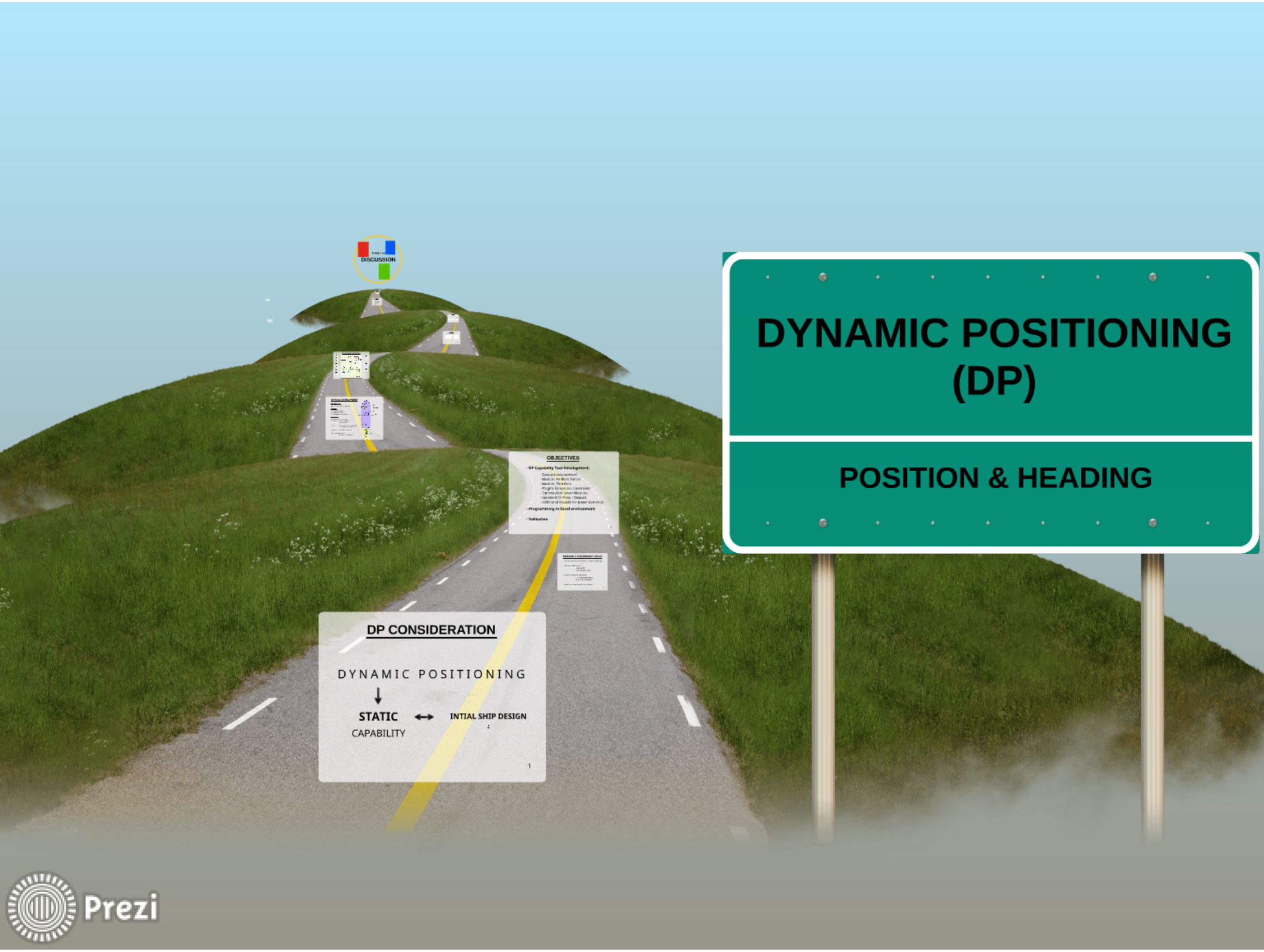
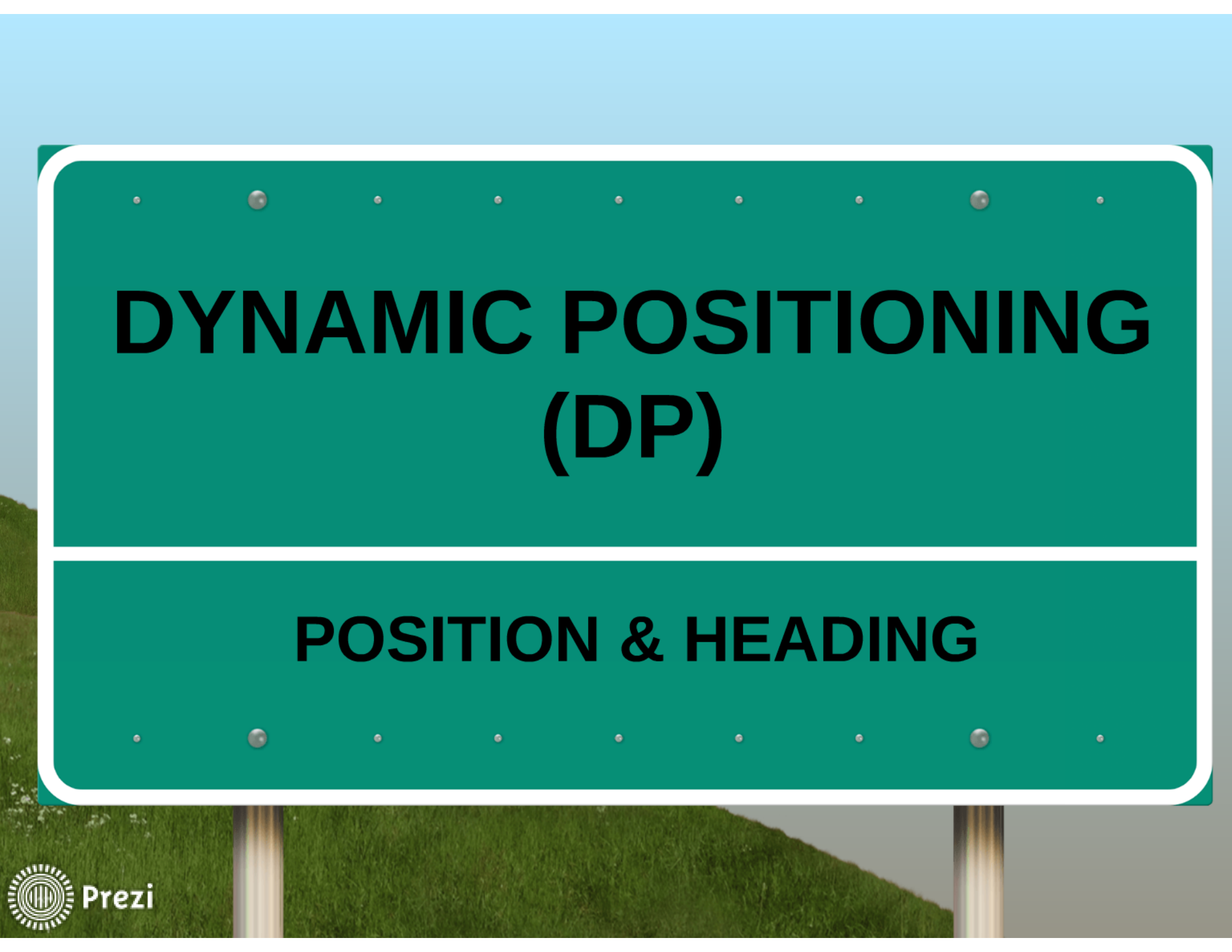
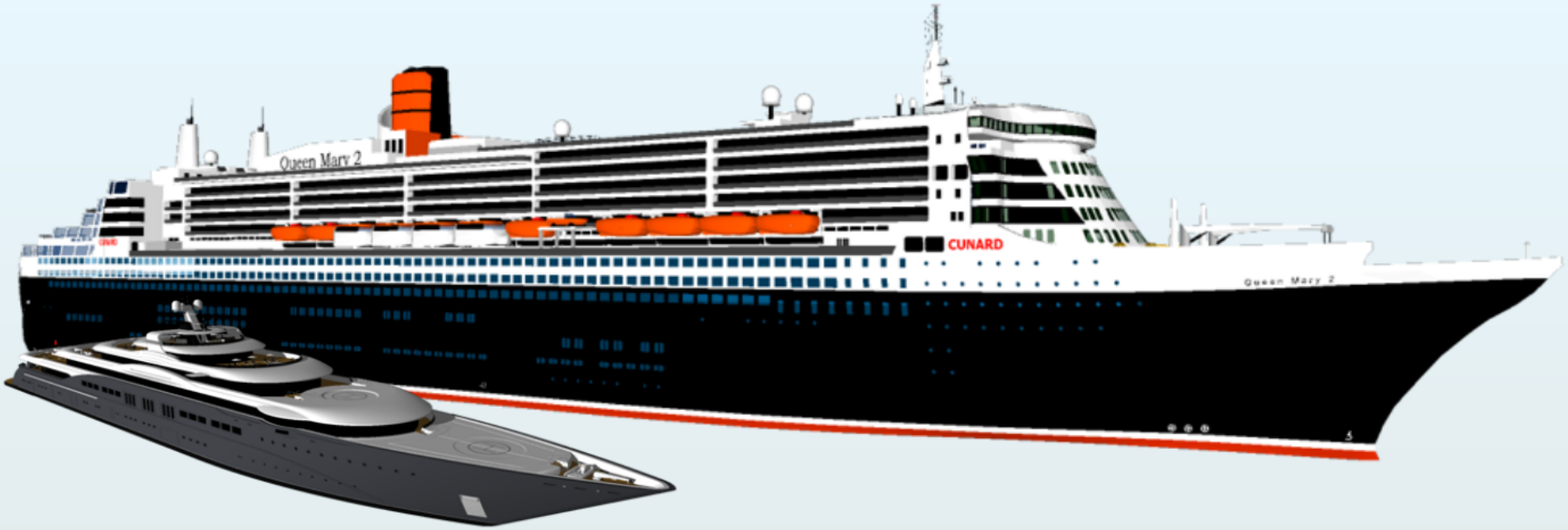
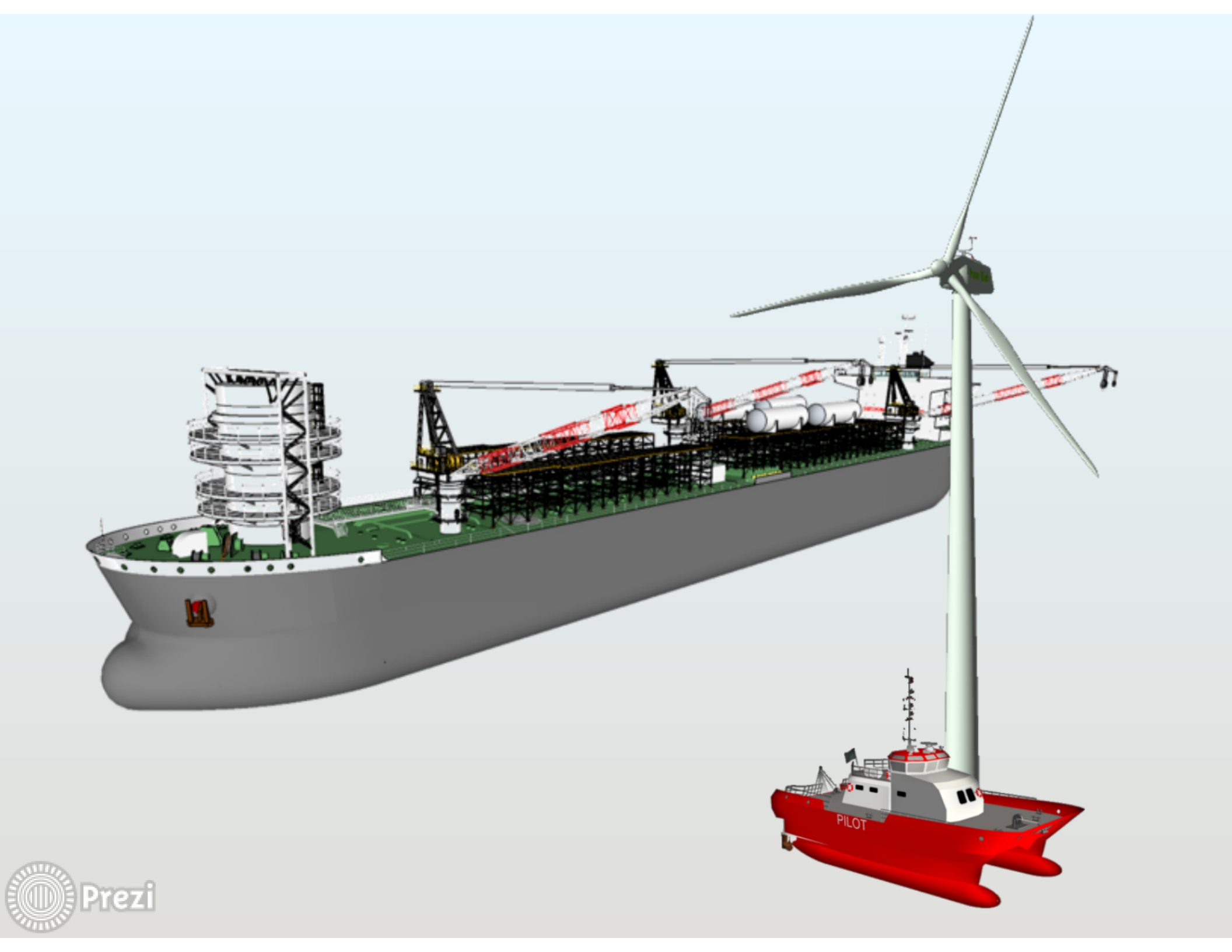

DISCUSSION
OBJECTIVES
DP CONSIDERATION
DYNAMIC POSITIONING
STATIC
CAPABILITY
INTIAL SHIP DESIGN
DYNAMIC POSITIONING (DP)
POSITION & HEADING

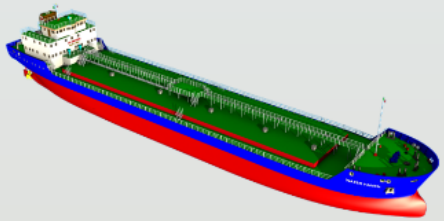

DYNAMIC POSITIONING
(DP)
POSITION & HEADING
Prezi



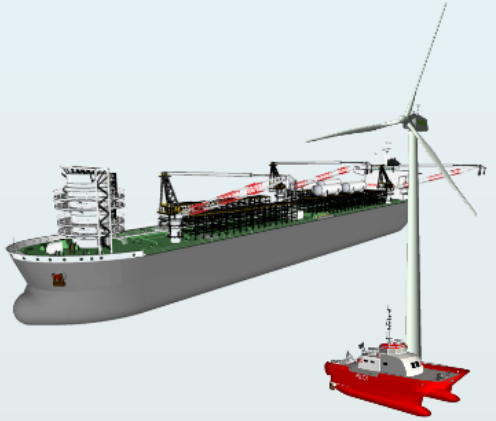

RESEARCH

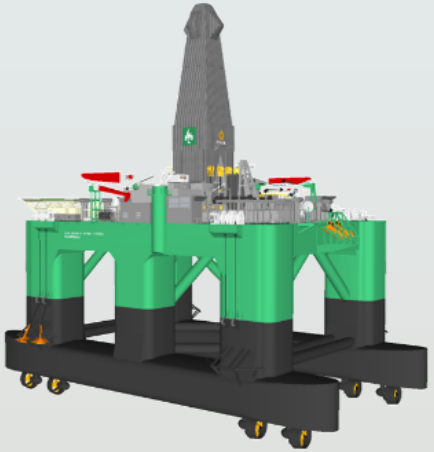

PILOT

DP VESSELS



- Platform Supply Vessel (PSV)
- Diving Support Vessel (DSV)
- Drill-ship
- Cable Laying Ship
- Pipe Laying Ship
- Dredger
- Crane Barge
- Passenger Vessel and Motor Yachts
- Semi-sub Heavy Lift Vessel
- Mobile Offshore Drilling Unit (MODU)
- Shuttle Tanker
- Floating Production Storage and Offloading (FPSO)





A Procedure for the Dynamic Positioning Estimation in Initial Ship-Design

Syed Marzan Ul Hasan

Academic Supervisor : Prof. Dr.-Ing. Robert Bronsart, University of Rostock

Industrial Supervisor : Dr. Harald Jensen, SDC Ship Design & Consult GmbH

EMship Advanced Design

LIÈGE université

CENTRALE NANTES

Universität Rostock Traditio et Innovatio


SDC
SHIP DESIGN & CONSULT
HSVA
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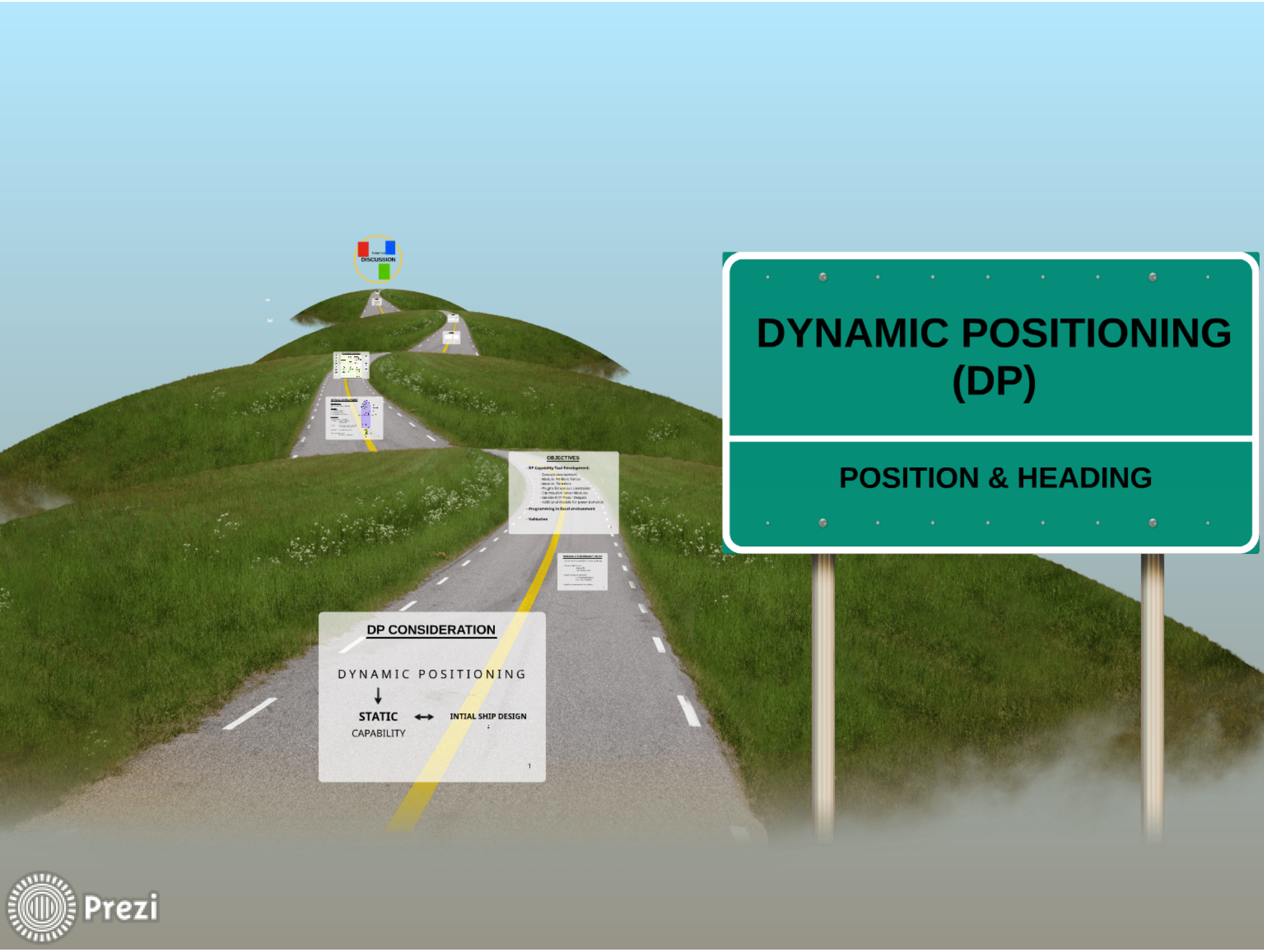
CONTENTS

