures themselves. This is of obvious benefit to the watchkeeper on the standby vessel, especially at locations where there is a high traffic volume or several installations are being guarded.

It is also noted that the number of targets that can be simultaneously plotted by an ARPA system is restricted, normally to around 40 targets and that any installations within the area to be covered by the radar will take up one target allocation. As a result of this it is emphasised that an assessment of the shipping should be performed in advance to ensure that the radar in operation has the capacity to track the likely maximum vessel volumes in the required area.

Another feature of ARPA that is very useful in the effective management of collision risk is its ability to allow alarm zones to be established around the installation. These can be actuated when either CPA and TCPA warning parameters are infringed which results in audio/visual signals being emitted at the display screen and/or at a remote sight.

As noted earlier, the use of ARPA will not improve the likelihood of theoretical detection since it is a system which is dependent on the radar to which it is attached. The location of the ARPA/radar will, as discussed in Section 0, be improved with being sited on a fixed and stable platform and with the radar antenna at an elevated position. If this is to be performed an assessment is required to ensure that the range setting required on the radar (for effective enacting of the platform emergency procedures) does not pose a problem in so far as the maximum number of targets that the ARPA can select is exceeded.

In addition to the above points, it is noted that trials should be undertaken to ensure that the power of the radar and the elevation of the radar scanner is such that the coverage provided is in line with that required by the installations emergency procedures. Also the workload being placed on the SBV crew requires assessment to ensure it is acceptable.

B2.4.3 PC Based Systems

PC based systems have recently become available which offer more functionality to that of SMR or SMR with an ARPA. In general there is a core of features that is common to most PC systems and thereafter some products provide additional features which are considered relevant in terms of managing collision risk. As a result of this the following subsection provides a general overview of the key functions of PC systems and following this a subsection is presented which provides an overview of additional features that are currently available.

Core Features of PC Radar systems

The main benefits of the PC based systems stem from their superior processing power. Unlike ARPA which is limited by the number and shape of alarm zone settings (circular or arc), the PC based systems offers the potential to establish any number of alarm settings of any shape. This has proved to be useful for the management of collision risk as it can be used to set:

- Operational envelopes for the SBV when monitoring traffic based on environmental conditions and the manning status within the field as well;
- More complex alarm configurations based on a combination of TCPA, CPA and range relative to the installation;
- Alarms round pipelines and subsea equipment to monitor vessel fishing or drifting over these structures.

Figure B0.1 illustrates guard zones around a pair of offshore installation which are utilising a shared SBV.

