

OBJECTIVES

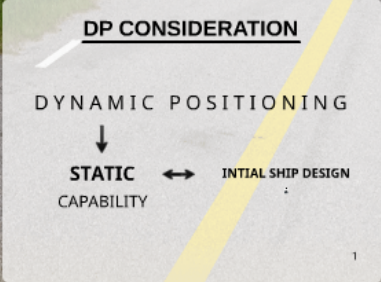
- DP Capability Tool Development:
 - Concept Development
 - Module Architecture
 - Module Definition
 - Plug-in for various controllers
 - DP Controller Selection
 - Validation of DP Module / Design
 - Model and results for power requirements
- Programming in Real environment
- Validation

REFERENCES

1. ...

2. ...

3. ...

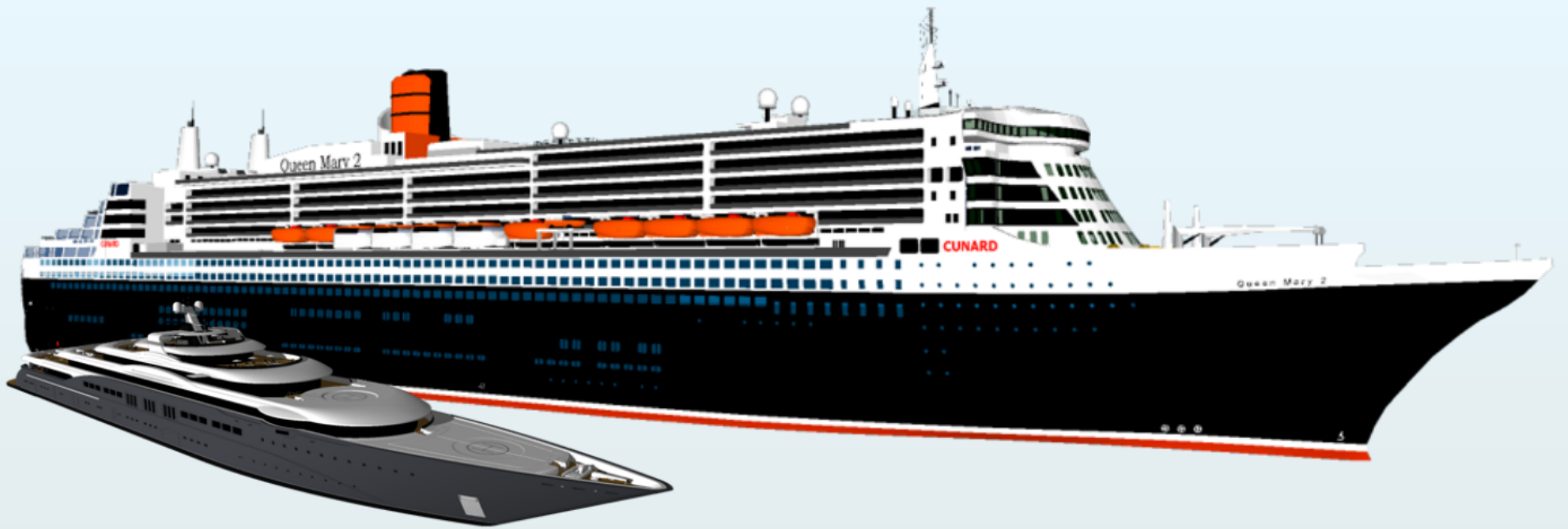


DYNAMIC POSITIONING (DP)

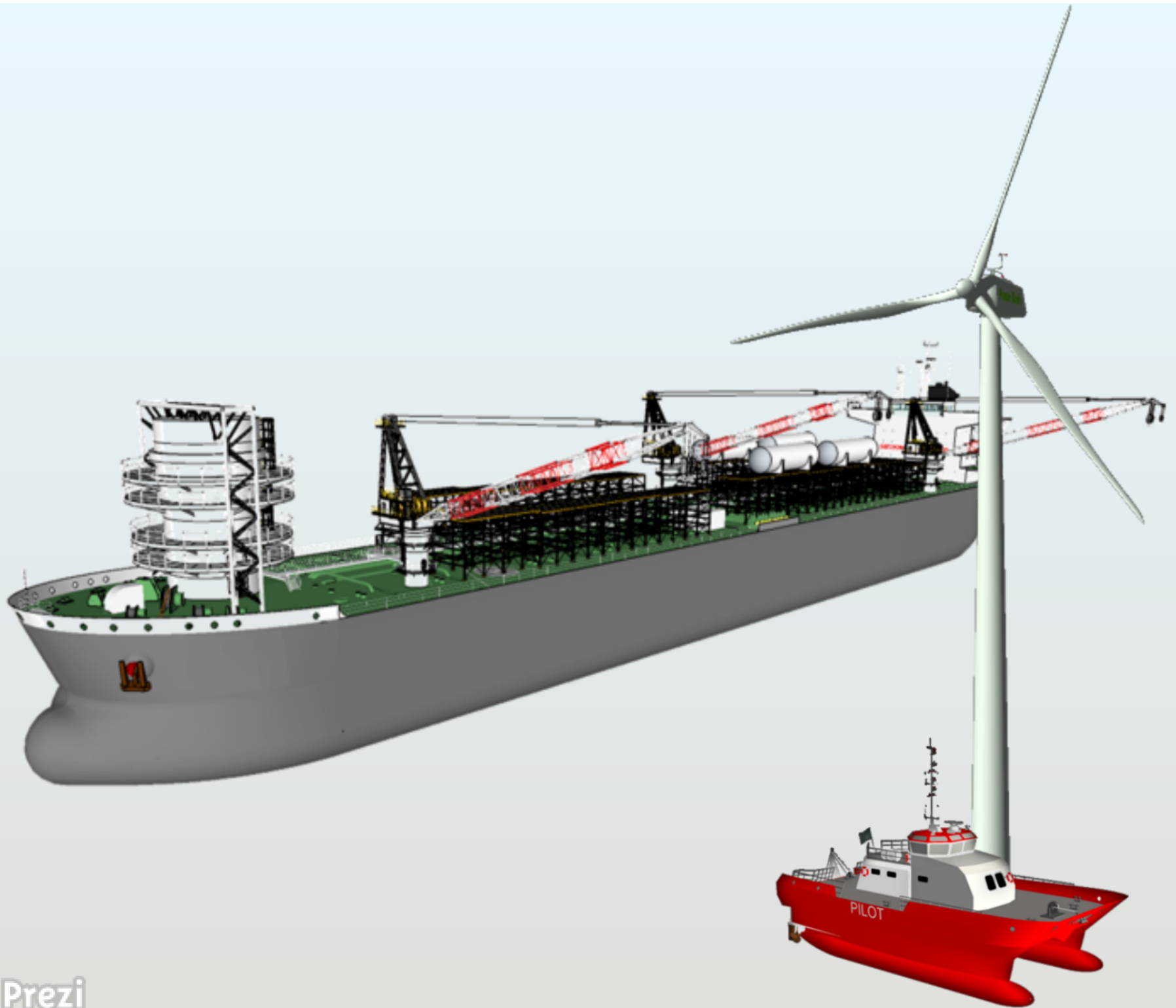
POSITION & HEADING

DYNAMIC POSITIONING (DP)

POSITION & HEADING

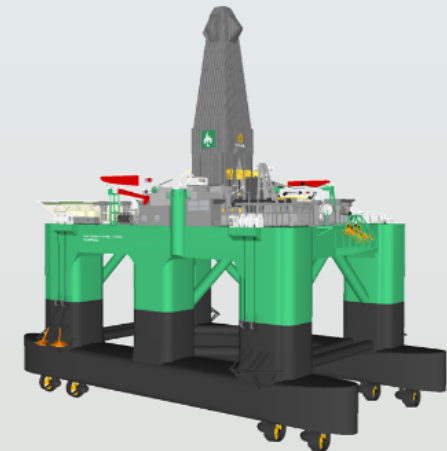
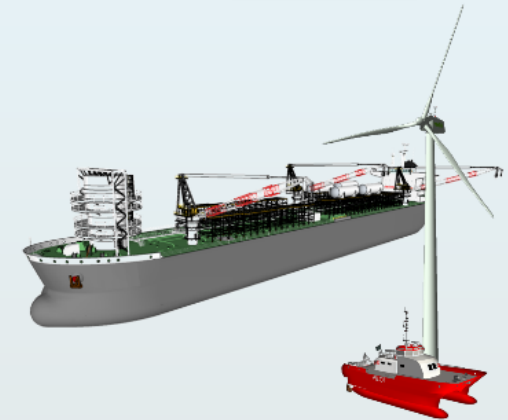
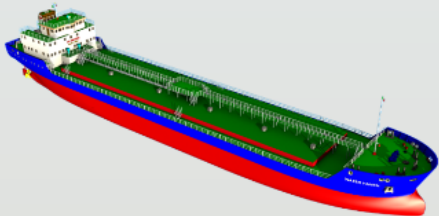






DP VESSELS

- 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

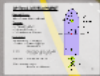
Industrial Supervisor : Dr. Harald Jensen, SDC Ship Design & Consult GmbH





CONTENTS

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



OBJECTIVES

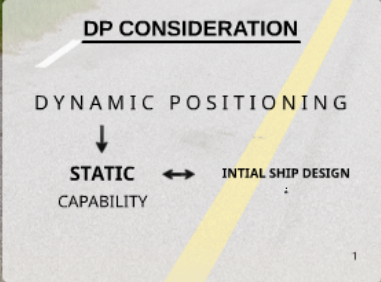
- DP Capability Tool Development:
 - Concept Development
 - Module Architecture
 - Module Definition
 - Plug-in for various controllers
 - DP Controller Selection Module
 - Controller DP Module / Design
 - Validation Module for power distribution
- Programming in Real environment
- Validation

REFERENCES

1. ...

2. ...

3. ...