- Objectives
- Concept Development
- DP Estimation Procedure
- Output Plots
- Validation
- Conclusions
- Recommendations


DISCUSSION
OBJECTIVES
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CAPABILITY
INTIAL SHIP DESIGN
DYNAMIC POSITIONING (DP)
POSITION & HEADING

DP CONSIDERATION

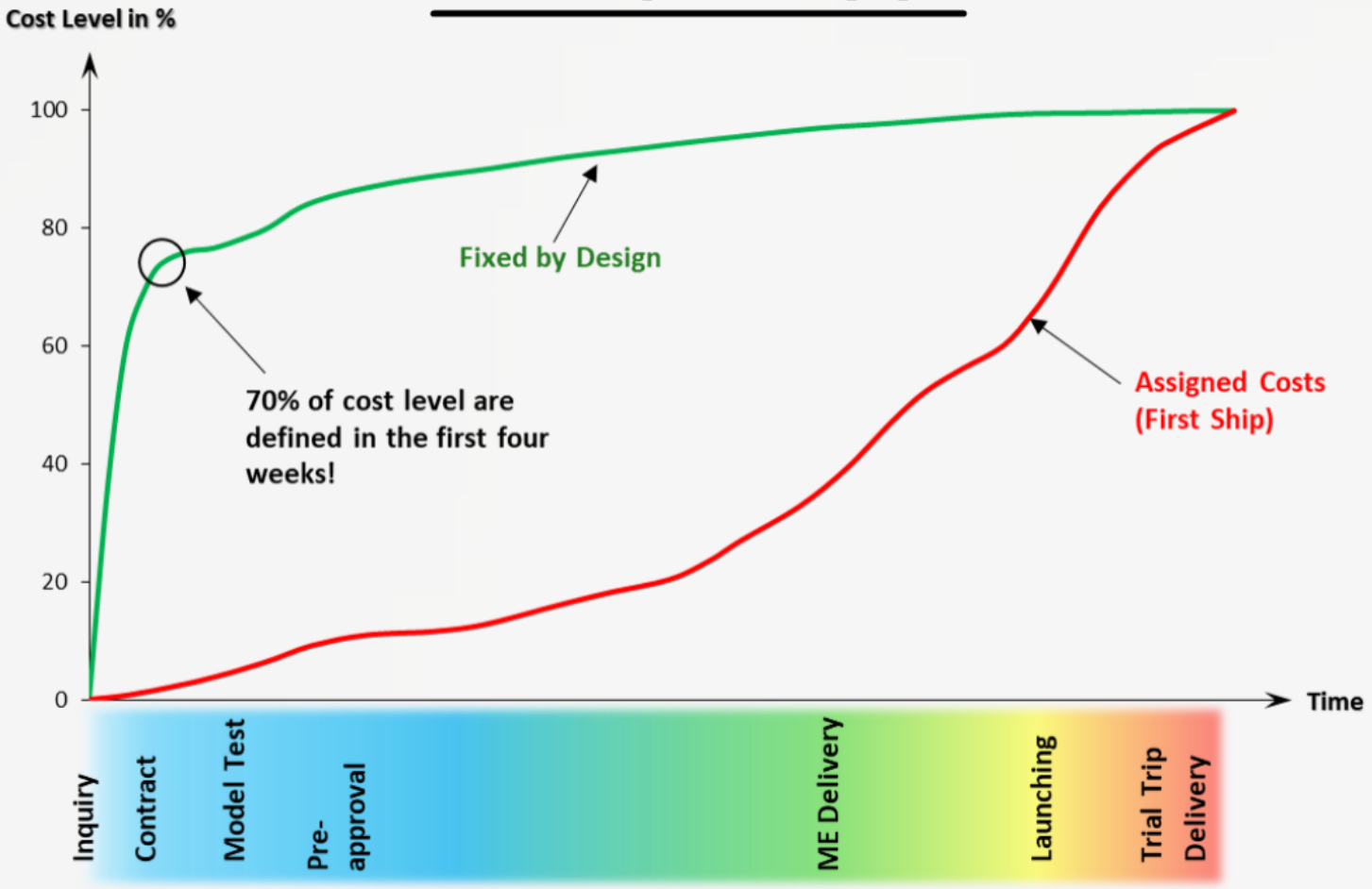
D Y N A M I C P O S I T I O N I N G

↓

STATIC ⟷ **INTIAL SHIP DESIGN**

CAPABILITY

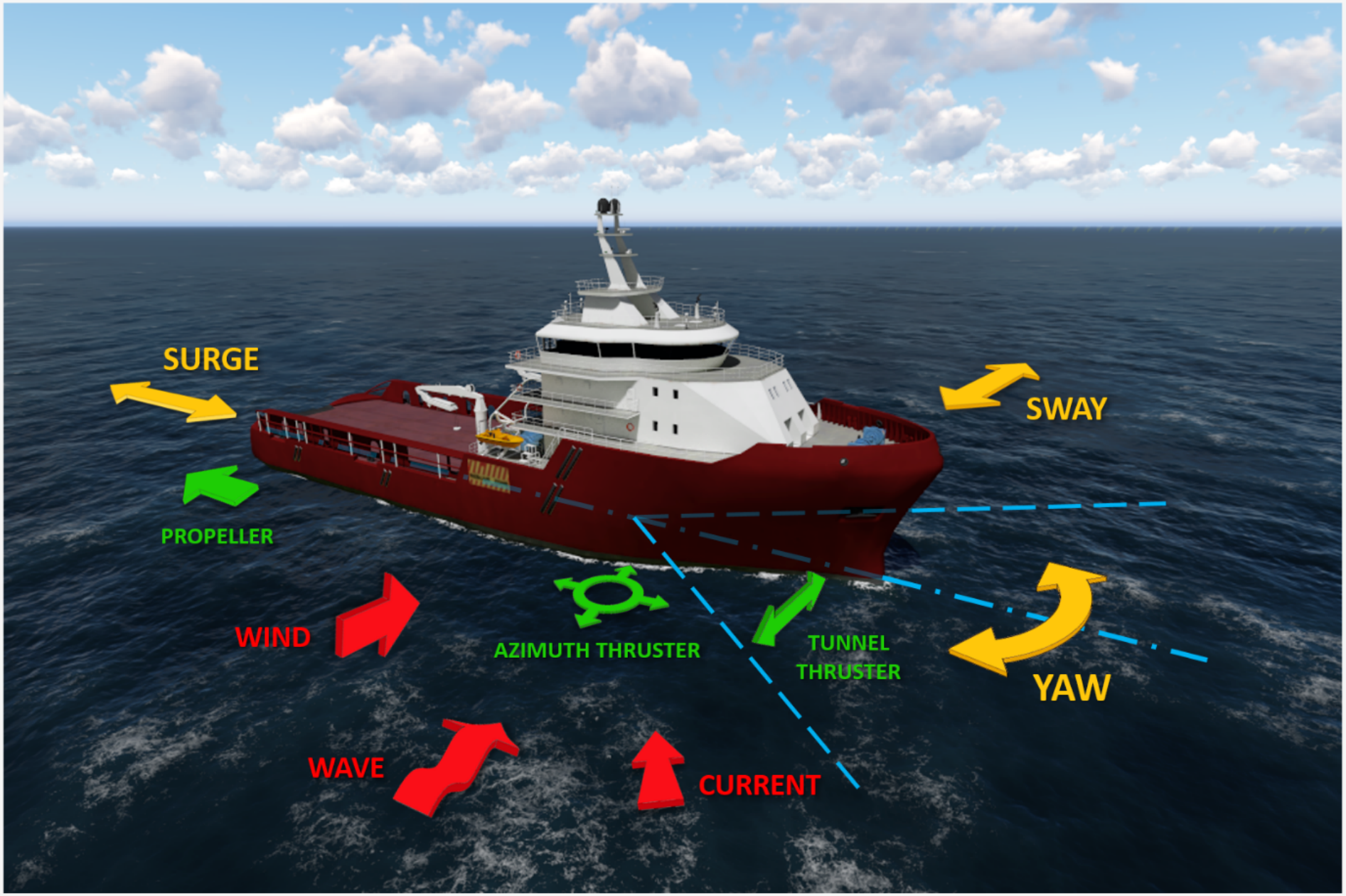
INITIAL SHIP DESIGN



- Initial cost determinants
- Lifetime operational realization → Economic success
- DP: Estimation → Accuracy (?)
- DP: Propulsion → Test Trial (!)
- Major drawback - Time, cost of rework, contract

* Graph developed from: Krüger, S. 2003. "The Role of IT in Shipbuilding."

STATIC BALANCE



Force balance → Position **Moment balance → Heading**

RATIONALE FOR PRESENT STUDY

- DP performance prediction - a great challenge

- Commercial interests
  - save costs
  - add design value

- Avoid 3rd Party involvement
  - confidentiality issues
  - black-box reliability

- Avoid over-conservative compliance

OBJECTIVES

- **DP Capability Tool Development:**
  - Concept development
  - Module: Ambient Forces
  - Module: Thrusters
  - Plugins for various constraints
  - Optimization Solver Modules
  - Standard DP Plots / Outputs
  - Additional module for power demands
- **Programming in Excel environment**
- **Validation**

DP TOOL DEVELOPMENT

External Forces

Wind, Current, Wave, Additional

Thrusters

- 6 x Tunnel Thrusters
- 6 x Azimuth Thrusters
- 4 x Propellers with Rudders

Convention

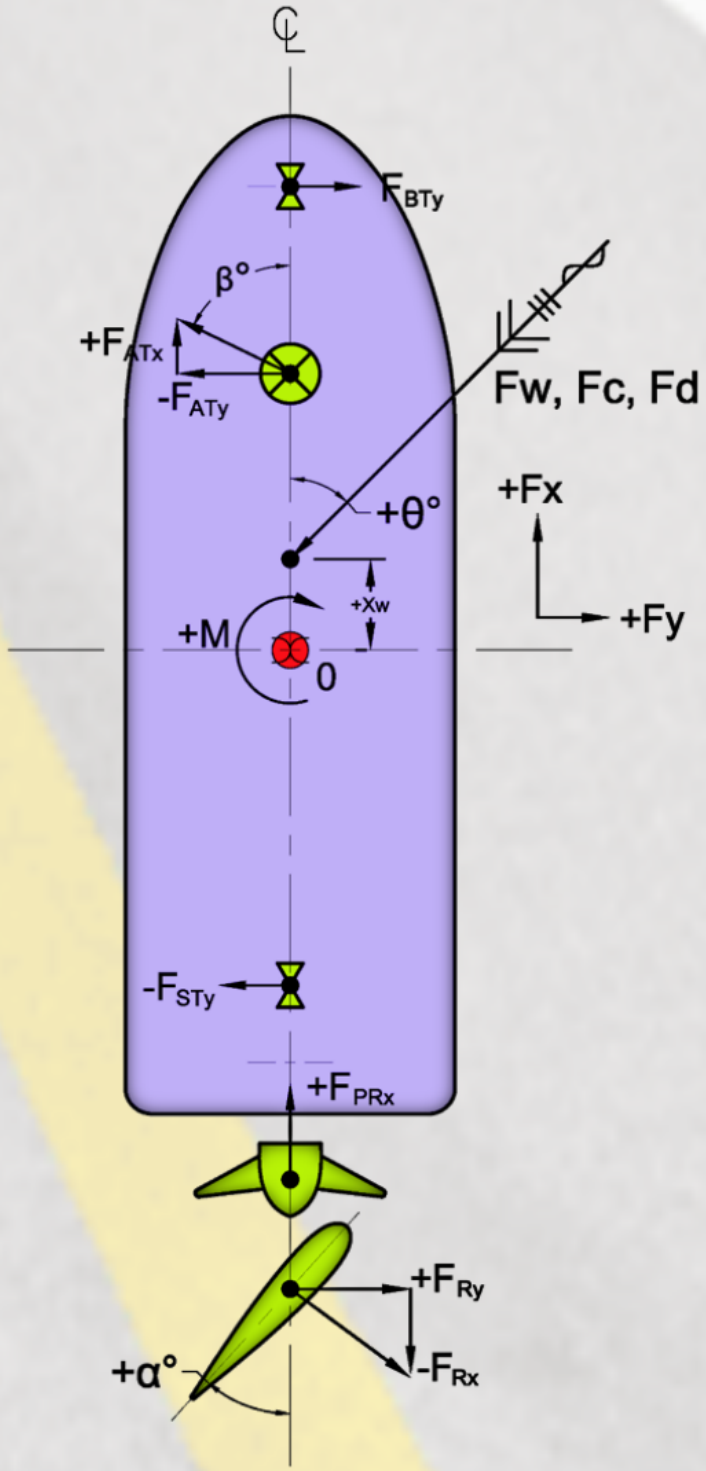
Sign Convention (+ve directions)

1. Position → Forward of Midship
   Starboard OCL

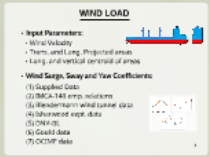
2. Force → Forward direction (Stern to Bow)
   Center outwards Starboard

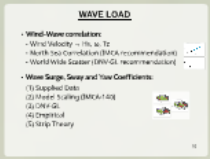
3. Moment → Clockwise about Midship

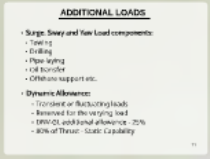
4. Rudder/Azimuth Angles
   → Clockwise from 0 degrees

