Evaluation of the Qualification of Dynamic Positioning Operators Using Analytic Hierarchy Process

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Offshore vessel operations are always important for the industry as the consequences of incidents related to dynamic positioning systems may affect people, cargo, vessels, and the environment. The aim of this paper is to determine the qualification factors and improve the competency standards of Dynamic Positioning Operators (DPOs). The Analytic Hierarchy Process method has been used for this study by processing expert views of senior operators who have at least fifteen years of dynamic positioning experience. The results show that quality of trainer, importance of sea time collected after achieving a full DPO certificate, experience with different types of DP systems, and practical knowledge are defined as the most important factors to becoming a qualified dynamic positioning operator. Besides, situational awareness of DP operators is considered another important factor to reduce possible dynamic positioning incidents. In conclusion, this study provides the following recommendations: promote incentive programmes in order to appeal to potential trainers, increase the length of minimum required sea time after a simulator course, increase the required practical time onboard *in lieu* of transferring excessive active sea time to further stages, companies to provide familiarisation courses for operators regarding the equipment onboard prior to joining the vessel for the first time, and promote online training programmes to improve the situational awareness of operators. By using these recommendations, there is a possibility to improve the qualification of DP operators and reduce incidents related to dynamic positioning operations. Last but not least, this research can also be used as a reference in the offshore industry for the training of Dynamic Positioning Operators (DPOs).

KEY WORDS

~ Dynamic Positioning system
~ Dynamic Positioning Operator
~ Analytic Hierarchy Process
~ Offshore industry
~ DPO training
~ The Nautical Institute

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1. INTRODUCTION

As more Dynamic Positioning (DP) vessels of varying complexity have been built over the years, the requirements for Dynamic Positioning Operators (DPOs) have been changing. However, with the large number of DPOs available worldwide, it seems quite an alarming situation that offshore vessel operators are still unable to find competent personnel to the required level, whereby their interests can be protected from potential lawsuits related to DP incidents resulting from incompetency of the personnel. Furthermore, DP systems have become more reliable with more robust hardware, as well as software. Nevertheless, the trend of DP incidents gives no indication of any decrease according to IMCA DP incident reports.

A DP system can be described as a system which is able to automatically control the position and heading of the vessel by using active thrust in accordance with the International Marine Contractors' Association (IMCA, 2003). The DP system is a combination of seven components. DP system components include DPO, DP computers, DP station (console), power supply, thruster propulsion system, position reference systems, and sensors, as presented in Figure-1.

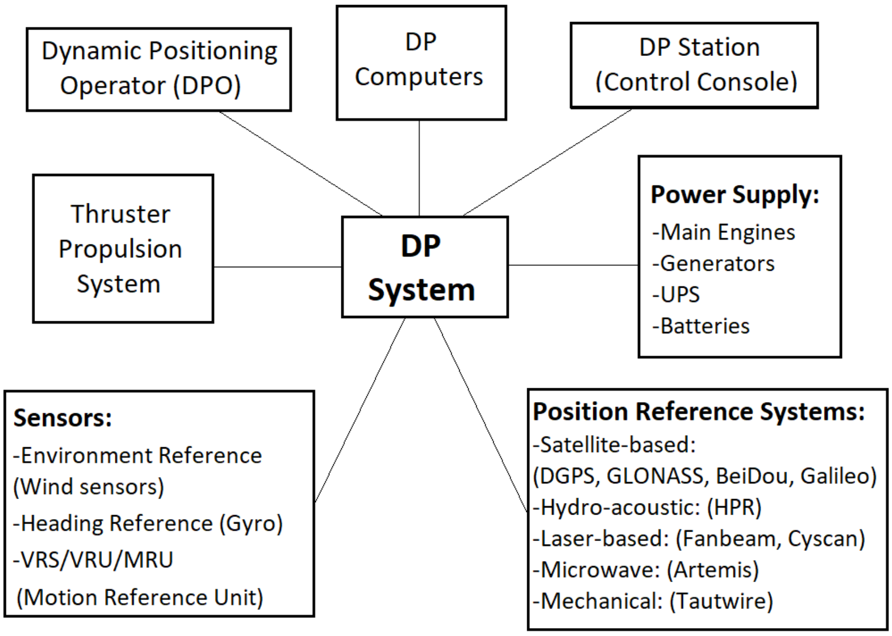

Figure 1. The components of DP system (Source: Authors)

According to regulatory bodies and industry standards, the DP vessels are always to be manned by competent and qualified DPOs. DPO is the responsible person for monitoring and controlling the DP system, movements of the vessel, and performing the required tests and control over the DP equipment. According to IMCA (2020), there are currently three organisations offering DPO certification. The Nautical Institute is the most common one that manages the training and certification system on behalf of IMCA; however, there are other training schemes, such as the ones by Det Norske Veritas (DNV) and Offshore Service Vessel Dynamic Positioning Authority (OSVDPA).

In this paper, thorough research is conducted to find out the significant factors which detect the training requirements on how to become a qualified DPO. The factors that affect the quality of DPO are revealed by using Analytic Hierarchy Process (AHP) analysis method. The objective of this study is to enhance the training and competency standards, as well as the quality of DPOs to improve the safety of offshore vessel operations and reduce potential DP incidents in the future. AHP analysis is applied by processing experts' views who are senior DPOs with more than fifteen years of offshore experience onboard different types of DP vessels. The results of this paper go beyond previous studies, showing that DP related factors have been wisely paired, compared with each sub-factor that was created in AHP analysis to reveal relative priorities. By means of the results of this research, strategies and recommendations are provided to improve the quality of DP operators and minimise the risk of DP incidents.

