GUIDANCE NOTES ON

STATIONKEEPING OPERATIONS OF SELF-ELEVATING UNITS EQUIPPED WITH DYNAMIC POSITIONING SYSTEMS

AUGUST 2018

American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862

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Foreword

These Guidance Notes provide technical recommendations and guidance on the operation of the elevated DP unit while approaching and leaving the location, with a specific focus on the effects of DP capability during lowering/lifting legs and during touch down.

The number of elevated units in use equipped with Dynamic Positioning (DP) systems for position keeping is increasing. These units use DP while approaching and leaving the operation location. Compared to conventional floating units with DP systems, elevated units have unique characteristics when operating in DP mode, such as the leg effect during lowering down, raising up, and touching down.

These Guidance Notes are intended to be used in conjunction with the ABS *Guide for Dynamic Positioning Systems*.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of these Guidance Notes is the most current.

These Guidance Notes become effective on the first day of the month of publication.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.

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CONTENTS

SECTION 1 Introduction

1 General

These Guidance Notes provide guidance for the effective management of DP operations for Self-Elevating Units (SEU). This document is not meant to replace or supersede any rules, regulations, or operational manuals. The information presented here is compiled from various industry sources and from experience not previously available in the public domain. This document is not intended to address all aspects of DP operations for SEUs, but rather presents a collection of best practices with a focus on important DP operational themes aimed at effective DP operations and a reduction in DP related incidents.

Self-elevating units (SEUs) equipped with dynamic positioning systems include units for construction, wind turbine IMR (installation, maintenance, and repair), accommodation, well services, and other non-drilling activities. The term 'liftboat' is sometimes used in some geographic areas or by some companies to describe SEUs. Thus the DP operations for SEUs are typically limited to repositioning operations and jacking operations. This document provides guidance on these specific operations.

3 Objective

These Guidance Notes were created to provide guidance on the effective DP operations of SEUs. The following subjects are addressed in this document:

- DP class
- FMEA/FMECA
- DP Capability Plots
- DP Footprint Plots
- Modes of Operations
- Operation Manuals

5 Definitions

DP System: Components and systems acting together to achieve reliable position keeping capability. The DP system includes the power system (power generation and power management), thruster system and DP control system.

DP Control System: All control components and systems, hardware and software necessary to dynamically position the vessel. The DP control system comprises computer systems, sensors, display systems, position reference systems and associated cabling and routing.

DP Capability Plots: These define by theoretical calculation the vessel's ability to maintain position in various environmental conditions, (i.e., wind, sea state and current). It considers external forces including pipe tension, thruster and power configurations.

DP Footprint Plots: Plots detailing the vessel's DP stationkeeping performance and limitations in various environmental conditions (wind, sea state and current). It considers external forces including pipe tension, thruster and power configurations. These are created by observation onboard the vessel in real time conditions.

FMEA: A systematic analysis of systems and sub-systems to a level of detail that identifies all potential failure modes down to the appropriate sub-system level and their consequences.

SECTION 2 DP Operations for SEUs

1 DP Operational Documentation

1.1 General

It is recommended that DP vessel owners/operators maintain the documentation listed in Table 1, below and develop and implement associated processes so as to:

- Achieve sound and effective management of the vessel in DP
- Achieve technical suitability of the vessel for each DP activity to be carried out
- Determine the configuration for the mode of operation
- Understand the vessel's station keeping capabilities following the worst case failure
- Comply with appropriate standards and guidelines
- Provide training and familiarization material to vessel crews

1.3 Recommended Documentation

A full list of recommended documentation can be found in Section 3 of Marine Technology Society (MTS) DP Operations Guidance Part 2 Appendix 1.

Specific to DP SEUs, documentation for DP footprint plots may be different for typical DP vessels due to the difficulty of recreating the conditions assumed when developing the DP capability plots.

3 DP Class

MTS DP Operations Guidance Part 2 Appendix 1 recommends a minimum of Class 2 level for DP Equipment for a DP Vessel with logistics operations applications. For self-elevating units, the most common DP operations are repositioning and jacking. The primary function of a SEU is not realized until the vessel has been fully deployed and jacked into position. Thus, functions such as drilling and crane operations should not be considered for the DP system. Due to this limited scope of DP operations, the notation **DPS-2** is recommended for DP SEUs.