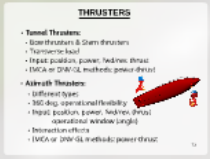


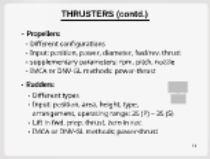
DP CAPABILITY ESTIMATION

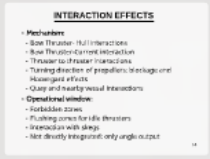


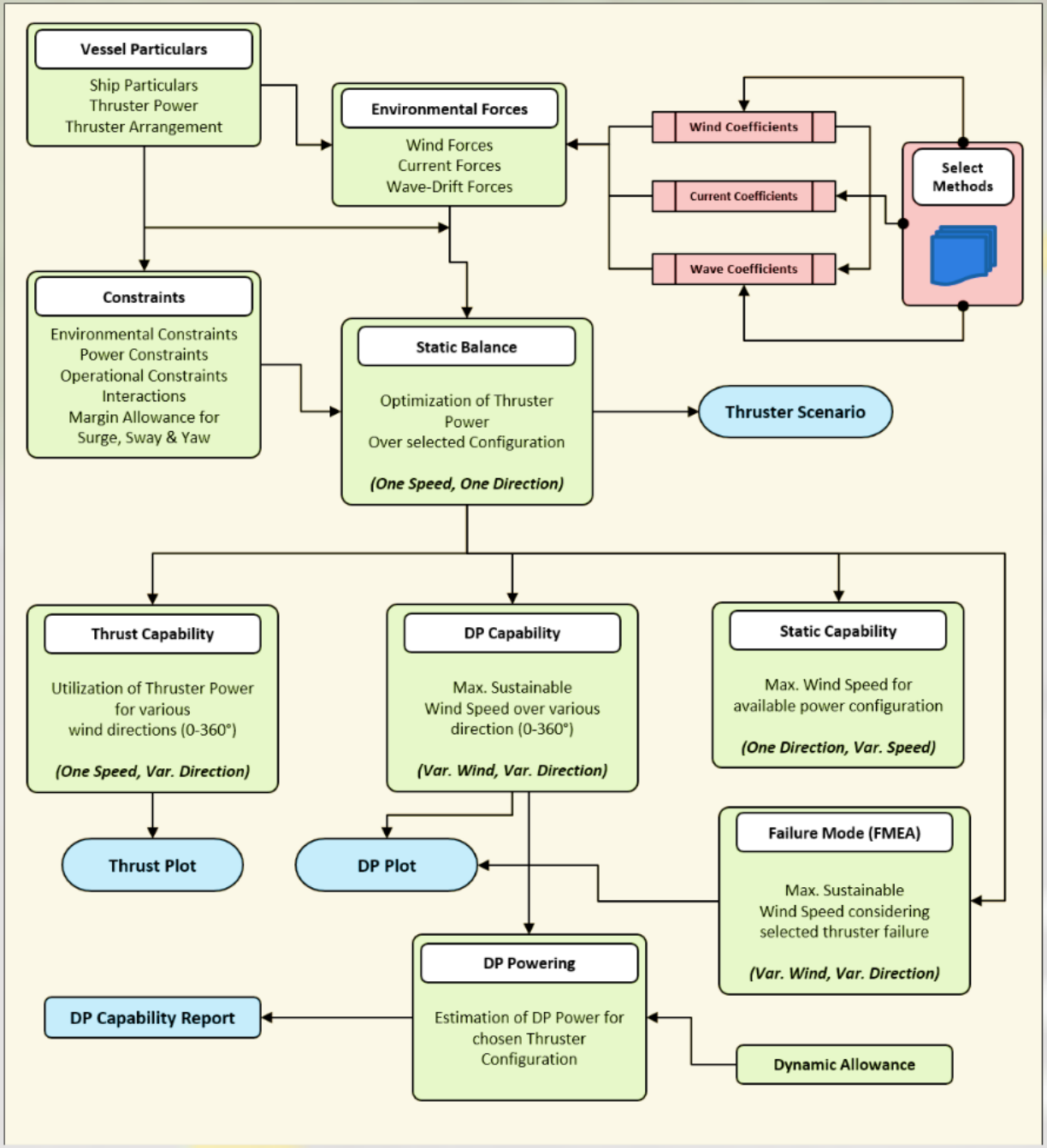


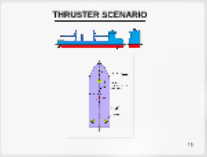


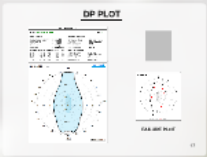


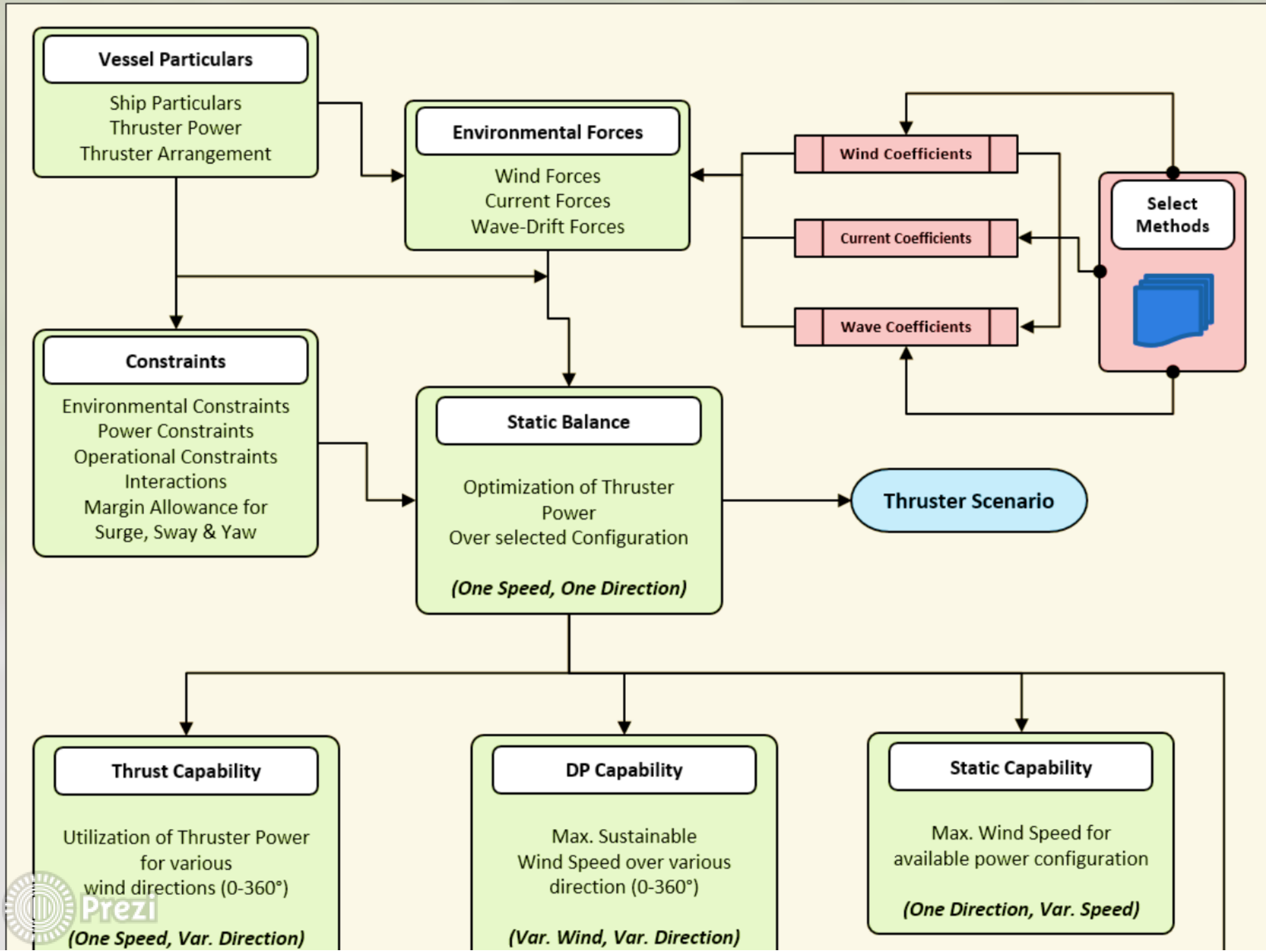




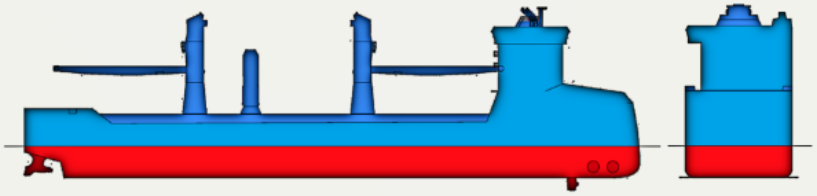







Vessel Particulars
Ship Particulars
Thruster Power
Thruster Arrangement
Environmental Forces
Wind Forces
Current Forces
Wave-Drift Forces
Wind Coefficients
Current Coefficients
Wave Coefficients
Select Methods
Constraints
Environmental Constraints
Power Constraints
Operational Constraints
Interactions
Margin Allowance for
Surge, Sway & Yaw
Static Balance
Optimization of Thruster
Power
Over selected Configuration
(One Speed, One Direction)
Thruster Scenario
Thrust Capability
Utilization of Thruster Power
for various
wind directions (0-360°)
(One Speed, Var. Direction)
DP Capability
Max. Sustainable
Wind Speed over various
direction (0-360°)
(Var. Wind, Var. Direction)
Static Capability
Max. Wind Speed for
available power configuration
(One Direction, Var. Speed)

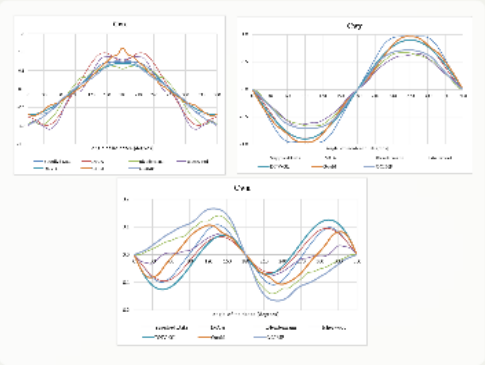
WIND LOAD

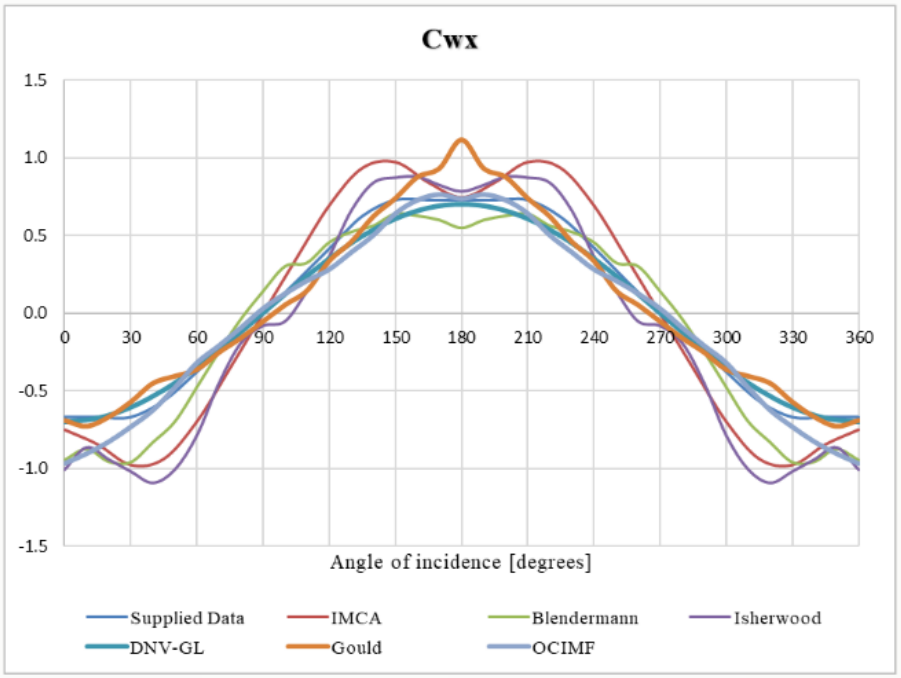


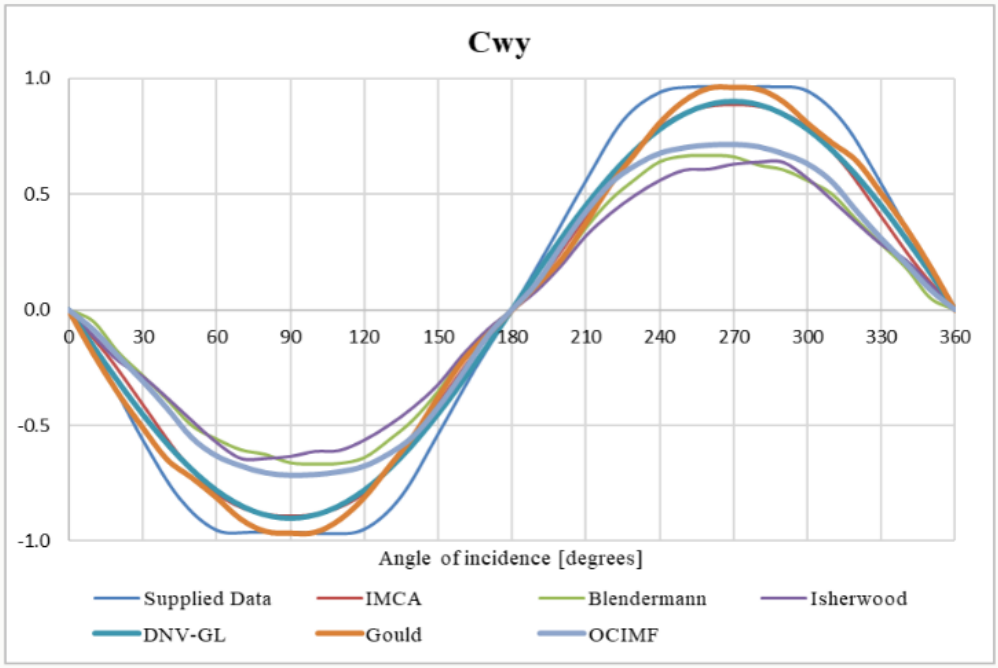
- **Input Parameters:**
  - Wind Velocity
  - Trans. and Long. Projected areas
  - Long. and vertical centroid of areas

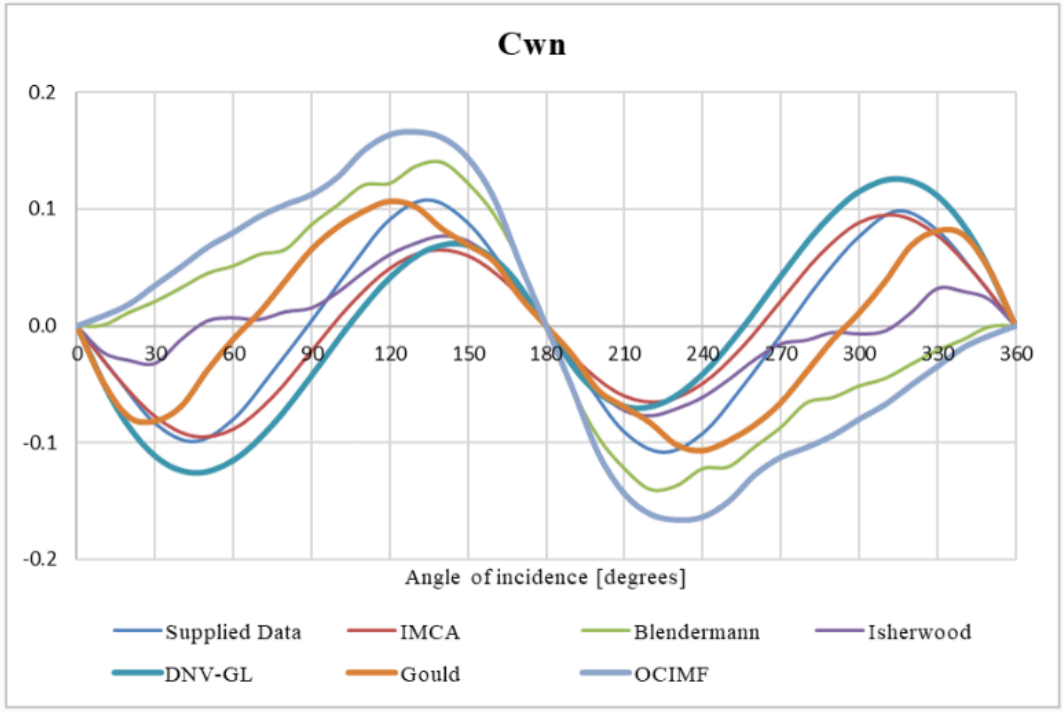
- **Wind Surge, Sway and Yaw Coefficients:**

  (1) Supplied Data
  (2) IMCA-140 emp. relations
  (3) Blendermann wind tunnel data
  (4) Isherwood expt. data
  (5) DNV-GL
  (6) Gould data
  (7) OCIMF data

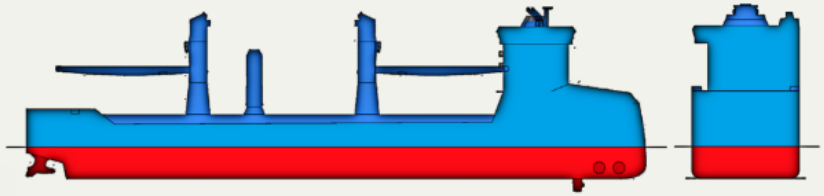



Cwx
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0 30 60 90 120 150 180 210 240 270 300 330 360
Angle of incidence [degrees]
Supplied Data
IMCA
Blendermann
Isherwood
DNV-GL
Gould
OCIMF


Cwy
1.0
0.5
0.0
-0.5
-1.0
0 30 60 90 120 150 180 210 240 270 300 330 360
Angle of incidence [degrees]
Supplied Data
IMCA
Blendermann
Isherwood
DNV-GL
Gould
OCIMF


Cwn
0.2
0.1
0.0
-0.1
-0.2
0 30 60 90 120 150 180 210 240 270 300 330 360
Angle of incidence [degrees]
Supplied Data
IMCA
Blendermann
Isherwood
DNV-GL
Gould
OCIMF

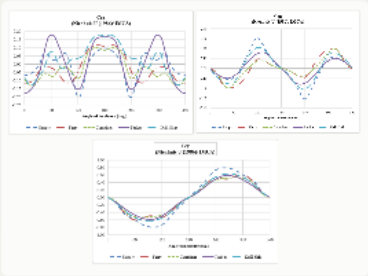
CURRENT LOAD

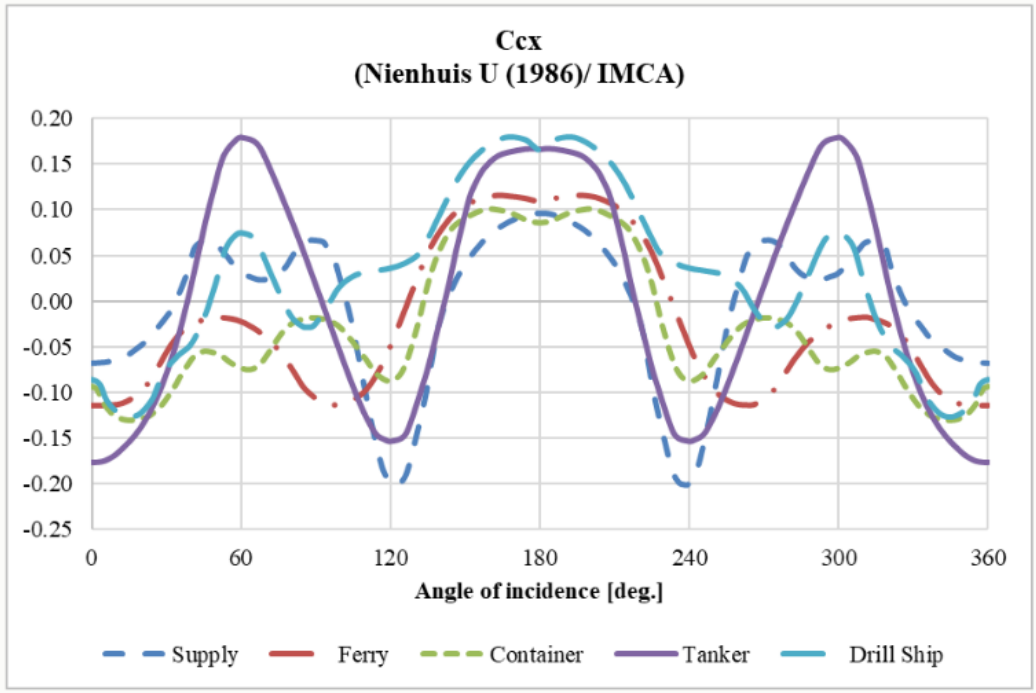


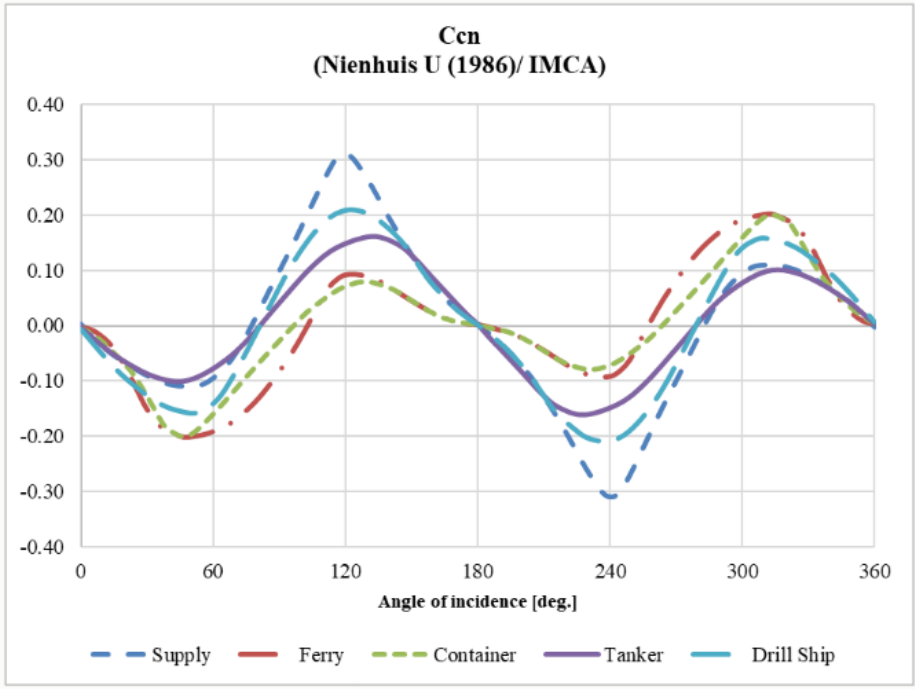
- **Input Parameters:**
  - Current Velocity
  - Trans. and Long. u/w Projected areas
  - Long. and vertical u/w centroid of areas

