Optimizing Platform Configurations in the Early Design Phase of Floating Wind Turbines

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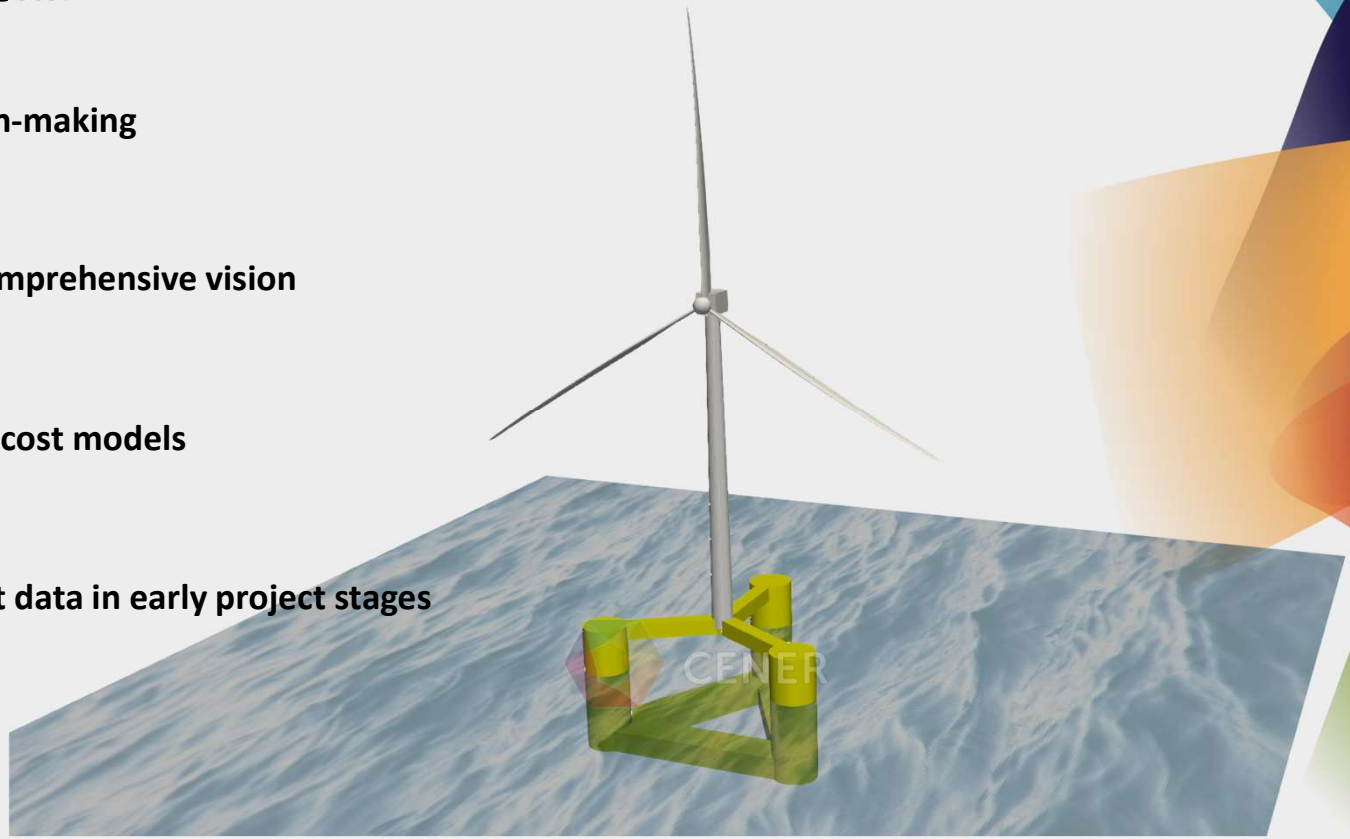
Introduction

<u>Needs</u> detected in floating wind projects:

- **Efficient tools for decision-making**
- **Analyze FOWTs with a comprehensive vision**
- **Low complexity and CPU cost models**
- **Deal with uncertain input data in early project stages**



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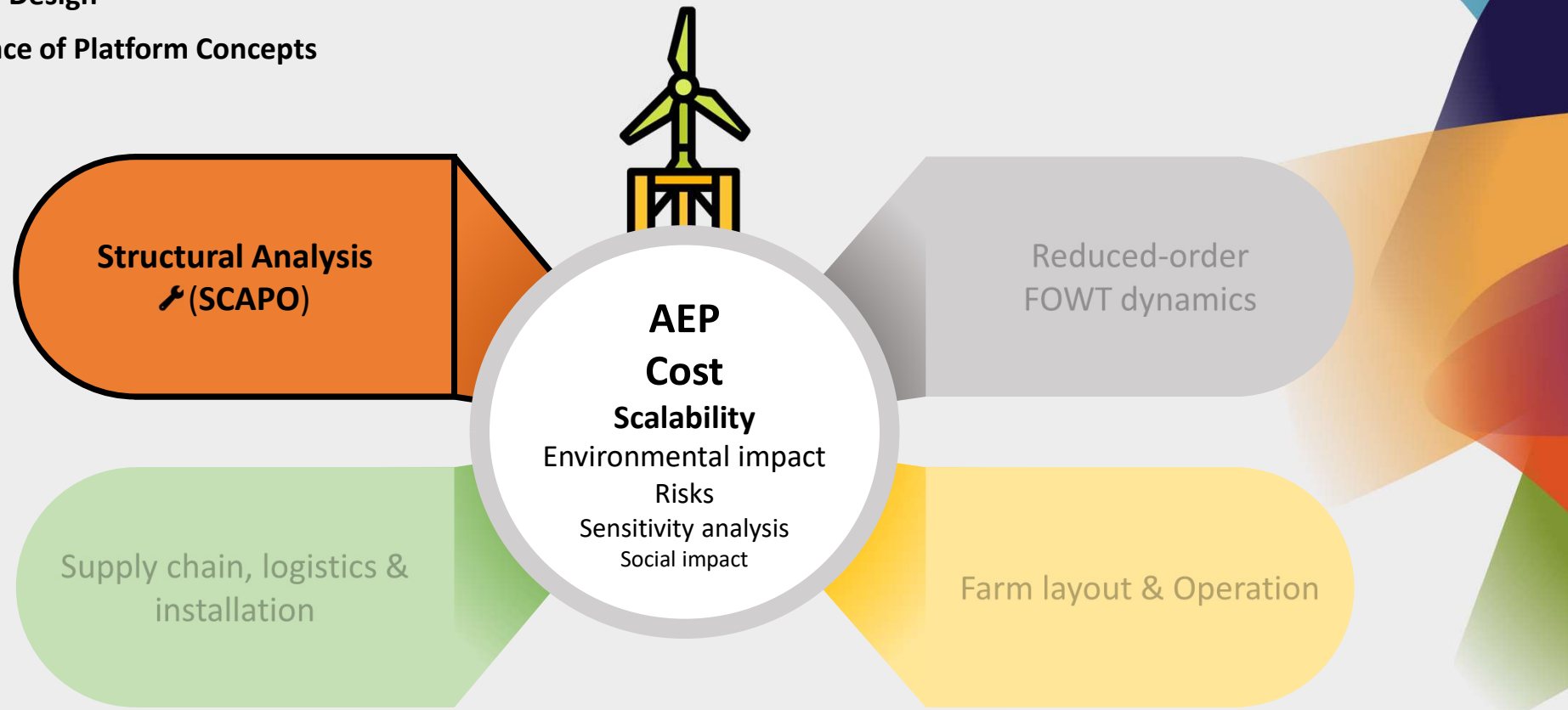
Introduction