5 DP FMEA

The ABS *Guide for Dynamic Positioning Systems* can be used for the FMEA of the DP systems. MTS DP Operations Guidance Part 2, Appendix 1 provides a concise overview of the underlying philosophy, analytical processes, and technical content of a DP FMEA for DP MODUs. Similarly, International Marine Contractors Association (IMCA) M166 and M04/04 detail the considerations taken during the development of the DP FMEA.

Development and use of DP FMEAs for SEUs should mirror those for MODUs. Additional consideration should be given to jacking and repositioning operations while operating in dynamic positioning mode.

7 DP Capability Plots

DP Capability Plots should be calculated for the vessel. Guidance is provided on DP Capability Plots in the ABS *Guide for Dynamic Positioning Systems* and IMCA M140 Rev 1, "Specification for DP Capability Plots".

These plots are calculated from detailed information of the vessel's hull and superstructure form and available thruster power. The calculations should use environmental data (sea state, wind and current) appropriate to the DP vessel's intended area of operations.

DP Capability Plots should include the following scenarios at current speeds that are representative of the location in the DP vessel's intended area of operations:

- Fully intact power generation and thrusters
- Loss of most effective thruster(s)
- Following the worst case failure

The DP Capability Plots should be provided in a format that is intuitive to the user on board (e.g., Polar Plot).

Specific to SEUs, leg position should be taken into account when developing DP capability plots, as leg position affects the wind loads and the current loads as the vessel undergoes jacking procedures. DP capability plots should be developed to encompass the maximum wind load, maximum current load, and an appropriate combination of the two loads. These conditions reflect the leg positions at the highest, lowest, and a transient water depth.

Jackup legs may be of a solid or lattice design. Wind and current drag coefficients are influenced by the cross-sectional area of the legs. For lattice legs, an equivalent cross-sectional area can be calculated from the cross-sectional areas of all the chords in the leg. ABS *Guidance Notes on Structural Analysis of Self-Elevating Units*, Appendix 1 details the calculations for determining an equivalent cross sectional area.

Appendices 1 and 2 present examples of DP capability plots for different leg positions. This method uses "snapshots" of the leg lowering or raising operations. It is assumed that leg raising or lowering operations will be conducted at a slow pace in order to minimize any dynamic effects.

Impact loads against the seabed when lowering legs or sudden freedom when pulling legs off the soil do not need to be incorporated into the DP capability plots. It is understood in the industry that the environmental inputs at the moment of setting down or pulling out are omitted by the DP model to prevent impulse loading, which may lead to thruster drive off.

9 DP Footprint Plots

DP Footprint Plots are typically produced on board using actual measurements of the vessel's DP stationkeeping performance in actual environmental conditions and thruster configurations. Typically, DP footprint plots are developed during sea trials using local environmental conditions. These plots serve as a functional check to confirm the vessel is functioning within the calculated DP Capability.

However, SEUs undergo very different dynamics during jacking operations because of the leg positions. The DP Capability plots should be developed with the maximum and minimum leg positions in order to encapsulate the largest wind loads and current loads. These conditions may be impractical to recreate during sea trials. Therefore, the utility of DP footprint plots is much more limited with respect to SEUs and will likely only consider the footprint of the vessel with legs fully elevated. However, this information is relevant when the vessel is approaching and leaving the work site and can confirm the assumptions made when developing DP capability plots.

11 DP Control Modes for Self Elevating Units

The DP SEU should be equipped with suitable DP control modes and features with due consideration of operational needs, both with regard to restrictions caused by the activity and performance criteria necessary to execute DP operations prudently and successfully.

The two most common DP control modes for SEUs include DP operations for SEU repositioning and jacking operations.

When repositioning, the DP system should continually monitor environmental conditions and adjust the DP model accordingly.

The DP control mode for jacking operations should account for changing wind, wave, and current loads due to leg position. In practice, the DP system stays online throughout the jacking operation. For setting down operations, the DP model is frozen just before soft pinning of the legs to prevent impulse feedback into the DP model leading to thruster runoff. Similarly, the DP model is frozen until the spudcans are fully free from the seabed. After the spudcans are free, the DP model resumes utilizing sensor readings to control the DP system.