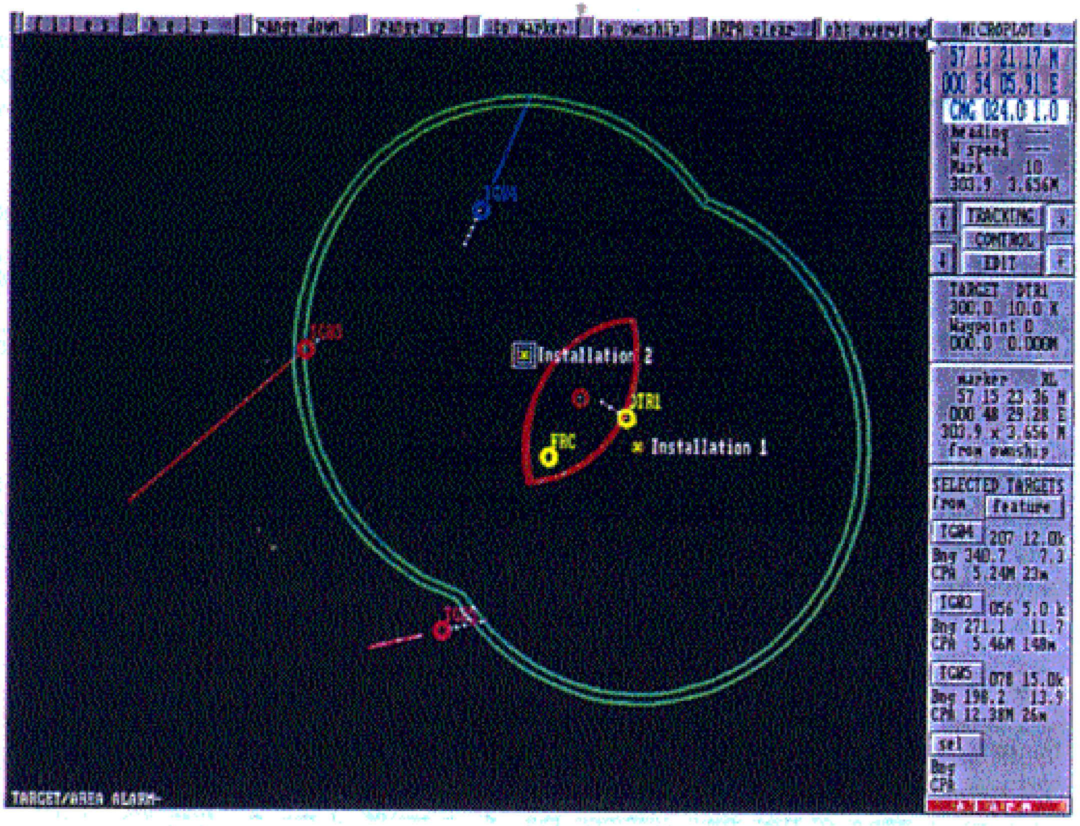

Figure B0.1
Screen View of a PC Radar System Showing Typical Guard Zones for a Shared SBV
(Photo courtesy of Sea Information Systems (SIS))

In addition to this, the PC systems provide the capability to transmit information, processed in the PC, to any remote site, (e.g. shore, installation, or SBV), to ensure that if an alarm is sounded each site can be aware of the situation. Again the benefits of this type of monitoring requires to be assessed, since remote surveillance can lead the command of a ship collision avoidance incident to someone who has neither local, up to date knowledge or possesses relevant marine experience.

In terms of visual enhancement the PC system also allows the tracked vessels to be presented on Hydrographic Office Charts. This allows the watchkeeper to assess the situation relative to other navigation features and platforms in the area.

Additional Features
In addition to the basic functionality which is common to PC based systems, some offer enhancing features which have been designed to assist the operator of an installation to manage more cost effectively not only collision risks but, in some systems, the risks associated from other hazards such as personnel rescue from the sea. The main enhancing features currently available are discussed below:

Transponder Tracking
Transponders which can be automatically tracked by PC based systems can be fitted to installations located in the area and in-field vessels (e.g. supply vessels, FRC, Daughter craft etc.), which are operating in the vicinity. This allows the radar watchkeeper to be aware of their position and to ensure that they do not continually trigger automatic alarms when working in close to the installation.

Scanner coverage
With a vessel based scanner system, blind spots generally tend to only exist during close standby and in most cases this is overcome by moving the vessel. However, with a platform mounted system, where is it not practical to move the scanner persistent blind

spots can be a problem. This requires detailed assessment by the operator and if the scanner cannot be mounted in a position to offer full coverage, consideration should be given to:

- Mounting one scanner in a manner that minimises the blind spot and places in an area know to be void of shipping, (e.g. over shallows). It is noted that this is not a commonly available solution.
- Mounting two scanners.

In the cases when two scanners are required there tends to be two solutions as to how these are monitored. Firstly there is the possibility to switch between scanners and observe what signals each system is picking up. Although this can be set up to be effective, this method is considered to be more cumbersome and error prone to the alternative which synchronises the input signals and displays the processed figure to the operator with all information presented.