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

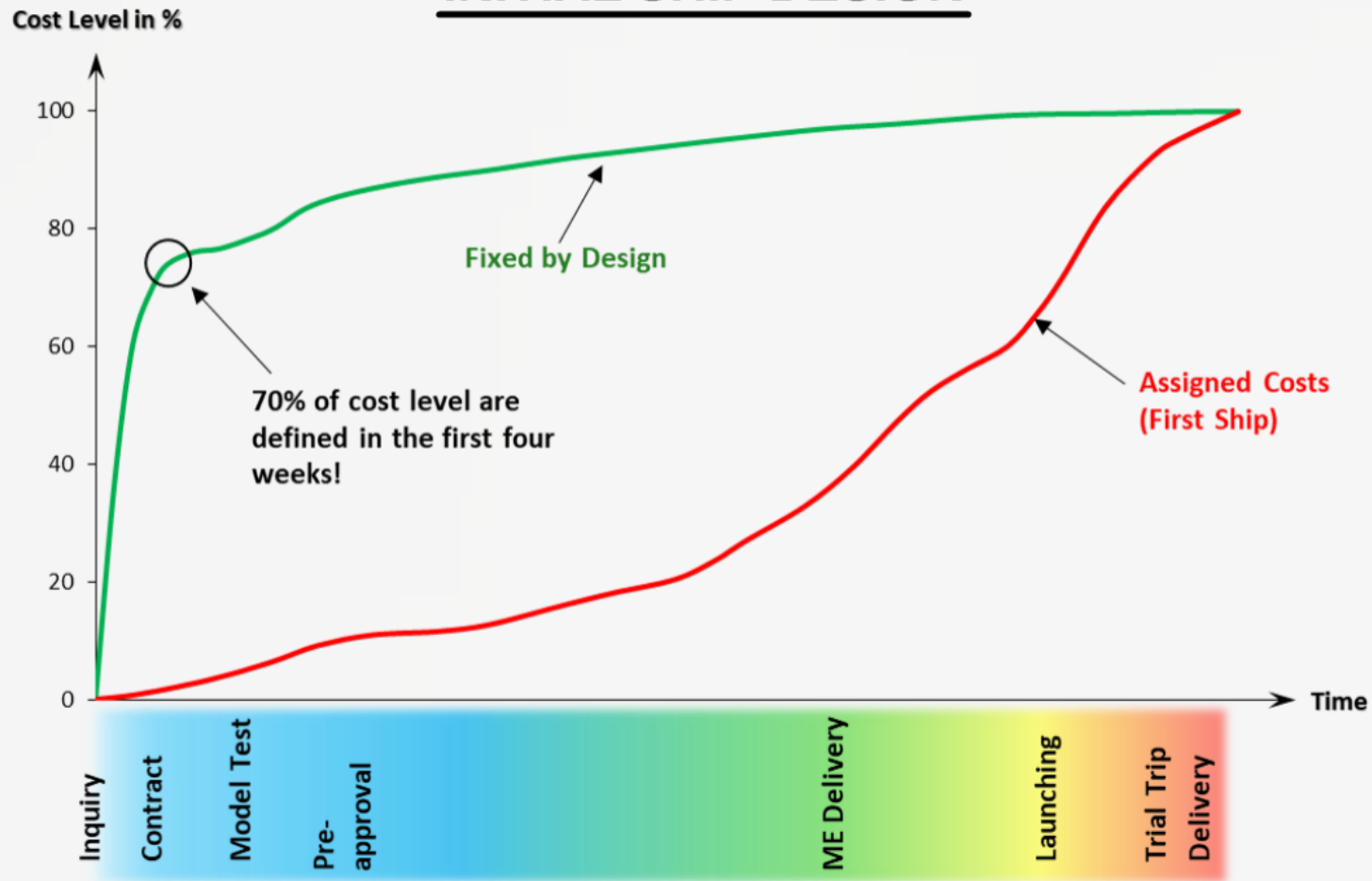


STATIC
CAPABILITY



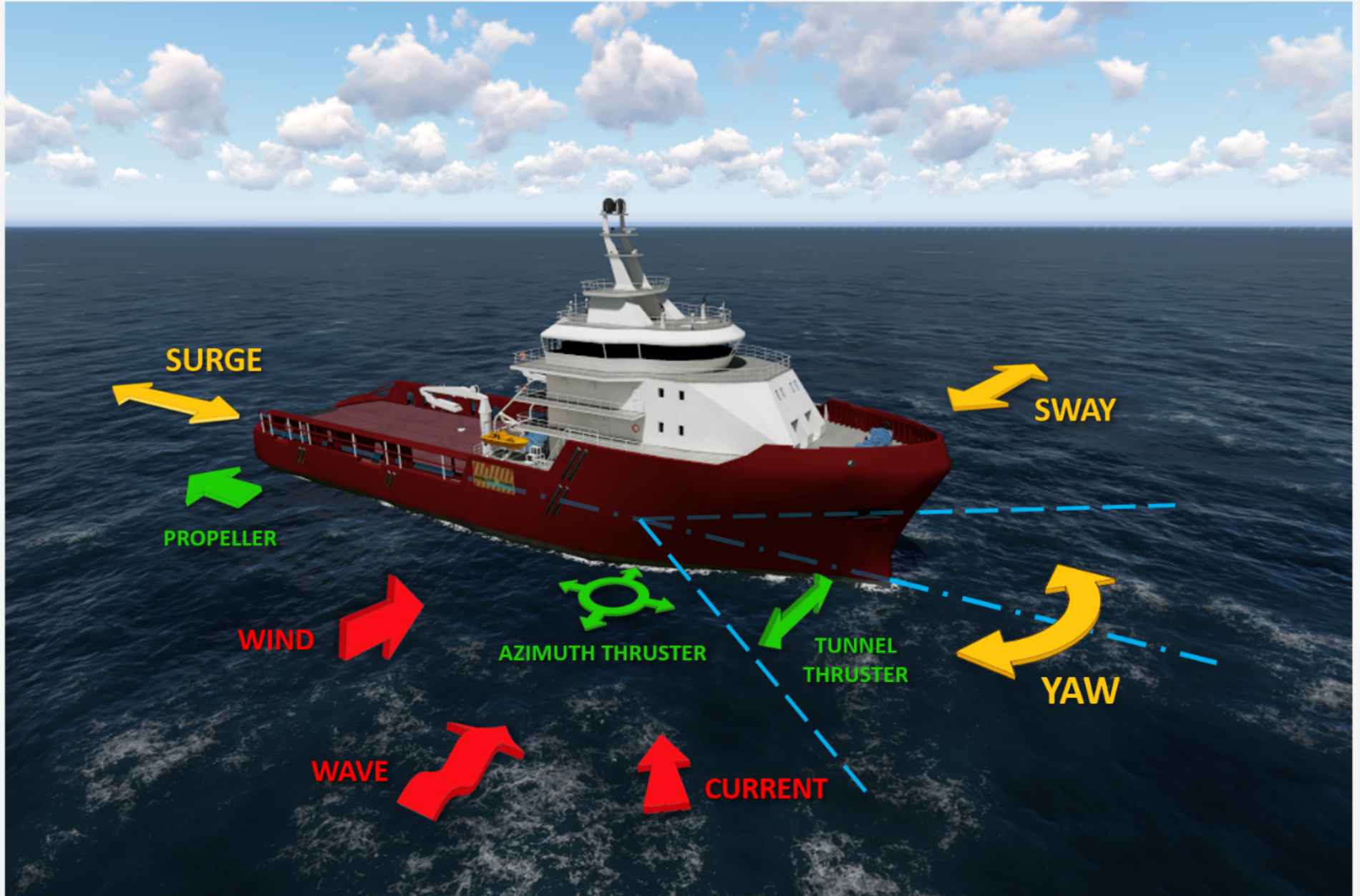
INITIAL SHIP DESIGN

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

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

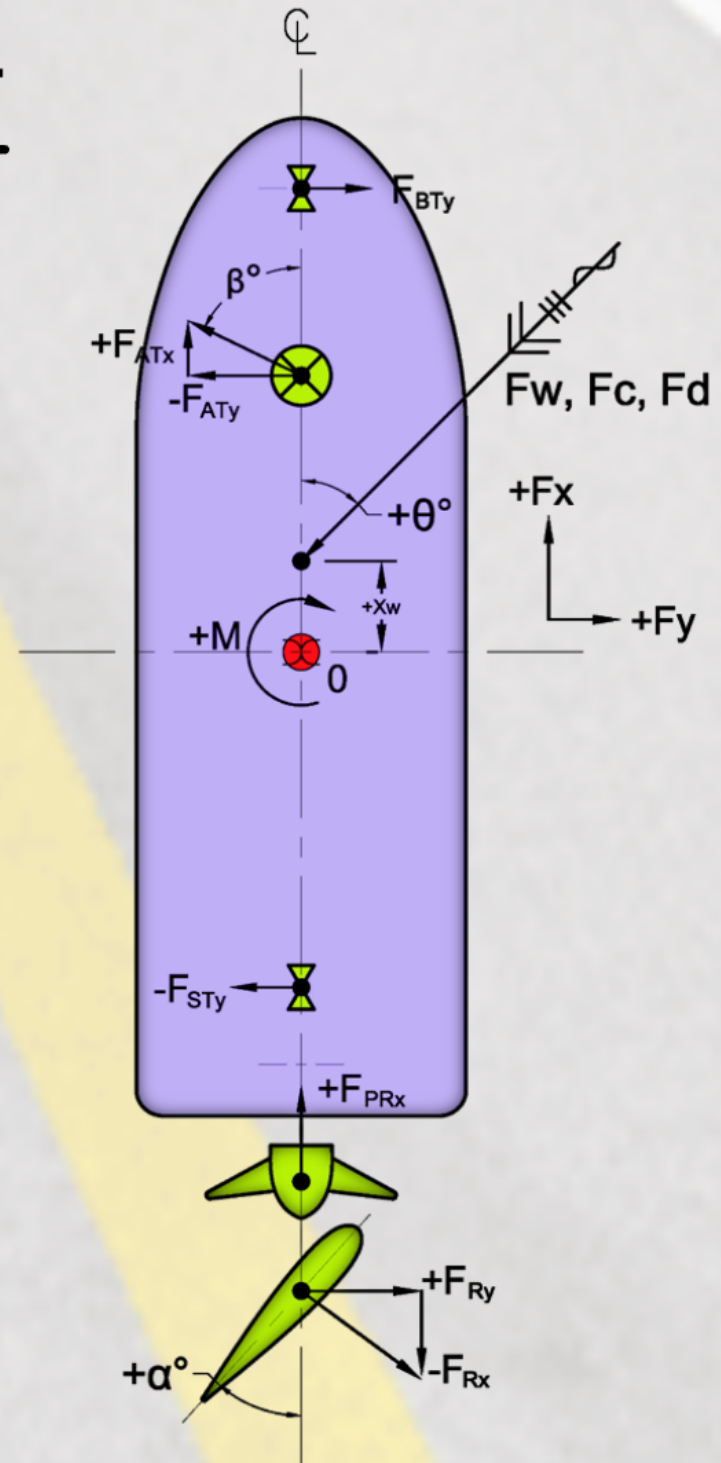
Thrusters

- 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

WIND LOAD

- Input Parameters:
 - Wind Velocity
 - Trim and Long. Projection
 - Long. and Vertical Center of Area
- Wind Surge, Sway and Yaw Coefficients:
 - Supplier Data
 - BACA 148 emp. relations
 - Weatherman wind power data
 - Observed emp. data
 - DNV-G
 - GC&M Data
 - GC&M Data

CURRENT LOAD

- Input Parameters:
 - Current Velocity
 - Trim and Long. Proj. Center of Area
 - Long. and Vertical Center of Area
- Current Surge, Sway and Yaw Coefficients:
 - Supplier Data
 - BACA 148 (A) relation data
 - DNV-G
 - GC&M Data
 - Ship Theory

WAVE LOAD

- Wind-Wave correlation:
 - Wind Velocity - H_s to North Sea Correlation (BACA recommendation)
 - World Wide Scatter (DNV-G recommendation)
- Wave Surge, Sway and Yaw Coefficients:
 - Supplier Data
 - DNV-G
 - GC&M Data
 - Ship Theory

ADDITIONAL LOADS

- Surge, Sway and Yaw Load components:
 - Thruster
 - Drilling
 - Pipe Laying
 - Lift Bumper
 - Offshore support etc.
- Dynamic Allowance:
 - Torsion or Bending Loads
 - Revised for diverging load
 - 100% G₀ and 100% allowance: 20%
 - 80% of Thrust: 30% Capability

THRUSTERS

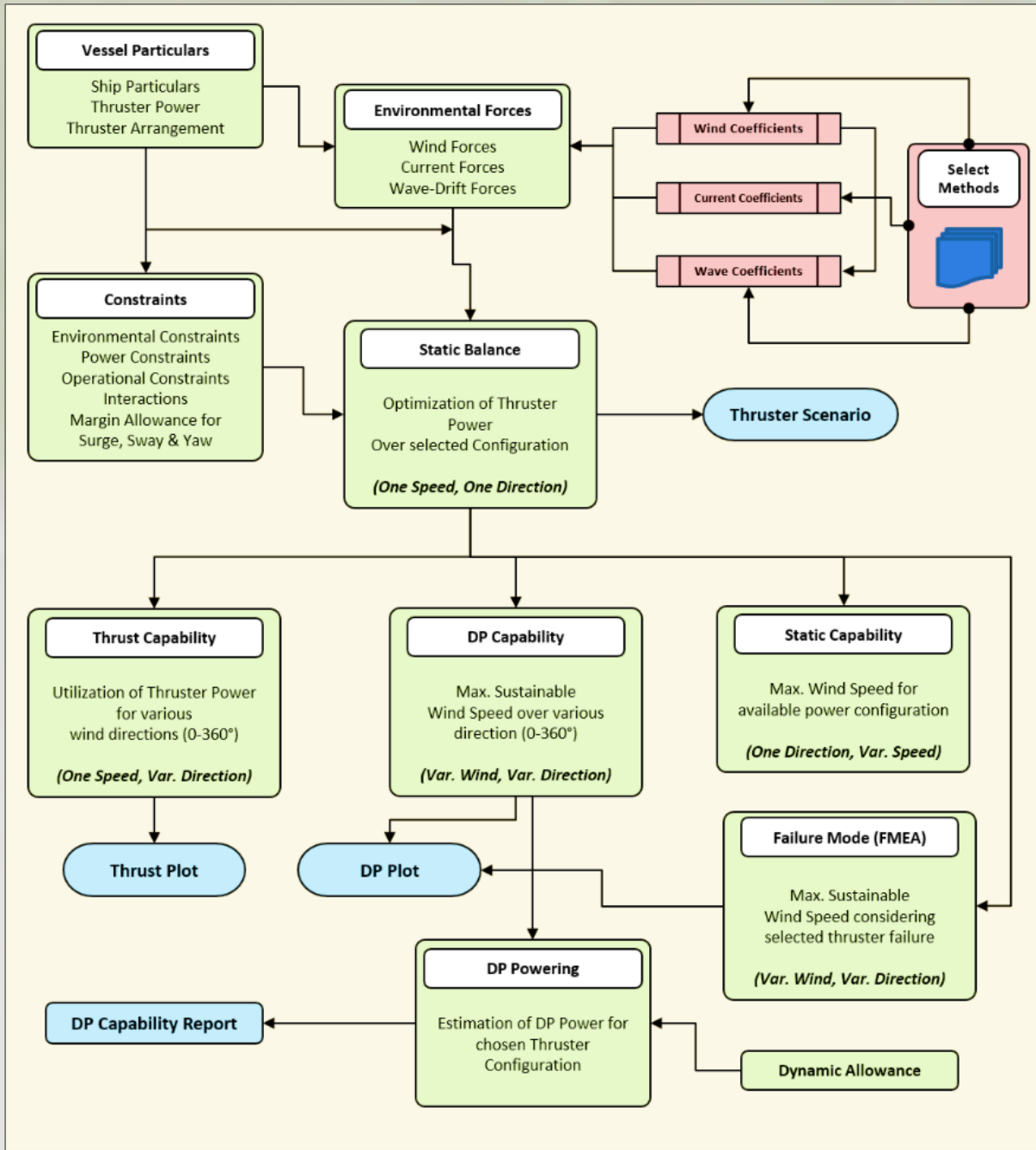
- Thruster Types:
 - Bow Thrusters & Stern Thrusters
 - Transverse Thrust
 - Input: position, power, diameter, thrust
 - DNV-G or DNV-GL methods: power thrust
- Align Thrusters:
 - Different types
 - 360-deg. operational flexibility
 - Input: position, power, diameter, thrust, operational window length
 - Interaction effects
 - DNV-G or DNV-GL methods: power thrust

THRUSTERS (contd.)

- Propellers:
 - Different configurations
 - Input: position, power, diameter, thrust, thrust interaction parameters, rpm, pitch, noise
 - DNV-G or DNV-GL methods: power thrust
- Rudders:
 - Different types
 - Input: position, area, height, type, arrangement, operating range: 25° - 25° (25°)
 - Left = Red, prop. thrust, turn to starboard
 - DNV-G or DNV-GL methods: power thrust

INTERACTION EFFECTS

- Methods:
 - Base Thruster - Hull Interaction
 - Base Thruster - Rudder Interaction
 - Thruster to Thruster Interaction
 - Turning direction of propellers, thrusters and rudders effects
 - Quay and nearby vessel interactions
- Operational window:
 - FastStart/Stop
 - Pushing power for idle thrusters
 - Interaction with sleep
 - Not diversity integrated; only single output



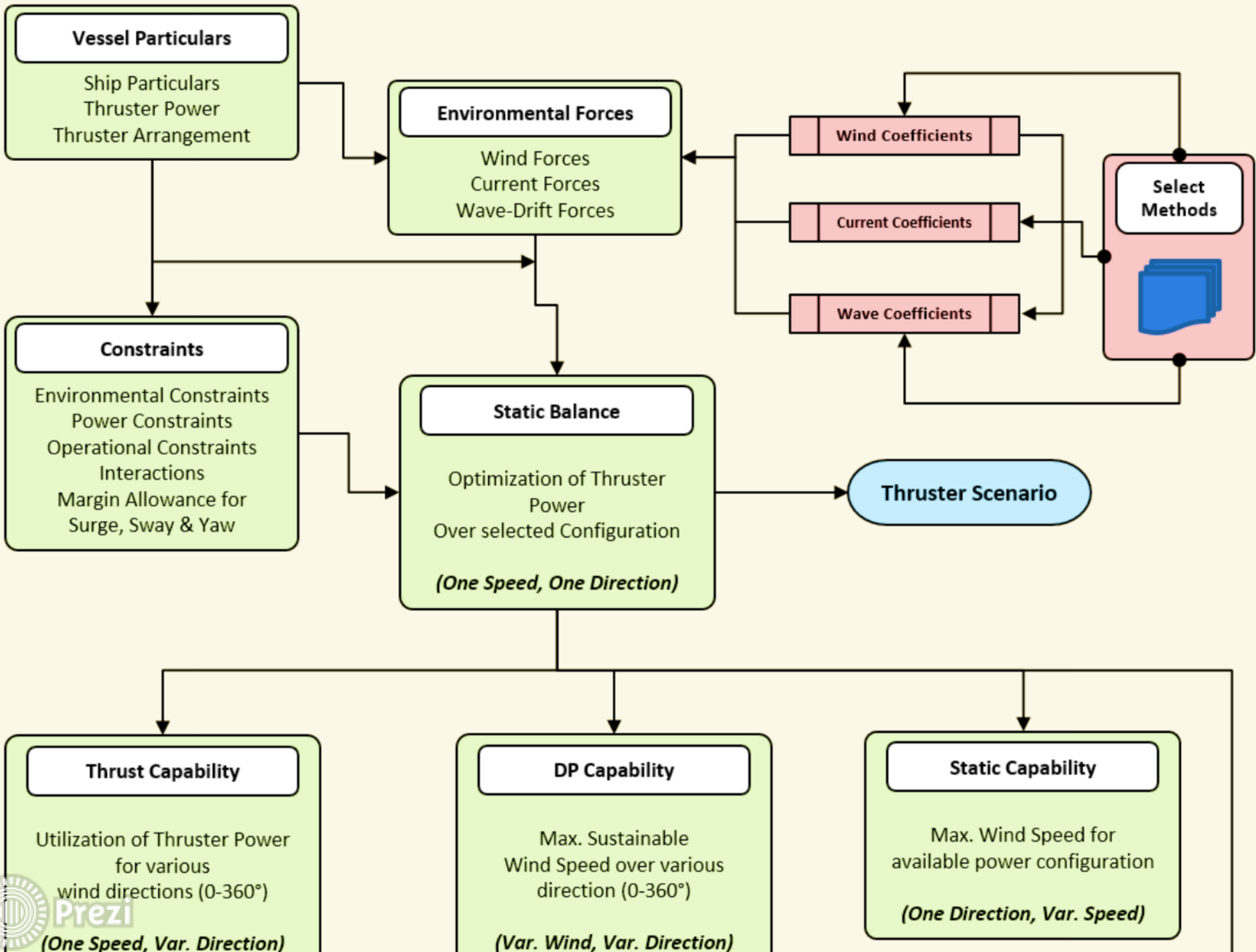
SOLVER MODULE

- Major work: Implementation of vessel data
- Modified Code: Solver Module for DP, structure reorganization, coding updates
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THRUSTER SCENARIO