13 DP Operations Manuals

A vessel-specific DP Operations Manual should be prepared for each DP vessel.

Of all required documents, the vessel-specific DP Operations Manual is the primary operational document. The need for a manual has its origins in IMO MSC/Circ 645 (1994) “Guidelines for Vessels with Dynamic Positioning Systems”. Refer to ABS *Guide for Dynamic Positioning Systems* for full details of the DP Operations Manual.

For SEUs, the manual should specifically address critical operations such as jacking procedures and repositioning. Details should be provided with regards to the DP model in order to prevent impulse loading due to contact with the seabed. Environmental conditions should be cited such that critical operations are conducted within design parameters.

IMCA Guidance for the Positioning of Dynamically Positioned (DP) Jackup Vessels on and off the seabed provides operational guidance on jacking operations while operating under DP.

15 Recommended Procedures for DP Self Elevating Vessel Going On and Off Location

IMCA M223 provides guidance on jacking operations on and off the seabed while in DP mode. Recommended procedures are presented on going on and leaving location and takes into account the potential external forces due to the soft-pinning of the legs during set down and the sudden freedom of the leg during extraction. Some of the recommendations are summarized in the following sections.

15.1 Procedure for DP Self Elevating Vessel Going on Location

The following should be considered in developing DP jacking procedures when going on location:

i) Environmental conditions and forecast should be reviewed to such that operational limits are not exceeded. DP capability plots developed for different leg lengths of the jacking process should be reviewed and compared to live conditions.

ii) The site seabed map report should be obtained and reviewed by the operator.

iii) Transit to location should be conducted at an appropriate vessel speed in accordance with vessel procedures

iv) Once at site, lowering of the legs should commence according to vessel procedures. Environmental conditions should be monitored for any exceedance of the theoretical DP capability.

v) Once the legs are properly positioned on location above the seabed, the DP system should be given time to fully stabilize. Once the system is stabilized, the DP system should be frozen to prevent any additional input forces generated by impact loading of the legs before continuing with soft pinning of the legs.

vi) The legs should be lowered onto the seabed to initiate soft pinning. Once soft pinning has been achieved, the DPO can select manual joystick mode once the DP system is no longer required for position keeping. At this time, the DPO can manually keep the thruster propulsion at zero thrust. Alternatively, the DPO can turn off the thrusters if it has been determined that soft pinning has provided enough anchoring of the vessel.

vii) The DP system should be able to be switched off for hull raising and preloading operations.

15.3 Procedure for DP Self Elevating Vessel Leaving Location

The following should be considered when developing DP jacking procedures for leaving location:

i) Environmental conditions and forecast should be reviewed and be within the operational limits. DP capability plots developed at different leg lengths of the jacking process should be reviewed and compared to live conditions.

ii) Lowering of the hull into water should commence according to vessel procedures. The DP system should be placed on standby.

iii) Extraction of the legs from the seabed should commence as buoyancy increases. At the moment the vessel becomes free-floating the DP system should be turned on with manual control. The DPO should then confirm that zero resultant forces are acting on the vessel at this time.

