The following case studies have been chosen in order to create discussion points for all Key DP personnel. The events have already taken place but, what could have been done differently? Hindsight is a wonderful thing, but these cases allow us to stop, think and positively learn lessons that can be carried into future DP operations.

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

1 Case Study – Masking of PRSs – SIMOPS

1.1 Overview of Event

An Offshore Supply Vessel (OSV) was working alongside a Pipelay Vessel, discharging cargo whilst the Pipelay Vessel was executing moves ahead approximately 25m every 10 minutes. The Pipelay Vessel was also moving abeam and making minor heading changes as per typical pipelay operations.

The OSV was in Auto DP using 4 PRS's selected into DP Control all with automatic weighting, the PRS's selected were:

- x1 laser system
- x1 microwave system
- x2 DGNSS

As the Pipelay Vessel's crane hoisted the cargo off the deck of the OSV, it was noted that the cargo would interrupt the laser and microwave signal causing loss of signal and therefore, weighting to fall, making DP Control solely reliant on the DGNSS.

As the Pipelay Vessel moved ahead, the OSV was also instructed to match the move, simultaneously discharging cargo. Alarms continued to appear on the DP Control system for the drop out of the relative PRS's which, the DPO cancelled as if normal.

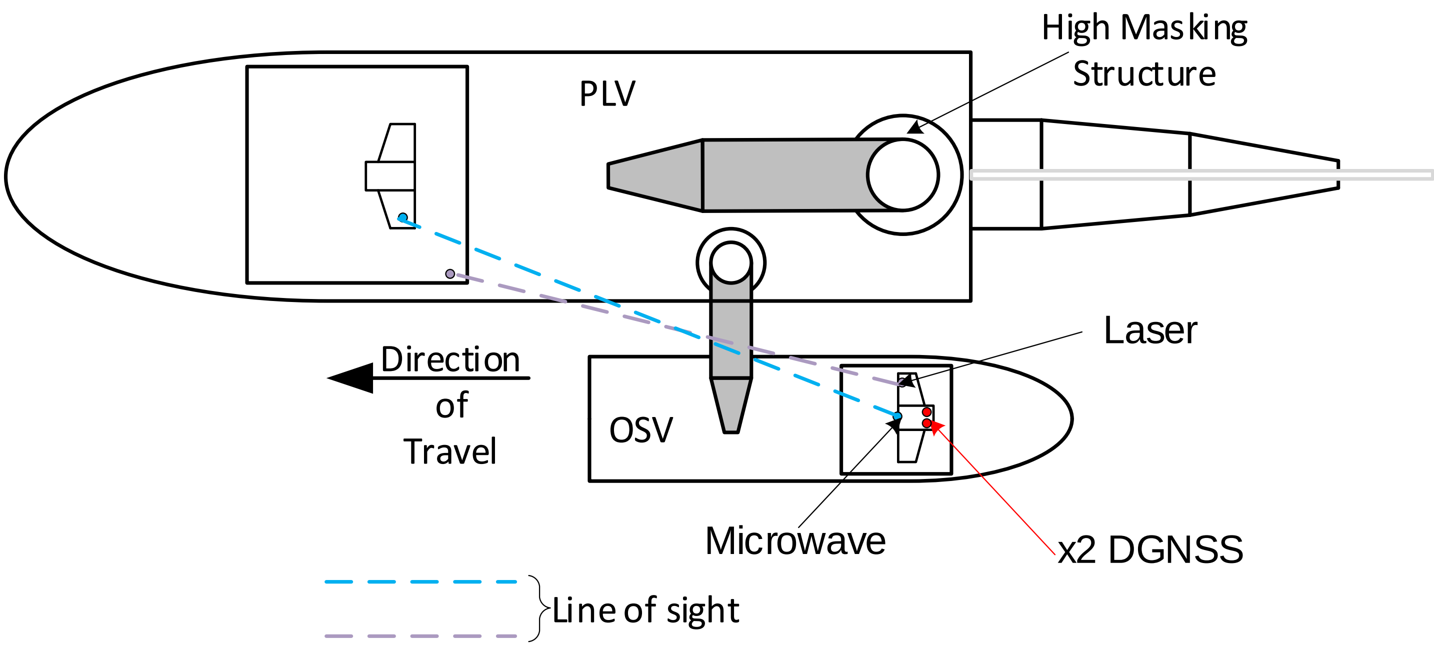
With the Pipelay Vessel changing its heading and, the difference in speeds between the two vessels, the effect was to also mask the DGNSS. Alarms were generated and cancelled without assessment.