DP PLOT

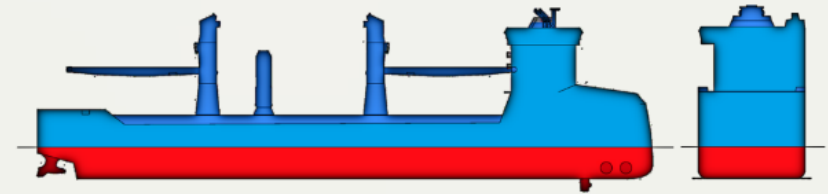
COMPREHENSIVE PLOTS



WIND LOAD

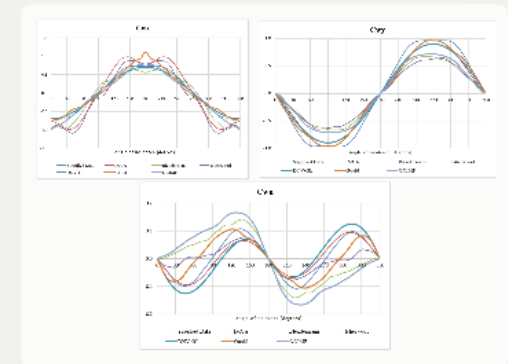
- **Input Parameters:**

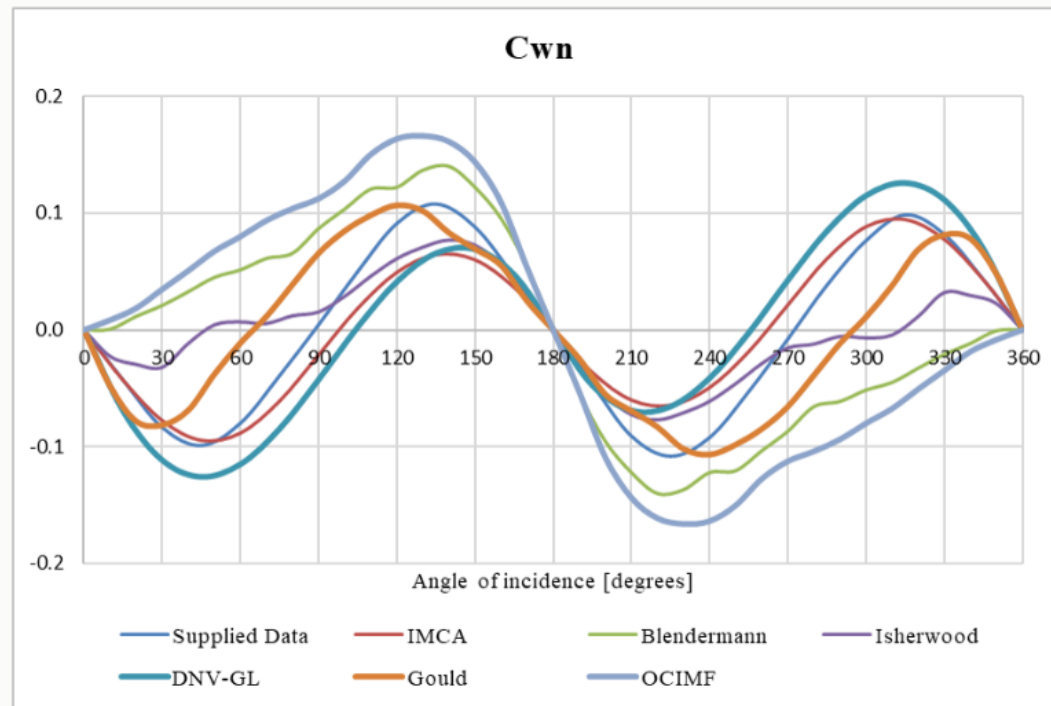
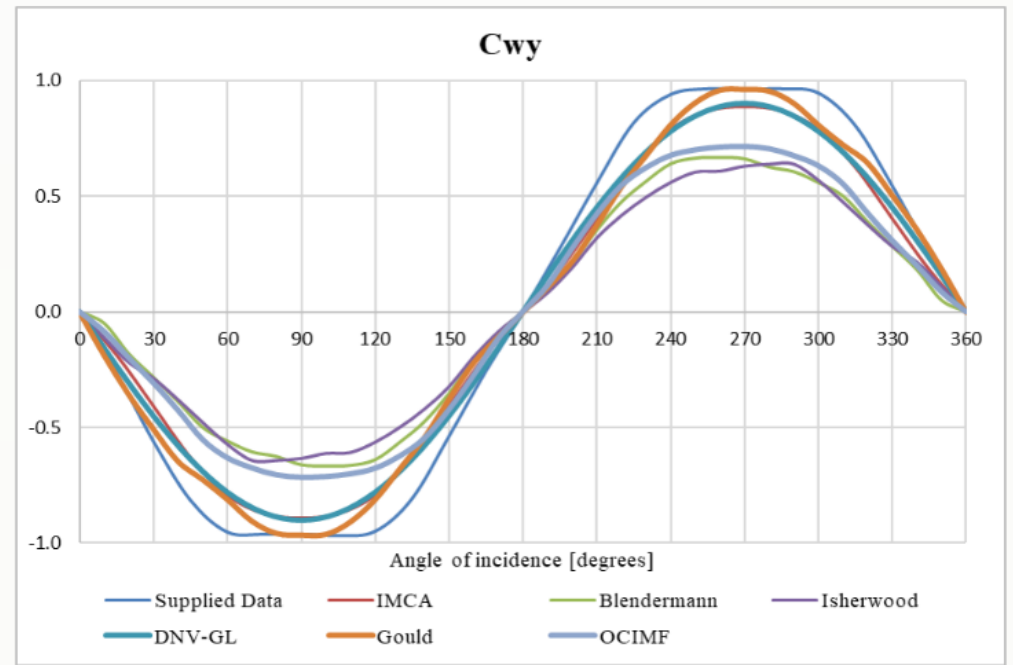
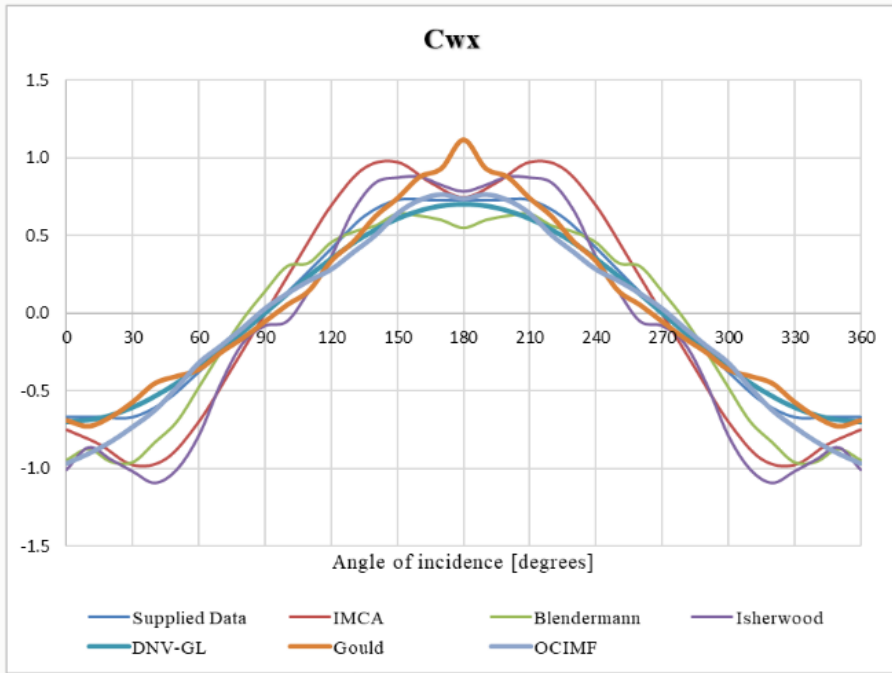
- Wind Velocity
- Trans. and Long. Projected areas
- Long. and vertical centroid of areas



- **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

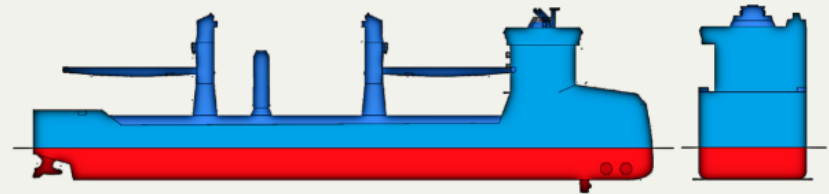




CURRENT LOAD

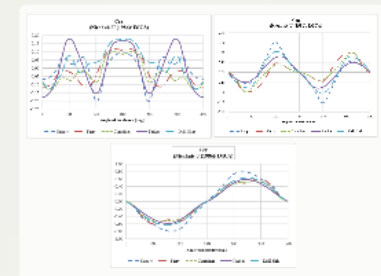
- **Input Parameters:**

- Current Velocity
- Trans. and Long. u/w Projected areas
- Long. and vertical u/w centroid of areas

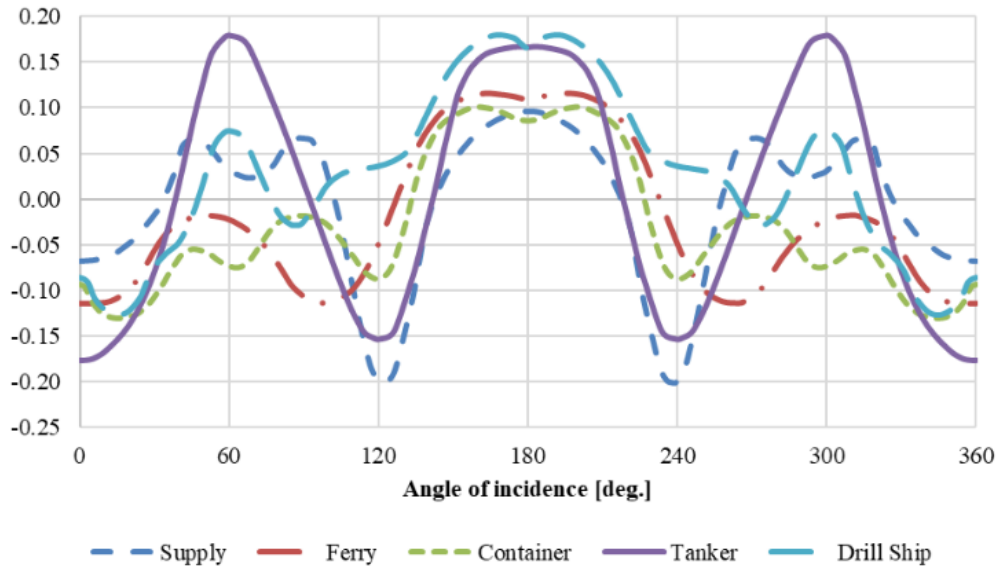


- **Current Surge, Sway and Yaw Coefficients:**

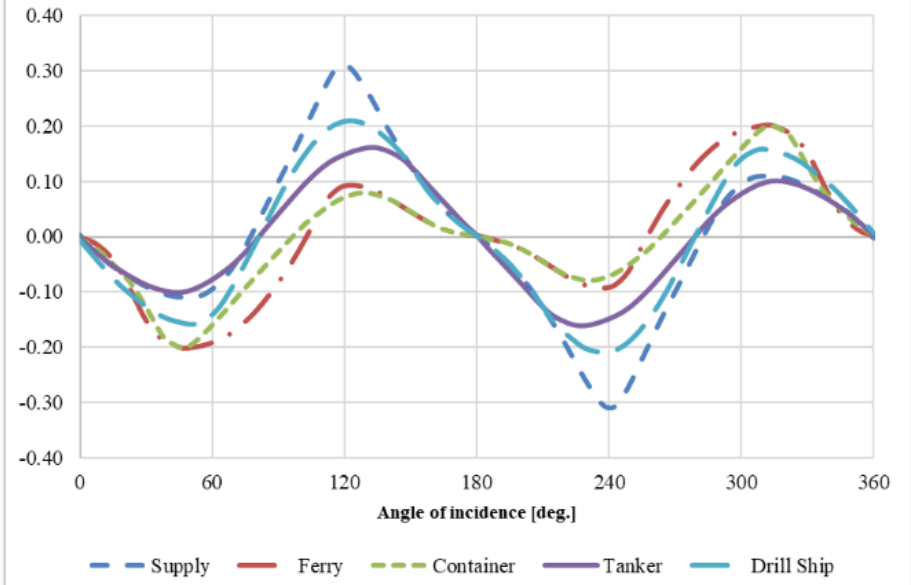
- (1) Supplied Data
- (2) IMCA-140 (Nienhuis data)
- (3) DNV-GL
- (4) OCIMF data
- (5) Strip Theory



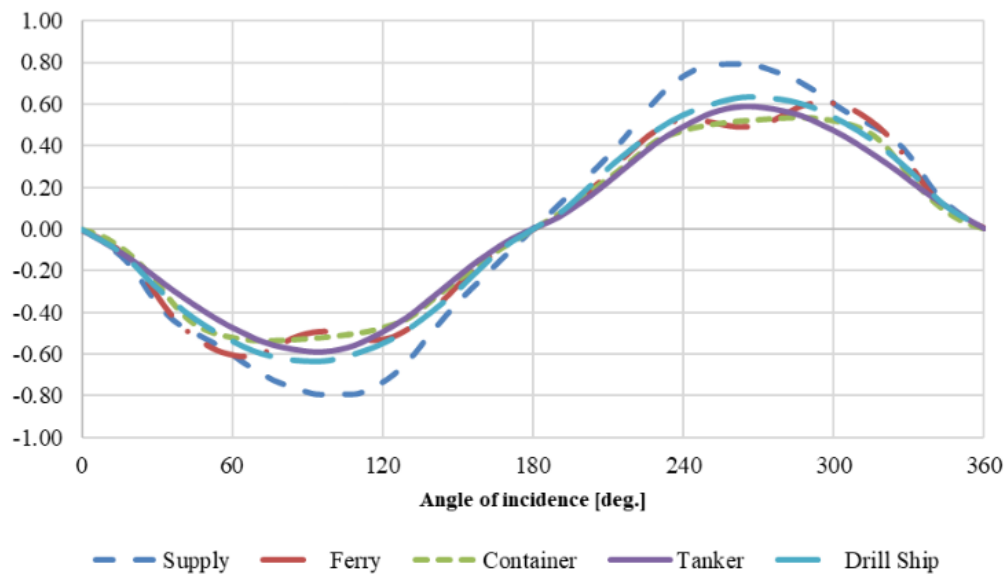
Ccx
(Nienhuis U (1986)/ IMCA)



Ccn
(Nienhuis U (1986)/ IMCA)

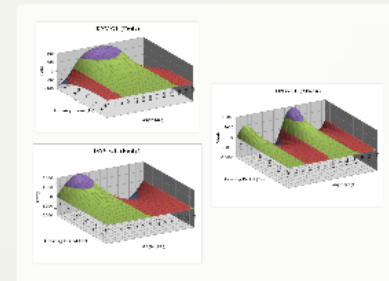
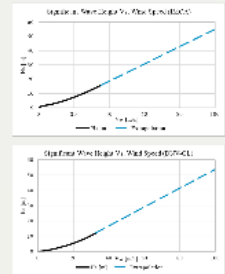


Ccy
(Nienhuis U (1986)/ IMCA)