Processing and Tuning

The majority of PC systems base the presented information on NMEA output from ARPA radar, which is dependent on the ability of the ARPA to hold on to targets. Although currently there have been no trials to suggest this is a limitation, some PC systems have been developed to bypass the ARPA process and perform all raw return data processing within the PC. This has facilitated a number of other opportunities:

- It allows tuning to be set for specific areas within the system as opposed to having an optimised tuning setting for the entire area of coverage of the radar. (As mentioned previously the benefits of this over SMR or SMR with ARPA have not been demonstrated and are therefore not presented within this document).
- It does not limit the number of tracks which can be monitored which is a limitation of the ARPA based systems.
- It allows automatic tuning to be performed by the PC, however, again trials have not been performed to assess whether this is advantageous or a limitation. It is noted that the views received from mariners operating in certain fields considered manual tuning a significant feature of the watcheeping process.

Personnel Locator Beacons (PLBs)

PC based systems also offer the opportunity to receive a variety of inputs to the central system and this has been used to assist in monitoring the position of personnel in water through PLB's. These are small hand held devices that are increasingly being used in the offshore industry by personnel especially in perceived higher risk operations, (e.g. helicopter transportation). When in contact with salt water these devices emit a signal that can be traced by the SBV, daughter craft, or FRC to assist in the search and rescue process.

Figure B0.1 illustrates a display of a PC based system which enables PLBs to be tracked and information presented to assist in a rapid rescue operation.

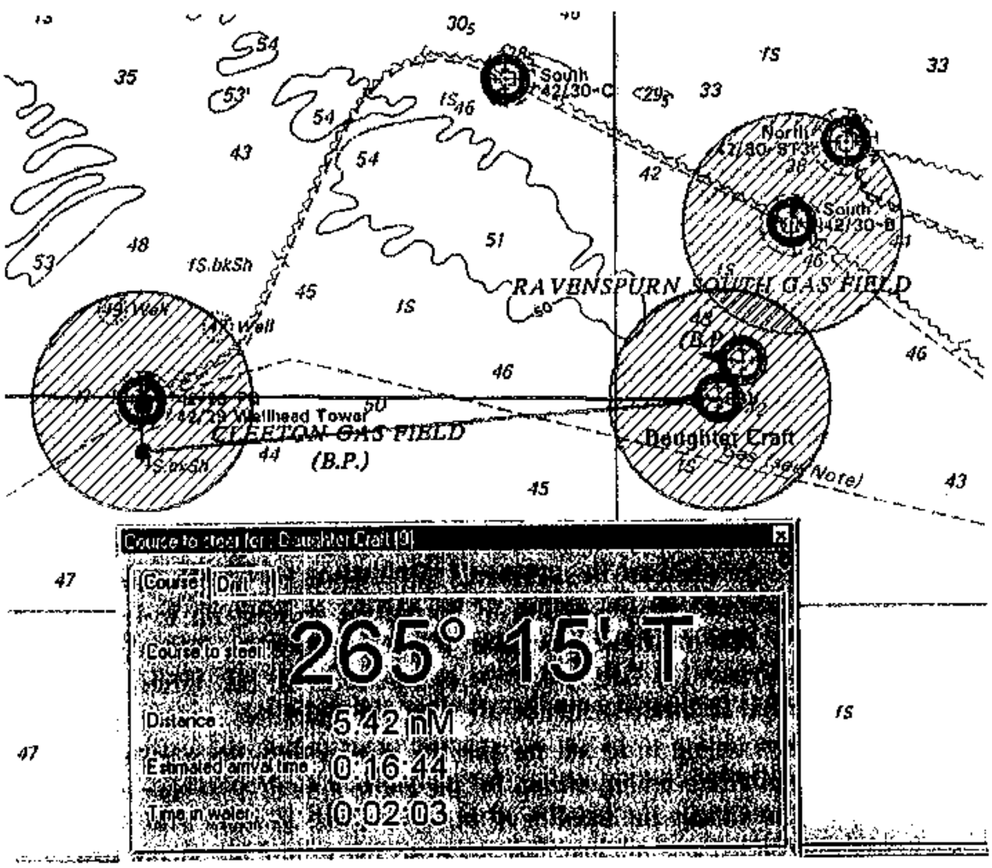

Figure B0.1
Screen View of a PC Radar System Showing PLB Tracking for Rescue Assistance
(Photo courtesy of Safe Marine)