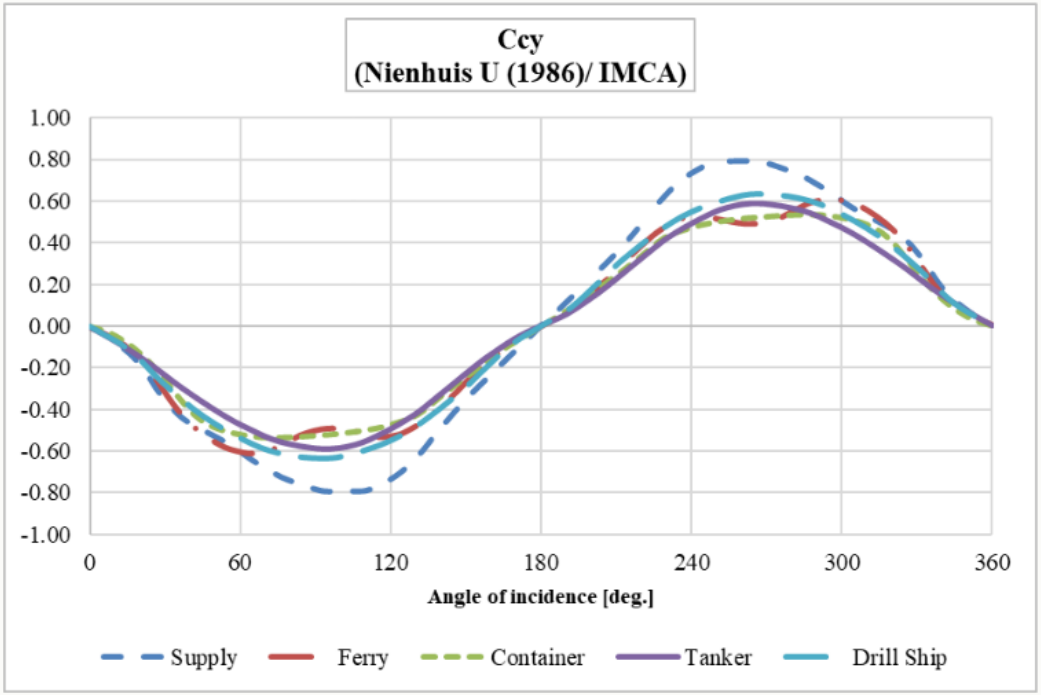
- **Current Surge, Sway and Yaw Coefficients:**

  (1) Supplied Data
  (2) IMCA-140 (Nienhuis data)
  (3) DNV-GL
  (4) OCIMF data
  (5) Strip Theory



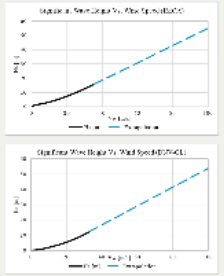

Ccx
(Nienhuis U (1986)/ IMCA)
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
0
60
120
180
240
300
360
Angle of incidence [deg.]
Supply
Ferry
Container
Tanker
Drill Ship


Ccn
(Nienhuis U (1986)/ IMCA)
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
0
60
120
180
240
300
360
Angle of incidence [deg.]
Supply
Ferry
Container
Tanker
Drill Ship


Ccy
(Nienhuis U (1986)/ IMCA)
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
0
60
120
180
240
300
360
Angle of incidence [deg.]
Supply
Ferry
Container
Tanker
Drill Ship

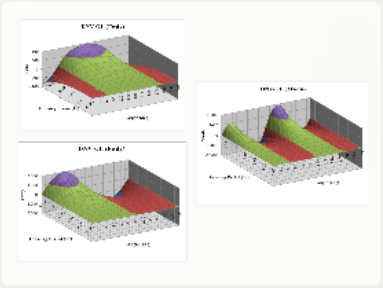
WAVE LOAD

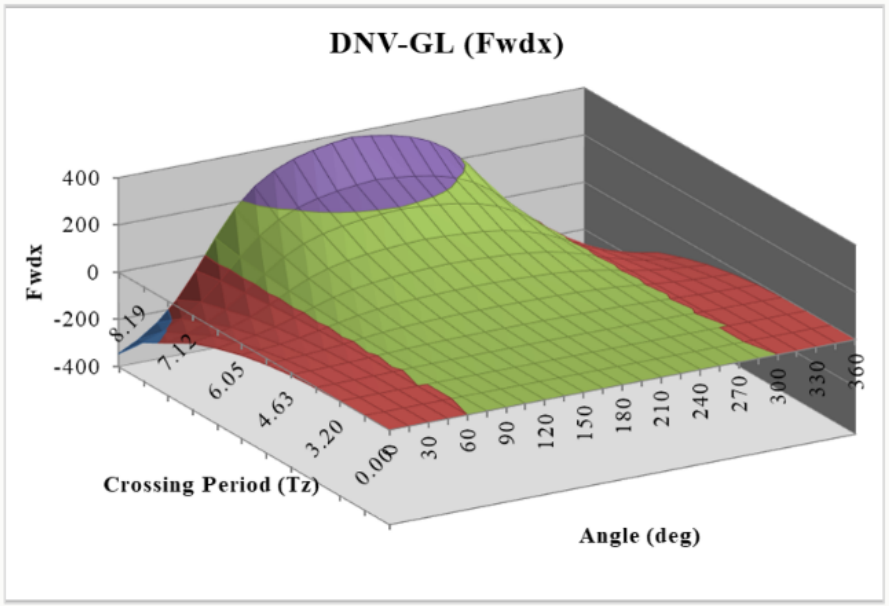
- **Wind-Wave correlation:**
  - Wind Velocity → Hs, ω, Tz
  - North Sea Correlation (IMCA recommendation)
  - World Wide Scatter (DNV-GL recommendation)

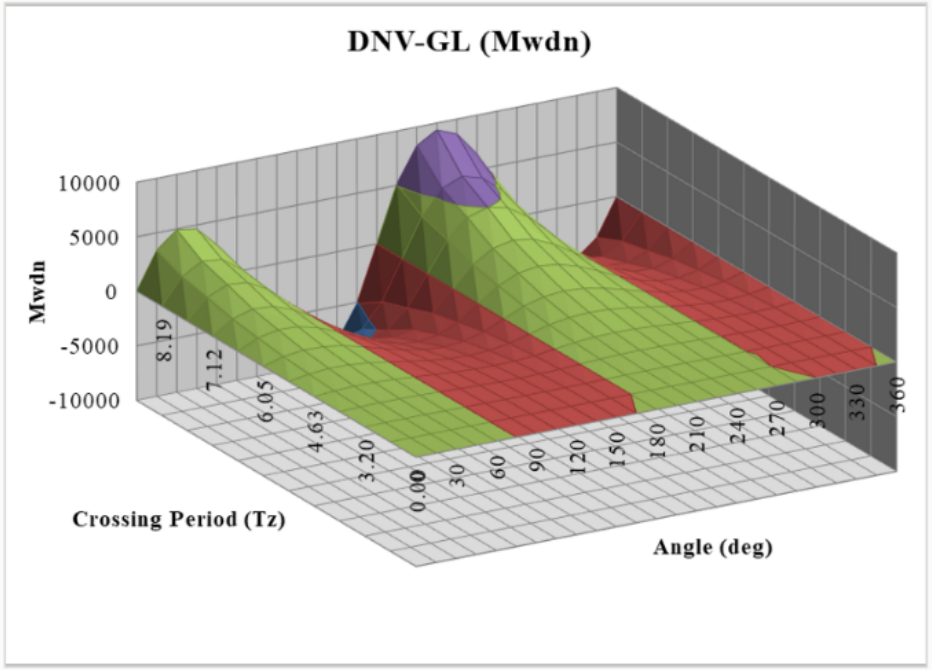


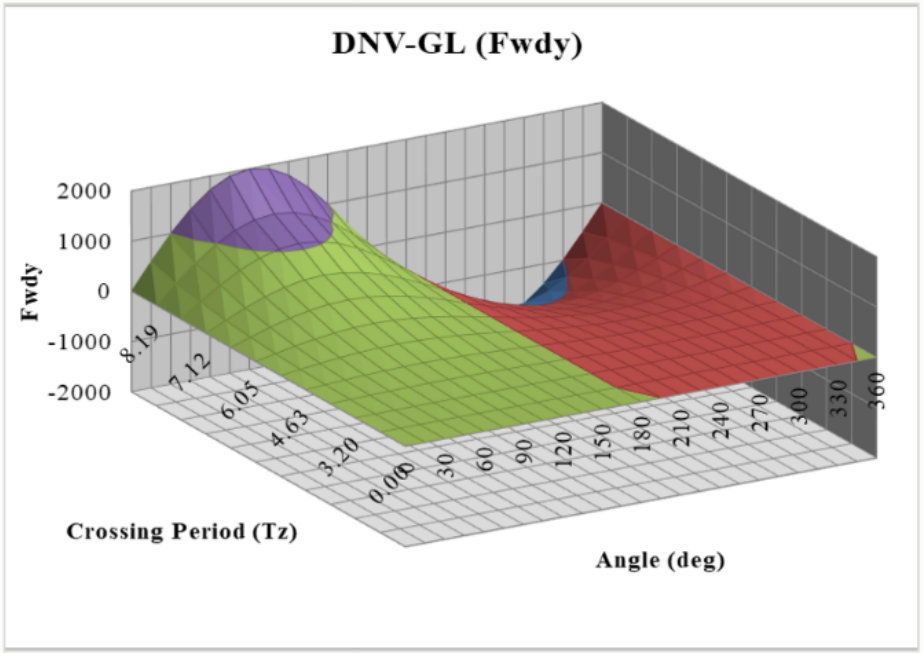
- **Wave Surge, Sway and Yaw Coefficients:**

  (1) Supplied Data
  (2) Model Scaling (IMCA-140)
  (3) DNV-GL
  (4) Empirical
  (5) Strip Theory




DNV-GL (Fwdx)
Fwdx
400
200
0
-200
-400
8.19
7.12
6.05
4.63
3.20
0.00
Crossing Period (Tz)
30
60
90
120
150
180
210
240
270
300
330
360
Angle (deg)


DNV-GL (Mwdn)
Mwdn
10000
5000
0
-5000
-10000
8.19
7.12
6.05
4.63
3.20
0.00
Crossing Period (Tz)
30
60
90
120
150
180
210
240
270
300
330
360
Angle (deg)

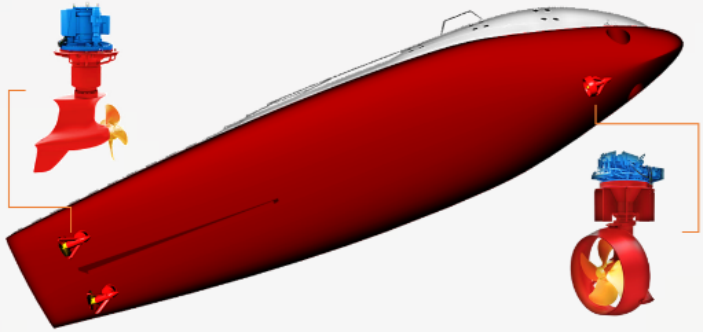

DNV-GL (Fwdy)
Fwdy
2000
1000
0
-1000
-2000
8.19
7.12
6.05
4.63
3.20
0.00
Crossing Period (Tz)
30
60
90
120
150
180
210
240
270
300
330
360
Angle (deg)

ADDITIONAL LOADS

- **Surge, Sway and Yaw Load components:**
  - Towing
  - Drilling
  - Pipe-laying
  - Oil transfer
  - Offshore support etc.
- **Dynamic Allowance:**
  - Transient or fluctuating loads
  - Reserved for the varying load
  - DNV-GL additional allowance - 25%
  - 80% of Thrust - Static Capability

THRUSTERS

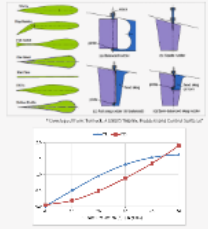
- **Tunnel Thrusters:**
  - Bow thrusters & Stern thrusters
  - Transverse load
  - Input: position, power, fwd/rev. thrust
  - IMCA or DNV-GL methods: power-thrust

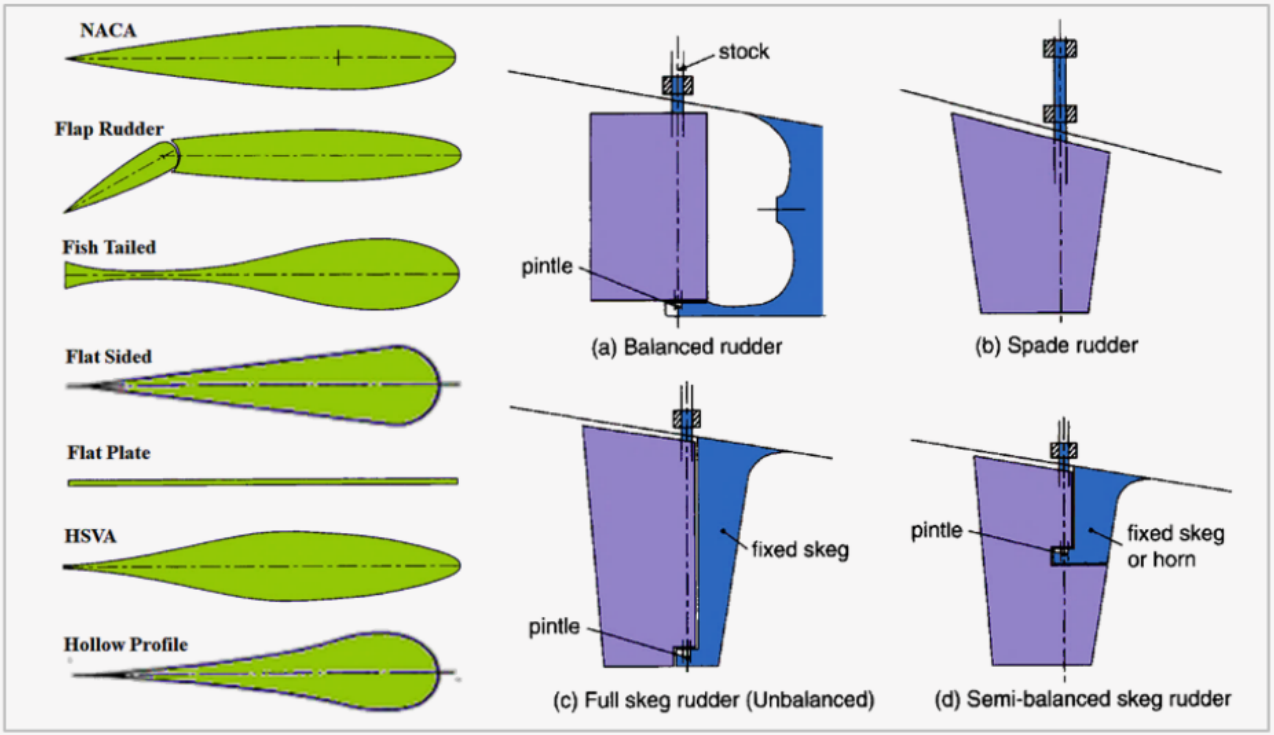


- **Azimuth Thrusters:**
  - Different types
  - 360 deg. operational flexibility
  - Input: position, power, fwd/rev. thrust
    operational window (angle)
  - Interaction effects
  - IMCA or DNV-GL methods: power-thrust

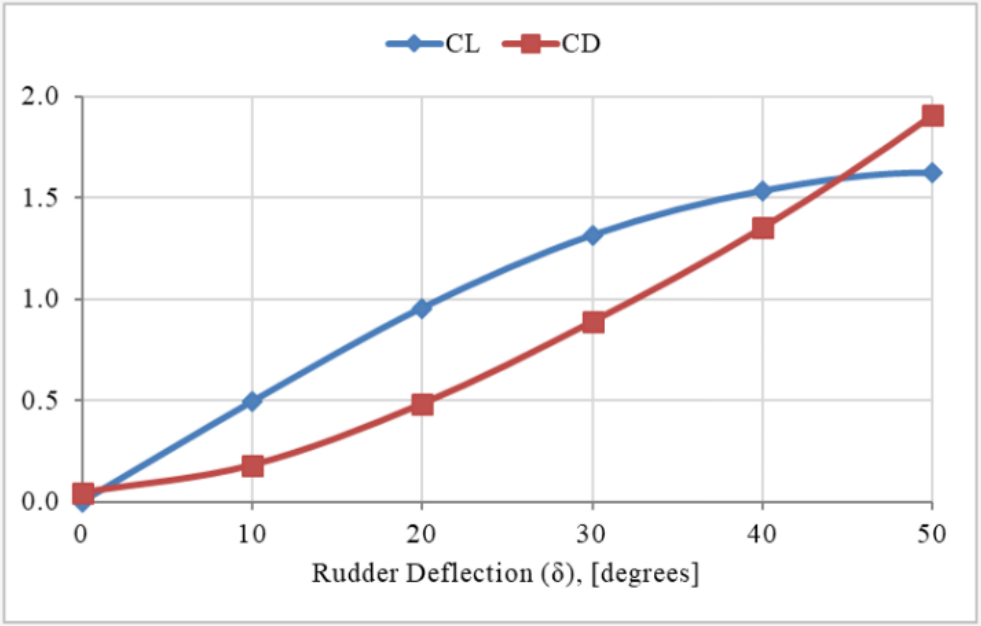
THRUSTERS (contd.)

