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DSV ADAMS CHALLENGE

DP Capability Plot

DP Capability Analysis

Balenciaga H 400

Project:	2926215		
Product	Kpos		
Synopsis:	This document contains a DP capability analysis for Balenciaga H 400. The Kongsberg Maritime computer program StatCap has been used for the simulations.		
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Rev.	***Date***	***Reason for issue***	***Made by***	***Checked***	***Approved***
A	26-06-2008	First Issue	EG	EG	EG
B	28-10-2008	Added bus failure cases	JH	VE	EG
C					
D					
E					

Table of contents

1 ABOUT THIS DOCUMENT

1.1 Document history

Revision	*Description of Change*
A	First Issue
B	Added bus failure cases

1.2 References

References	
Reference 1	*The International Marine Contractors Association* Specification for DP capability plots *IMCA M 140 Rev. 1, June 2000.*
Reference 2	*Det Norske Veritas* Rules for classification of Mobile Offshore Units, Part 6, Chapter 7, *Det Norske Veritas July 1989.*
Reference 3	*Faltinsen, O. M.* Sea Loads on Ships and Offshore Structures *Cambridge University Press 1990.*
Reference 4	*Brix, J. (editor)* Manoeuvring Technical Manual *Seehafen Verlag, 1993.*
Reference 5	*Walderhaug, H.* Skipshydrodynamikk Grunnkurs *Tapir (in Norwegian).*
Reference 6	*OCIMF* Prediction of Wind and Current Loads on VLCCs *Oil Companies International Marine Forum, 2nd Edition – 1994.*

References	
Reference 7	*Lehn, E.* On the propeller race interaction effects *MARINTEK publication P-01.85, September 1985.*
Reference 8	*Lehn, E.* Practical methods for estimation of thrust losses *MARINTEK publication* R-102.80*, October 1990.*
Reference 9	*Lehn, E. and Larsen, K.* Thrusters in extreme condition, part 1. Ventilation and out of water effects *FPS-2000 1.6B, January, 1990.*
Reference 10	*Lehn, E.* Thrusters in extreme condition, part 2. Propeller/hull interaction effects *FPS-2000 1.6B, January, 1990.*
Reference 11	*Svensen, T.* Thruster considerations in the design of DP assisted vessels *NIF, June, 1992.*
Reference 12	*MARIN, Maritime Research Institute Netherlands* Training Course OFFSHORE HYDRODYNAMICS, lecture notes, 1993.
Reference 13	*Norwegian Petroleum Directorate* Regulations relating to loadbearing structures in the petroleum activities *Guidelines relating to loads and load effects etc. (Unofficial translation), 1998.*
Reference 14	Model for a doubly peaked wave spectrum *SINTEF STF22 A96204, 1996.*
Reference 15	General Arrangement *Drawing 1091343, 2008-Oktober-27.*
Reference 16	Thruster size and location input *Single line diagram, Doc number 1054122.*

1.3 Definitions / Abbreviations

DNV	Det Norske Veritas
DP	Dynamic Positioning
ERN	Environmental Regularity Numbers
IMCA	The International Marine Contractors Association
NPD	Norwegian Petroleum Directorate
OCIMF	Oil Companies International Marine Forum
StatCap	Kongsberg Maritime Static DP Capability computer program
VLCC	Very Large Crude Carrier

1.4 Disclaimer

Kongsberg Maritime AS has made its best effort to ensure that this DP capability analysis is correct and reflects the vessel's actual performance and capability most likely to be attained during operation. The DP capability analysis is however a simulation analysis only and must not be considered as a guarantee of actual performance and capability. The DP capability analysis is based on calculations, expectations, estimates and input data subject to uncertainties, which may influence on the correctness, accuracy, reliability and completeness of the results herein. The correctness of the DP capability analysis is inextricably related to the correctness of input data received by Kongsberg Maritime AS from client, thruster vendors and others, and the client shall be fully responsible for the correctness and accuracy of the input data made available to Kongsberg Maritime AS prior to the execution of the DP capability analysis. Any change or alteration made to the input data such as vessel design, vessel equipment, vessel operational draught, wind area projections, thruster data or configuration, area of operation or any other input data on which the analysis is based may alter the results hereof and render this analysis inapplicable to the new context. Kongsberg Maritime AS can make no representation or warranty, expressed or implied as to the accuracy, reliability or completeness of this DP capability analysis, and Kongsberg Maritime AS, its directors, officers or employees shall have no liability resulting from the use of this DP capability analysis regardless of its objective.

2 SUMMARY AND CONCLUSIONS

This report contains a DP capability analysis for Balenciaga H 400 in DNV (ERN) conditions. The analysis has been based upon the information given in Reference 15 and Reference 16. The Kongsberg Maritime computer program StatCap has been used for the simulations.

The simulation case definitions are given in Table 1. T1 denotes thruster number 1, T2 thruster number 2 and so on. For details regarding thruster layout, see Figure 2.

Case no.	*Current speed [kts]*	*Thrusters active*	*Case description*
1	1.5	T1-T5	T1-T5 ERN
2	1.5	T1-T3, T5	T1-T3, T5 Min eff. Single Thr. T4 Lost
3	1.5	T1-T2, T4-T5	T1-T2,T4-T5Max eff.Single Thr. T3 Lost
4	1.5	T2-T3, T5	Bus A Failure T1, T4 Lost
5	1.5	T1, T3-T4	Bus B Failure T2, T5 Lost

Table 1: Simulation case definitions.

The simulation results are summarised in Table 2 showing the limiting weather conditions at the most unfavourable wind directions.

Case no.	*Wind speed [kts]*	*Wind direction [deg]*	*Hs [m]*	*Tz [sec]*	*Current speed [kts]*
1	58.6	90.0	8.9	11.7	1.5
2	49.8	60.0	7.4	11.0	1.5
3	44.5	70.0	6.5	10.5	1.5
4	38.2	60.0	5.5	10.0	1.5
5	38.7	300.0	5.6	10.1	1.5

Table 2: Limiting conditions at most unfavourable wind directions.

Note that a certain amount of dynamic load allowance is included in the simulations. The dynamic allowance is the 'spare' thrust required to compensate for the dynamic effects of the wind and wave drift loads, see section 4.4.

DNV ERN results for case 1: ERN (99, 99, 99). These are subject to DNV approval. The minimum effect of single-thruster failure occurs when thruster 4 is lost and the maximum effect of single-thruster failure occurs when thruster 3 is lost.

The nominal bollard thrust is calculated from power according to Reference 1. In normal operating conditions the thrust is reduced due to current, waves and the presence of the hull. Approximations for the thrust losses are taken into account in the simulations, see section 5.2.

3 COORDINATE SYSTEM

The coordinate system used is the orthogonal right-handed system shown in Figure 1 with the positive z-axis pointing downwards. The origin of the coordinate system can be offset a longitudinal distance x_0 from $L_{pp}/2$.

The directions of the wind, waves and current are defined by means of coming-from directions and are considered positive when turning clockwise, e.g. a wind direction equal to 0 degrees exerts a negative longitudinal force on the vessel.

Unless otherwise stated, the directions of the wind, waves and current are coincident in the analyses.

