MASTER THESIS PRESENTATION

Comparison Of Seakeeping Performance Of The Two Super Yachts Of 53 And 46 m In Length

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Master thesis developed in the framework of the Erasmus Mundus Master Course
in Integrated Advanced Ship Design
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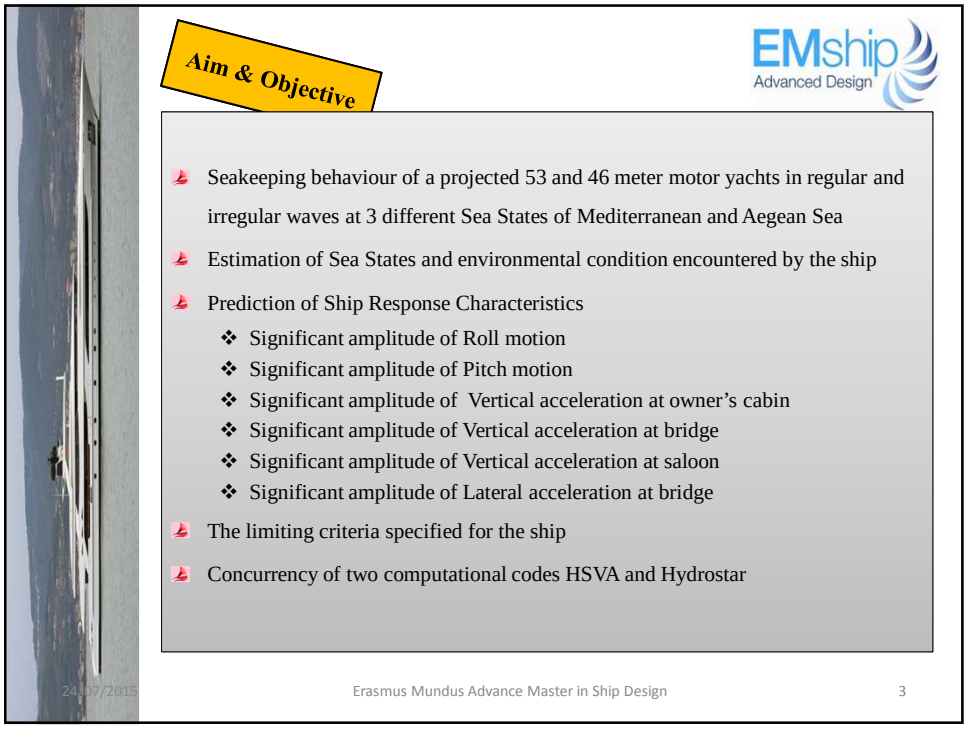
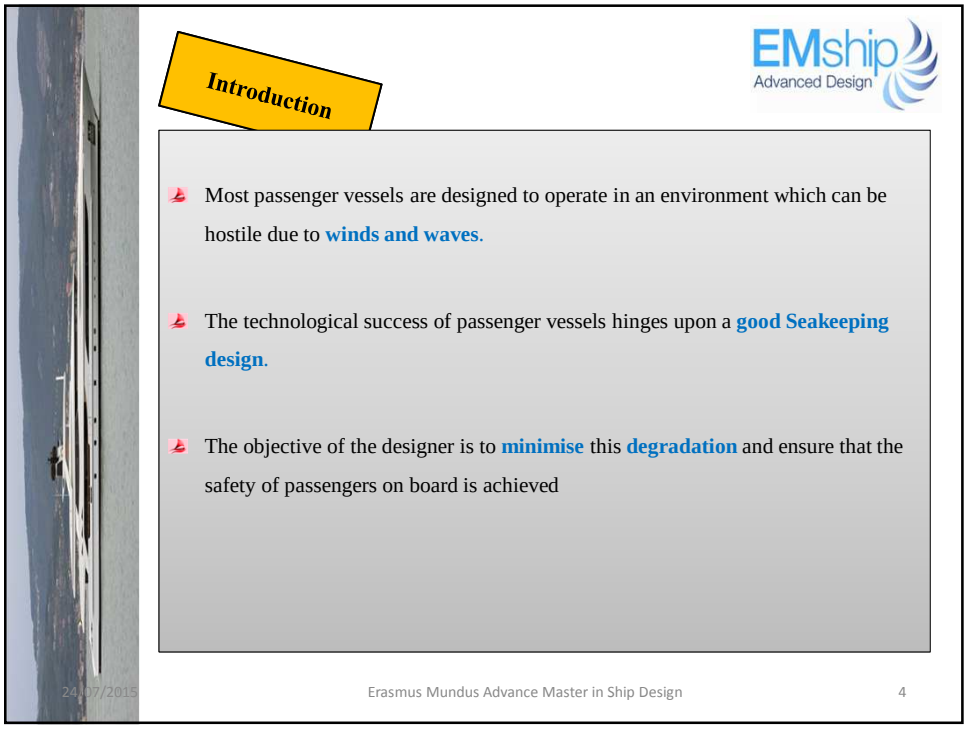
Outline

- Aim And Objective
- Introduction
- Input and Response variable
- Methodology
- Hydrostar work flow
- Wave spectrum
- Hierarchy
- Results
- Conclusion



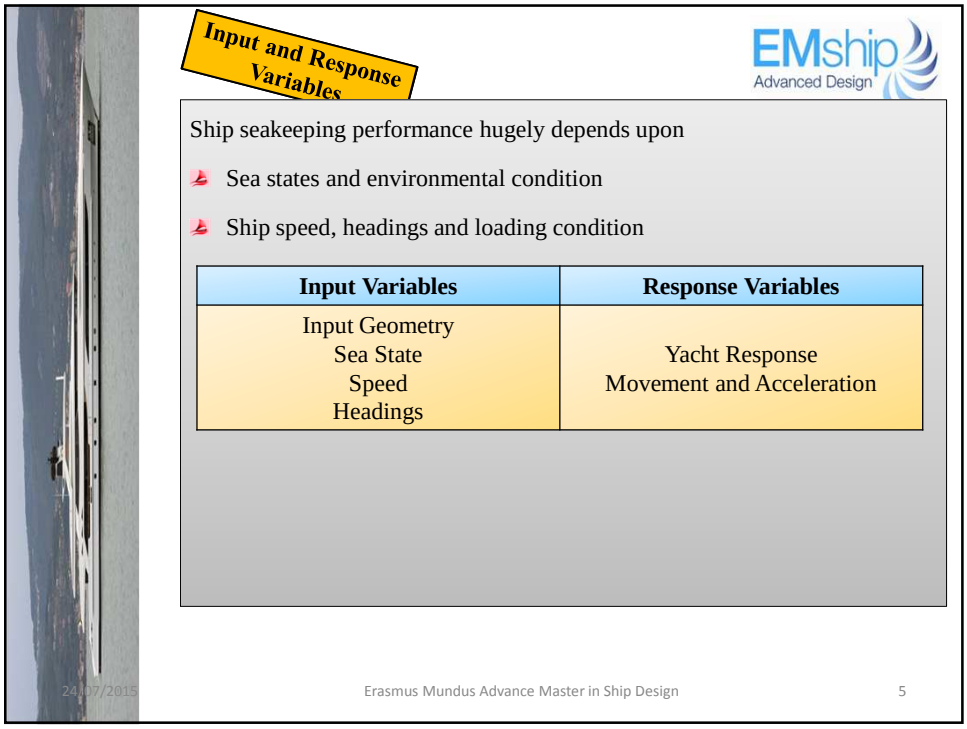
Aim & Objective

- Seakeeping behaviour of a projected 53 and 46 meter motor yachts in regular and irregular waves at 3 different Sea States of Mediterranean and Aegean Sea
- Estimation of Sea States and environmental condition encountered by the ship
- Prediction of Ship Response Characteristics
  - Significant amplitude of Roll motion
  - Significant amplitude of Pitch motion
  - Significant amplitude of Vertical acceleration at owner's cabin
  - Significant amplitude of Vertical acceleration at bridge
  - Significant amplitude of Vertical acceleration at saloon
  - Significant amplitude of Lateral acceleration at bridge
- The limiting criteria specified for the ship
- Concurrency of two computational codes HSVA and Hydrostar



Introduction

- Most passenger vessels are designed to operate in an environment which can be hostile due to **winds and waves**.
- The technological success of passenger vessels hinges upon a **good Seakeeping design**.
- The objective of the designer is to **minimise** this **degradation** and ensure that the safety of passengers on board is achieved

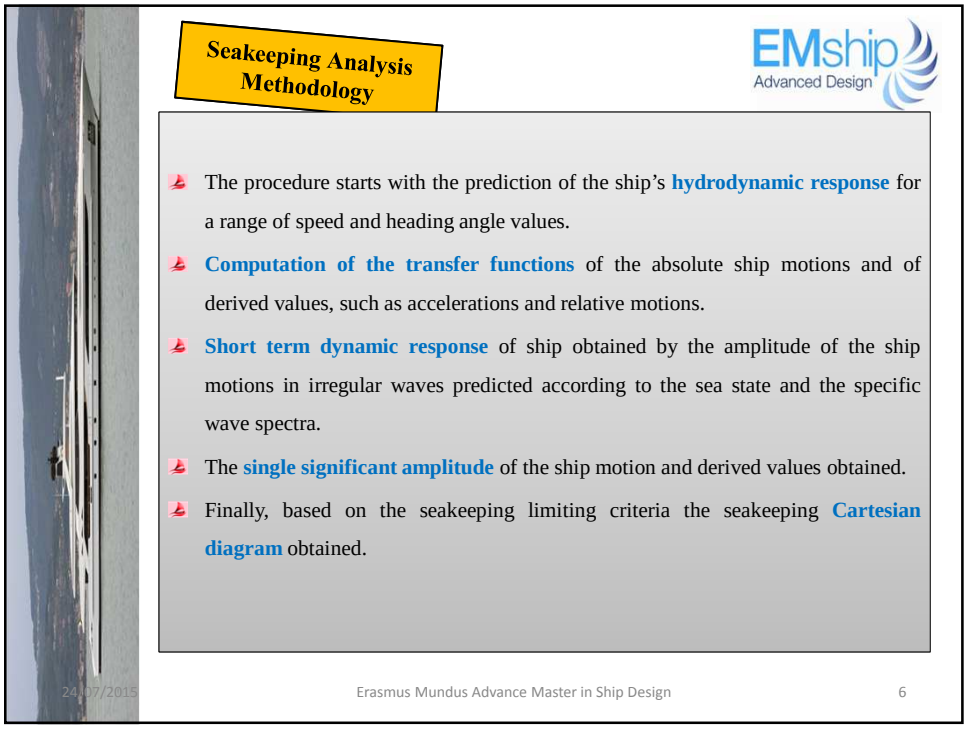


Input and Response Variables

Ship seakeeping performance hugely depends upon

- Sea states and environmental condition
- Ship speed, headings and loading condition