This happened during a 25m Simultaneous Operations (SIMOPS) move. The OSV failed to come to a stop at the set point and the thrusters were noted to be increasing in speed (starting to ramp up). The DPO took the action to remove the surge functionality to bring the vessel to rest and thereby taking the vessel out of auto station keeping. The total overshoot was 7m.

A discussion was held between the PLV co-ordinator (located on the PLV Bridge), and the bridge team of the OSV and it was decided to continue the operation.

Another 25m SIMOPS move was executed by both vessels resulting in the exact same effect as the previous move, and a similar overshoot of 7m.

The OSV was ordered outside the 500m to investigate.



1.2 What can be concluded?

- The Pipelay Vessel was using the smaller crane on the port side. The large main crane located on the transom was in the upright position. This crane is a large capacity crane and as such, has a high structure when in the upright position.
- At the startup of this operation, the DPO on the OSV should make a concentrated effort to indicate the blind sector for the DGNSS satellites in the DGNSS equipment, via the HMI. This function is available in modern DGNSS equipment and should form part of the DP ops setup check list.
- The cargo lifts caused the line of sight to be broken for both the relative position references. An alarm was raised at the DP Operating Station and accepted by the DPO, in the knowledge that the DGNSS weighting would increase and compensate for the loss of the two relative units.
- SIMOPS was being carried out with the Pipelay Vessel co-ordinating the OSV to move at the same time as the Pipelay Vessel (25m). Cargo operations continued and so did the intermittent masking of the relative signals.
- Poor practice due to safety concerns – mismatch of vessel positioning when moving – to continue to use the crane for loading pipes when both vessels were moving, especially when there was also a heading change.
- The two vessels did not move at the same speed relative to each other. Not only did the main crane move relatively to the OSV, the whole pipelayer moved (hull, accommodation, deck equipment, mission equipment, etc). The blind sector was dynamic and was able to mask the satellite signal to the 2 DGNSS's located on the OSV, an alarm was raised which the DPO accepted.
- At the point of the first overshoot there had been approximately 20 cargo moves during the continuous pipelay operation with the drop out alarms being accepted as a normal part of the operation. However, when the masking of the Relative PRS's <u>and</u> the masking of the Absolute PRS's happened at the same time, the DPO did not realise the significance of the alarms (even though a specific alarm for all PRS drop out would have been generated) as they had been accepting them all through the operation.

1.3 Additional Comments

- The DP control system on the OSV could be equipped with a "Follow Target" function that allows the OSV to automatically follow both pipelayer's position and heading to prevent a mix of absolute and relative systems. If they do not have a "Follow Target" function, then they should use only Absolute PRS and make operator initiated position move together with the pipelayer.
- OEM Manuals & training should give advice to how best to manage PRS's within their system. This can be included into the DP Operations Manual.
- If possible, the OSV should be on the same heading as the pipelayer to give the relative systems better working conditions due to the crane.
- How detailed was the ASOG, was it being followed? From the details it would be reasonable to conclude that either an ASOG was not in place, or it was not being followed.

1.4 Guidance that would be relevant

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

- IMCA M203 – *Guidance on Simultaneous operations (SIMOPS)*
- IMCA M220 – *Guidance on operational planning*
- IMCA M252 – *Guidance on position reference systems and sensors for DP Operations*
- IMCA M242 – *Guidance on satellite-based positioning systems for offshore applications*

2 Case Study – Force off Position

2.1 Overview

A DP Class 3 vessel was conducting pipelay operations in the high North Sea area. Weather conditions were deteriorating quickly and in accordance with the ASOG, it was decided to suspend operational activities and remove all connection with the seabed and recover equipment.

Problems with the mission equipment meant that there were delays in recovering equipment and laying down the pipe for abandonment. The vessel was being hit by ever increasing large waves. At half past midnight, the vessel was hit by a series of large waves creating a 36m excursion from position. This change in position caused the DP system to reject all DP reference systems as they passed the prediction error rejection limit. This "limit" allowed for a 5m deviance between the estimated (model) position of the DP system and the position derived from the reference systems. All DP positions were rejected from DP Control.