Although there is a lot of research regarding maritime education and training, there is a lack of studies related to DP operator qualifications. The study presented by Giddings (2004) describes the training and certification of DPOs and validation of DP training centres. Nevertheless, it does not provide any analysis on the competency of DPOs. Smith (2018) studied DP sea time validation and revealed suggestions how the industry could improve in practice. Lloyd (2018) studied the training demands of continuing professional development for the Dynamic Positioning Operators. Another paper, written by Olson (2008), highlights the concept of simulator training for DPOs. The study questions solely the standards of advanced simulator training for DP operators, in terms of requirements and efficiency (Olson, 2008). In another study, Smith (2014) presents a gap analysis between the existing DPO competency guidance and the best practices of DP operations onboard offshore vessels (Smith, 2014). The paper also discusses how information from regulatory bodies has been analysed and integrated to create a new training system to develop DPO competency. Similarly, Singh (2014) dealt with DP training and competency evaluation. The study reveals that the root causes of most DP incidents are found to be human error, incompetency, or inadequate procedures (Singh, 2014). Despite the research on competency and training systems for DPOs, there is still a lack of clear conclusion as to how to improve the quality of DPOs and maintain worldwide standards. Singh proposes an evaluation of existing DPOs at regular intervals by neutral assessors (Singh, 2014). Additionally, Ismail et al. (2014), studied 219 DP incidents through descriptive statistics. They found that crew training, discipline, and continuous maintenance are critical components for DP operations (Ismail et al., 2014). Another study, performed by Overgard and others (2015), was about critical incidents during dynamic positioning with regards to situation awareness and decision making of DPOs. The paper revealed more about the human factor side of dynamic positioning related incidents (Overgard et al., 2015). Last but not least, Chae (2017) produced a study of Formal Safety Assessment (FSA) application to human errors involved with DP incidents. The aspect of research demonstrated most DP drive-off incidents to be caused by human error; skill-based error, or unsafe supervision. The paper suggested mandatory DPO training and installation of DP simulators aboard the vessels (Chae, 2017).

In addition to the above studies, there are a few regulatory organisations, such as the International Maritime Organisation (IMO), the NI, IMCA, and the Dynamic Positioning Committee (DPC). These organisations provide useful guidelines to improve the training requirements and competencies for DPOs and the safety and operational performance of DP operations. First of all, IMCA provides comprehensive guidance in dynamic positioning operators' training and competencies. IMCA M117 document presents detailed guidance for the training and experience of key DP personnel, internationally recognised as an industrial standard (IMCA, 2016). According to the guidance document, the training and certification process for DPOs are administered by the NI, which is based in London, the United Kingdom. In order to become fully certified DPOs, it is required to go through the NI approved DP training scheme which is internationally recognized by the offshore industry. Similarly, there are other approved schemes such as that the DNV classification society has issued competency guidance for DPOs in 2009 (DNV, 2009), and Offshore Service Vessel Dynamic Positioning Authority (OSVDPA) started training and certification process in 2016 (OSVDPA, 2016).

Additionally, the IMO has implemented several guidelines through the Maritime Safety Committee (MSC) using circulars referring to IMCA publications. In example, MSC Circular-738 provides internationally accepted guidance for the training, competency and experience of key DP personnel, onboard training and familiarization programmes (IMO, 2017). Additional information is included within the STCW Code that comprises the requirements under section B-V/f, explaining the guidance on the training and experience for personnel operating dynamic positioning systems (STCW, 2010).

The results of current literature demonstrate that the training and competency of DPOs have critical importance for the safety of the offshore industry. It is thought that, by improving the standards of the aforementioned processes, it will be possible to significantly decrease the number of DP incidents in the future.

2. REQUIREMENTS FOR DYNAMIC POSITIONING OPERATOR CERTIFICATION

The training and certification process for DPOs comprises a total of five phases, in accordance with the NI requirements. A flow chart for the NI training and certification phases of DPOs are illustrated in Figure 2. According to terminology, a DP day can be defined as a day in which at least two hours were spent on DP watch. Besides, active sea time can be defined as a sea time day involved with numerous operations related to DP system, in which ship's DP components are actively used. It includes setting the DP system, manoeuvring in auto position, movement by joystick control, etc. On the other hand, a passive sea time day can be described as a sea time without the use of the ship's propulsion. This may include any training mode using the ship's own DP simulator onboard.