Design ecosystem developed at CENER for:

- **Early Phase Design**
- **Due Diligence of Platform Concepts**



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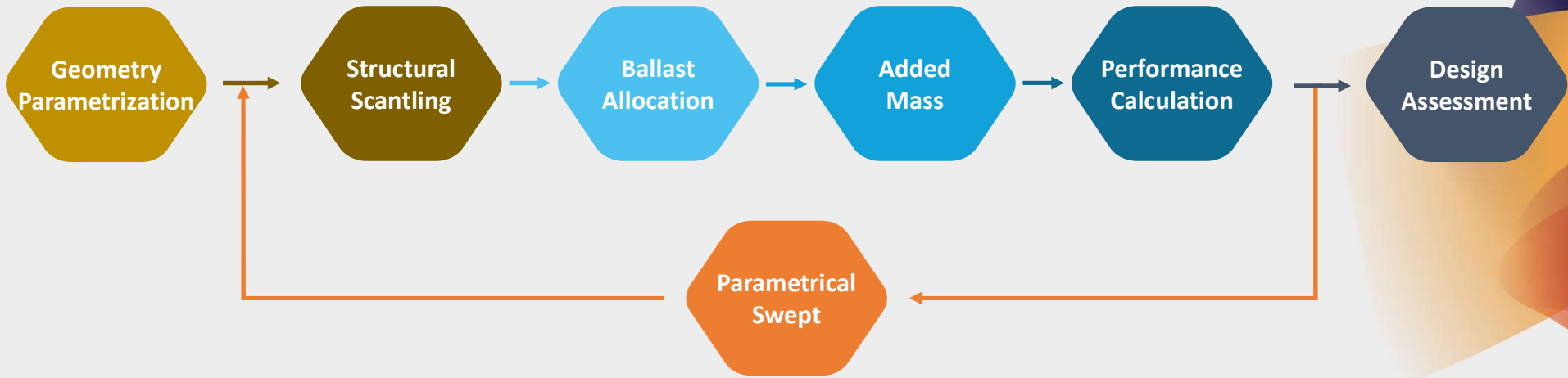
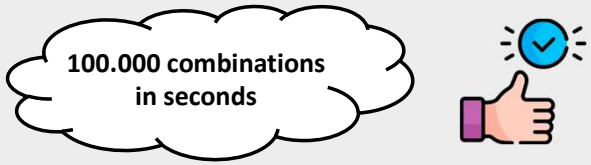
Methodology – Flow Diagram

SCAPO - SCAntling Platform Optimizator

Structural steel estimation with low computational cost.





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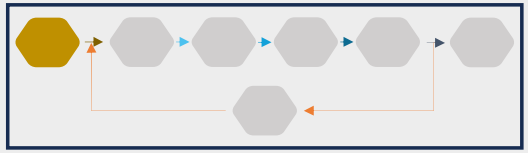
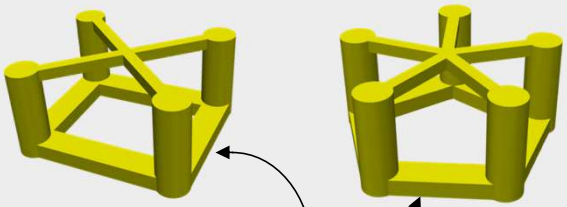
Methodology

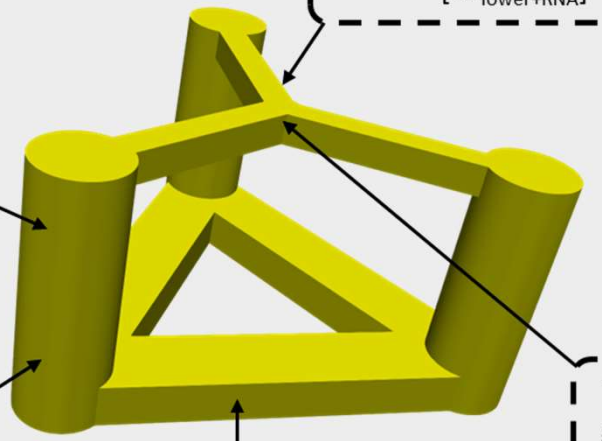




Geometry Parametrization

Parameters:
- Nº of Columns
- Column Distance to Tower (C-C)
- Column Height
- Column Ø
- Draft
- Pontoon Width and Height

Tower + RNA Inertia Matrix
$[M_{Tower+RNA}]$



Tower located at the geometry barycenter

Cyclic symmetry

Mooring Stiffness Matrix
$[K_{Moor}]$

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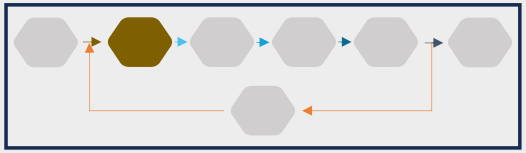
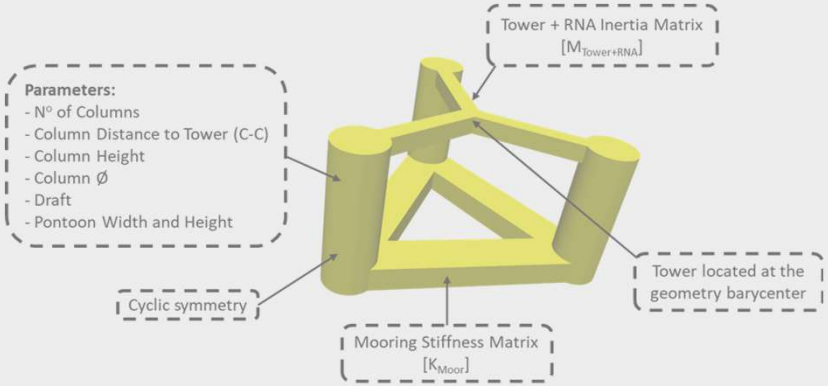
Methodology