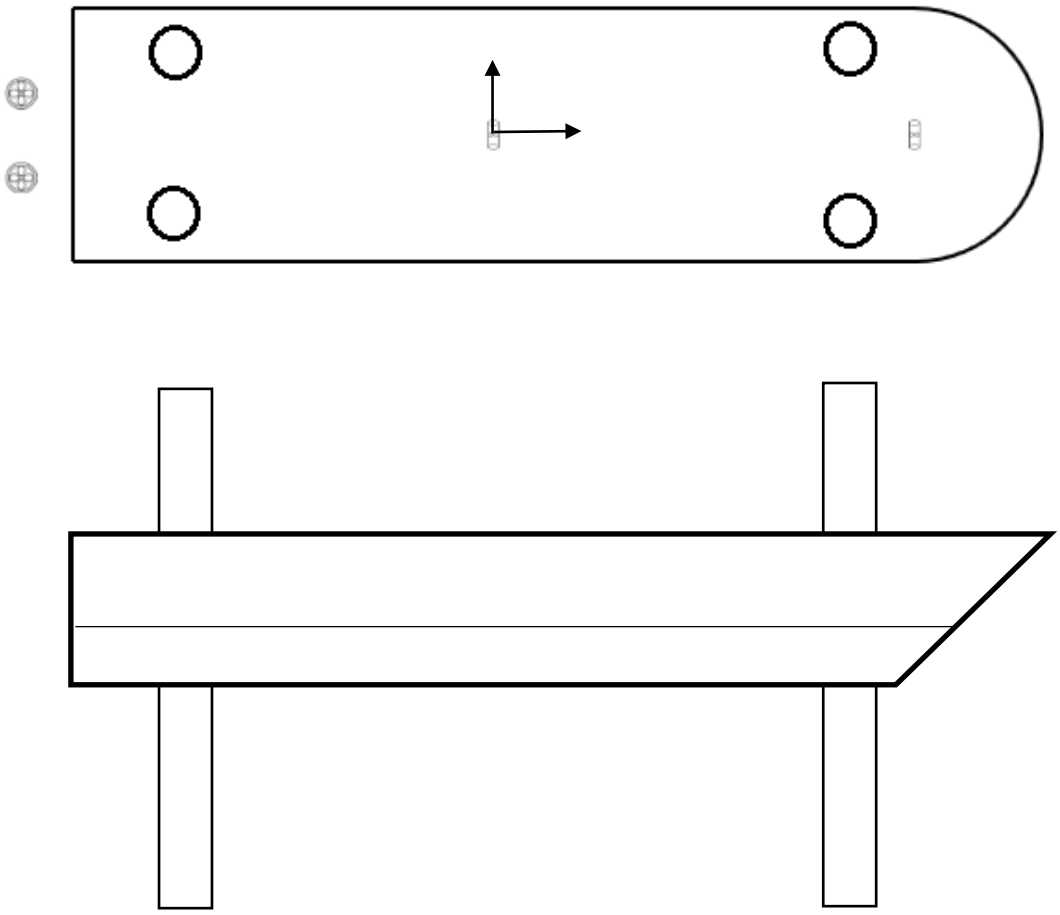
iv) The vessel should be transited away from location with manual control until relocating at a pre-defined area where full auto DP can be selected. The DPO should be aware of the leg depths and drag forces on the submerged legs during transit to the pre-defined area.

v) Once the vessel arrives at the pre-defined area, the DP system can be placed in full auto mode and full extraction of the legs can then be performed. Care should be taken to confirm the environmental conditions do not exceed the DP capability at different leg depths.

APPENDIX 1 DP Capability Plots – SEU #1

This Appendix shows an example of a DP Capability Plot for a generic ship-shape SEU developed using the ABS Dynamic Positioning Station keeping (DPSK) software.

FIGURE 1
Generic SEU #1 Schematic



Appendix 1, Figure 1 shows a schematic of SEU #1 used in this analysis. The vessel has four solid legs, two tunnel thrusters located amidship and at the bow, and 2 azimuthing thrusters located at the stern. The main particulars of the vessel are listed in Appendix 1, Table 1 and the thruster system is detailed in Appendix 1, Table 2.

TABLE 1
SEU #1 Main Particulars

	SI	*US*
Lpp	80 m	262 ft
B	30 m	98 ft
Draft	6 m	20 ft
Displacement	10000 m^3	353147 ft^3

TABLE 2
SEU #1 Thruster Parameters

Thruster	*Type*	*LongPos*		*TransPos*		*Diameter*		*TiltAng*	*MaxThrust*	
#	-	*m*	*ft*	*m*	*ft*	*m*	*ft*	*deg*	*kN*	*lbf*
1	Tunnel	40	131.2	0	0	2	6.6	0	100	22.5
2	Tunnel	0	0	0	0	2	6.6	0	100	22.5
3	Azimuthing	-45	-147.6	-5	-16.4	3	9.8	0	100	22.5
4	Azimuthing	-45	-147.6	5	-16.4	3	9.8	0	100	22.5

For this analysis, North Sea conditions and a current speed of 1 and 2 knots were used. The work site depth was identified as 40 m (131 ft). The analysis was performed for the following conditions:

- Legs fully retracted
- Legs lowered to a depth of 17 m (56 ft)
- Legs lowered to a depth of 37 m (121 ft) just above the seabed.