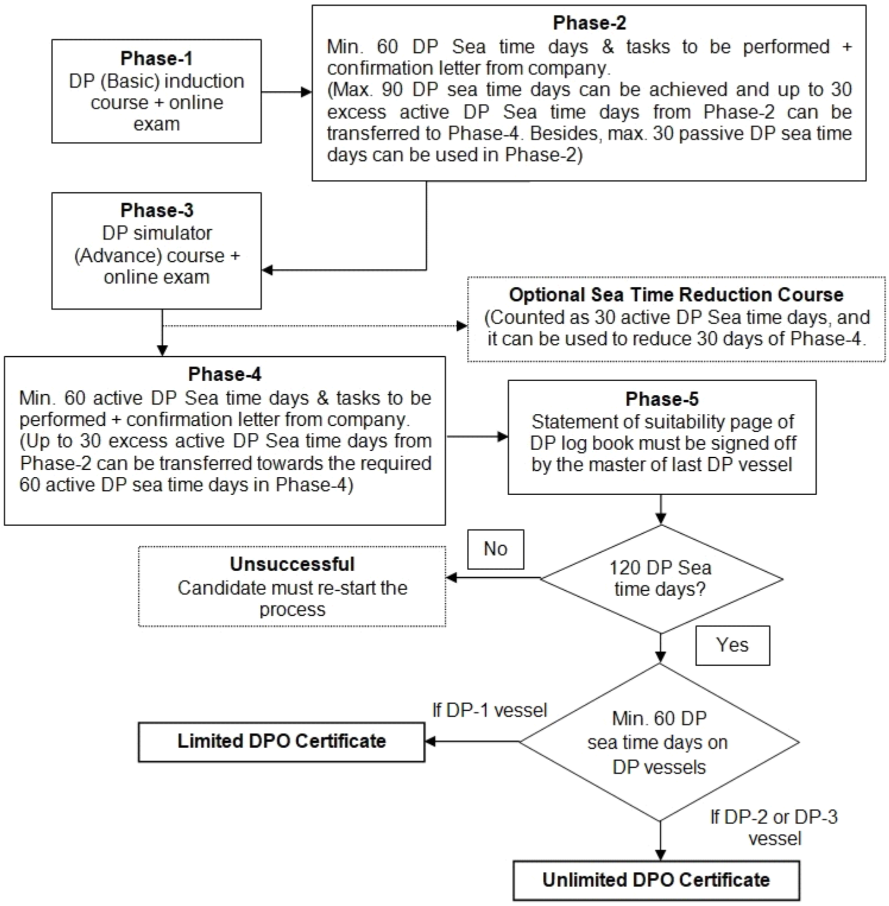

Figure 2. Training scheme of DPO (Source: The Nautical Institute, 2022)

According to IMO (1994, 2017), there are three DP equipment classes that provide different levels of safety, redundancy, and station-keeping reliability. These are DP 1, DP 2, and DP 3 equipment classes.

DP 1 equipment class can be described as follows: in the event of a single failure in any ship's active components or system, there may be loss of position and/or heading. In other words, it can be said that there is no redundancy.

DP 2 equipment class can be described as follows: in the event of a single failure in any ship's active components or system, loss of position and/or heading will not occur. It means there is redundancy if there is any problem in condition that a single failure, such as loss of one generator or loss of one of thrusters, or fault in one of main engines. However, loss of position may occur after a failure of a static component such as pipe, cable manual valve, etc. DP 2 system can be considered as backup system which will enable DP system to still keep its position and heading to cease the operation and pull out in a safe manner or time. For DP 2 vessels, static components are not normally considered to have failed, in which case adequate protection from damage is provided and proven.

DP 3 equipment class can be described in the following way: in the event of a single failure in any ship's active or static components or system, loss of position and/or heading will not occur. DP 3 vessels have the same requirements as DP 2 vessels. In addition to the requirements of DP 2 vessels, there are more requirements for extra precautions.

- any normally static components are assumed to fail;
- all components in any one watertight compartment, from fire or flooding;

– all components in any one fire sub-division, from fire or flooding.

3. METHODOLOGY

3.1. Analytic Hierarchy Process (AHP)

The AHP approach is an effective tool for dealing with complex decision-making, and may aid the policymaker to set priorities and make the best conclusion (Saaty, 1980). It provides pair wise comparisons among the selected factors in order to prioritise them, and assist with the determination of strategies (Sharma et al., 2008). Lamii and others (2002) identified the risks in seaport system using DELPHI-AHP method. AHP also allows the factors to measure their weights and prioritise them in a quantitative way. Fuzzy logic, optimisation of problems, and finding the best alternative are some of the areas in which the selected method has already been used (Vaidya et al., 2006). In this study, relative priorities are determined by making paired comparisons. The pair wise comparison scale is used to assign numbers, and the explanations are provided next to these numbers to introduce the importance of each factor (Saaty, 1980). The prioritisation mechanism is accomplished by assigning a number from a comparison scale, which is shown in Table 1, to represent the relative importance factor.

Importance	Definition
1	Two criteria contribute equally to the objective
3	Experience and judgement slightly favour one over another
5	Experience and judgement strongly favour one over another
7	Criterion is strongly favoured and its dominance is demonstrated in practice
9	Importance of one over another affirmed on the highest possible level
2, 4, 6, 8	Used to represent compromise between the priorities listed above

Table 1. Pair wise comparison scale (Source: Saaty, 1980)

A dynamic decision-making framework was studied by Liu, Y.N. and others (2022) to select the best supplier. Similarly, Gwarda, K. (2022) studied AHP method to decide on the best production company. In this paper, AHP is used for prioritisation of the main goal and to describe how to become a qualified DP operator. The analysis and main goal factor are prepared by means of the meetings held with six senior DPOs. The AHP method benefits from expert opinion for qualifying the items. Each expert working onboard DP vessels, is questioned separately to discuss specific tasks which are accepted to be the most crucial factors within the context. The experience of experts ranges from 15 to 20 years onboard different types of DP vessels, as shown in Table 2. All of the experts have DP-3 class experience, which is considered to be the most complex system within the offshore industry.