The DPO on the bridge observed a total loss of reference systems as well as, critical alarms for breach of the red watch circle, the violent nature of the vessel motion the decision was made to abandon the pipe to the seabed.

2.2 Events leading up to the incident

Several hours earlier, the weather reports received on the vessel bridge forecast advised adverse weather inclusive of wind speeds exceeding 50 knots which required the vessel to go in to "yellow DP alert mode" according to the ASOG.

At this time the DP system was set up with three position reference systems online:

- x2 DGNSS's which includes inertial aided navigation and, 1 additional DGNSS which was in monitoring mode only.
- 1 HPR operating in Long Base Line (LBL) mode with three transponders on the seabed.

A red watch circle was set to 35m (ASOG states max 36m), and a yellow watch circle set to 15m. The "Reduced GPS weight" setting was not chosen, and all reference systems appeared to have equal weighting.

HPR2 was using gyro 3 as heading reference and MRU3 as pitch and roll reference. The DP system was using MRU1 as pitch and roll reference.

The power system was operating in two split modes with all six generators and all six thrusters online. The environment was such that thruster high force and switchboard power limits alarms were being activated and some being issued by the thruster drives themselves rather than the PMS.

Acceptance limits for prediction error was set to "normal", which is 5m. This mode is recommended by the OEM for "rough" weather conditions. This was also the recommendation stated within the vessels DP Operations Manual.

The vessel was positioned to take the current straight on the bow the wind coming from approximately 20 degrees port bow. The water depth at the location was 105m.

The weather peak was forecasted around midnight, and the vessel should, according to their time plan, be disconnected and on standby around 22.00hrs. This left them over 6hrs to be in a safe condition. This was deemed sufficient time.

Work continued until they experienced problems with the A&R Winch laydown system which caused a delay in the operation.

New assessments of the latest weather forecasts were analysed. However, no significant change was anticipated.

All of the problems experienced delayed the operation substantially and major work was required in order to get the A&R winch in service.

In the time immediately preceding the event, there were a number of alarms relating to high utilization of the thrusters. The environmental forces were increasing and in line with the received forecasts which suggested the consequence analysis alarm was triggered.

The DPO described a series of large waves just ahead of the incident. The investigation analysed the raw data from the GNSS logs and with the help of OEMs found that this wave, or series of waves, made the vessel move around 30m, causing the vessel to exceed the prediction error rejection limit.

2.3 What can be concluded?

- Time to Terminate – Difficulties in terminating the operation caused the vessel to still be connected for too long into the weather event.
- Environment – The environment was above the vessels DP Position Keeping capabilities. The vessel was already utilizing a lot of its power and propulsion capabilities to counteract the existing environmental forces.
- Sudden high amplitude\long period waves – This caused the excursion. The DP systems then had to combat additional forces presented by the sudden increase in wave action.
- Prediction error setting – Had the setting for prediction error acceptance limit been set to "wide", the deviation between DP model and the average position calculated based on the PRSs may not have caused the system to reject the reference systems. However, the force off was so great and fast that even set in 'wide' the same results could have been realised. The forces affecting the vessel created a position excursion that was so wide and quick that it exceeded the set limit between predicted position and actual "average position" which is calculated based on input from all PRS.
- A train wave resulted in the vessel being forced off position with a high speed and resulting in activation of the prediction error rejection of the PRS. The DPO should be familiar with the recovery action, which is OEM and DP control system generation specific.

2.4 Root Cause

- At the time of the incident, the vessel was being operated beyond its DP Position Keeping Capabilities. An experienced DPO knows that in case of wave trains, the vessel can be forced off and activate the prediction error and should know the recovery procedure.
- Inadequate procedure for description of settings of rejection limit. The recommendation from the vendor is not specific enough when describing weather criteria for settings. In this case the "normal" setting did not allow enough deviation to avoid losing reference systems input to the DP system. Even though the weather at the time could be described as rough.
- Inadequate plan for securing the pipe before weather peak. The vessel had planned for what they believed to be enough time to lay down and be disconnected before the weather peak. In this specific case, the plan was foiled due to unforeseen problems. This was difficult to plan for. Correct maintenance and regular function test of mission equipment would have reduced probability of such misfunction.

