Monitoring and Identification of DP Operators Behavioural Traits and Common Errors During Simulator Training

Y. Bogachenko[1] & O. Pipchenko[2]
[1] *Lerus Training Center, Odessa, Ukraine*
[2] *National University "Odessa Maritime Academy", Odessa, Ukraine*

ABSTRACT: The article presents factors influencing decision making by Dynamic Positioning Operator (DPO) and statistics of the DPOs behaviour in an emergency situation. Considering that supply operation is performed by a DP vessel at a distance comparable to its width of the hull to the installation, unit, or another vessel, the thruster failure may lead to a rapidly developing incident such as collision, pollution, or human injuries. Based on the IMO guidelines on formal safety assessment authors suggested a risk model of platform supply operation in dynamic positioning mode. It is shown that different approaches shall be applied for rule-making and active decision support applications. While rulemaking can be mainly based on retrospective incident-based data, decision support shall be developed on the basis of the dynamic state of the system. Therefore, it is necessary to understand the nature of the human element in the specific operation to build up proper technological and organizational barriers to prevent the forthcoming critical error.

1 INTRODUCTION

Oil platform operations demands a constant supply of water, fuel, provisions and deck cargo. Freight transport between port and platform in the oil industry is provided by Offshore Supply Vessels (OSV). Supply vessels approach platforms and hold the position at short distances using a dynamic positioning system.

These operations contribute to high-risk tasks since incidents associated with the loss of a ship's position can lead to damage to the ship and platform, fire, significant environmental pollution or multiple casualties.

For example, in 2005 the collision of a supply vessel with the Mumbai High North platform resulted in a fire and the death of 22 people. Fire losses were estimated at $200 million. Another illustrative accident is the collision between the supply vessel Sjoborg and the oil platform Statfjord A [12], which occurred during cargo operations on June 7, 2019. A technical malfunction on the vessel led to the activation of the load reduction mode, as a result of which the power of all the thrusters decreased to 10-15%. At approximately 01:50, power was lost on two of the three bow thrusters. As a consequence, the vessel lost the position and collided with the platform, sustaining serious damage to the mast and equipment above the bridge and a dent on the starboard side at the stern. Due to collision oil platform boat station was also damaged and the supply vessel struck the oil platform drilling shaft.

2 DP SYSTEM OVERVIEW

As per IMO MSC Circular 1580 [8]: "Dynamically positioned vessel (DP vessel) means a unit or a vessel

which automatically maintains its position and/or heading (fixed location, relative location or predetermined track) by means of thruster force".

Dynamic Positioning System is a joint work of seven components (Thrusters, Power, DP Controller, Human Machinery Interface, Sensors, Position Reference Systems and DP Operator) with the purpose to maintain vessel's position and heading. The simplified process of positioning can be described as follows (figure 1):
- DP Operator must assure of proper operational conditions of other components;
- provide DP Controller with necessary data from Sensors and Position Reference Systems;
- provide control of thrusters to DP controller;
- designate tasks through Human Machinery Interface (HMI), observe the adequate operation of all the DP System and satisfactory performance of the task.
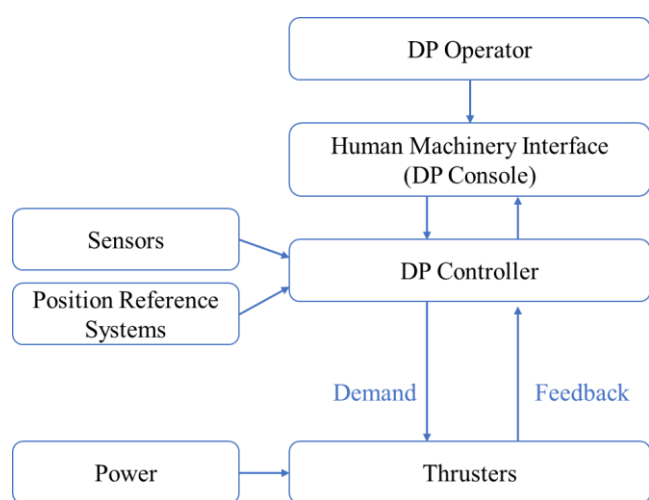

Figure 1. Simplified diagram of a position control process

When the vessel maintains a position and heading by means of the DP System, the role of the DP Operator is to observe proper action of all its components on the screen of the DP Console. On DP Class 1 vessels a single failure, like improper operation of a thruster or malfunction of a diesel generator, may lead to loss of position. That's why for critical operations which may lead to loss of human life, pollution or significant damage of asset the design of the DP System implies the redundancy concept.