The wind and wave coefficients of the hull were calculated utilizing the frontal and side projected areas of the hull. Wind and wave coefficients for the legs were calculated using drag coefficients for solid cylinders and adjusted to reflect the different leg positions.

Appendix 1, Figures 2 and 3 show the results of the analysis. The DP capability decreases as the legs are lowered due to increased current loads. The beam-on condition with legs close to the seabed presents the lowest DP capability. This indicates that appropriate planning must be conducted in order to minimize the possibility of maximum load. Vessel operators should consider the weathervaning effects to avoid the beam-on condition.

FIGURE 2
DP Capability Plot for Current Speed of 1 Knot

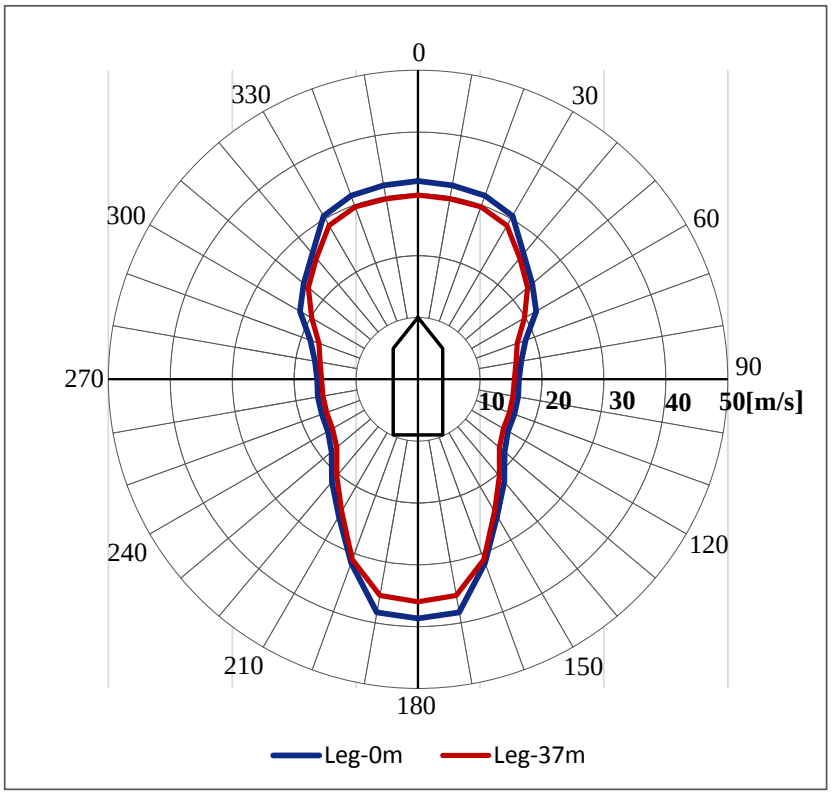
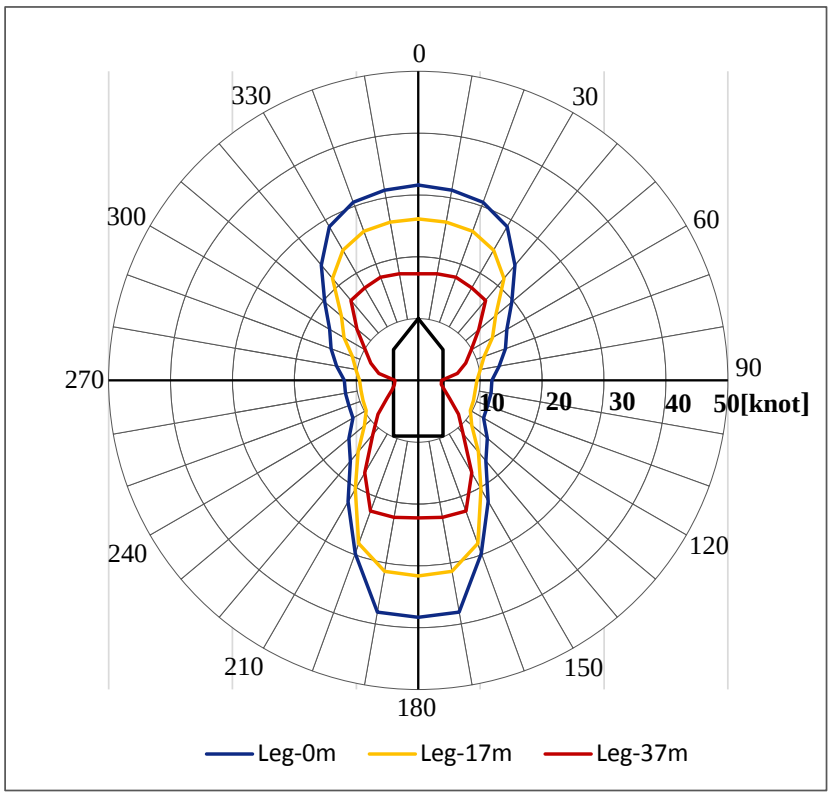