- **Propellers:**
  - Different configurations
  - Input: position, power, diameter, fwd/rev. thrust
  - supplementary parameters: rpm, pitch, nozzle
  - IMCA or DNV-GL methods: power-thrust
- **Rudders:**
  - Different types
  - Input: position, area, height, type, arrangement, operating range: 35 (P) ~ 35 (S)
  - Lift in fwd. prop. thrust, zero in rev.
  - IMCA or DNV-GL methods: power-thrust





* Developed from: Turnock, A (2007) "Marine Rudders and Control Surfaces"

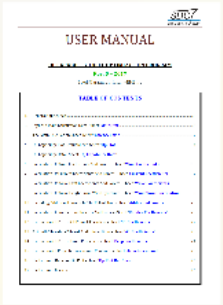


INTERACTION EFFECTS

- **Mechanism:**
  - Bow Thruster- Hull interactions
  - Bow Thruster-Current interaction
  - Thruster to thruster interactions
  - Turning direction of propellers: blockage and Hoovegard effects
  - Quay and nearby vessel interactions
- **Operational window:**
  - Forbidden zones
  - Flushing zones for idle thrusters
  - Interaction with skegs
  - Not directly integrated: only angle output

SOLVER MODULE

- Major work: Digitization of research data
- Modified Excel Solver Module: method, precision, convergence, scaling controls
    - 10 mins. (0~180° @ 5° intervals)
- 14 Worksheets (database, input, output recognition)
- 25 Programmed Modules (interlinking loop)
- 48575 linked calculation cells.
- User Manual



SDC
SHIP DESIGN & CONSULT

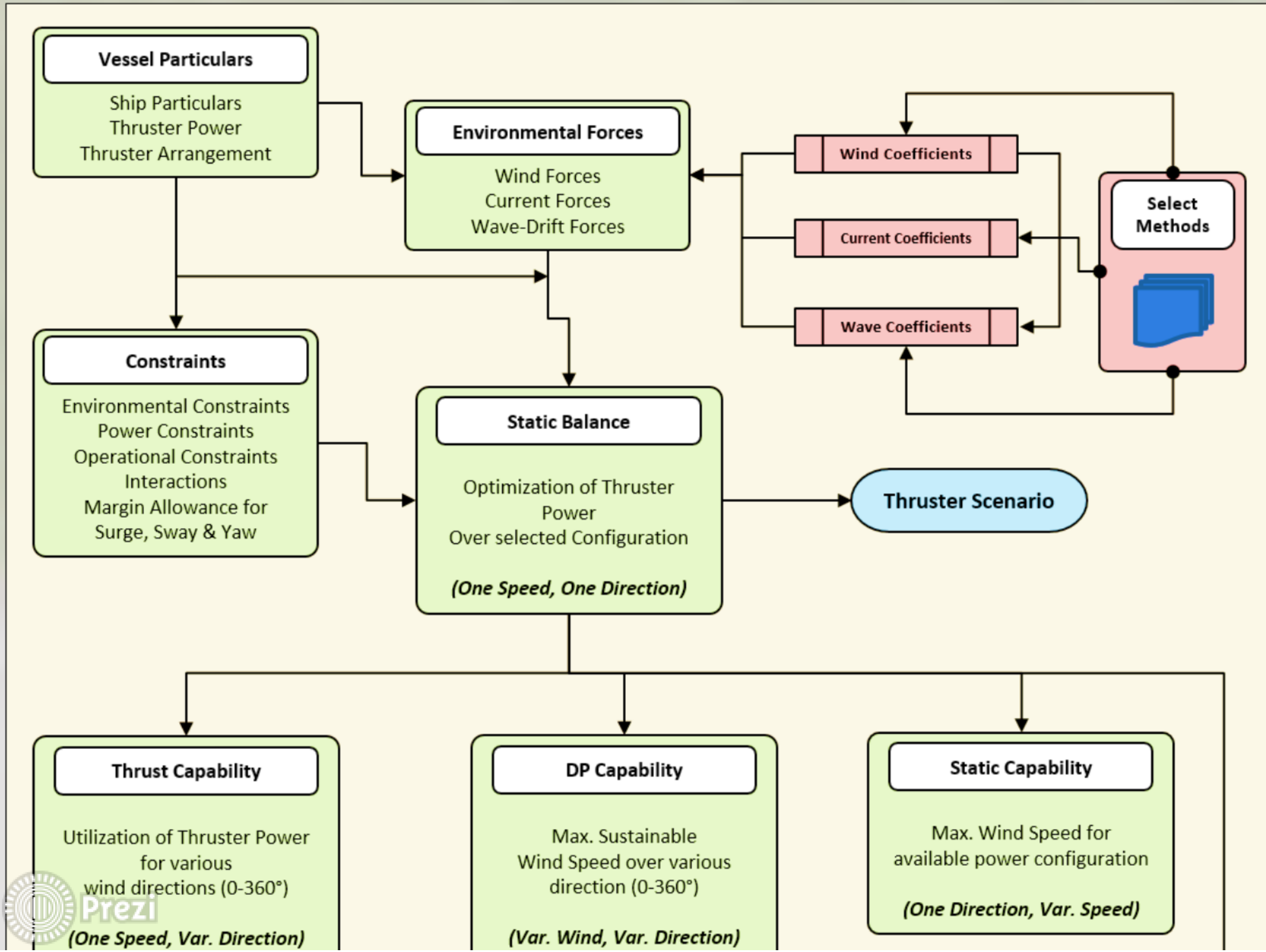
USER MANUAL

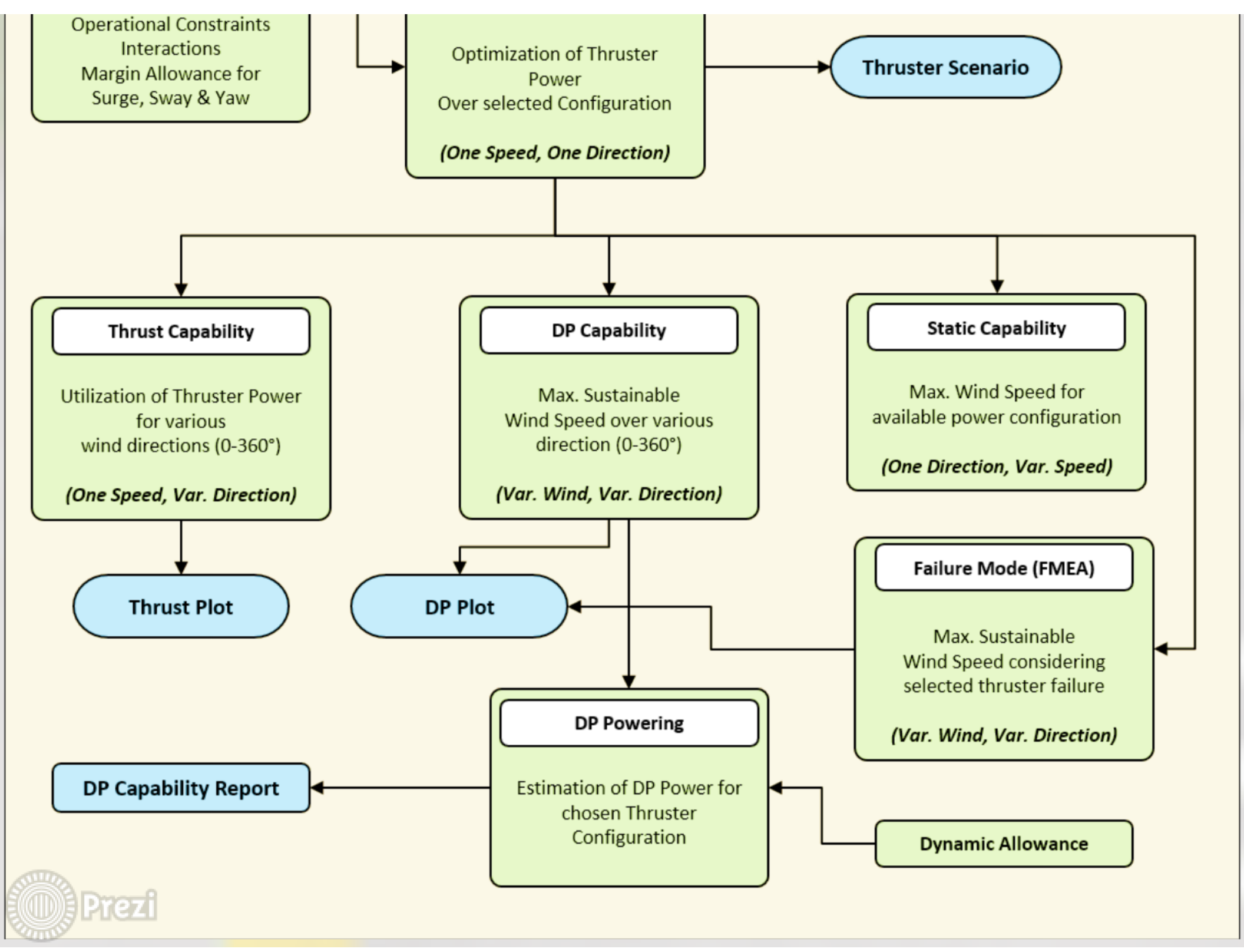
DP CAPABILITY EXCEL OPTIMIZATION PROGRAM

Rev. 0 – 2017

(Syed Marzan Ul Hasan –EMShip)

TABLE OF CONTENTS


Vessel Particulars
Ship Particulars
Thruster Power
Thruster Arrangement
Environmental Forces
Wind Forces
Current Forces
Wave-Drift Forces
Wind Coefficients
Current Coefficients
Wave Coefficients
Select Methods
Constraints
Environmental Constraints
Power Constraints
Operational Constraints
Interactions
Margin Allowance for
Surge, Sway & Yaw
Static Balance
Optimization of Thruster
Power
Over selected Configuration
(One Speed, One Direction)
Thruster Scenario
Thrust Capability
Utilization of Thruster Power
for various
wind directions (0-360°)
(One Speed, Var. Direction)
DP Capability
Max. Sustainable
Wind Speed over various
direction (0-360°)
(Var. Wind, Var. Direction)
Static Capability
Max. Wind Speed for
available power configuration
(One Direction, Var. Speed)


Operational Constraints
Interactions
Margin Allowance for
Surge, Sway & Yaw
Optimization of Thruster
Power
Over selected Configuration
(One Speed, One Direction)
Thruster Scenario
Thrust Capability
Utilization of Thruster Power
for various
wind directions (0-360°)
(One Speed, Var. Direction)
DP Capability
Max. Sustainable
Wind Speed over various
direction (0-360°)
(Var. Wind, Var. Direction)
Static Capability
Max. Wind Speed for
available power configuration
(One Direction, Var. Speed)
Thrust Plot
DP Plot
Failure Mode (FMEA)
Max. Sustainable
Wind Speed considering
selected thruster failure
(Var. Wind, Var. Direction)
DP Powering
Estimation of DP Power for
chosen Thruster
Configuration
DP Capability Report
Dynamic Allowance

DP PLOT

DP Capability Plot

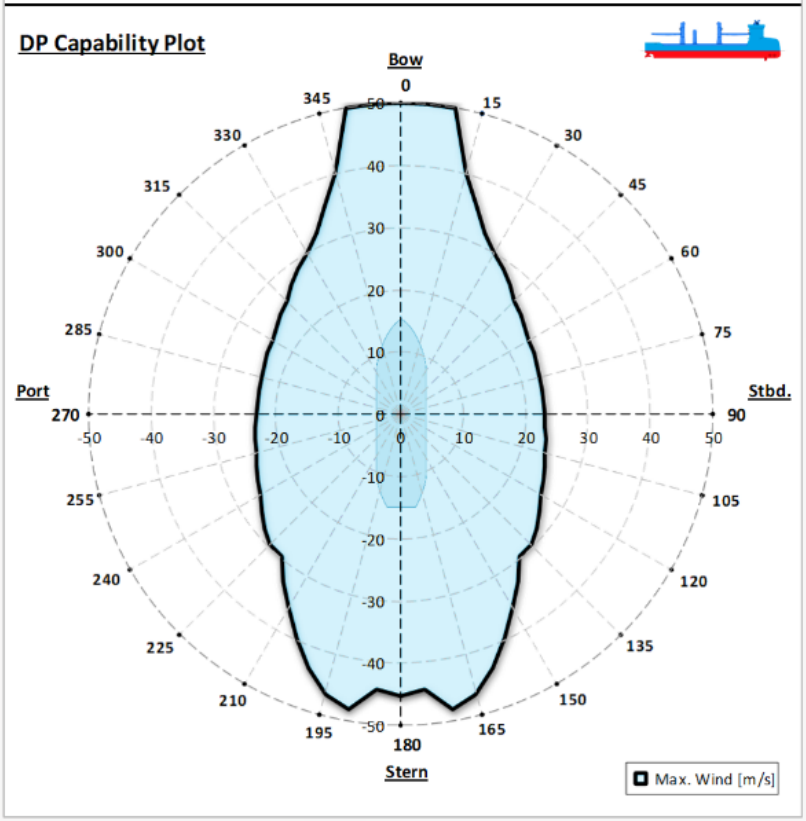
Project: Multipurpose Vessel **Rev.** 0

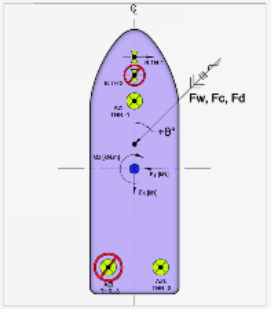
Main Particulars		
Length betw een perpendiculars	142.1	[m]
Loaded Waterline Length	145.0	[m]
Breadth moulded	25.0	[m]
Draught	7.2	[m]
Block coefficient	0.835	[---]
Displacement	21902	[tonnes]

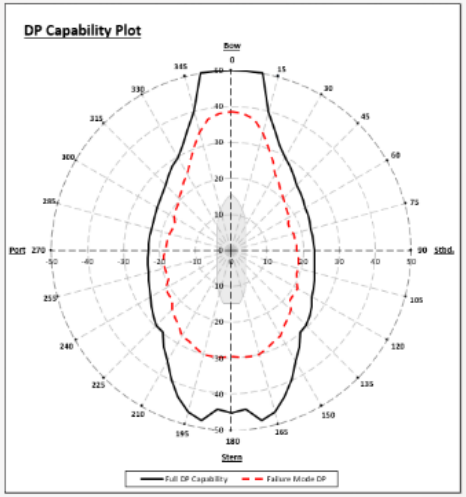
Calculation Parameters		
Maximum Wind Speed	50.0 [m/s]	(97.2 Knots)
Current Speed (fixed)	0.51 [m/s]	(1Knots)
Wave Height	Wind Dependant	
Wind Load Estimation	IMCA	
Current Load Estimation	IMCA	
Wave-Drift Estimation	DNV-GL	

Thruster	Thrust [kN]		(+ve=Fwd)	P [kW]	[%]
TT No. 1	-271	to	271	2340	80%
TT No. 2	-271	to	271	2340	80%
AT No. 1	-160	to	260	1900	80%
AT No. 2	-427	to	694	5075	80%
AT No. 3	-427	to	694	5075	80%

Other Considerations	
Wind Incedent Angle	0 ~360 [deg]
Wave & Current	Collinear with Wind
Dynamic Allow ance	25.0 %
Interaction Effects	Not Included
Additional Forces	Not Included







FAILURE PLOT

DP Capability Plot

Project: Multipurpose Vessel **Rev.** 0

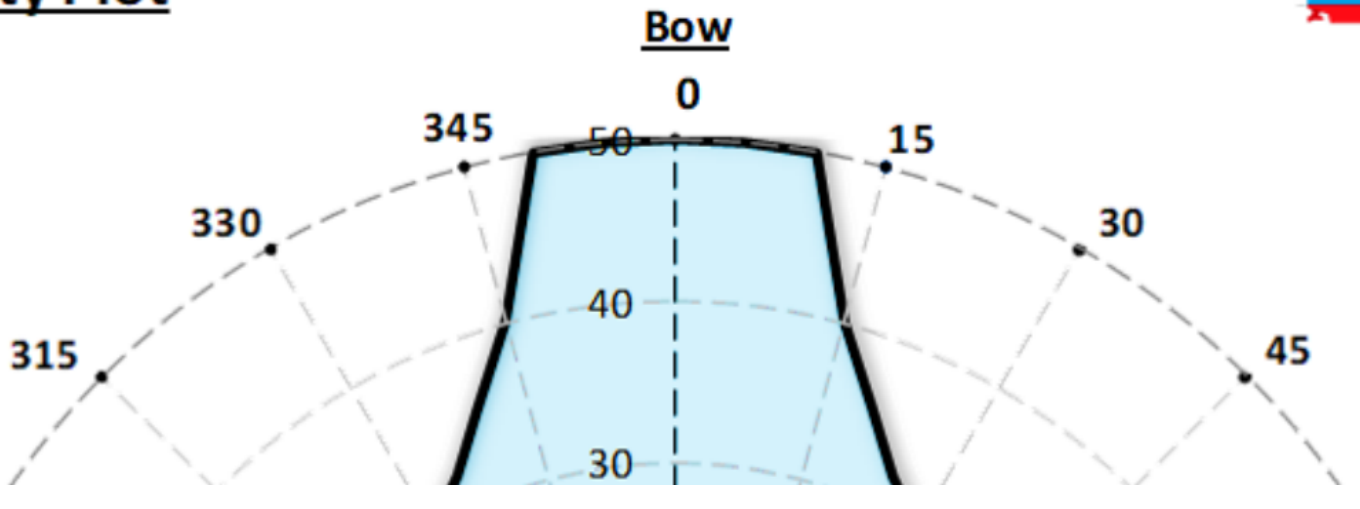
Main Particulars			
Length betw een perpendiculars	:	**142.1**	[m]
Loaded Waterline Length	:	**145.0**	[m]
Breadth moulded	:	**25.0**	[m]
Draught	:	**7.2**	[m]
Block coefficient	:	**0.835**	[---]
Displacement	:	**21902**	[tonnes]

Calculation Parameters			
Maximum Wind Speed	:	**50.0**	[m/s] (97.2 Knots)
Current Speed (fixed)	:	**0.51**	[m/s] (1Knots)
Wave Height	:	**Wind Dependant**	
Wind Load Estimation	:	**IMCA**	
Current Load Estimation	:	**IMCA**	
Wave-Drift Estimation	:	**DNV-GL**	

