The following case studies and observations have been compiled from information received by IMCA. All vessel, client, and operational data has been removed from the narrative to ensure anonymity. Case studies are not intended as guidance on the safe conduct of operations, but rather to assist vessel managers, DP operators and DP technical crew in appropriately determining how to safely conduct their own operations. Any queries should be directed to IMCA at dpreports@imca-int.com. Members and non-members alike are welcome to contact IMCA if they have experienced DP events which can be shared anonymously with the DP industry.

The following case studies have been chosen with the intention of creating discussion points for all Key DP personnel. The events have already taken place but, what could have been done differently? Hindsight is wonderful, but these case studies allow us to stop, think and learn lessons that can be carried into future DP operations.

The IMCA DP Committee has contributed to each of the studies by adding their knowledge and experience.

## 1 Case Study – Hybrid Failure

### 1.1 Overview of the Event

A PSV was conducting DP operations within a 500m Zone. The vessel had an energy storage system (ESS) fitted and was configured closed bus with a single generator connected as per below:

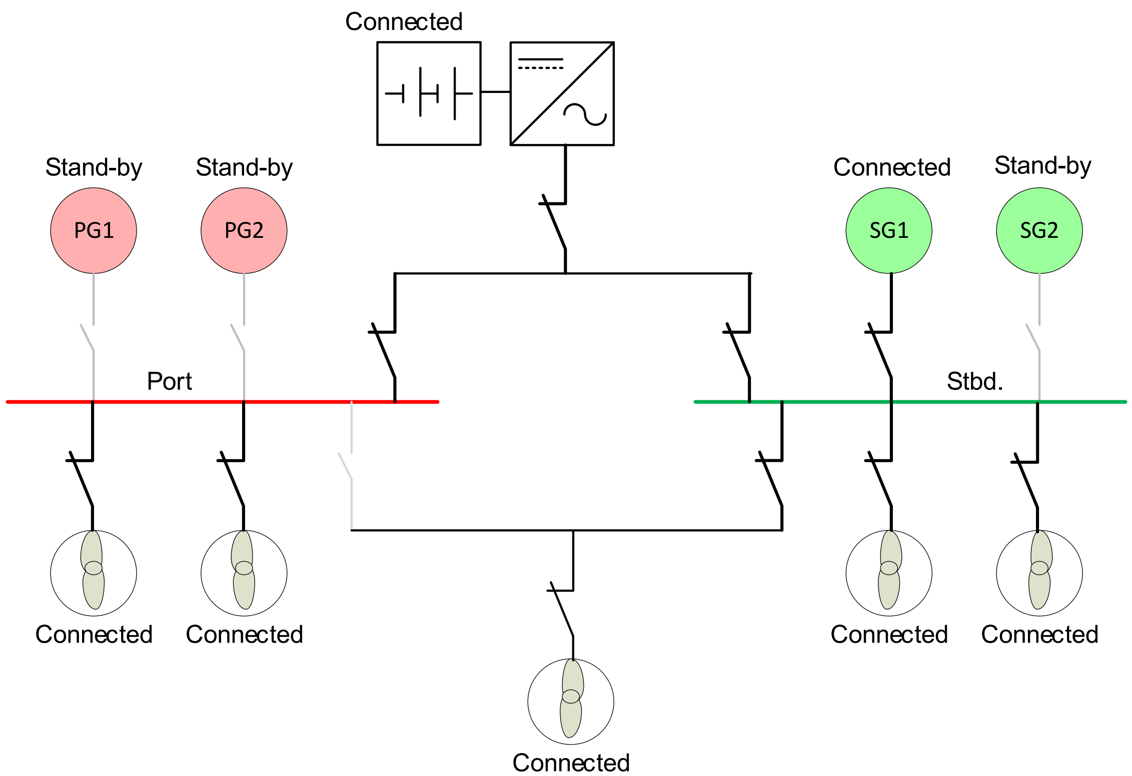


*Figure 1-1 Initial Setup*

Three out of the five thrusters were powered from the starboard switchboard with a single generator connected. The port switchboard provided power to two of the five thrusters, with no generators connected. The two electrical systems were linked with the ESS connected to that link.

A malfunction in the battery converter system caused the battery incomer circuit breakers to trip, resulting in the separation of the switchboard, the loss of power to the port switchboard and the subsequent failure of two thrusters. The generators PG1, PG2 & SG2 automatically started and connected to restore power. There was no positional loss.