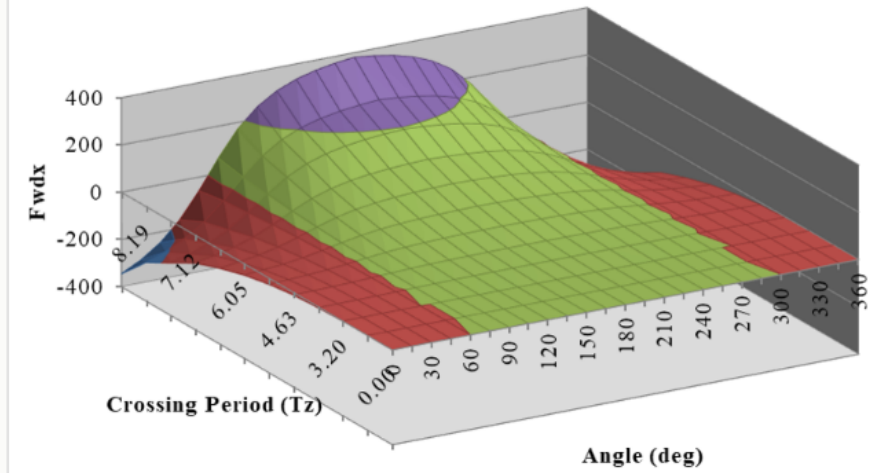


WAVE LOAD

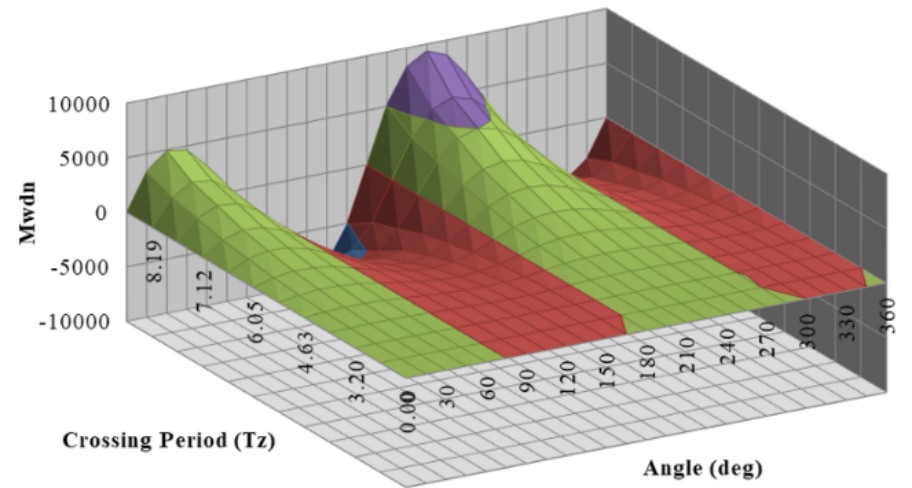
- **Wind-Wave correlation:**
 - Wind Velocity $\rightarrow H_s, \omega, T_z$
 - North Sea Correlation (IMCA recommendation)
 - World Wide Scatter (DNV-GL recommendation)
- **Wave Surge, Sway and Yaw Coefficients:**
 - (1) Supplied Data
 - (2) Model Scaling (IMCA-140)
 - (3) DNV-GL
 - (4) Empirical
 - (5) Strip Theory



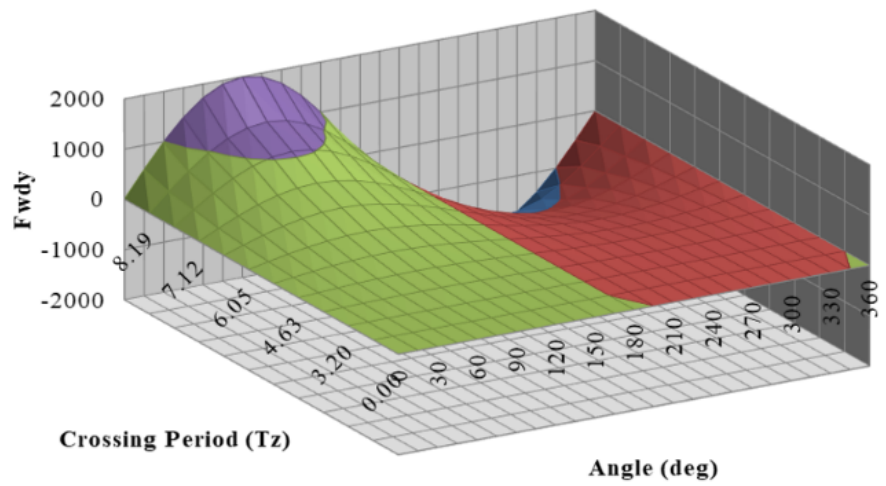
DNV-GL (Fwdx)



DNV-GL (Mwdn)



DNV-GL (Fwdy)



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

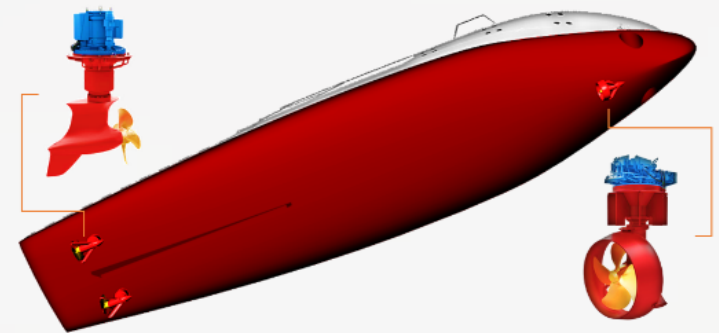
THRUSTERS

- **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



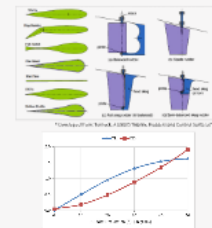
THRUSTERS (contd.)

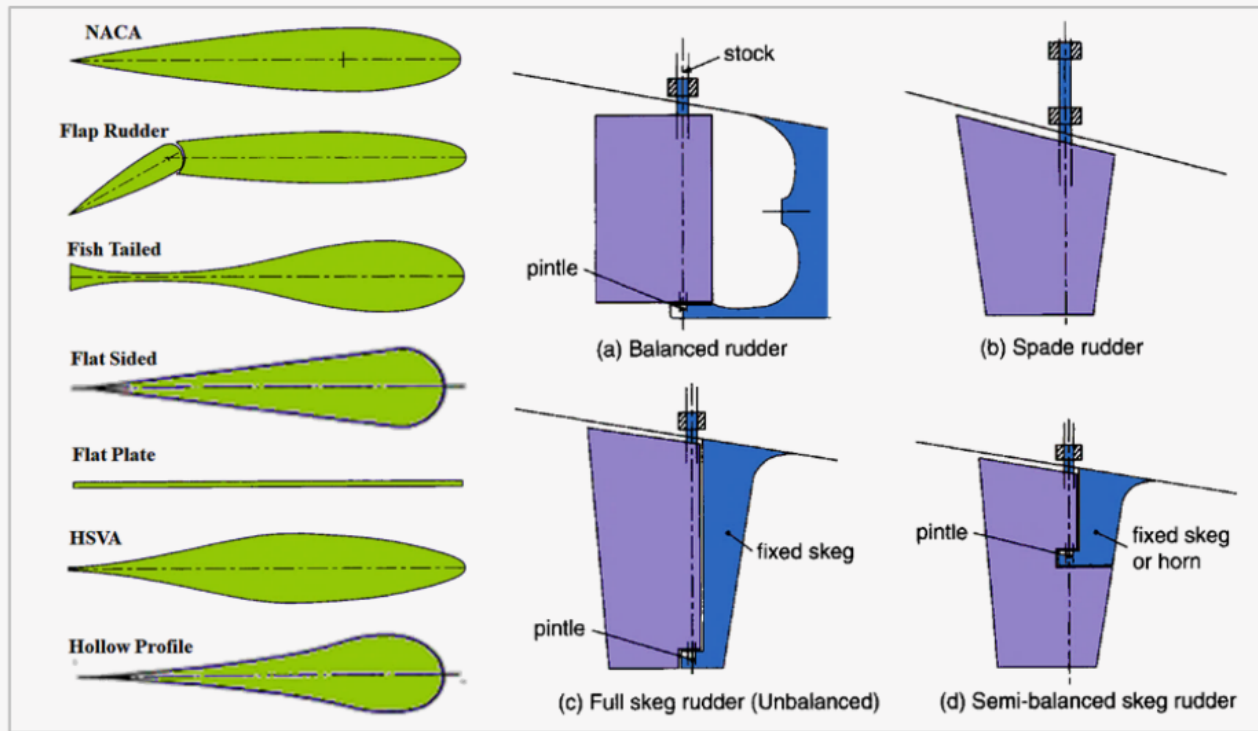
- **Propellers:**

- Different configurations
- Input: position, power, diameter, fwd/rev. thrust
- supplementary parameters: rpm, pitch, nozzle
- IMCA or DNV-GL methods: power-thrust

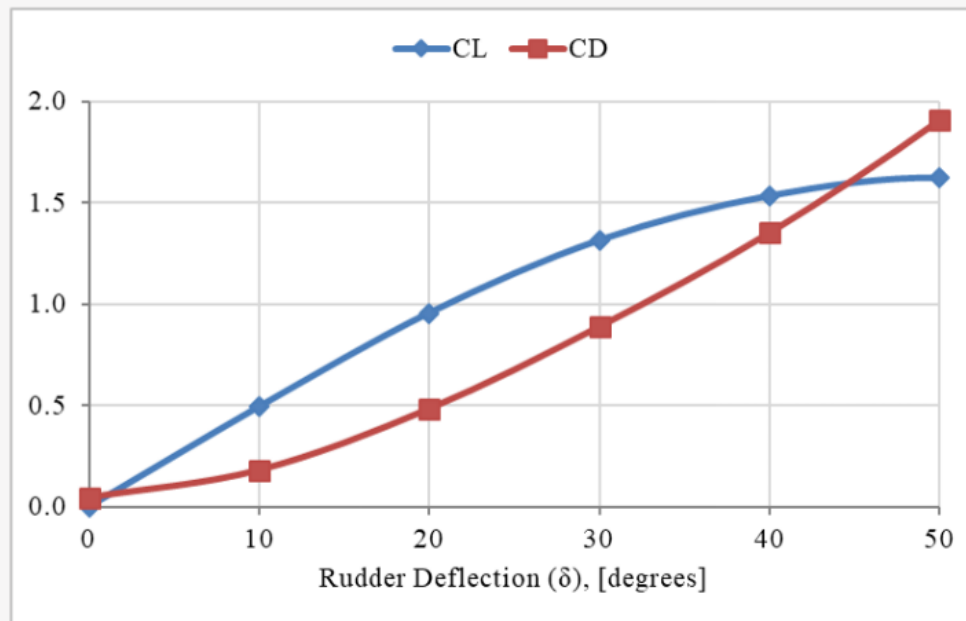
- **Rudders:**

- 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"

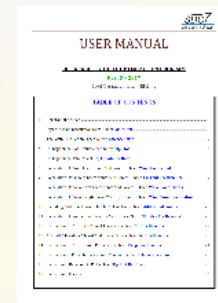


INTERACTION EFFECTS

- **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



USER MANUAL

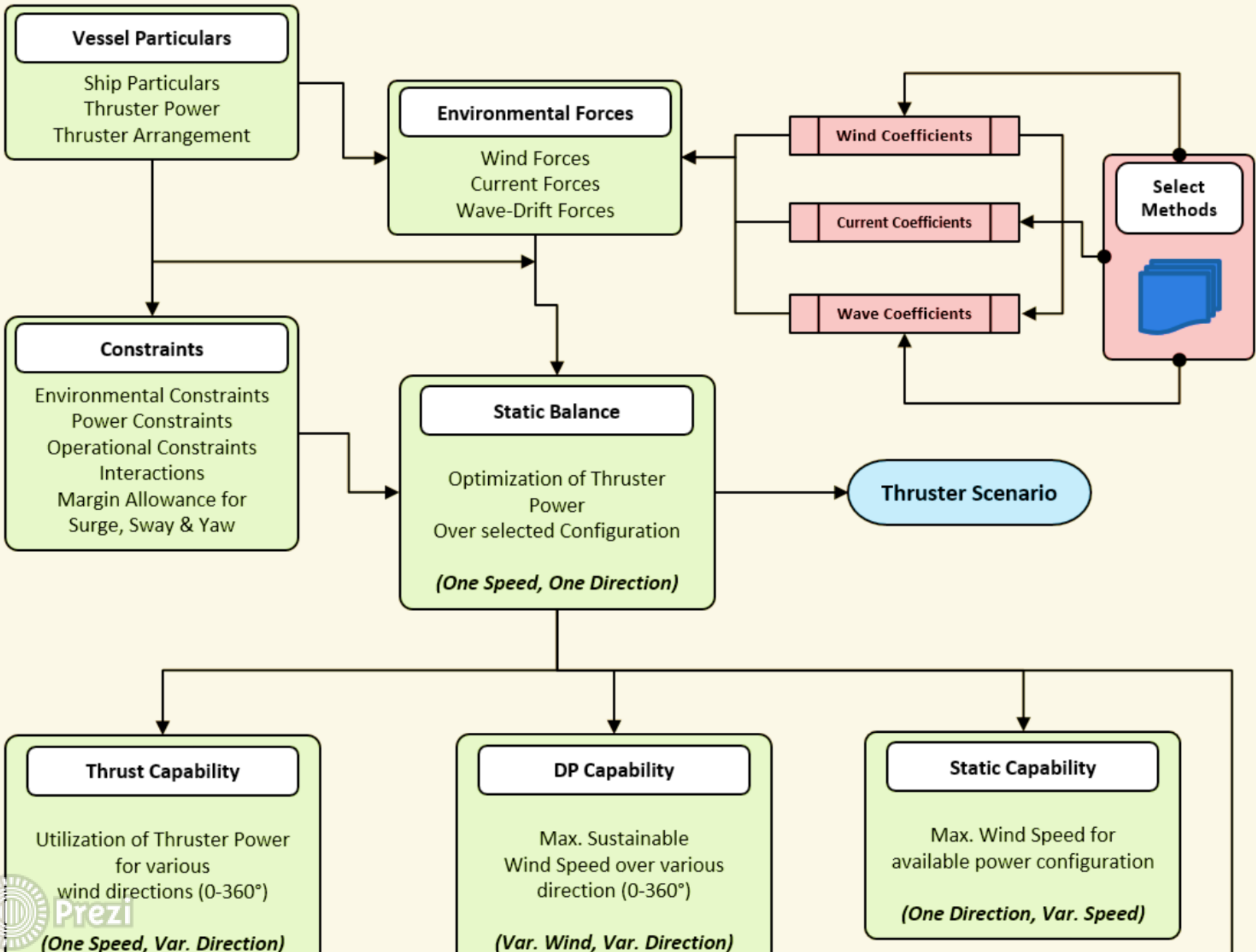
DP CAPABILITY EXCEL OPTIMIZATION PROGRAM

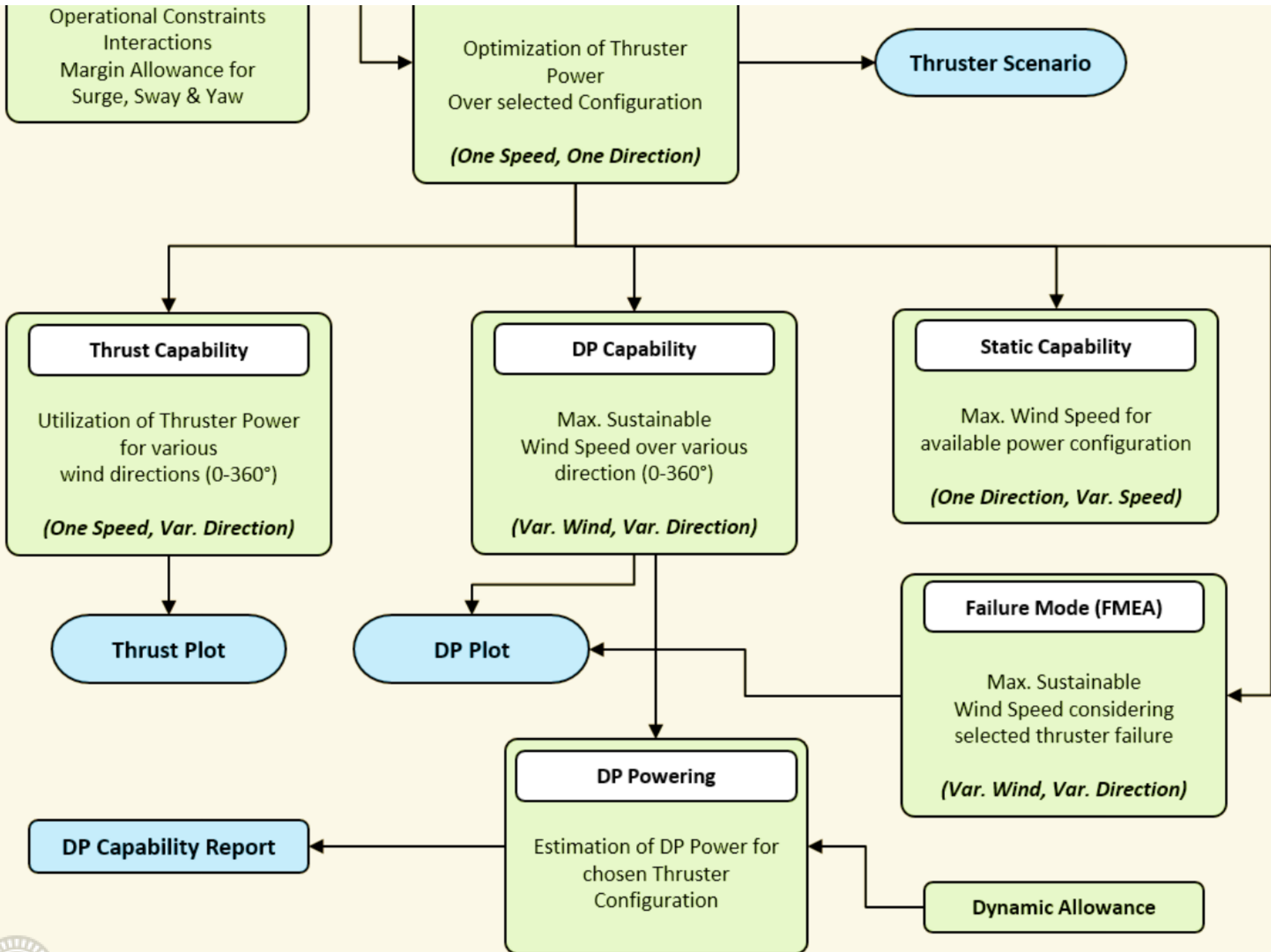
Rev. 0 - 2017

(Syed Marzan Ul Hasan -EMShip)