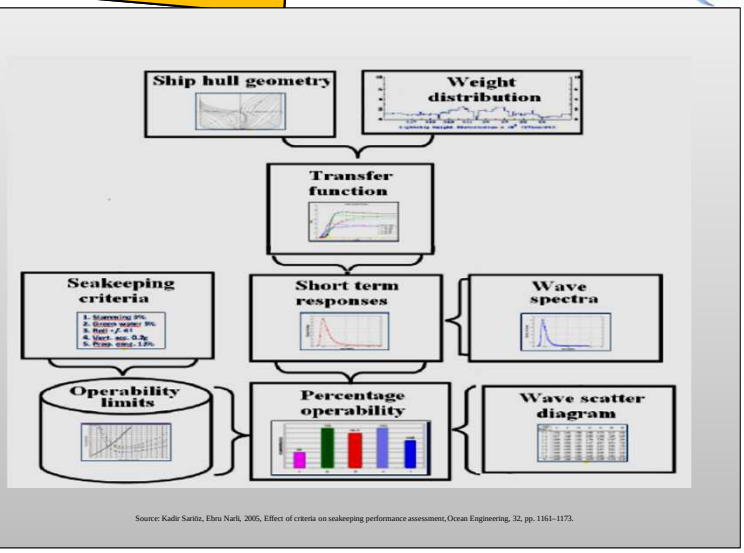
Input Variables	Response Variables
Input Geometry Sea State Speed Headings	Yacht Response Movement and Acceleration



Seakeeping Analysis Methodology

- The procedure starts with the prediction of the ship's **hydrodynamic response** for a range of speed and heading angle values.
- **Computation of the transfer functions** of the absolute ship motions and of derived values, such as accelerations and relative motions.
- **Short term dynamic response** of ship obtained by the amplitude of the ship motions in irregular waves predicted according to the sea state and the specific wave spectra.
- The **single significant amplitude** of the ship motion and derived values obtained.
- Finally, based on the seakeeping limiting criteria the seakeeping **Cartesian diagram** obtained.

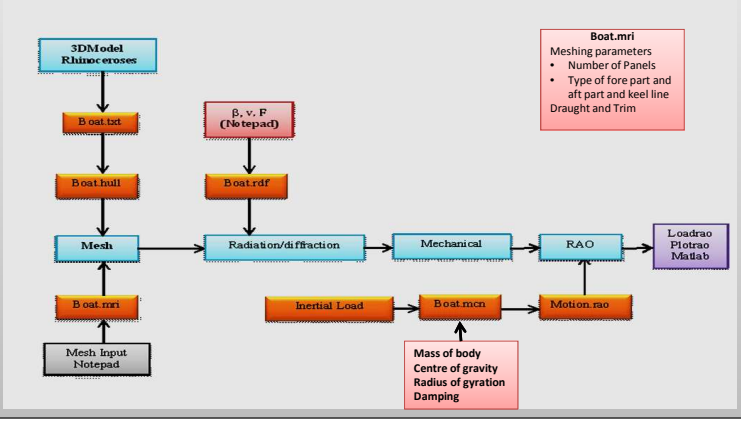
Seakeeping Analysis Methodology

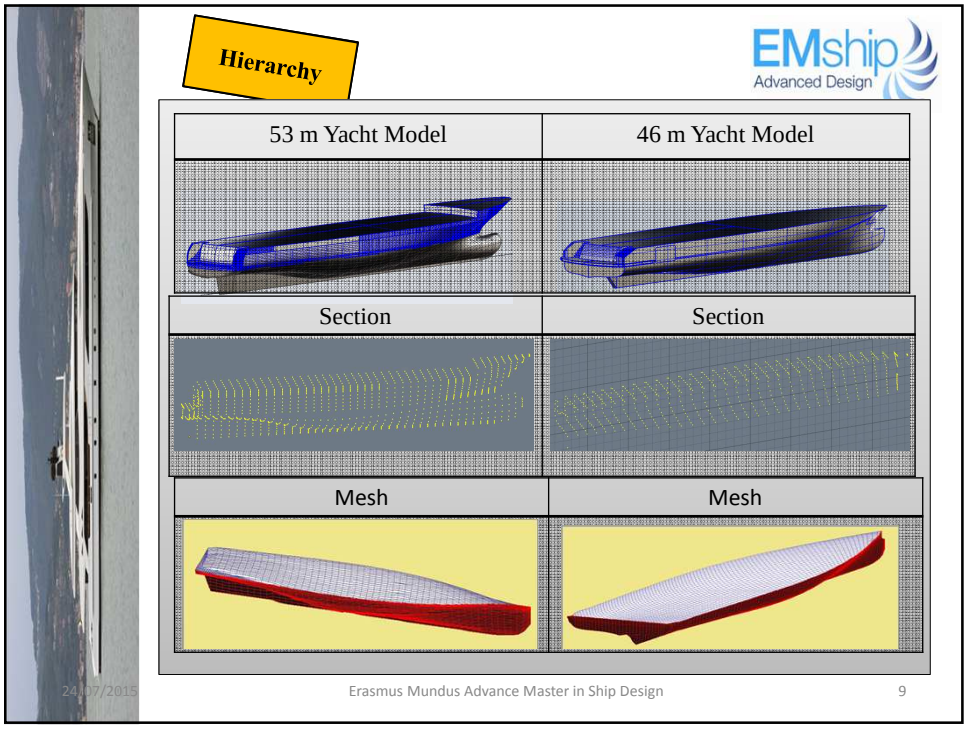


Source: Kadir Sariöz, Ebru Narli, 2005, Effect of criteria on seakeeping performance assessment, Ocean Engineering, 32, pp. 1161–1173.

Hydrostar

Hydrostar is hydrodynamic software that is used to calculate induced motion of one or several ships or any kind of floating structure in a deep and finite water depth.




Hierarchy
EMship
Advanced Design
53 m Yacht Model
46 m Yacht Model
Section
Section
Mesh
Mesh
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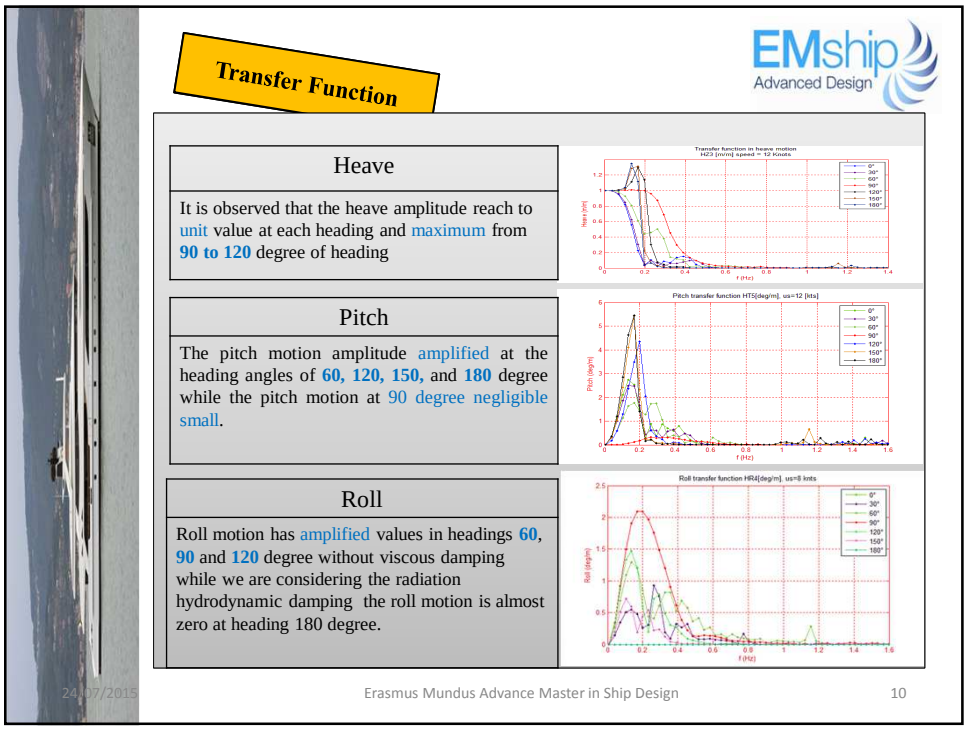
Transfer Function
EMship
Advanced Design
Heave
It is observed that the heave amplitude reach to unit value at each heading and maximum from 90 to 120 degree of heading
Pitch
The pitch motion amplitude amplified at the heading angles of 60, 120, 150, and 180 degree while the pitch motion at 90 degree negligible small.
Roll
Roll motion has amplified values in headings 60, 90 and 120 degree without viscous damping while we are considering the radiation hydrodynamic damping the roll motion is almost zero at heading 180 degree.
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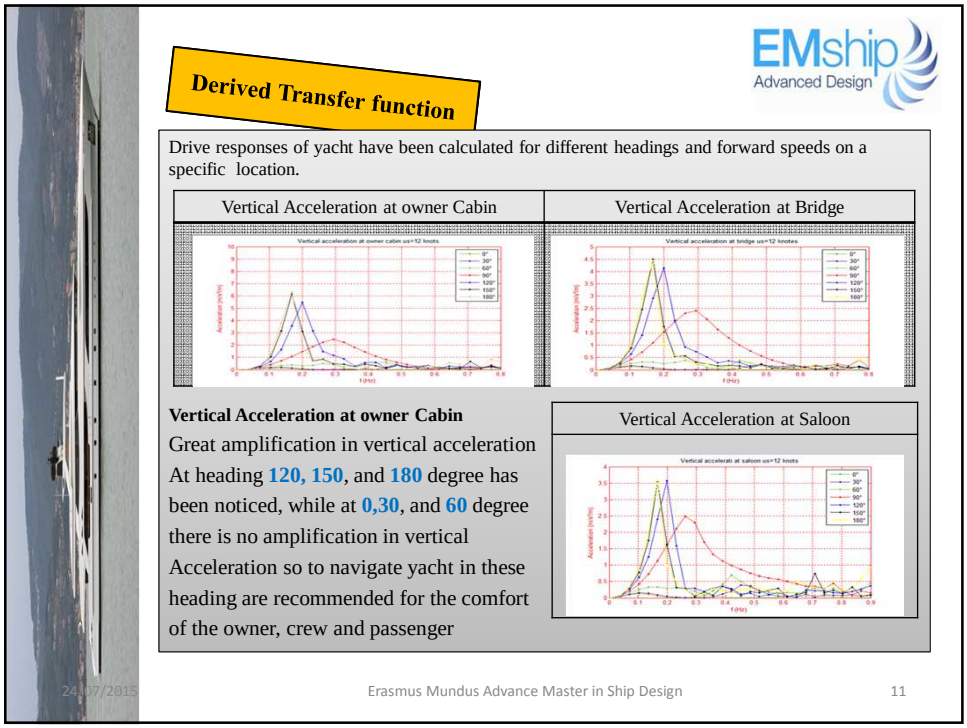