Geometry Parametrization



Structural Scantling

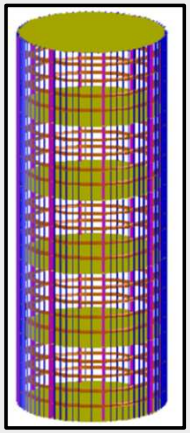
DNV-OS-J103

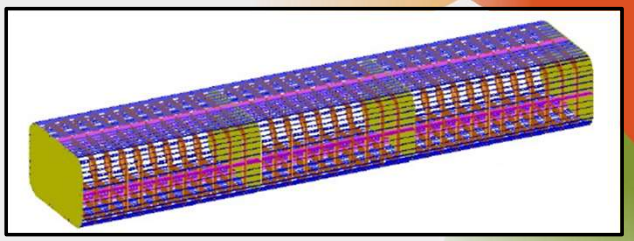
DNV-OS-C103

Steel Mass

Steel Inertias

Steel CM





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Methodology

Ballast Allocation

In platform geometry →

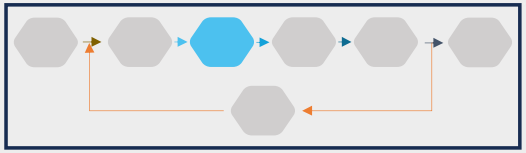
Tank i

Location

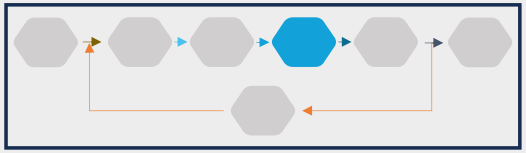
Mass

Inertias

CM



Methodology

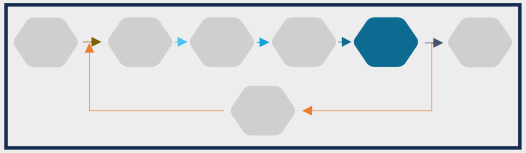


Ballast Allocation → In platform geometry → Tank i

- Location
- Mass
- Inertias
- CM

Added Mass → **Strip Theory**

Methodology



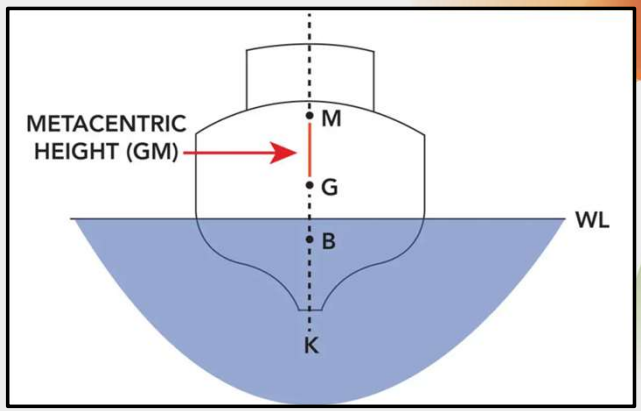
Ballast Allocation — In platform geometry → Tank i

- Location
- Mass
- Inertias
- CM

Added Mass — Strip Theory

Performance Calculation

- Platform Dimensions
- Steel Mass
- Ballast Distribution
- System Mass, Inertias, CM and CoB
- Transverse Stability (GM) →
- Hydrostatic Stiffness
- Natural Periods



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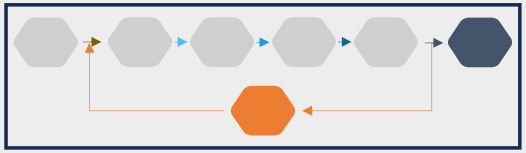
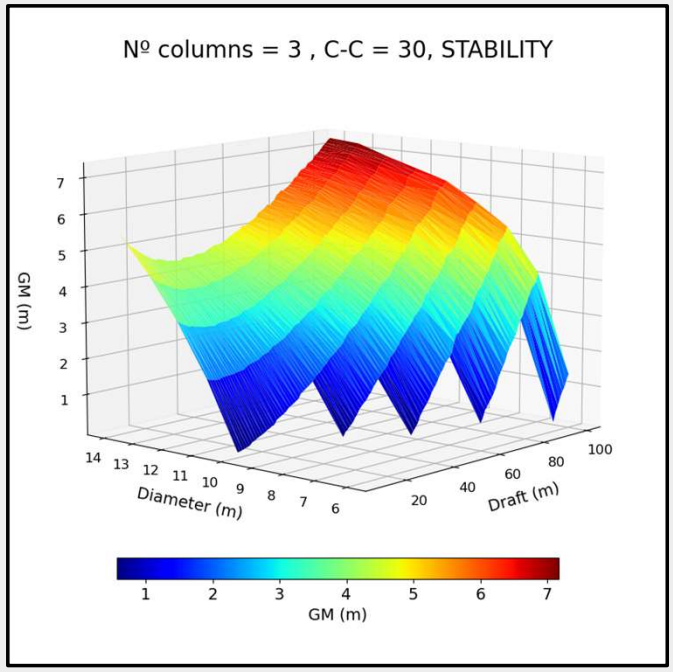
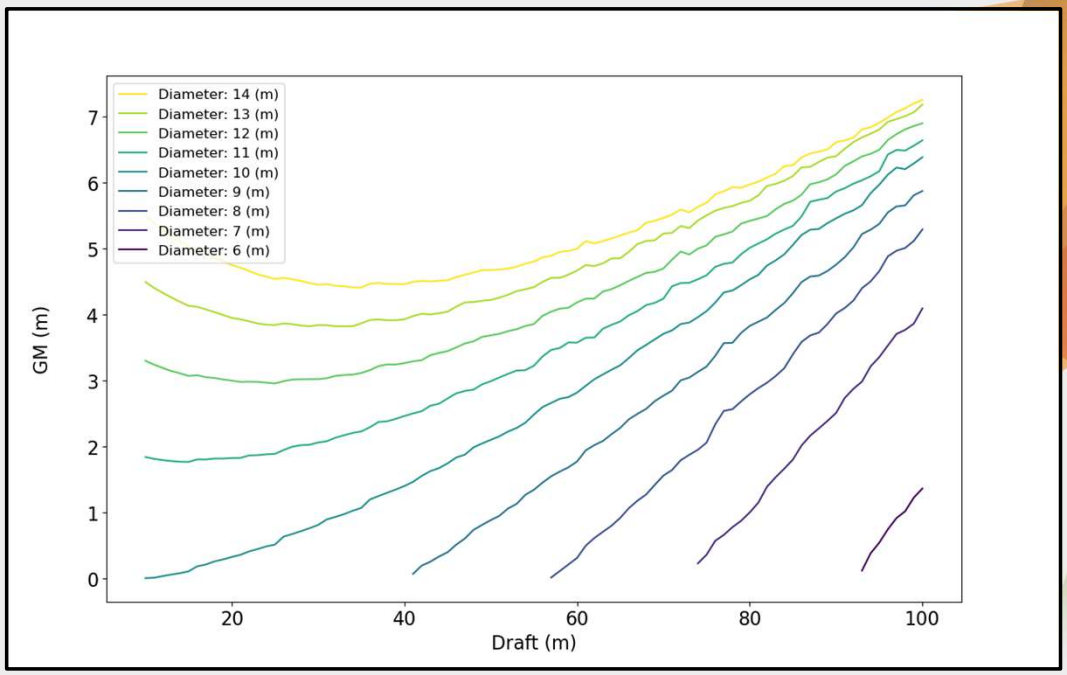
Methodology