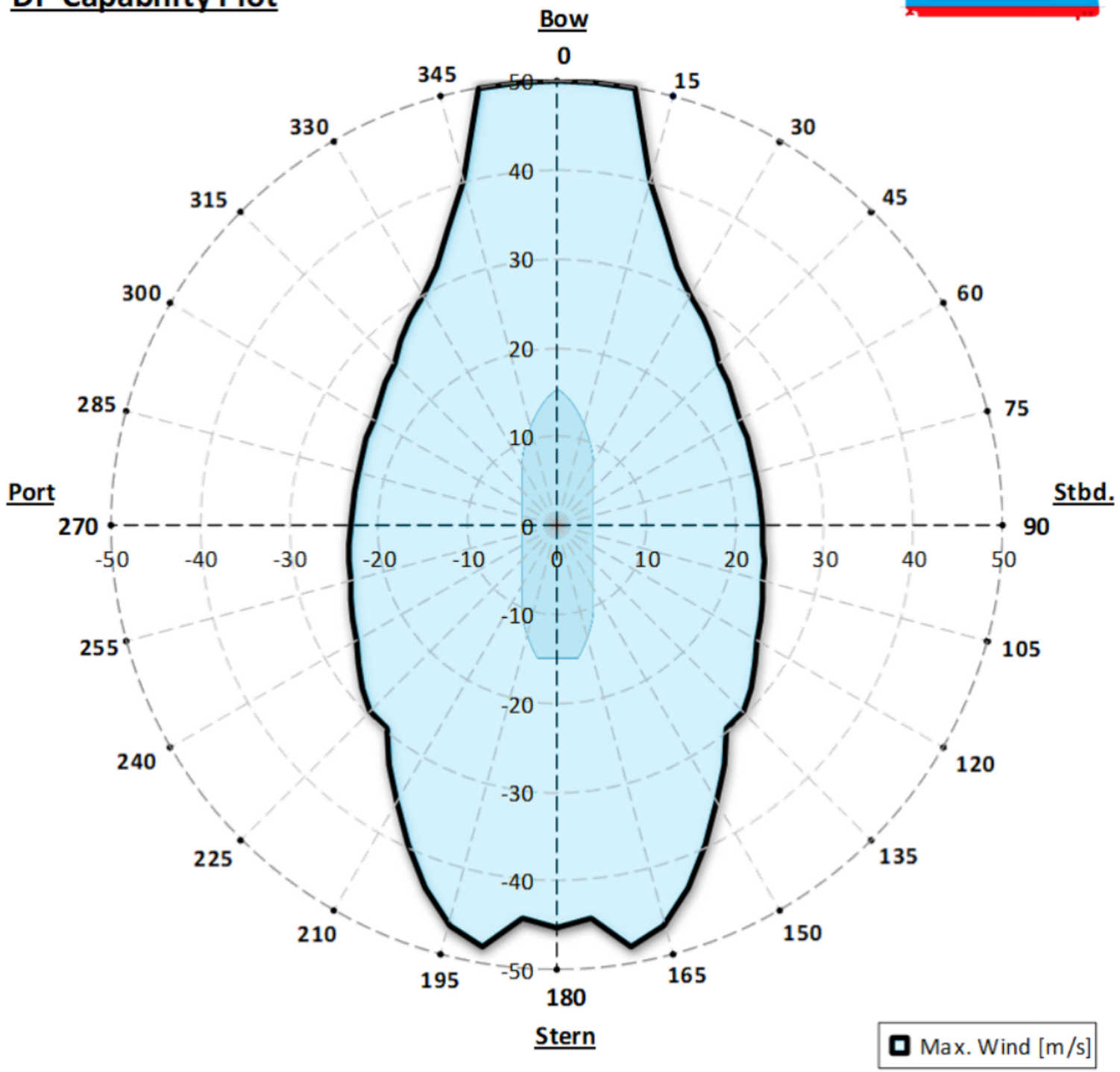
Thruster	Thrust [kN] (+ve=Fwd)			P [kW]	[%]
TT No. 1	-271	to	271	2340	80%
TT No. 2	-271	to	271	2340	80%
AT No. 1	-160	to	260	1900	80%
AT No. 2	-427	to	694	5075	80%
AT No. 3	-427	to	694	5075	80%

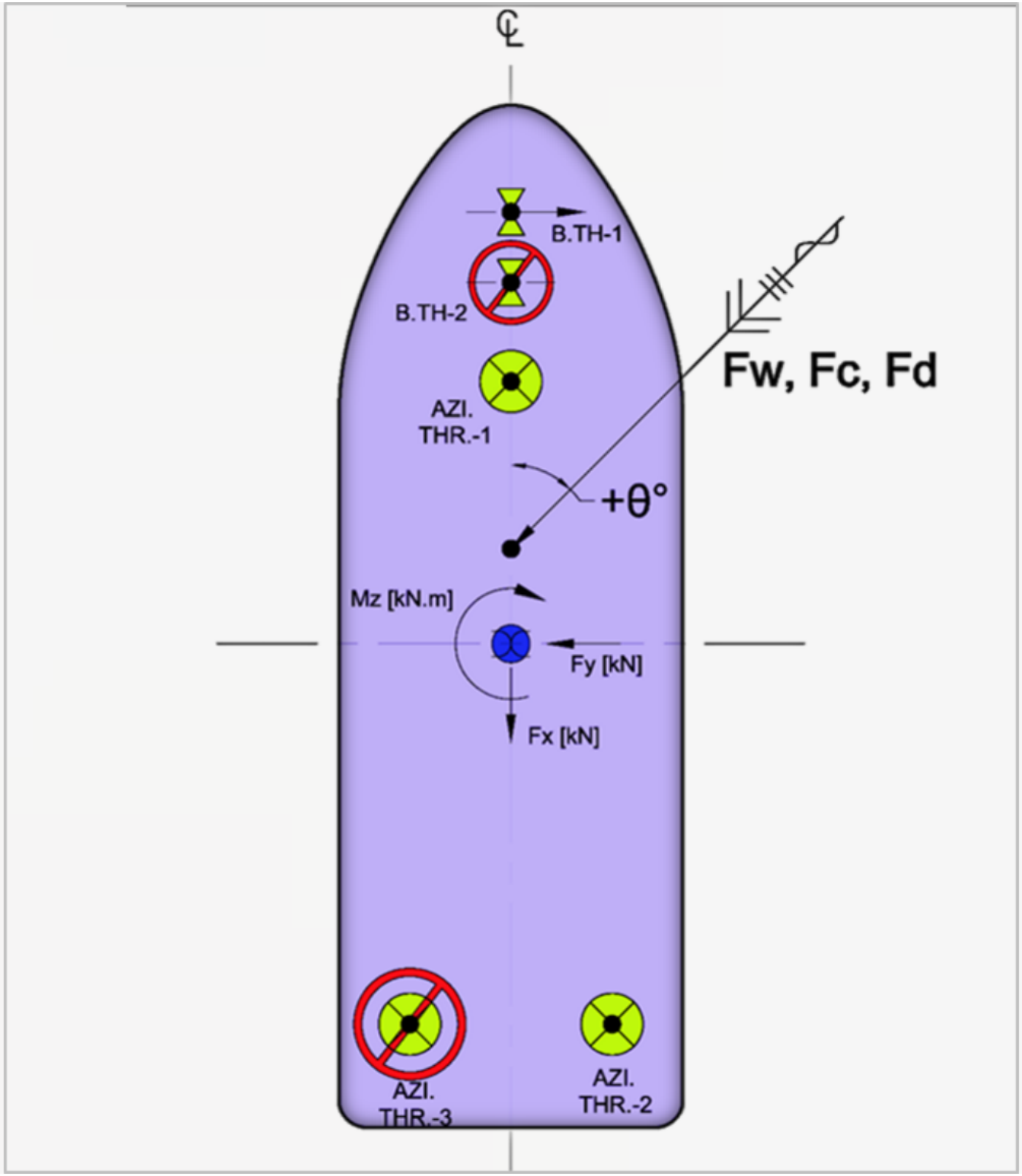
Other Considerations		
Wind Incedent Angle	:	**0 ~360** [deg]
Wave & Current	:	**Collinear with Wind**
Dynamic Allow ance	:	**25.0** %
Interaction Effects	:	**Not Included**
Additional Forces	:	**Not Included**

DP Capability Plot

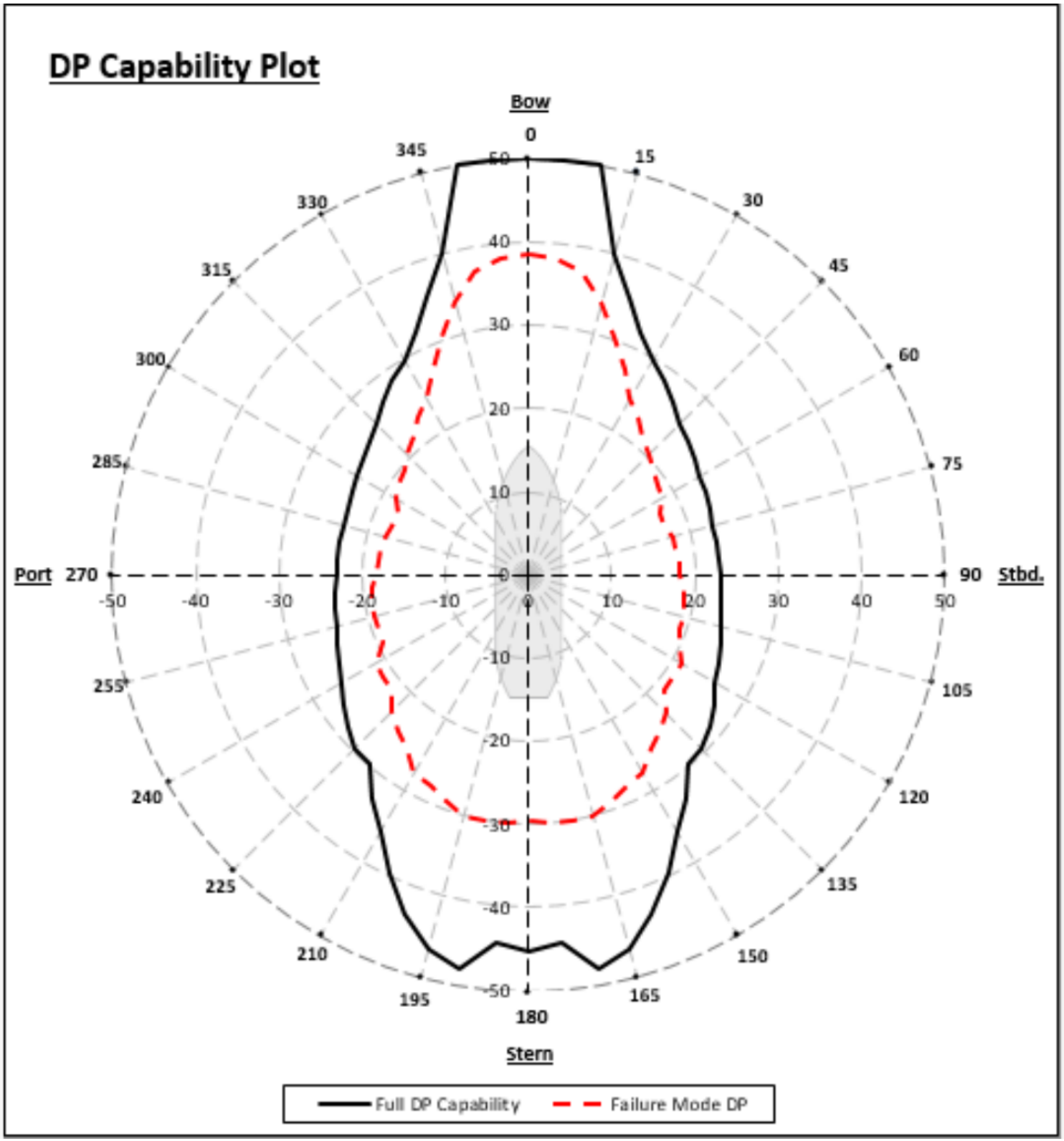


DP Capability Plot

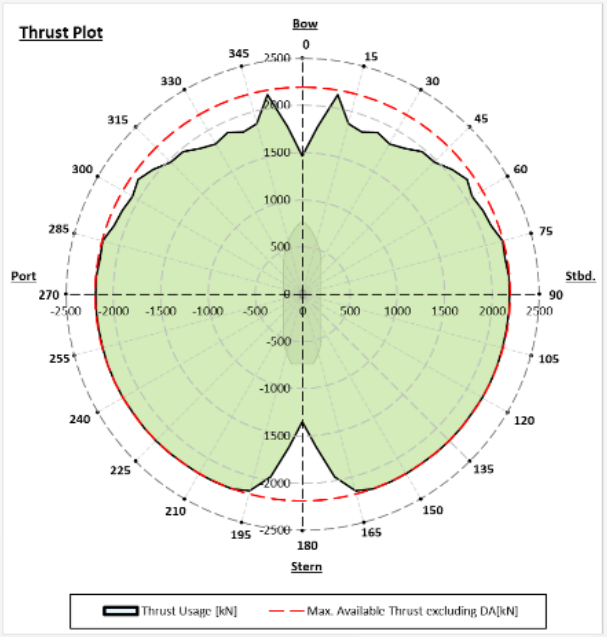


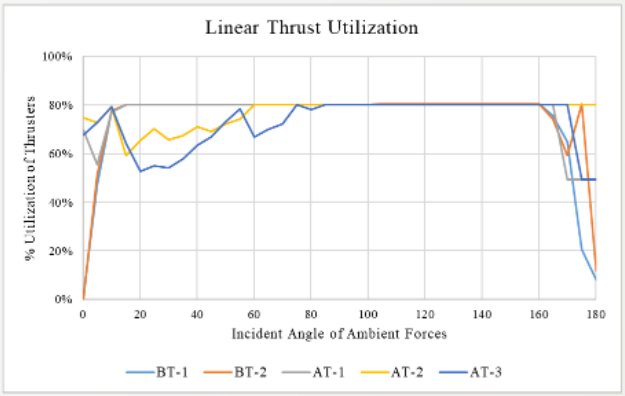

B.TH-1
B.TH-2
AZI.
THR.-1
Fw, Fc, Fd
+θ°
Mz [kN.m]
Fy [kN]
Fx [kN]
AZI.
THR.-3
AZI.
THR.-2