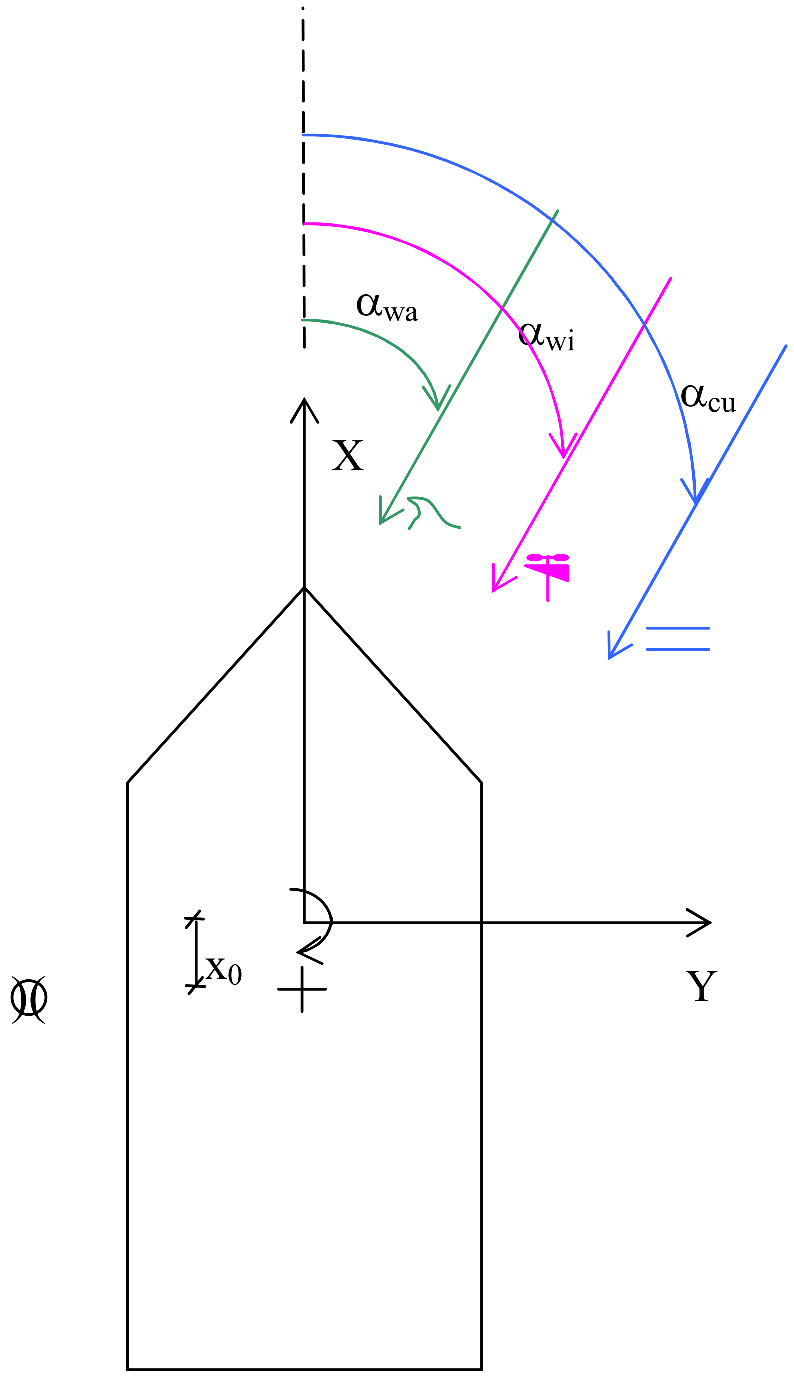


Figure 1: Coordinate system and sign conventions.

4 DP CAPABILITY

4.1 Definition

DP capability defines a DP vessel's station-keeping ability under given environmental and operational conditions.

4.2 Wind Speed Envelopes

DP capability analyses are generally used to establish the maximum weather conditions in which a DP vessel can maintain its position and heading for a proposed thruster configuration. The environmental forces and moments are increased until they are exactly balanced by the maximum available thrust offered by the thruster configuration. Thus, a limiting weather condition is obtained as a combination of a mean wind speed, significant wave height and a sea current speed. Wind, current and waves are normally taken as coming from the same direction. By allowing the environmental components to rotate in steps around the vessel, the results of a DP capability analysis can be presented by means of a limiting mean wind speed for a discrete number of wind angles of attack. The resulting polar plot is often referred to as a DP capability envelope.

4.3 Thrust Utilisation Envelopes

When a design sea state is determined by the client, DP capability can be presented by means of a thrust utilisation envelope instead of a limiting wind speed envelope. The required thrust to maintain position and heading in the design sea state is calculated and compared to the vessel's maximum available thrust. The ratio between the two is plotted as a function of wind direction. A thrust utilisation less than or equal to 100% means that the vessel is able to hold position and heading in the specified design sea state. If the ratio exceeds 100%, the vessel will experience poor positioning performance or drift off.

4.4 Dynamic Allowance

A DP vessel needs a certain amount of 'spare' thrust to compensate for the dynamic behaviour of the wind and wave drift loads. The 'spare' thrust can be included as a given percentage of the wind and wave drift loads or it can be calculated from the spectral densities of the wind and wave drift loads and the controller's restoring and damping characteristics. The manner in which the dynamic allowance is included is stated on each capability envelope sheet.

5 INPUT DATA

5.1 Main Particulars

The vessel main particulars are listed on each capability envelope sheet.

5.2 Thruster Data

General thruster data such as locations on the hull and capacities, see Reference 16, is listed on each capability envelope sheet.

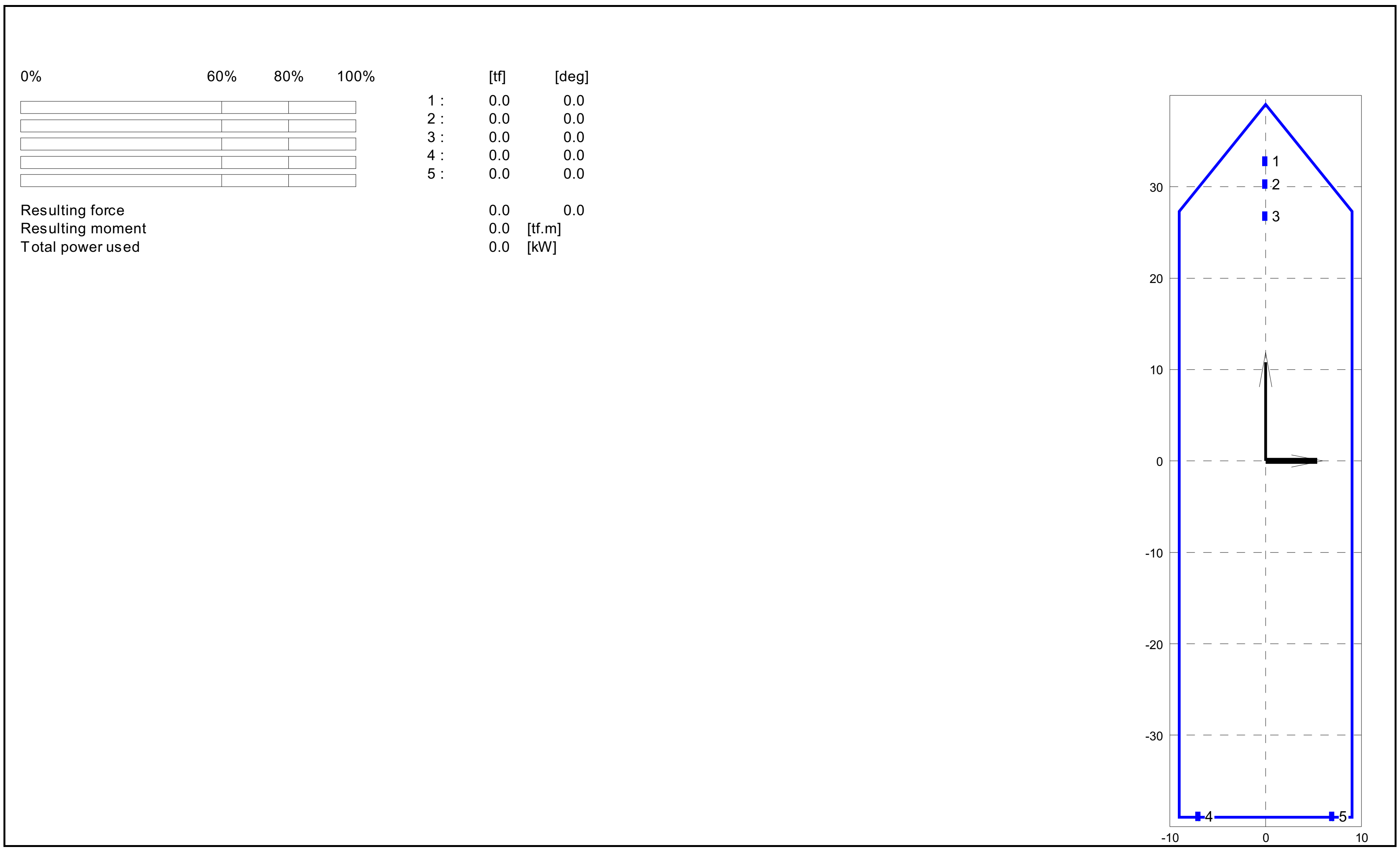


Figure 2: Thruster layout.

5.3 Wind Load Coefficients

StatCap offers several methods for obtaining wind load coefficients. Each of the methods is listed in Table 3 together with a short description. The method used is indicated on the capability envelope sheets. The wind affected areas are calculated on the basis of Reference 15.

