International Guidelines for

The Safe Operation of Dynamically Positioned Offshore Supply Vessels

182 MSF Rev. 2 – April 2015

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These international guidelines have been produced by a cross-industry workgroup.

Its secretariat has been provided by IMCA – the International Marine Contractors Association – which is also making the guidelines available as part of its publications service. For this purpose, the guidelines may be referred to as 182 MSF.

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International Guidelines for the Safe Operation of Dynamically Positioned Offshore Supply Vessels

Preface

Reliable and robust methods of positioning are required for safe vessel operations in close proximity to offshore installations.

Dynamic positioning (DP) is well established as a primary method of vessel positioning, in the diving, drilling, construction, accommodation and shuttle tanker sectors, and it is especially suited to deep-water developments.

As development and management of DP becomes more refined, increasingly logistics support vessels are becoming equipped with DP systems with increasing reliance being given to such systems.

Accepted industry guidance that forms the basis of safe DP operations is the International Maritime Organization (IMO) MSC/Circ.645 – *Guidelines for vessels with dynamic positioning systems*.

DP operators should also refer to the relevant DP rules of the main classification societies and all appropriate IMCA and Marine Technology Society (MTS) documents.

Such rules and guidelines are focused principally on design, construction and operation of DP vessels and, in particular, apply the principles of redundancy in creating a hierarchy of DP equipment classes. They also set generic requirements for the verification of DP systems, including DP failure modes and effects analyses (FMEA) survey and testing procedures, as well as requirements for vessel operators to develop appropriate operating instructions.

There are also internationally recognised standards for DP training, which are set out in IMO MSC/Circ.738 – *Guidelines for dynamic positioning system (DP) operator training*. That document recommends the use of IMCA M 117 – *The training and experience of key DP personnel* (International Marine Contractors Association (IMCA)).

In addition, the 2010 amendments to the IMO International Convention on Standards of Training, Certification & Watchkeeping for Seafarers (STCW) Code introduced new guidance on the training and experience of personnel operating DP systems.

Other training guidance can be found, for example, in the Nautical Institute certification programme.

All of these documents are augmented by a range of DP related guidance from IMCA.

In addition to these industry rules and guidelines, the day to day operation of a DP vessel is considered a critical operation and is therefore being managed by vessel operators as part of their safety management system. In addition, individual charterers have specified their own requirements to safeguard the integrity of their own offshore installations. National and regional requirements are also in force. Whilst reflecting the existing industry framework, the guidelines contained in this document provide vessel operators, charterers, masters and officers with sector-specific methods for the safe operation of DP offshore supply vessels.

These guidelines were originally drawn up by an international cross-industry workgroup, and have recently been updated by the Marine Safety Forum in conjunction with IMCA and the Guidelines for Offshore Marine Operations (GOMO) Group. This document is published by IMCA but with an MSF reference (182 MSF) as it does not necessarily reflect guidelines given in other IMCA documents.

The intention is that this document will provide guidance, when DP is to be used on an offshore supply vessel, which is suitable for international application.

This document is to be revised every three years unless necessity requires a shorter review period.

Cross-Industry Workgroup Circulation List

Atlantic Towing
Blade Offshore Services
BP Exploration Operating Company
Braemar Engineering (Wavespec)
C-Mar (Americas)
DNV GL
ExxonMobil Development Company
Farstad Shipping
GOMO (Guidance for Offshore Marine Operation) Group
IMCA – International Marine Contractors Association
Island Terminals
L-3 Communications
Maersk Oil North Sea
Maersk Supply Service
Maritime and Coastguard Agency
McDermott International
MSF – Marine Safety Forum
Nederlandse Aardolie Maatschappij
Noble Drilling Services
OCIMF – Oil Companies International Marine Forum
OMSA – Offshore Marine Services Association
OSVDPA – Offshore Support Vessels DP Authority
Pemex
Petrobras
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Technip
The Dynamic Positioning Centre
Tidewater
Total Exploration & Production
Transocean
US Coast Guard

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Appendices

1 Introduction

1.1 Basis of these Guidelines

These guidelines are based on the specific characteristics of DP equipped offshore supply vessel operations.

In particular, unlike many other DP vessel operations, offshore supply vessels can, under normal operating circumstances:

i) *Terminate supply operations and move away from the offshore installation at a moment's notice*; and/or

ii) Safely manoeuvre through the use of *independent* joystick or 'manual' control whilst supply operations are being carried out.

Such operations are usually only of short duration.

It should be noted, however, that the above may not be possible when handling bulk cargo through hoses whereby safe disconnection times should be taken into consideration.

Furthermore, as offshore supply vessels routinely operate in close proximity to offshore structures and therefore pose a significant collision risk, all supply operations close to such structures should be considered as critical activities.

1.2 Application of these Guidelines

These guidelines primarily apply to DP equipped offshore supply vessels, but may also include all other types of vessels carrying out supply and other ancillary operations (usually accepted as cargo, anchor-handling and towing operations), subject to section 1.1 (i) and (ii) above, when in DP mode either inside or outside of the 500 metres safety zone of an offshore installation.

These guidelines do not preclude non-DP-equipped vessels from carrying out supply operations but merely offer guidance for those using DP. Acceptance of the limitations of vessels and decisions on suitability of DP use inside installation safety zones shall always lie with the charterer.

1.3 Purpose and Scope

The purpose of these guidelines is to make risk management tools available to vessel operators, charterers, masters and officers that will help ensure safe operation of DP offshore supply vessels in automatic DP mode.

These guidelines fit into an existing framework of rules and guidance issued by various authorities and organisations. Efforts have been made to ensure compatibility with the existing documents wherever possible.

It is recognised that both the DP and offshore supply vessel sectors are constantly evolving. Consequently, these guidelines are only fully relevant to the circumstances in which they were prepared and will have to be updated at least within a three-year cycle to incorporate such changes.

The demands placed upon vessels and the intended work scope are areas that need addressing by these guidelines through the technical and operational capabilities of the vessels themselves or limitations demanded by charterers.

Vessel operators are recommended to take account of these guidelines when carrying out DP supply and other ancillary operations. They are also encouraged to incorporate these guidelines into their own vessel management systems, including preparation of company and vessel documentation. This can be done simply by reference if necessary.

In particular, it is recommended that vessel operators take account of these guidelines when developing company and vessel documentation in accordance with document IMCA M 109 – *A guide to DP-related documentation for DP vessels*.

Section 4 (Operations) of this document addresses the application of existing international rules and guidelines and considers such measures as classification society requirements for their DP class notation and continuing verification processes.

It gives guidance on what vessel operators should have in place, as far as certification and documentation are concerned, and also contains guidance on manning, including levels of training, certification, skills and experience.

It also offers guidance on managing risk within DP operations aimed at minimising the risk of loss of position.

It also provides guidance on further risk reduction measures, DP operating procedures and DP incident reporting.

This document takes into consideration all areas that need to be factored into the risk assessment and activity specific operating guidelines (ASOG) including but not limited to:

Vessel capability:

- vessel DP equipment class;
- equipment status and performance;
- vessel manning;
- DP watchkeeper/operator experience.

Local conditions:

- proximity to installations;
- available sea room;
- environmental conditions;
- charterer's restrictions.

More detailed guidance is contained in the relevant parts of this document.

1.4 Abbreviations

The following abbreviations are used in these guidelines:

AHV	Anchor handling vessel
ASOG	Activity specific operating guidelines
AVM	Automatic vessel management
CAMO	Critical mode of operation
CCTV	Closed-circuit television
DG	Diesel generator
DGPS	Differential global positioning system
DNV	Det Norske Veritas
DP	Dynamic positioning
DPO	DP operator
DPS	DP specialist
DPVOA	The Dynamically Positioned Vessel Owners Association
EDS	Emergency disconnect sequence
FMEA	Failure modes and effects analysis
FPSO	Floating production storage and offloading unit
FSVAD	Flag state verification and acceptance document
GOMO	Guidelines for Offshore Marine Operations

HAZID	Hazard identification study
HAZOP	Hazard and operability study
HiPAP	High precision acoustic positioning system
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ICS	Integrated control system
IJS	Independent joystick
IMCA	International Marine Contractors Association
IMO	International Maritime Organization
ISM	International Safety Management Code
MRU	Motion reference unit
MSC	IMO Maritime Safety Committee
MSC/Circ.	IMO Maritime Safety Committee Circular
MTS	Marine Technology Society
NI	The Nautical Institute
NMA	Norwegian Maritime Authority
OIM	Offshore installation manager
PMS	Power management system
PPE	Personal protective equipment
PRS	Position reference system
PSV	Platform supply vessel
SIMOPS	Simultaneous operations
STCW	International Convention on Standards of Training, Certification & Watchkeeping for Seafarers
TAM	Task appropriate mode
TLP	Tension leg platform
TW	Taut wire
UMS	Unmanned machinery spaces
UPS	Uninterruptible power supply
VMS	Vessel management system
VOD	Vessel overview document
VRU	Vertical reference unit
WAAS	Wide area augmentation system
WCF	Worst case failure

1.5 Terms and Definitions

The following limited list of terms and definitions are used in these guidelines. Further definitions can be found in appropriate IMCA and MTS documents.

Ancillary operations	Supply vessel operations involving the transfer of deck, dry bulk and liquid cargoes, or any other marine surface operations such as, for example, anchor handling and supply to a pipelaying vessel.
Available (system)	A system that is capable of operating.
Capability plot	This plot provides an indication of a vessel's DP station keeping ability expressed in a common format.

DP class notation	Notation used by classification societies in grading DP vessels, based on IMO equipment class principles.
DP footprint plot	A plot designed to record the observed movement of the DP vessel from its desired target location over a period of time.
DP incident	An unexpected loss of position and/or heading; or an unexpected loss of functionality or availability of equipment, which results in a reduced level of redundancy leading to a degraded operational status; or when the DP system performance differs from the operator's expectations.
DP offshore supply vessel	A PSV, AHV or towing vessel which automatically maintains its position (fixed location or predetermined track) by means of thruster force, as defined in IMO MSC/Circ.645. Other operations may be undertaken by this type of vessel and, unless there is other more relevant guidance, these guidelines should still be applied where appropriate in those cases.
DP system	The complete installation necessary for dynamically positioning a vessel and comprising the following sub-systems as defined in IMO MSC/Circ.645: 1) power system, 2) thruster system, 3) DP control system.
Equipment class	The classification listing used in IMO MSC/Circ.645 to grade the equipment capability of DP vessels comprising the following classes: DP class 1, DP class 2 and DP class 3.
Hazmat	Hazardous materials.
Lee side	Position where any combination of environmental forces through wind, waves, swell, wave drift, surface current, surge current, tidal current, as well as changes in those factors, could move the vessel away from the installation.
Offshore installation	Fixed or mobile structure, vessel or unit used in the offshore oil and gas industry for the exploration, exploitation, storage or transfer of hydrocarbons, or as locally defined.
Online	Equipment actively interfaced with the DP system.
Operating (system)	A system that is running online.
Redundancy	The ability of a component or system to maintain or restore its function when a single failure has occurred. Redundancy can be achieved, for instance, by installation of multiple components, systems or alternative means of performing a function.
Supply operations	Cargo, anchor handling and towing operations.
Weather side	Position where any combination of environmental forces through wind, waves, swell, wave drift, surface current, surge current, tidal current, as well as changes in those factors, could move the vessel towards the installation.
Worst case failure	The identified single failure mode in the DP system resulting in maximum effect on DP capability as determined through the FMEA study.
Worst case failure intent	A single failure with the maximum consequences derived from the basis of the system's design and operational conditions. This usually relates to a number of thrusters and generators that can fail simultaneously.

2 Existing Rules and Guidance

Vessels with DP systems are subject to various international and regional rules and guidelines. This section gives a brief overview.

2.1 International Rules and Guidance

The principal internationally accepted reference on which the rules and guidelines of other authorities and organisations, including classification societies and IMCA, are based is IMO MSC/Circ.645 – *Guidelines for vessels with dynamic positioning systems*.

It provides an international standard for dynamic positioning systems on all types of new vessel, built after 1 July 1994. Its stated purpose is to recommend design criteria, necessary equipment, operating requirements and a test and documentation system for dynamic positioning systems to reduce the risk to personnel, the vessel, other vessels or structures, subsea installations and the environment, whilst performing operations under dynamic positioning control.

The responsibility for ensuring that the provisions of IMO MSC/Circ.645 are complied with rests with the operator of the DP vessel.

A central feature of IMO MSC/Circ.645 is to give guidance on DP equipment classification and redundancy requirements. Equipment classes are defined by their worst case failure modes, in accordance with the following IMO definitions:

Equipment class 1	Loss of position may occur in the event of a single fault.
Equipment class 2	Loss of position is not to occur in the event of a single fault in any active component or system. Normally static components will not be considered to fail where adequate protection from damage is demonstrated and reliability is to the satisfaction of the administration. Single failure criteria include: any active component or system (generators, thrusters, switchboards, remote controlled valves, etc.) and any normally static component (cables, pipes, manual valves, etc.) which is not properly documented with respect to protection and reliability.
Equipment class 3	Loss of position is not to occur in the event of a single fault as above for class 2 but also for normally static components which could be assumed to fail. This includes all components in any one watertight compartment, from fire or flooding; all components in any one fire sub-division, from fire or flooding, including cables, where special provisions apply under section 3.5 of IMO MSC/Circ.645.

Additionally, for equipment classes 2 and 3, a single inadvertent act should be considered as a single fault if such an act is reasonably probable.

IMO MSC/Circ.645 also gives guidance on the functional requirements for all components in the DP system.

2.2 Flag State Verification and Acceptance Document (FSVAD)

Operators should be aware that the annex to MSC/Circ.645, particularly at paragraph 5.2, describes the requirements for an FSVAD. In practice, classification societies implement these requirements on behalf of flag state administrations as 'organisations duly authorised'.

The independence of authorities who issue FSVAD should be maintained. It should always be against IMO MSC/Circ.645 and not class rules.