No of Expert	Experience	DP Class	Competency / Position	DP licence
Expert 1	20 years	DP-3	Unlimited Master, Offshore Installation Manager (OIM), Senior DPO	Unlimited DPO
Expert 2	20 years	DP-3	Unlimited Master, Stability Section Leader (SSL), Senior DPO	Unlimited DPO
Expert 3	15 years	DP-3	Unlimited Master, Senior DPO	Unlimited DPO
Expert 4	10 Years	DP-3	Unlimited Master, Senior DPO	Unlimited DPO
Expert 5	15 years	DP-3	Unlimited Chief Mate, Senior DPO	Unlimited DPO
Expert 6	15 years	DP-3	Unlimited OOW, Senior DPO	Unlimited DPO

Table 2. Scope of experts (Source: Authors)

Figure 3 presents the phases of the proposed methodology. Phase 1 comprises a building model. Phase 2 includes modifying the model; confirming the factors, sub-factors, and leading to a final model by meetings settled with DP experts. Based on the experience of Senior DPOs, a conversation was conducted and questions were asked to identify the factors and sub-factors, starting with the main question; 'What are the main factors to become a qualified DPO?' Question and answer teaching method was applied to find out the main goals to becoming qualified DPO. After identifying the main factors, sub-factors were listed under each main group. Lastly, Phase 3 comprises the identification of weights for each factor via the AHP method.

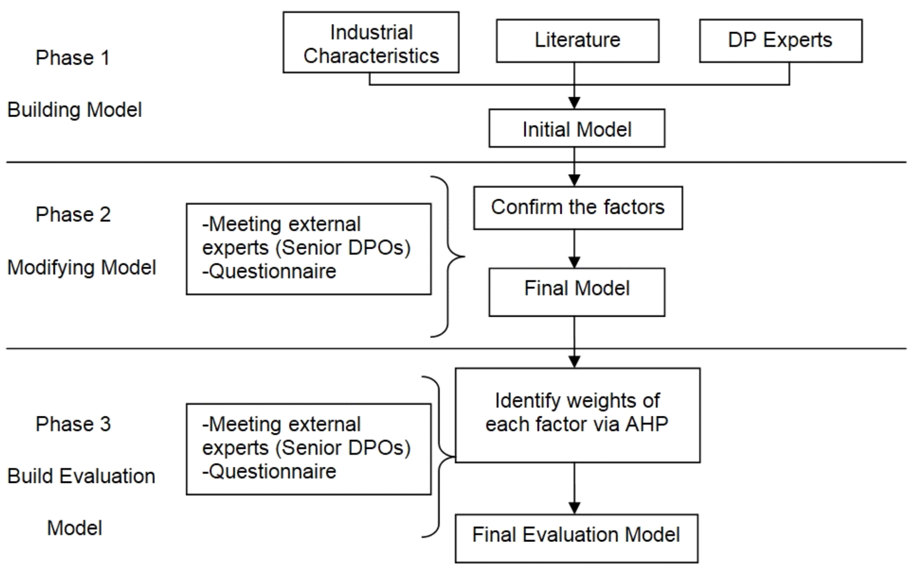

Figure 3. Phases of proposed methodology (Source: Gorener et al., 2012)

With the answers received from experts, each sub-factor is weighed. The detailed application steps of the AHP method are further presented. The data derived from the defined factors is processed by pair wise comparison among factors. The pair wise comparison matrix can be shown by a square and reciprocal matrix illustrated in Figure 4.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

Figure 4. Pair wise comparison matrix (Source: Saaty, 1980)

Furthermore, all matrices are normalised and relative weights are found. Decision elements steps are illustrated in Figure 5.

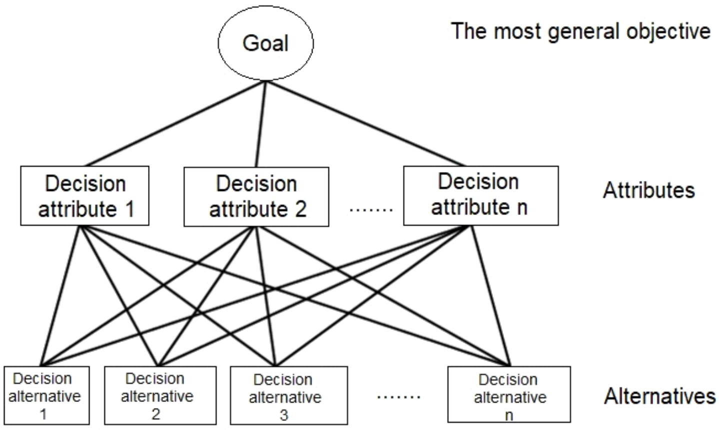

Figure 5. Decision elements in AHP (Source: Saaty, 1980)

AHP performs pair wise comparisons between evaluation factors in order to prioritise them, using the eigenvalue calculation. The usual AHP approach consists of the following steps:

i. Defining the main goal
ii. Performing analysis to identify factors with the experts (senior DPOs on DP vessels).
iii. Pair wise comparison of group factors is made by using a 1-9 Saaty’s comparison scale.
iv. Defining the weights for pair comparison matrix results for each group’s factors.
v. Identifying priorities.
vi. Using results for evaluation and developing strategies.