Method	*Applicable to*	*Description*
Blendermann	Mono-hulls	The method describes wind loading functions which can be combined with the vessel's wind resistance in head, stern and beam wind. Typical wind resistance for a number of relevant offshore ship types is also described, see Reference 4.
Hughes	Mono-hulls	The method describes a wind loading function which can be combined with the vessel's wind resistance. Typical wind resistance for a number of merchant ship types is also described, see Reference 5.
Database scaling	Mono-hulls/semi-submersibles	The wind load coefficients are obtained through scaling of data for a similar vessel in the Kongsberg Maritime database. The coefficients are scaled with respect to the wind-affected areas of the frontal and lateral projections.
External file input	Mono-hulls/semi-submersibles	Specific wind load coefficients, supplied by the client, are read and used by StatCap.

Table 3: Methods for obtaining wind load coefficients in StatCap.

Last Modified	:	2008-10-28 11.17
Vessel Name	:	Balenciaga H 400
File Ref.	:	Foot_2963_RevA.scp
Vessel type	:	Diving vessel
Area of frontal projection	:	334.2 m² (20 points)
Area of lateral projection	:	1039.8 m² (97 points)
Mean height of lateral projection	:	12.1 m
Dist. to centroid of lateral projection	:	7.8 m

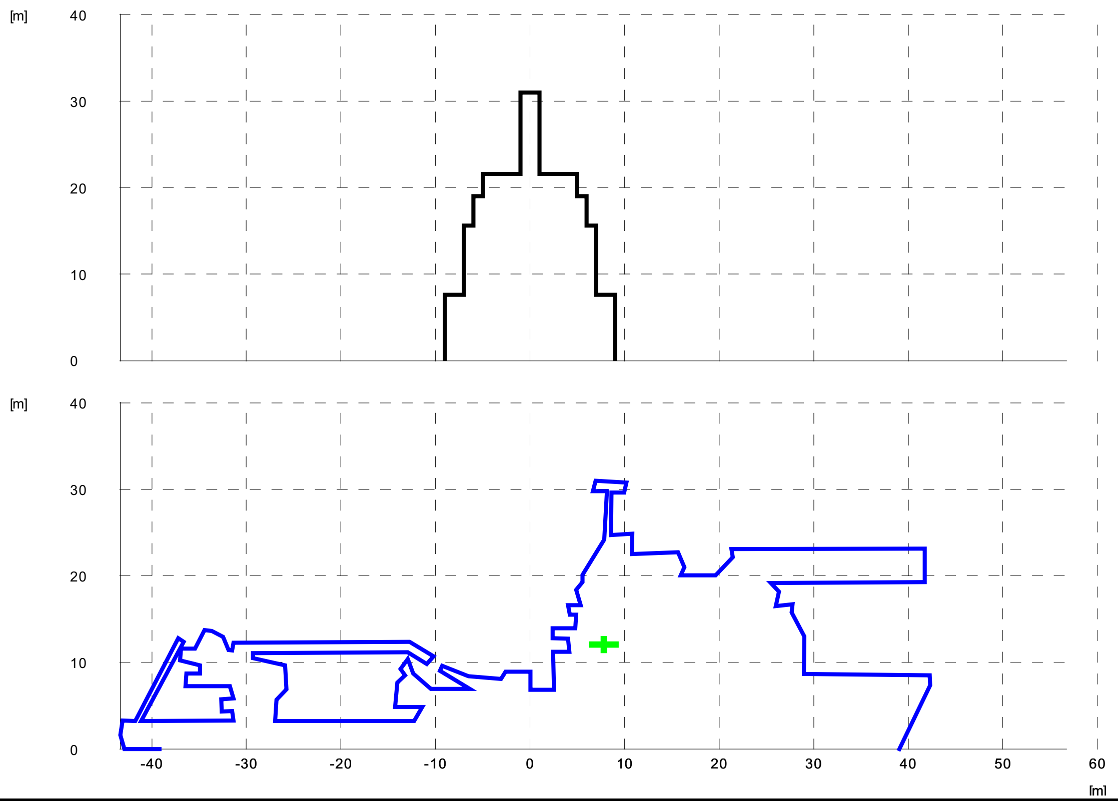


Figure 3: Wind area projections.

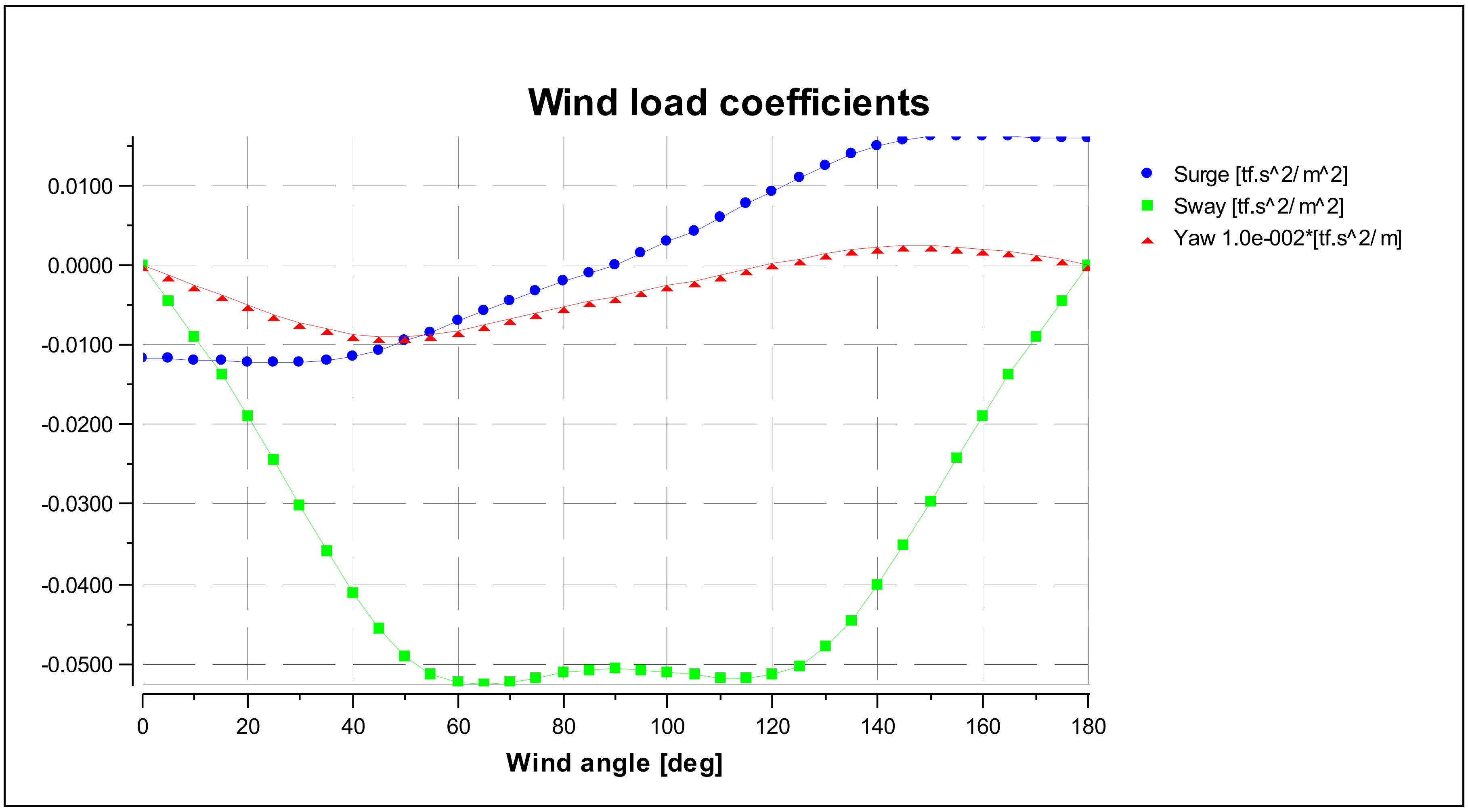


Figure 4: Wind load coefficients.

5.4 Current Load Coefficients

StatCap offers several methods for obtaining current load coefficients. Each of the methods is listed in Table 4 along with a short description. The method used is indicated on the capability envelope sheets.

Method	*Applicable to*	*Description*
Modified strip-theory	Mono-hulls	A simplified strip-theory approach is applied in order to calculate the transverse and yawing moment current load coefficients. For a description of the strip-theory approach, see Reference 3. The longitudinal load coefficient is calculated using the method described in Reference 3. However, the longitudinal coefficient has been adjusted for improved match against a number of model test results in the Kongsberg Maritime database.
OCIMF	VLCCs	The current load coefficients are calculated based on the results presented in Reference 6.