Derived Transfer function

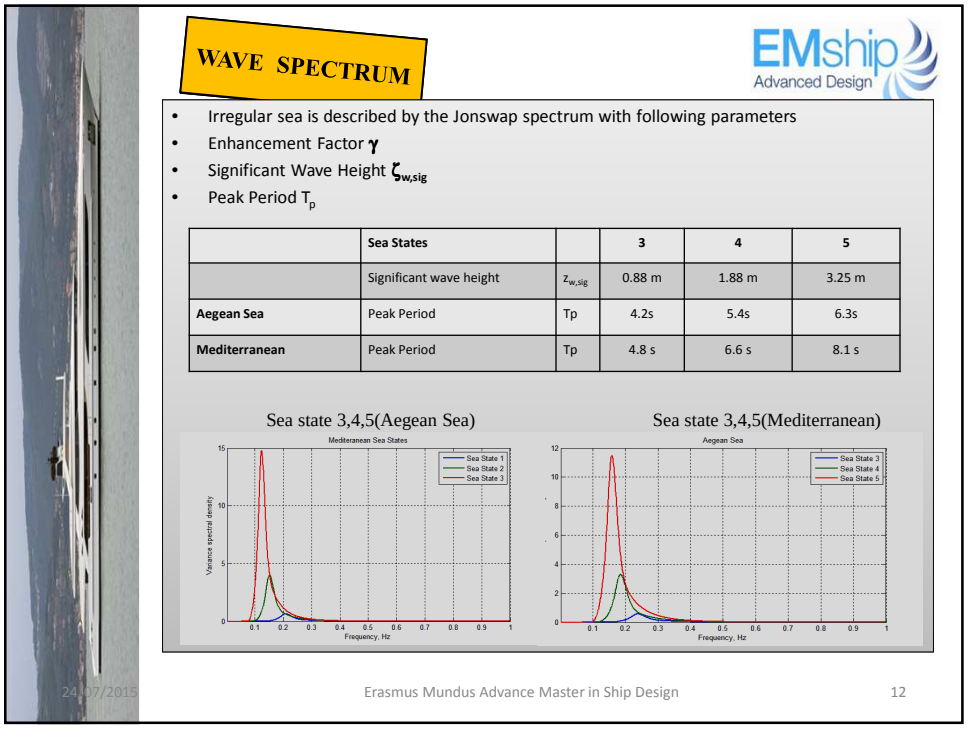
Drive responses of yacht have been calculated for different headings and forward speeds on a specific location.

Vertical Acceleration at owner Cabin	Vertical Acceleration at Bridge

Vertical Acceleration at owner Cabin

Great amplification in vertical acceleration At heading **120, 150**, and **180** degree has been noticed, while at **0,30**, and **60** degree there is no amplification in vertical Acceleration so to navigate yacht in these heading are recommended for the comfort of the owner, crew and passenger

Vertical Acceleration at Saloon



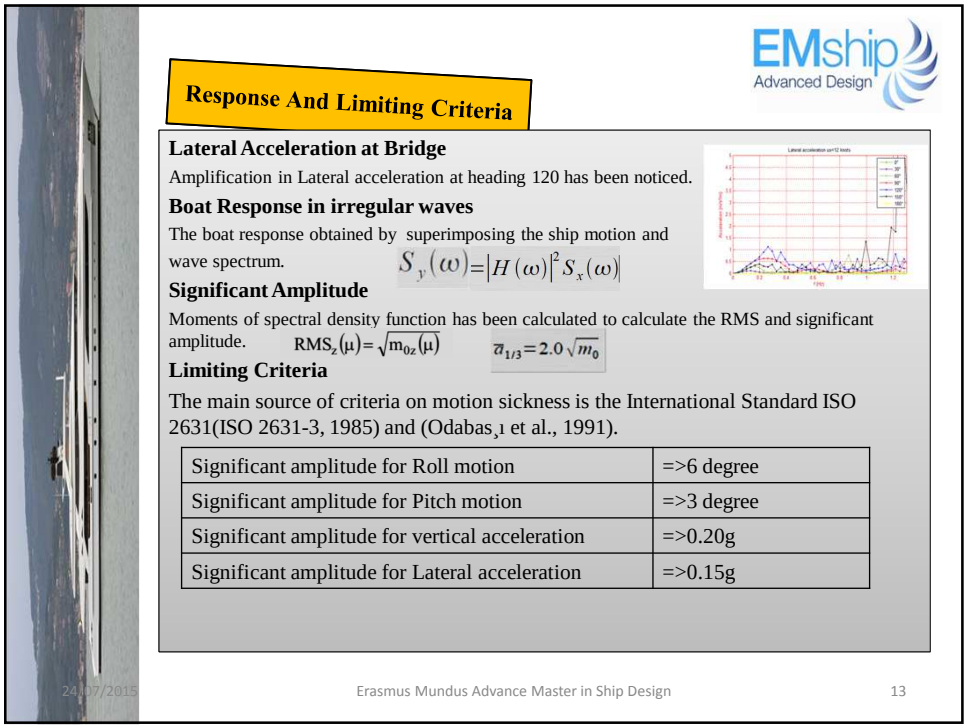
WAVE SPECTRUM

- Irregular sea is described by the Jonswap spectrum with following parameters
- Enhancement Factor γ
- Significant Wave Height $\zeta_{w,sig}$
- Peak Period T_p

	Sea States		3	4	5
	Significant wave height	$z_{w,sig}$	0.88 m	1.88 m	3.25 m
Aegean Sea	Peak Period	Tp	4.2s	5.4s	6.3s
Mediterranean	Peak Period	Tp	4.8 s	6.6 s	8.1 s

Sea state 3,4,5(Aegean Sea)

Sea state 3,4,5(Mediterranean)



Response And Limiting Criteria

Lateral Acceleration at Bridge

Amplification in Lateral acceleration at heading 120 has been noticed.

Boat Response in irregular waves

The boat response obtained by superimposing the ship motion and wave spectrum. $S_y(\omega) = |H(\omega)|^2 S_x(\omega)$

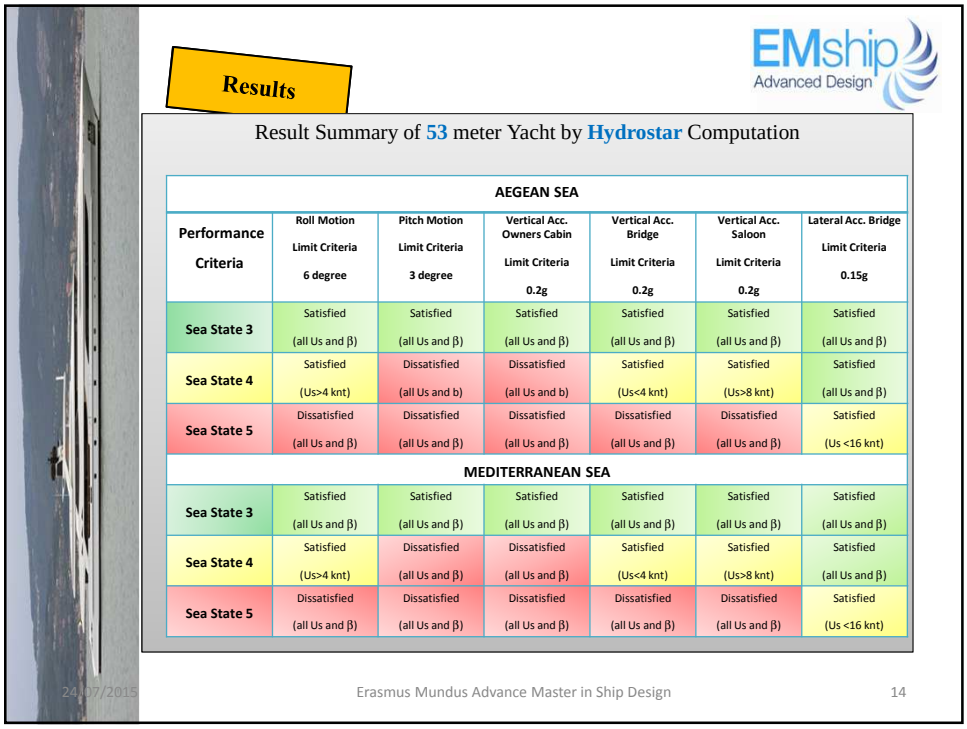
Significant Amplitude

Moments of spectral density function has been calculated to calculate the RMS and significant amplitude. $RMS_z(\mu) = \sqrt{m_{0z}(\mu)}$ $a_{1/3} = 2.0\sqrt{m_0}$

Limiting Criteria

The main source of criteria on motion sickness is the International Standard ISO 2631(ISO 2631-3, 1985) and (Odabaşı et al., 1991).