2.3 Classification Societies

Most classification societies use the IMO principles of equipment class and redundancy requirements as the basis for their own DP rules. Classification society rules differ and evolve and none is a direct copy of IMO MSC/Circ.645. Table 1 provides an overview of classification society DP class notations and the equivalent IMO DP equipment classes. It is, however, prudent to check with the relevant classification society to obtain its current requirements.

Class rules below do not always completely conform to IMO MSC/Circ.645 which should be the basis for all DP operations.

2.3.1 Equipment Classification

Table 1 lists equivalent notations attributable to some leading classification societies.

		No IMO Equivalent	IMO Equipment Class		
			Class 1	Class 2	Class 3
ABS	American Bureau of Shipping (USA)	DPS-0	DPS-1	DPS-2	DPS-3
BV	Bureau Veritas (France)	DYNAPOS SAM	DYNAPOS AM/AT	DYNAPOS AM/AT R	DYNAPOS AM/AT RS
CCS	China Classification Society (China)		DP-1	DP-2	DP-3
DNV	Det Norske Veritas (Norway)	DYNPOS AUTS	DYNPOS AUT	DYNPOS AUTR	DYNPOS AUTRO
		DPS 0	DPS 1	DPS 2	DPS 3
GL	Germanischer Lloyd (Germany)		DP 1	DP 2	DP 3
IRS	Indian Register of Shipping (India)		DP(1)	DP(2)	DP(3)
KR	Korean Register of Shipping (Korea)		DPS (1)	DPS (2)	DPS (3)
LR	Lloyd's Register (UK)	DP (CM)	DP (AM)	DP (AA)	DP (AAA)
NK	Nippon Kaiji Kyokai (Japan)		Class A DP	Class B DP	Class C DP
RINA	Registro Italiano Navale (Italy)	DYNAPOS SAM	DYNAPOS AM/AT	DYNAPOS AM/AT R	DYNAPOS AM/AT RS
RS	Russian Maritime Register of Shipping (Russia)		DYNPOS-1	DYNPOS-2	DYNPOS-3

Table 1 – Principal equivalent classification society DP class notations

Note: The equivalency to IMO DP class is approximate only because of differences between the various classifications and the allowance for class societies to allow exemptions etc.

These guidelines apply to offshore supply vessels in the shaded area of Table 1, i.e. equivalent to IMO equipment class 1 or higher. This minimum level excludes offshore supply vessels that are fitted with DP systems with lower levels of equipment, although this does not prevent such vessels from following these guidelines where practicable to do so.

Table 1 is not exhaustive. Other classification societies have DP rules. A DP class notation from another classification society should also be acceptable as long as it is equivalent to IMO equipment class 1 or higher.

Class societies often publish guidance on failure modes and redundancy concepts.

2.3.2 Explanatory Note

The lowest of the four categories in Table 1 refers to systems with a centralised manual control using a single position reference system and no redundancy. Although, by definition, this notation refers to a dynamic positioning system there may, however, be no automatic control element. It may be manual control, albeit through an 'intelligent' joystick.

The category includes DYNPOS AUTS, where the vessel is fitted with an automatic position keeping system, but with no centralised back up manual control system. DYNPOS AUTS does require independent manual control levers for the DP thrusters to be placed in the DP control centre. Only DNV has given a notation to this configuration.

2.4 Regional Rules and Guidance

2.4.1 Overview

There are also DP rules and guidance applicable on a regional basis, full details of which are not included in this document. Vessel operators should also be aware of any charterer's guidance or requirements. Vessel operators should make sure that they refer to the latest edition of the relevant regional rules and/or guidance.

2.5 DP System and Verification

2.5.1 Introduction

Vessel operators should be able to demonstrate to charterers and authorities that their vessels comply with relevant IMO guidelines and classification society rules and they have taken account of other recognised DP guidance. This section gives vessel operators additional guidance on how to achieve that objective.

2.5.2 DP Classification Society Notation

Vessel operators should ensure that their DP offshore supply vessels possess and maintain an appropriate DP class notation issued by a classification society. In cases where the DP system is integrated with other control systems, such as vessel management, thruster controls and position reference systems, this might be reflected in the classification society notation.

2.5.3 DP FMEA

Vessel operators should ensure that FMEAs of the DP system, and where appropriate on associated components and systems, are carried out for each of their DP offshore supply vessels. The main purpose of the DP FMEA is to determine by analysis the effects of single failures on the DP system and the consequential effects on the ability of the vessel to maintain position and heading. For equipment class 2 and 3 vessels the DP FMEA should also determine the worst case failure mode and confirm the redundancy capability of the DP system.

Although classification societies do not require DP FMEAs for an equipment class 1 vessel, there may be occasions when charterers will require a DP FMEA to ensure the quality of the system design and operation and to identify the effects of single failure on the operation of the vessel.

There are industry standards for carrying out FMEAs which are based on paragraph 5.1.1 of IMO MSC/Circ.645 and classification societies have their own specific rules. There are appropriate guidelines in IMCA M 166 – *Guidance on failure modes and effects analyses (FMEAs)* – and IMCA M 178 – *FMEA management guide*. Further information on this topic is contained within Appendix 2.

2.5.4 Annual DP Trials

Vessel operators should ensure that annual DP trials are carried out on their DP offshore supply vessels. The purpose of these trials is to ensure that the DP system has been maintained properly, is in good working order and meets the requirements of industry guidelines and assigned DP class notation.

Vessel operators should take account of guidance in IMCA M 190 – *Guidance for developing and conducting annual DP trials programmes for DP vessels*.

Annual DP trials are not as extensive as DP FMEA trials. Annual DP trial programmes should be based on a predetermined sampling basis. Where appropriate, annual trials should include associated integral control systems. Further information on annual trials is contained within Appendix 3.

2.5.5 DP Capability Plots

Vessel operators should recognise the value of DP capability plots. Specifications for capability plots are provided in IMCA M 140 – *Specification for DP capability plots.*

The purpose of DP capability plots is to determine by calculation, based on assumed propulsive power, the position keeping ability of the vessel in fully intact, certain degraded conditions and in various environmental conditions. DP capability plots should be used in the risk assessment process to determine the safe working limits of the vessel at offshore installations.

Vessel operators should also recognise that recent developments have resulted in DP capability plots being made available online as an added facility in the DP control system. Vessel operators should, however, be aware that such online information is based on theoretical calculation of assumed propulsion/thruster power and may not necessarily represent the vessel's actual DP capability. DP capability plots should be treated with caution and their results assessed for validity against the observed performance of the vessel as measured by DP footprint plots. More information on DP capability plots is contained within Appendix 4.

Important note: DP capability plots do not show vessel excursions when in DP. They show the likely environmental limits within which a DP vessel will return to the target position when an excursion takes place caused by external environmental forces. This can be for intact and degraded conditions, including, for equipment class 2 and 3 vessels, after worst case failure.

2.5.6 DP Footprint Plots

Masters and DP bridge watchkeepers should, where possible and practicable, conduct the DP footprint plots frequently. DP footprint plots are used to measure the actual position-keeping performance of the vessel in intact and degraded conditions and in various environmental conditions. It is prudent to complete footprint plots at the time of annual trials and whenever opportunities arise.

DP footprint plots serve two main purposes:

- They show the vessel's excursions in relation to the selected target position, thereby the tightness of the position keeping circle;
- They are also valuable in assessing validity of DP capability plots.

*Where there are differences between the **measured** footprint plot and the **theoretical** capability plot, vessel operators, master and DP operators (DPOs) should always ensure that the results of the footprint plot take precedence over the capability plot.*

Where results are significantly different from capability plots then vessel operators, master and DPOs should consider investigating the reason and (if appropriate) modifying the capability plots. An example DP footprint plot is provided in Appendix 5.

3 Managing Risk in DP Operations – Competence

3.1 Key DP Personnel Competence – Training and Certification

3.1.1 Introduction

Vessel operators should ensure that key personnel involved in DP operations, including DP system maintenance and repair, are competent, given necessary training and have appropriate certification. This covers masters who are in command of their vessels, navigating officers and others who operate the DP control system, engineering officers and, where applicable, electricians and electronics officers who maintain and repair other parts of the DP system.

It is recognised through the nature of operations supporting cargo, anchor handling and towing operations, that traditional manning regimes apply with additional DP specific training being supplemented to allow safe DP assisted operations.

Manual and joystick handling of the vessel in close proximity to offshore installations must however be the base skill suitably supplemented by DP training.

Additionally, competence in change-over between manual/joystick and DP assisted modes is of critical importance in the training regime.

It is highly recommended that ship operators have comprehensive training programmes for ship-handling skills as a prerequisite for DP competence.

Vessel operators should take account of appropriate training standards and guidance contained within:

- STCW 2010 part B v/f – *Guidance on the training and experience of personnel operating DP systems*;
- IMO MSC/Circ.738 – *Guidelines for dynamic positioning systems (DP) operator training*;
- IMCA M 117 – *The training and experience of key DP personnel*;
- IMCA C 002 – *Guidance document and competence tables: Marine Division*.

DPO certification is carried out by the Nautical Institute and DNV. The Norwegian Maritime Authority (NMA) has recently recognised DNV DPO certification as being a recognised equivalent to the Nautical Institute (and other international) certification.

Vessel operators should follow an appropriate DP logbook scheme, where all key DP personnel are issued with, and maintain, a personal DP logbook in which details of their DP experience are recorded. Examples are the Nautical Institute's DPO training standards and certification scheme (see www.nautinst.org) which is required for application for a DP certificate and, following certification, the IMCA DP logbook, so that the DPOs can keep a record of DP hours that they have completed.

Details of the routes to DPO certification from DNV SeaSkill can be found on the website of one of the providers, the Ship Modelling & Simulation Centre: www.smsc.no.

Other internationally recognised DPO certification and training schemes may be developed from time to time.

Other key DP personnel should also use the IMCA DP logbook to keep a record of DP experience.

3.1.2 Masters, Navigating Officers and Other Operating Personnel

The following guidance is given to vessel operators on how to achieve appropriate competency levels for masters, navigating officers and other personnel who operate the DP control system. The guidance has been developed specifically for DP offshore supply vessels and takes account of one of the main characteristics of DP supply vessel operations: in that, unlike most other DP vessel operations, a DP supply vessel operating in DP mode can usually instantaneously be switched to joystick/manual mode and moved away from the offshore installation without incurring injury, loss or damage.

Masters should satisfy themselves that the DPOs are capable of taking the vessel into manual control and moving the vessel safely out of danger (see 'Escape Route' in section 4.7).

In developing the following guidance, reference has been made to the existing training and certification schemes operated by the Nautical Institute or DNV GL and to IMCA guidance.

3.1.3 Competency Categories – DP Bridge Watchkeepers on DP Offshore Supply Vessels

DP bridge watchkeepers are defined as masters, navigating officers and, where relevant, others on watch on the navigating bridge, or other location, who are given 'hands-on' control at the DP control console in accordance with the limitations of their competence category.

Vessel operators should consider making two competency categories, 'A' and 'B', for persons taking a DP bridge watch on a DP offshore supply vessel.

The higher category 'A' applies to masters and navigating officers who are considered competent to operate the DP control system of the offshore supply vessel unsupervised and who are considered competent ship-handlers in manual control of the vessel in which they are serving.

The lower category 'B' applies to navigating officers and others who are *able* to operate the DP control system whilst under supervision by a category 'A' operator *and who are considered competent to move the vessel away from the installation in manual control*. Qualified navigating officers in category 'B' can, with appropriate training and experience, achieve category 'A' status, whereas others remain in category 'B'. This means therefore that all category 'A' DP bridge watchkeepers will be navigating officers.

It is recommended that vessel operators develop a documented training programme and maintain appropriate records.

Competency recommendations are given in Table 2.

The expression 'vessel type' means vessels of similar power, similar propulsion layout and the same DP system.

Category 'A' Master or navigating officer	♦ STCW master, chief officer or officer in charge of a navigational watch certificate of competency appropriate for class of vessel. ♦ Nautical Institute or equivalent internationally recognised DP certificate. ♦ Full competence in operating the offshore supply vessel in manual control and independent joystick when in close proximity to an offshore installation. ♦ Adequate experience on the vessel type – recommend minimum 14 days. ♦ Adequate experience of the DP control system type and equipment classification – recommend minimum 14 days. ♦ Knowledge of the vessel's DP FMEA, together with a detailed understanding of the implications of all identified failure modes. ♦ Detailed knowledge of the vessel's DP operations manual and adequate knowledge of the content of the vendor manuals. ♦ Knowledge of relevant IMCA guidelines including DP incident reporting. ♦ Consideration should also be given to providing manufacturers' courses for masters and officers in this category, in particular for the DP control system and position reference systems.
Category 'B' Navigating officer or other person[1]	♦ STCW master, chief officer or officer in charge of a navigational watch certificate of competency appropriate for class of vessel or other appropriate certification, as required by the DP offshore supply vessel operator. ♦ Received onboard training on the vessel DP system, using an appropriate logbook to record training received. ♦ Good practice would ensure that the Category 'B' operator has undertaken a recognised basic induction DP course and completed the 30 day familiarisation in line with the NI training programme or equivalent scheme and IMCA guidance. This recognises the type of vessel operation and likely manning. This should be verified by the vessel master. ♦ Competent in taking control of the vessel in manual and independent joystick and moving away from the installation.

Table 2 – Competency recommendations for bridge watchkeepers on DP offshore supply vessels

3.1.4 Competency Categories – Engineers, Electricians and Electronics Officers

Vessel operators should ensure that their engineers and, where relevant, electricians and electronics officers are suitably qualified and experienced in DP systems.

Competency recommendations are given in Table 3.

[1] Other persons may include engineers, electricians, electronics officers, etc.