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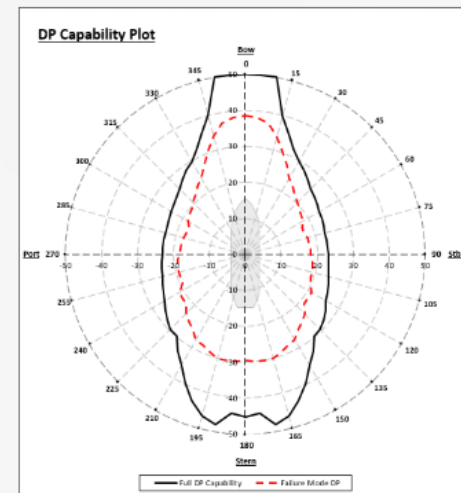
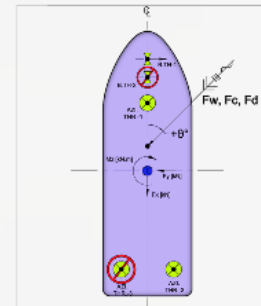
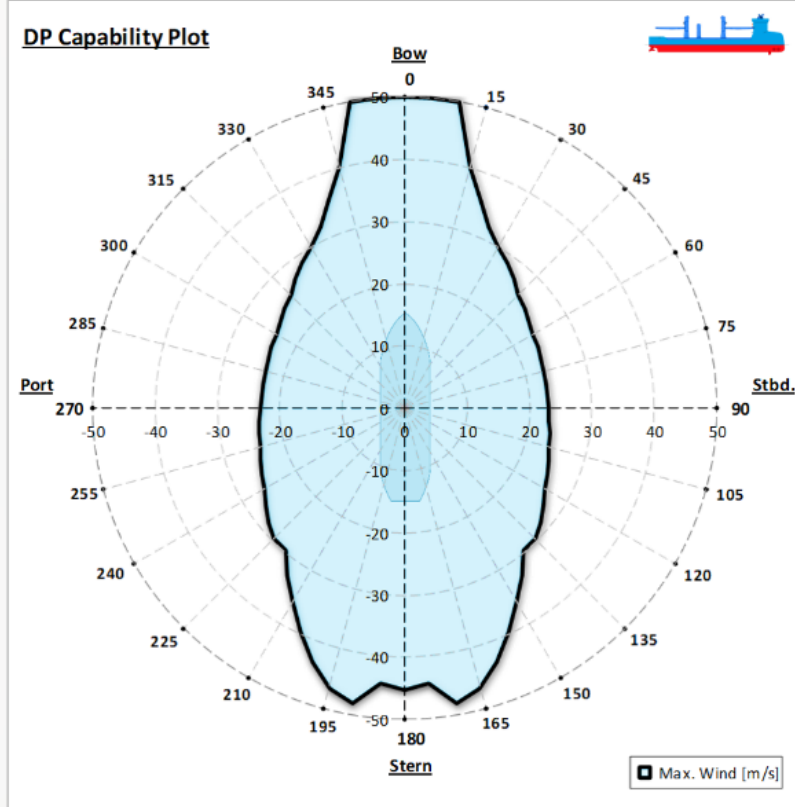
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DP PLOT

DP Capability Plot					
Project: Multipurpose Vessel		Rev. 0			
Main Particulars		Calculation Parameters			
Length between perpendiculars	: 142.1 [m]	Maximum Wind Speed	: 50.0 [m/s] (97.2 Knots)		
Loaded Waterline Length	: 145.0 [m]	Current Speed (fixed)	: 0.51 [m/s] (1Knots)		
Breadth moulded	: 25.0 [m]	Wave Height	: Wind Dependent		
Draught	: 7.2 [m]	Wind Load Estimation	: IMCA		
Block coefficient	: 0.835 [---]	Current Load Estimation	: IMCA		
Displacement	: 21902 [tonnes]	Wave-Drift Estimation	: DNV-GL		
Thruster Thrust [kN] (+ve=Fwd) P [kW] [%]		Other Considerations			
TT No. 1	-271 to 271	2340	80%	Wind Incident Angle	: 0 ~360 [deg]
TT No. 2	-271 to 271	2340	80%	Wave & Current	: Collinear with Wind
AT No. 1	-180 to 260	1900	80%	Dynamic Allowance	: 25.0 %
AT No. 2	-427 to 694	5075	80%	Interaction Effects	: Not included
AT No. 3	-427 to 694	5075	80%	Additional Forces	: Not included



FAILURE PLOT

DP Capability Plot

Project: **Multipurpose Vessel**

Rev. **0**

Main Particulars

Length between 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

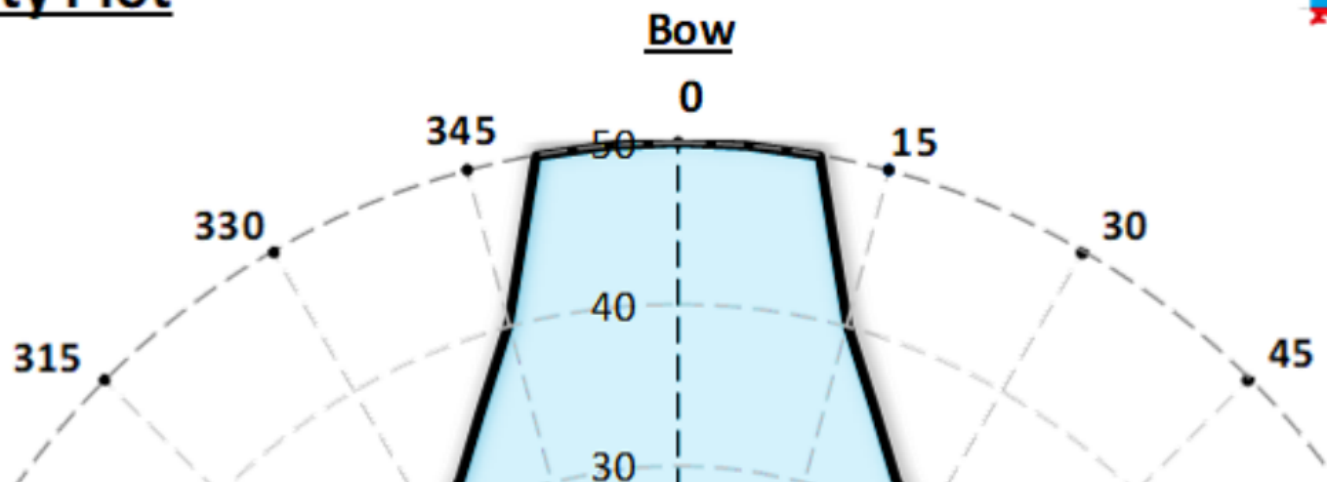
Thruster Thrust [kN] (+ve=Fwd) P [kW] [%]

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%

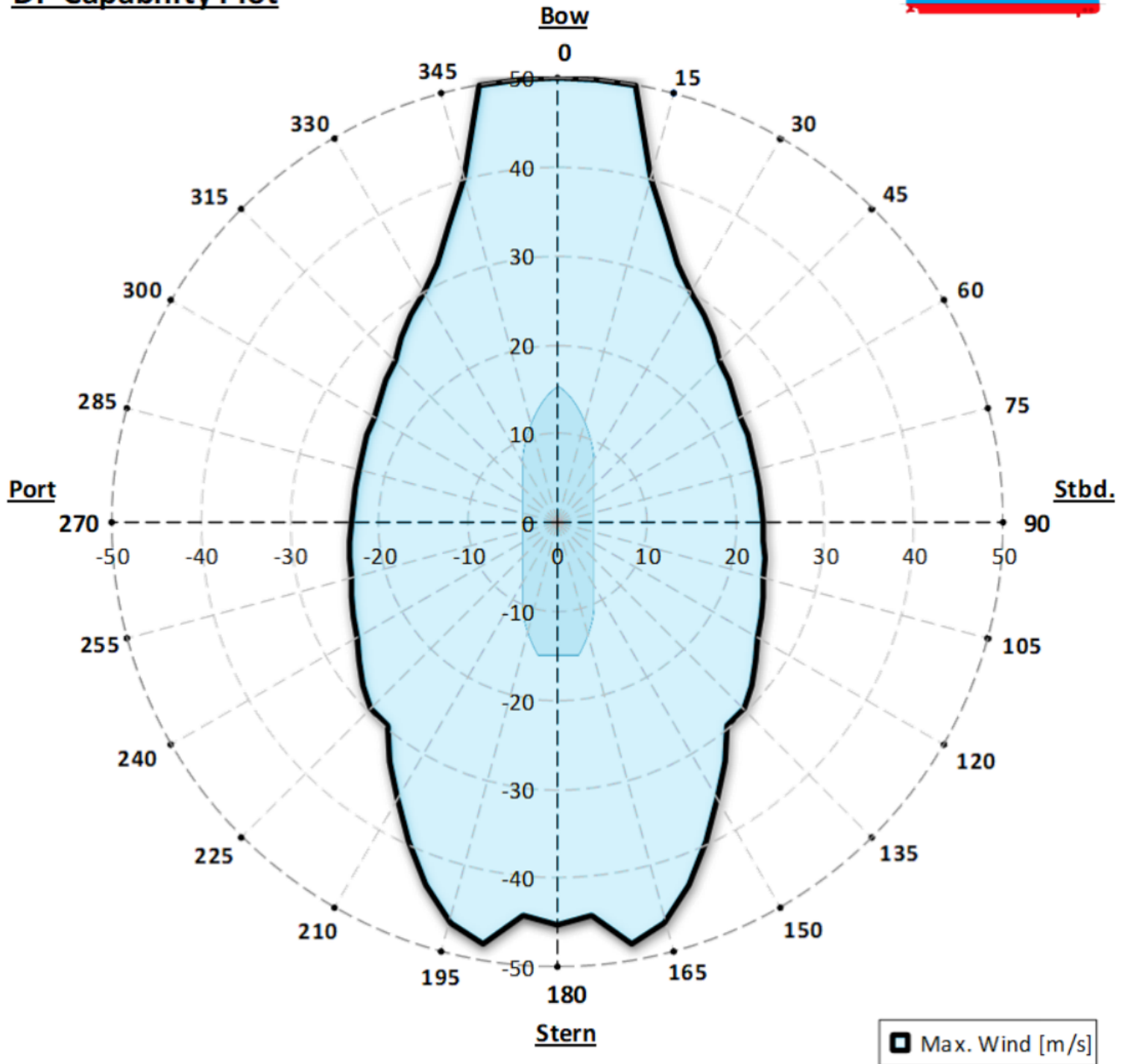
Other Considerations

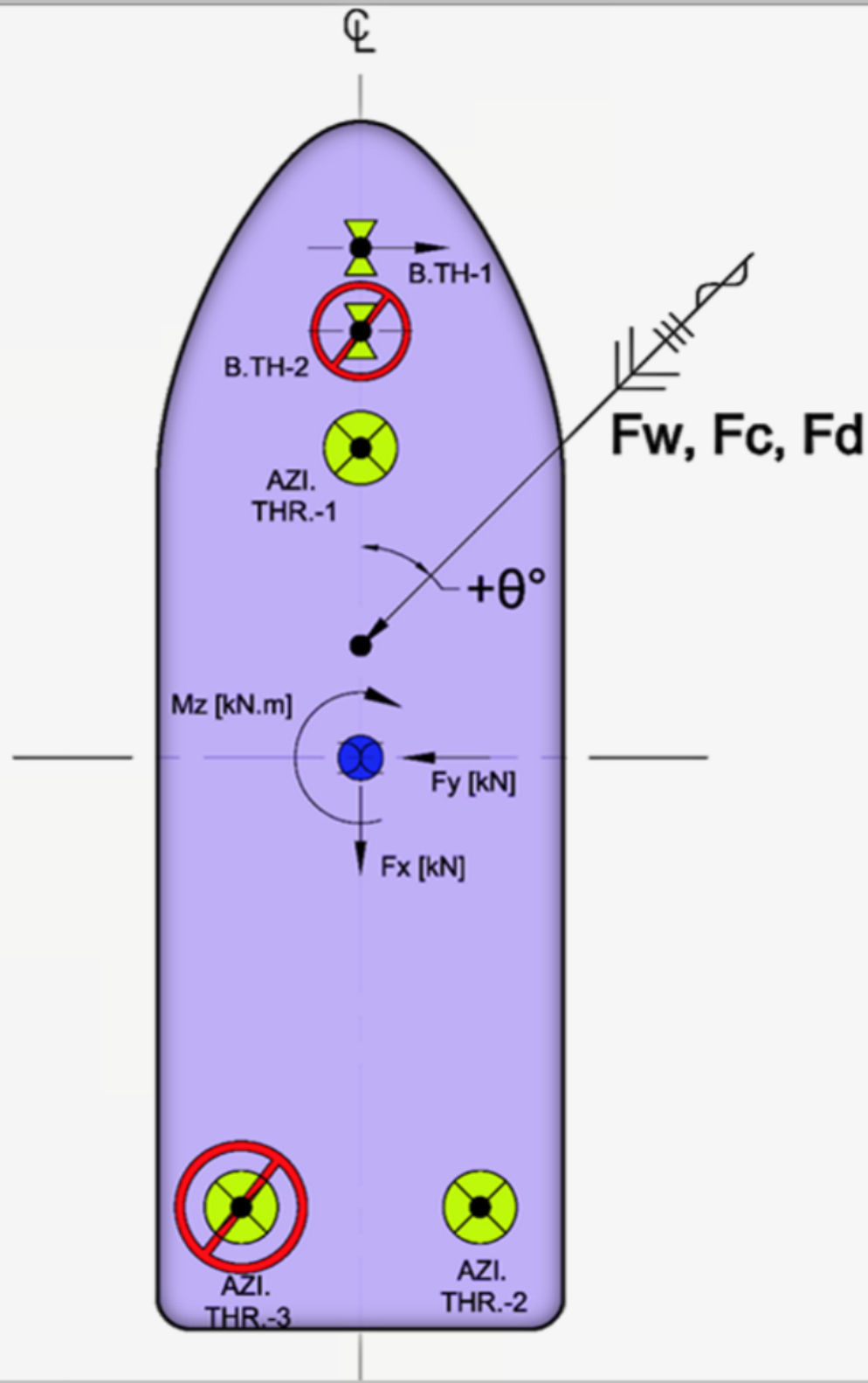
Wind Incident Angle	:	0 ~360 [deg]
Wave & Current	:	Collinear with Wind
Dynamic Allowance	:	25.0 %
Interaction Effects	:	Not Included
Additional Forces	:	Not Included