B2.4.4 Additional Comment on Radar Detection

Throughout this review of detection system it has been emphasised that there is potential to locate the scanner on either the installation or SBV at the field and also to transmit the data to be monitored from the SBV, installation or shore. There are a number of implications associated with these variations which require to be considered by the operators, some of which are listed below:

- For a system being monitored on the installation, it is unlikely that there will be a dedicated person with marine background. It is considered more likely that the control room operator will be given this task of monitoring the radar. This person may well, however, be distracted by other duties. This poses the obvious problem of delays in detecting a potential hazard but also poses a problem with regard to tuning, maintenance and interpretation of the target data.
- In terms of monitoring, visual confirmation of any target is likely to be impractical for an installation or shore-based system, as the watchkeeper will normally be located in the control room or at too great a distance to have a view of the situation. The use of integrated CCTV systems could help reduce this problem but to-date CCTV technology has not been used for this purpose.
- For a scanner on the installation it may not be possible to achieve 360° coverage and two scanners may be required which can be expensive.
- The theoretical coverage achievable from an installation system is greatly increased, however it should be noted that effective coverage is also a feature of the radar's power rating, receiver performance and data acquisition capabilities. It is also noted that in some cases extended coverage may not be required or desirable and that this should be assessed when developing any Collision Risk Management strategy.
- Locating a scanner on the installation provides a more stable base, which is of benefit to the performance of the system especially in bad weather.

It is emphasised that irrespective of which system is opted for by the operator, as mentioned within the main body of this document, particular attention should be paid to the training of operators, the reliability of the system and also on undertaking trials to monitor the system performance against performance standards.

B2.4.5 Other Detection Systems

In addition to radar detection and the various "add-ons" to this system which have been discussed previously, there are other facilities in use around the UK which have potential to assist in detection of a vessel on a collision course, (i.e. VTS and satellite surveillance). These systems, although being (relatively) very expensive, have relevance to the offshore management of collision risk and are therefore considered to provide useful background to this study.

B2.4.5.1 VTS

The official definition of this is defined in IMO A578(XIV) as any service implemented by a competent authority primarily designed to improve the safety and efficiency of traffic and the protection of the environment. Essentially a VTS is a system, based on one or more powerful radar's, which:

- Complies with IMO Performance Standards A422(XI);
- Is located at a fixed site;
- Offers additional features which will assist in the monitoring and organisation of traffic.

The points to note with regard to the application of a VTS system are similar to those presented for the PC based systems. The main difference between these systems is that VTS always have dedicated watchkeepers monitoring the area being covered, who are trained specifically for this task. The main limitation associated with these systems is the cost associated with the hardware and of having personnel dedicated to this task on an offshore installation.

B2.4.5.2 Satellite Surveillance

The use of satellite surveillance as a detection system in the offshore/marine environment is a very sophisticated and expensive system. It is not known to be in use outside the military and for environmental surveillance purposes. The use of satellites as a navigational aid using DGPS – Digital Global Positioning System, has however been developed to be used as a detection and identification system.

The principle of the DGPS system is as follows: Mobile transponders on board different vessels automatically and continuously report via a communication link. The reports transmitted contain identity, position, speed, heading etc. Transponders within the range of the communication link receive all the reports transmitted. All information received can then be extracted and processed using software interfacing the transponder. The system is used as a supplement to the radar system, as the necessary equipment (software, hardware transponder etc.) is not installed on all vessels. The information this system produces in connection with vessel traffic surveillance is very accurate.

Detection of vessels by receiving transmitted DGPS data requires the installation of special equipment both in the passing vessels and the installation or SBV. This is likely to be a system which will become more popular in years to come, but it is still in a fairly embryonic state for the purposes of collision control and avoidance.

