HUMAN ERROR ANALYSIS IN DYNAMIC POSITIONING INCIDENTS ACCORDING TO THE NATURE OF THE OPERATIONS IN PROGRESS

ZALOA SANCHEZ-VARELA
University of Split, Faculty of Maritime Studies, Nautical Engineering department, Split, Croatia
e-mail: zsanchezv@pfst.hr
Orcid: 0000-0001-9212-0330

ZLATKO BOKO
University of Split, Faculty of Maritime Studies, Nautical Engineering department, Split, Croatia
e-mail: zboko@pfst.hr
Orcid: 0000-0001-9842-890X

IVICA SKOKO
University of Split, Faculty of Maritime Studies, Nautical Engineering department, Split, Croatia
e-mail: iskoko@pfst.hr
Orcid: 0000-0002-1620-1945

DAVID BOULLOSA-FALCES
University of the Basque Country UPV/EHU, Faculty of Engineering in Bilbao, Department of Nautical Sciences and Marine Systems Engineering, Portugalete, Spain
e-mail: david.boullosa@ehu.eus
Orcid: 0000-0002-3242-0283

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Abstract

Human errors are known to contribute to incidents in the maritime industry. Although the dynamic positioning operator has to undergo a standard training schedule before becoming a full operator, human errors contribute to 20% of the incidents in dynamic positioning operations. This research aims to investigate which dynamic positioning operations have a more considerable percentage of human errors. With a 266 dynamic positioning incidents database, different offshore operations are classified and then cross-tabulated with the human causes, classified as either primary or secondary cause as described in the incident report. The results and discussion present that drilling and diving operations are significantly correlated with human causes. This study's results could help provide better directions for the training schedule, proposing simulator exercises based on these scenarios.

1 INTRODUCTION

A dynamic positioning (DP) system is a piece of automation that helps the vessel to maintain her position by analysing data received from wind, current and motion sensors and then sending a signal to thrusters and rudders. DP is also used for moving a vessel along a pre-set track (1).

It started to be used during the 1960s, and it is mainly applied in the offshore industry. The complexity and high accuracy requested for the different offshore operations make the dynamic positioning system a great asset for this sector. Not only the drilling platforms but also the vessels that handle the anchors and other vessels supplying different services to these offshore platforms, as well as cable layers, all have in common the accuracy of their positions using DP systems.

However, DP systems do not always perform smoothly. The study of the incidents reported by vessels is essential to discover any failures that could be corrected and to improve the safety of DP operations. Different institutions currently deal with these incidents and have contributed to the safety improvement of DP operations by publishing guidelines and circulars.

Among the groups that have more actively provided feedback information to the industry regarding safety in DP operations, two professional groups should be highlighted: the International Marine Contractors Association (IMCA) and the Marine Technology Society (MTS). Other organisations, such as the International Maritime Organisation (IMO), classification societies, or flag states, base their guidelines on the documents provided by IMCA or MTS.

The IMCA is, without any doubt, one of the most prolific authors to the cause of safety in DP operations. They have published all kinds of different recommendations to the industry, along with guidelines for operations, sensors, personnel, and many more, which they have published (2).

It is also important to outstand the collection of DP incidents that IMCA has published since 1994 (3). The high volume of DP incidents reported anonymously, and carefully published by IMCA, have been the base of this research. Different authors based their academic work on these databases; for example, Chen et al. (4) introduced the safety of DP operations through a model based on barriers. Previously, the same research team had already approached the research topic in an article about the safety of such units (5). Chae investigated the human error in DP incidents (6) and applied formal safety assessment (7).

1.1 DP training and certification scheme

During the study period, the training and certification scheme had undergone some changes to adapt to the new situation derived from the oil and gas sector's crisis back in 2014 when the prices of crude oil came down (8-9).

On behalf of IMCA and since 1983, the Nautical Institute (NI) has managed the training scheme for prospective dynamic positioning operators (DPO) candidates and issued the corresponding certificates. Every few years, NI renews the standards and add new content. Their latest certification program (10) proposes three different certificates: the general DP certificate, the DP shuttle tanker, and the DP self-elevating platform certificate. Although there are other training schemes (DNV or OVDA, to mention a few), the industry recognises the Nautical Institute certification scheme widely.