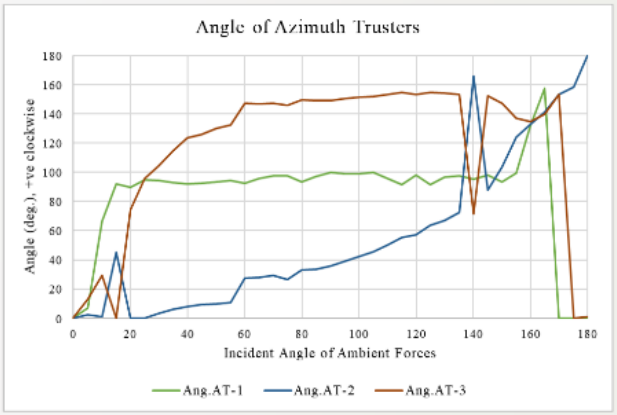
DP Capability Plot



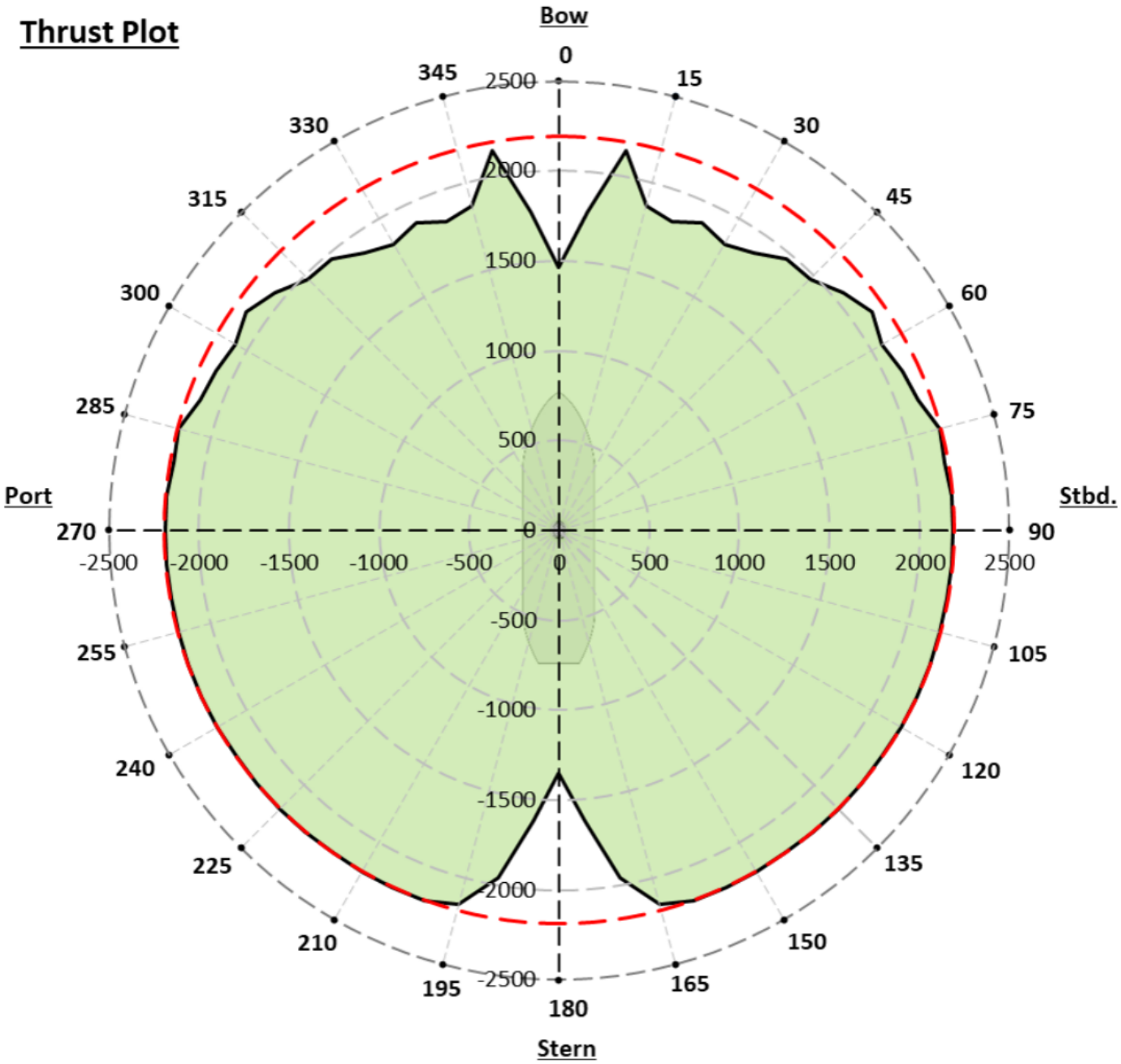
COMPREHENSIVE PLOTS

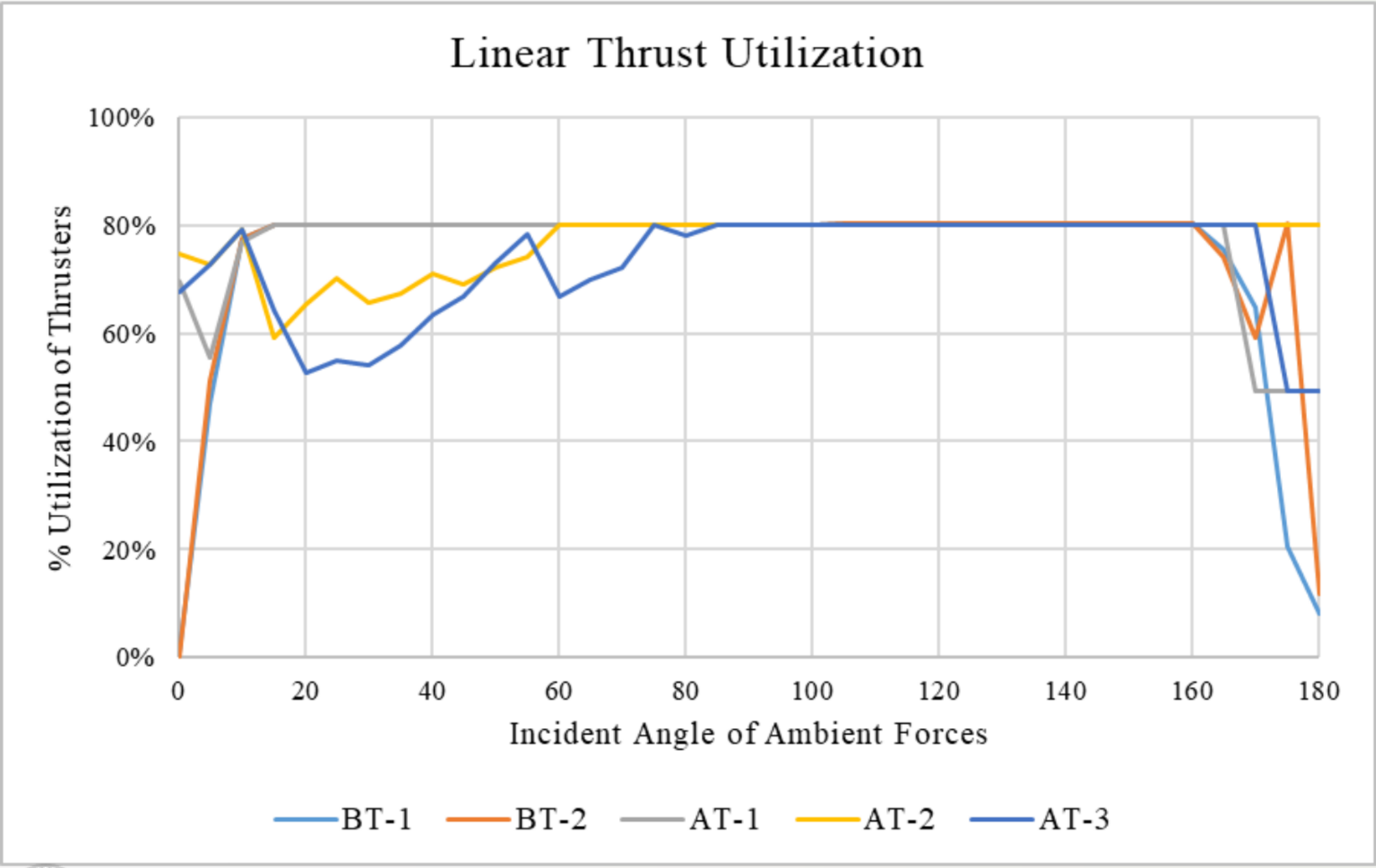


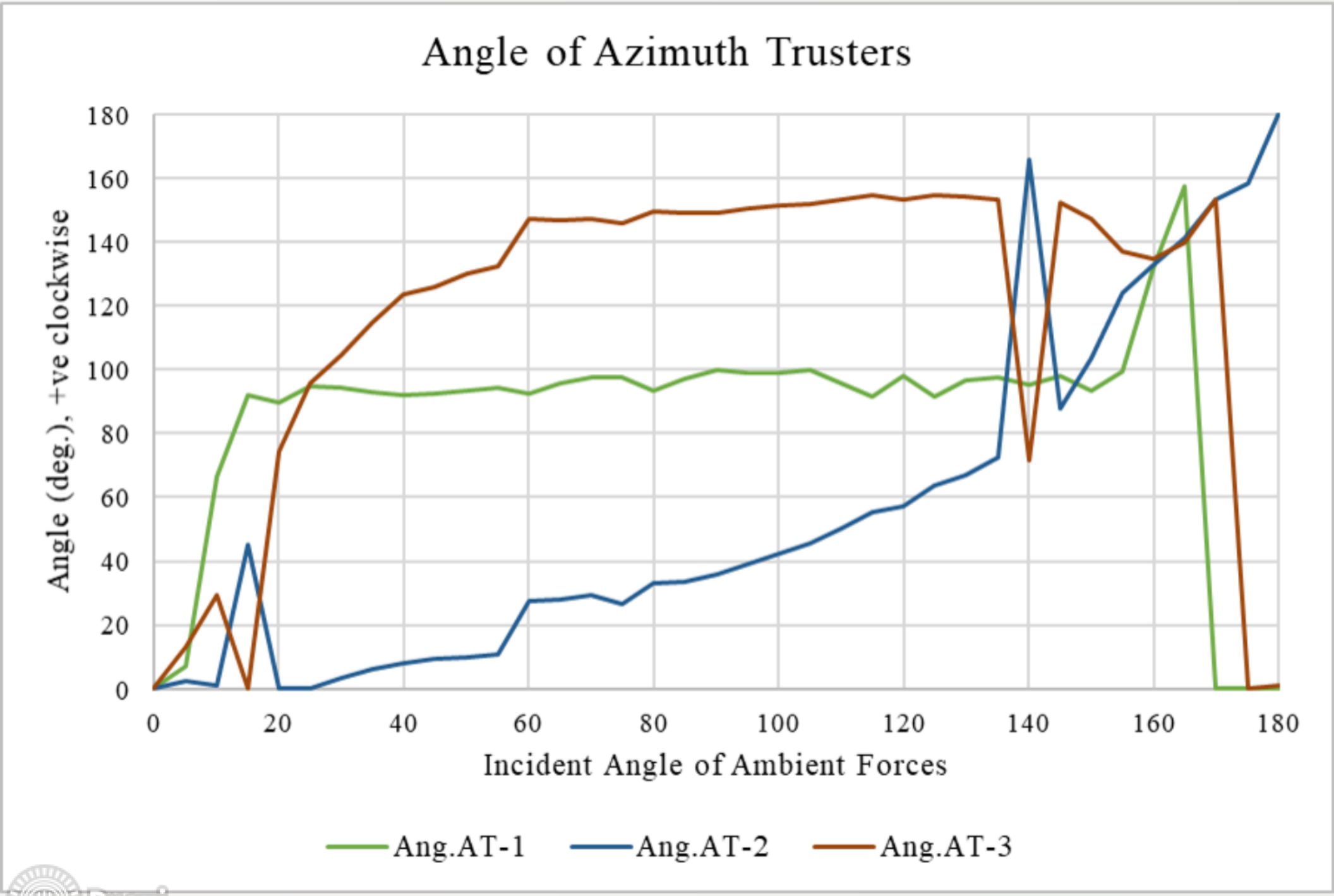




Thrust Plot

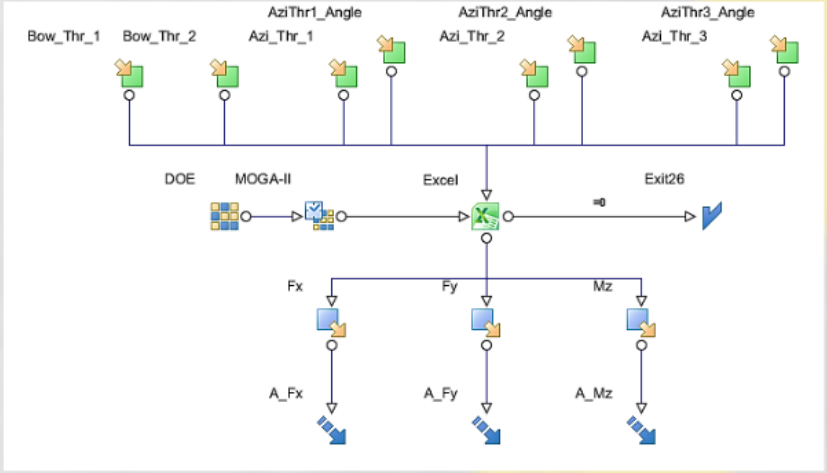


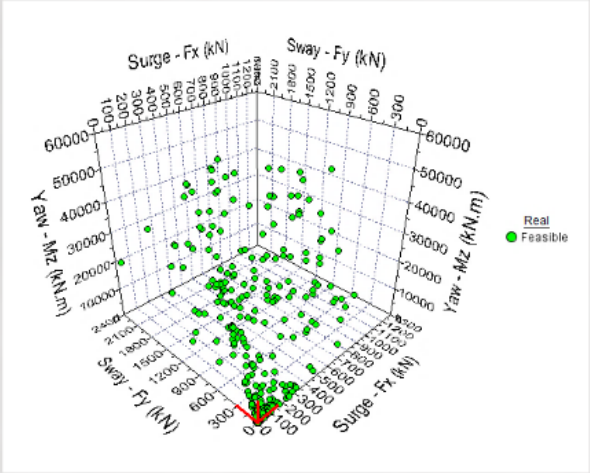

Linear Thrust Utilization
100%
80%
60%
40%
20%
0%
% Utilization of Thrusters
0
20
40
60
80
100
120
140
160
180
Incident Angle of Ambient Forces
BT-1
BT-2
AT-1
AT-2
AT-3


Angle of Azimuth Trusters
Angle (deg.), +ve clockwise
180
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
180
Incident Angle of Ambient Forces
Ang.AT-1
Ang.AT-2
Ang.AT-3

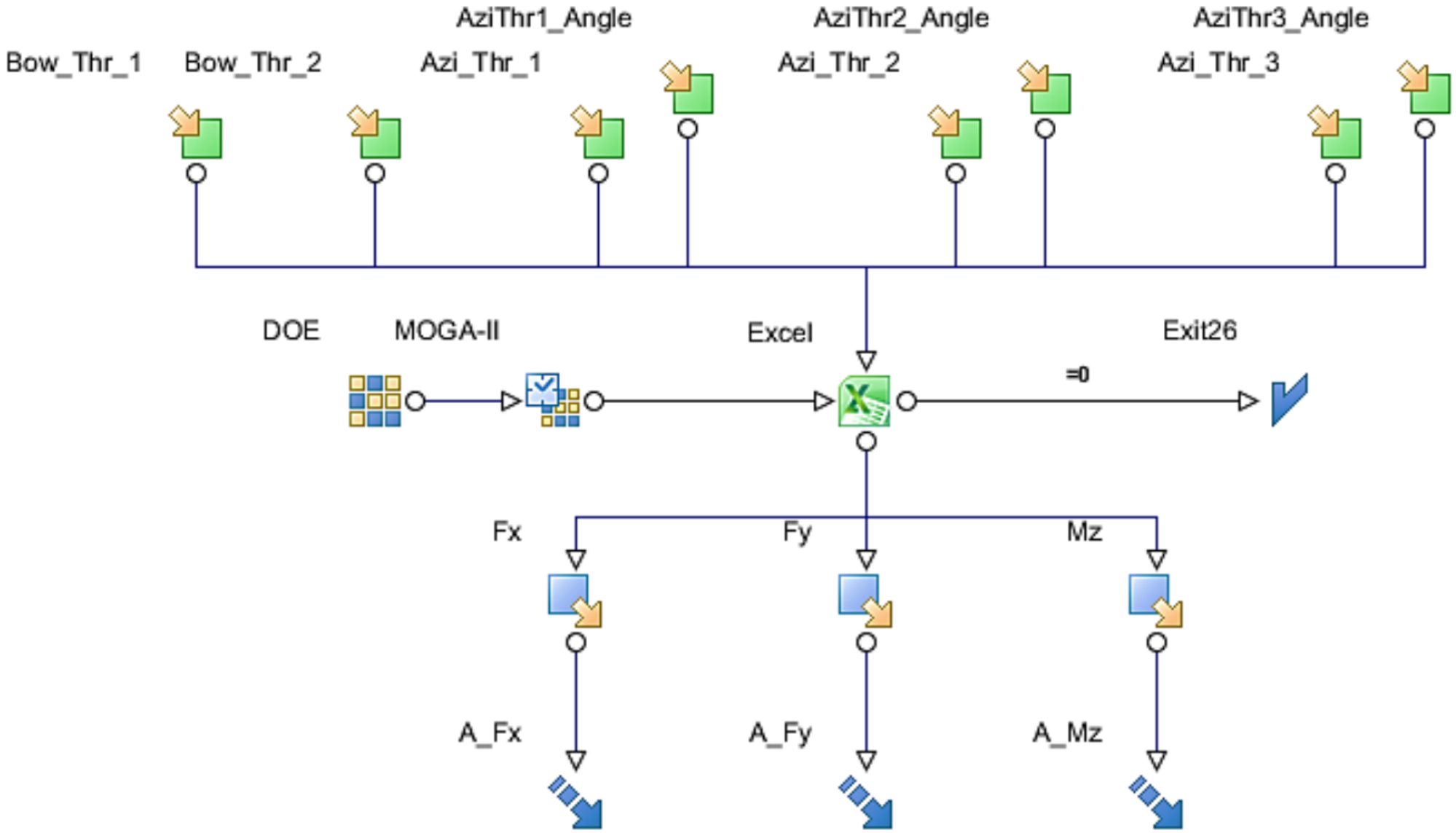
VALIDATION

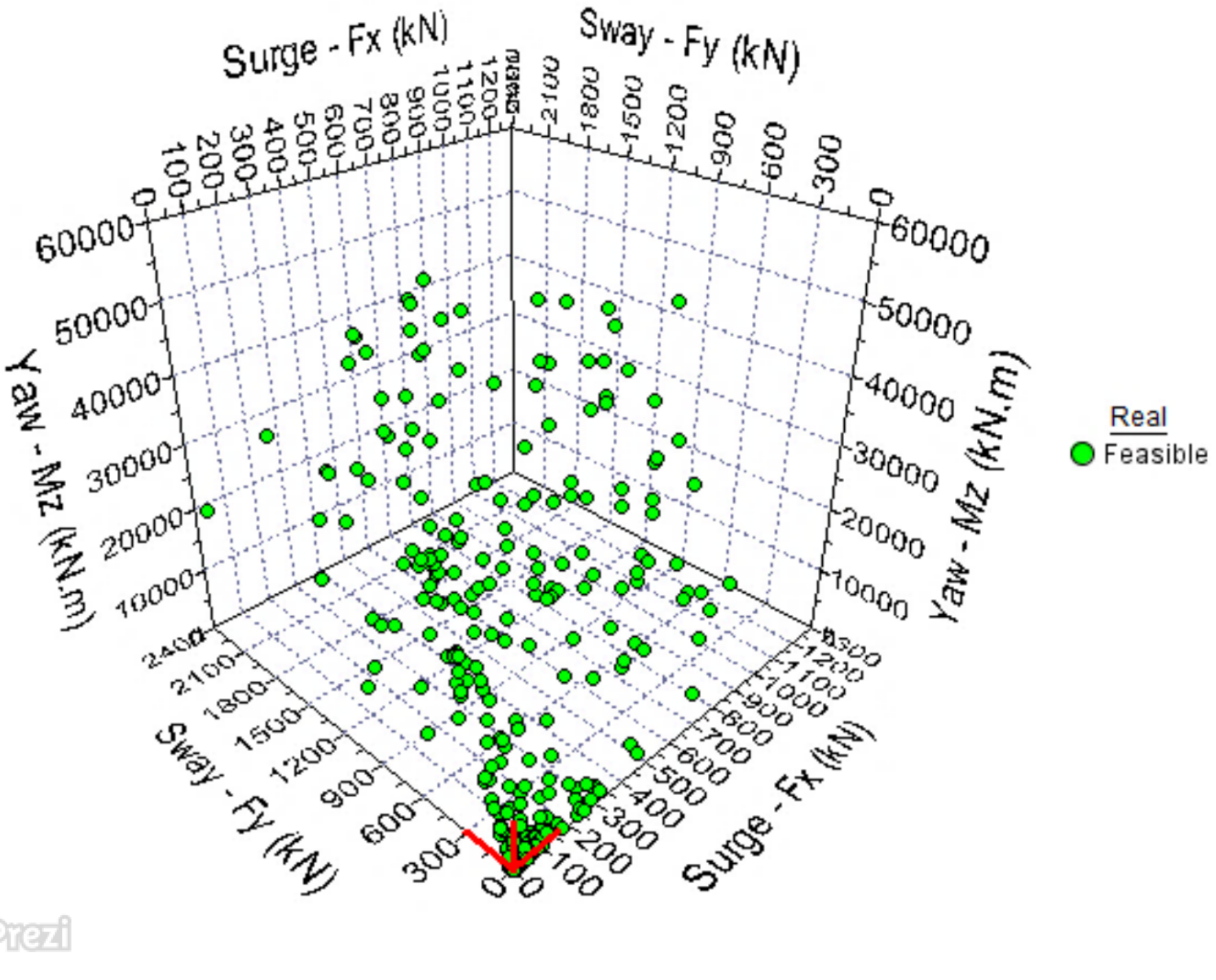
Modified Excel Solver Vs. ModeFrontier





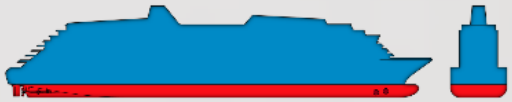
	Thrust Values [kN]			Azimuth Thruster Angles [deg]		
	Excel Solver	ModeFrontier MOGA	Difference [%]	Excel Solver	ModeFrontier MOGA	Difference [%]
Bow Thruster-1	271	271	0	-	-	-
Bow Thruster-2	271	271	0	-	-	-
Azimuth Thruster-1	260	260	0	85.7	86.7	1.15
Azimuth Thruster-2	429	423.6	1.28	0	0	0
Azimuth Thruster-3	493.2	494.9	0.34	73.6	72.64	1.30


AziThr1_Angle
AziThr2_Angle
AziThr3_Angle
Bow_Thr_1
Bow_Thr_2
Azi_Thr_1
Azi_Thr_2
Azi_Thr_3
DOE
MOGA-II
Excel
Exit26
=0
Fx
Fy
Mz
A_Fx
A_Fy
A_Mz

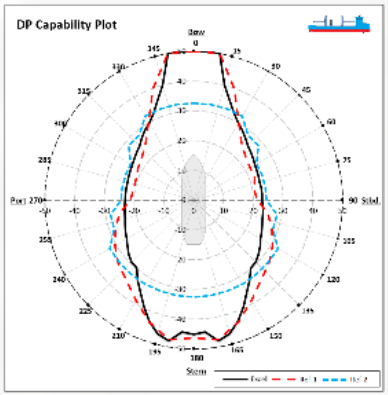

Surge - Fx (kN)
Sway - Fy (kN)
Yaw - Mz (kN.m)
Real
Feasible

	Thrust Values [kN]			Azimuth Thruster Angles [deg]		
	Excel Solver	ModeFrontier MOGA	Difference [%]	Excel Solver	ModeFrontier MOGA	Difference [%]
Bow Thruster-1	271	271	0	-	-	-
Bow Thruster-2	271	271	0	-	-	-
Azimuth Thruster-1	260	260	0	85.7	86.7	1.15
Azimuth Thruster-2	429	423.6	1.28	0	0	0
Azimuth Thruster-3	493.2	494.9	0.34	73.6	72.64	1.30