B3 ALERTING SYSTEMS

B3.1 INTRODUCTION

The purpose of an alerting system is to enable the installation to warn an incoming vessel on a collision course of the potential threat it poses. Limited information is available of the efficiency of the measures which will depend very much on the cause of the vessel being on a collision course and the environmental condition under which the equipment is used. The measures considered in the assessment are summarised as follows:

- Enhancement of Platform radar signal – preventative;
- Radio communication – responsive;
- Light Signals – responsive;
- Sound signals – responsive;
- Ship to ship contact – responsive;
- Helicopter fly past – responsive.

Each of these is discussed separately in Sections 0to 0.

B3.2 PLATFORM BASED RACON TRANSPONDERS

A RACON is triggered by the pulse received. It then generates and transmits its own pulse omnidirectionally, to be picked up by the incoming vessel's radar tranceiver. There are various different types of RACONS (e.g. slow sweep and fast sweep) all having different ways of responding to the incoming signal from the passing vessel radar.

RACON can send out an identification code together with the amplified radar signal since each transponder is given it's own identity code. The codes are listed in a register or in a database which is connected with the vessels radar system. Hence, if a RACON system is located on an installation, the passing vessels will receive a radar "reflection" including an ID-code. This is considered to be a useful tool for navigation, especially in bad weather conditions where fixed, identified points can be a significant help.

Other points to note with regard to RACON are the fact that it can mask other targets in a busy area (e.g. nearby installations or vessels). In addition, vessels are known to use RACONs as navigation waypoints which could result in RACON equipped installations attracting vessels thus potentially leading to a higher risk of a vessel being on a collision course with the installation.

B3.3 RADIO COMMUNICATION

As a collision avoidance measure, the purpose of a radio communication system is to enable the SBV or installation to warn an incoming vessel of the potential hazard. Radio communication is the most common warning system used offshore. The range of the radio is limited by its transmitting and receiving power however, in general, if a vessel is located at a range which is detected to pose a threat it can be contacted by radio. International regulations of travel at sea obligate all vessels to listen to the emergency channel 16.

It is worth noting that there are limiting factors in using the radio in many situations. These include the likelihood of the volume being turned down to limit the amount of background "chatter" on the bridge as well as language or other communication problems, (e.g. noise etc). One factor which must be considered with respect to the likely success probability of radio communication in a collision scenario is the causation factor of the collision scenario, since if the watchkeeper is absent from the bridge, incapacitated due to substance abuse, or had an accident, it is unlikely that a radio call will solicit a collision avoidance response.

In general, radio communication is the primary means of attempting to inform a vessel that it is on a collision course, however, it should be noted that there is no statutory requirement for a vessel to respond to attempts made to communicate with it by the standby vessel or an offshore installation. As a result, some vessels choose not to reply to standby vessel calls, which may lead to a standby vessel and OIM believing that the approaching vessel is not under command, whilst in fact it is following a predetermined path, which by planned course change will pass at a close distance from the installation.

B3.4 LIGHT SIGNALS

Light signals are a frequently used warning signal offshore and especially for vessels in distress. However, light signals have also been used to get attention from vessels on collision course and are therefore considered in this assessment. The two methods of emitting light considered in this section are:

- Pyrotechnics
- Search Lights

Each of these are discussed in the following sub-sections:

B3.4.1 Pyrotechnics

Pyrotechnics are, in this sense, any device which pyrotechnically can potentially produce a sufficient signal to gain the attention of crew onboard a vessel. The light signals can be in different colours which are emitted by devices such as a signal pistol or by a hand flare. Typical burning time for a light signal cartridge fired from a signal pistol is 8 sec and for a hand flare in the region of 10 to 40 seconds depending on whether the signal is a parachute signal or not. The altitude (firing vertically) is approximately 100 meters for the signal pistol and 300-400 meters for the hand flare and therefore the signal has the potential in reasonable weather to be seen from any vessel which is considered to pose a threat of collision. It is noted that these warning devices are likely to be particularly effective in calm conditions in darkness, and that in rough weather during daylight, and particularly in poor visibility it is less likely that the watchkeeper or crew will be alerted.