### 1.2 What can be concluded?

- The vessel was operating within its Worst Case Failure Design Intent (WCFDI) environmental constraints.
- The protection system operated as designed.

### 1.3 How can lessons learned from this event be applied to prevent future DP incidents?

- The vessel was conducting cargo operations beside a fixed asset.
- The vessel was operated as designed for DP redundancy but shows that failures can happen in the ESS 'static' power supply. i.e. failures are not just reserved for spinning (dynamic) machines.
- The significance of a proper FMEA, annual DP trials, and CAM-compliant setup. Understand your vessel for both DPOs and Engineers.
- Do not wait until the Consequence Analysis alarm has activated. Stay within the weather window of the present configuration, as partial blackouts can happen at any time.

### 1.4 Guidance that would be relevant

The following IMCA Guidance would be relevant to this case study:
IMCA M220 – *Guidance on operational planning*
IMCA M250 - Introduction to hybrid battery systems for DP vessels
IMCA M103 - *Guidelines for the design and operation of dynamically positioned vessels*
IMCA M166 - *Guidance on failure modes and effects analysis (FMEA)*
IMCA M190 - Guidance for developing and conducting DP annual trials programmes.

## 2 Case Study – Common Power Supplies - Don't have all your eggs in one basket.

### 2.1 Overview

A vessel was conducting operations while operating in DP Follow Target Mode alongside a pipelayer. Unexpectedly, all six thrusters stopped functioning and were unavailable to DP Control. The vessel began to drift towards the pipelayer; however, after some time, two thrusters were activated in manual control and the vessel was able to avoid the pipelayer and manoeuvre into a safe position. The vessel eventually was able to recover all thrusters and return to DP Control.