Database scaling	Mono-hulls/semi-submersibles	The current load coefficients are obtained through scaling of data for a similar vessel in the Kongsberg Maritime database. The coefficients are scaled with respect to length and draught or displacement.
External file input	Mono-hulls/semi-submersibles	Specific current load coefficients, supplied by the client, are read and used by StatCap.

Table 4: Methods for obtaining current load coefficients in StatCap.

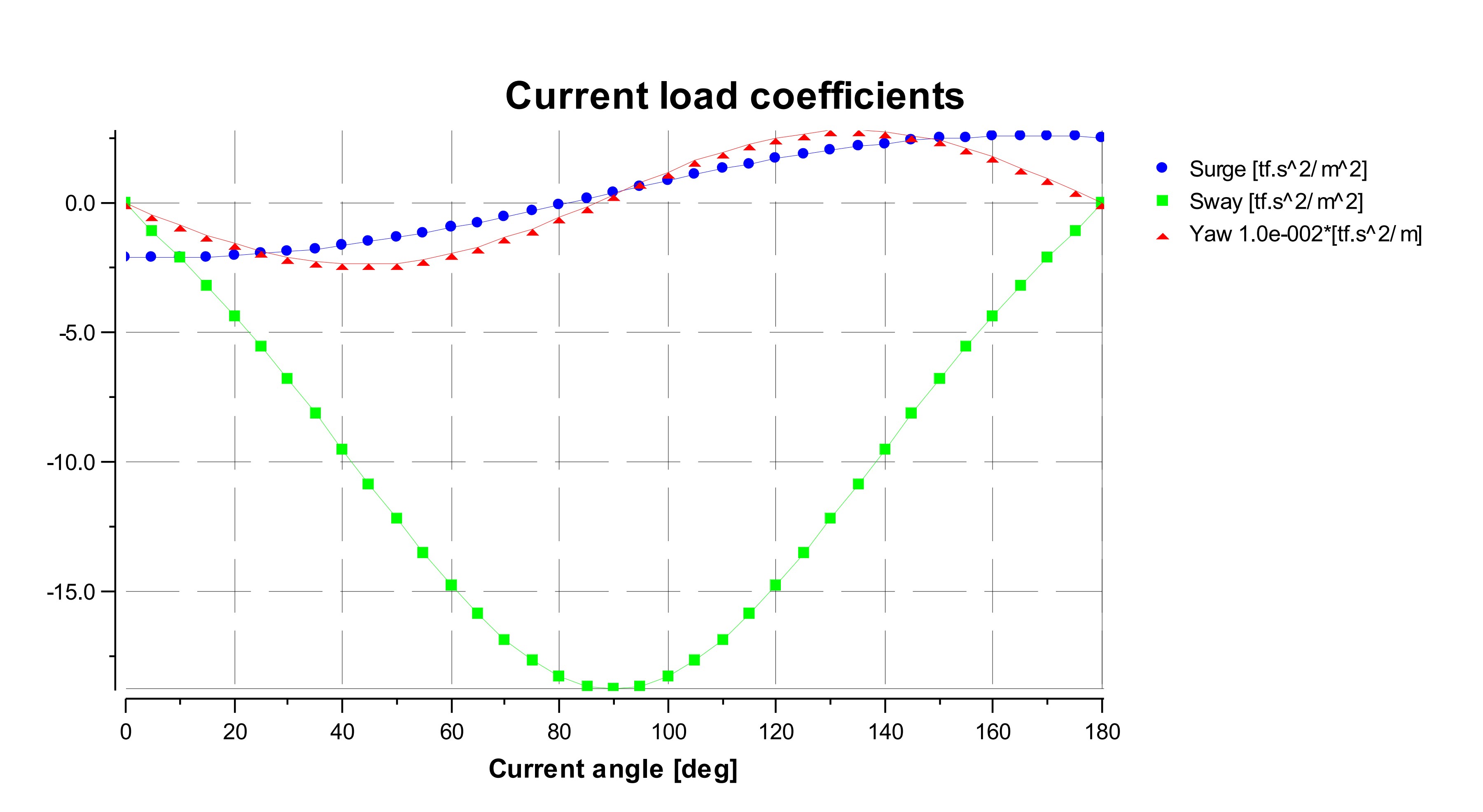


Figure 5: Current load coefficients.

5.5 Wave-Drift Load Coefficients

StatCap offers two methods to arrive at wave-drift load coefficients, see Table 5. The method used is indicated on the capability envelope sheets.

Method	*Applicable to*	*Description*
Database scaling	Mono-hulls/semi-submersibles	The wave-drift load coefficients are obtained through scaling of data for a similar vessel in the Kongsberg Maritime database. The coefficients are scaled with respect to length and breadth, length or displacement.
External file input	Mono-hulls/semi-submersibles	Specific wave-drift load coefficients, supplied by the client, are read up and used by StatCap.

Table 5: Methods for obtaining wave-drift load coefficients.

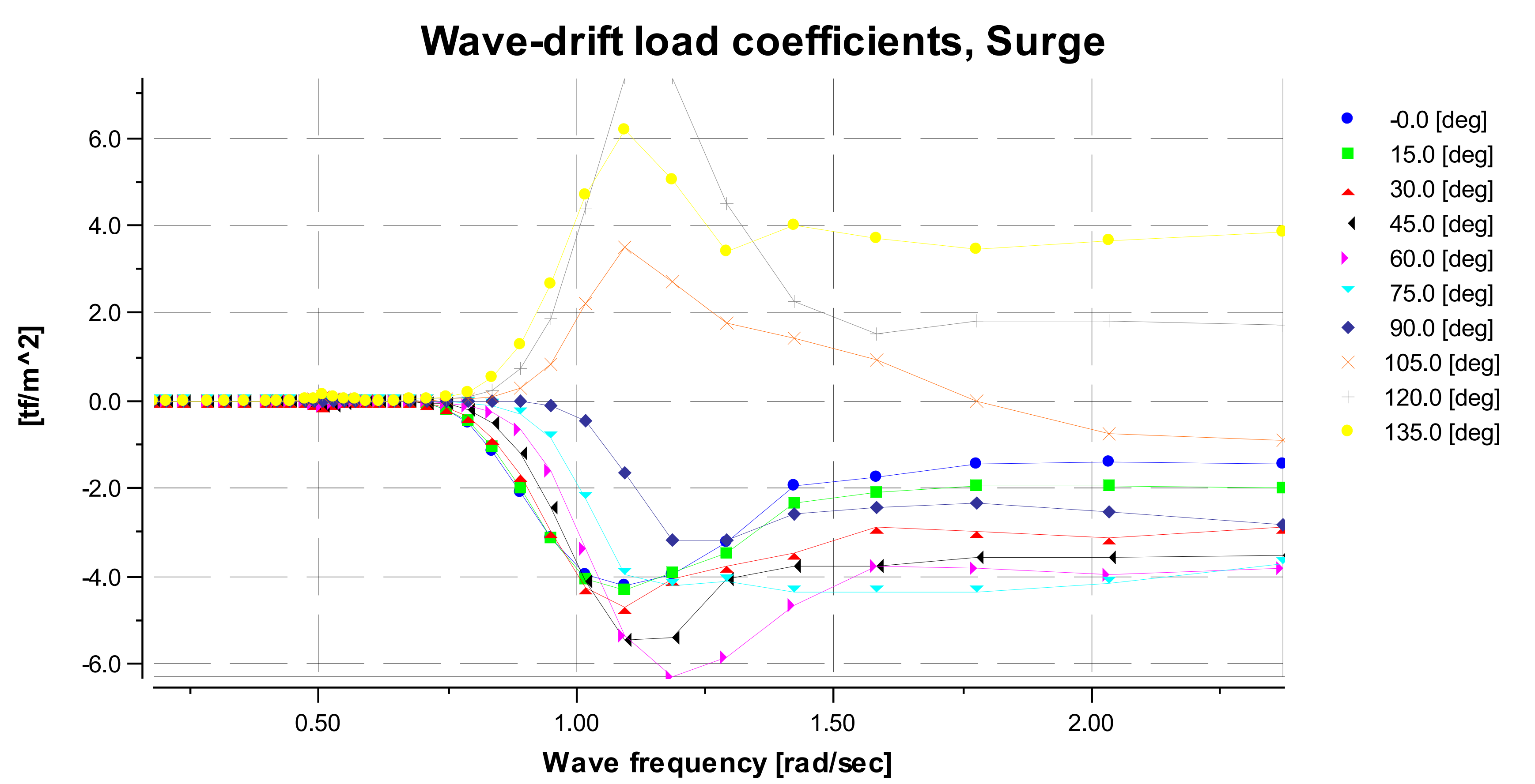


Figure 6: Wave-drift load coefficients for surge.