The analysis of data was performed with the help of the Super Decision programme to implement the AHP methodology and results. Super Decision is free decision-making software which is also designed by Saaty (Saaty, 2002). Figure 6 presents the main goal, factors, and sub-factors for this study.

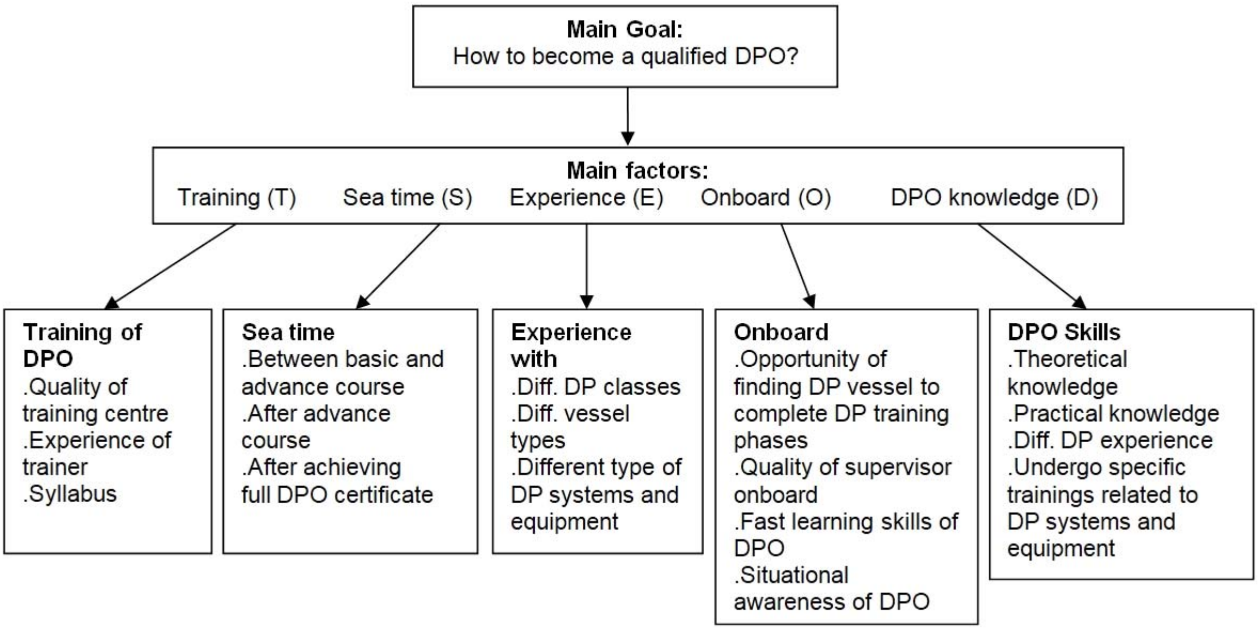

Figure 6. Factors and sub-factors of AHP model (Source: Authors)

Each sub-factor has been assigned respective codes such as T1, T2, and T3, for training sub-factors in order to explain the analysis clearly. Table 3 provides an explanation of each sub-factor.

Code	Explanation	Code	Explanation
T1	Quality of training centre	E1	Experience with different DP classes
T2	Experience of trainer	E2	Experience with different types of DP vessel
T3	Syllabus	E3	Experience with different types of DP systems and equipment
S1	Sea time between DP basic course and DP advance course		
S2	Sea time after DP advance course	O1	Opportunity of finding DP vessel to complete DP training phases
S3	Sea time after achieving full DPO certificate	O2	Quality of supervisor onboard
D1	Theoretical knowledge of DPO	O3	Fast learning skills of DPO
D2	Practical knowledge of DPO	O4	Situational awareness of DPO
D3	Different types of DP experience of DPO (approach, incident, joystick, etc.)		
D4	Undergo specific trainings related to DP systems and equipment		

Table 3. Explanation of each sub-factor (Source: Authors)

4. RESULTS

After the factors have been defined by means of experts' opinion, each sub-factor has been compared by pair wise comparison via the AHP model. The percentage contributions of factors and priorities have been identified. Table 4 presents an example of the preparation of the AHP initial model for training factors. Each expert provides their opinion and makes a comparison among each training sub-factor. At the end of the table, scores are summed up and the average result is further used to reflect priorities.

(T) Training factors	Expert1	Expert2	Expert3	Expert4	Expert5	Expert6	Avg.
(T1) Quality of training centre comparison with (T2) Experience of trainer	1/5	1/7	1/7	1/7	1/7	1/9	0.147
(T1) Quality of training centre comparison with (T3) Training syllabus	1	1	1/7	1/5	1/7	1/7	0.438
(T2) Experience of Trainer comparison with (T3) Training syllabus	7	3	3	5	5	1	4.000

Table 4. Example for comparisons of experts for (T) "training" sub-factors (Source: Authors)

In Table 4, the importance of T1 (quality of training centre) compared to T2 (experience of trainer) is considered as 0.147, based on the average result. On the other hand, the importance of T2 compared to T1 can be found by means of dividing '1' by '0.147' (1 / 0.147 = 6.798).