The scheme for this study is the offshore scheme, which applies to mobile offshore platforms and the vessels that service the same: anchor handlers, diving support vessels, suppliers and others.

The DP training and certification scheme consists of 4 phases, named with letters. Phase A is the DP Basic or Induction course, and the eligible candidate should have a certificate of competence (CoC) as mentioned in STCW Regulation (II/1, II/2, II/3 Deck, III/1, III/2, III/3 Engine and III/6 ETO), or to be in its way to achieve one.

The Induction course consists of 28 hours of tuition, of which approximately 80% are theoretical and 20% practical lessons. The practical part of the course has to take place in a simulator that fulfils the predetermined conditions. After the tuition, the online exam takes place, where the candidates need to obtain a score of at least 70% to pass. The Alexis platform manages the online exam on behalf of the Nautical Institute.

Once the candidate owns the DP Induction certificate, he or she goes for Phase B on board a DP vessel and needs to achieve a minimum of 60 DP days. A DP day is considered a day in which the DP system was used for at least 2 hours, both actively (with propulsion) and passively (without propulsion). The claimed time in this phase has to be at least 75% in active mode. The tasks performed by the candidate during the period have to be evidenced in the NI DP logbook.

When the candidate has achieved the minimum number of DP days, he or she can take part in the DP Simulator course (Phase C). This course has 28 hours, of which 30% is theoretical tuition and 70% consist of practical exercises on a simulator.

This course has three different assessments: an online assessment, again managed by the Alexis platform on behalf of the Nautical Institute; a practical assessment (called DP Set Up practical assessment) which is managed by the training centre and in which certain items are defined by the NI are assessed, and a formative assessment, in order to manage the training during the course and adapt to the needs of the candidates.

After the DP Simulator certificate is obtained, the candidate is ready for Phase D of the scheme, in which he or she again joins a DP vessel in order to get the final training of the scheme. After evidencing at least 60 DP days, the candidate is ready for applying for a DP Operator license (Phase E). Optionally, the candidate can take a Sea time reduction (STR) course, which counts up to 30 DP days, and so only 30 extra DP days have to be obtained in Phase D in this case.

The time to complete the training scheme for those who start the Induction course after January 2015 is 5 years. This license should be renewed every 5 years by evidencing at least 150 DP days during the period.

Training centres that wish to receive accreditation from the Nautical Institute to deliver DP courses must pass an audit where simulators, administration processes and quality management are revised thoroughly for compliance with the NI standards (11). As of March 2022, the total number of accredited training centres is 83 (20 in America, 28 in Asia and Australia, 35 in Europe and Africa) (12).

The themes that should be covered for each course are mentioned in the Training and Certification standard (11) and reviewed by the NI when the accreditation for the training centre is granted. However, the training centres have the freedom to recreate the scenarios and operations for the different simulations required. There are no guidelines regarding the different scenarios that could be presented for the candidates, nor a list of different operations to be covered.

Several studies have covered the importance of human errors in the maritime industry in general (13-15) and during DP operations in particular (16-18). Human errors are very interesting from the training point of view because they can be studied and somewhat corrected through different training. The feedback required for achieving this is already in place, being the annual IMCA station keeping incident reports the best asset for this purpose.

This paper aims to find out, from the IMCA reports, which operations are more commonly having incidents in the DP industry and obtain evidence about the possible relation between human errors and some of these operations. It is believed that this correlation could be helping in developing a more convenient and detailed program for the simulations of the different DP courses.

2 MATERIALS AND METHODOLOGY

The original database consists of 312 cases, and it is obtained by examining the event trees provided by IMCA for the period 2007-2015. The following variables are recorded in this database: Main Operation, Main Cause, and Secondary Cause.

Regarding the main operation, the different categories recorded are listed in Table 1.