Design Assessment





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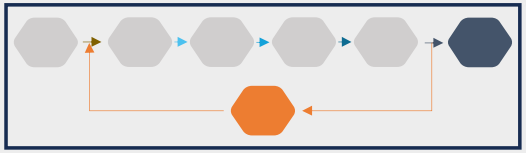
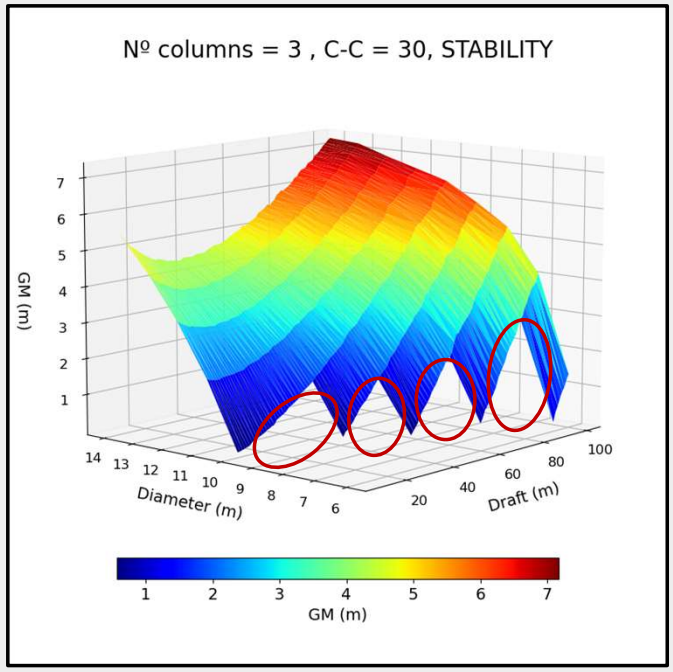
Methodology



Design Assessment



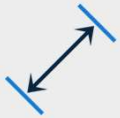
Cutoff criteria for negative GM

Results – 3 Column Floater

Floater characteristics:

INNWIND 10MW

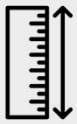
3 Columns



C-C Distance 40m

1

Optimization parameters:



Draft

Columns Diam.

2 param. for 3D graphs printing

2

Design objective & restrictions:

Minimize Steel Mass

Platform Pitch = 3.5° under rated wind speed

Natural Periods

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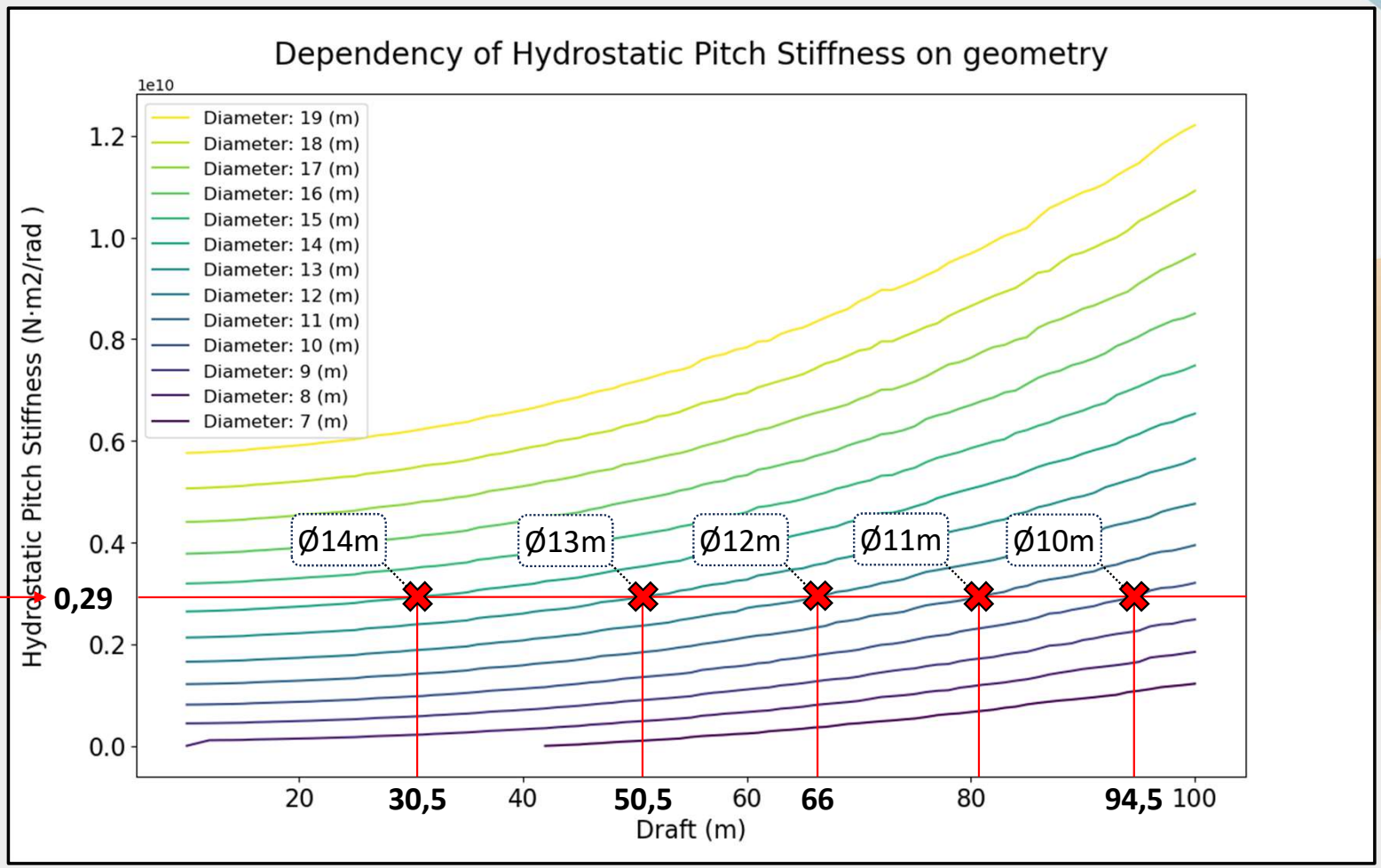
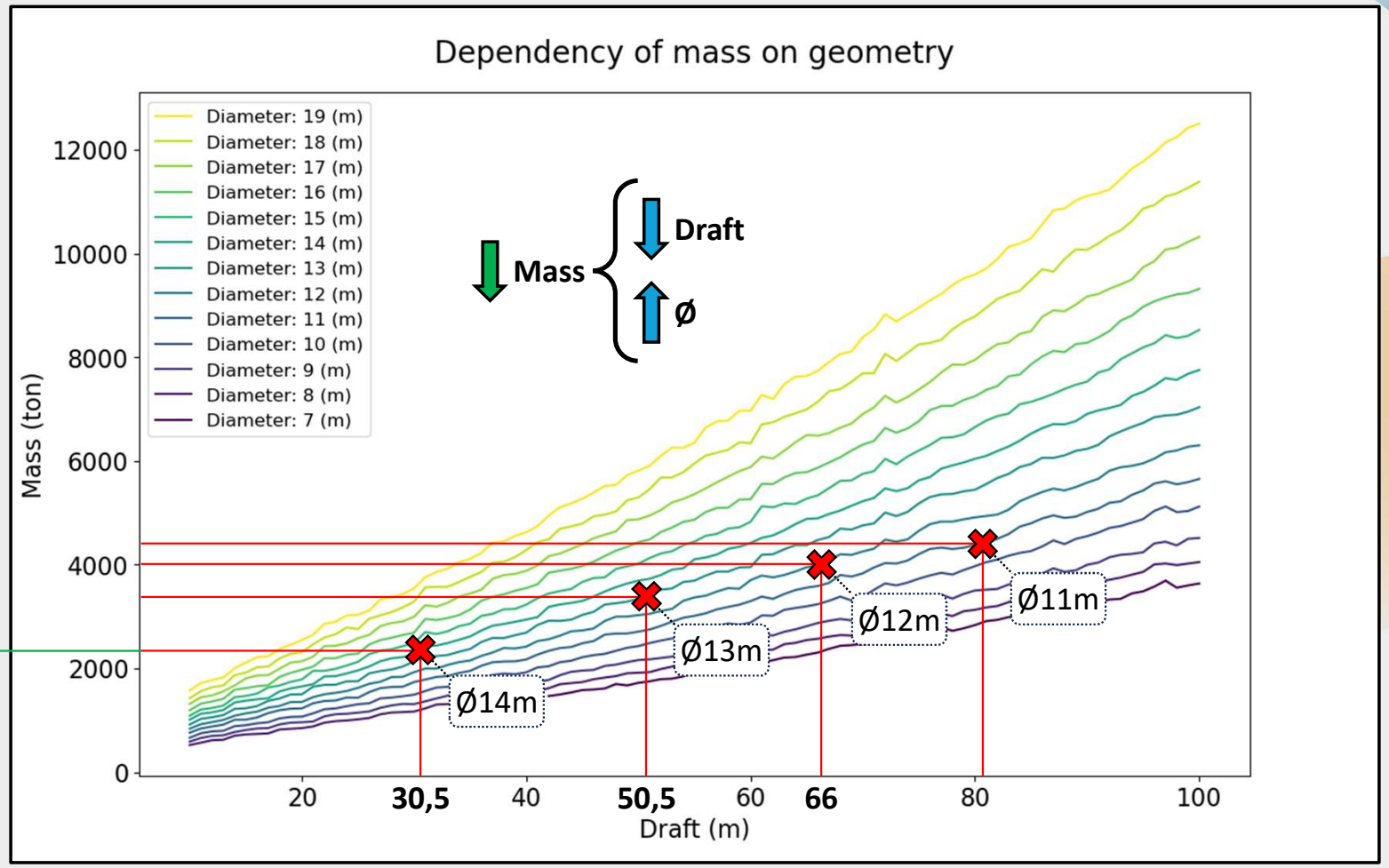
Results – 3 Column Floater