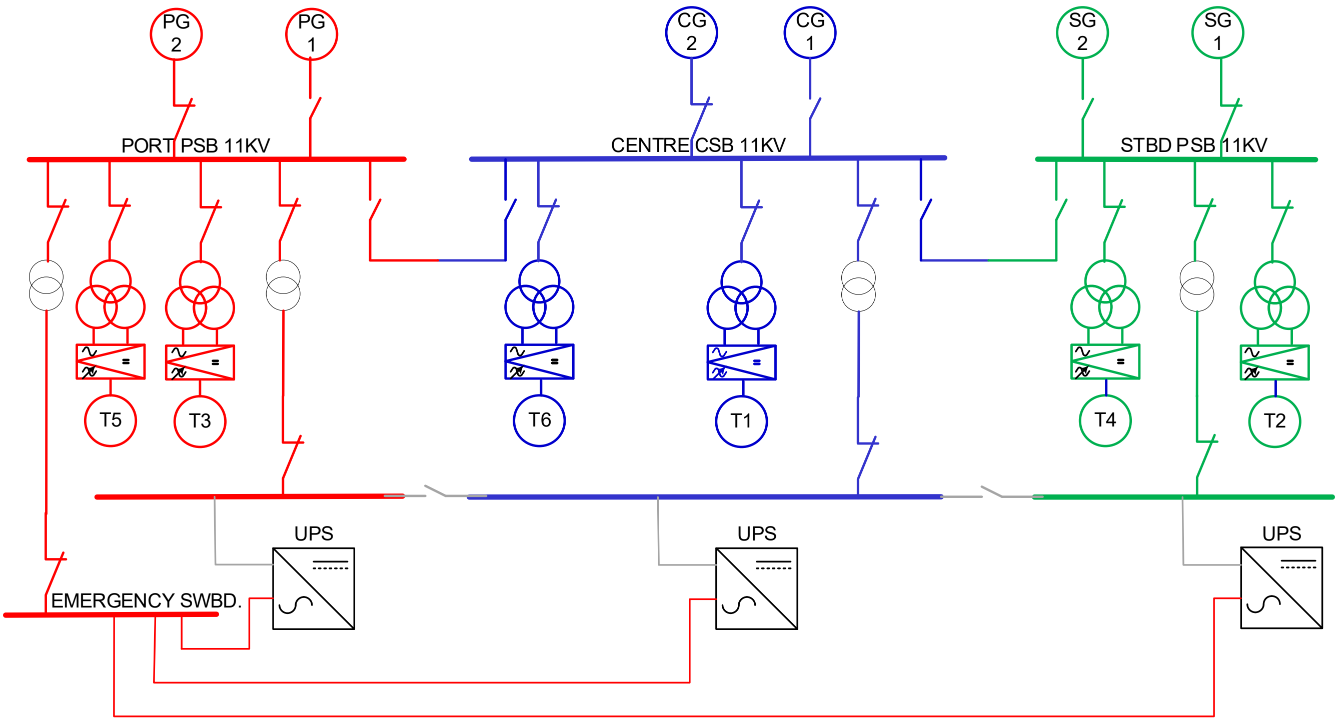


*Figure 2-1 Vessel Power Configuration at time of incident*

The switchboard was configured as a three-way split with one generator connected to each section, each section supplied power to two thrusters.

### 2.2 Cause

The underlying cause was the unintended closure of one of two rigsavers on one of the connected bus sections, which resulted in a loss of power and a reduction in speed on one engine, resulting in a decrease in frequency on the affected bus. In this instance, the affected bus supplied power to the emergency switchboard, which consequently experienced a reduction in frequency. During this time, the standby generator for the affected bus attempted to start and connect, but could not, due to the low frequency of the bus.

The three 440Vac switchboard UPS's were supplied from the emergency switchboard; upon detecting the low frequency, these units sounded alarms on Inverter failure, triggering multiple communication alarms and causing the thrusters to de-select from DP Control and shut down. Finally, the affected generator tripped and locked out, initiating a blackout recovery on the affected bus; with normalised frequency levels, all thrusters were able to be recovered back into DP Control.

Note:

The RIG SAVER™ is a swing-gate, spring-operated, air-to-close, shut-off device mounted in the air intake system of the generator engine. The device uses stored energy by way of a spring to physically move the swing-gate into a closed position. Once the swing-gate is in the closed position it will latch. The RIG SAVER™ can only be reset (opened) locally with a 19mm wrench. Once activated it will impede the airflow into the cylinders and positively stop the engine. The RIG SAVER™ can be remotely operated (in this case using the engine start air) and/or locally by a pull toggle.