Main Operation	Number of cases	Percentage (%)
Drilling	81	26.0
Cargo	54	17.3
ROV	54	17.3
Diving	48	15.4
Cable/pipe lay	29	9.3
Stand-by	10	3.2
Personnel transfer	7	2.2
Trials	7	2.2
Topside Works	4	1.3

Anchor Handling	3	1.0
Seabed	2	1.0
Approaching	2	0.6
Construction	2	0.6
Shuttle	2	0.6
Trenching	2	0.6
Jacking	1	0.3
FPSO	1	0.3
Rock dumping	1	0.3
Transit	1	0.3
Total	312	100.0

Table 1 Categorisation of the variable Main Operation, indicating the number of cases and overall percentage. (n=312)

According to this data, some categories have a significantly low number of cases. In order to avoid the chi-square losing significance because of the degrees of freedom, the categories with less than 5% of the total number of cases will be eliminated. Thus, the categories that will be considered for this research are drilling, cargo, ROV, diving, and cable/pipe lay. The database is thus reduced to 266 cases.

A new variable, called Human Cause, is obtained by assigning the value 1 to the cases where either the main or the secondary (or both) causes are due to human error.

Then, a correlation between the variables Main Operations and Human causes is performed using Pearson's residues (r) with the following formula:

$$r_{ij} = \frac{o_{ij} - e_{ij}}{\sqrt{e_{ij}}} \tag{1}$$

Where e_{ij} is the expected frequency value, and o_{ij} is the observed frequency for different rows i and columns j. The residue's sign helps determine whether the correlation is proportional or inversely proportional.

Chi-square χ^2 represents the empirical chi-square, obtained by the formula:

$$\chi^2 = \sum_{i,j} \frac{\left(o_{ij} - e_{ij}\right)^2}{e_{ij}} \tag{a2}$$

Furthermore, the contribution (c) of each pair to the chi-square is then calculated as follows:

$$c_{ij} = \frac{r_{ij}}{\chi^2} \tag{3}$$

A bigger value of this contribution indicates a stronger correlation between the pair.

3 RESULTS

The database consists of 266 incidents. There are 57 incidents caused, directly or indirectly, by human error (19.7%), while the rest are attributed to other causes. When considering the main causes only, the distribution followed is shown in Table 2.

Main Cause	Frequency	Percentage
Thruster	79	29.7
Power	41	15.4
Computer	39	14.7
Human	37	13.9
References	28	10.5
Environmental	22	8.3
Sensors	10	3.8
Electrical	8	3.0

External	2	0.8

Table 2 Distribution of the cases by Main Cause (n=266)

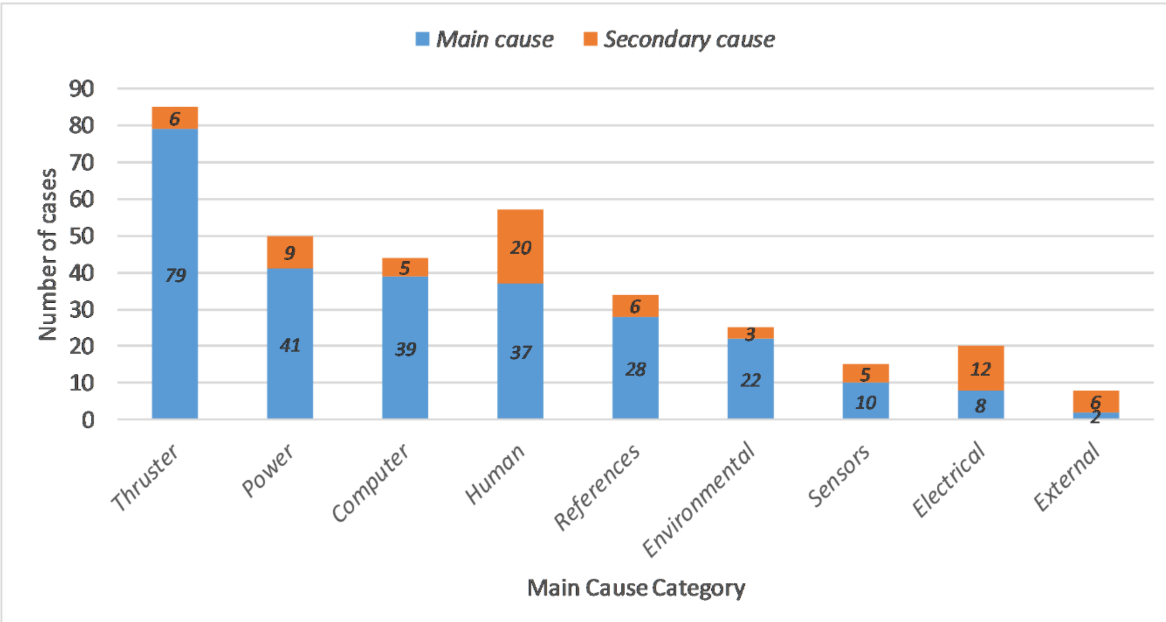

Fig. 1 Diagram showing the number of cases for main causes (in blue) and secondary causes (in orange). (n=266)