2.5 Guidance that would be relevant

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

- IMCA M220 – *Guidance on operational planning*
- IMCA M252 – *Guidance on position reference systems and sensors for DP Operations*
- IMCA M242 – *Guidance on satellite-based positioning systems for offshore applications*

3 Case Study – Closed Bus Common Cause

3.1 Overview of event

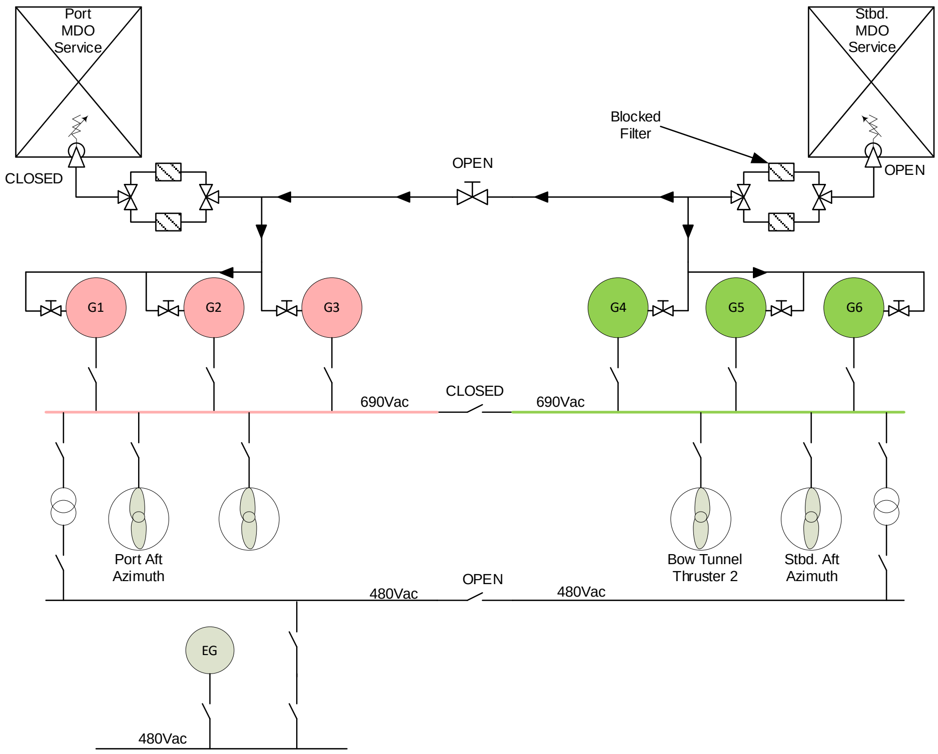
A DP2 ROV Support Vessel was conducting a pipe survey in open water. As the consequence of loss of position was considered low, it was decided to close the bus ties to minimise the number of connected generators. At the same time, the technical staff wanted to open up and inspect one of the fuel service tanks. The vessel had suffered fuel contamination with water throughout the fuel system which caused a build-up of sludge affecting the fuel filters.

The technical department was given approval to common up (cross connect) the fuel supply system to a single service tank from the starboard redundancy group. The port service tank was emptied and opened ready for inspection and cleaning. After 48hrs configured in this way, it was noted that there was the odd frequency alarm being reported on the vessels management system. Three out of the six generators were connected with the load on each generator between 60-65%.

At around midday of the third day, the weather had increased slightly, and engine loading increased. Another generator was started and connected. Once connected, bus frequency alarms were activated and didn't clear. The frequency continued to fall to the level where all generator incomer breakers tripped along with the bus tie on under frequency and blacked out the vessel. The engines on standby auto started. It was apparent that all running engines were slowing down to the point they stopped.

The emergency generator started and connected to the emergency switchboard. The bridge was informed of the situation. The vessel was left without propulsion drifting in open water. The ROV crew made provision for the ROV.

The technical department immediately identified that the fuel supply filters were the immediate issue and changed them to the clean set-in order to restore a supply to the engines. In the meantime, the blocked set were being cleaned.