DP Capability Plot

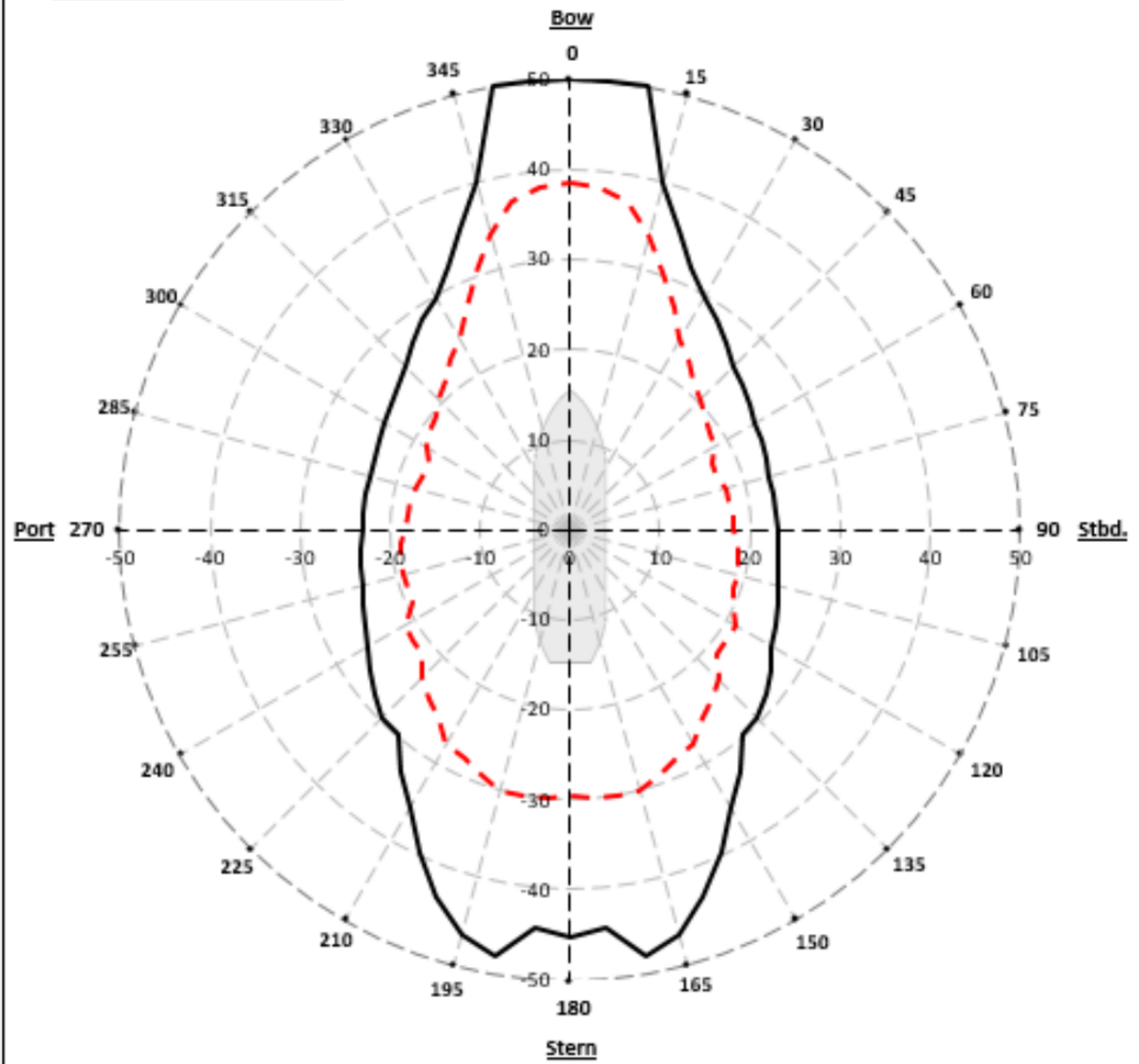


DP Capability Plot

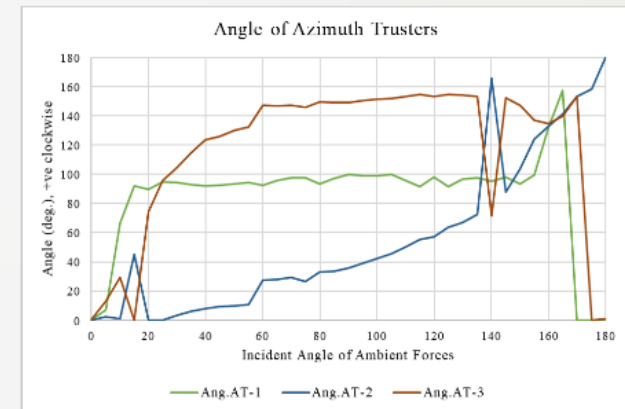
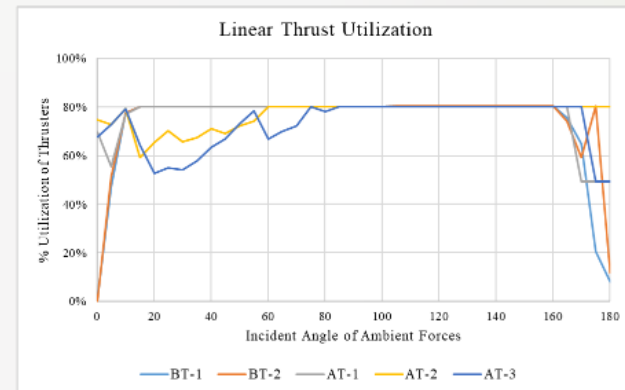
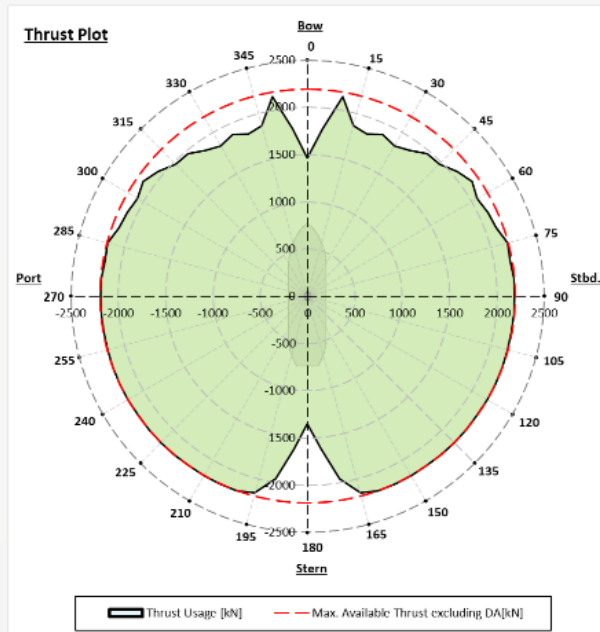




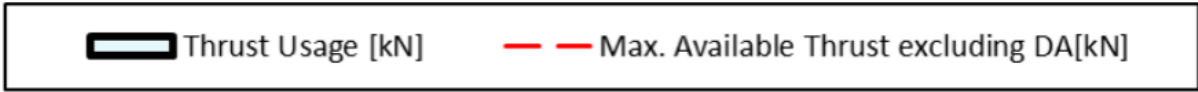
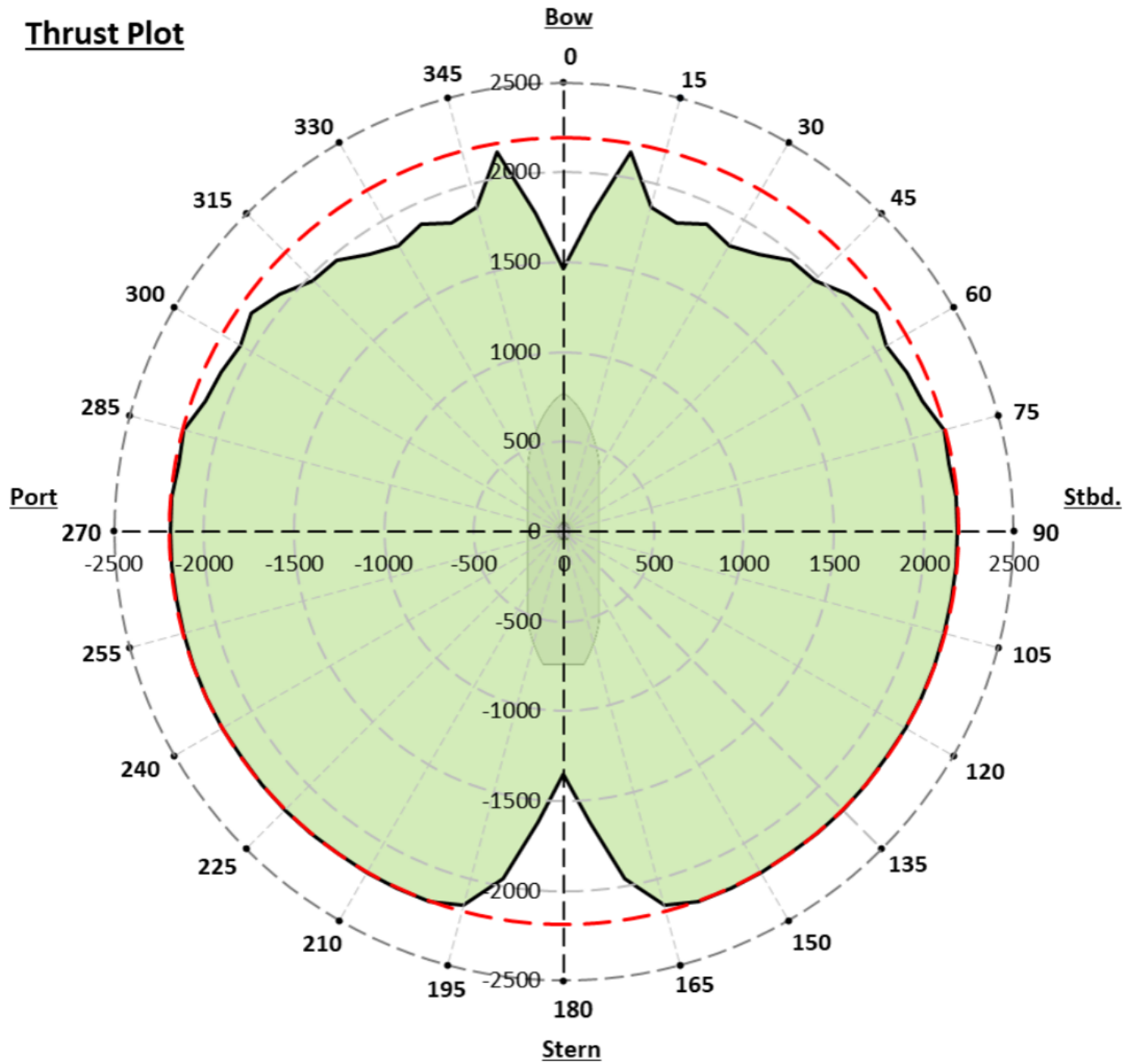
DP Capability Plot