DP Class 2 and DP Class 3 vessels have redundancy to ensure positioning capabilities if single case failure occurs, i.e. loss of thruster or generator or switchboard with connected generators and thrusts. Redundant components and systems should be immediately available without needing manual intervention from the operators according to IMO guidelines [8].

3 INCIDENTS STATISTICS

Researches conducted over the years, including J. Herdzik [10], K. I. Øvergård et al. [13], K. S. Hauff [9], conclude 'thruster failure' as the main cause of drive-off situation. Rules and guidelines on levels of operator intervention in response to a failure in a DP Class 2 or DP Class 3 vessel have changed over the years and different classification societies have chosen to place different levels of emphasis and different interpretations on these rules (MTS DP Operations Guidance [2]).

Statistics made by the International Maritime Contractor Association (IMCA) on the basis of DP Station Keeping Reports [3–8] also confirms that 'Thruster/propulsion' failure has the highest percentage (more than 30%) of main failure causes, which lead to DP incident, DP undesired event or DP observation, for last 5 years (figure 2).
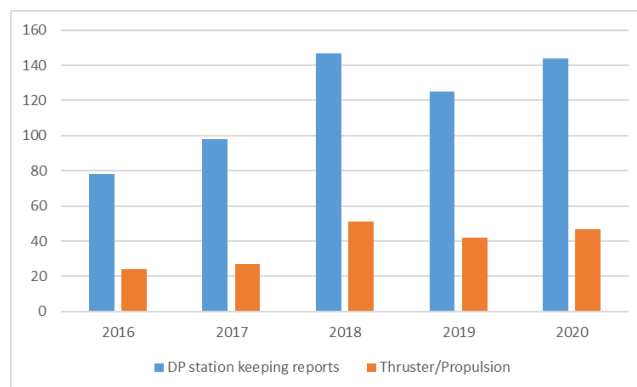

Figure 2. Thrusters and propulsion failures in relation to DP station keeping reports by IMCA

Top positions of secondary causes of failures are taken by 'Electrical' and 'Human factors' categories.

'Human Factors' is broad in nature. However, all 30 causes reported in 2020 could be categorized as 'unintentional behaviour' for which there are four categories: 'sensory error'; 'memory error'; 'decision error'; and 'action error'. 'Decision' and 'action' errors led to proportionately more events and the loss of DP control than any others. 'Decision' errors are defined as errors where a clear decision was made to operate in a particular way and 'Action' errors – where a function or control was selected incorrectly.

The redundancy concept is to make the vessel fault tolerant without the intervention of the DP Operator, but there is a number of examples when the proper action of the DP Operator in an emergency situation will mitigate the worst consequences of the incident and stabilize the situation. On the other hand, the DP operator can make a wrong decision and take an action that will degrade the vessel capabilities, such as the push of the 'Emergency stop' button of one of the properly working thrusters. International requirements for DP equipment classes 2 and 3 recognize a single inadvertent act of any person, including DP Operator as a single fault, if such an act is reasonably probable [11].

The partial risk model of the collision event between a supply vessel and platform based on IMO Guidelines on Formal Safety Analysis [11] is represented in figure 3. The risk model is focused on the DP operator's actions that may lead to a drive off situation. The risk model shows that the incident may be influenced either by a technical failure in the DP system and thruster or by human error.
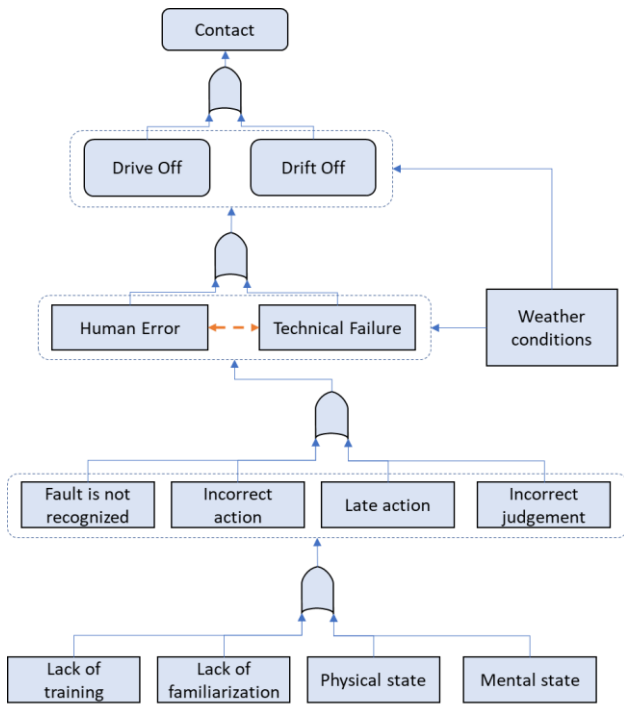
Figure 3. Partial risk model of the OSV – platform contact incident