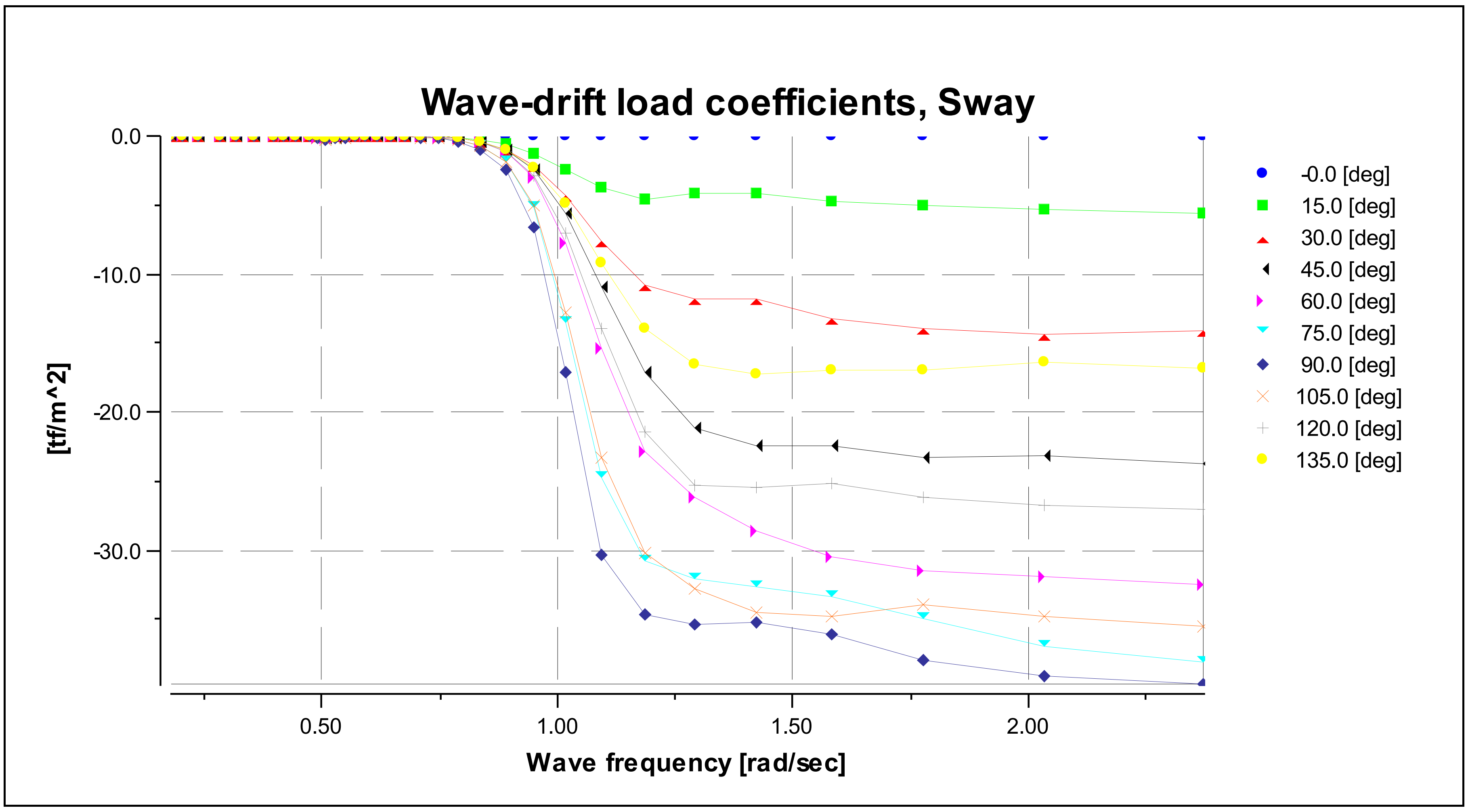


Figure 7: Wave-drift load coefficients for sway.

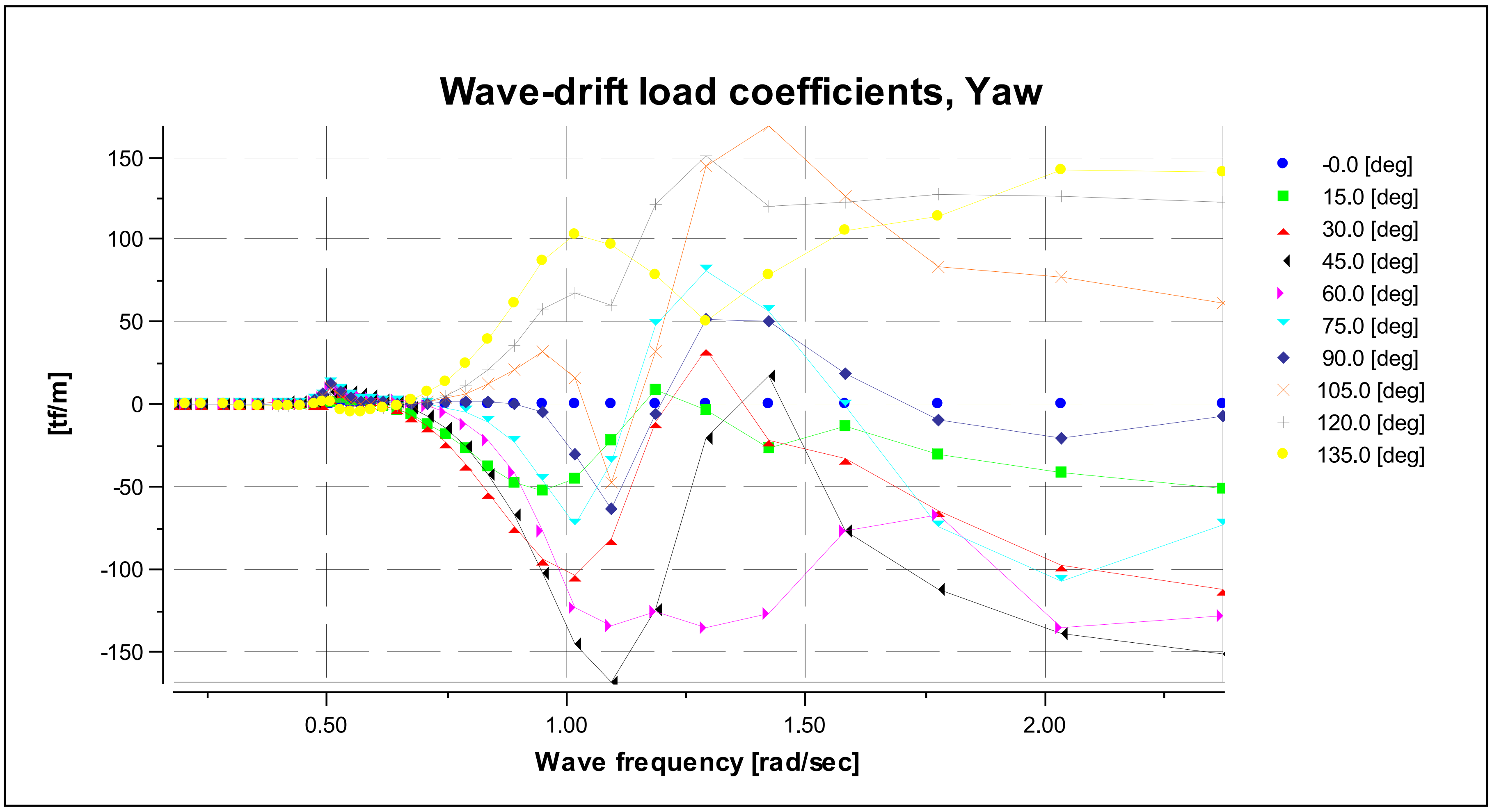


Figure 8: Wave-drift load coefficients for yaw.

5.6 Wind Speed and Wave Height Relationship

Several wind and wave spectrum types are available in StatCap. Each of the wave spectrum types is listed in Table 6 together with a short description. The wind spectrum type selected does not affect the wind loads as such, but has an influence on the dynamic allowance, see section 4.4. For a description of the NPD spectrum, used as default wind spectrum in StatCap, see Reference 13. For descriptions of the other wind spectrum types refer to the literature, e.g. see Reference 12. The spectrum types used in each case are indicated on the capability envelope sheets.