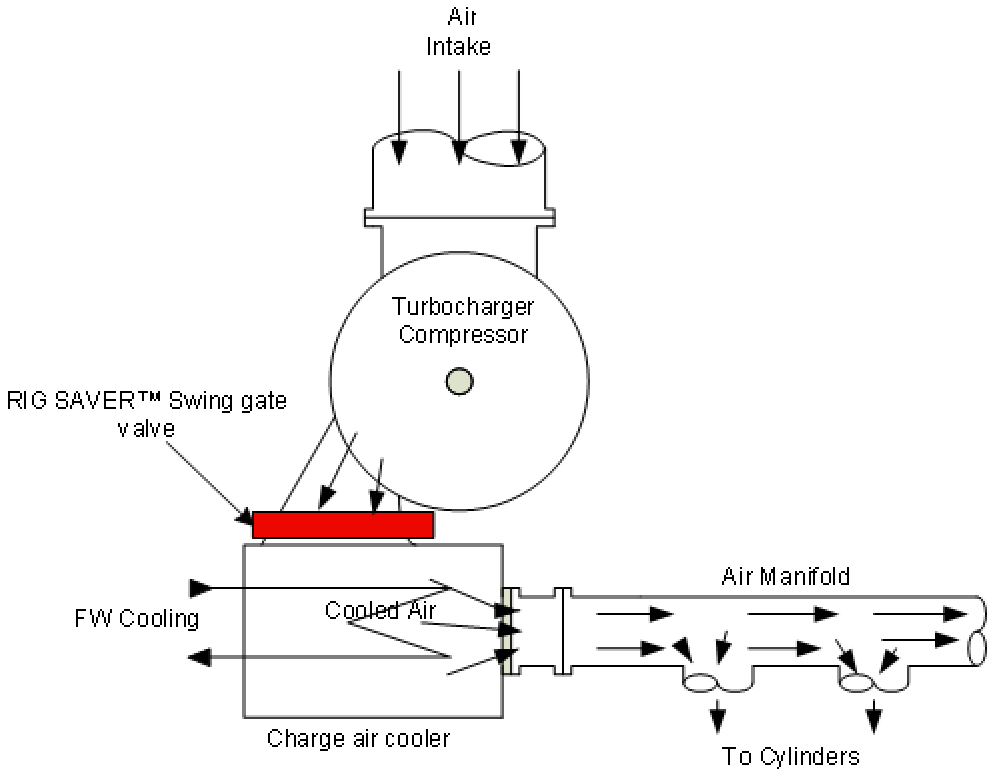


*Figure 2-2 Location of RIG SAVER™ Swing Gate Valve on Generator Engines*

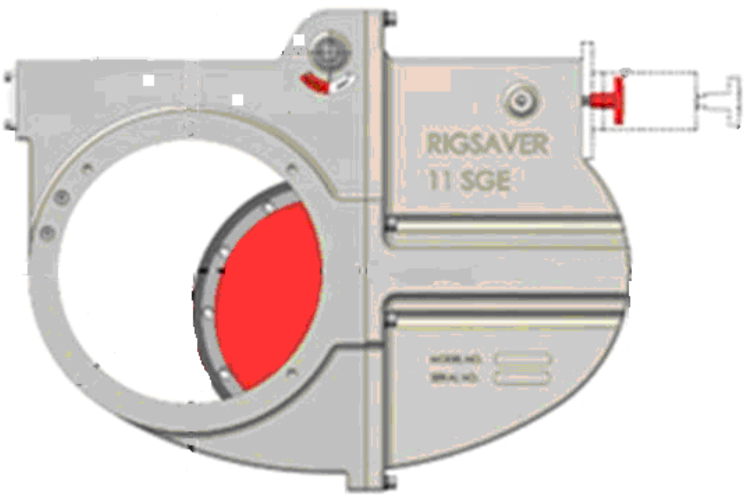


*Figure 2-3 RIG SAVER™*

## 2.3 What can be concluded?

- A common failure caused the failure of all thrusters.
- Question: what is the normal operating configuration for the UPS's?

- Should the Standard Operating Procedures (SOP) be that each UPS is fed by the individual LV switchboards? The feeder to the UPS from the emergency switchboard should only kick in during full black out, to keep the batteries charged.

### 2.4 Additional Comments

- Do not supply all your UPS units from the same switchboard, even if it is the Emergency Switchboard (ESB). This is a potential fault propagation path, and other types of voltage failures (such as over-voltage) could potentially be transferred as well.
- All ESB UPS unit power supply should have been identified as a concern in the FMEA and rectified accordingly during build and commissioning.

### 2.5 Guidance that would be relevant

The following IMCA Guidance would be relevant to this case study:

IMCA M220 - Guidance on operational activity planning
IMCA M103 – 2.12 (first part), 2.14, 2.7, 3.44, 3.5 and 3.7.
IMCA M117 - The training and experience of key DP personnel
IMCA M166 - Section 3.12 - Guidance on failure modes and effects analysis (FMEA)
IMCA M247 - Sections 2.5, 3.4 & 4.4.5 - Guidance to identify DP system components and their failure modes.

## 3 Case Study – Human Factor – Training for new Vessel essential

### 3.1 Overview of the Event

A DP2 vessel was conducting Pull Back operations on an FPSO, the vessel DP Mode was set to towing at 60 tons, utilising the thrusters at 35% thrust in the forward direction. Approximately 800m of wire and polypropylene was connected to the FPSO and vessel with a pulling force on the FPSO equivalent to 40 tons.

At a certain point, without warning or indication, the propellers began to rotate with a 51 percent astern pitch, causing the vessel to approach the FPSO at a speed of 4 knots.

The senior DPO confirmed that all levers and joysticks were in the zero position. The Senior DPO then attempted to exit Towing Mode. When manual control of all thrusters was eventually achieved, the vessel was then able to return to its original Pull Back position.

The incident lasted 10 minutes and the drive and subsequent drift off totalled 400m.