Several attempts were made to start an engine however, it wasn't until the governor was reset that the engine was able to start and be connected to the dead bus. Gradually, the vessel systems were brought back online and full power was restored.

It was decided to monitor the filters and change onto a clean set every hour. The port service tank was sealed and filled with clean fuel. Once filled and with the bus ties closed, the port engines were stopped. The fuel system was split, and the port engines were started and connected to the common bus. Once all checks had been made and the technical staff were happy, the bus tie was opened. The vessel was now on two independent redundancy systems.

3.2 What can be concluded?

- The vessel was working in 'Task Activity Mode' (TAM) which allowed for the risks associated with closed bus operation. The ASOG accounted for TAM.
- The jeopardy was cross connecting the fuel system and removing the redundancy of supply by isolating the port service tank for inspection and cleaning.
- Even in open water, care must be taken in assessing the risks. This vessel was fortunate that it did manage to recover without any significant effect on human safety or asset damage. However, if the incident had been prolonged, the comfort of the crew with regards to the vessel's sea keeping ability, would have been affected.
- What started out as a good idea to take advantage of the open water low consequence effects soon rapidly turned into a much degraded and a potentially dangerous situation.
- It was unclear if the auxiliary system configurations were included within the ASOG. If they were not considered, then this event clearly shows that they should be taken into account.
- The implications of contaminated fuel in the system were not fully understood.
- Were the full blackout recovery drills training adequate and effective? The vessel did recover but could there be room for improvement?

3.3 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 Solitons – Be Mindful

A number of our members have submitted DP Event Reports which highlighted the phenomena of a sudden loss of position due to Solitons. Solitons are large amplitude, often highly nonlinear, internal waves. They are responsible for complex vertical profiles of rapidly fluctuating ocean currents. These current profiles and their effects are not fully quantified and there is very little supporting data.

Solitons are difficult to predict. IMCA recommends that the bridge crew research their geographic area of operation and be mindful that the vessel is susceptible to sudden increase of sea currents.