Wave spectrum	*Applicable to*	*Description*
Pierson-Moskowitz	North Atlantic	Wave spectrum for fully developed sea and open sea conditions, see Reference 3.
JONSWAP	North Sea	Joint North Sea Wave Project, see Reference 3, valid for sea not fully developed (the fetch has limited length).
Doubly-Peaked	Norwegian Sea	Wave spectrum for wind-generated sea and swell. A modified JONSWAP model is used for both peaks, see Reference 14.

Table 6: Wave spectrum types.

The relationship between wind speed and wave height used in the analyses is defined in Reference 2.

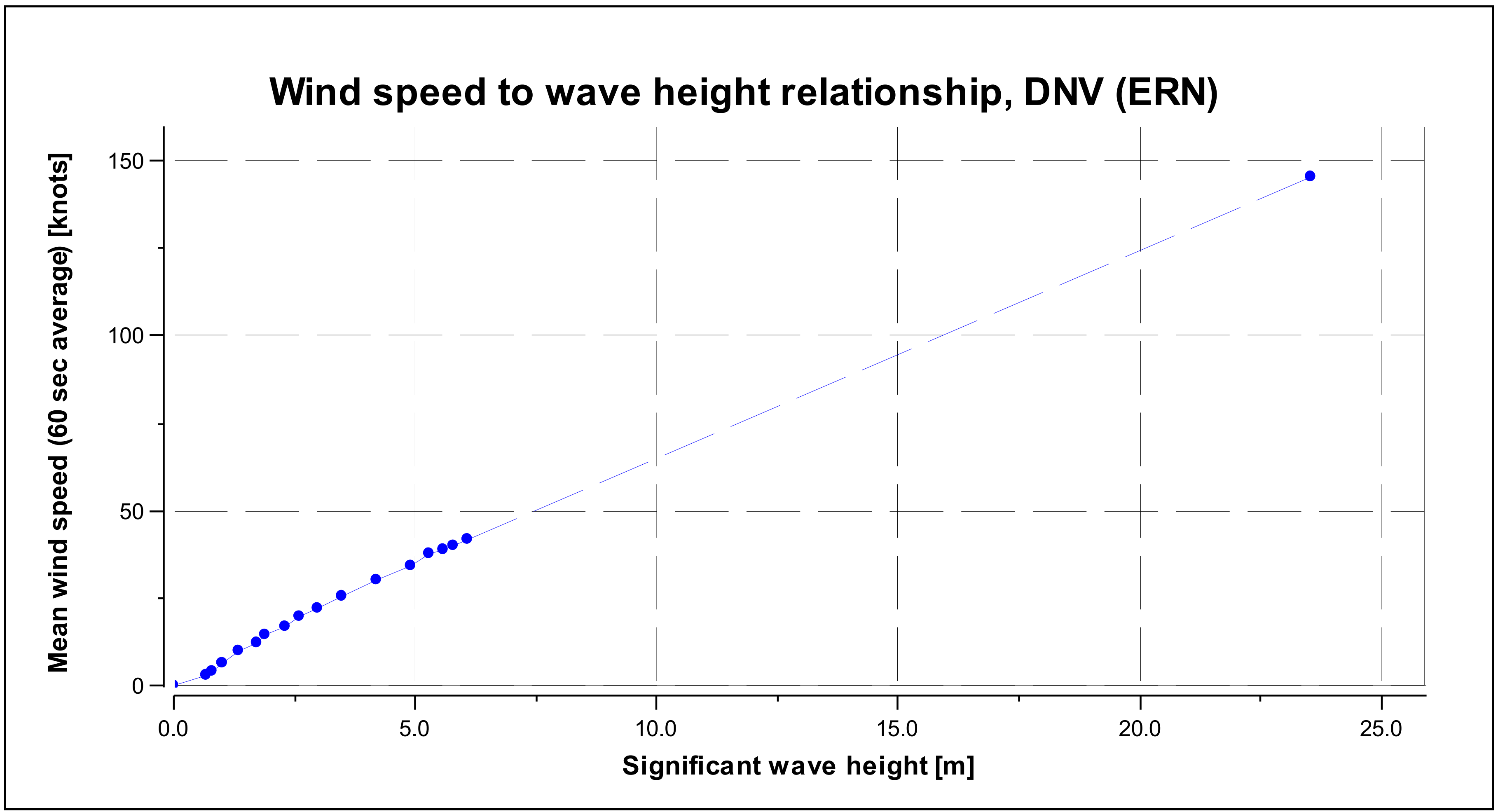


Figure 9: Wind speed to wave height relationship.

6 RESULTS

6.1 Case 1

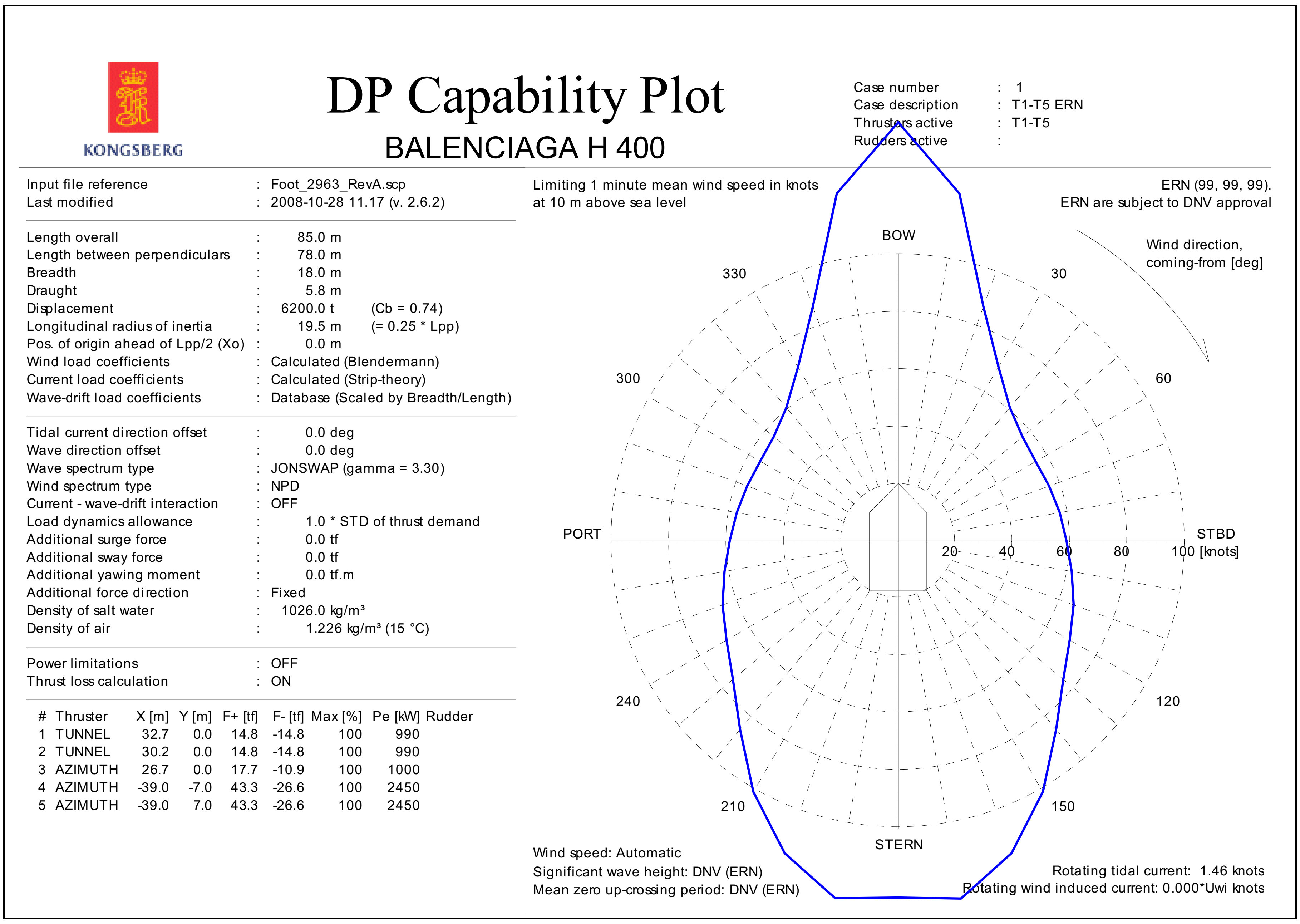


Figure 10: DP capability envelope for case 1.