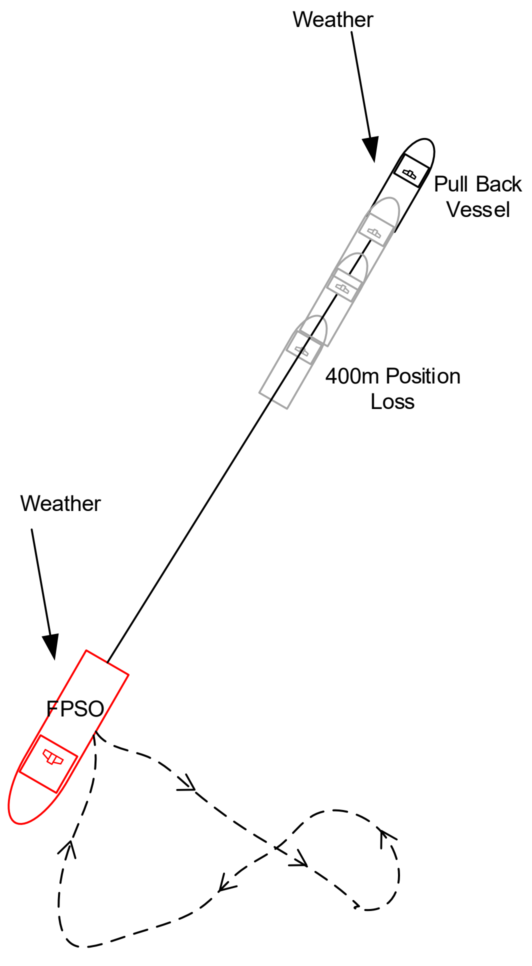


*Figure 3-1 Overview*

### 3.2 Cause

During investigations, it was determined that the cause of this incident was the operator's inadvertent movement of the joystick lever. Using the event's playback log and crew interviews, it was possible to determine the underlying cause of this incident. Both DPOs who had assumed command of the watch were new to the vessel and unfamiliar with all the towing mode functions (including free surge movement during DP operations).

### 3.3 What can be concluded?

Free Surge mode is a dynamic positioning control mode that allows the DPO to move the vessel by manual IJS or lever in the direction of the surge. This mode is typically employed for operations that require the vessel to produce a large Surge force for trenching or towing.

In Free Surge mode, the dynamic positioning control system uses the thrusters to automatically control the heading and sway of the vessel but does not attempt to control the surge motion. Instead, the surge motion is determined by the manual use of IJS or levers by the DPO and the forces acting on the vessel, including wind, waves, and currents.

Free Surge mode is useful for operations that require the vessel to be in a specific location, but do not require the vessel to be perfectly stationary. However, it is important to note that in Free Surge mode, the vessel will be more susceptible to environmental forces than in other modes. Therefore, caution is required when operating in Free Surge mode.

- The conclusion should focus on the training and competence of key DP personnel in general, as well as training specific to the DP control system on the vessel. It is assumed the crew would have read and signed off on the DP Operations Manual.
- The DPO must always be aware of how the vessel 3 axis is being controlled: Surge, Sway and Yaw. Both in relation to “over the ground” and “through the water”. This mental picture must be always present as soon as the vessel leaves the quay. When going into DP mode the best practice is to take one axis at a time: Yaw, sway and surge.
- Once in Auto Pos mode, whenever the auto control mode of one axis is deselected, the DPO must compensate that axis in manual mode. Depending on the DP functionality, for example in “towing mode” the joystick or manual lever can be used for surge when auto control surge is deselected.
- Guidance that would be relevant

The following IMCA Guidance would be relevant to this case study:

- IMCA M117 – *The Training and experience of key DP personnel*
- IMCA M220 – *Guidance on operational planning*

# 4 Case Study – Human Factor – Position Reference Confusion

## 4.1 Overview

A DP 2 vessel was engaged in diving operations and had deployed an ROV. The vessel was on Auto DP with two DGNSS and two HPR position references selected in DP Control, all four references were weighted equally.

Both HPRs became unstable after the vessel executed a position change. After a short time, the two DGNSS references began to drift in the opposite direction of the HPRs for no apparent reason. The bridge crew deselected one DGNSS to recalibrate, followed by the remaining references multiple times over the course of forty minutes.

Total vessel travel from desired position was measured at 37m.

## 4.2 What happened?

Soon after the position reference drift off was noticed, #1 DGNSS was deselected by the SDPO. The reference 'point of origin', which was based on the position when #1 DGNSS was initially calibrated, was lost and a new 'point of origin' was calculated when #1 DGNSS was re-enabled a few seconds later, based on the newly measured median position. When the first DGNSS was deselected, HPR1 and 2 took preference over the second DGNSS, and the DP model relied on the incorrect HPR position.

## 4.3 What can be concluded?

It was HPR-1 and HPR-2 that were giving erroneous position measurements. They drifted in the opposite direction to DGNSS 1 & 2. At this stage, the weighting was equal on all four reference systems, which meant the DP model was not able to decide which reference system was sending the erroneous measurements and the DP model was calculating a median position based on the four reference inputs.