Pitch 3.5°
At max thrust

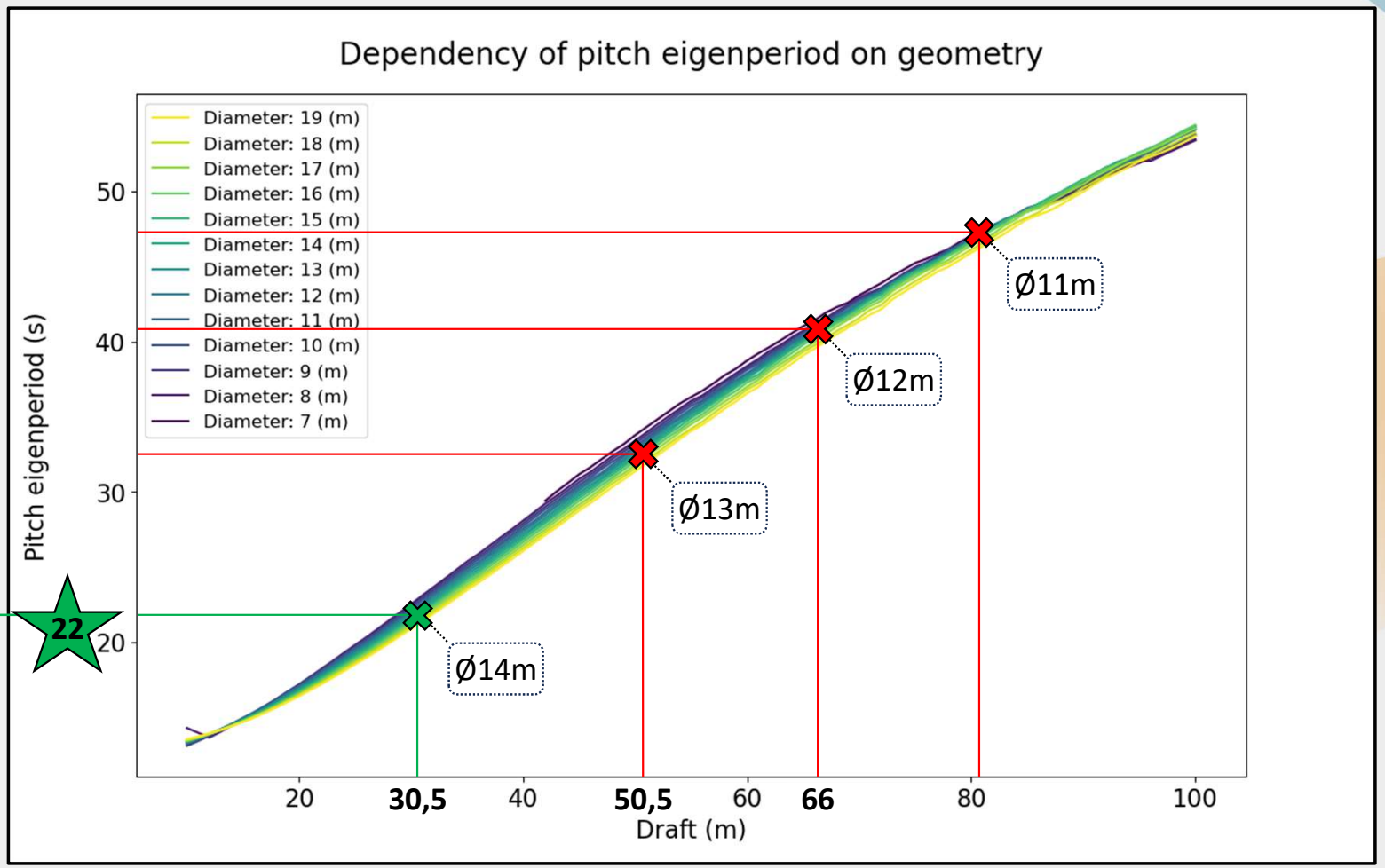
Pitch Stiffness
$2.9 \cdot 10^9$ (N·m/rad)