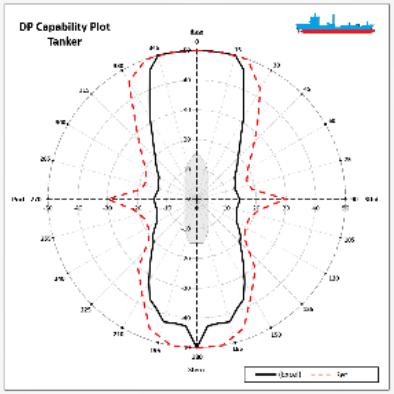
VALIDATION



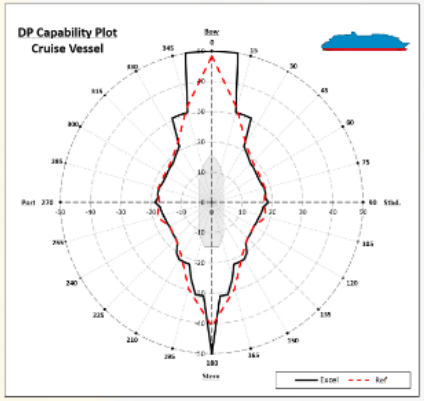
MPV

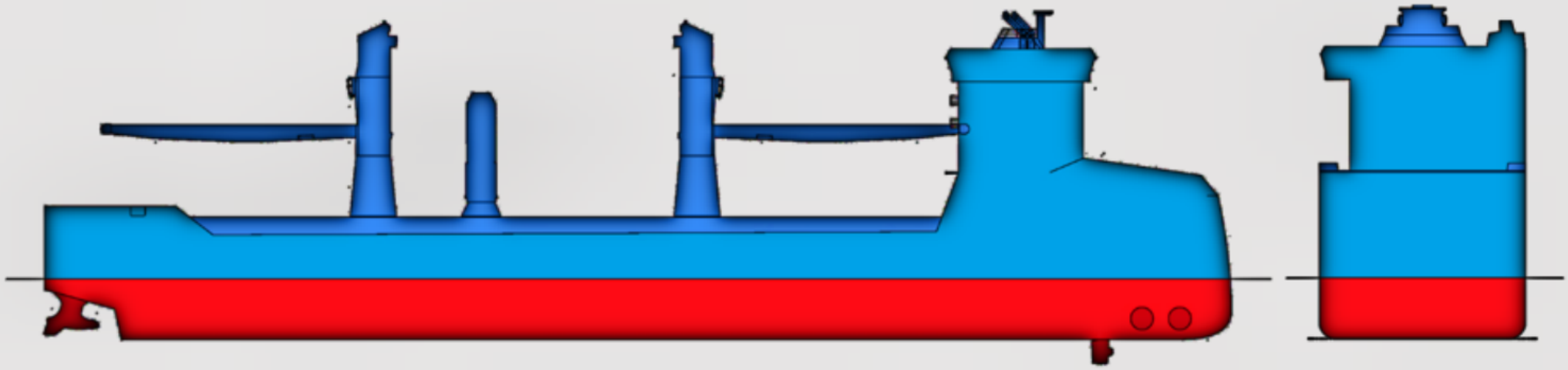


TANKER

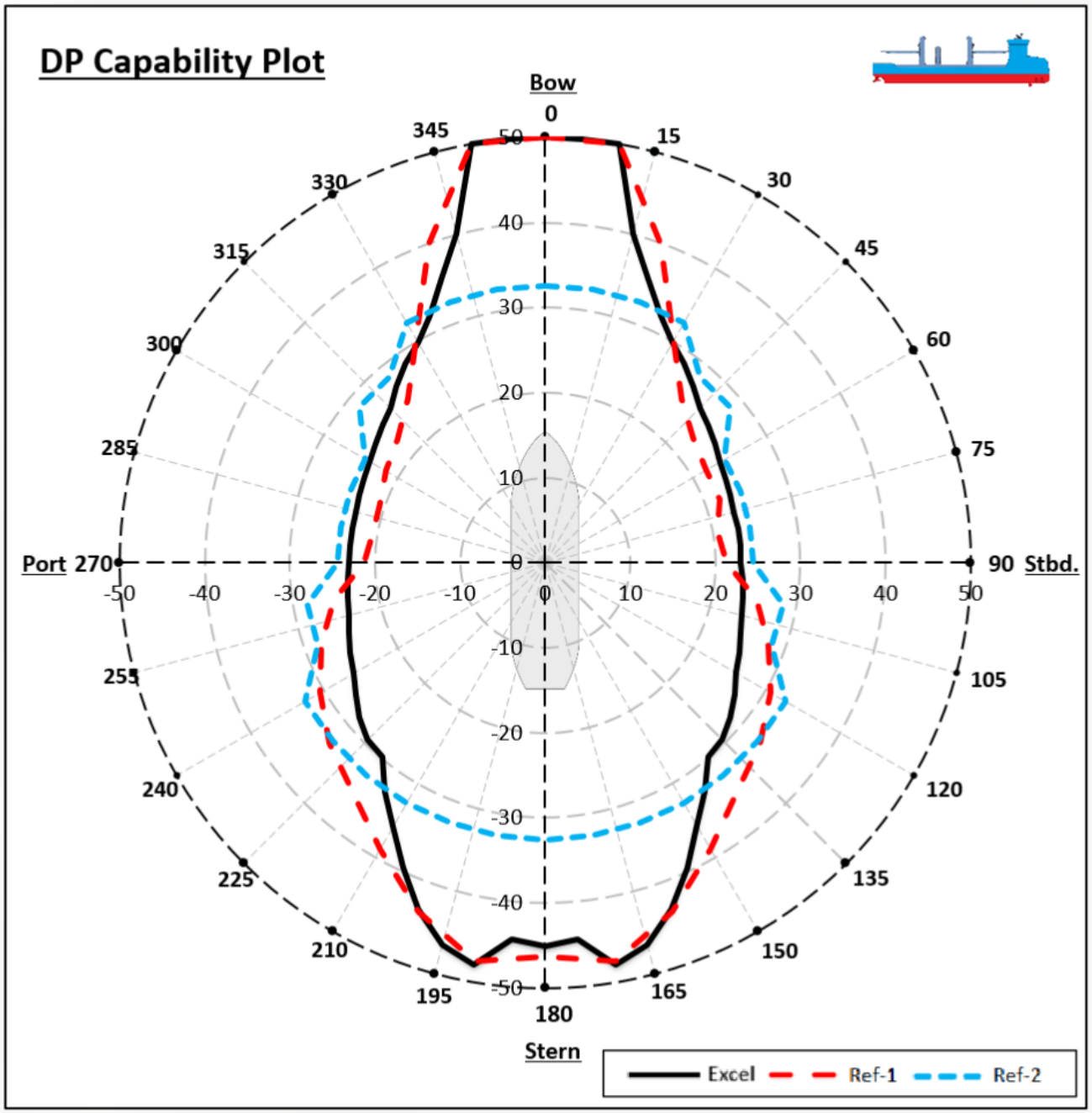


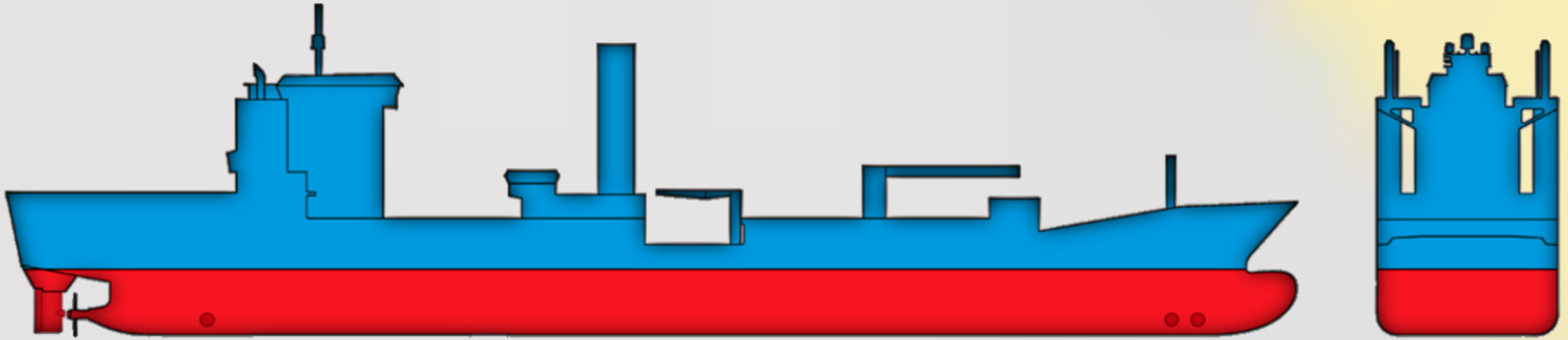
CRUISE VESSEL





MPV


DP Capability Plot
Bow
0
15
30
45
60
75
90
Stbd.
105
120
135
150
165
180
Stern
195
210
225
240
255
Port
270
285
300
315
330
345
50
40
30
20
10
0
-10
-20
-30
-40
-50
-50
-40
-30
-20
-10
0
10
20
30
40
50
Excel
Ref-1
Ref-2



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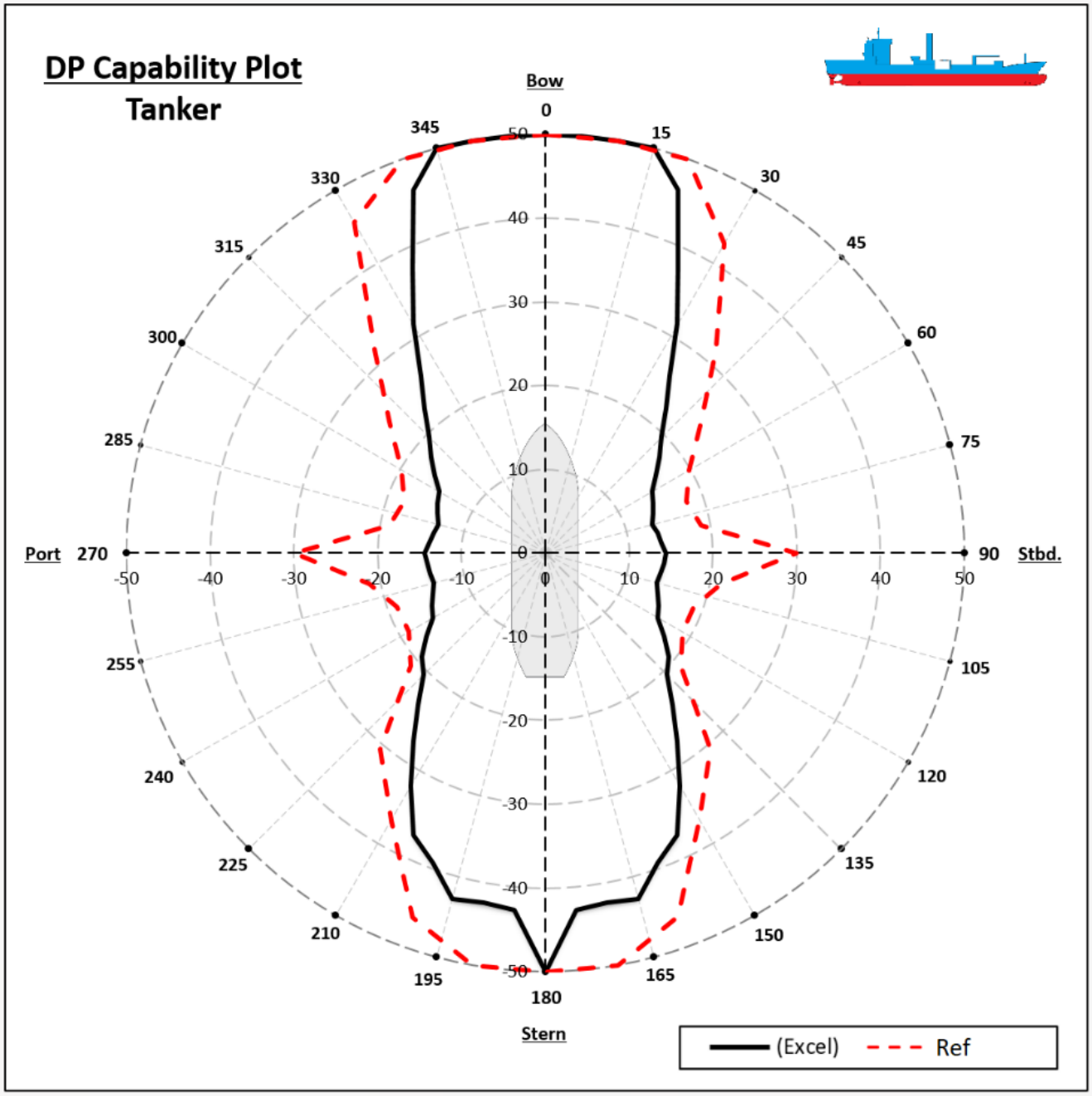
DP Capability Plot
Tanker
Bow
0
15
30
45
60
75
90
Stbd.
105
120
135
150
165
180
Stern
195
210
225
240
255
270
Port
285
300
315
330
345
50
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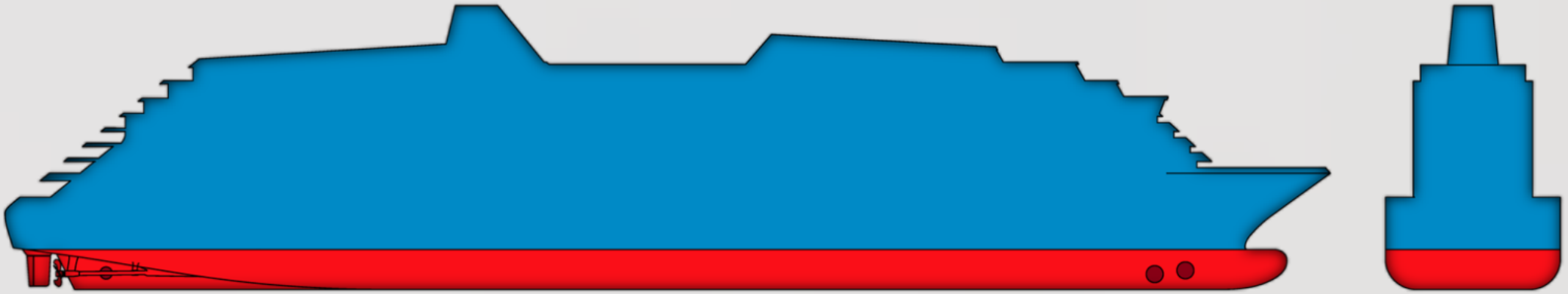
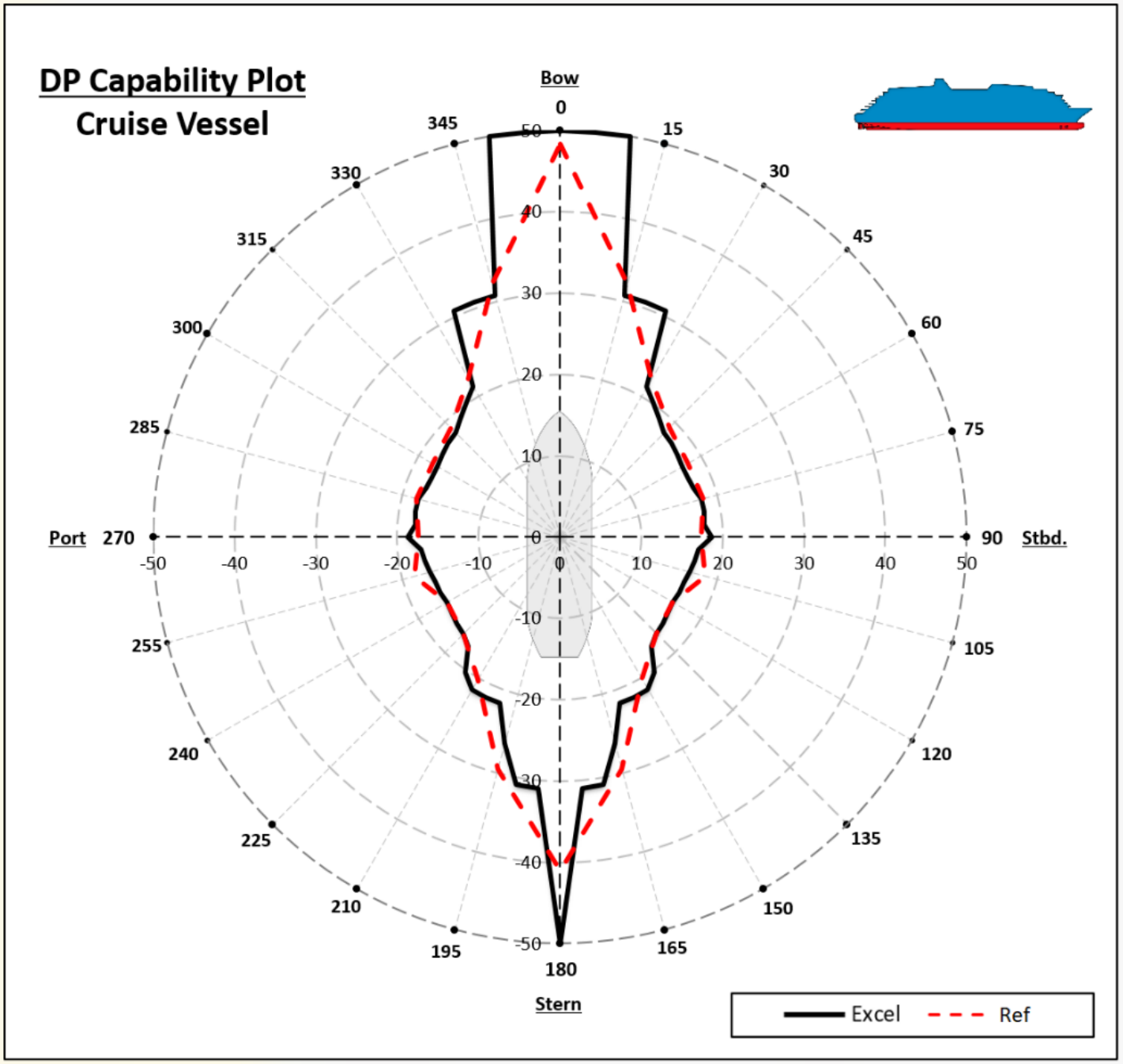
30
20
10
0
-10
-20
-30
-40
-50
(Excel)
Ref



CRUISE VESSEL

CRUISE VESSEL



CONCLUSIONS

Outcome from DP tool formulation:

- Based on initial design values
- Wide range of vessels and propulsion
- Comparison with diff. methods possible
- Arbitrary condition analysis (8 SC simult.)
- Flexibility of use: excel based
- Convenient: user interaction with real physics of the problem itself
- Reliable and robust convergence

REFERENCE TO FUTURE WORKS

Areas requiring further attention:

- Highly method oriented: further development of methods used to increase accuracy.
- More accurate coefficients req. for diff. vessel types.
- Interaction effects and their integration
- Analysis of other affecting factor like draft, position of superstructure etc.
- Better method for estimating wave drift.

THANK YOU

DISCUSSION