Chief engineer	♦ STCW chief engineer, second engineer or officer in charge of an engineering watch certificate of competency appropriate for class of vessel. ♦ Adequate experience on the vessel type – recommend minimum 14 days. ♦ Adequate experience of the DP operations – recommend minimum 14 days. ♦ Detailed knowledge of the vessel's DP FMEA and adequate knowledge of the vendor manuals. ♦ Knowledge and understanding of failure modes. ♦ Knowledge of the maintenance requirements for DP systems. ♦ Adequate knowledge of the vessel's DP operating manual. ♦ Knowledge of relevant IMCA guidelines including DP incident reporting. ♦ Consideration should also be given to providing manufacturers' courses for chief engineers, particularly for the DP control system and maintenance requirements and, where applicable, power generation, power management and propulsion systems.
Watchkeeping engineers	♦ STCW chief engineer, second engineer or officer in charge of an engineering watch certificate of competency appropriate for class of vessel. ♦ Adequate knowledge of the vessel's DP FMEA and vendor manuals. ♦ Adequate experience of vessel type and nature of DP operations. ♦ Knowledge and understanding of failure modes.
Electricians and electronics officers	♦ It is recognised that offshore supply vessels seldom carry these officers but good practice should consider that the electrical/ electronic/engineer officer(s), as appropriate, attend the relevant course as per below. ♦ Detailed knowledge of the vessel's DP FMEA and the vendor manuals. ♦ Knowledge and understanding of failure modes. ♦ Consideration should also be given to providing manufacturers' courses for electricians and or electronics officers, particularly for the DP control system and, where applicable, power generation, power management and propulsion systems.

Table 3 – Competency recommendations for engineers, electricians and electronics officers on DP offshore supply vessels

Vessel operators should always have at least one engineer or electrician on board who has received adequate training to ensure competence and knowledge of the control systems of the vessel (DP, PMS, ICS, AVM, etc.), so that there is a first level of response to a problem on board and a person well qualified to execute recommendations from the vendors of such equipment when further help is needed.

3.2 DP Offshore Supply Vessel Manning

The level of manning of competent DP personnel on offshore supply vessels is wholly dependent upon the following:

- The way the vessel is being operated;
- The vessel capabilities and hardware configuration;
- The tasks and roles the vessel and crews are being requested to do;

This is summarised in section 4.1.

4 Managing Risk in DP Operations – Operations

The basis of safe offshore DP supply vessel operations is an adequate assessment of the risk and this should be carried out before commencing any such operations.

4.1 DP Offshore Supply Vessel Capability

Table 4 lists the factors that make up DP offshore supply vessel capability.

DP offshore supply vessel capability status level 1	♦ DP IMO equipment class 1 (class society equivalent DP class notation). ♦ Vessel operating within limits of intact thruster capability in existing environmental force conditions. ♦ DP control location manned by at least one category 'A' bridge watchkeeping officer and one other person. ♦ At least one certificated engineering officer on watch in the engine room. ♦ At least one position reference system operating and online.
DP offshore supply vessel capability status level 2	♦ DP IMO equipment class 2 or 3 (class society equivalent DP class notation). ♦ Vessel operating to identified 'worst case failure' limits in existing environmental force conditions. ♦ DP control location manned by at least one category 'A' bridge watchkeeping officer and one category 'B' bridge watchkeeping officer. ♦ At least one certificated engineering officer on watch in the engine-room. ♦ Two independent position reference systems operating and online. A third position reference system should be immediately available.
DP offshore supply vessel capability status level 3	♦ DP IMO equipment class 2 or 3 (class society equivalent DP class notation). ♦ Vessel operating to identified 'worst case failure' limits in existing environmental force conditions. ♦ DP control location manned by two category 'A' bridge watchkeeping officers. ♦ At least one certificated engineering officer on watch in the engine-room. ♦ At least three independent position reference systems operating and online.

Table 4 – DP offshore supply vessel status level capability conditions

'DP control location' manning requires the DP watchkeeper 'A' and/or 'B' to be in attendance at the DP control console at all times the vessel is operating in DP mode.

The need to man the bridge in accordance with the above only applies when the vessel is operating in DP. At other times the requirements of the watchkeeping sections of the STCW Code and/or charterer's requirements are applicable.

Table 5 describes three close proximity situations. The separation distance between the DP offshore supply vessel and the offshore installation is given as 'x' metres. The actual distance for each level of proximity should be agreed between the DP offshore supply vessel and the offshore installation before the start of operations. Some companies, vessel operators and charterers may set a minimum separation distance between the DP offshore supply vessel and the offshore installation. In setting the separation distance, consideration should be given to such influences as crane jib radii, hose length, size of load and cargo storage location.

Each situation requires its own risk assessment.

	Close Proximity Factors
Close proximity 1 (low risk)	♦ 'x' metres from the offshore installation on lee side. ♦ More than 'x' metres from the offshore installation on weather side. ♦ Short time to terminate.
Close proximity 2 (medium risk)	♦ Less than 'x' metres from the offshore installation on lee side (for brief periods only). ♦ 'x' metres from the offshore installation on weather side.
Close proximity 3 (high risk)	♦ Less than 'x' metres from the offshore installation on lee side. ♦ Less than 'x' metres from the offshore installation on weather side (for brief periods only). ♦ Long time to terminate.

Table 5 – Close proximity situations

The distances in Table 5 refer to the set-up position of the vessel in relation to the closest point on the nearby offshore installation.

There may be occasions when the risk assessment might show the advisability of joystick or manual control, such as occasions when (for operating reasons) it may be necessary for a capability 2 vessel to come closer than 'x' metres for more than brief periods.

Ship masters are encouraged to make agreement with the installation prior to arrival to determine the value of 'x'. Where platform data cards are provided then operators are encouraged to use these to indicate the required separation distance.

Table 6 shows that the least capable vessels should only be used in close proximity 1 situations (low risk) and that vessels with greater capability should be used for higher risk situations.

	DP offshore supply vessel Capability 1	**DP offshore supply vessel Capability 2**	**DP offshore supply vessel Capability 3**
Close proximity 1 (low risk)	✓	✓	✓
Close proximity 2 (medium risk)		✓	✓
Close proximity 3 (high risk)			✓

Table 6 – Vessel positioning matrix

A vessel with DP offshore supply vessel capability 1 is restricted to close proximity 1 (low risk) situations only. Note that in determining what a close proximity 1 (low risk) situation means for a DP offshore supply vessel capability 1 vessel, in particular the distance 'x', due consideration should be given to the vessel's power, its proven level of equipment redundancy and the environmental conditions. For example, some DP offshore supply vessel capability 1 vessels do have redundant features in power and propulsion even though not meeting DP class 2 equipment standards.

A vessel with DP offshore supply vessel capability 2 can do close proximity 1 and 2 (low and medium risk) operations but, where it is operating in close proximity 1, it can drop down from DP offshore supply vessel capability 2 to 1 for the time it is in that close proximity 1 situation.

Similarly, a vessel with DP offshore supply vessel capability 3 can do all three close proximity (low, medium and high risk) operations, but it can drop down to the capability required for the particular close proximity operation it is carrying out. Any planned reduction in DP offshore supply vessel capability level should be subject to agreement between the master and the OIM.

The above guidance may be used in the development of an ASOG.

4.2 Guidance on Activity-Based Operational Planning

All operations undertaken by DP vessels in the offshore oil and gas sector should be subject to activity-based operational planning and risk assessment in line with company ISM safety management systems. This is as relevant to DP offshore supply vessels as it is to other DP vessels, whether engaged in drilling, dive support, accommodation support or pipelay, etc. It should also be recognised that, in many instances, the risks and consequential losses incurred by DP offshore supply vessels in the event of a loss of position are often greater than those experienced by other DP vessel types.

Activity-based operational planning, where properly implemented, provides an effective barrier against loss of position and the resultant potential for consequential loss.

Activity-based operational planning does the following:

- Defines the vessel's systems and equipment configuration as being appropriate to the location and activity the vessel is undertaking;
- Defines the variable limits for equipment and operational parameters of the location and specific activity (ASOG);
- Defines the actions to be taken by the operator (DPO) in response to faults, deteriorating conditions and performance identified in the ASOG; and,
- Provides guidance to the operator (DPO) in a user friendly tabular format.

4.2.1 Critical Activity Mode of Operation (CAMO)[2]

Any DP vessel, including DP class 2 and 3, can have the redundancy concept defeated if its systems and equipment are not configured and operated in the correct manner. The purpose of a critical activity mode of operation is to detail in a clear and unambiguous manner how to configure a vessel's DP system, including power generation, distribution, propulsion and position reference systems, so that the DP system, as a whole, meets its maximum level of redundancy, functionality and operation and is as fault tolerant and fault resistant as it can be. For DP class 2 and 3 vessels the CAMO usually defines the most robust fault tolerant configuration of the DP system, ensuring that a single point failure[3] does not result in a condition exceeding the vessel's identified worst case failure.

The CAMO gives tabular guidance to the operator (DPO) on actions to take when the CAMO configuration is not met.

Every DP vessel has a unique CAMO configuration. A CAMO configuration is derived from a detailed review of the vessel's DP FMEA[4] and its operational characteristics. The CAMO configuration should be the default operational mode for a DP vessel, when conducting activities deemed to be critical.

It is suggested that the results of the above review are summarised in a vessel overview document (VOD). The VOD serves as a useful tool to onboard crew as well as on-coming personnel and others involved in the vessel's operations. This should be included in the DP operations manual.

4.2.2 Task Appropriate Mode (TAM)[5]

This is a risk based mode and should be derived from a comprehensive risk assessment process. Task appropriate mode is how to configure and operate the vessel's DP system, accepting that a failure could result in a condition exceeding the vessel's identified worst case failure possibly leading to blackout or loss of position.

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2 The term 'safest mode of operation' (SMO) has been previously used to describe CAMO.

3 For DP class 3 vessels a single point failure includes the loss of a single compartment through fire or flood. The term 'single compartment' is used in its widest sense and includes large compartments for thrusters/switchboards/engine rooms, etc. It may also include small enclosures containing data and control lines, etc.

4 It is assumed that the vessel's DP FMEA contains sufficient detail of the vessel's DP system to determine the CAMO. Where this is not the case it will be necessary to review as-built drawings of the DP system and associated systems and it may also require a survey of the vessel.

5 Task appropriate mode (TAM) in this context is not to be confused with thruster assisted mooring (TAM).

A TAM configuration is a choice that is consciously made. This mode may be appropriate in situations where it is determined that the risks associated with a loss of position are low and will not result in damage to people, environment or equipment. The conditions under which a DP offshore supply vessel may operate in TAM should be defined and could, for example, relate to operations well clear of the 500 metre safety zone of floating or critical subsea assets and where the consequences of a loss of position have been evaluated and deemed acceptable.

4.2.3 Activity Specific Operating Guidelines (ASOG)

Activity specific operating guidelines differ from CAMO and TAM in that it relates, specifically, to a known location and activity. The ASOG sets out operational, environmental and equipment performance limits for the DP vessel in relation to the location and specific activity that it is undertaking. A DP offshore supply vessel should have an ASOG appropriate to every location 'type' and activity 'type', although it is not usually necessary to prepare an ASOG for each specific location and activity.

Performance limits in the ASOG are set according to the level of risk. Where the risks are deemed to be high, the performance limits are set at their tightest. Limits may be relaxed where the risks are low.

4.2.4 Tabular Format – Column Definitions

Guidance for CAMO, TAM and ASOG is presented in tabular format in four categories, as follows:

4.2.4.1 Green DP Status

GREEN indicates NORMAL OPERATIONS. DP status is GREEN where all items in the GREEN column are met, indicating that the vessel is able to maintain position with adequate redundancy in all critical systems, and have the ability to handle expected environmental variations.

4.2.4.2 Blue Advisory DP Status

BLUE is an *ADVISORY* condition which applies to all operations or situations where the vessel HAS NO IMMEDIATE RISK of losing position, *but something has occurred that requires a re-evaluation of the risk*. Any ADVISORY status should immediately start the risk assessment process. The vessel cannot remain in any ADVISORY status without the DPO taking action. After a comprehensive risk assessment, operations may continue with mitigating measures in place where the ADVISORY status may be decreased to GREEN. The outcome of the risk assessment process, however, could also mean increasing to YELLOW preparing to cease operations.

There are no conditions where ADVISORY status should be considered or treated as a normal situation. If the DP system is fitted with consequence analysis this may trigger an ADVISORY status.

An example of the ADVISORY DP status is a failure of one of the main engine starting air compressors. This failure would not normally create a risk to activities that do not consume supplied air but the vessel should postpone any activity that would use a lot of air until the backup compressor is repaired.

4.2.4.3 Yellow DP Status

YELLOW is a *WARNING* condition indicating *there is a high risk of the vessel losing position should another failure occur*. The vessel is still maintaining position although some DP critical equipment will have lost redundancy. In YELLOW DP status, *operations the vessel is undertaking should be stopped so that contingency procedures can be initiated*, such as getting ready to disconnect a hose line and moving to a safe location. If the DP system is fitted with consequence analysis this may trigger YELLOW status.

An example of YELLOW DP status would be the loss or failure of one bow thruster where the vessel is only fitted with two. In this example redundancy has been lost. The vessel would still be able to maintain position but would lose position if the remaining bow thruster failed.

4.2.4.4 Red DP Status

RED indicates a ***severely degraded status or emergency***. A RED status should *immediately initiate a disconnection with all DP reliant operations terminated since the vessel may be losing position*.

When RED DP status is initiated it is essential to inform all relevant personnel immediately.

An example of a RED DP status would be a fire in a DP critical compartment or space.