Results – 3 Column Floater

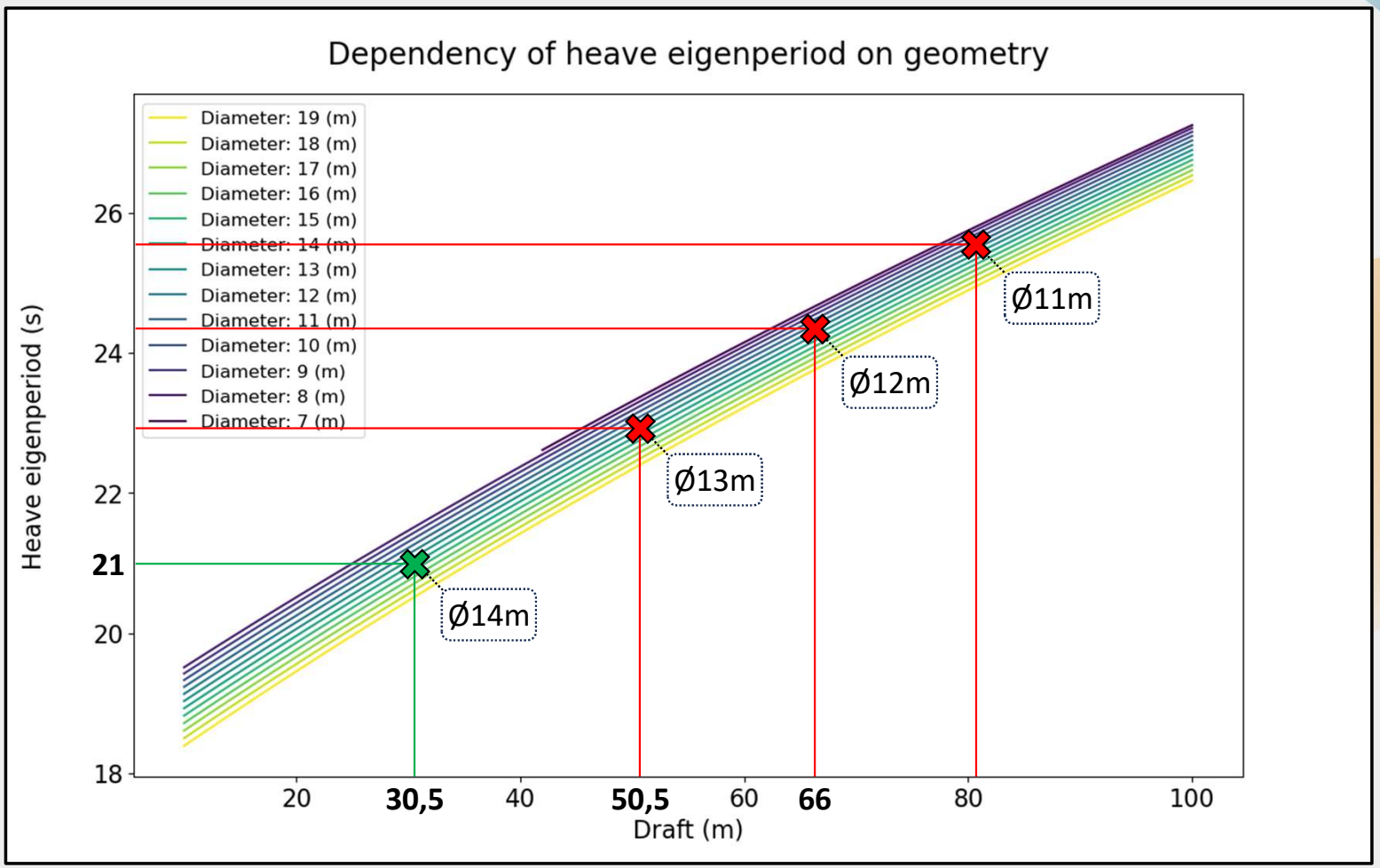


Results – 3 Column Floater



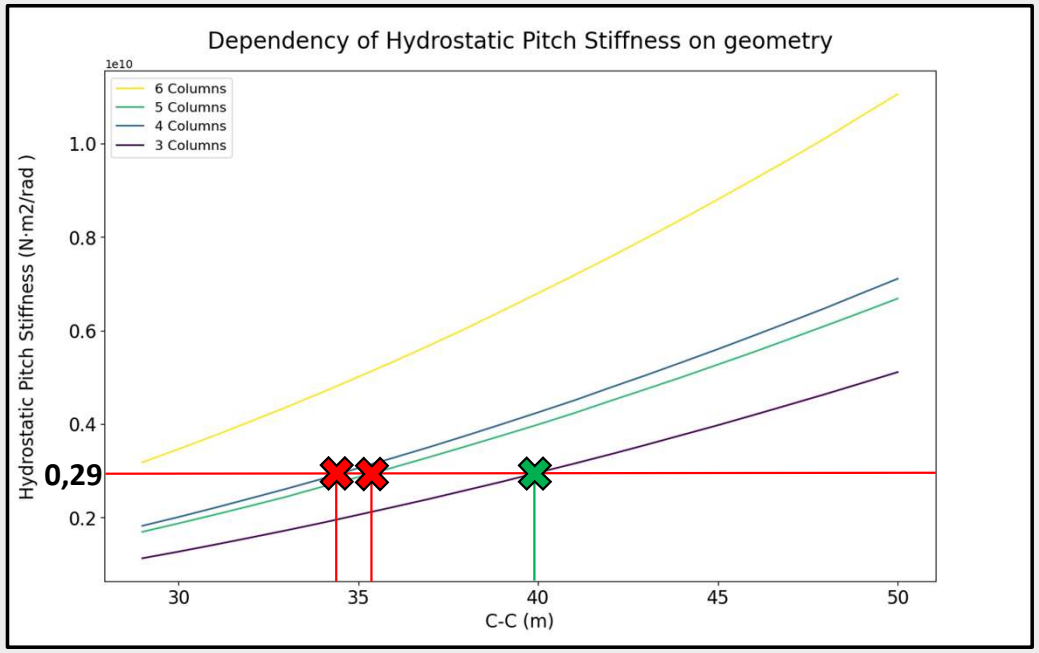
Longer than most wave periods

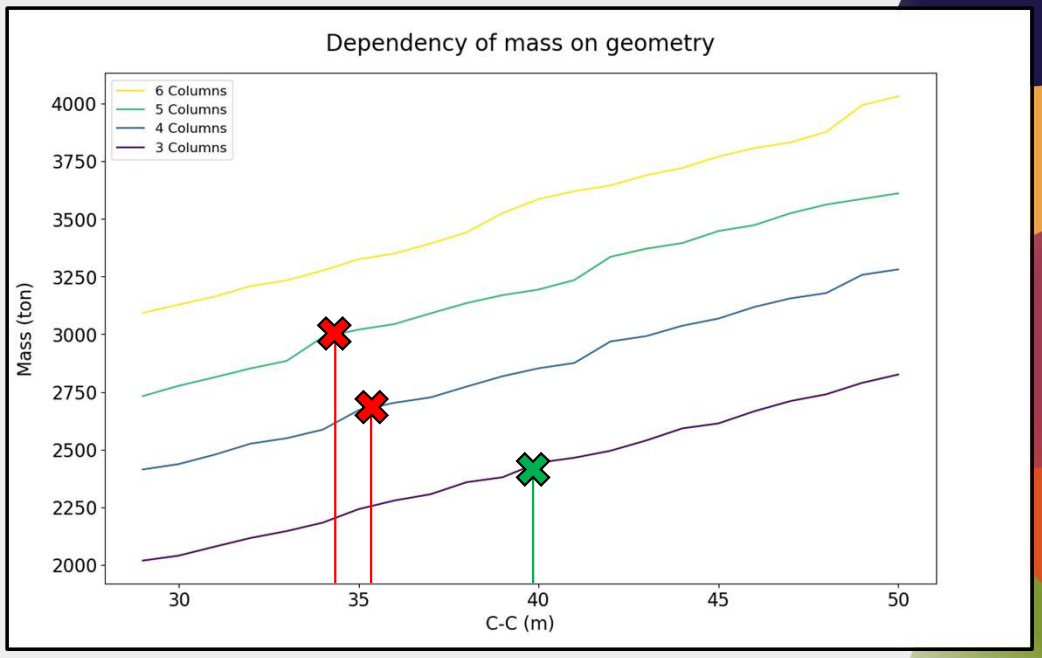
Results – 3 Column Floater



Results – Multiple Columns

Adding Ø14 (m) Columns





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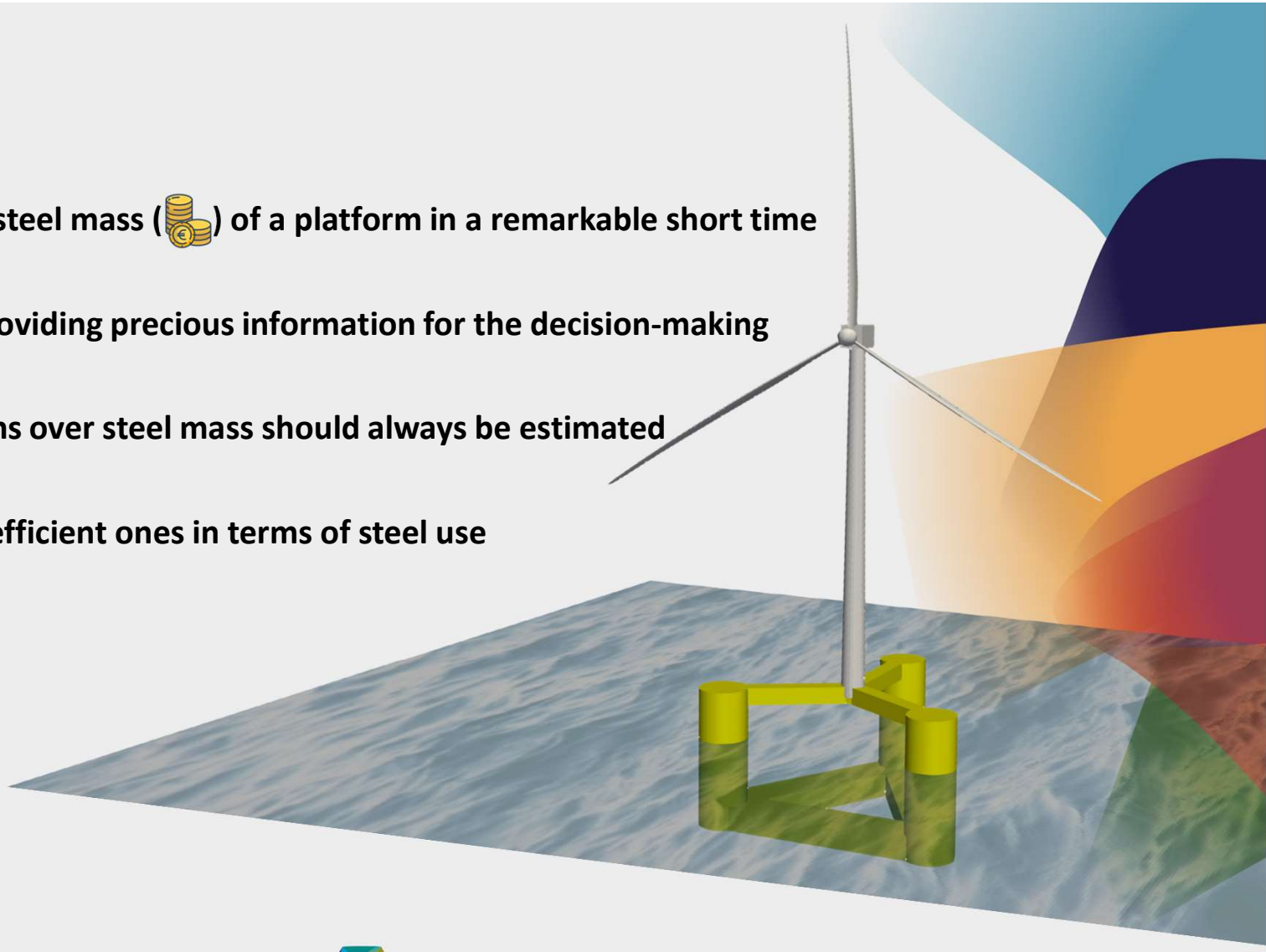
Conclusions

- SCAPO is able to estimate a fair steel mass ( ) of a platform in a remarkable short time
- Can cover a vast design space providing precious information for the decision-making