After reviewing the log files, the OEM concluded that there were no errors or faults recorded on the DGNSS's during the event. A comparison with the survey DGNSS' verified this conclusion.

During the event #1 DGNSS was recalibrated several times (then subsequently the other position references) which further contributed to the DP model being inaccurate to real time events.

The HPRs started to be unstable in the period prior to the event due to minor vessel movements/thruster wash and the fact that the horizontal distance from the transducer to the transponders was quite high (approx. 3 x water depth).

According to the OEM report, water column conditions and reflections contributed to bad position data in this case.

Some considerations:

- Do not re-calibrate position references when the position reference systems (PRS) are drifting and there is no indication of which system is providing inaccurate measurements, as this will result in new coordinates for the reference 'point of origin' and the DP model will not be aware of any position deviation.
- If the position reference is recalibrated, the historical trace will disappear from the DP position plot making it difficult to see if the vessel has moved.
- Operating with 2 x DGPS and 2 x HPR requires extreme caution because the DP model could use equal weighing on all four PRSs, even though one system may provide incorrect inputs.
- During operations, the PRS weighting usually changes depending on the condition of the received signal. If the system had been allowed to adjust the weighting dynamically, it could have identified the poor HPR signals and adjusted accordingly. However, if both HPR signals were moving away from the DGNSS signals, the system may struggle to determine which pair were incorrect.

- DPO training and experience should have been sufficient to understand that deselecting one PRS would weigh the 'paired' system against the other PRS of the same type, so having fixed weighting and deselecting one PRS is effectively guessing which one is incorrect without a thorough review of the individual PRS panels and stations to see if signals were of poor quality.

In general, regardless of whether the PRS is local or global, the first one chosen determines the Reference Origin which is used in the DP controller for internal calculations.

Please refer to the Reference Origin section of an OEMs operator manual, copied below:

*To change the Reference Origin, one must deselect all PRS and then select the one PRS you want as Reference Origin.*

*Each time the Reference Origin is changed, the position setpoint for Auto Pos is changed, as there will be a difference between the PRS calculated position. This will impact the geographical position of the vessel, which is not a good idea while for example in pipelaying mode or drilling with BOP down. So this change of Reference Origin is tricky.*

In addition, the weighting of PRS in the DP controller can be influenced by the DPO by selecting “Reduced GPS”.

Based on experience, the GNSS systems have a higher weight than the local PRS. In some cases, the total weight of 2 GNSS was 90% and the total weight of 2 HPR was 10%. Therefore the “reduced GPS” function was developed.

### 4.4 Guidance that would be relevant

The following IMCA Guidance would be relevant to this case study:

IMCA M117 – *The Training and experience of key DP personnel*
IMCA M220 – *Guidance on operational planning*
IMCA M252 – *Guidance on position reference systems and sensors for DP Operations*

## 5 DP Drill Scenario

DP emergency drill scenarios are included to assist DP vessel management and DPOs / Engineers and ETOs to conduct DP drills onboard. The intent is that the template can be used on any DP vessel so specific details regarding the technical outcome are not included. The benefit of using this template is to monitor and learn from the human reactions of key DP personnel. It is also important that the crew are familiar with various DP system setups including their failure modes.

Refer to IMCA M117 The training and experience of key DP personnel - Appendix 6.

## EXERCISE SCENARIO LOSS OF ALL POSITION REFERENCES

**Objective:**

To demonstrate the behaviour of the vessel and DP system following the loss of Position Reference Systems data into the DP Control System

**Method:**

With the vessel on full auto DP control and vessel equipment and systems set up in accordance with applicable DP checklists:

1. Allow the Mathematical model to build until the integral component has stabilised for a 30-minute period. Deselect all PMSs and monitor position using an independent Position Measuring Equipment (PME) over a 5-minute period. If possible, select a waypoint at the original position on DGPS and note the range and bearing. Alternatively, use UTM coordinates and note heading, northings and eastings at one-minute intervals. Note environmental conditions then deselect all PMEs and note the position below
2. This drill may be combined with Joystick, Independent Joystick, and/or Manual Thruster Control drills for DPOs. Depending on vessel operations and Time to Safely Terminate, discuss how the vessel can be made safe for personnel and operations in actual operating scenarios

**Prior to executing, discuss the expected results:**

- Is the methodology appropriate to gain the best outcome of the exercise?
- Who will be involved with the exercise and what roles will individuals have?
- What equipment will be impacted?
- What are the risks of the exercise?
- Is the exercise scenario appropriately documented?
- Who will observe and accurately record exercise data including the DP system configuration pre exercise?