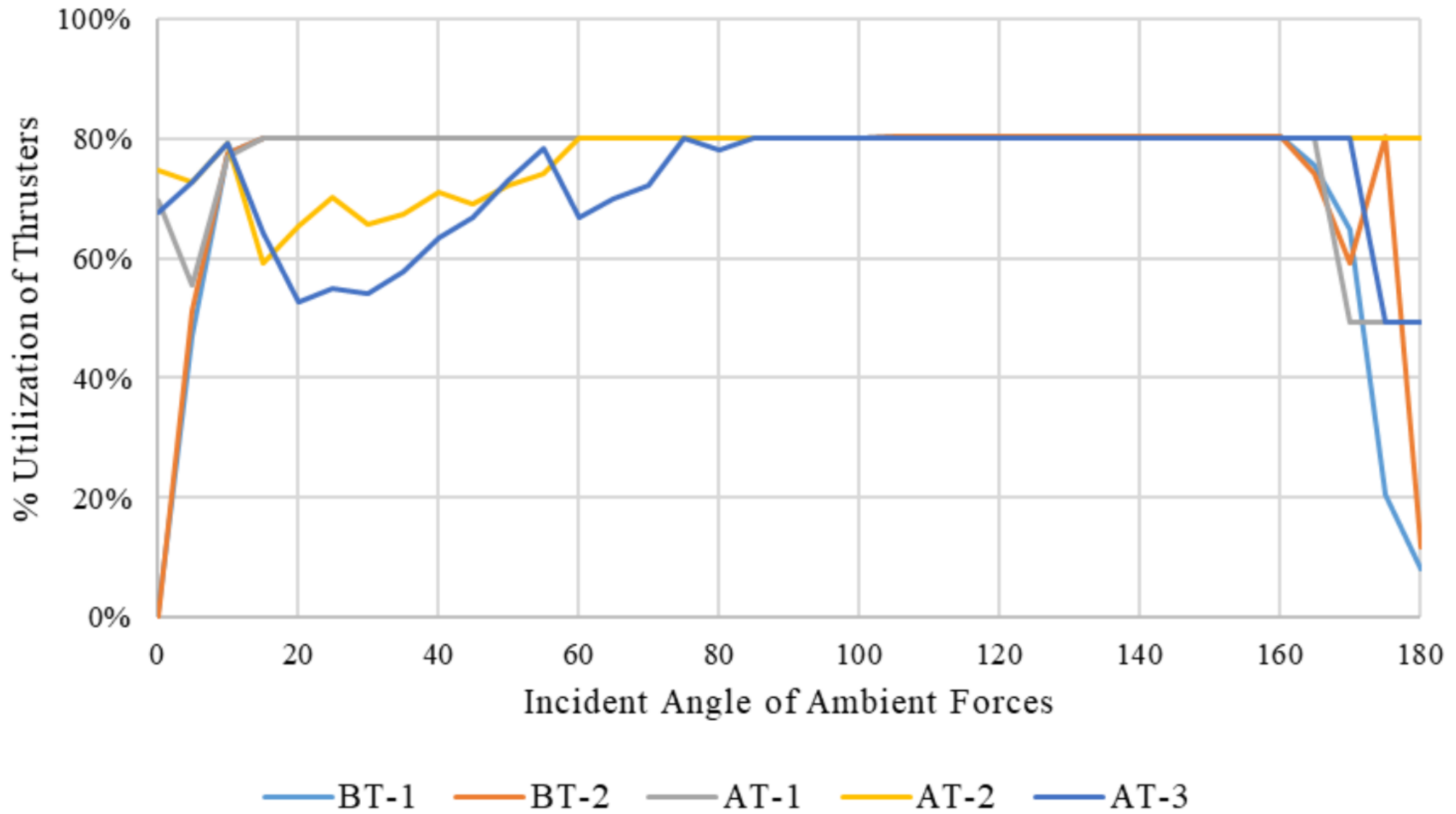
COMPREHENSIVE PLOTS



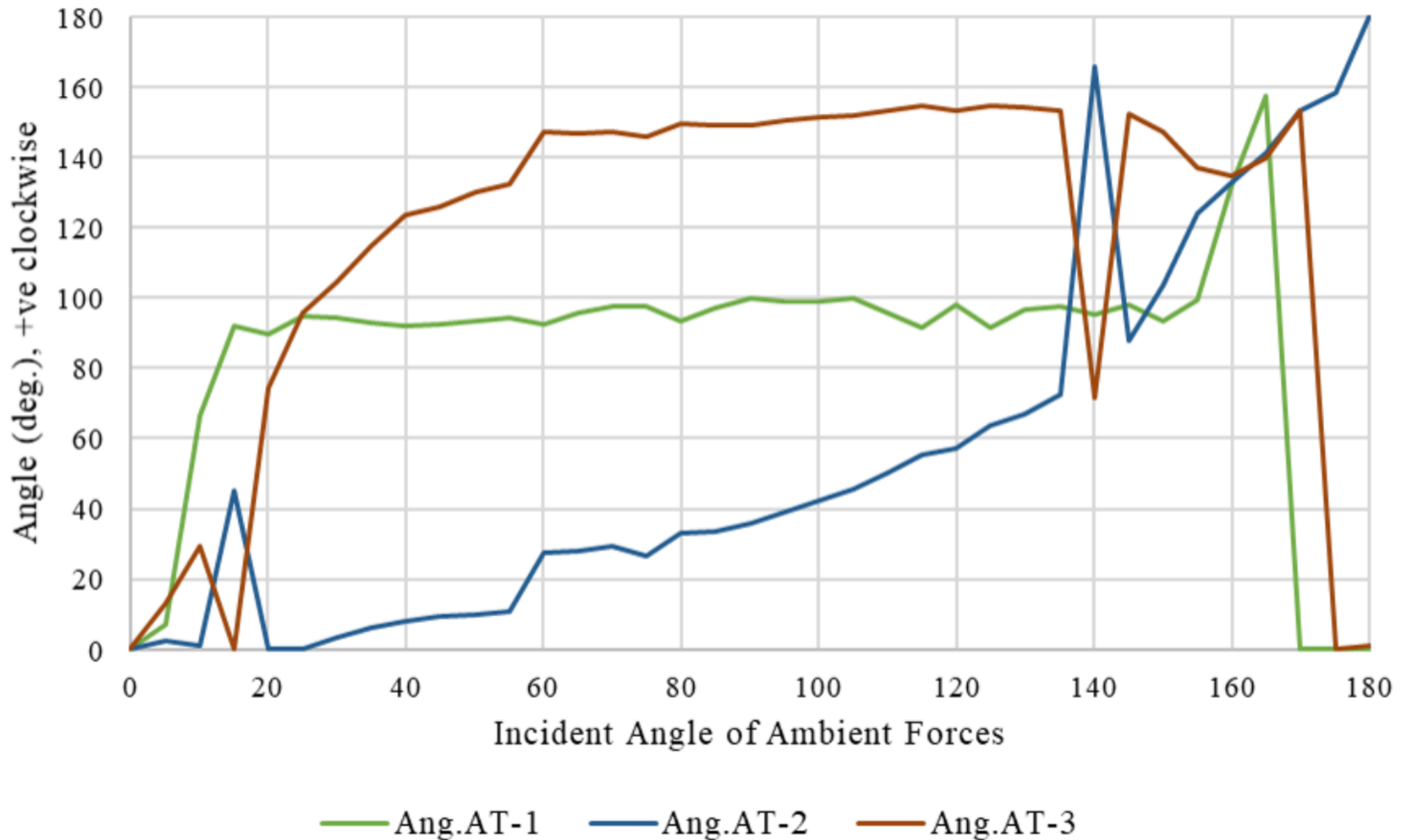
Thrust Plot



Linear Thrust Utilization

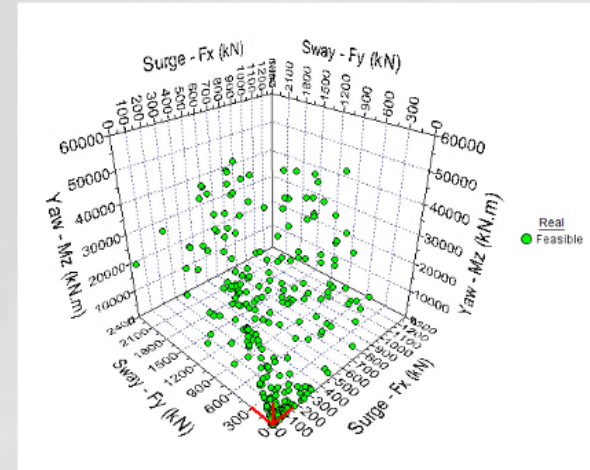
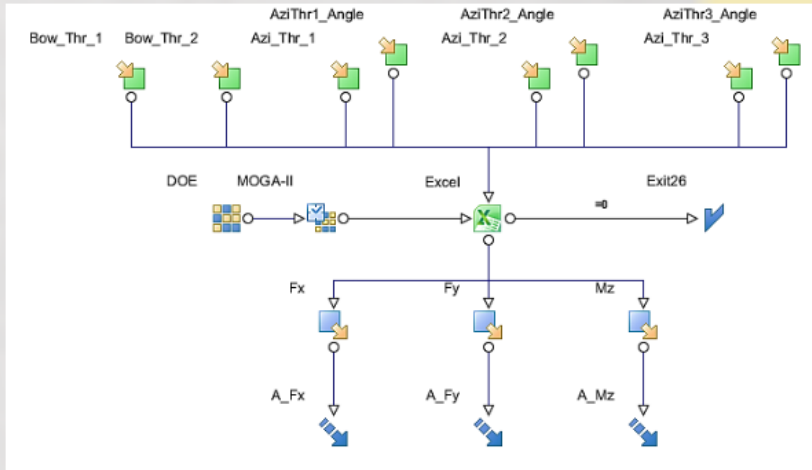


Angle of Azimuth Trusters

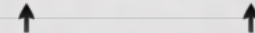


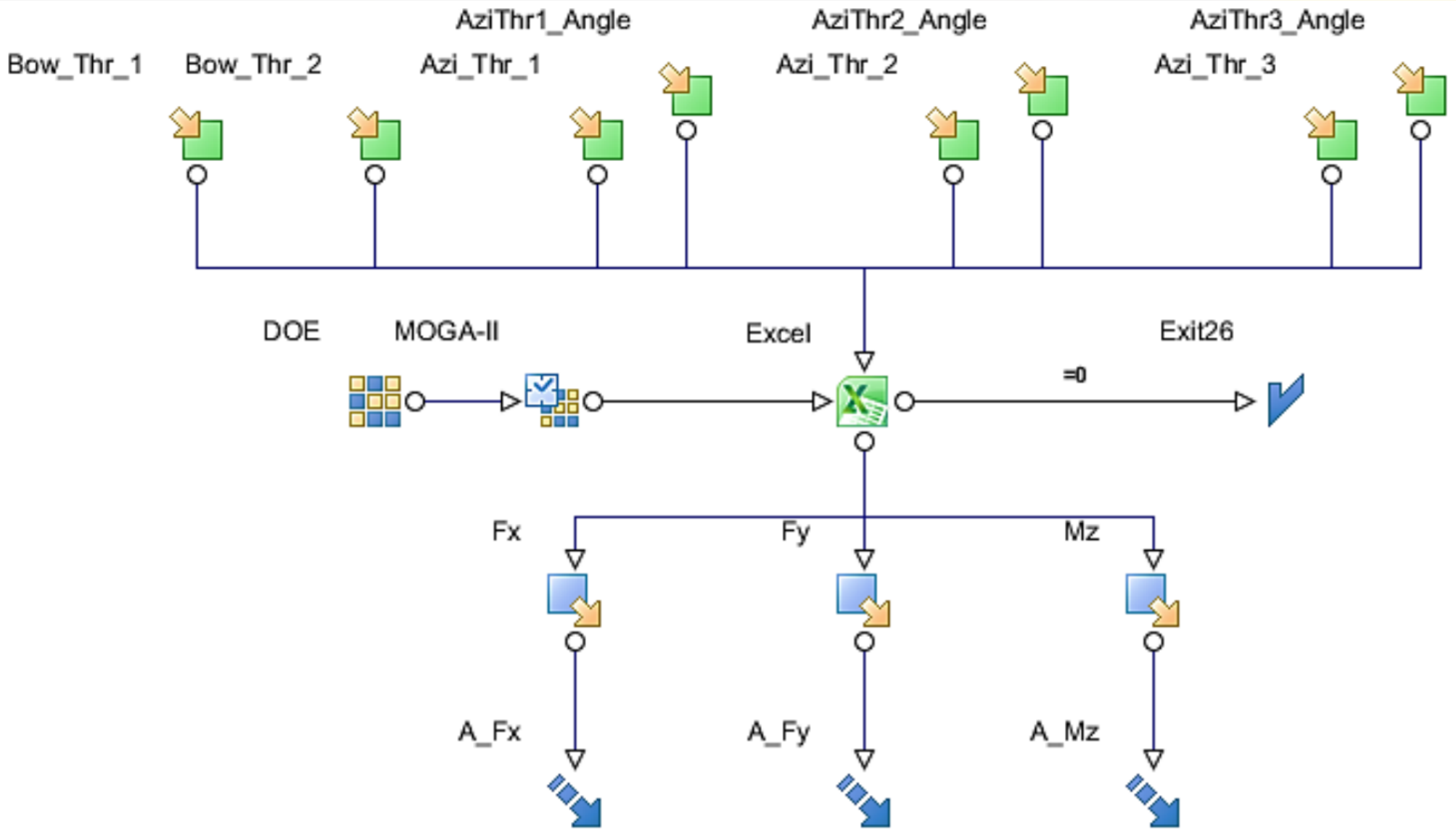
VALIDATION

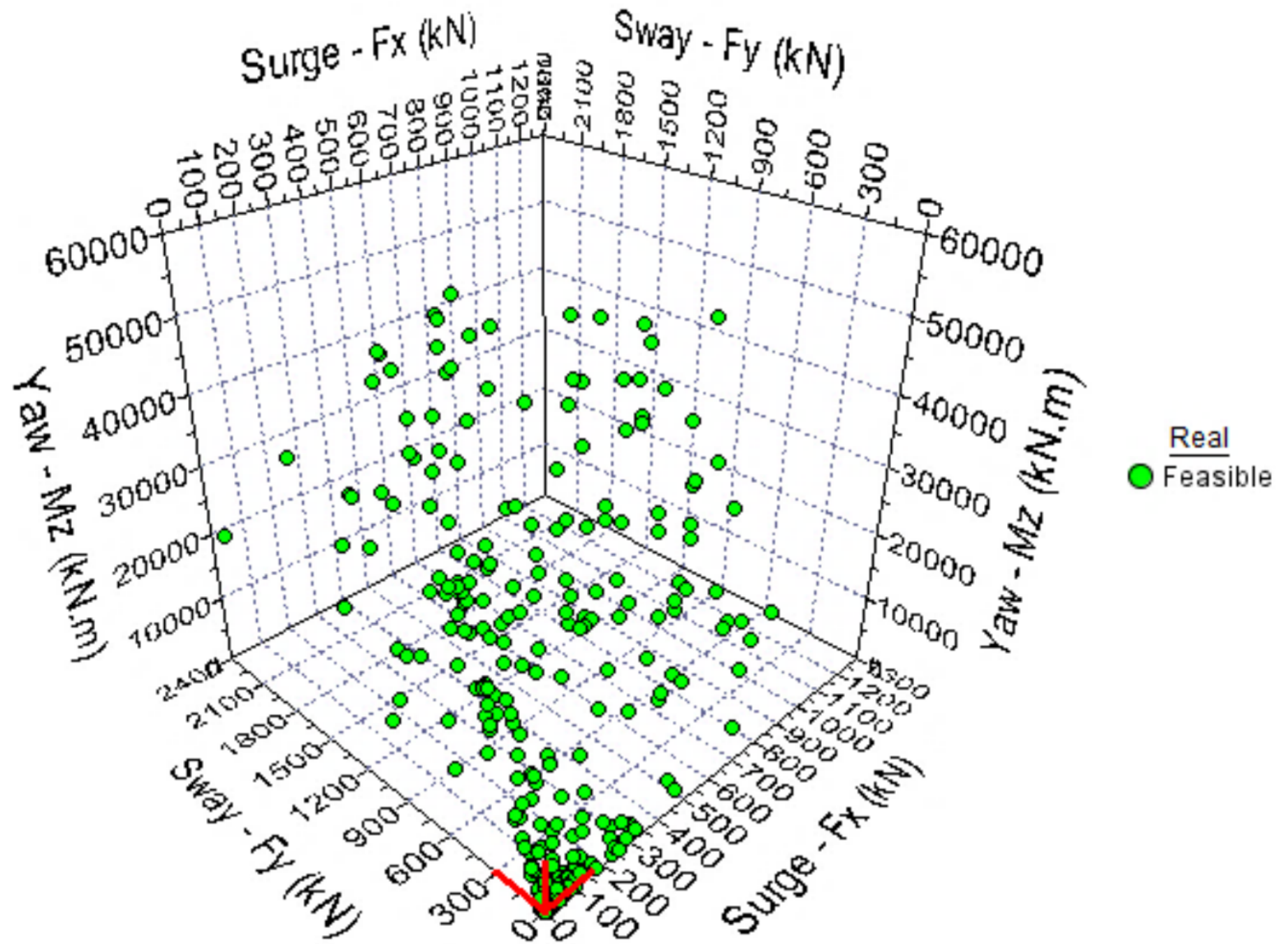
Modified Excel Solver Vs. ModeFrontier



	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



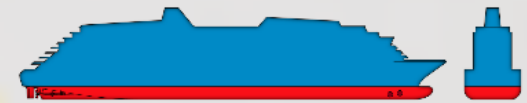




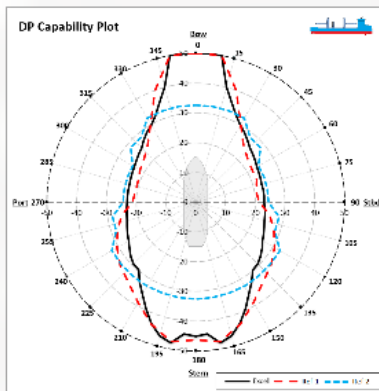
	Thrust Values [kN]			Azimuth Thruster Angles [deg]		
	Excel Solver	ModeFrontier MOGA	Difference [%]	Excel Solver	ModeFrontier MOGA	Difference [%]
Bow Thruster-1	271	271	0	-	-	-
Bow Thruster-2	271	271	0	-	-	-
Azimuth Thruster-1	260	260	0	85.7	86.7	1.15
Azimuth Thruster-2	429	423.6	1.28	0	0	0
Azimuth Thruster-3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