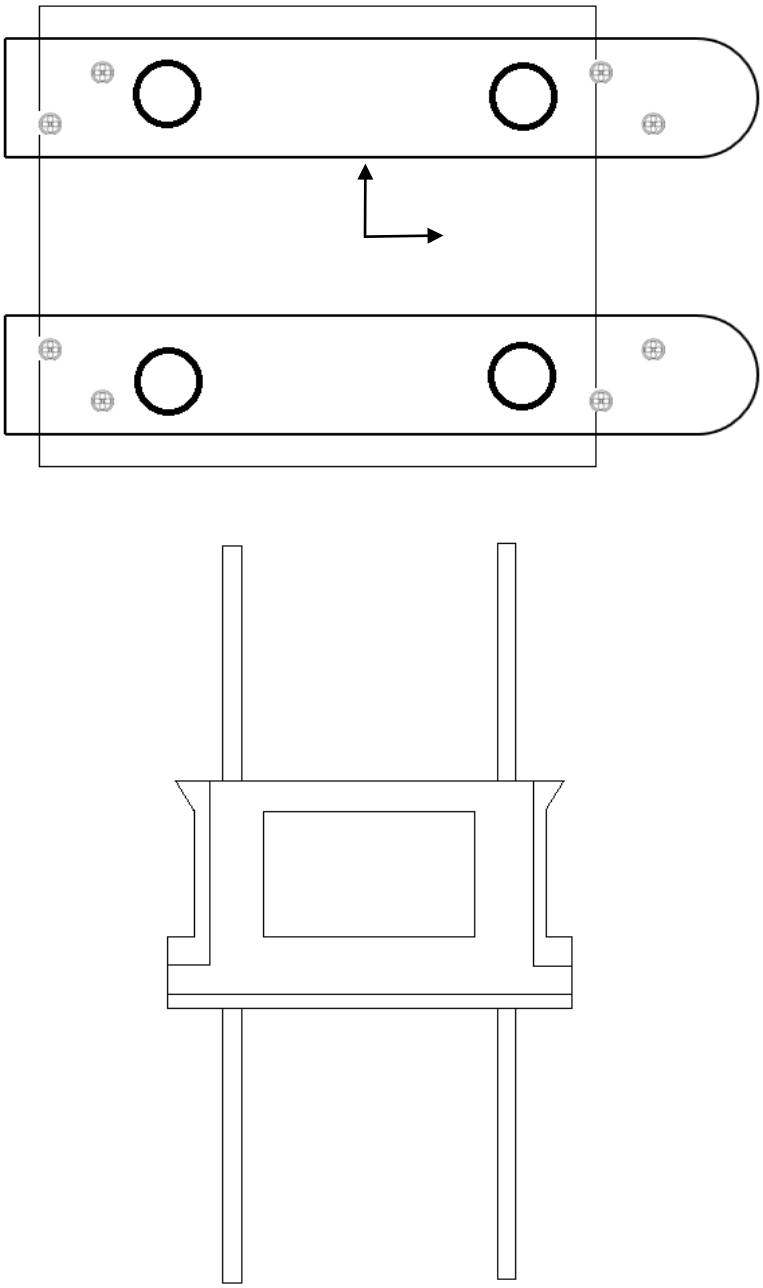
FIGURE 3
DP Capability Plot for Current Speed of 2 Knots



APPENDIX 2 DP Capability Plots – SEU #2

This Appendix details a sample DP capability plot for a generic self-elevating platform using ABS DPSK software for the analysis.