4.1. AHP Analysis for (T) Training Factors

Each sub-factor in its own group has been compared pair wise and their normalised weights have been calculated respectively. Table 5 presents AHP matrices for training group, and pair wise comparison of each sub-factor.

AHP matrices for (T) sub-factors			
Code	T1	T2	T3
T1	1	0,147	0,438
T2	6,7985	1	4,000
T3	2,2826	0,25	1
Total	10,0811	1,3971	5,4381

Table 5. AHP matrices for (T) training (Source: Authors)

Afterwards, normalised weighted matrices are calculated for training sub-factors. In order to find out priorities, normalised weighted matrices are summed up laterally and divided by the number of sub-factors. A summary of normalised weighted matrices for training sub-factors is given in Table 6.

Normalised-weighted matrices for (T) sub- factors				Sum-up laterally / n (3)	Code	Explanation
Code	T1	T2	T3			
T1	0.0991	0.105	0.081	0.0950	T1	Quality of training centre
T2	0.6743	0.7157	0.736	0.7085	T2	Experience of trainer
T3	0.2264	0.1789	0.1838	0.1964	T3	Syllabus
Total	1	1	1			

Table 6. Normalised-weighted matrices for (T) training (Source: Authors)

The results provided in Table 6 can be explained by means of the calculation below:

[T1-T1 (0.0991) + T1-T2 (0.105) + T1-T3 (0.081)] / 3 = 0.0950

[T2-T1 (0.6743) + T2-T2 (0.7157) + T2-T3 (0.736)] / 3 = 0.7085

[T3-T1 (0.2264) + T3-T2 (0.1789) + T3-T3 (0.1838)] / 3 = 0.1964

Priorities can be listed as T2 > T3 > T1 (0.7085 > 0.1964 > 0.095). From the short review above, the results show that the priority among the 'training' group is (T2) ''Experience of trainer'' with the largest weight (0.7085) compared to other sub-factors.

4.2. AHP Analysis for (S) Sea Time Factors

Furthermore, each sub-factor for the (S) 'sea time' group has been pair wise compared and their normalised weights have been calculated respectively. Table 7 presents AHP matrices for sea time group, and pair wise comparison of each sub-factor.

AHP matrices for (S) sub-factors			
Code	S1	S2	S3
S1	1	0.1904	0.1936
S2	5.25	1	0.3312
S3	5.1639	3.0191	1
Total	11.4139	4.2096	1.5248

Table 7. AHP matrices for (S) sea time (Source: Authors)

Afterwards, normalised weighted matrices are calculated for sea time sub-factors, as seen in Table 8.

Normalised-weighted matrices for (S) sub-factors				Sum-up laterally / n (3)	Code	Explanation
Code	S1	S2	S3			
S1	0.0876	0.0452	0.127	0.0866	S1	Sea time between DP basic course and DP advance course
S2	0.4599	0.2375	0.2172	0.3049	S2	Sea time after DP advance course
S3	0.4524	0.7172	0.6557	0.6084	S3	Sea time after achieving a full DPO certificate
Total	1	1	1			

Table 8. Normalised-weighted matrices for (S) sea time (Source: Authors)

The results provided in Table 8 can be explained by means of the calculation below:

[S1-S1 (0.08761) + S1-S2 (0.04525) + S1-S3 (0.127)] / 3 = 0.0866

[S2-S1 (0.4599)6 + S2-S2 (0.23755) + S2-S3 (0.21721)] / 3 = 0.3049

[S3-S1 (0.45242) + S3-S2 (0.7172) + S3-S3 (0.65579)] / 3 = 0.6084

Priorities can be listed as S3 > S2 > S1 (0.6084 > 0.3049 > 0.0866). The results show that the priority for sub-factors under the 'sea time' group is (S3) ''Sea time after achieving a full DPO certificate'' with the largest weight (0.6084) compared to other sub-factors.

4.3. AHP Analysis for (E) Experience Factors

Furthermore, another main factor which is defined as (E) experience has also been analysed using the AHP method. Three sub-factors have been pair wise compared and their normalised weights have been calculated respectively. Table 9 presents AHP matrices for experience group, and pair wise comparison of each sub-factor.

AHP matrices for (E) sub-factors			
Code	E1	E2	E3
E1	1	0.5238	0.4222
E2	1.9090	1	0.4222
E3	2.3684	2.3684	1
Total	5.2775	3.8922	1.8444

Table 9. AHP matrices for (E) experience (Source: Authors)

Afterwards, normalised weighted matrices are calculated for (E) experience sub-factors, as seen in Table 10.

Normalised-weighted matrices for (E) sub-factors				Sum-up laterally / n (3)	Code	Explanation
Code	E1	E2	E3			
E1	0.1894	0.1345	0.2289	0.1843	E1	Experience with different DP classes
E2	0.3617	0.2569	0.2289	0.2825	E2	Experience with different types of DP vessel
E3	0.4487	0.6085	0.5421	0.5331	E3	Experience with different types of DP systems and equipment
Total	1	1	1			

Table 10. Normalised-weighted matrices for (E) experience (Source: Authors)

The results provided in Table 10 can be explained by means of the calculation below:

[E1-E1 (0.18948) + E1-E2 (0.13458) + E1-E3 (0.22892)] / 3 = 0.1843

[E2-E1 (0.36174) + E2-E2 (0.25692) + E2-E3 (0.22892)] / 3 = 0.2825

[E3-E1 (0.44878) + E3-E2 (0.6085) + E3-E3 (0.54217)] / 3 = 0.5331

Priorities can be listed as E3 > E2 > E1 (0.5331 > 0.2825 > 0.1843). The results show that the priority for sub-factors under the 'experience' group is (E3) ''Experience with different types of DP systems and equipment'' with the largest weight (0.5331) compared to other sub-factors.