4.3 Critical Activity Mode of Operation

Typical items contained in the CAMO include the following:

- Power plant set up, including whether operating with open or closed bus ties;
- Diesel generators, including confirmation of 100% output in DP;
- Thrusters including confirmation of 100% output in DP;
- Power management, including configuration confirming that auto stop is disabled and black out recovery start is enabled;
- Uninterruptible power supplies (UPS), including confirmation of power supply, function testing, and absence of cross connections;
- Manual controls and independent joystick, including confirmation of readiness and testing of operation;
- DP control system, including availability of consequence analysis, mode availability and selection;
- Position reference systems, including number, availability, testing and selection, absolute or relative systems, polling, optimum placing of targets for type and local area of operation;
- Setting of vessel centre of rotation; such as bow, mid-ships and stern;
- Setting of heading rotation speed and speed of vessel moves; for example 10 degrees per minute and 0.3 m/sec, respectively;
- Sensors, including availability, testing and selection;
- Fuel systems, including confirmation of redundancy, tank levels, standby pump starts, isolations and crossovers;
- Sea water cooling, including confirmation of redundancy, standby pump starts, isolations and crossovers;
- Fresh water cooling, confirmation of redundancy, standby pump starts, isolations and crossovers;
- Compressed air/control air, confirmation of redundancy, safest compressor operating mode;
- DP and engine room manning, including watchkeeping schedules, qualifications and competency of watchkeepers;
- Trials and checklist completions.

4.3.1 CAMO – Table Outline

A CAMO table typically uses only two columns; GREEN (Normal) and BLUE (Advisory). The same two-column table can be used for a TAM although the GREEN (Normal) conditions will differ from the CAMO.

	Green	Blue
Definition	Normal operations – all systems and equipment fully operational, DP verification processes completed and DP set up confirmed.	Advisory status – where any GREEN conditions are not met.
Response	For DP operations to commence and continue the conditions in the GREEN column must be met.	Conduct risk assessment to determine whether to continue, change position or cease operations.

Table 7 – Critical activity mode of operation – outline

An example of a CAMO can be found in Appendix 9.

4.4 Activity Specific Operating Guidance

Typical items contained in the ASOG include the following:

- Maximum watch circle radius (if applicable) for worst weather conditions identified for that activity;
- Maximum environmental operating conditions, including wind speed and current limits, and wave height;
- Weather specific vessel positioning performance, including position and heading excursions;
- Maximum offsets permissible from the set point position;
- Drive off, drift off scenarios;
- Diesel generators, including the minimum number required for the activity, performance limits and failures;
- Diesel generator loading;
- Thrusters, including the minimum number required for the activity, performance limits and failures;
- Thruster loading;
- Batteries;
- Power management system (PMS) and vessel management system (VMS) status of operation;
- Auxiliary systems performance limits and failures, including fuel, seawater and freshwater cooling and compressed air;
- Uninterruptible power supplies (UPS) operation, charger output, supply status and failures;
- DP control system, including operation and performance of DP controllers and failures;
- DP control system displays, including mimics, performance and failures;
- DP networks, including operation, redundancy and failures;
- Position reference systems, including number and types of enabled systems, suitability, performance and criticality to operation and failures;
- Sensors, including number of enabled systems, performance and criticality to operation and failures;
- Communications, including onboard systems, performance and failures;
- Non-essential DP related systems, including ventilation and air conditioning performance and failures;
- Fire, flood, visibility, collision, including threat to the DP operation;
- Simultaneous operations, including communications with assets.

4.4.1 ASOG – Table Outline

An ASOG table uses four columns: GREEN (Normal), BLUE (Advisory), YELLOW (Degraded) and RED (Emergency).

	Green	Blue	Yellow	Red
Definition	Normal operations – all systems fully functional and operating within acceptable performance limits.	Advisory status – approaching performance limits or reportable alarm status. Operations may continue whilst risks are being assessed. A failure has occurred that does not affect DP redundancy.	Reduced status – pre-defined performance limits reached, component or system failure resulting in loss of redundancy. The vessel maintains position although the vessel has lost its redundancy.	Emergency status – pre-defined operational or performance limits exceeded, component or system failure resulting in loss of control or position.
Response	For DP operations to commence and continue the conditions in the GREEN column must be met.	Conduct risk assessment to determine whether to continue, change position or cease operations.	Stop operations and initiate contingency procedures with a view to reducing the time to terminate. Prepare to disconnect. The operation should not be resumed before the vessel has regained redundancy or before all risks have been fully assessed to determine whether it is acceptable to resume operations with compromised redundancy.	Abandon operations. Take immediate action, i.e. initiate EDS (disconnect sequence) to ensure the safety of people, the environment, the operation and the vessel. The vessel should be moved to a safe position. No DP operation is to be recommenced until a full investigation has been implemented, failure resolved and fully tested.

Table 8 – Critical activity mode of operations – outline

An example of an ASOG can be found in Appendix 10.

4.5 Guidance on the Application of CAMO, TAM and ASOG

CAMO, TAM and ASOG should be developed by those who have appropriate knowledge and understanding of the vessel and its expected operations. Although the development process may involve external specialists this does not alter the strong recommendation that the vessel crew should own the CAMO, TAM and ASOG documents and the processes used to develop them, from inception through to implementation. Importantly, the master and DPOs of the vessel should be involved throughout.

Discussions on CAMO, TAM and ASOG should be carried out prior to the DP offshore supply vessel starting operations. These discussions should involve the vessel's master, DPOs, chief engineer, engineer/electric/electronics officers as appropriate and may be included as part of the pre-arrival procedure.

All parties with an interest in vessel activity based operational planning should agree on the contents of the CAMO, TAM and ASOG. All three documents should be kept up to date and combined into one readily available document. There should be a signature section at the end of the combined document.

Where a DP offshore supply vessel is operating at a charterer's offshore installation it is recommended that the combined activity based operational planning document be signed by a representative of the charterer as well as the master, chief engineer and the DPOs. The charterer's representative may be a shore based superintendent or, where possible, the OIM of the offshore installation.

The final combined activity based operational planning document should be displayed at the DP control console and in the engine control room. It should be clearly visible to the DPOs and engine room watchkeepers and used by them in setting up and operating the vessel for DP operations as well as providing them with a range of responses to degraded conditions in each mode.

4.5.1 Considerations when Developing CAMO, TAM and ASOG

When developing the CAMO, TAM and ASOG consideration should be given to the following:

- Capabilities of the vessel, for both the intact condition and degraded condition following a worst case failure (WCF) as defined by the FMEA study and appreciation of the limitations imposed upon operations in the degraded condition after such a failure;
- An understanding of the limitations imposed by weather conditions, water depth and tidal influences on the vessel's position keeping capability;
- Consequences of a loss of position and/or heading both within and outwith the limits that have been predetermined in the ASOG;
- Simultaneous operations (SIMOPS) and the effects of vessel interaction when the DP offshore supply vessel is operating in close proximity to other vessels, including the consequences of any change in status of own vessel or other vessels, e.g. Green to Blue, Yellow or Red;
- The activity being performed and the necessary time delay to safely terminate that activity before being able to manoeuvre the vessel to a safe position following a failure;
- A central component in the ASOG is a proven knowledge of black out recovery capability and time.

4.5.2 The Initiation of 'Positioning Standby'

'Positioning standby' is a heightened state of alertness initiated during the vessel's DP operation and may be triggered by a number of different conditions. It is initiated to bring all station keeping critical elements (equipment, people and processes) to a higher state of readiness, for a defined period, with the objective of preventing a loss of position.

'Positioning standby' ensures that:

- All necessary equipment is available and/or running;
- All personnel are in position to quickly respond to an event and so prevent an escalation.

'The initiation of positioning standby' may initiate:

- A change in configuration from TAM to CAMO;
- Immediate or planned cessation of non-critical activities.

Examples of 'positioning standby' are:

- Heavy lift operations;
- Increase in time to terminate;
- Deteriorating weather;
- Station keeping equipment issues;

- Other non-specified difficulties.

4.5.3 Risk Assessments Instigated to Validate the Use of TAM

Risk assessments used to validate a TAM should take account of the following:

- Fault tolerance/resistance and fault ride through capability of station keeping critical elements;
- Benefits of power plant stability (usually the reason why a TAM is initially considered) compared to the potential for a complete loss of the power plant and associated consequences.

For diesel electric vessels a task appropriate mode could mean operating with closed bus ties, whereas a critical activity mode of operation may require open bus tie configuration.

4.6 DP Operations Manual

A vessel specific DP operations manual should be prepared for each DP offshore supply vessel.

IMO MSC/Circ.645 requires a series of checklists, test procedures and DP operating instructions to be incorporated into one manual. Each classification society has its own specific requirements for a DP operations manual, each with different requirements for content.

The manual should contain sufficiently detailed instruction and guidance to enable the vessel to be operated safely in DP and safely execute its intended activities. This will include a clear statement on the DP philosophy for the vessel.

The vessel specific manual should also contain generic content, such as company policies, procedures and standing orders. However, the manual should represent the way the vessel is operated in DP.

The vessel specific DP operating manual should contain, as a minimum:

- Organisation, roles and responsibilities of key DP personnel and shore management;
- Competency, training, watchkeeping and manning regimes;
- Vessel specifications and data;
- DP philosophy;
- DP system description;
- DP standing orders;
- DP operating instructions;
- DP checklists – field arrival, location, watchkeeping and handover (bridge and engine room);
- Annual tests and procedures with summary reports;
- Initial and periodic tests and procedures with summary reports;
- Example of tests and procedures after modifications and non-conformities;
- Detailed description of power management, thrust, control and reference systems;
- Emergency procedures;
- Incident reporting;
- Capability plots and DP footprints;
- Details of all repairs, modifications and servicing attributable to the DP system.

4.7 List of DP Operational Procedures

Arrival checks	Arrival checks should be carried out before the vessel comes within 500 metres of the installation. The purpose of the arrival checks is to ensure satisfactory operation of the DP system and should include full functional checks of the operation of the thrusters, power generation, auto DP and joystick/manual controls. The checks should also ensure that the DP system is set up correctly for the appropriate DP capability class, e.g. the bridge manning should be in accordance with DP capability class requirements. These checks should be documented and kept on board the vessel and are done once for each location/ operation (an example is in Appendix 6).
Communications	There should be an effective means of communication between the DP offshore supply vessel and the offshore installation. In most cases this will be by VHF and will link the DP control console with appropriate personnel on the installation. These are likely to be the crane driver, deck foreman and radio room. Communications should be tested before arrival. There should also be effective communications between the DP console and the vessel crew on deck.
Approaching the installation	The vessel should be manoeuvred at a safe speed when within 500 metres of the installation. The vessel should not approach the installation unless authorised to do so. When making a final approach to the installation the vessel should not head directly towards it. Where a final approach is made to the installation having conducted DP set up checks, this approach should be conducted on DP or in manual control using the DP joystick.
DP location set-up checks	Location set-up checks should be carried out on every occasion and before the vessel moves into the final working location. The principal objectives of these checks are to assess the vessel's station keeping performance at the working location and to ensure that the position reference systems are properly set up. These checks should be carried out at a safe distance from the installation, in the region of 50 metres. They should also be carried out, wherever possible, at a location where, in the event of a loss of thrust, the vessel would drift clear of the installation. These checks should be documented and kept on board the vessel. Time should be allowed for the DP model to build-up (recommended 30 minutes).
Close proximity time	Close proximity time at the working location should be kept to a minimum. The vessel should only remain in the working location when supply operations are being carried out. During periods of inactivity, e.g. when the installation crane is not available for cargo transfers, the vessel should move a safe distance away from the installation. Wherever possible, when undertaking hose transfers, sufficient hose length should be given to allow the vessel to increase the separation distance.
Separation distance	The separation distance at set-up between the vessel and the installation should be carefully selected. The distance should be agreed between the vessel and offshore installation before the start of operations. The separation distance should take account of the combined movements of the vessel and the installation, where the installation is not fixed in position (such as an FPSO, spar buoy or TLP). The separation distance should be as large as is attainable in the circumstances, without adversely affecting the safety of the supply operation. Wherever possible, such as when hose transfers alone are being carried out, consideration should be given to maximising the distance by extending hose length.
Selecting a safe working location	A safe working location should be selected for every supply operation. It is safer to work on the lee side of the installation than on the weather side. Even where the ASOG shows that vessels may operate on the weather side, it is always preferable to set up on the lee side. Other elements to be considered in selecting a safe working location include the position and reach of the installation cranes, obstructions on the installation and interaction with installation thrusters.

Safe working heading	The most appropriate vessel heading should be selected on the basis that it may be necessary to make a rapid escape from the installation by driving ahead or astern. It can be an advantage to provide a good steadying vector by placing the vessel such that environmental forces are opposed by a steady state thrust output.
Escape route	An escape route should be identified. The escape route should provide a clear path for the vessel to follow when making a routine or emergency departure from the installation. Other vessels should stay clear of the escape route. The escape route should, if possible, extend 500 metres from the installation. Where circumstances demand (due to critical failures), consideration should be given to a safe anchorage clear of the installation, taking into account the surrounding subsurface infrastructure.
Environmental forces monitoring	Environmental forces are never constant. Wind, current and swell should be monitored continuously as should their effects on position keeping. Electronic monitoring methods, such as wind sensors and resultant force vectors, provide the DP control system with inputs, but these methods should be supported by visual monitoring and forecasting. Great care should be taken where there is likely to be sudden wind and/or current changes. Preventative measures may require the vessel to cease operations during these periods and move off to a safe location. Great care should also be taken in areas where lightning strikes are likely. Preventative measures may also require the vessel to cease operations during these periods and move off to a safe location.
Maintaining a safe working location	A safe working location should be maintained at all times at the installation. In particular this will require constant vigilance in respect of a possible cumulation of a number of hazards. These could include, for example, those from environmental forces and other potential dangers, such as marine and airborne traffic, or cargo operations. It will also require the vessel to operate within its design parameters and within the range of the vessel's DP capability plots. Consideration should be given to unrestricted view of the work area from the DPO position. CCTV or an observer could be of assistance. The vessel's worst case failure (DP) should be taken into consideration
DP watchkeeping handovers	Wherever possible, watch handovers should take place when the vessel is in a steady state and where the vessel is settled in position. Using a checklist handover ensures that all relevant information is passed on to the oncoming watchkeeper (see Appendix 7 for an example of a checklist).
Onboard engineering, electrical and electronics support	An engineer should be available on watch in the engine control room when the vessel is within 500 metres of the installation. Regardless of whether a vessel is equipped with or without UMS, the engineer should be in the engine control room. Good practice requires a manned engine room for all DP operations. Wherever possible, electricians and, where carried, electronics officers should be on call when the vessel is inside the 500 metre zone. Engineers, electricians and electronics officers should take account of the following when the vessel is inside the 500 metre zone: ♦ Do not start, stop or carry out maintenance on any machinery or equipment that could affect the DP system while the vessel is in DP. When in doubt a check should be made with the DP bridge watchkeeper; ♦ If problems or potential problems are detected with any DP or associated equipment during a DP operation then the DP bridge watchkeeper is to be informed immediately.
Critical and allowable vessel excursions	Critical and allowable excursion limits should be set. The critical limit should not exceed half of the separation distance between the vessel and the installation. The allowable limit should not exceed half of the critical limit.