FIGURE 1
Vessel Schematic



The SEU shown in Appendix 2, Figure 1 is equipped with 8 azimuthing thrusters. Appendix 2, Tables 1 and 2 detail the main particulars of the vessel and the relative thruster position from the midship.

TABLE 1
SEU #2 Main Particulars

	SI	*US*
Lpp	100 m	328 ft
B	80 m	262 ft
Draft	3 m	10 ft
Displacement	10000 m^3	353147 ft^3
Width of Pontoon	24 m	79 ft

TABLE 2
SEU #2 Thruster Parameters

Thruster	*LongPos*		*TransPos*		*Diameter*		*TiltAng*	*MaxThrust*	
#	*m*	*ft*	*m*	*ft*	*m*	*ft*	*deg*	*kN*	*lbf*
1	-48	-157.5	-25	-82.0	4	13.1	0	800	179.8
2	-42	-137.8	-35	-114.8	4	13.1	0	800	179.8
3	42	137.8	-35	-114.8	4	13.1	0	800	179.8
4	48	157.5	-25	-82.0	4	13.1	0	800	179.8
5	-48	-157.5	25	82.0	4	13.1	0	800	179.8
6	-42	-137.8	35	114.8	4	13.1	0	800	179.8
7	42	137.8	35	114.8	4	13.1	0	800	179.8
8	48	157.5	25	82.0	4	13.1	0	800	179.8

The vessel is considered to be operating in the North Sea at a seabed depth of 40m. The analysis took into account the DP capability at three different leg positions: 0 m (0 ft), 17 m (56 ft), and 37 m (121 ft) from the keel of the vessel at a 3m draft. The vessel was analyzed at current speeds of 2 knots and 4 knots, and the JONSWAP spectrum was used to calculate wave loads. As with the analysis in Appendix A, the wind and current coefficients of the hull were calculated for the projected areas, and the coefficients of the legs were calculated based on solid cylinders. The wind and current coefficients of the legs were adjusted according to water depth to simulate the lowering of the vessel legs.

Appendix 2, Figures 2 and 3 show the DP capability of the vessel at the different leg depths for a current speed of 2 knots and 4 knots. Due to the non-ship shape of the SEU, the DP capability is relatively uniform from all wind directions. DP capability diminishes as the legs are lowered into the water. Therefore, special consideration should be given to the DP capability when setting down and pulling out.