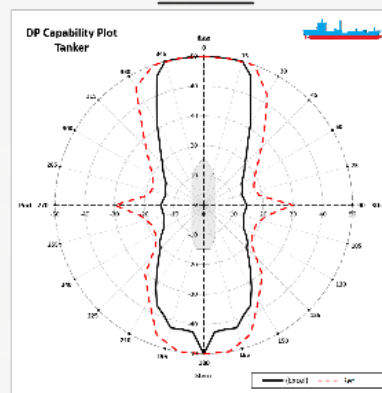
VALIDATION



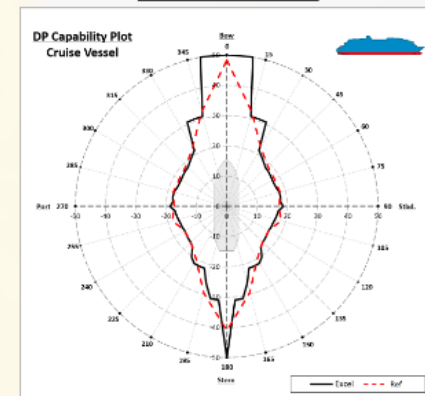
MPV

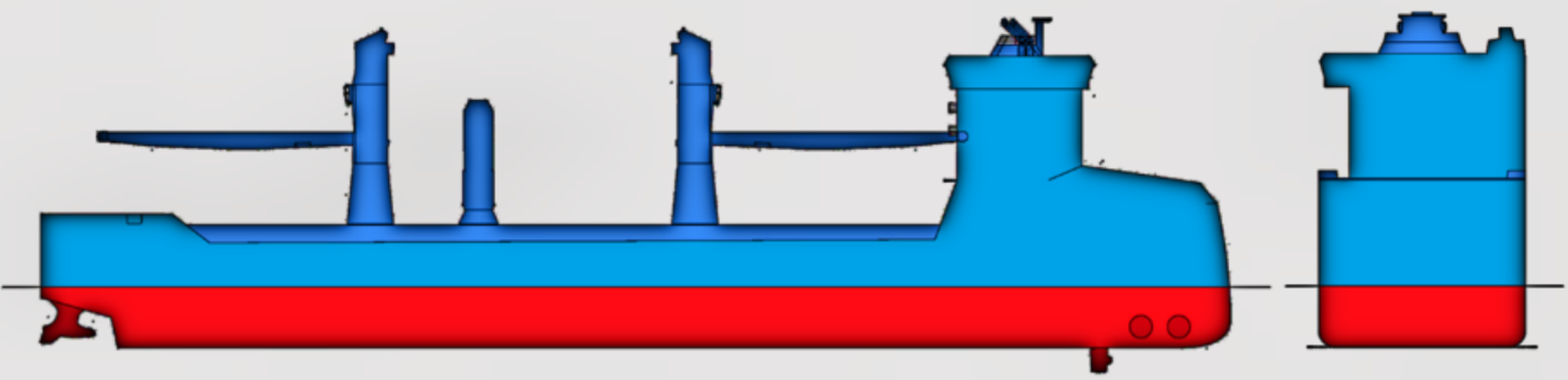


TANKER



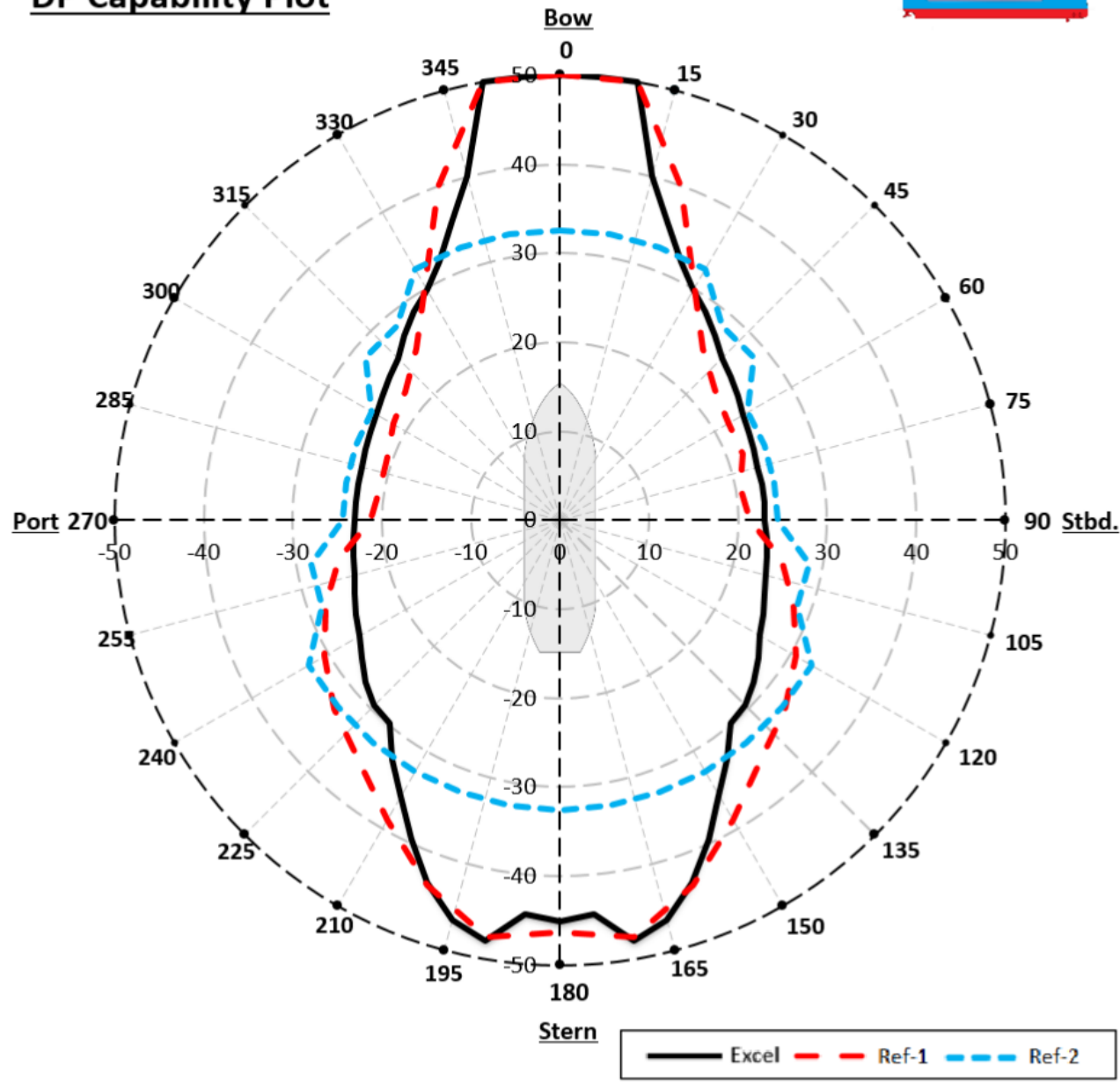
CRUISE VESSEL

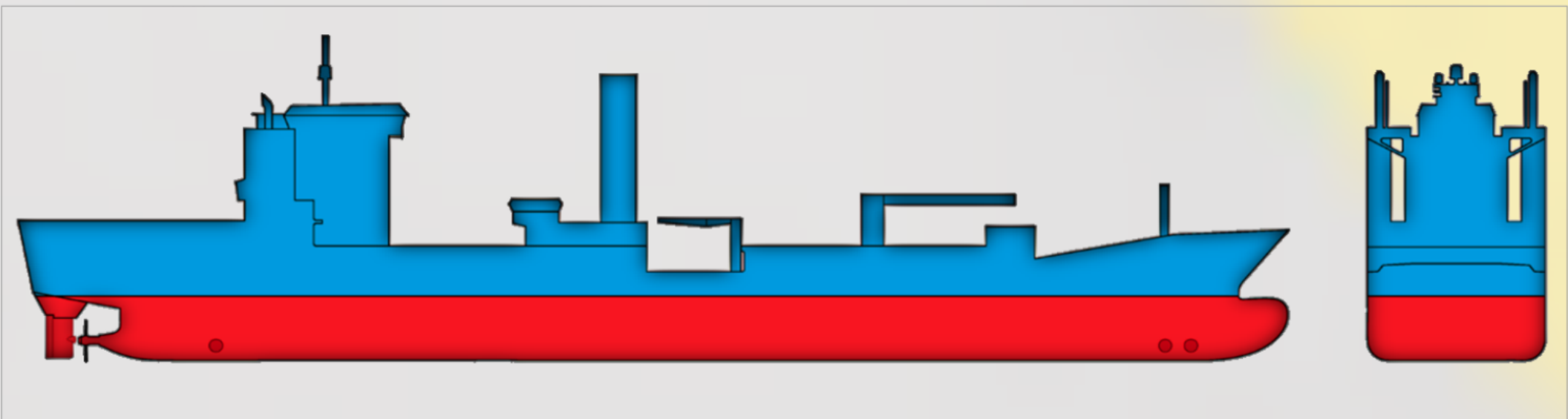




MPV

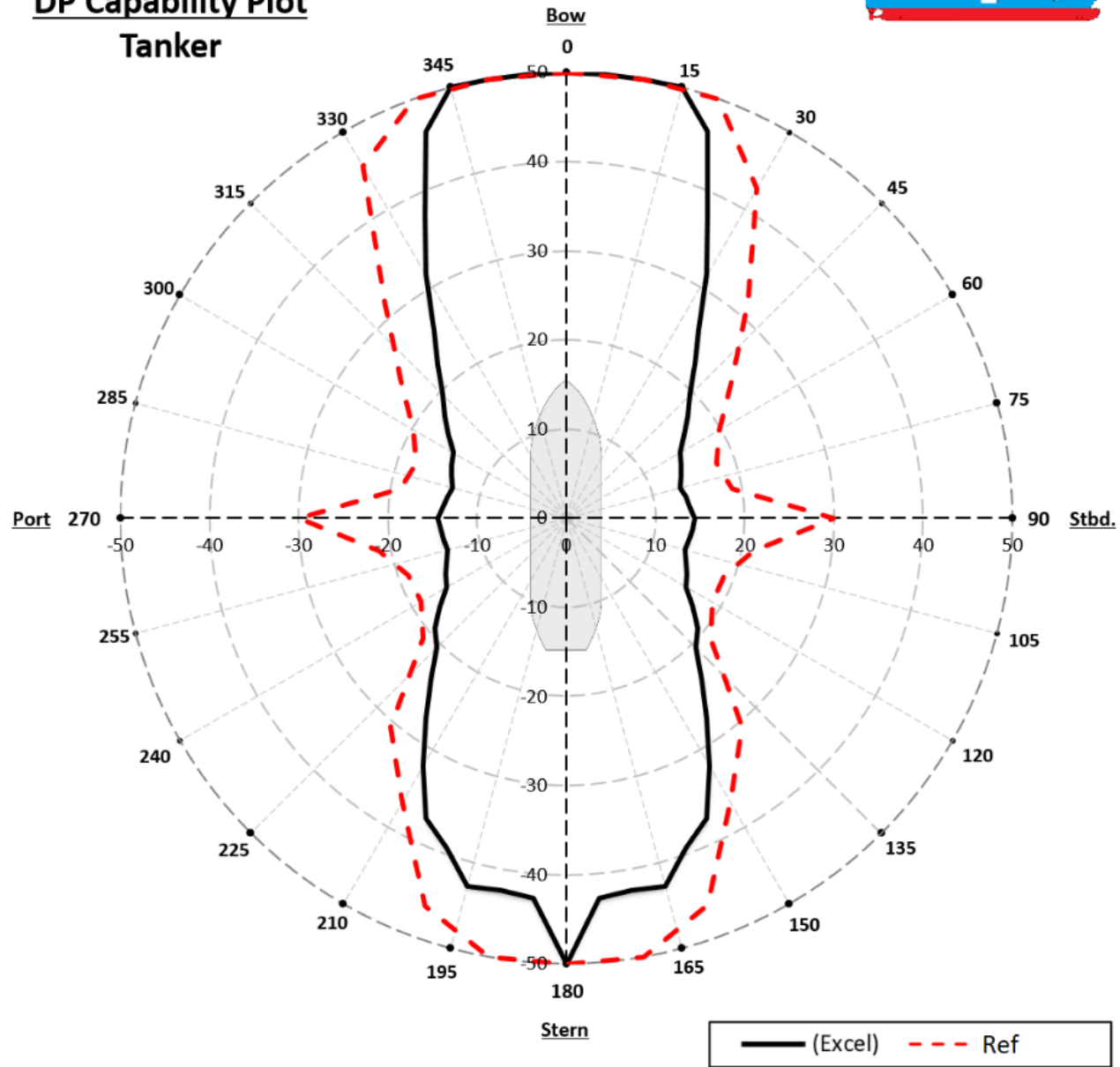
DP Capability Plot

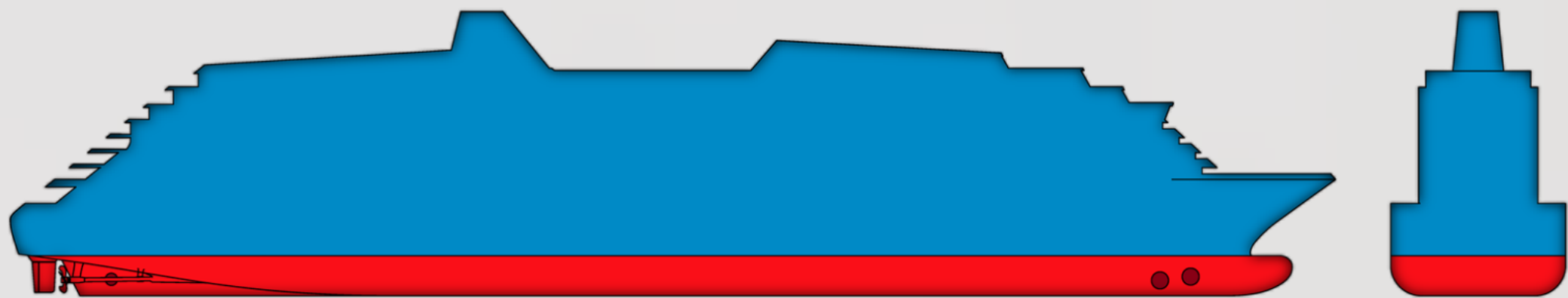




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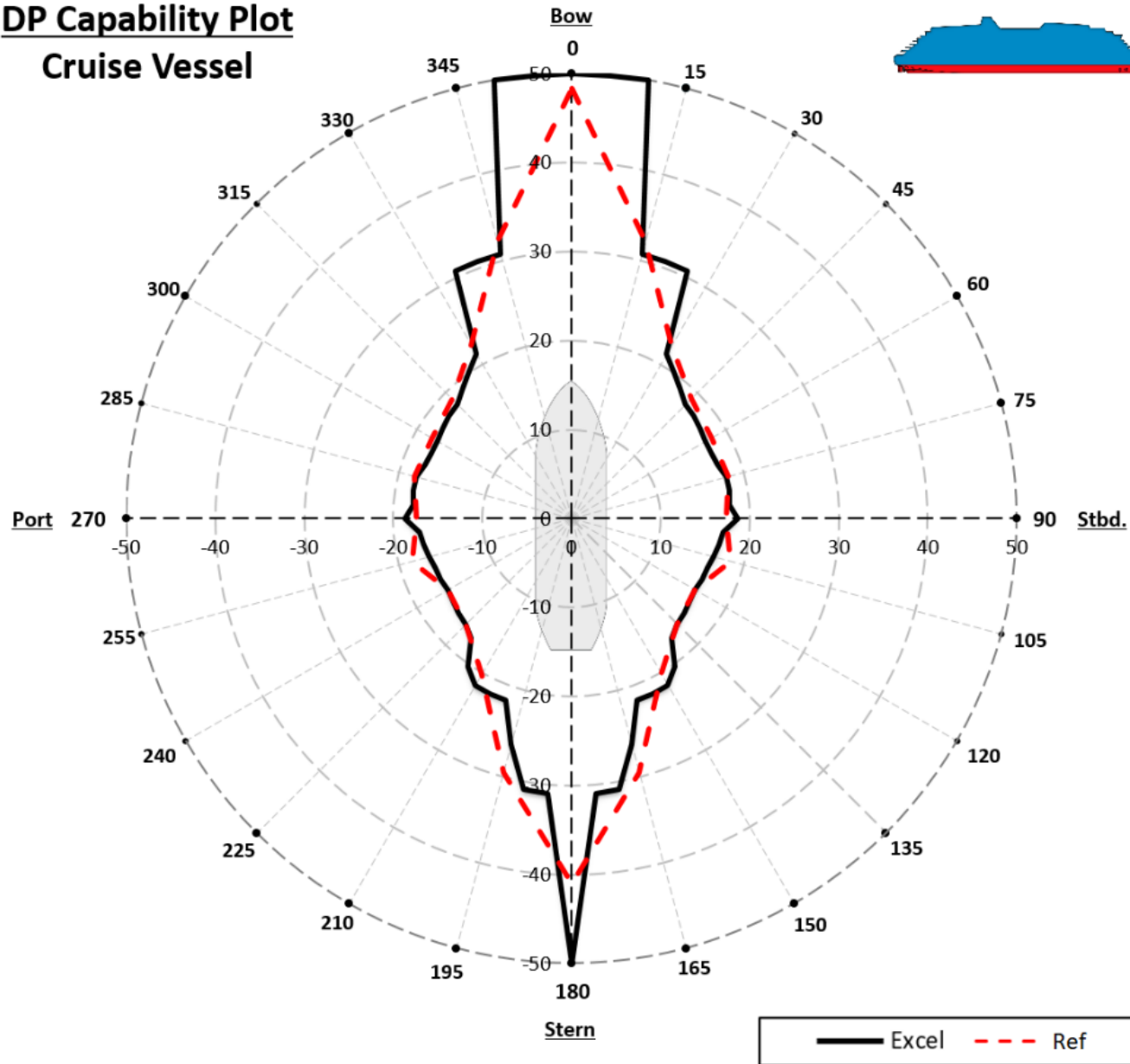
DP Capability Plot
Tanker





CRUISE VESSEL

DP Capability Plot
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