Electronic off-position warning and alarm limits	The electronic warning limit should not exceed the allowable excursion limit above. The electronic alarm limit should not exceed the critical excursion limit above. For example, where the separation distance is 10 metres, the warning limit should not exceed 2.5 metres and the alarm limit should not exceed 5 metres. However, wherever possible, the warning and alarm limits should be less than the critical and allowable excursion limits. From the risk assessment, enter parameters for acceptable excursion and ensure all operators are familiar with set limits and necessary actions thereof and that these are clearly displayed adjacent to the DP console.
Electronic off-heading warning and alarm limits	The electronic off-heading warning limit should be set at a value that does not result in movement of any part of the vessel greater than the allowable excursion limit. The electronic off-heading alarm limit should be set at a value that does not result in movement of any part of the vessel greater than the critical excursion limit. However, wherever possible, the off-heading warning and alarm limits should be set at lower values. In setting the off-heading limits consideration should be given to the alignment of the vessel and the installation and the vessel's point of rotation. From the risk assessment, enter parameters for acceptable excursion and ensure all operators are familiar with set limits and necessary actions thereof and that these are clearly displayed adjacent to the DP console.
Position and heading changes	Changes in vessel position and heading are frequently necessary during supply operations when supply vessels are alongside fixed installations, typically because of wind and/or current changes, or for operational reasons. Such changes should be carried out in small increments. Operators should be aware of the potential dangers of a number of cumulative changes, e.g. that they may affect the line of sight for some position reference systems, such as optical systems. Ensure centre of rotation is correctly set for type of operation.
Power consumption and thruster output limits	Consideration should be given to the use of the Guidelines for Offshore Marine Operations (GOMO) as good practice for operational limitations. The power and thruster limits will depend on the nature of the vessel/ installation interface. Vessels with DP class notations 2 and 3 can, if agreement is reached with the installation OIM and/or charterer if applicable, operate to DP class 1 standards on those occasions when a DP class 1 vessel would be permitted alongside. Refer to the CAMO, TAM and ASOG as appropriate. For vessels that are operating to DP class 2 or 3 standards, the limits should be set so that the vessel will be left with sufficient power and thrusters to maintain position after worst case failure – based on running machinery. The guidelines thus provide two possible limits. For DP offshore supply vessel capability 2 and 3, the vessel operates to worst case failure in the given environmental conditions. For DP offshore supply vessel capability 1, the vessel operates to the intact capability in given environmental conditions. Methods of monitoring power consumption and thruster output limits include the use of the DP computer system's consequence analyser and effective DPO watchkeeping. After a failure the main objective would be to make the situation safe. The route to getting back to work again is to carry out a risk assessment, taking account of all possibilities. The risk assessment should determine whether it is safe to do so. Regional and or charterer's guidelines may take precedence.
Consequence analyser	Where consequence analysers are fitted they should be used.

Safe operating limits	Safe operating limits are not solely based on power consumption and thruster output levels. In setting safe operating limits consideration should be given to other relevant factors such as a mariner's awareness of the weather environment, the nature of the operation, the safety of the crew and the time needed to move clear. The safe operating limits should be governed by risk assessment.
Position reference systems	Wherever possible, if multiple position references are in use, they should be independent of each other and should be based on different principles. Relative position references should be used at installations that are not fixed in position, such as FPSOs, spar buoys and TLPs. Relative systems include, for example, optical or microwave systems. The use of both relative and absolute position reference systems together can cause conflicts particularly with moving targets. A possible example of 'three position references' could be a laser system, a microwave system on-line with one DGPS available.
Interfacing with third party equipment	Caution should be exercised when the DP system shares information with third-party equipment such as DGPS and gyro heading that performance reliability of the DP systems are not adversely affected. The need for additional trials should be considered by way of management of change.
Change of operating control mode	There may be occasions during a normal supply operation when it is appropriate to change over from auto DP control to joystick/manual control. In this case the vessel will revert to conventional supply vessel mode and will be subject to appropriate controls. Where the vessel transfers control from DP to manual or conventional control, transfer back to DP control should be subject to a repeat of location set up checks. Another possible issue in relation to control is that the preferred location for the DP control console would be the aft end of the bridge to allow unrestricted view for the DPO of the work deck and the installation. Where this is not possible some other means should be available to observe external conditions, e.g. CCTV at the DP control console or an observer on the bridge with unrestricted view.
Standby time	There are frequently occasions when the vessel is stood down for a period of time. Standby time should be put to good use. Standby time is useful since it provides opportunities to practice skills, such as ship handling, DP operating experience and taking DP footprint plots away from the installation. This standby time could be used for training and familiarisation purposes including drills.
Vessel thruster efficiency at different drafts and trims	Changes in vessel draft/trim usually occur at an installation. A shallower draft can have an adverse effect on thruster efficiency, particularly for bow tunnel thrusters. This can result in a significant loss of thruster effect, resulting in poor station keeping as well as impacting on thruster redundancy. Wherever possible, measures should be taken to maintain an appropriate draft/trim at all times when at an installation. This may mean taking in water ballast.
DP alert status	The operational status of the vessel in DP control should be monitored continuously. Vessel operators should consider a monitoring system already in use in the industry, to ensure a consistency of understanding with operators and charterers. The commonly understood system, used internationally in the offshore industry utilises a concept of red, blue, yellow and green status levels. This system does not necessarily need a system of lights or alarms, although it is useful to have an appropriate method on board to alert the relevant crew to changes in status level.

Table 9 – List of DP operational procedures

4.8 DP Incident Reporting

DP incident records are of enormous help to the industry. DP incident reports, collected and analysed over a period of more than 20 years, have helped with the understanding of faults and errors and provided manufacturers, trainers and operators with valuable assistance in their contributions toward the safe and efficient use of DP.

There should be an effective DP incident reporting procedure, details of which should be included in the vessel's DP operations manual. Vessel operators are recommended to participate in IMCA's DP incident reporting scheme.

Vessel operators should have their own incident reporting procedures which give guidance on how incidents might be categorised in their systems and for developing their own DP incident reporting procedures.

Note that even the least serious incidents can be of importance in analysing incident data.

Vessel operators should ensure that all incidents are investigated fully, that the root cause is identified and that appropriate measures are taken to prevent a recurrence. Vessel operators should also ensure that information and lessons learnt are made known to other company vessels and, where appropriate, to wider interests in the industry.

5 Managing Risk in DP Operations – Practical Application

Guiding Principles when Comparing Weather Conditions with Spinning Reserve against Loss of 50% of Available Power

DP capability is based around redundancy and the vessel's ability to maintain a desired position within the normal excursions of the control system and the prevailing environmental conditions.

A successful DP vessel design is one where the proven worst case failure (as derived from the vessel's FMEA) experienced is less than or equal to the intended system design. Single fault tolerance is achieved by the provision of redundant systems. *Adequate position-holding capability is achieved by provision of adequate remaining power and thrust.*

DP capability plots are produced and presented as a polar diagram with a number of envelopes, depicting the vessel's theoretical ability to keep position in a certain environment with various combinations of thrusters in service, including the worst case failure status. The capability plots are often set against a scale of increasing wind speed with a fixed current speed and wave height. Normally all three environmental forces are acting from the same direction.

In conventional diesel electric DP vessels, the switchboards are separated as two independent sections with power supply to the different thrusters distributed between these two. Hence if there is a failure in one of the switchboard sections, typically about 50% of all thruster capacity will be lost.

Hybrid vessels may have multiple engine rooms, complex switchboards and control systems which can give even more power redundancy, up to 75% in some cases.

In order for the vessel to be fault tolerant and be able to withstand its defined worst case failure the vessel must be managed to ensure that at all times it is capable of maintaining position within the acceptable below defined limits;

i) **Environmental conditions that either currently exist or are forecast** (worst case weather working conditions);

ii) **Available power on line** – 'redundancy is to be based on systems which are 'immediately available' for use, thus on running machinery'.

It is the available redundant power after the defined worst case failure condition noted in (ii) above that is considered as spinning reserve to allow a vessel to maintain position as defined in IMO MSC/Circ.645.

Relevant Publications

Check appropriate websites for latest revisions of each document.

Reference	Document Title
IMCA M 103	*Guidelines for the design and operation of dynamically positioned vessels*
IMCA M 109	*A guide to DP-related documentation for DP vessels*
113 IMO	*Guidelines for vessels with dynamic positioning systems (MSC Circular 645)*
IMCA M 117	*The training and experience of key DP personnel*
118 DPVOA	*Failure modes of Artemis Mk IV position referencing system*
IMCA M 119	*Fires in machinery spaces on DP vessels*
121 DPVOA	*DP position loss risks in shallow water*
IMCA M 125	*Safety interface document for a DP vessel working near an offshore platform*
IMCA M 129	*Failure modes of CPP thrusters*
IMCA M 131	*Review of the use of the fan beam laser system for dynamic positioning*
IMCA M 138	*Microbiological contamination of fuel oil IMCA questionnaire exercise results*
IMCA M 140	*Specification for DP capability plots*
IMCA M 141	*Guidelines on the use of DGPS as a position reference in DP control systems*
IMCA M 149	*Common marine inspection document*
IMCA M 155	*DGPS network provision and operational performance – A world-wide comparative study*
IMCA M 162	*Failure modes of variable speed thrusters*
IMCA M 166	*Guidance on failure modes and effects analyses (FMEAs)*
IMCA M 170	*A review of marine laser positioning systems – Part 1: MK IV Fanbeam® and Part 2: CyScan*
IMCA M 178	*FMEA management guide*
IMCA M 190	*Guidance for developing and conducting annual DP trials programmes for DP vessels*
IMCA M 206	*A guide to DP electrical power and control systems*
IMCA M 209	*RadaScan microwave radar sensor for dynamic positioning operations*
IMCA M 212	*Example of an annual DP trials report*
IMCA M 216	*Thruster integrity management guidance*
IMCA M 219	*Example specification for a DP FMEA for a new DP vessel*
IMCA M 220	*Guidance on operational activity planning*
IMCA C 002	*Guidance document and competence tables: Marine Division*
Annual IMCA DP incident reports	
IMCA safety flashes	
IMCA M 04/04	*Study on 'Methods of establishing the safety and reliability of DP systems'* (information note)
MTS Guidance	www.dynamic-positioning.com/dp_operations_guidance.cfm

DP FMEA and Annual Trials

FMEA Planning

Every classification society has rules for DP class notation and most class societies require FMEAs. There are a number of differences between each classification society, but all have based their rules for DP FMEA on the guidance contained in paragraph 5.1.1.1 of IMO MSC/Circ. 645, which calls for an initial and complete survey of the DP system. In addition, vessel operators should take account of the guidance contained in IMCA M 166 – *Guidance on failure modes and effects analyses (FMEAs)*, IMCA M 178 – *FMEA management guide* and IMCA M 219 – *Example specification for a DP FMEA for a new DP vessel*.

Outline guidance is given below:

- A DP FMEA which has been approved by a classification society with rules for DP vessels is sufficient, provided that the FMEA is maintained and updated, as required, for example when equipment is upgraded or changes made to equipment configurations;
- Additionally, however, vessel operators should consider the following guidance in respect of the FMEA;
- DP FMEAs should be carried out by appropriately qualified DP specialist(s) referred to in this appendix as DPS. Vessel operators should ensure that the chosen DPS is suitably experienced and knowledgeable in FMEA techniques. It may often be necessary for more than one person to carry out the function of DPS, as indicated below;
- An FMEA team should be gathered together. This team approach is essential for identifying FMEA elements. Although actual document preparation and data input to the FMEA is often the responsibility of an individual, FMEA input should come from a multi-disciplinary team. Each should have previous experience to some degree in carrying out FMEAs. Where DP is concerned, the team should consist of knowledgeable individuals with expertise in systems relating to machinery, control, electrical and naval architecture. They should also have knowledge of design, engineering, manufacturing, assembly, service, quality and reliability. The DPS consultancy carrying out the FMEA should make qualifications and experience of the team members available for scrutiny;
- The above requirement inevitably highlights the issue of competence. The expression 'competent' or 'competence' is rarely defined. UK Management of Health & Safety at Work Regulations 1999 provides that 'a person shall be deemed competent where he has sufficient training and experience or knowledge and other qualities to enable him properly to assist in undertaking the measures referred to'. The following may assist in selection of an FMEA team.

  It is necessary to identify the following minimum standards within an independent DPS consultancy:
  - Guidelines and standards the DPS will follow when carrying out an FMEA and how they interpret them
  - FMEA management controls, communications and administration within the DPS consultancy
  - Competency of individual DPS with respect to:
    - Number of years in marine industry (e.g. sea-going/offshore/superintendent/technical management)
    - Number of years in discipline (e.g. marine engineer, electrical engineer, control engineer, navigator, naval architect)
    - Number of years in FMEA/risk analysis work/DP auditing
    - Formal academic qualifications
  - Facilities (internal or external) for formal FMEA training such as in risk analysis, hazard and operability (HAZOP) and hazard identification (HAZID) studies
  - In-house training facilities for new recruits and those who have got 'rusty' (i.e. 'on the job' training)
  - If the DPS consultancy is an IMCA member this will ensure full access to all the available IMCA documentation. The company and its personnel should be able to demonstrate a track record or reference list relating to previous FMEA work and DP expertise
  - DPS on a specific contract should work as a team, but need not necessarily be from the same company. For existing vessels, one of the vessel's experienced DP staff should be appointed to the FMEA team, i.e. someone who knows where to source the information and why it is required. For

new vessels, a vessel operator's company representative experienced in DP vessel operation should be appointed to the team

- Further reading: IMCA M 166 – *Guidance on failure modes and effects analyses (FMEAs)* – and IMCA M 178 – *FMEA management guide*
- International standard IEC 61508-1 Annex B outlines general considerations for the competence of persons involved in any E/E/PES (electrical/electronic/programmable electronic safety-related system) or software safety lifecycle activity.