FIGURE 2
SEU #2 DP Capability Plot for Current Speed at 2 Knots

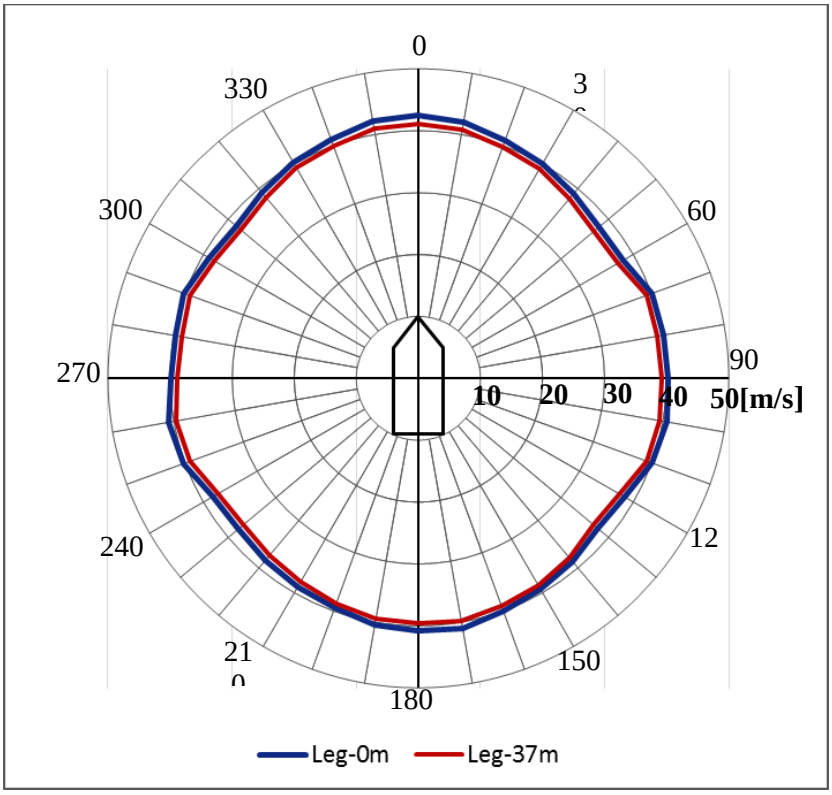
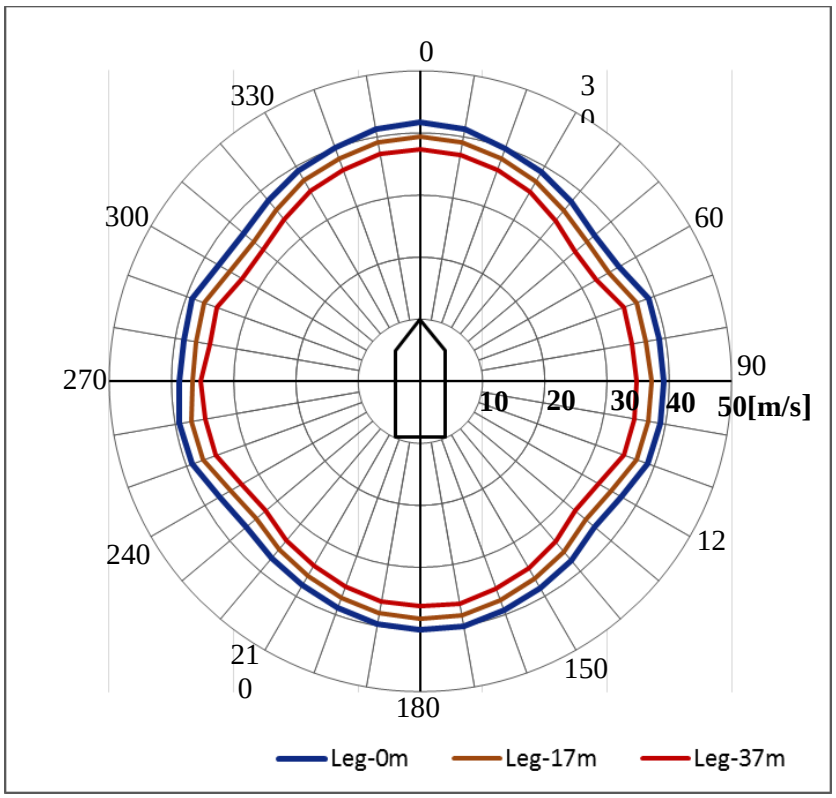


FIGURE 3
SEU #2 DP Capability Plot for Current Speed at 4 Knots



APPENDIX 3 Acronyms

DP	Dynamic Positioning
DPO	DP Operator
FMEA	Failure Modes and Effects Analysis
IMCA	International Marine Contractors Association
IMO	International Maritime Organization
MTS	Marine Technology Society
SEU	Self-Elevating Unit

APPENDIX 4 References

1. ABS *Guidance Notes on Structural Analysis of Self-Elevating Units*
2. ABS *Guide for Dynamic Positioning Systems*
3. ABS *Rules for Building and Classing Steel Vessels*
4. ABS *Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*
5. IMCA M04/04 *Methods of Establishing the Safety and Reliability of Dynamic Positioning Systems*
6. IMCA M103 *Guidelines for the Design and Operation of Dynamically Positioned Vessels*
7. IMCA M109 *A Guide to DP Related Documentation for DP Vessels*
8. IMCA M140 *Specification for DP Capability Plots*
9. IMCA M166 *Guidance on Failure Modes & Effects Analyses (FMEAs)*
10. IMCA M223 *Guidance for the Positioning of Dynamically Positioned (DP) Jackup Vessels On and Off the Seabed*
11. IMO *Guidelines for Vessels with Dynamic Positioning Systems (IMO MSC/Circ 645)*