In addition, for pyrotechnics to be effective at attracting attention, there must be a member of crew in a position where they can see the surrounding area. Obviously, if the crew are asleep and/or below deck, pyrotechnics by themselves will likely be ineffective.

B3.4.2 Searchlights

Searchlights are mainly installed for emergency situations. Due to the powerful effect of these lights, they are suitable as warning measures for collision avoidance purposes. A wide variety of these lights are available for marine applications, from manually controlled low power searchlights (>100 Watt) to remote operated high power ice searchlights (up to 6500 Watts). The ice searchlight is specially designed with high luminous output and long range. In addition, it has electrical focusing for narrow or wide beam, which makes it very applicable as a collision avoidance measure. In a similar manner to that discussed for pyrotechnics these warning devices are likely to be particularly effective in calm conditions in darkness, and that in rough weather during daylight it is less likely that the watchkeeper or crew will be alerted. It is noted that standby vessels have searchlights installed to assist in search and rescue operations which can be used to warn incoming vessels on a collision course but the range of such lights may not be great, particularly in poor visibility conditions.

B3.5 SOUND SIGNALS

The intention of a sound signal is to warn a vessel on collision course of the potential hazard. Sound signals can be generated in various ways. The most common ways are firing a fulminating cartridge from a signal gun and using horns or sirens which can be located on either the installation or SBV.

The use of fulminating cartridge (pyrotechnic measure) fired from a signal pistol is considered to provide a good signal (approx. 170 dB) under most conditions, but its effect depends on proper use. The signal is a combined acoustical and optical signal, where the optical signal consists of flash and smoke.

Sirens available today need high pressure air in order to create a sufficient effect which requires the installation of a complete high pressure air compression system on the installation/vessel. On smaller vessels this may be impossible, but on bigger vessels it is a more realistic option. The sirens need to be directed towards the collision threat in order to increase the effectiveness. As a result of this, if this function is to be performed from the installations, there has to be either several sirens installed (facing all directions) or a direction controlled siren mounted high on the installation.

It is also noted that most standby vessels have one or more water cannons installed for fire fighting purposes. These measures may also be used as a warning measure by spraying water at the vessel. In order to avoid damage to vital instruments and injury to the crew it is important that the water spray is not directed at crew or places where sensible instruments are located (e.g. bridge). Directing the spray towards the hull of the ship may have a desirable effect by producing significant noise. It is noted that water fired directly at or in the line of any manned vessel may have a hazardous effect on man or equipment.

In addition to these sources it was identified that there were a variety of methods utilised by military organisations which may have the potential to generate significant noise to warn an incoming vessel. These include:

- Depth charges
- High powered sirens

Depth charges and other explosives have been developed for military purposes, but it is not known whether these are available for civilian use. The potential use of these military measures have been considered for use by offshore operators, but have so far been evaluated to be too hazardous.

The use of high power sirens, installed on SBV's is also being evaluated by the military. These investigations have shown that the high intensity of the sound waves produced by these systems can be hazardous to people. The use of high powered sirens directed at manned vessels may therefore impose a threat to people and as a result the use of this kind of measure is therefore limited. In addition, this technology is for the time being limited to military purposes.

B3.6 SHIP TO SHIP CONTACT

When it appears that a vessel is errant and on a collision course with the installation there is prospect to approach the incoming vessel to "nudge" it off course. This is considered a high risk manoeuvre, especially for standby vessel, which contravenes ship collision avoidance regulations and is not considered to be a optimal method of using the SBV which will ultimately be required to rescue personnel in the sea should a collision occur. It also places the crew of the SBV at extreme risk. It is noted that vessels under the control of an autopilot will probably not be moved off course

B3.7 HELICOPTER FLY-PAST

If available in the vicinity, a helicopter could be used to "buzz" a non-responding (to radio), approaching vessel. This alerting method has been performed successfully in the Norwegian waters.