**Observations During Exercise:**

- Is the drill procedure being followed?
- Is the equipment reacting as expected?
- Are those individuals directly involved in the exercise reacting appropriately given their assigned duties?
- Are those individuals indirectly involved reacting in an appropriate manner?
- Is the degree of participation and diligence as expected?
- What is the duration from commencement to concluding a safe outcome for the vessel?
- Bridge team should take the opportunity to take 'Footprint' plots

**Actual results witnessed:**

EXAMPLE: DP system alarm. The vessel is now on dead reckoning.

The vessel will attempt to maintain its position based on the mathematical model and environmental conditions. A position change of no more than 20m in 5 minutes is generally considered acceptable.

| Settings and Environment during Test | | |
|---|---|---|
| Gain(H/M/L): | Speed: xx m/min | Draft: XXm |
| Wind: XX kts | Current: XX kts | Wave: X m |

| Time | Heading | Northings/Latitude | Eastings/Longitude | ΔL (m) |
|---|---|---|---|---|
| Start | | | | |
| +1 min | | | | |
| +2 mins | | | | |
| +3 mins | | | | |
| +4 mins | | | | |
| +5 mins | | | | |
| +20 mins | | | | |

| EXERCISE SCENARIO    LOSS OF ALL POSITION REFERENCES |
|---|

**Discussion Points (Post-exercise):**

Human Factors

- What are the potential risks due to "multi-tasking" during DP operations that may directly lead to the scenario outlined during this drill?  (Examples include managing / monitoring deck operations, radio traffic, etc.)
- What are the potential risks due to distractions in the workspace (i.e., Bridge, Engine Room) that may directly lead to the scenario outlined during this drill?  (Examples include routine maintenance procedures, social media, personnel interactions, etc.)
- Discuss the alternative actions / reactions that may occur in response to a similar scenario.  Are there multiple paths to a successful resolution or is there a preferred solution?  Why?
- Following a review of the simulated exercise and the vessel and crew's reaction, what different operator (Bridge and/or ECR) reaction(s) might be warranted if faced with a similar situation during operation?

Review of DPO and other key DP personnel reaction

- What potential gaps in the existing DP Familiarisation program have been highlighted as a result of the exercise?
- What changes / revisions should be considered for the training and familiarisation procedures?

Review the applicable checklists (ASOG CAM / TAM / DP operations Manual / bridge & engine room checklists / FMEA / DP Annual Trials programmes / etc.)

- What additional necessary actions and considerations should be addressed?
- What potential changes should be made to make the checklists more appropriate?
- Time to Safely Terminate (TST) is the time the vessel requires following a major incident to cease operations and to become fully capable of moving to a safe location. This time will vary depending on vessel operation and should be discussed in regard to the ASOG for a given project. If not provided in the available documentation, TST should be discussed and agreed upon by DP operating personnel.
- What additional necessary operating conditions and parameters should be considered?
- What potential changes should be considered to make Decision Support Tools more applicable to the vessel and her equipment?
- How would these changes improve / affect the vessel's capabilities and limitations?

**Conclusion:**

Based on the results of the exercise and related discussions before and after, any suggestions for follow up including any corrective actions deemed appropriate should be accurately detailed and managed to close out.

## 6 News in Brief from the DP Committee

### 6.1 Information Notes

- IMCA Information Note 1633 Combined Heading/Motion and Gyro Sensor Concerns
- IMCA Information Note 1634 Increasing Solar Activity and the Effect on GNSS Positioning

### 6.2 Codes & Recommended Practice

- M190 & M191 will be published July 2023.
- M117 published June 2023.

### 6.3 Station Keeping Events STATS:

The information below is a snapshot of the DP Station Keeping events to date for 2023.