6.2 Case 2

KONGSBERG

DP Capability Plot

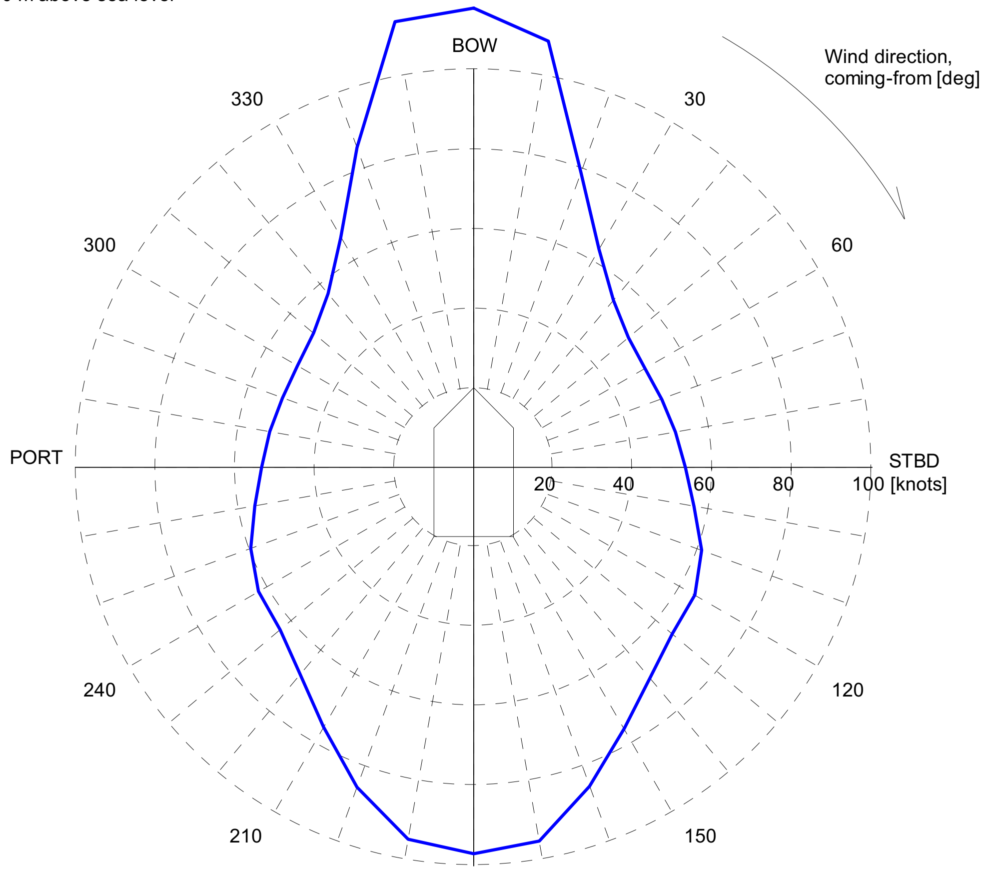
BALENCIAGA H 400

Case number	:	2
Case description	:	T1-T3, T5 Min eff. Single Thr. T4 Lost
Thrusters active	:	T1-T3, T5
Rudders active	:	

Input file reference	:	Foot_2963_RevA.scp	
Last modified	:	2008-10-28 11.17 (v. 2.6.2)	
Length overall	:	85.0 m	
Length between perpendiculars	:	78.0 m	
Breadth	:	18.0 m	
Draught	:	5.8 m	
Displacement	:	6200.0 t	(Cb = 0.74)
Longitudinal radius of inertia	:	19.5 m	(= 0.25 * Lpp)
Pos. of origin ahead of Lpp/2 (Xo)	:	0.0 m	
Wind load coefficients	:	Calculated (Blendermann)	
Current load coefficients	:	Calculated (Strip-theory)	
Wave-drift load coefficients	:	Database (Scaled by Breadth/Length)	
Tidal current direction offset	:	0.0 deg	
Wave direction offset	:	0.0 deg	
Wave spectrum type	:	JONSWAP (gamma = 3.30)	
Wind spectrum type	:	NPD	
Current - wave-drift interaction	:	OFF	
Load dynamics allowance	:	1.0 * STD of thrust demand	
Additional surge force	:	0.0 tf	
Additional sway force	:	0.0 tf	
Additional yawing moment	:	0.0 tf.m	
Additional force direction	:	Fixed	
Density of salt water	:	1026.0 kg/m³	
Density of air	:	1.226 kg/m³ (15 °C)	
Power limitations	:	OFF	
Thrust loss calculation	:	ON	

#	Thruster	X [m]	Y [m]	F+ [tf]	F- [tf]	Max [%]	Pe [kW]	Rudder
1	TUNNEL	32.7	0.0	14.8	-14.8	100	990	
2	TUNNEL	30.2	0.0	14.8	-14.8	100	990	
3	AZIMUTH	26.7	0.0	17.7	-10.9	100	1000	
- 4	AZIMUTH	-39.0	-7.0	43.3	-26.6	100	2450	
5	AZIMUTH	-39.0	7.0	43.3	-26.6	100	2450	

Limiting 1 minute mean wind speed in knots at 10 m above sea level



Wind speed: Automatic
Significant wave height: DNV (ERN)
Mean zero up-crossing period: DNV (ERN)

Rotating tidal current: 1.46 knots
Rotating wind induced current: 0.000*Uwi knots

Figure 11: DP capability envelope for case 2.

6.3 Case 3

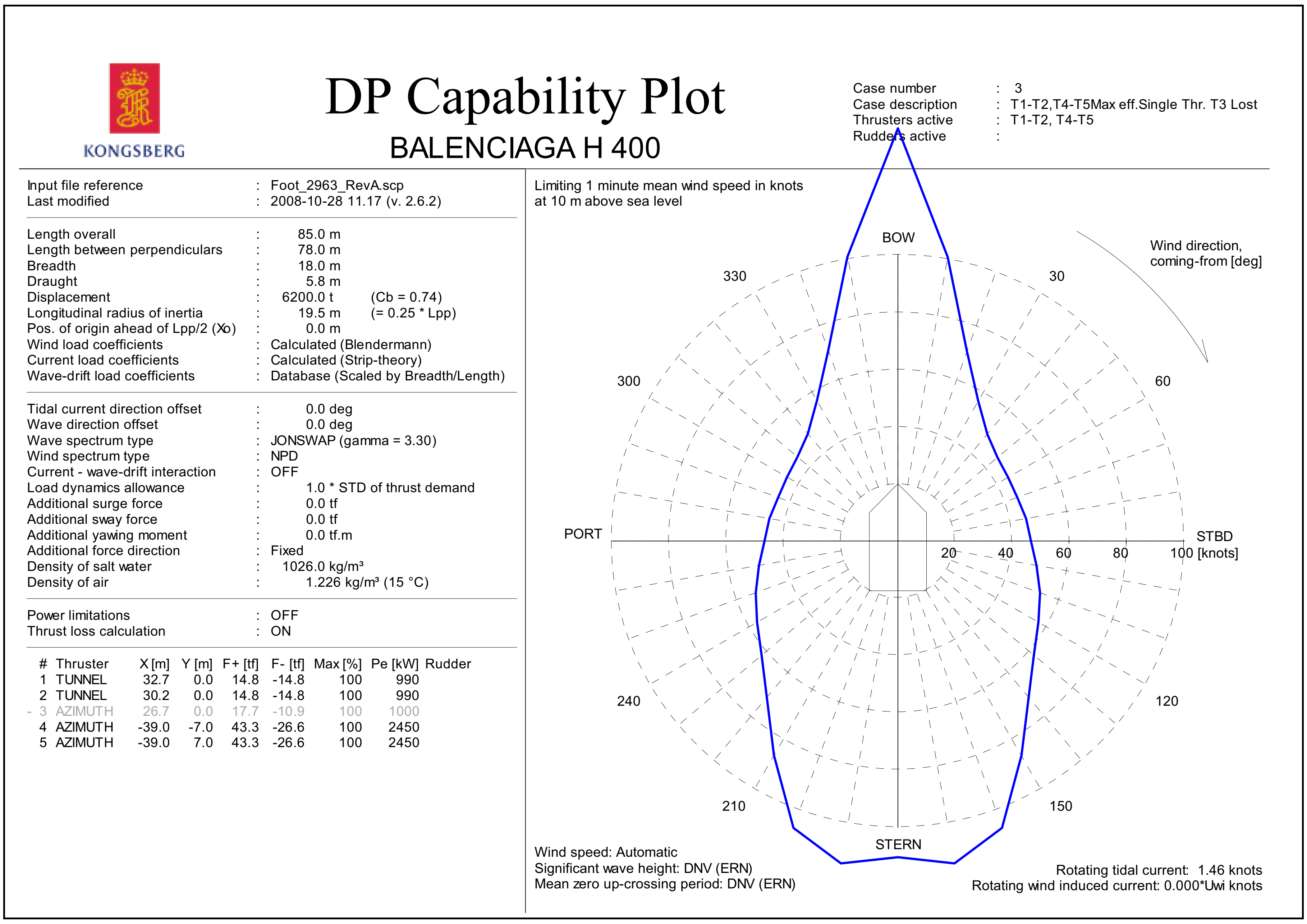


Figure 12: DP capability envelope for case 3.