4.4. AHP Analysis for (O) Onboard Factors

Another main factor, is defined as (O) onboard, has been analysed and its four sub-factors have been pair wise compared before their normalised weights have been calculated. AHP matrices for the onboard group, and pair wise comparison of each sub-factor, are presented in Table 11, and the normalised weighted matrices that are calculated for (O) onboard sub-factors are presented in Table 12.

AHP matrices for (O) sub-factors				
Code	O1	O2	O3	O4
O1	1	0.926	2.502	0.198
O2	1.08	1	2.222	1.089
O3	0.3997	0.45	1	2.413
O4	5.0534	0.9183	0.4144	1
Total	7.5332	3.2942	6.1382	4.6994

Table 11. AHP matrices for (O) onboard (Source: Authors)

Normalised-weighted matrices for (O) sub-factors					Sum-up laterally / n (4)	Code	Explanation
Code	O1	O2	O3	O4			
O1	0.1327	0.281	0.408	0.042	0.2158	O1	Opportunity of finding DP vessel to complete DP training phases
O2	0.1433	0.3035	0.362	0.232	0.2601	O1	Quality of supervisor onboard
O3	0.0530	0.1366	0.1629	0.513	0.2164	O3	Fast learning skills of DPO
O4	0.6708	0.2787	0.0675	0.2127	0.3074	O4	Situational awareness of DPO
Total	1	1	1	1			

Table 12. Normalised-weighted matrices for (O) onboard (Source: Authors)

All normalised weighted (O) matrices have been laterally summed up and divided by 4, the number of sub-factors. The results provided in Table 12 can be explained by means of the calculation below:

[O1-O1 (0.1327) + O1-O2 (0.281) + O1-O3 (0.408) + O1-O4 (0.042)] / 4 = 0.2158

[O2- O1 (0.1433) + O2-O2 (0.3035) + O2-O3 (0.362) + O2-O4 (0.232)] / 4 = 0.2601

[O3- O1 (0.053) + O3-O2 (0.1366) + O3-O3 (0.1629) + O3-O4 (0.513)] / 4 = 0.2164

[O4- O1 (0.6708) + O4-O2 (0.2787) + O4-O3 (0.0675) + O4-O4 (0.2127)] / 4 = 0.3074

Priorities can be listed as O4 > O2 > O3 > O1 (0.3074 > 0.2601 > 0.2164 > 0.2158). The results show that the priority for sub-factors under the ‘onboard’ group is (O4) ‘‘Situational awareness of DPO’’ with the largest weight (0.3074) compared to other sub-factors.

4.5. AHP Analysis for (D) DPO Skills Factors

In the last main factor, each sub-factor in its own group has been pair wise compared and their normalised weights have been calculated respectively. Table 13 presents AHP matrices for training group, and pair wise comparison of each sub-factor.

AHP matrices for (D) sub-factors				
Code	D1	D2	D3	D4
D1	1	0.2	0.1809	0.4793
D2	5	1	1.667	3.333
D3	5.5263	0.6	1	4.667
D4	2.0860	0.3	0.2142	1
Total	13.6124	2.1	3.0619	9.4793

Table 13. AHP matrices for (D) DPO skills (Source: Authors)

A summary of normalised weighted matrices for (D) DPO skills sub-factors is given in Table 14. Similar to previous calculations, normalised weighted matrices are summed up laterally and divided by 4, the number of sub-factors.

Normalised-weighted matrices for (D) sub-factors					Sum-up laterally / n (4)	Code	Explanation
Code	D1	D2	D3	D4			
D1	0.0734	0.0952	0.0591	0.0505	0.0695	D1	Theoretical knowledge of DPO
D2	0.3673	0.4761	0.544	0.352	0.4348	D2	Practical knowledge of DPO
D3	0.4059	0.2857	0.3265	0.492	0.3776	D3	Different types of DP experience of DPO (approach, incident, joystick, etc.)
D4	0.1532	0.1428	0.0699	0.1054	0.1178	D4	Undergo specific trainings related to DP systems and equipment
Total	1	1	1	1			

Table 14. Normalised-weighted matrices for (D) DPO skills (Source: Authors, 2022)

The results provided in Table 14 can be explained by means of the calculation below:

[D1-D1 (0.0734) + D1-D2 (0.0952) + D1-D3 (0.0591) + D1-D4 (0.0505)] / 4 = 0.0695

[D2-D1 (0.3673) + D2-D2 (0.4761) + D2-D3 (0.544) + D2-D4 (0.352)] / 4 = 0.4348

[D3-D1 (0.4059) + D3-D2 (0.2857) + D3-D3 (0.3265) + D3-D4 (0.492)] / 4 = 0.3776

[D4-D1 (0.1532) + D4-D2 (0.1428) + D4-D3 (0.0699) + D4-D4 (0.1054)] / 4 = 0.1178

Priorities can be listed as D2 > D3 > D4 > D1 (0.4348 > 0.3776 > 0.1178 > 0.0695). The results show that the priority for sub-factors under the 'DPO skills' group is (D2) ''Practical knowledge of DPO'' with the largest weight (0.4348) compared to other sub-factors.