**How many in 2023**

- Total 51 Reported to date

**What type**

- 1 Observation
- 29 Undesired Event
- 21 Incident

**Bus Configuration**

- 42 Open
- 8 Closed

**Main Cause (Overall Effect)**

- 0 Human
- 10 Computer
- 20 Thruster/Propulsion
- 12 Power
- 0 Electrical
- 0 External Factors
- 9 Position References
- 0 Environmental
- 0 Mechanical
- 0 Sensors

**Secondary (Root) Cause**

- 6 Human
- 7 Computer
- 0 Thruster/Propulsion
- 0 Power
- 17 Electrical
- 2 External Factors
- 2 Position References
- 10 Environmental
- 7 Mechanical
- 0 Sensors

*Figure 6-1 Event Stats*

The percentage of DP incidents reported per year has increased since 2019, a year before the pandemic, which is a concerning trend. The 2022 figures showed that the percentage of incidents has decreased and this was encouraging. However, so far this year we are seeing a sharp increase to date. See the graph below;

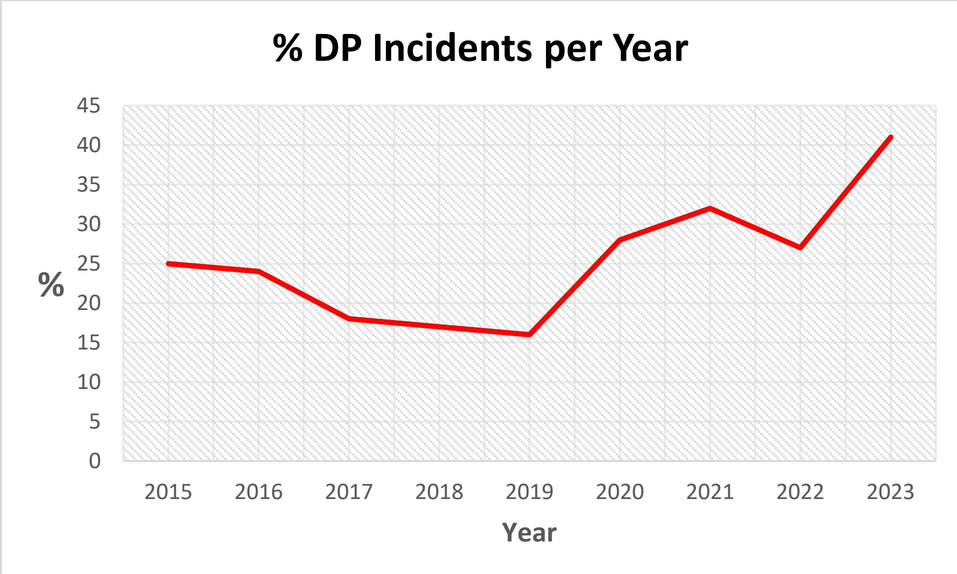


*Figure 6-2 Percentage of DP Event Reports received resulting DP Incidents (Loss of Position/Heading)*

Dynamic Positioning Station Keeping Review – Incidents and Events Reported for 2021 can be downloaded here. The 2022 review will be available shortly.

If you are employed by an IMCA member company, you can register on the website using your company domain email address. Once registered, you will be given direct access to the members area including all guidance and publications. This also applies to Bridge, ECR or Rank email addresses onboard vessels.

The IMCA DP reporting form is available here. You may want to consider using this form for your vessels. Please forward reports to dpreports@imca-int.com

### 6.4 Continuous Professional Development (CPD)

Following the announcement from the Nautical Institute (NI) about the new requirements for revalidating the DPOs Certificate, a Key DP Personnel continuing professional development (CPD) learning programme has been developed by IMCA and the Nautical Institute to provide valuable CPD learning to DPOs who perform a safety critical role onboard offshore DP vessels.

The learning programme is accessible to all Key DP Personnel to ensure that their technical knowledge of the latest industry practices is up to date and measured though questions delivered through an application available on desktop and on mobile devices. This will ensure professional currency with the latest IMCA / industry guidance, DP safety bulletins, DP exercise and training drills, and help prevent knowledge and skill fade in the various DP related roles on vessels,

The content has been designed for use on mobile devices. The delivery of the content is through the EdApp application software which is a mobile device learning management software. The application is available across a wide range of operating systems, for example, iOS and Android, and the app functionality provides offline capability meaning the content remains available without internet connection, an important factor for seagoing personnel.

Registration and payment for the app is undertaken via the NI Alexis Platform which is accessible by all Key DP Personnel who wish to purchase the CPD programme.

Find out more @ https://www.imca-int.com/certification/dp/cpd/