6.4 Case 4

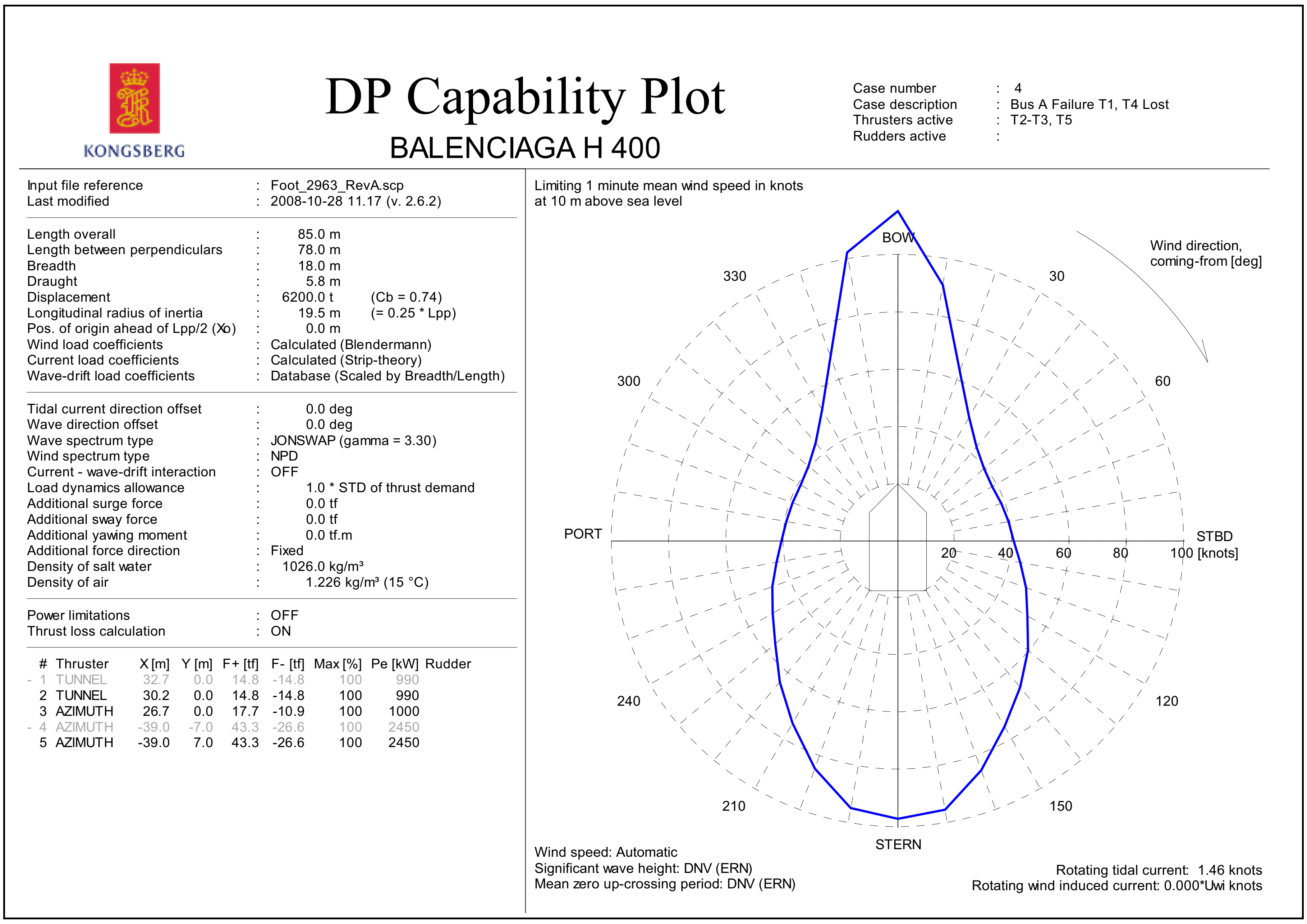


Figure 13: DP capability envelope for case 4.

6.5 Case 5

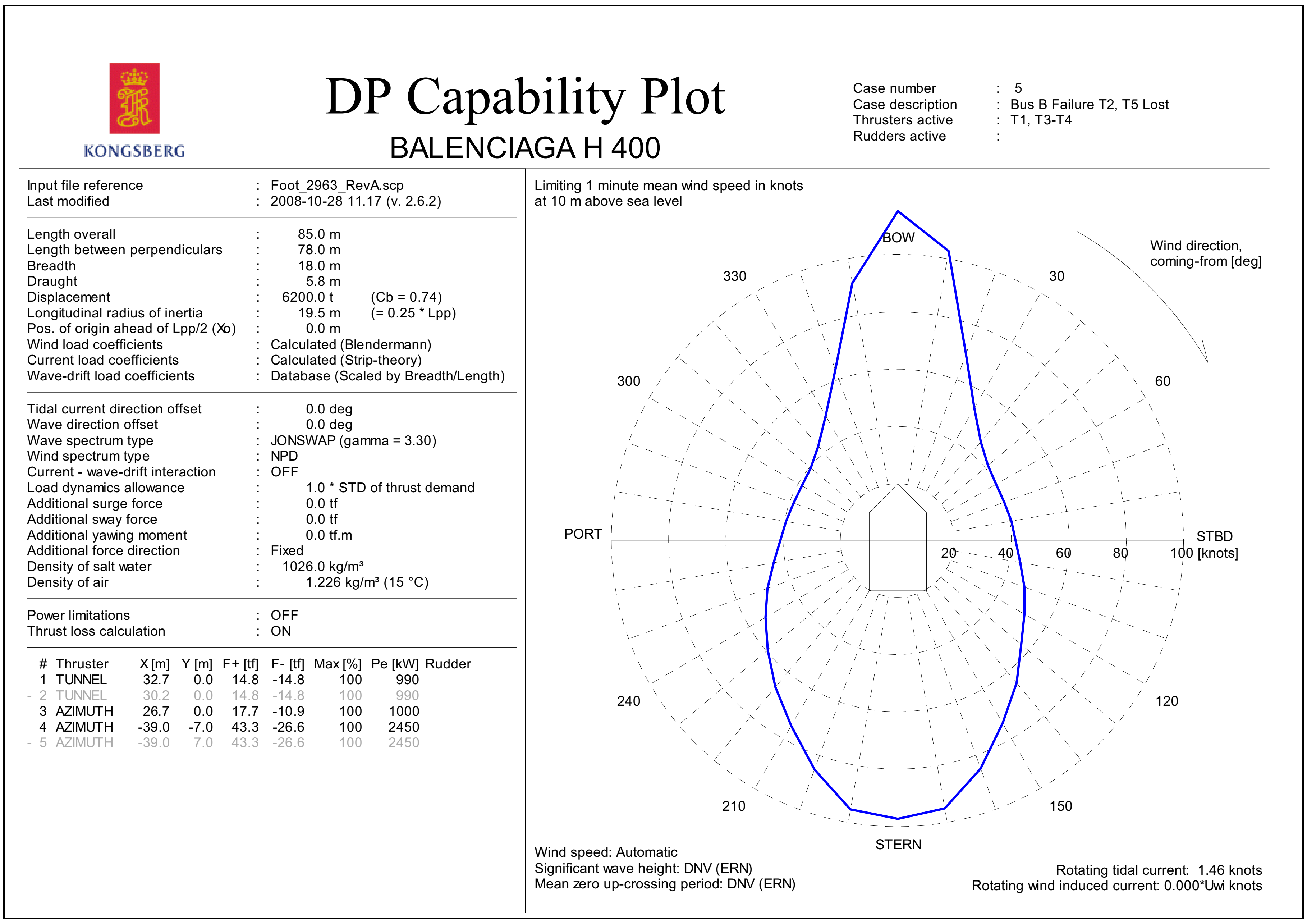


Figure 14: DP capability envelope for case 5.

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