Performing the FMEA

Some items from IMCA M 166 and IMCA M 178 are included in the summary below, but the full text of those documents will be found to be helpful.

- A responsible engineer, who is fully conversant with the type of system to be analysed and its intended operation and who has good communication and administration skills, typically leads the FMEA team. Members and leadership may vary as the system design matures. Initially, it is important that some time is taken for the team to get to know the system under analysis.
- The DP FMEA should provide a clear and readable description of the vessel's DP systems and functions. At least one copy should be kept on board the vessel for reference by the vessel's crew. Vessel operators should consider a format of presentation and a depth of content that will be of assistance to the vessel's crew in their understanding of the DP system.
- The FMEA report structure should be modular so as to make updating easier. A loose-leaf folder style means that pages can be revised and replaced easily under the quality control system. Two levels of reporting are required; a comprehensive executive summary (or management overview) and a main report (with building blocks or subsections relating to each discipline). Operational assumptions should be included in the top level executive summary.
- Boundaries should be defined both physically and operationally. Guidance on defining the physical boundaries with respect to the system and sub-systems is found in IMCA M 166 section 5.5. A list of the components to be analysed by the FMEA can be found in information note IMCA M 04/04 Appendix D. This list should be used only as a guide, as DP systems are different from one another and may either include additional items to those on the list or exclude some of those items on the list.
- Manufacturers' FMEAs should be integrated into the overall FMEA. Whilst they tend to be generic, they should be reviewed and the results included in the FMEA. Any areas of weakness should be readdressed, with the manufacturer providing relevant data. Vessel operators commissioning the FMEA should use their power as customers to ensure sufficient detailed information is made available by the manufacturers to independent DP specialists (DPS).
- The DP FMEA should be subject to initial proving trials, which should be carried out before a new vessel enters service and, in the case of a new build, after the customer acceptance trials. The DP proving trials are quite distinct from the customer acceptance trials and, unless prior agreement has been reached between the owner/vessel operator, builder, classification society and DP specialist, they should be carried out independently of each other. The proving trials should be prepared or approved by the chosen DPS. The purpose of the proving trials is to verify the contents of the theoretical FMEA.
- IMCA M 166 section 5.9 gives guidance on how to administer the recommendations arising from the FMEA, i.e. actions with respect to raising, ranking and closing out the recommendations. For example:
  - What is 'critical' (safety related items and those mandatory for class);
  - What is 'best practice' (safety related items and those important but non-mandatory);
  - The time to close out the recommendations should be stated. For example, an item under A would be 'Immediate', i.e. before putting to sea, as the vessel could possibly be in non-compliance of class. An item under B would have to be addressed within a certain timeframe agreed between all parties. A successful completion or 'close out' of the recommendation should be recorded, as well as a decision not to take action.
- The strategy for carrying out an FMEA on an existing vessel should be no different to that for carrying out an FMEA on a new vessel. Both cases require good documentation. For existing vessels, if drawings are not available then, if necessary, trace the systems (e.g. cables/pipelines) to enable accurate drawings to be produced. An inferior FMEA is not acceptable just because of a lack of good documentation.
- With respect to criticality, it is the responsibility of the DPS to determine whether or not the FMEA technique is appropriate for the complete analysis. More critical systems and sub-systems within the

overall DP system such as interfaces, software and power management may require the use of other analysis tools.

- The DP FMEA should also be subject to proving trials after changes have been made to the DP system. Experience has shown that even some minor modifications to the DP system can have a disproportionate effect on its overall performance. Vessel operators should ensure that all modifications, either major or minor, are subject to management of change procedures. Documented records of the modifications and subsequent proving trials should be kept on board the vessel.
- Vessel operators should respond appropriately to external triggers in managing the DP FMEA. For example, vessel operators should be aware of advances in technical knowledge and in the industry's understanding of the many interrelated complexities of DP systems and should take appropriate measures to accommodate them. This may require vessel operators to modify existing equipment or systems in the light of latest developments, such as in power management systems. Modifications made on this basis should be managed in the same way as for other changes to the system.
- The purpose of these periodic DP trials is to verify the continued relevance of the vessel's DP FMEA and, for equipment class 2 and 3 vessels, confirm the worst case failure and the vessel's redundancy capability. Vessel operators should also ensure that their vessels' key DP personnel take an active part in the conduct of the proving trials, as this is often a good opportunity to witness a worst case failure scenario, experience the redundancy consequences or practice recovery procedures. FMEAs should be carried out on all vessels but there is a strong benefit in having them carried out for all DP classes and have them reviewed every five years or after major changes, to fully understand the vessel's capabilities and limitations under certain failure modes.

Annual DP Trials

IMCA M 190 provides guidance for the development and conduct of annual DP trials programmes for DP vessels. Chapter 4 provides guidance on the development of trials linking responsibilities, competence, type of test, planned maintenances or survey of records in lieu of test amongst other things. Chapter 5 deals with the trials themselves covering planning of trials, persons who would normally attend, their responsibilities and output of trials including management of actions. Chapter 6 gives practical guidance on the format and trials report.

Annual DP trials may be conducted as a single, separate event, or as part of a rolling test programme over the year, possibly as part of the vessel's planned maintenance programme. The industry norm is for the trials to be carried out as a single, separate event. Where the trials are held on this basis, vessel operators should ensure that they are witnessed by a third party. This could be an independent third party, or any competent person separate from the relevant operational team, such as the master or chief engineer of another vessel, or an appropriate shore-based technical specialist. Where the trials are part of a rolling test programme over the year, the vessel operator should ensure that the trials and the results are subject to independent scrutiny and approval. If it is a formal event with an external witness then this becomes part of an auditable trail. Full documentary evidence of the processes engaged are to be collated for audit purposes.

Vessel operators should ensure that the vessel's key DP personnel participate actively in the conduct of the annual DP trials programme, regardless of the form that it takes. Documented records of the annual DP trials should be kept on board the vessel for the use of the crew and made available to charterers as required.

Continued validity of the flag state verification and acceptance document (FSVAD) should be assessed.

DP Capability Plot

Following are three examples of DP capability plots. Further details can be found in IMCA M 140 – *Specification for DP capability plots.*

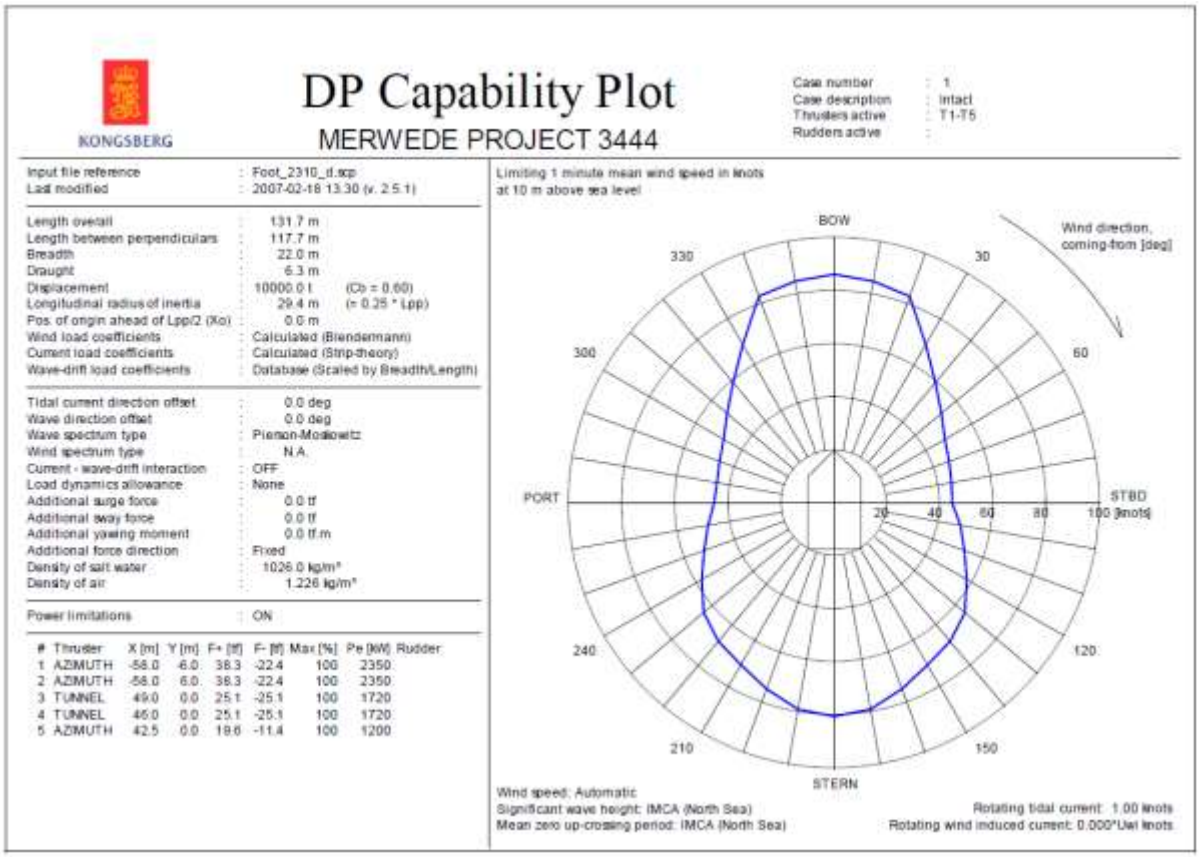


Figure 1 – Sample capability plot 1: All thrusters available vessel intact

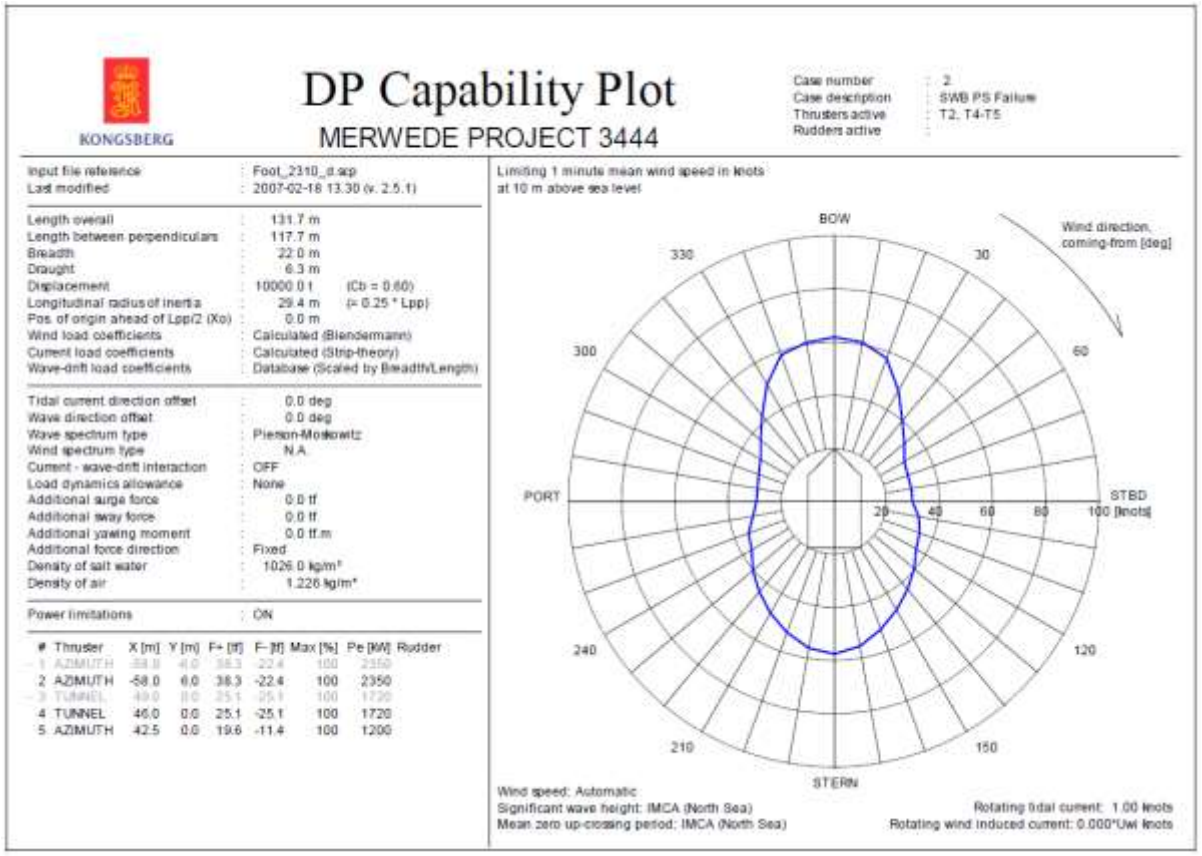


Figure 2 – Sample capability plot 2: Worst case failure loss of port side switchboard