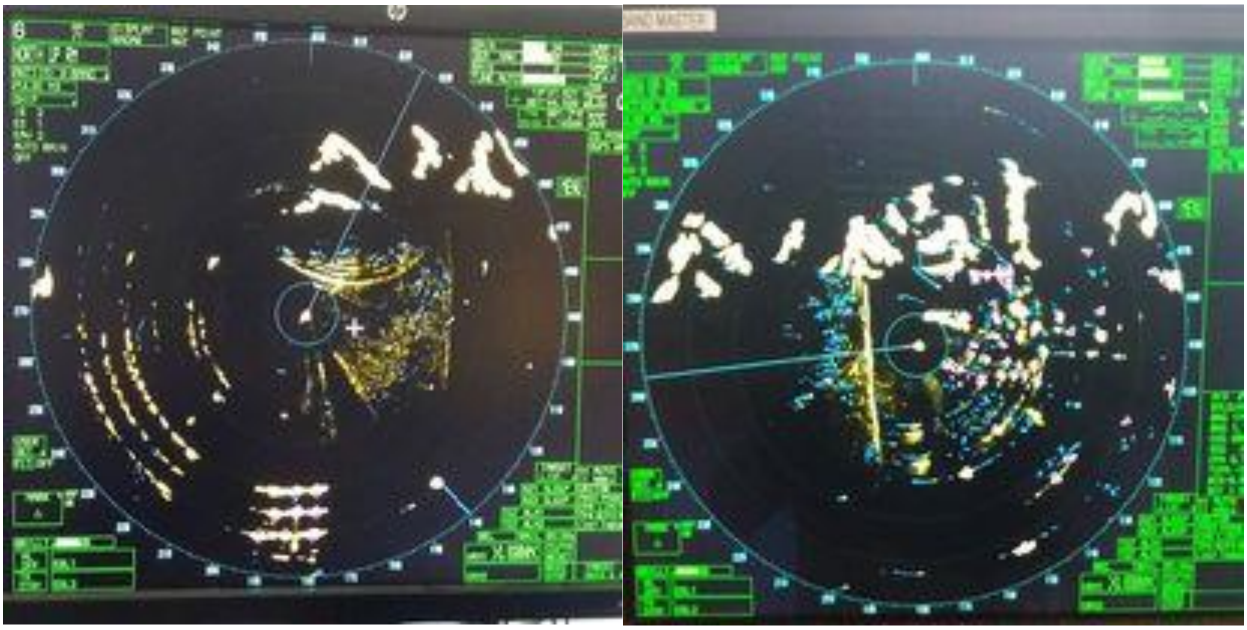


Figure 4-1 Radar image of Soliton

Figure 4-1 above shows how a Soliton can be shown on Radar. These waves can travel at 2 to 4 knots. This along with the physical effects of the waves can cause a sudden loss of position followed by severe ramp up of thrusters and generators.

In the case of DP vessels, there is insufficient time for the vessel mathematical model to update. The vessel may remain unstable in terms of position and heading for some time after, overshooting and hunting the set point values. At the same time, unreliable results will be obtained from subsea position references. Both taut wire and HPR systems will be degraded due to velocity of surface and subsea water with additional noise and aeration from thrusters.

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 from 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.

EXERCISE SCENARIO AUTO/MANUAL - HUMAN INTERVENTION
Objective: To familiarise all vessel crew what the consequences of switching essential DP equipment into Local/manual whist in auto DP. There have been many event reports submitted that have detailed the effects of switching running equipment into local/manual, mainly because the effects of doing so were unknown, carrying out this drill will enable the Key DP Personnel to further understand the consequences of their actions.
Method: This test can be undertaken when the vessel is in a safe open space with no risk of excessive position excursion causing an unsafe condition. Vessel in auto DP 1. **Thrusters:** • At local position switch thruster into local – Observe effect on DP control – Reinstate. • At local thruster lever control switch thruster to manual– Observe effect on DP control – Reinstate. 2. **Engines:** • At local position switch engine into local – Observe effect on DP control – Reinstate. • At remote engine control switch thruster to manual– Observe effect on DP control – Reinstate. 3. **Pumps:** • At local position switch running seawater pump into local – Observe effect on SW system – Reinstate. (Carry out for all systems pumps). • At local position switch running freshwater pump into local – Observe effect on FW system – Reinstate. (Carry out for all systems pumps). • At local position switch running fuel pump into local – Observe effect on SW system – Reinstate. 4. **DP Controllers:** • On running/in use controller, reset – Observe effect on DP control – Reinstate.
Observations During Drill: 1. Does the action effect the DP Control? Are the expected alarms generated? 2. Are the systems affected and how? 3. Document all the effects.

EXERCISE SCENARIO	AUTO/MANUAL - HUMAN INTERVENTION

Discussion Points (Post exercise):

Vessel

- Are all effects understood?

Human Factors

- Are all effects understood with regards Human intervention?
- What should be the response of the DPO?
- What would be the worst-case scenario?
- 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?

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 and 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?
- 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.

Handling of essential DP systems in the correct manner requires knowledge of the Key DP Personnel and how the DP system reacts to human intervention.

Items to consider include:

- DP system reaction to failures.
- Appropriateness of communication.
- Training requirements.

6 News in Brief

DP Conference 2022

IMCA will be hosting an International DP Conference on the 31 May – 1 June 2022. The conference is to be held at the Steinberger Airport Hotel in Amsterdam Netherland with a program of topics to be announced. You can now register for the event here. Sea going staff will qualify for member rates upon proof of service.

Station Keeping Events STATS:

The information below is a snapshot of the DP Station Keeping events to date for 2022.

How many in 2022

- Total 50 Reported to date

What type

- 10 Observation
- 29 Undesired Event
- 11 Incident

Bus Configuration

- 43 Open
- 7 Closed

Main Cause (Overall Effect)

- 0 Human
- 23 Thruster/Propulsion
- 1 Position References
- 7 Power
- 0 Electrical
- 1 Environmental
- 5 Sensors
- 13 Computer
- 0 Mechanical

Secondary (Root) Cause

- 6 Human
- 0 Thruster/Propulsion
- 0 Position References
- 0 Power
- 14 Electrical
- 1 Environmental
- 5 Sensors
- 12 Computer
- 7 Mechanical

Dynamic Positioning Station Keeping Review – Incidents and Events Reported for 2021 can be downloaded here.

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.

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