5. DISCUSSION AND CONCLUSION

Human factor is one of the most significant subjects for DP incidents in the offshore industry. Studies relating to human error in the offshore domain are typically undertaken utilising expert opinion due to the limitation of data. This section outlines the conclusion of the study, followed by recommendations.

After an examination, the priorities from the AHP analysis have been identified accordingly. The significant factors affecting the qualification of DPOs are revealed. In future studies, it may be useful to perform detailed research on particular aspects of these factors. By means of the priorities calculated from each main group, a total of five factors have been listed as the most important points to become a qualified DPO. Table 15 presents the ranking list for priorities, showing the qualification of DPOs. From each main group, one sub-factor with the strongest weights was selected.

Final ranking can be listed as T2 > S3 > E3 > D2 > O4 (0.7085 > 0.6084 > 0.5331 > 0.4348 > 0.3074).

Ranking	Code	Weight	Factor: Sub-factor
1	T2	0.7085	Training: Experience of trainer
2	S3	0.6084	Sea time: Sea time gained after achieving full DPO certificate
3	E3	0.5331	Experience: Different types of DP systems and equipment onboard
4	D2	0.4348	DPO: Practical knowledge of DPO
5	O4	0.3074	Onboard: Situational awareness of DPO

Table 15. Results ranking (Source: Authors, 2022)

According to Table 15, experience of trainers and the sea time, gained after achieving a full DPO certificate, are found to be the most significant factors affecting the quality of dynamic positioning operators. Furthermore, the third most important factor is experience with different types of DP systems and equipment with the weight of 0.53. Fourth, the practical knowledge of DPOs is listed as another significant factor with the weight of 0.43. Last but not least, situational awareness of DPO is found to be the fifth most significant factor. Recommendations have been made in order to improve the qualifications and competencies of DPOs. As a result of the findings, the authors recommend the following points:

Although the requirements and training scheme for becoming a DP trainer are sufficiently explained in the DPACSS (Dynamic Positioning Accreditation and Certification Scheme Standard) by the NI, it is recommended that the qualification requirements for DP instructors should be continuously updated and improved in parallel with the development of technologies and the changing perceptions of the younger generation. Not only the DP courses, but also other trainings, such as communication skills, problem-solving, leadership development, andragogy, and life-long learning modules can be included to assist DP trainers in continuous professional development for the future's requirements. Furthermore, it is recommended for DP training centres to encourage DP trainers to work onboard DP vessels for at least one month each year to refresh their practical skills and follow up on recent professional developments wherever applicable. *(Ref. T2: Training: Experience of trainer)*

The experience gained during practical learning is considered more effective and utilises the competence of DPOs. This may be considered a promising aspect of this paper. Since a DP sea time day includes only two hours in a day, the duration of required DP sea time (60) days, after completing DP simulator course (Phase 3) is considered insufficient. Consequently, another recommendation for policymakers is to increase either the hours of DP sea time day or increase the length of required DP sea time (60) days. By means of this change, trainee DPOs will have more chance to gain practical experience. *(Ref. S3: Sea time gained after achieving full DPO certificate, E3: Experience with different types of DP systems and equipment onboard, D2: Practical knowledge of DPO)*

Another significant finding is that, although DP system and principles are mainly similar, the contents of different type of offshore vessels and their operations may differ from each other and require additional skills and experience from DPOs. Therefore, expert specialisation program can be developed for the industry. To give an example, a DPO who has experience onboard DP-3 Drill Ship for a minimum of 90 DP sea time day can have a specialised ticket or certificate enabling him/her to work onboard specific offshore vessel. Unless a DPO has specialised certificate for that type of DP vessel, s/he can be employed as trainee DPO until s/he gains specific knowledge and experience. (*E3: Experience: Different types of DP systems and equipment onboard, D2: Practical knowledge of DPO)*

Moreover, it is strongly believed that, if the trainees have longer time onboard with active DP operations, it is considered of great value for enhancing their knowledge. It will also enable trainees to gain more practical skills and experience from different DP operations and interact with different senior DPOs. Consequently, it is advised that the excessive (or any extra) active sea time days, gained before the DP simulator course (Phase-3), should not be transferred to further steps, such as Phase-4, as shown in Figure 2. *(Ref. E3: Experience: Different types of DP systems and equipment onboard, D2: Practical knowledge of DPO)*

Situational awareness of DPO is found to be another significant factor, as presented in Table 15. Situational awareness gives individuals to be more alert and make a better decision that has vital importance for DPOs during emergencies. The playmakers are recommended to develop specialised mandatory programmes for DP trainees, such as: training course in how to react and take actions in emergency situations, i.e. during black-out, losing all gyros, losing all wind sensors, drift-off, drive-off, common mode failures for position reference systems, etc. It is believed that these types of training will improve the situational awareness of DPOs and decrease the potential DP incidents. (*Ref. O4: Onboard: Situational awareness of DPO)*

For future studies, competency factors of DPO for different types of DP vessel can also be identified in more detail. The competency factors can be achieved by taking a specific vessel type or incident model via more state-of-the-art methodologies, such as machine learning, or Bayesian network method, etc.

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CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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