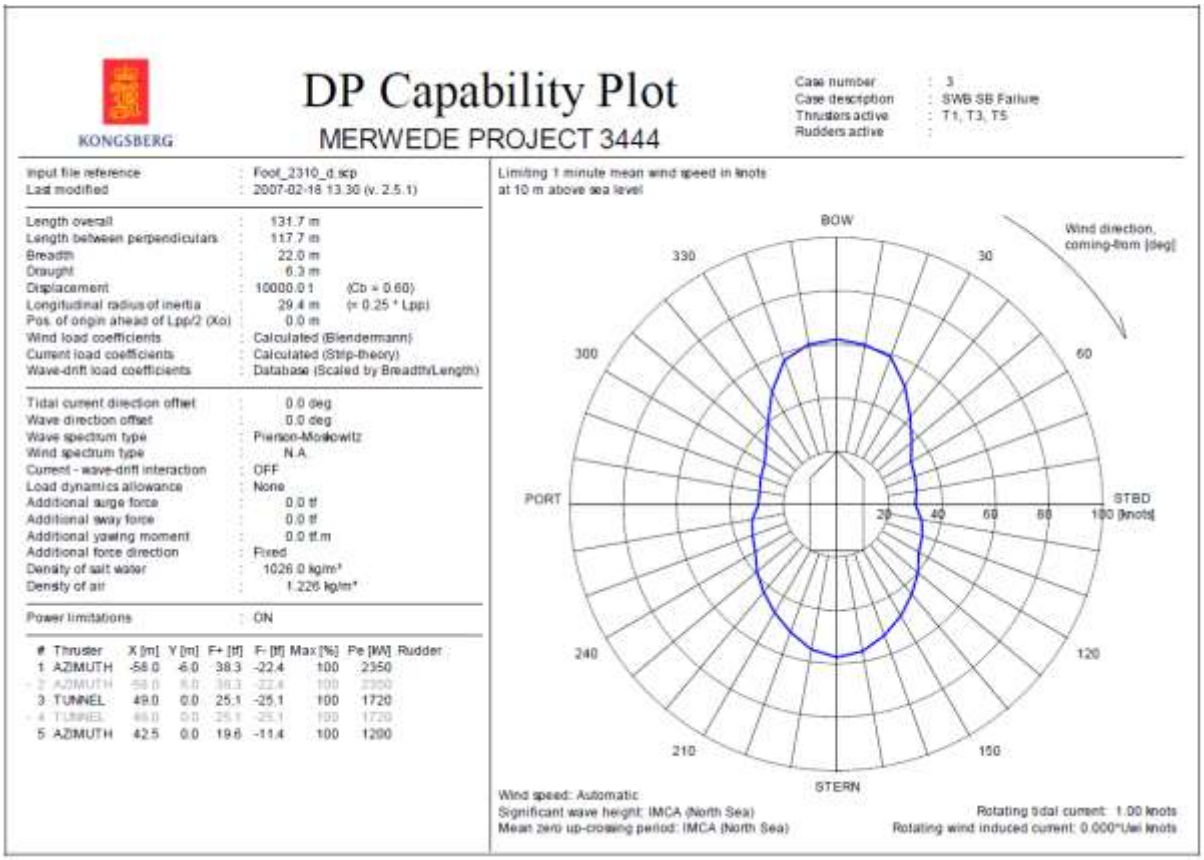


Figure 3 – Sample capability plot 3: Loss of starboard switchboard

DP Footprint Plot

Concentric scale:

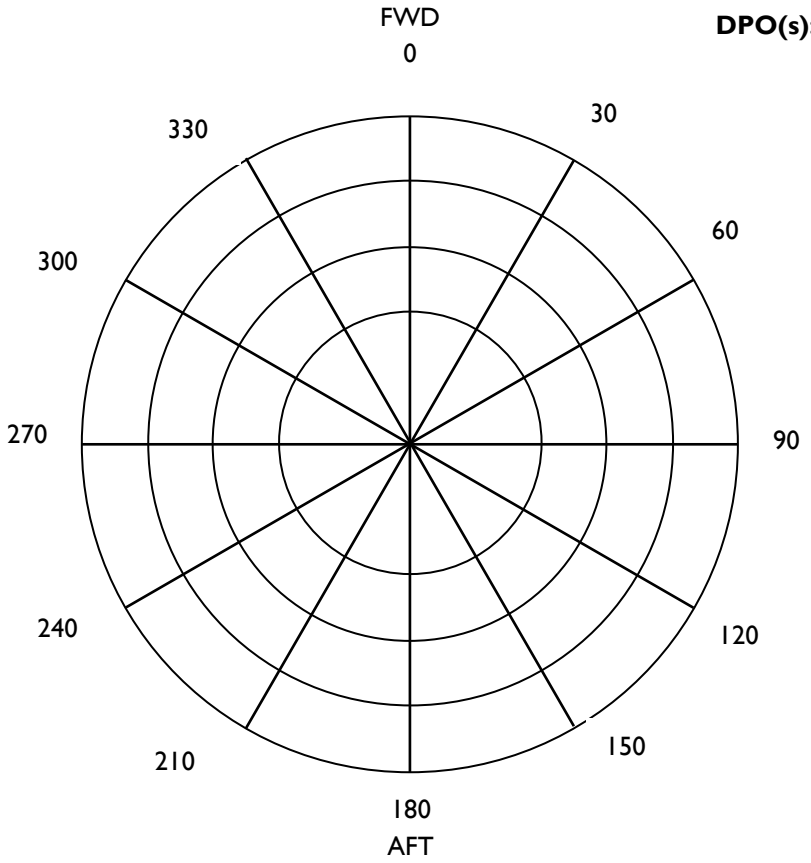
One division = _____ metres

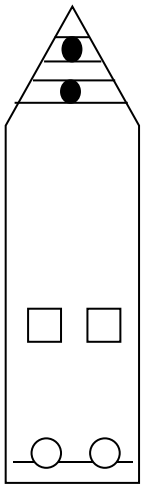
Date: _____

Time: _____

Location: _____

DPO(s): _____





Port prop

Stbd prop

Environment

Wind direction	
Wind speed	
Wave period	
Wave height	
Current direction	
Current speed	

Position References

DGPS 1	
DGPS 2	
Fanbeam	
CyScan	
Other	

Note: Draw wind and current vectors on the plot

Comments

Guidance for Conducting DP Footprint Plots

A DP footprint plot is designed to record the observed movement of the DP vessel from its desired target location over a period of time. Thruster configuration is selected at the beginning of the plot. The environmental forces of wind and waves are known from visual observation. Current is usually estimated.

A DP footprint is polar in outline with the bow, head up, at 0 degrees and the desired or target position is at the centre of the circle.

- Select a safe location away from structures, other vessels, etc.;
- Make entries on the lines in the top right hand corner, identifying when, where and by whom;
- Indicate in the vessel outline which of the thrusters is selected and on line for the duration of the plot;
- Complete the environment boxes, putting a value against all of the forces and directions. Draw arrows on the plotting chart to indicate force and direction. Note that values for current should preferably be from an independent current meter. If not available, estimates for current from other appropriate sources include surface current charts and the DP estimated current;
- Indicate which of the position references are on line for the duration of the plot;
- Select the concentric scale. One division could equal 1 metre, so that the total scale extends to 5 metres from the centre, or, if more vessel movement is expected, one division could equal 2 metres, hence increasing the total range to 10 metres from the centre;
- Start plotting by marking with an X at regular intervals, say every 30 seconds, the observed position of the vessel in relation to the target position. The vessel's position can be taken from the DP system display screen;
- Continue plotting until sufficient information is gained about the vessel's position keeping performance in the given environmental conditions. A completed plot will show the accuracy with which the vessel kept position. Plots can also show the occasions when the vessel is unable to keep position, i.e. when there is insufficient thruster force for the given environment. (This is a good check of the relevance of the calculated DP capability plots.)

DP footprint plots should be conducted whenever opportunities arise. Accumulated knowledge of the vessel's position keeping performance and the expected vessel excursions are helpful when selecting separation distance, critical and allowable excursion limits.

Note: A DP footprint is different to a DP capability plot. A DP capability plot shows by calculation maximum environmental conditions in which a DP vessel should not lose position.

Where the facility exists, the vessel's footprint in DP can be captured by enabling the 'snail trail' and then performing a screen dump. It is recommended that this method is used as well as the hard copy DP footprint plot described above.

DP Vessel Specific Location Checks Document

DP vessel specific location checks are to be carried out before the vessel commences DP operations or after any mode change.

These checks are to ensure satisfactory operation of the DP system. It is essential that full operational checks of the thrusters, power generation, auto DP and joystick/manual controls are carried out. The checks also ensure that the DP system is set up correctly and that DP manning is adequate.

Completed checklists should be kept on board the vessel in accordance with the company's document control procedures.

Notes:

- Tick or circle YES or NO throughout the checklist;
- 'YES' indicates that the item is operating satisfactorily;
- Where 'NO' is given as an answer, an explanation should be given;
- These checks are to be carried out by the DPOs on watch, signed and dated.

1 Main Engines					
Port Main Engine	YES	NO	**Stbd Main Engine**	YES	NO
Both main engines are required for DP class 2.					

2 Power Generation								
Aux DG 1	YES	NO	**Aux DG 2**	YES	NO	**Aux DG 3**	YES	NO
Two aux DGs are required for DP class 2. *Three aux DGs are required when the main crane is to be used.* **Comment**								

3 Main Stern Propulsion					
Port Z-Drive Thrust	YES	NO	**Stbd Z-Drive Thrust**	YES	NO
Port Z-Drive Rotation	YES	NO	**Stbd Z-Drive Rotation**	YES	NO
Both z-drives are required for DP class 2. **Comment**					

4 Bow Tunnel Thrusters					
BTH 1	YES	NO	**BTH 2**	YES	NO
Both bow tunnel thrusters are required for DP class 2. **Comment**					

5 Thruster Control					
Independent Joystick (IJS)	YES	NO	**Manual**	YES	NO
Test IJS and manual thruster controls in all axes to maximum thrust levels. **Comment**					

6 DP Console					
Op System 1	YES	NO	**Op System 2**	YES	NO

Lamp test and full function test of DP control console.

Test position and heading movements in auto DP control.

Test change over from auto DP to IJS and manual thruster control and back.

Comment

7 Position Reference Systems								
DGPS 1	YES	NO	**DGPS 2**	YES	NO	**DGPS 3**	YES	NO
Fanbeam	YES	NO	**HPR 400**	YES	NO	**Other**	YES	NO

Test all PRS individually and in combination.

Three PRS are required to be available for DP class 2, two of which are to be independent, e.g. 2 x DGPS plus 1 x Fanbeam or HiPAP is an acceptable combination.

Comment

8 Gyros								
Gyro 1			**Gyro 2**			**Gyro 3**		
Heading	YES	NO	**Heading**	YES	NO	**Heading**	YES	NO

Record gyro headings

Comment

9 Wind Sensors								
Anemometer 1				**Anemometer 2**				
Speed	**Direction**	YES	NO	**Speed**	**Direction**	YES	NO	

Record wind speed and direction

Comment

10 Motion Sensors								
MRU 1				**MRU 2**				
Pitch	**Roll**	YES	NO	**Pitch**	**Roll**	YES	NO	

Record pitch and roll values

Comment

11 Heading and Position Settings			
Hdg Wg = °	**Hdg Alarm = °**	**Pos Wg = m**	**Pos Alarm = m**

Comment

12 Consequence Analysis Activated?	YES	NO

Consequence analyser is required for DP class 2.

13 DP Alarm Printer Active and Clear?	YES	NO

14 Machinery Alarm Printer Active and Clear?	YES	NO
Comment		

15 Environment	
Sea State	**Current Speed and Direction**

16 Offshore Location	
Field Name	**Water Depth**

17 DP Operators	
Enter the names of all DPOs who will operate the DP system during the voyage.	
DPO Name	**DP Qualification (full or limited)**

Signed	**Time and Date**
Signed	**Time and Date**

Sample DP Watchkeeping Handover Checklist

Time and Date	:	/ /	:	/ /	:	/ /
General						
Online computer	A	B	A	B	A	B
Auto-switch on						
Consequence analysis	Off	Class 2	Off	Class 2	Off	Class 2
Alarm page clear						
Vessel mode	Auto Pos	Follow Sub	Auto Pos	Follow Sub	Auto Pos	Follow Sub
Gain	Low	Med / High	Low	Med / High	Low	Med / High
Position set-point	N		N		N	
	E		E		E	
Vessel speed	m/s		m/s		m/s	
Limits pos/head	m	°	m	°	m	°
Rate of turn	°/min		°/min		°/min	
Posplot range	m		m		m	
References						
Selected	DGPS1 / DGPS2	TW / HiPAP	DGPS1 / DGPS2	TW / HiPAP	DGPS1 / DGPS2	TW / HiPAP
HiPAP Pole	Up	Down	Up	Down	Up	Down
Transponder no.s						
Deployment						
Divers	In	Out	In	Out	In	Out
Others						
Follow Target						
ROV	In	Out	In	Out	In	Out
TP no./location						
Reaction radius	m		m		m	

Sensors																								
Gyros		1		2		3			1		2		3			1		2		3				
Wind																								
Compare																								
Environment																								
Wind dir/speed (T)		°			kts				°			kts				°			kts				
Current dir/speed (T)		°			kts				°			kts				°			kts				
Thrusters																								
Online		1	2	3	4	5			1	2	3	4	5			1	2	3	4	5				
Mode		Var.			90/270				Var.			90/270				Var.			90/270				
Set-point/F.back																								
Rudder zero																								
Power																								
Generators online		1	2	3	4	5	6		1	2	3	4	5	6		1	2	3	4	5	6			
Available		1	2	3	4	5	6		1	2	3	4	5	6		1	2	3	4	5	6			
Clutched in		1	2	3	4				1	2	3	4				1	2	3	4					
Available power		kW							kW							kW								
Maximum used		kW							kW							kW								
Communications																								
Field																								
Dive control																								
ROV																								
Deck/crane																								
Others																								
DPO Signature																								

DP Incident Reporting

Background

IMCA (and its predecessor DPVOA) has been collecting DP incident reports provided by members and publishing them as annual summary reports since 1991. IMCA reviewed the system in 2005 to make the reporting process and form more meaningful and easy to use. IMCA also decided in 2007 that DP incident reports would also be accepted in the submitting company's format providing the necessary details can be extracted from these.

Current Categorisations

The following categories of DP incidents have been proposed and agreed by IMCA. These categories should be used in conjunction with the current *IMCA DP Vessels Station Keeping Incident Form*, available free from www.imca-int.com/media/106404/imca-incidentreport-dpd.doc.