- The effect of design modifications over steel mass should always be estimated
- 3-Column designs are the most efficient ones in terms of steel use



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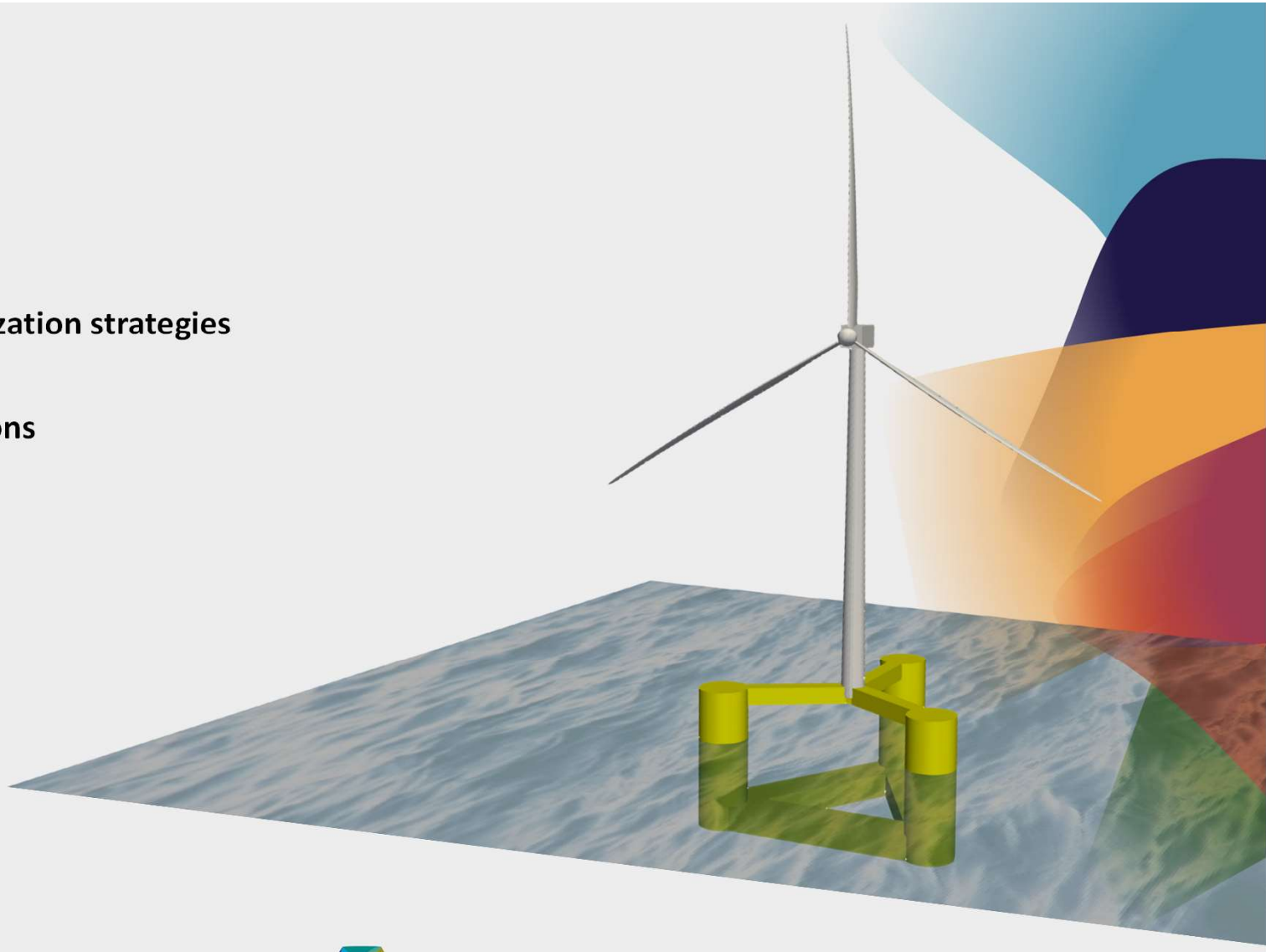
Future Works / Ongoing

- Include wave loading effects
- Implementation of other optimization strategies
- Possibility of other tower locations
- Consider manufacturing costs



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Thank you!

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