4 MONITORING AND IDENTIFICATION OF DP OPERATORS' ERRORS

Statistics cannot always comprehensively reflect the number of incidents that could be avoided by proper action of DP staff (operator and technical), as reports are formed in different circumstances (operators, ship types, specifics of the operation, etc.). In order to learn the behaviour of a DP Operator on the bridge under the same condition and operation, the case of faulty thruster was simulated on the full mission bridge simulator during the DP Simulator, DP Sea time reduction, DP Revalidation courses and DP Assessments.

Apparently, when the thruster commences developing its maximum force, it causes the DP Operator sudden stress, as it is usually unexpected, when no changes in DP operation settings were done by the officer, accompanied with a considerable amount of noise, and may happen at nighttime. If the person never encountered this specific situation before, mentioned factors could considerably affect the decision making. It is important to note that in this situation correct and timely actions are crucial.

So, it turns out that improper action of a DP Operator may create an uncertain situation till the incident the same as the inaction of a DP Operator during an emergency scenario will lead to undesired consequences. And it is possible to conclude that positive escalation of a near-miss scenario depends on the competence of the DP operator to properly analyse dynamic risks and the timeframe necessary for taking decision and action.

The goal of the research is to identify DP Operators behavioural traits during an emergency by means of simulator training, while they maintain vessel position and heading utilising the DP System, and encounter the thruster failure.

The research is based on the analysis of 148 practical exercises of 37 different groups on the full mission bridge simulator. Each group consisted of 2 or 3 candidates. All candidates passed the DP Induction course at different training centres and gained some DP seagoing experience. Candidates performed 4 exercises (figures 3 & 4) to test and train their ability to avoid incident in case of thruster failure.

4.1 Exercise 1

After familiarization with the bridge simulator candidates were given the task: to approach closely the oil platform utilising the DP System to perform cargo operations.

The necessary time was spent on the DP set-up and then on the approach from the 500 m zone towards the oil platform. The vessel approached closely to the 100 m zone of the oil platform, stopped and stabilised, and then continued the approach at speed of less than 0.5 knots. At a distance of about 30 m from the oil platform, the instructor simulates improper functioning of thruster: the demand and feedback of thruster have a difference of 10%.

100% of participants did not notice that.

The difference of demand and feedback is increased so that the DP system gives an alarm regarding this malfunction. The reaction of DPO in 100% of cases was to call ECR (Engine Control Room) to ask if everything was alright with the thruster. But the proper action is to disable the improperly working thruster from the DP system.

The instructor aggravates the situation further and simulates failure as full load of thruster's running.

The proper action of the DP Operator is to stop the faulty thruster by pushing the 'Emergency stop' button. The same is discussed during the DP Induction course as a part of the learning process. And all participants knew this.
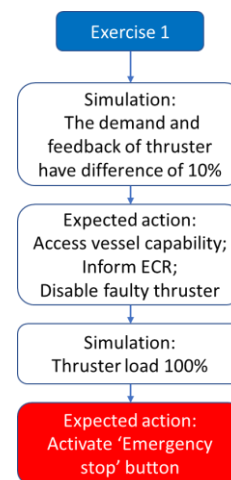

Figure 4. Exercise 1 flowchart

In 92% of cases, the action on the bridge was to call Engine Control Room (ECR) followed by disabling the

thruster from DP System, which does not solve the problem. The debriefing of the exercise was carried out and proper actions were discussed.

4.2 Exercise 2

On the next day, a similar exercise (figure 5) was performed. And upon approach close to 30 m from the installation, the instructor simulated another thruster as 'uncontrolled load to 100%'.

98% of participants took correct action and push the 'Emergency stop' button. But 12% of participants were confused during an emergency situation and stopped properly the working thruster, leaving the faulty thruster to create a load.

Debriefing was carried out with an explanation of what had happened and what would have been the proper actions.
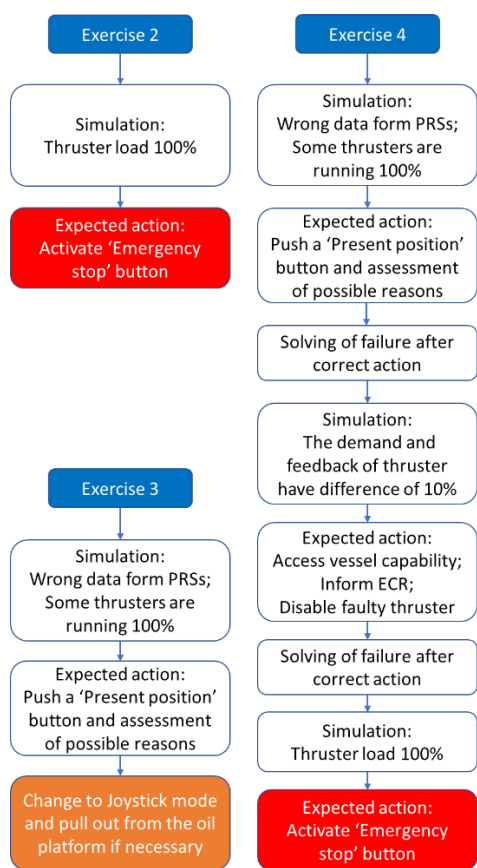

Figure 5. Exercises 2,3,4 flowcharts

4.3 Exercise 3

During the next practical exercise upon approach close to another vessel for ship-to-ship cargo operation, the instructor simulates the jump of reference systems, causing a shift in position data. In this situation, the DP system finds the position offset, in this specific case 8 metres. The reaction of the DP system is to bring the vessel to set position (which is currently 8 metres away) as soon as possible, which means using all available thrust. Considering that participants are awaiting thruster failure and when they see that some thruster runs full load, in 72% of cases the 'Emergency stop' button was pushed. But

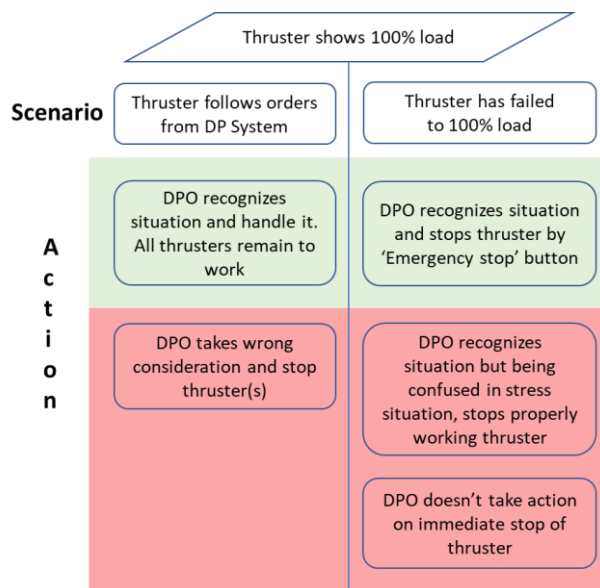thruster was working properly and followed commands of DP system.

Figure 6. DPO main behavioural traits in case of thruster failure

4.4 Exercise 4

To improve the operators' performance, it was decided to take the approach described in [1, 14, 15], where, based on the previous operators' errors and behaviour, action flowcharts were built and brought up to candidates as fault recognition and action algorithm. Before the final exercise, the thruster monitoring algorithm (figure 7) was provided. The final exercise included all failures described above. This allowed achieving a 95% exercise success rate.
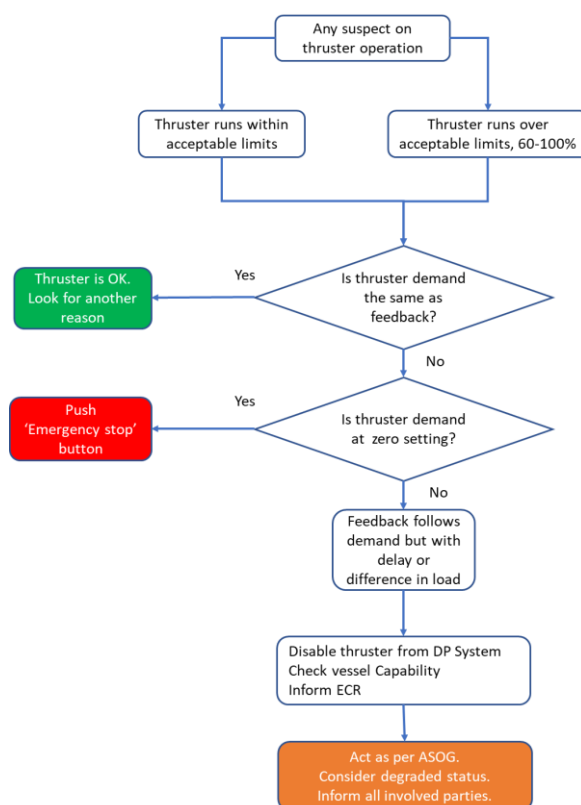

Figure 7. Thruster monitoring algorithm

All participants were aware that the 'Emergency stop' button must be activated when the thruster fails to 100% load, but most of them had never encountered such situation. Therefore, at first most of the participants couldn't grasp the situation. The important finding is that once the operator is aware of the situation when 100% load on the thruster is observed (in case when thruster follows the correct DP System order), the wrong action is taken in vast majority of the cases (stop the properly working thruster).

Only after proper risk analysis before the task and demonstration of all possible cases of thruster failures, the participants could recognize an emergency situation and take the correct action.

5 CONCLUSIONS

The conventional approach to the DPO behaviour in case of thruster failure concludes either DPO took proper action or not. It would seem like the probability for favourable coincidence is 50%. It is assumed that the probability of correct action being taken can be increased by explaining the necessity to push the 'Emergency stop' button.

The authors suggest dividing the situation with thruster under full load in two scenarios: when the thruster works properly and follows orders from DP System and when the thruster has failed to full load.

In both scenarios, there is a probability of taking proper and incorrect actions. Therefore, there may be a 60% probability of negative consequences. Practical exercises show that theory alone and the fact that DP Operator knows of the actions to be taken, don't lead to expected action. On the other hand, the expression 'experience beats theory' does not work either. When a DP Operator faces an emergency, where the 'Emergency stop' button must be pushed, in practice, it becomes a behavioural habit. In this case, DP Operator stops thruster(s) even when it is not required.

Therefore, continuing professional development of DP Operators under the supervision of experienced DP practitioner is strongly recommended.

REFERENCES

1. Bogachenko, Y.: DP Concept: Principles of Dynamic Positioning. Seredniak T. K., Dnipro (2020).
2. DP Operations Guidance: Marine Technology Society (2012).
3. Dynamic Positioning Station Keeping Review: Incidents and events reported for 2016 (DPSI 27). (2017).
4. Dynamic Positioning Station Keeping Review: Incidents and events reported for 2017 (DPSI 28). (2018).
5. Dynamic Positioning Station Keeping Review: Incidents and events reported for 2018 (DPSI 29). (2019).
6. Dynamic Positioning Station Keeping Review: Incidents and events reported for 2019 (DPSI 29). (2020).
7. Dynamic Positioning Station Keeping Review: Incidents and events reported for 2020 (DPSI 30). (2021).
8. Guidelines for vessels and units with dynamic positioning (DP) systems: (2017).
9. Hauff, K.S.: Analysis of Loss of Position Incidents for Dynamically Operated Vessels. Department of Marine Technology, NTNU (2014).
10. Herdzik, J.: Dynamic Positioning Systems during emergency or unexpected situations. Journal of KONES Powertrain and Transport. 20, 3, 153–159 (2013).
11. International Maritime Organisation: IMO MSC-MEPC.2/Circ.12/Rev.2 Revised Guidelines for Formal Safety Assessment (FSA) for Use in IMO Rule-Making Process. (2018).
12. Investigation of collision between Sjoborg supply ship and Statfjord A on 7 June 2019: Petroleum Safety Authority, Stavanger (2019).
13. Øvergård, K.I., Sorensen, L.J., Nazir, S., Martinsen, T.J.: Critical incidents during dynamic positioning: operators' situation awareness and decision-making in maritime operations. null. 16, 4, 366–387 (2015). https://doi.org/10.1080/1463922X.2014.1001007.
14. Pipchenko, O.: Monitoring and identification of errors during training on navigation simulators. Collection of Scientific Papers of Admiral Makarov National University of Shipbuilding. 3–11 (2020). https://doi.org/10.15589/znp2020.2(480).1.
15. Pipchenko, O., Tsymbal, M., Shevchenko, V.: Recommendations for Training of Crews Working on Diesel-Electric Vessels Equipped with Azimuth Thrusters. TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation. 12, 3, 567–571 (2018). https://doi.org/10.12716/1001.12.03.17.