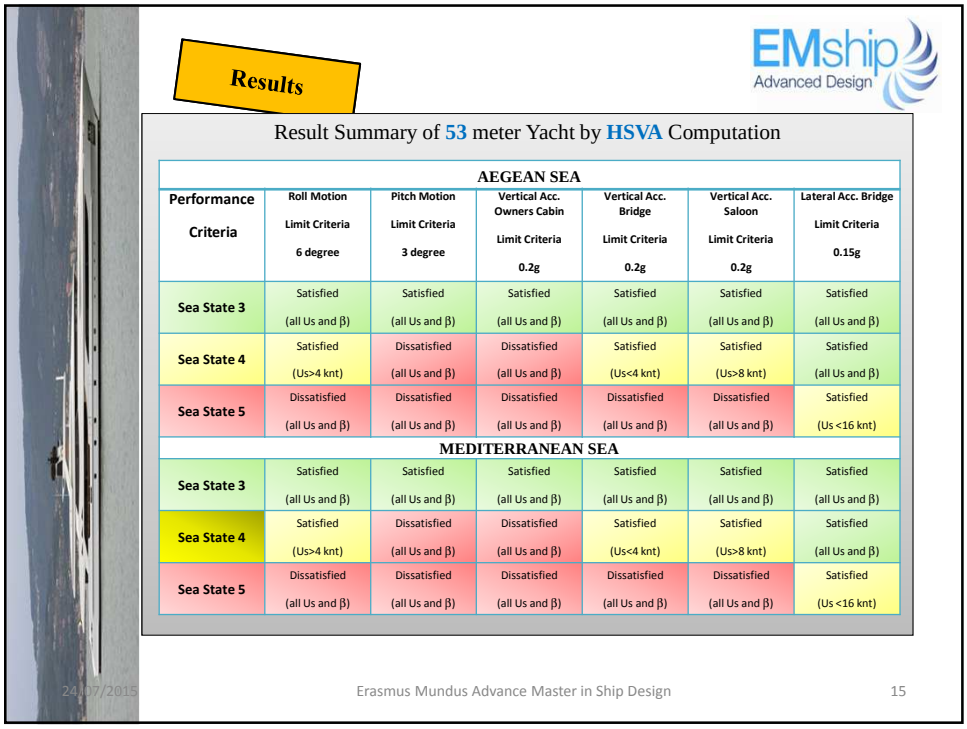
Significant amplitude for Roll motion	=>6 degree
Significant amplitude for Pitch motion	=>3 degree
Significant amplitude for vertical acceleration	=>0.20g
Significant amplitude for Lateral acceleration	=>0.15g



Results

Result Summary of **53** meter Yacht by **Hydrostar** Computation

AEGEAN SEA						
Performance Criteria	Roll Motion Limit Criteria 6 degree	Pitch Motion Limit Criteria 3 degree	Vertical Acc. Owners Cabin Limit Criteria 0.2g	Vertical Acc. Bridge Limit Criteria 0.2g	Vertical Acc. Saloon Limit Criteria 0.2g	Lateral Acc. Bridge Limit Criteria 0.15g
Sea State 3	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)
Sea State 4	Satisfied (Us>4 knt)	Dissatisfied (all Us and b)	Dissatisfied (all Us and b)	Satisfied (Us<4 knt)	Satisfied (Us>8 knt)	Satisfied (all Us and β)
Sea State 5	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Satisfied (Us <16 knt)
MEDITERRANEAN SEA						
Sea State 3	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)
Sea State 4	Satisfied (Us>4 knt)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Satisfied (Us<4 knt)	Satisfied (Us>8 knt)	Satisfied (all Us and β)
Sea State 5	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Satisfied (Us <16 knt)

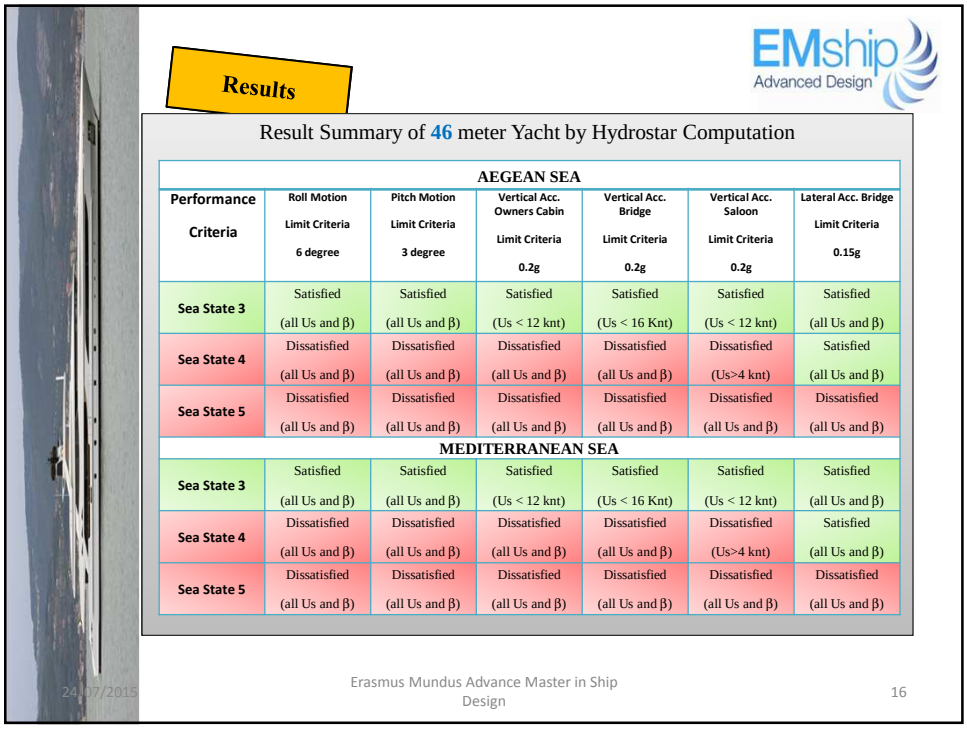


Results

EMship Advanced Design

Result Summary of **53** meter Yacht by **HSVA** Computation

Performance Criteria	Roll Motion Limit Criteria 6 degree	Pitch Motion Limit Criteria 3 degree	Vertical Acc. Owners Cabin Limit Criteria 0.2g	Vertical Acc. Bridge Limit Criteria 0.2g	Vertical Acc. Saloon Limit Criteria 0.2g	Lateral Acc. Bridge Limit Criteria 0.15g
AEGEAN SEA						
Sea State 3	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)
Sea State 4	Satisfied (Us>4 knt)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Satisfied (Us<4 knt)	Satisfied (Us>8 knt)	Satisfied (all Us and β)
Sea State 5	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Satisfied (Us <16 knt)
MEDITERRANEAN SEA						
Sea State 3	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (all Us and β)
Sea State 4	Satisfied (Us>4 knt)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Satisfied (Us<4 knt)	Satisfied (Us>8 knt)	Satisfied (all Us and β)
Sea State 5	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Satisfied (Us <16 knt)

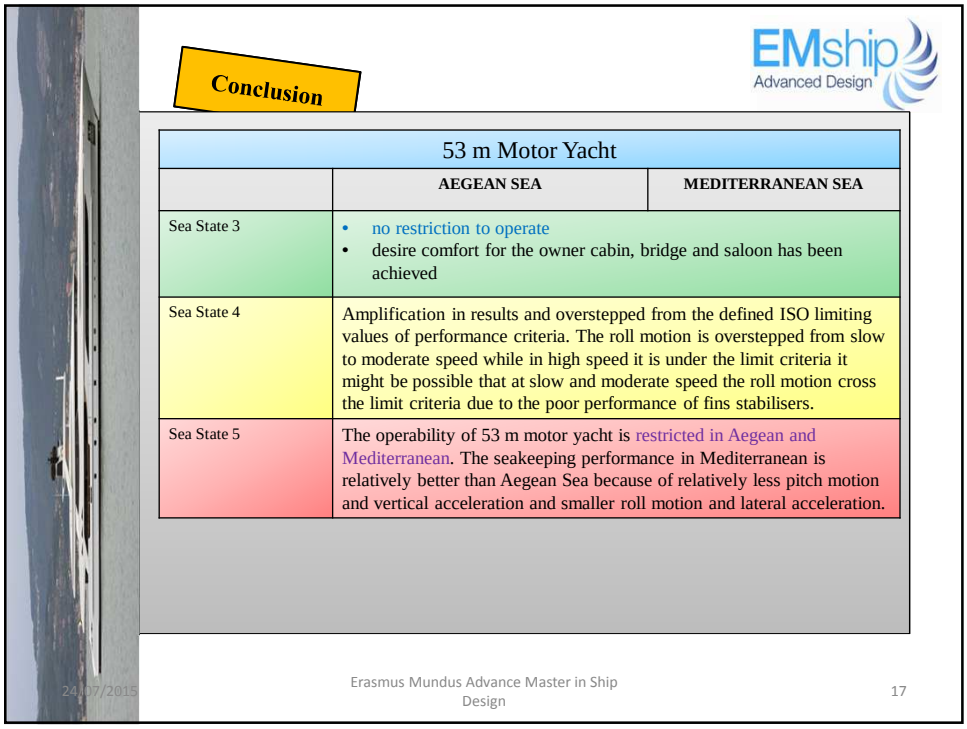


Results

EMship Advanced Design

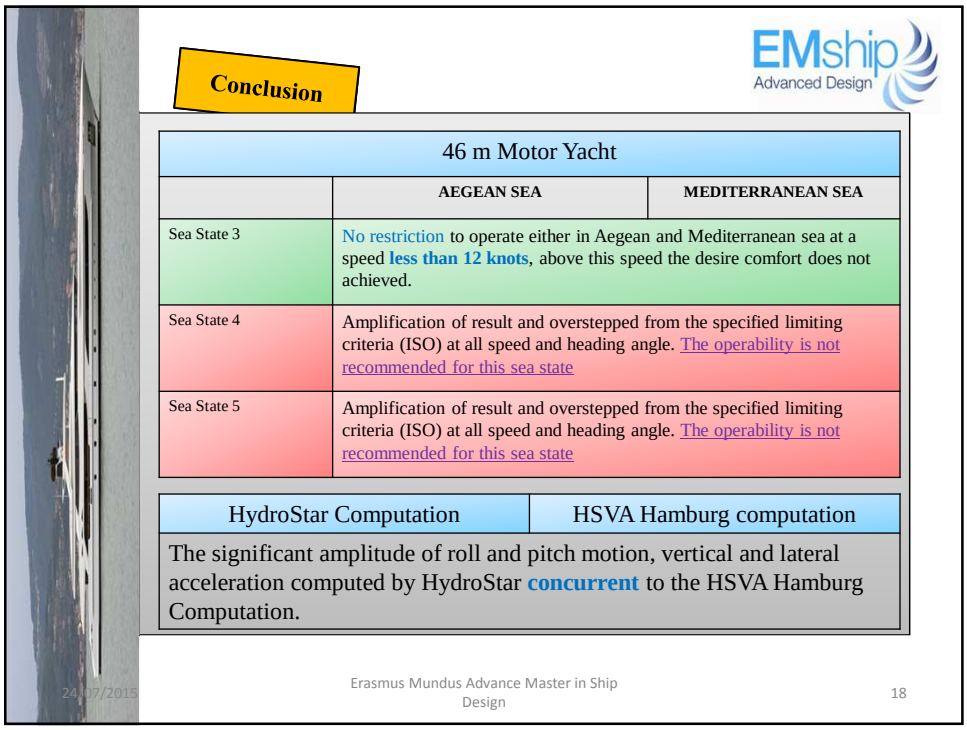
Result Summary of **46** meter Yacht by Hydrostar Computation

Performance Criteria	Roll Motion Limit Criteria 6 degree	Pitch Motion Limit Criteria 3 degree	Vertical Acc. Owners Cabin Limit Criteria 0.2g	Vertical Acc. Bridge Limit Criteria 0.2g	Vertical Acc. Saloon Limit Criteria 0.2g	Lateral Acc. Bridge Limit Criteria 0.15g
AEGEAN SEA						
Sea State 3	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (Us < 12 knt)	Satisfied (Us < 16 Knt)	Satisfied (Us < 12 knt)	Satisfied (all Us and β)
Sea State 4	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (Us>4 knt)	Satisfied (all Us and β)
Sea State 5	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)
MEDITERRANEAN SEA						
Sea State 3	Satisfied (all Us and β)	Satisfied (all Us and β)	Satisfied (Us < 12 knt)	Satisfied (Us < 16 Knt)	Satisfied (Us < 12 knt)	Satisfied (all Us and β)
Sea State 4	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (Us>4 knt)	Satisfied (all Us and β)
Sea State 5	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)	Dissatisfied (all Us and β)



Conclusion

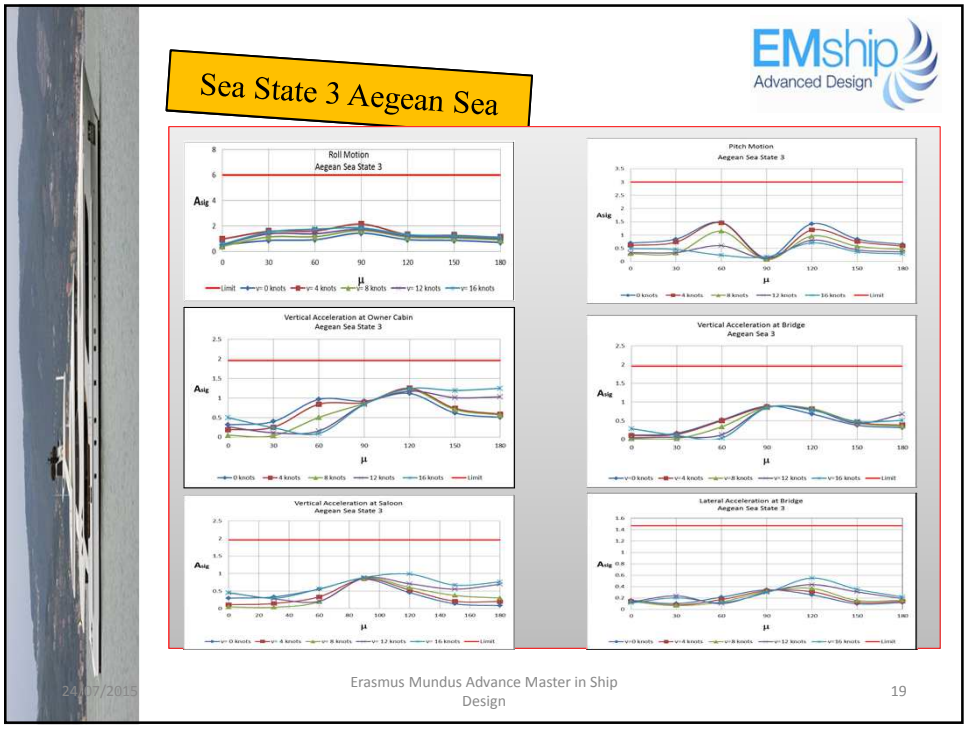
53 m Motor Yacht		
	AEGEAN SEA	**MEDITERRANEAN SEA**
Sea State 3	• no restriction to operate • desire comfort for the owner cabin, bridge and saloon has been achieved	
Sea State 4	Amplification in results and overstepped from the defined ISO limiting values of performance criteria. The roll motion is overstepped from slow to moderate speed while in high speed it is under the limit criteria it might be possible that at slow and moderate speed the roll motion cross the limit criteria due to the poor performance of fins stabilisers.	
Sea State 5	The operability of 53 m motor yacht is restricted in Aegean and Mediterranean. The seakeeping performance in Mediterranean is relatively better than Aegean Sea because of relatively less pitch motion and vertical acceleration and smaller roll motion and lateral acceleration.	



Conclusion

46 m Motor Yacht		
	AEGEAN SEA	**MEDITERRANEAN SEA**
Sea State 3	No restriction to operate either in Aegean and Mediterranean sea at a speed **less than 12 knots**, above this speed the desire comfort does not achieved.	
Sea State 4	Amplification of result and overstepped from the specified limiting criteria (ISO) at all speed and heading angle. The operability is not recommended for this sea state	
Sea State 5	Amplification of result and overstepped from the specified limiting criteria (ISO) at all speed and heading angle. The operability is not recommended for this sea state	

HydroStar Computation	HSVA Hamburg computation
The significant amplitude of roll and pitch motion, vertical and lateral acceleration computed by HydroStar **concurrent** to the HSVA Hamburg Computation.	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Roll Motion
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Pitch Motion
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Vertical Acceleration at Owner Cabin
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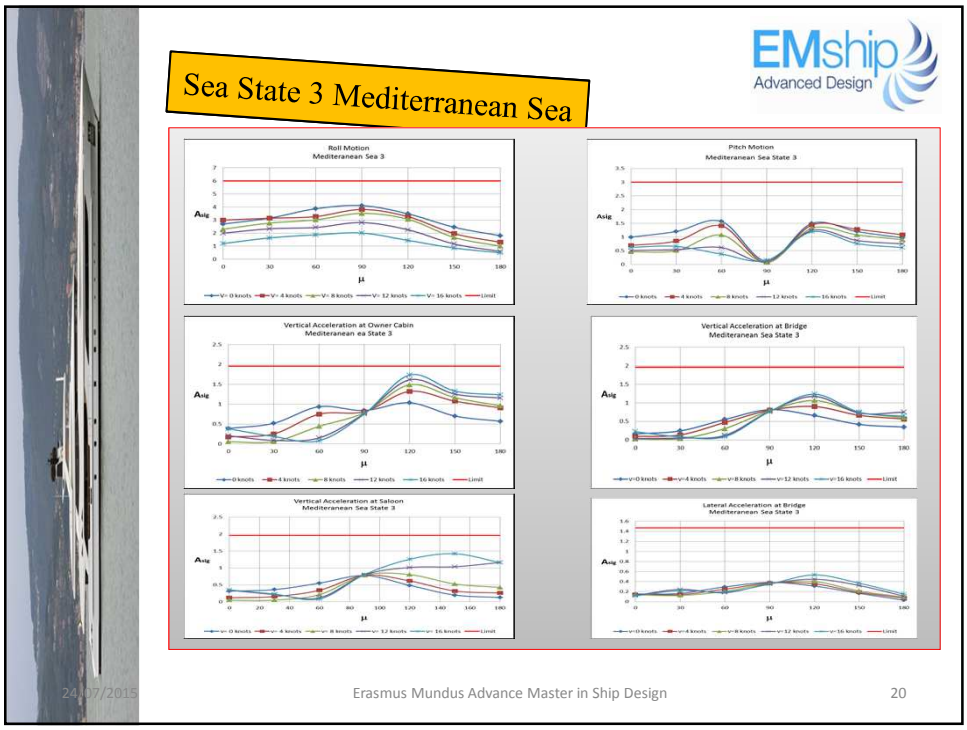
Vertical Acceleration at Bridge
Aegean Sea 3
Vertical Acceleration at Saloon
Aegean Sea State 3
Lateral Acceleration at Bridge
Aegean Sea State 3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Pitch Motion
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Vertical Acceleration at Owner Cabin
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Vertical Acceleration at Bridge
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Vertical Acceleration at Saloon
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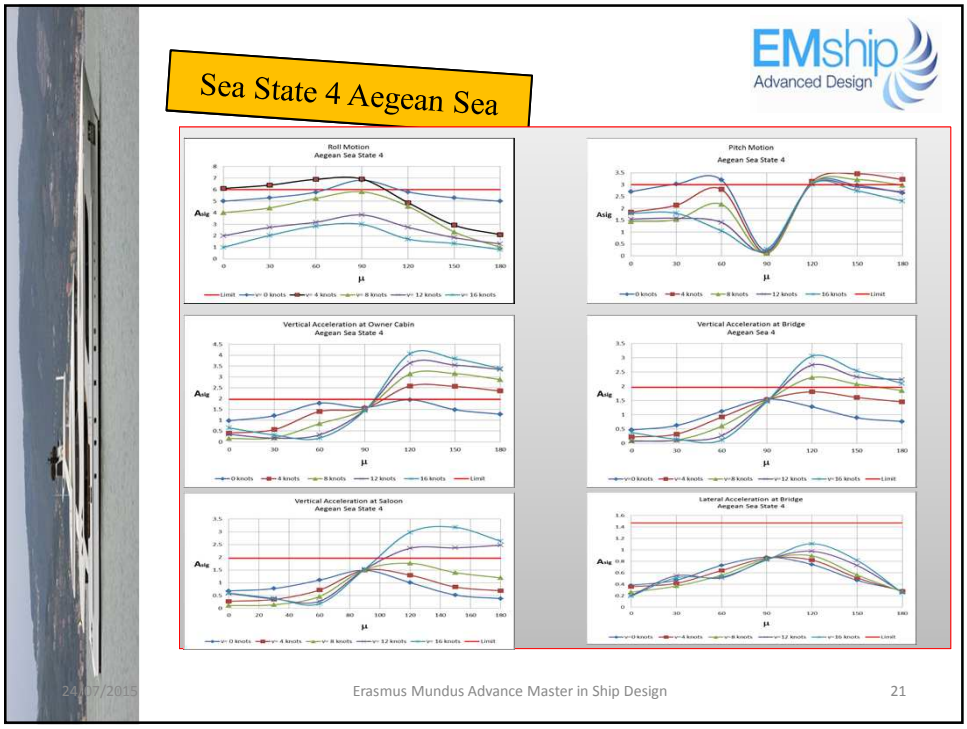
Lateral Acceleration at Bridge
Mediteranean Sea State 3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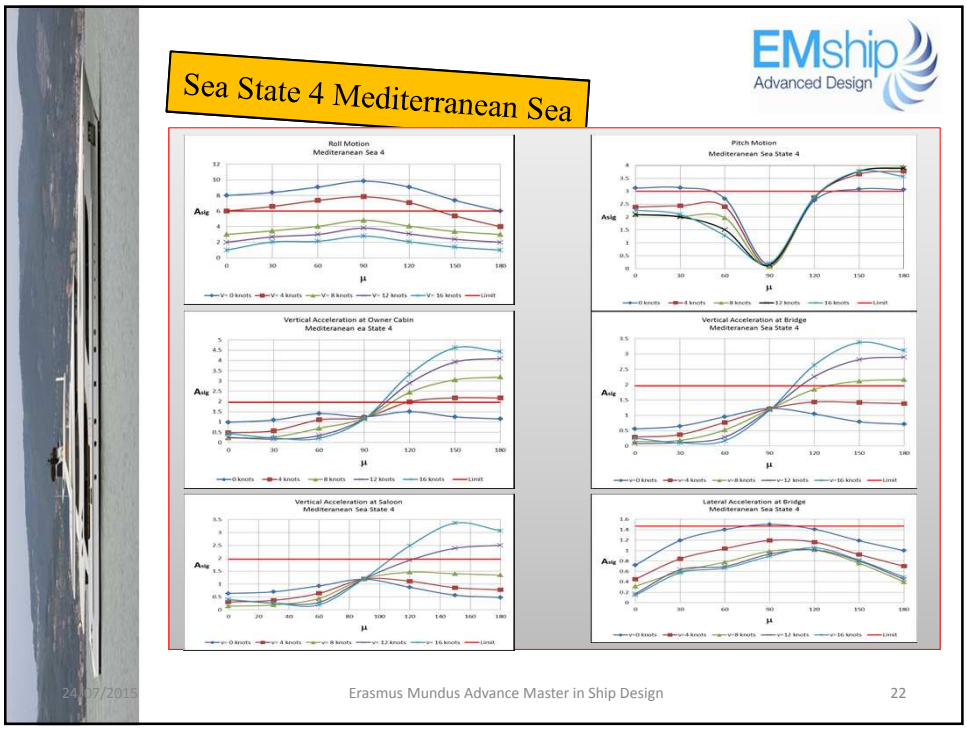
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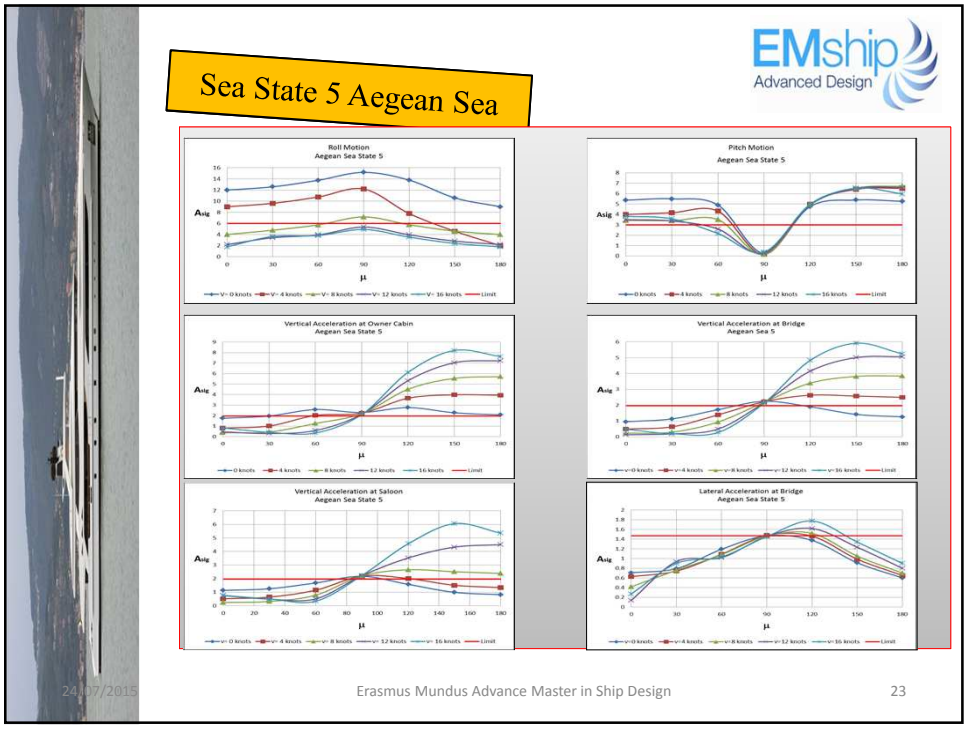
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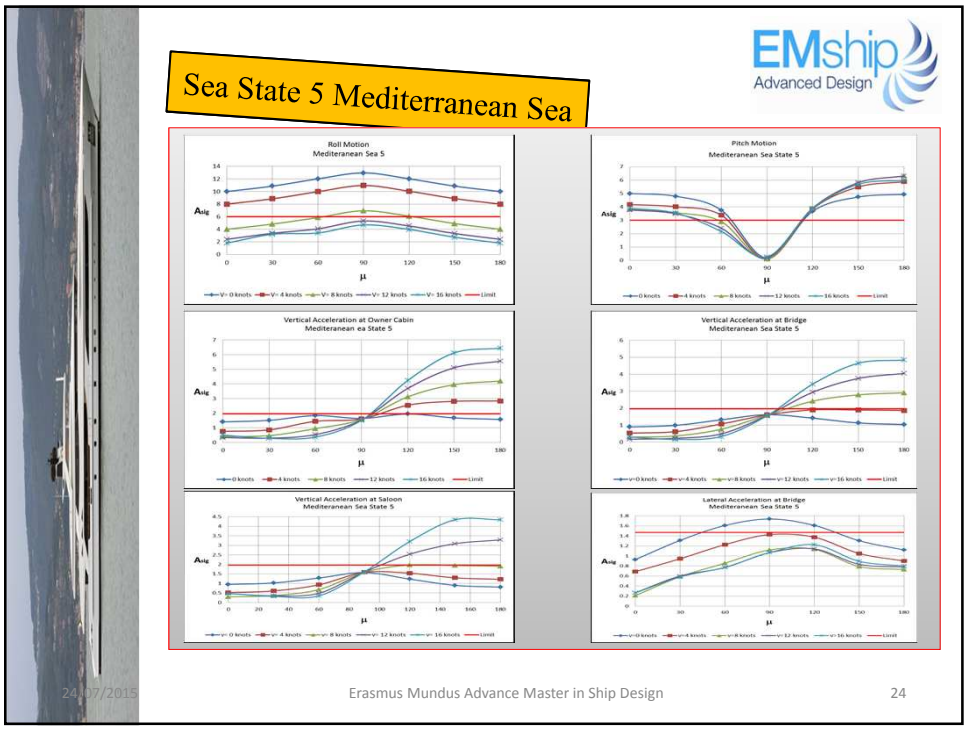
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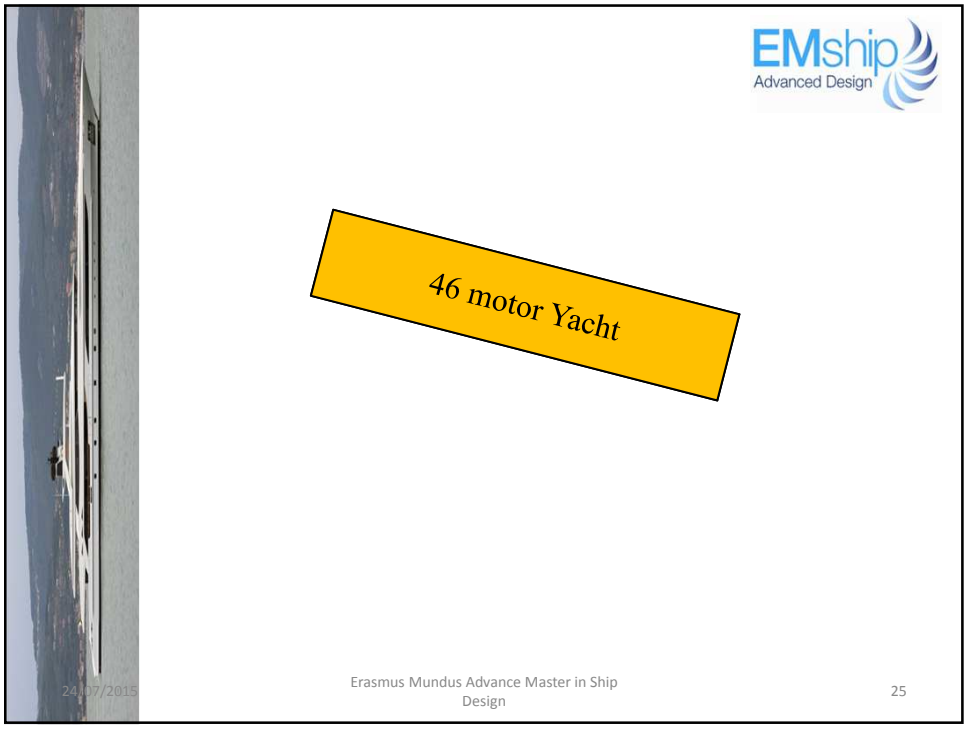
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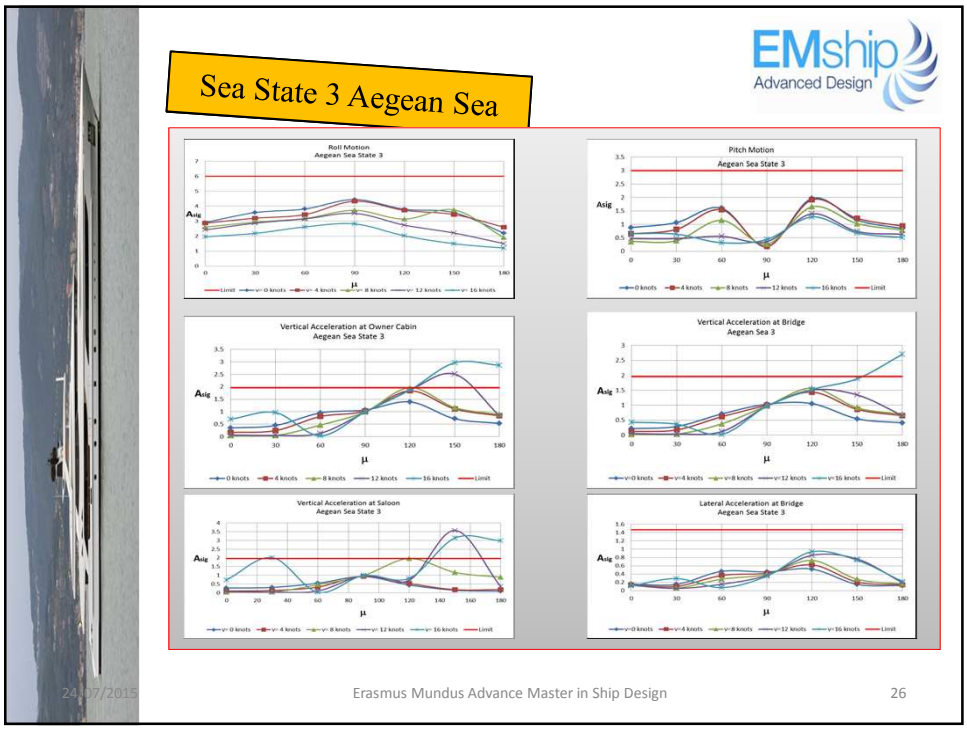
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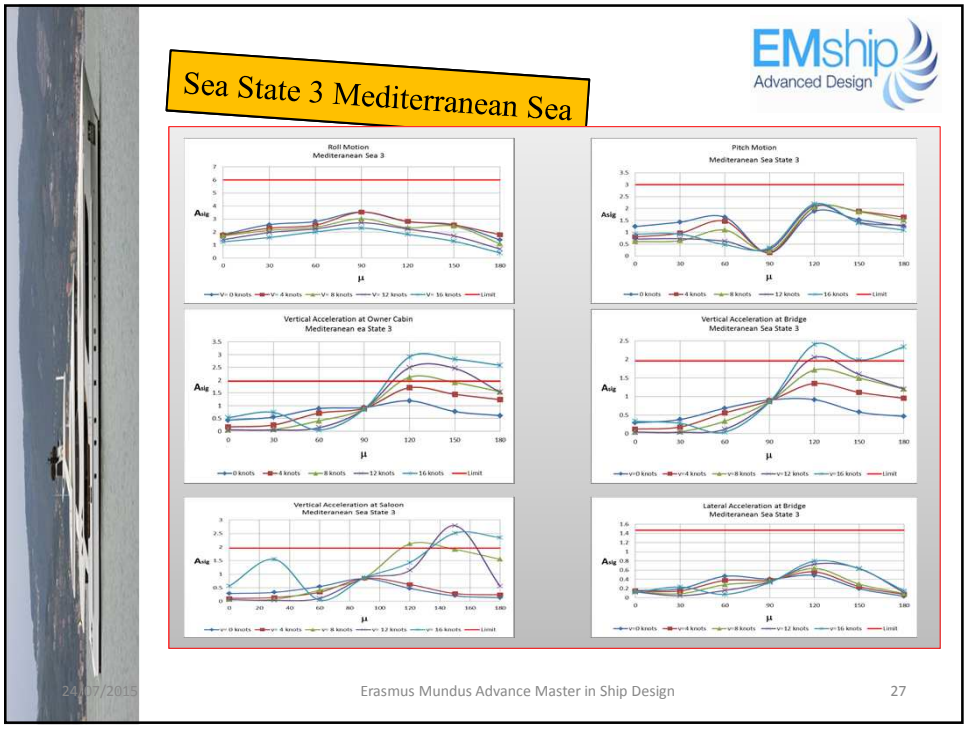
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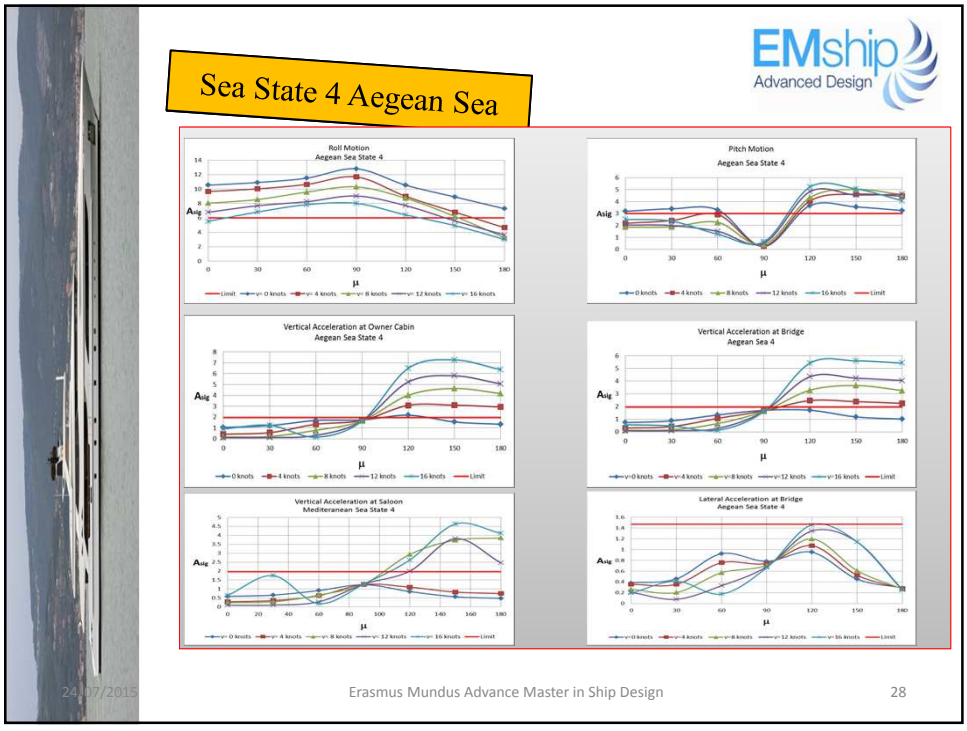
V= 0 knots
V= 4 knots
V= 8 knots
V= 12 knots
V= 16 knots
Limit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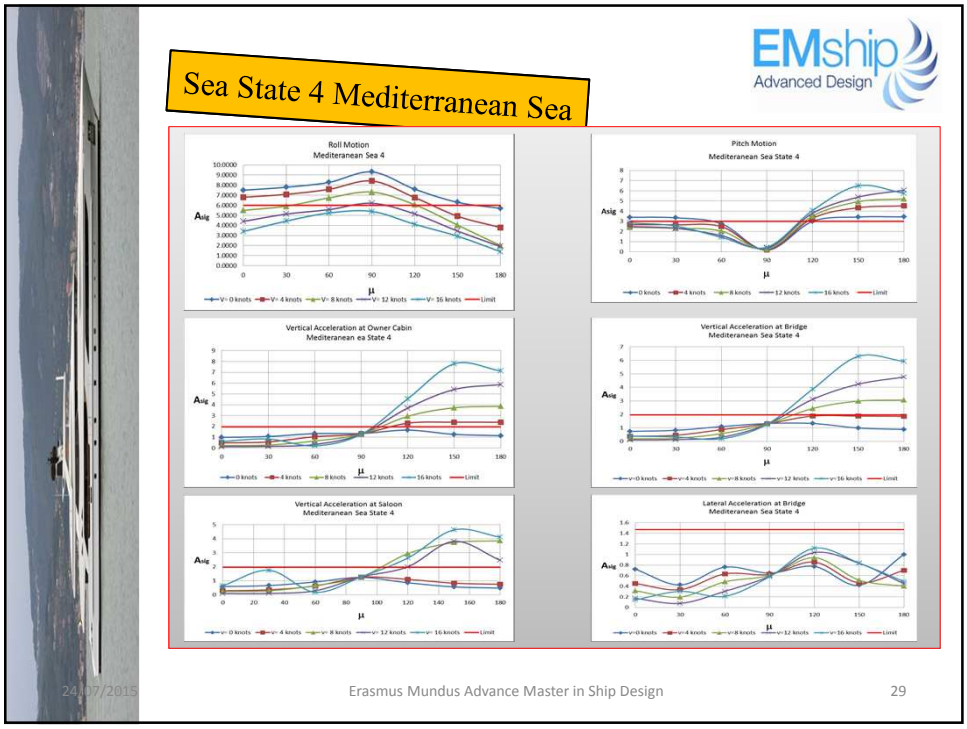
4 knots
8 knots
12 knots
16 knots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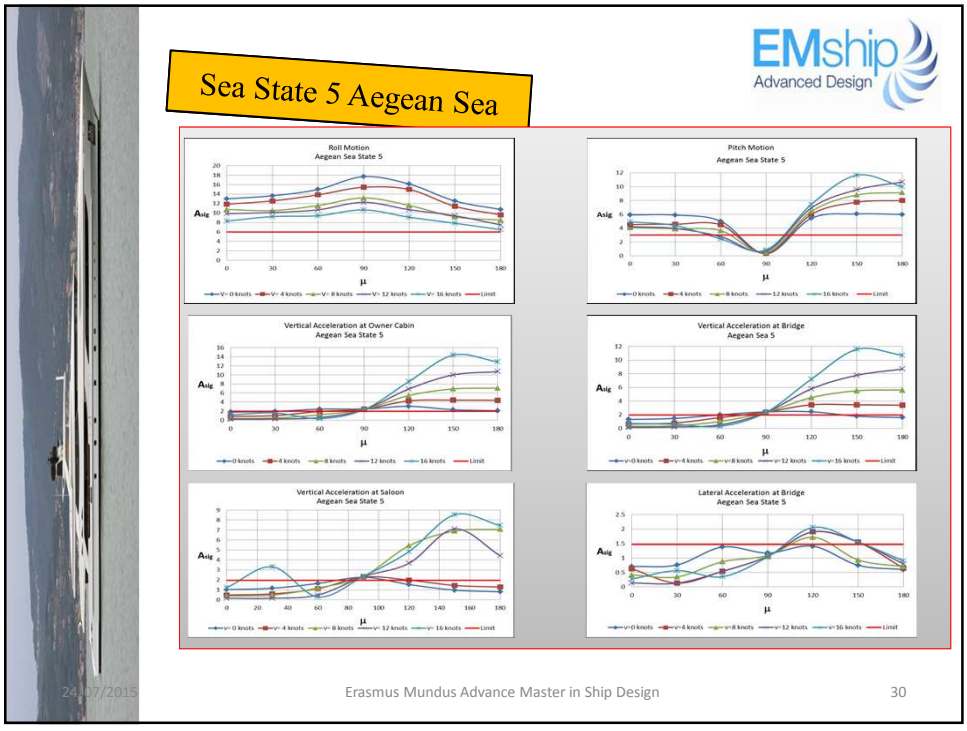
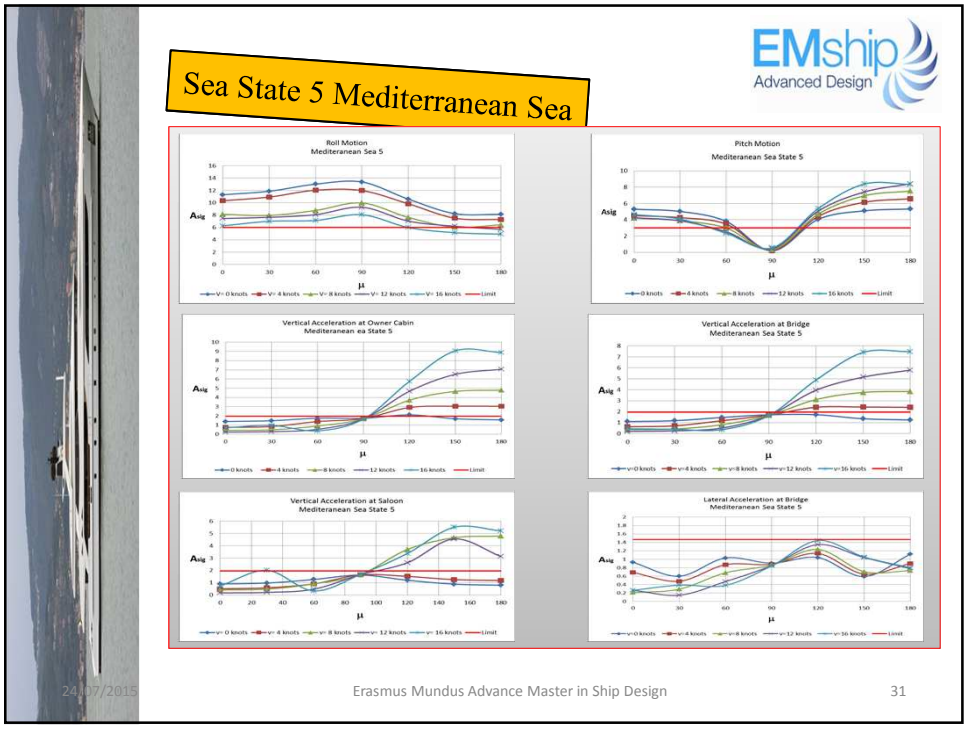
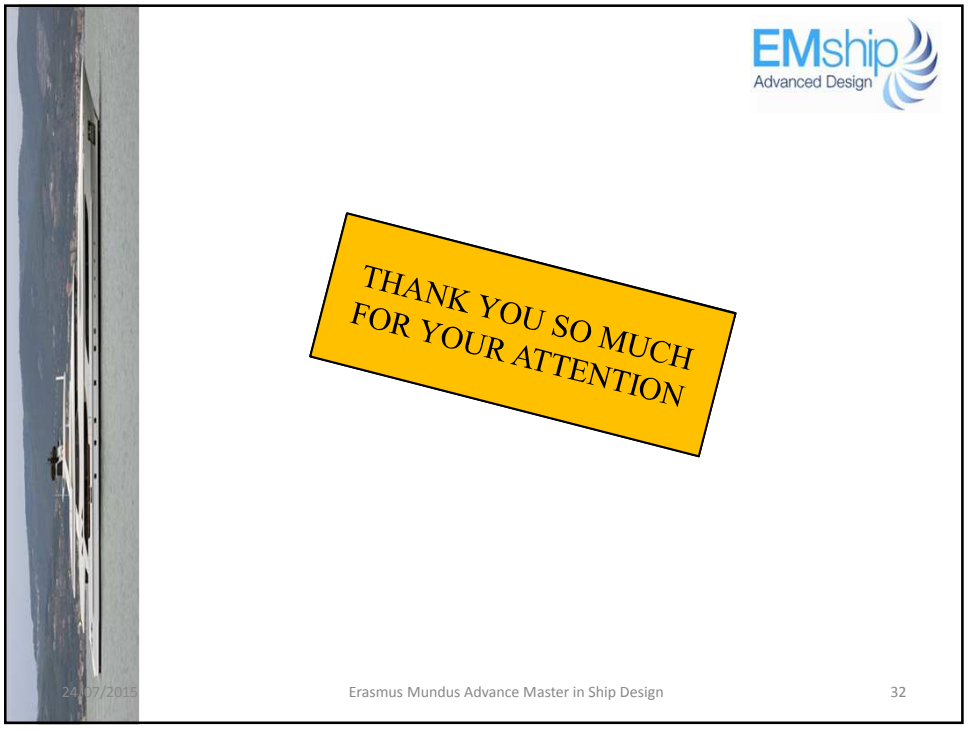

Sea State 5 Aegean Sea
EMship
Advanced Design
Roll Motion
Aegean Sea State 5
Pitch Motion
Aegean Sea State 5
Vertical Acceleration at Owner Cabin
Aegean Sea State 5
Vertical Acceleration at Bridge
Aegean Sea 5
Vertical Acceleration at Saloon
Aegean Sea State 5
Lateral Acceleration at Bridge
Aegean Sea State 5
24/07/2015
Erasmus Mundus Advance Master in Ship Design
30


Sea State 5 Mediterranean Sea
EMship
Advanced Design
Roll Motion
Mediteranean Sea 5
Pitch Motion
Mediteranean Sea State 5
Vertical Acceleration at Owner Cabin
Mediteranean ea State 5
Vertical Acceleration at Bridge
Mediteranean Sea State 5
Vertical Acceleration at Saloon
Mediteranean Sea State 5
Lateral Acceleration at Bridge
Mediteranean Sea State 5
Asig
μ
V= 0 knots
V= 4 knots
V= 8 knots
V= 12 knots
V= 16 knots
Limit


EMship
Advanced Design
THANK YOU SO MUCH
FOR YOUR ATTENTION