Although it is clear that thruster, power and computer failures comprise about 60% of the total incidents, some of the incidents' secondary or indirect causes show a different distribution, as shown in Figure 1. It is clear now that the human causes contribute as the second overall reason for the incidents in DP operations, after the thruster-failure incidents, which continue to lead the causality records.

It is important to outstand the weight of the human error in DP operations since it is very connected to the training system that the individual is receiving. Thus it is believed it could be improved, which constitutes the main objective of this research.

The observed values that result for each operation in progress, stratified by whether or not a human error caused the incident, can be seen in Table 3.

Operation in progress	No human cause	Human cause	Total
Drilling	61	20	81
Cargo	44	10	54
ROV	43	11	54
Diving	40	8	48
Cable/pipe lay	22	7	29

Table 3 Observed values for each category of operation in progress, stratified by whether the cause was attributed to a human error or not (n=266)

The correlation table showing the Pearson's residues is shown in Table 3. The negative coefficients indicate an inverse relationship between the given operation and the given classification. Based on this table, it is already clear that the operations with a bigger probability of having a human cause are drilling and cable/pipe lay.

Operation in progress	No human cause	Human cause

Drilling	-0.37	0.71
Cargo	0.21	-0.41
ROV	0.06	-0.11
Diving	0.34	-0.66
Cable/pipe lay	-0.19	0.36

Table 4 Pearson's residues were obtained for each operation in progress, considering the human nature or not of the incident.

The experimental χ^2 calculated is 1.591 for 4 degrees of freedom, which is bigger than the appointed critical χ^2 for a p-value of 0.05. This result indicates a correlation between the operations and the human nature of the incidents.

In order to get deeper into the results, the contributions to the chi-square are calculated and shown in Table 5. It is clear in this table that the operations contributing to the chi-square with bigger values are drilling (0.645) and diving (0.556).

Operation in progress	No human cause	Human cause	Total row contribution
Drilling	0.136	0.509	0.645
Cargo	0.044	0.165	0.209
ROV	0.003	0.012	0.015
Diving	0.117	0.439	0.556
Cable/Pipe Lay	0.035	0.131	0.166
Total column contribution	0.335	1.256	$\chi^2 = 1.591$

Table 5 Individual contributions to chi-square per operation in progress.

The bigger contributions are marked in red, and they both correspond to human causes, indicating that the correlation is bigger when considering the human causes than when other causes are regarded. Thus, the main contributions are given for drilling and diving operations.

4 DISCUSSION AND CONCLUSIONS

It is important to mention that the list presented in Table 1 represents only the incidents reported and not the real number of incidents happening in the industry, which could be even more, as has been already the object of research (19).

Personnel transfers and trial operations have no incidents related to human error. The reason for this could be the level of expertise required for performing such tasks. The prevailing weather conditions have an important role, and there are determinants in establishing the operating limits for these categories. Besides, including them in the correlation table would raise the chi-square, as there would be cells with an observed frequency of zero, which could be disguising the real results.

Incidents occurring during drilling and diving operations are the most correlated with human error, as can be seen in Table 5; however, the Pearson residues observed in Table 4 indicate that the relationship between diving operations and human error is inverse, that is, that these operations are having less influence by the human error than what it was expected with the data that was presented. In other words, the diving operations are the least influenced by human mistakes from all the operations selected.

On the other hand, drilling operations are marked as the most influenced by human errors. This evidence should be taken into account for future research. The different DP drilling incidents could be recreated in a simulator, and adequate procedures to avoid or reduce the human factor in the incident can be presented to the candidates attending a DP course.

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