DP Incident

- Loss of automatic DP control;
- Loss of position; or
- Any other incident which has resulted in, or should have resulted in, a 'Red Alert' status.

DP Undesired Event

- Loss of position keeping stability; or
- Other event which is unexpected/uncontrolled and has resulted in, or should have resulted in, a 'Yellow Alert' status.

DP Downtime

- Position keeping problem; or
- Loss of redundancy which would not warrant either a 'Red' or 'Yellow' alert, but where loss of confidence in the DP has resulted in a stand-down from operational status for investigation, rectification, trials, etc.

DP Near-Miss

- Occurrence which has had a detrimental effect on DP performance, reliability or redundancy but has not escalated into 'DP Incident', 'Undesired Event' or 'Downtime', such as:
  - Crane or load interfering with Artemis line of sight
  - Scintillation.

DP Hazard Observation

- Set of circumstances identified which have had the potential to escalate to 'Near-Miss' status or more serious, such as:
  - Fanbeam laser target being placed in a position on handrails of a busy walkway where heavy traffic of personnel wearing personal protective equipment (PPE) with retro reflective tape is identified
  - Crane-lift being swung close to Artemis line of sight.

This category should also capture relevant occurrences even when not operating in DP mode, such as:

- Speed and latitude corrections supplied to all gyros from single DGPS by installation engineer;

- Unexpected loss of essential DP components which would have had the potential to result in 'DP Incident', 'Undesired Event' or 'Downtime' if vessel had been operating in DP mode.

Guidance for Completing the IMCA Station Keeping Incident Form

Incident Types:

1. DP incident
2. DP undesired event
3. DP downtime
4. DP near-miss
5. DP hazard observation

- Incident types 1 and 2 are likely to result in type 3;
- Identify the option on the IMCA Station Keeping Incident Form which represents the greatest potential for harm;
- All sections of the form should be completed;
- For incident types 1, 2 and 3, please indicate 'Initiating Event', 'Main Cause' and 'Secondary Cause' where appropriate on the IMCA Station Keeping Incident Form, e.g.:
  - 'Initiating Event' – Additional thrust required due to increasing environmental conditions
  - 'Main Cause' – Stoppage of thrusters
  - 'Secondary Cause' – Operator error;
- Incident types 4 and 5 can be reported to IMCA by e-mail and should only require a short description of events.

Example of Critical Activity Mode of Operation (CAMO)

Please note that this example is based upon a CAMO where the operator applied specific requirements on the vessel and may not necessarily apply to all cases.

EXAMPLE Critical Activity Mode of Operation – Name of Logistics Vessel				
No TAM operations permitted				
This set-up applies when the vessel is carrying out DP operations within the 500m zone of an offshore facility – AFI (agreed for implementation)				
Date				
Vessel to be set up and stabilised on DP before entering the 500m zone. Exiting the 500m zone may be done on joystick, manual or DP				
Condition	**Green**	**Advisory**		
Notify master, chief engineer, client rep (if on board) and rig/ platform	**NO**	**YES**		
Action	**Continue normal operations**	**Informative/ consultative status (risk assessment)**		
Switchboard set up	All bus ties OPEN	Any other configuration		
SG1, SG2, AG1 and AG2 (testing)	SG1 and SG2 online. AG1 and AG2 standby	Any other set-up, or problems found		
Emergency generator	Selected to auto start and available for immediate use. Auto start/connect and load tested prior to arrival on field	Any other configuration or known deficiencies reducing redundancy		
Blackout drill (single fuel system)	Blackout drill conducted for all DPOs and engineers onboard, procedures in place	Any DPOs on watch or engineers not performed blackout recovery drill in last six months		
DP power supply	All UPS units fully functional, not operating on bypass and tested on load 24 hours prior to field arrival. Note: Batteries must be at optimum charge level before entering 500m)	Any other configuration or known deficiencies reducing redundancy or endurance. Not tested for 30 minute endurance prior to field arrival		
24Vdc power systems (load test)	All fully functional with DC10 and DC20 cross connect breakers open (breaker F3 open in both panels) plus DC30 and DC40 cross connect breakers open (breaker F3 open in both panels). 30 minute battery endurance test carried out on DC10, DC20, DC30, DC40, DC50 24 hours prior to field arrival. Note: Batteries must be at optimum charge level before entering 500m)	Any other configuration or known deficiencies reducing redundancy or endurance. Not tested for 30 minute endurance prior to field arrival		
24Vdc power systems (battery chargers)	All on main feed to charger	Any other set-up or problems found		
Main engines (drive)	Operational and tested to 100% at field arrival	Engine not capable of 100% command or problems found		
Propellers and rudders (configuration)	One pump running on each (seawater cooling, freshwater cooling, steering pumps) with standby pumps ready for operation	Any other set-up or loss of any rudder		

Condition	Green	Advisory		
Notify master, chief engineer, client rep (if on board) and rig/ platform	**NO**	**YES**		
Action	**Continue normal operations**	**Informative/ consultative status (risk assessment)**		
Bow thrusters 1 and 2	Thrusters tested to 100% command in both directions on manual (fwd and aft) and DP at field arrival	Thrusters not capable of 100% command or problems found		
Stern thrusters 1 and 2	Thrusters tested to 100% command in both directions on manual (fwd and aft) and DP at field arrival	Thrusters not capable of 100% command or problems found		
Thruster/main propellers/rudders manual levers	Tested and fully operational on field arrival	Any known deficiencies		
Independent joystick	Tested and fully operational on field arrival	Any known deficiencies or not tested at field arrival		
Manual control	Within 24 hours the captain and each DPO practise holding vessel on position for 10 minutes	Not completed		
Thrust levels checked to within ASOG level outside the 500m zone at operational heading	Within operating limits	Above operating limits		
Emergency stops	Stops tested from the bridge on field arrival	Stops not tested or function not operational		
Thrusters, main propellers and rudders	All on line and selected in DP system	Any known deficiencies, problems or issues		
DP control system	Consequence analysis enabled, no alarms active	Any other set-up		
DP related maintenance	Not being carried out	Requested by permit to work		
DP reference system	Median check set-up and enabled, with three references online	Less than three references online, position reference deviation >3m		
DGPS	Both units operational and available	Any other set-up		
DGPS (configuration)	DGPS 1 on IALA, DGPS 2 on WAAS	Any alarms or other set-up		
DGPS (line of sight)	Field of operation is clear of possible obstruction by cranes, superstructure, etc.	Possibility of masking by cranes/structures		
Relative pos ref (Cyscan)	Operational	Not operational or faulty	Note: Only snatch lifts permitted (no hose transfers or heavy lifts)	
Rig movement (check at 100m off and during operation)	Footprint or shading not preventing use of DGPS	Movement or shading of rig such that DGPS cannot be used in conjunction with relative systems		
Wind sensors	Both available	Any other set-up		
Gyros	All three units operational and visual heading reference available. Alignment less than 1 degree	Any other set-up		
Gyros (north speed correction)	Auto speed and latitude not enabled	Any other set-up		
VRUs	Both VRUs online, no alarms, alignment less than 1 degree	Any other set-up		

Condition	Green	Advisory		
Notify master, chief engineer, client rep (if on board) and rig/ platform	**NO**	**YES**		
Action	**Continue normal operations**	**Informative/ consultative status (risk assessment)**		
Radar and traffic	Both radars on and 100% operational; and no traffic with conflicting closest point of approach	Any other situation		
Communications (internal and external)	All vessel's hardwired and portable communications equipment operational	Loss of any principal item of communications equipment		
Environment: current, wind, existing weather and forecast	Reviewed and found within DP capability and DP footprint plots	Any other condition		
Position and heading alarms	Tested OK; heading warning and alarm set at 3 and 5 degrees, respectively; position warning and alarm set at 3 and 5 metres (10 and 15 ft) respectively	Any other condition		
Escape route (in degrees true)	Escape route identified and agreed with field operations	Escape route compromised or that possibility during time span of planned operation		
Speed or moves inside 500m zone	From 500m to 200m, <=0.5 m/sec; from 200m to work location <=0.3 m/sec	Any other setting		
Thrust values when exiting 500m zone on joystick or manual	200m <25% (minimum to safely pull away); 200m-500m <50% (minimum to safely pull away out of 500m zone)	Approaching 25% or 50% respectively		
Ventilation	All fans running in engine and thruster rooms	Any problems found		
Air conditioning	Adequate cooling of DP computer area on bridge and switchboard room	Any known deficiencies		
Watertight doors	All closed	Any open		
Engine room manning	Engine room manned	Engine room not manned		
Bow thruster room	Checked regularly every watch for machinery function, flooding, etc	Not checked		
Fuel systems	Supply and return cross connects closed. Both port and starboard supply and return lines open. Day tanks sludged regularly during watch. Day tanks filled via purifier prior to entering 500m	Any other set-up or level alarm for day tanks. Any sign or potential threat of fuel oil contamination, blockage or supply failure		
Air system	Both air compressors fully operational, auto start function tested and reservoirs full	Any other set-up		
Freshwater cooling system	All freshwater cooling systems operational. Standby pump tested prior to arrival on field	Any other configuration or known deficiencies reducing redundancies		
Seawater cooling system	All system 100% operational. Standby pump tested prior to arrival on field	Seawater temperature alarm		

Example of Activity Specific Operating Guideline (ASOG)

Please note that this example is based upon an ASOG where the operator applied specific requirements on the vessel and may not necessarily apply to all cases.

Activity Specific Operating Guidelines – Name of Logistics Vessel				
This set-up applies when the vessel is carrying out DP supply operations within the 500m zone of an offshore facility				
Condition	**Green**	**Advisory**	**Yellow**	**Red**
Notify master, chief engineer, client rep (if on board) and rig/ platform	**NO**	**YES**	**YES**	**YES**
Action	**Continue normal operations**	**Informative/ consultative status (risk assessment)**	**Safely terminate operations and be ready to move off. Vessel to safe position and on joystick or manual if applicable. Orderly removal of the vessel from the 500m zone if necessary**	**Cease operations – leave 500m zone immediately**
Weather forecast	Within operating limits	Approaching operating limits	Exceeding operational limits	
Checklists: 6H; watch; 500m	Completed	Not completed or abnormalities noted		
Drive off	All systems operating correctly	Immediately when recognised by DPO		Unable to bring vessel under control
Drift off	All systems operating correctly	Immediately when recognised by DPO		Unable to bring vessel under control
Vessel footprint/weather related excursion	On position	Position limits reach 3m (10 ft)	Approaching 5m (15 ft)	
Heading excursion	On heading	Heading limit reached 3 degrees	Approaching 5 degrees	
Heading and position control (thruster load/ DP feedback)	Heading and position control achieved with <45%	Approaching 50%	More than 50%	
Shaft generators SG1-2	SG1 and SG2 online, AG1 and AG2 standby. No alarms	Any other set-up or alarms	Any generator failure	
Shaft generator loads	Both generators <45%	Any SG approaching 50%	Either >50%, or failure of a generator	
DP UPSs	No UPS in bypass, no alarm	Any UPS in bypass or alarm	Loss of one DP UPS	
24Vdc system	All 24Vdc active and fully charged, no alarms	Any alarms	Loss of a 24Vdc system or charger failure	
Main propulsion (drive engines and rudders)	Both enabled, no alarms	Any other set-up, any alarms or poor control	Loss of either port or starboard	
Bow thrusters available	Both enabled, no alarms	Any other set-up, any alarms or poor control	Loss of any bow thruster	
Stern thrusters available	Both enabled, no alarms	Any other set-up, any alarms or poor control	Loss of any stern thruster	
Fuel systems	No alarms	Any sign or potential threat or fuel oil contamination, supply line blockage, or any other supply failure	Loss of any generator due to fuel oil contamination, line blockage, or any other supply failure	
DP control system (power mimics)	All displays check and up to date	Any incorrect information	Incorrect information that affects DP operation	
DP control system (controllers/operator stations)	All controllers and operator stations online	Any alarms or poor performance	Loss of one network	
DP network	Both networks available, no alarms	Any alarms or poor performance	Loss of one network	Complete loss of networks

Condition	Green	Advisory	Yellow	Red
Notify master, chief engineer, client rep (if on board) and rig/ platform	**NO**	**YES**	**YES**	**YES**
Action	**Continue normal operations**	**Informative/ consultative status (risk assessment)**	**Safely terminate operations and be ready to move off. Vessel to safe position and on joystick or manual if applicable. Orderly removal of the vessel from the 500m zone if necessary**	**Cease operations – leave 500m zone immediately**
Position references	All fully operational and verified there is no conflict between relative and absolute position reference systems due to movement of reflector, reflective clothing etc. on the platform	Any alarms or poor performance	Only one remaining	
Heading sensors (gyro)	All three gyros enabled	Gyro alarms, loss of one gyro	Failure of two gyros	
Wind sensors	Both available	Mismatch alarm or loss of either wind sensor	Both wind sensors failure and gust conditions	
VRUs/MRUs	Both units available	Mismatch alarm or loss of one unit	Loss of two units	
Loss or problem with any essential communications (engine control room/deck/ platform)	Redundant communications	One system remaining	No communications	
Machinery ventilation and air conditioning	Operational ventilation and air conditioning	Any reduced ventilation or air condition	Reduced ventilation or air conditioning resulting in power reduction	
Starting air	No alarm	Any alarm		
Fire	No fire or active alarms	Any fire alarm	Fire confirmed	
Flood	No bilge alarms active, no flooding	Multiple bilge alarms	Flood confirmed	
Visibility	Daylight with good visibility	Any other condition		
Collision (errant vessels)	No collision imminent/ minimum approach >500m	Minimum approach will be <500m	If collision possible	Collision imminent
Change from green DP status of any other vessel in the field	Green	Advisory	Advisory	Advisory
Comms/interaction with other vessels	Vessels operating normally with no known problems	Communications problem or possible position conflict	No communications or definite position conflict	
Comms with rig	Redundant communications	Communications problem	One communications system remaining	

DPO Name:

Captain Name:

Engineer Name:

Chief Engineer Name

Client Name: