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TPN - NUMERICAL OFFSHORE TANK

Utilization of numerical simulation tools for aiding decisions about DP operations

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Universidade de São Paulo

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SUMMARY

- Introduction
- Numerical Simulator
- DP Crane Barge
- DP Drilling Vessel
- DP Shuttle Tanker

Numerical Simulator

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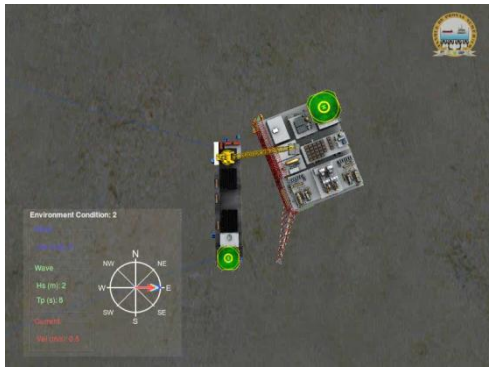
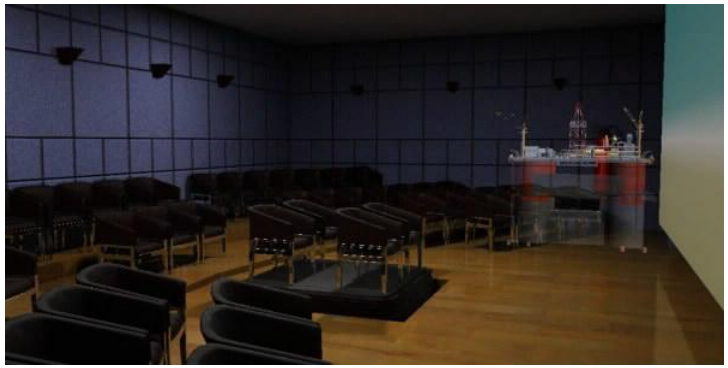
Tanque de Provas Numérico
(Numerical Offshore Tank)

Cluster: 1800 processors;
50 TeraFLOPS

Finite Element Line models
DP System
Multi-vessel dynamics



Virtual reality environment



Numerical Simulator

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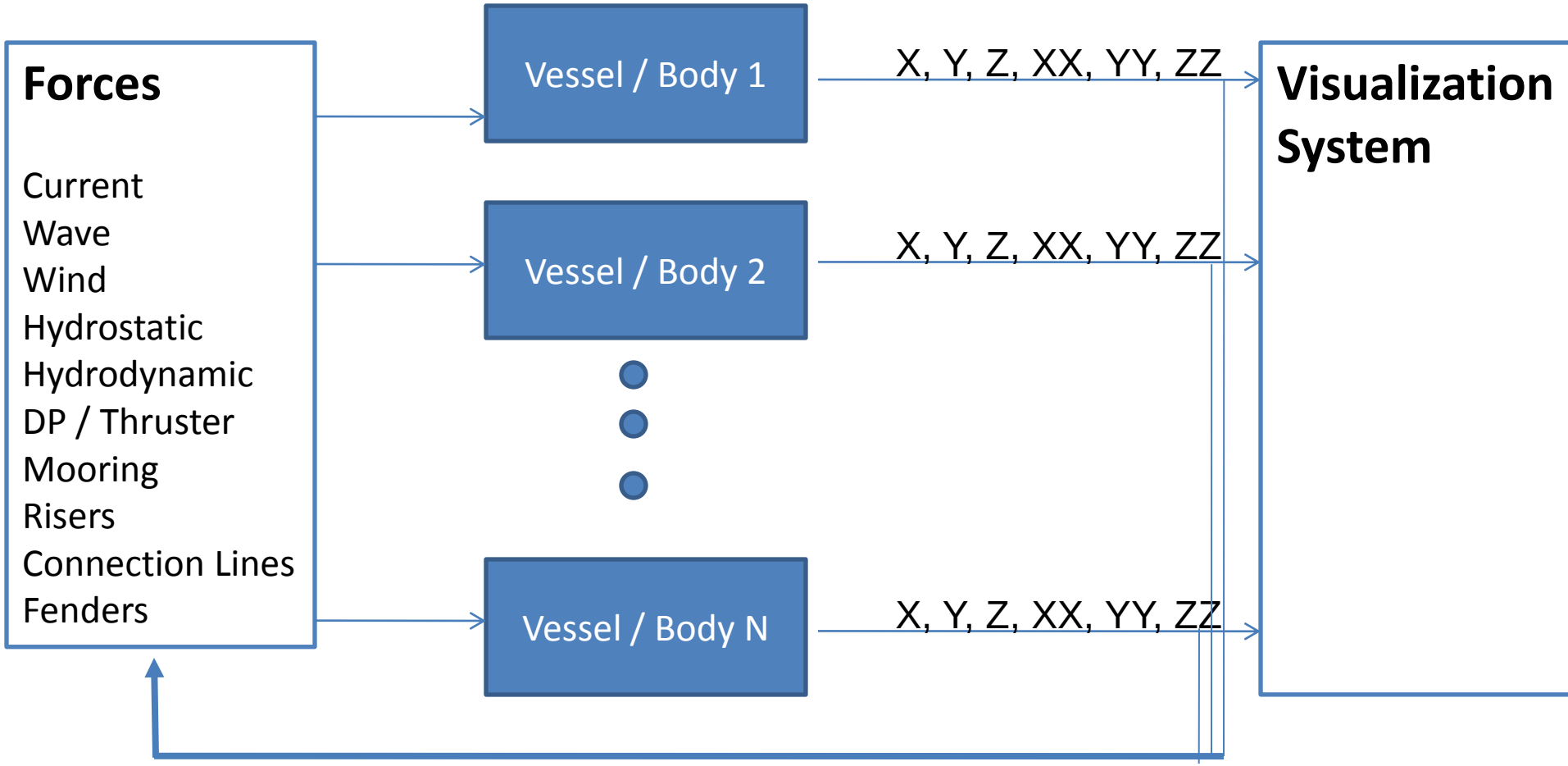
4th Order Runge Kutta Integration



Numerical Simulator

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TPN Time Domain Simulation System

Current

- Hydrodynamic Derivatives
- Cross Flow
- Optional: XY Current Field
  - Heuristic Model for Interference between Vessels (CFD based)

Waves

- Regular or Irregular Waves (several Spectrum formulations)
- 1st Order Haskind Forces
- 2nd Order Drift Forces (Including Vertical Motions – Under Research)
- Multi-Body Wave Field Interference
- Wave coefficients obtained from Wamit – fully integrated in the simulation loop
- Optional Coefficients from Hydrostar / Aqwa

Hydrostatic

- Integration with non-linear hydrostatic calculation software (under development)

Numerical Simulator

TPN Time Domain Simulation System

Winds

- Constant or Gusts (several spectrum formulations)
- Optional: XY wind field
  - Heuristic model for interference beween vessels (CFD based)

Lines (Risers, Mooring, Hawser)

- Characteristic curve
- Catenary Formulation
- Finite Element Model (Cluster Required)
- Fixed point anchor or multi-vessel connection lines

Fenders

- Non-linear restoring forces
- Drag and Friction

Numerical and Experimental Analysis of Floating Systems

TPN Time Domain Simulation System

DP + Thrusters

- PID Control + Kalman Filter
- Thruster Interference Based on Experimental Data
- Azimuth / Tunnel / Main Propeller

Extra Features

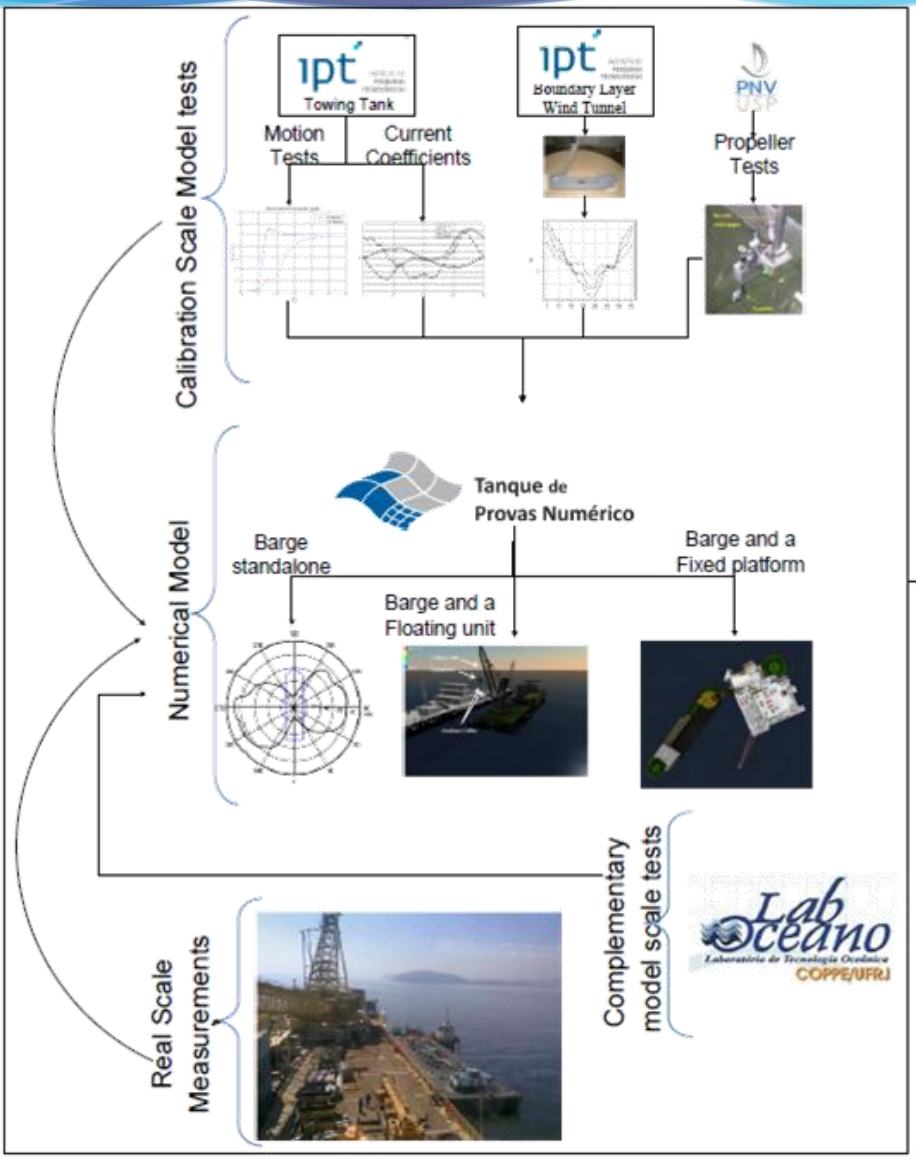
- Shallow Water /Confined Water Corrections
- Collision Detection

DP Crane Barge

Calibrate and validate the BGL-1 numerical models with the goal of make feasible and suffice the operation approval based in the numerical analysis with the TPN software.

DP Crane Barge

DP Crane Barge



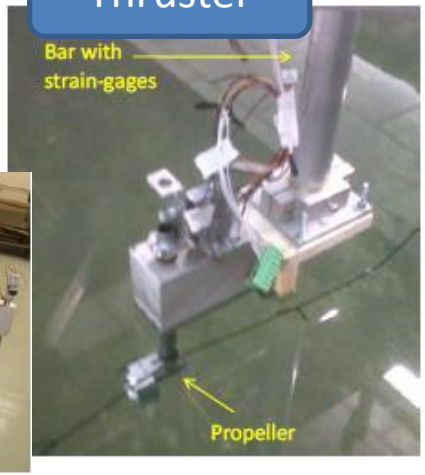
Analysis:

- Crane and Equipment Acceleration
- Thruster and DP Utilization
- Relative distance between units
- Motion
- Line Tension

Operational Window
&
Barge Safety position

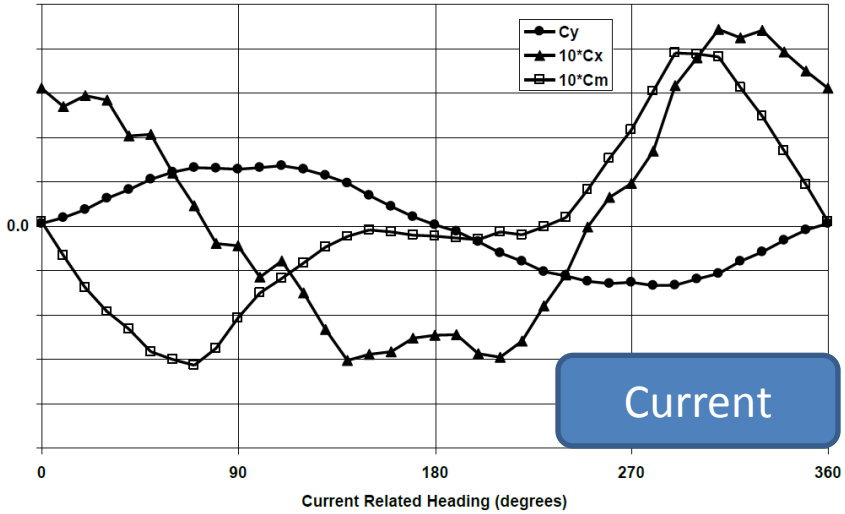
DP Crane Barge

Thruster



Small Scale Experiments

Wind



Current

Sea-Keeping

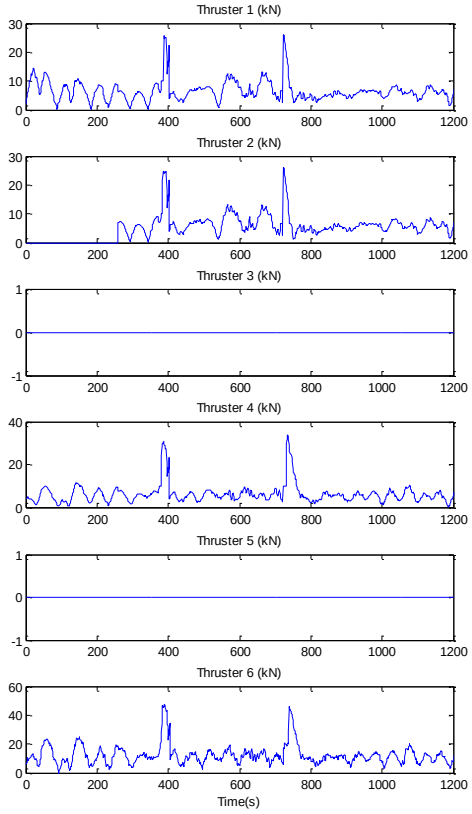
DP Crane Barge

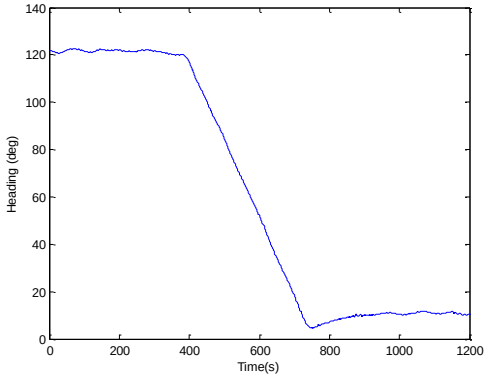
Small Scale Experiments

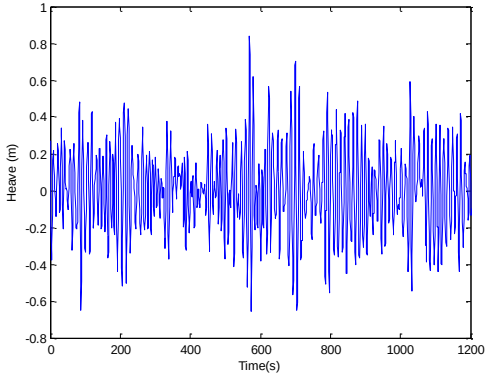
DP Tests

DP Crane Barge

Real-Scale Monitoring







DP Crane Barge

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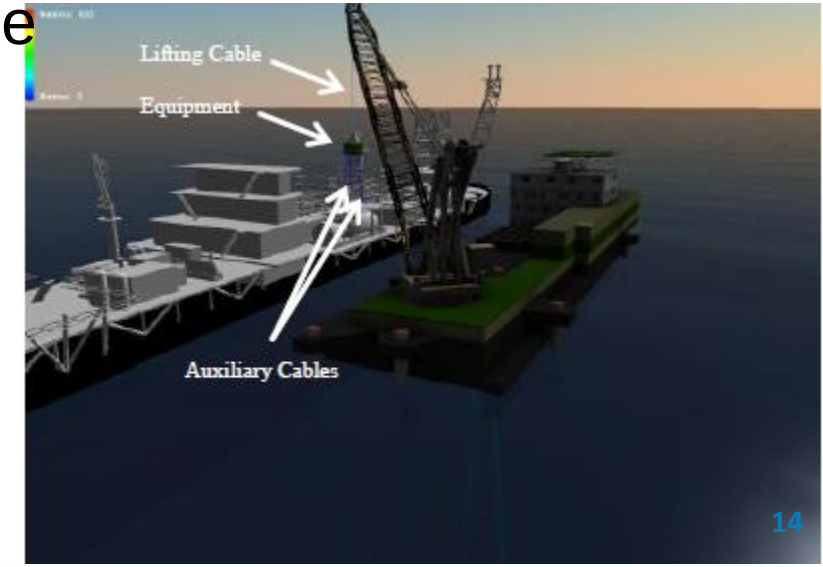
Numerical Simulation close to a FPSO

- Very important hydrodynamic couplig (see Vieira at al, OMAE 2011)
  - DP performance
  - Tension on lifting lines
  - Acceleration on the Top of crane
  - Relative Motion
    - Barge-Unit
    - Module-boom
  - Motions on DP control point



Numerical Simulation

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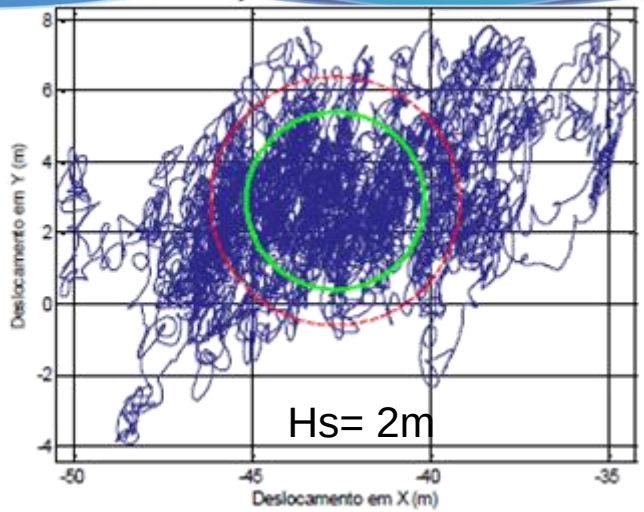
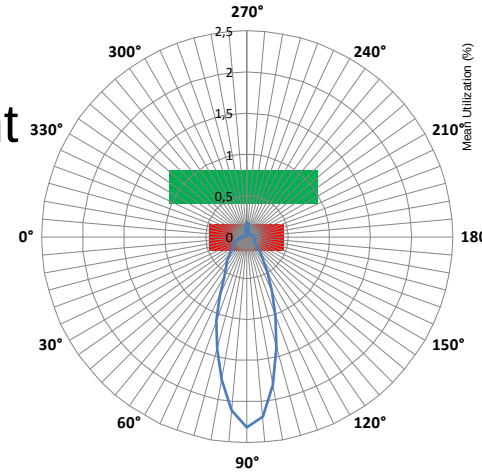
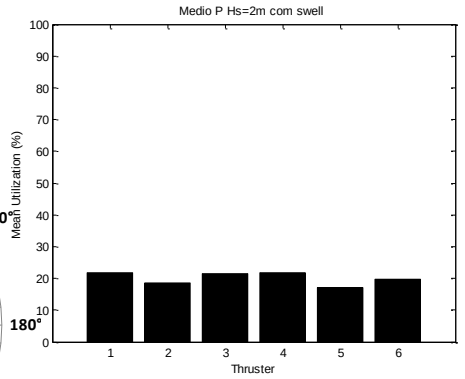
Numerical Simulation close to a FPSO

- Barge performing a module installation on a FPSO
  - DP performance
  - Tension on lifting lines
  - Acceleration on the Top of crane
  - Relative Motion
    - Barge-Unit
    - Module-boom
  - Motions on DP control point

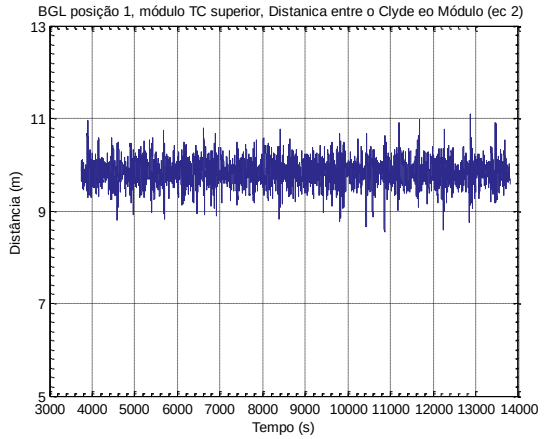




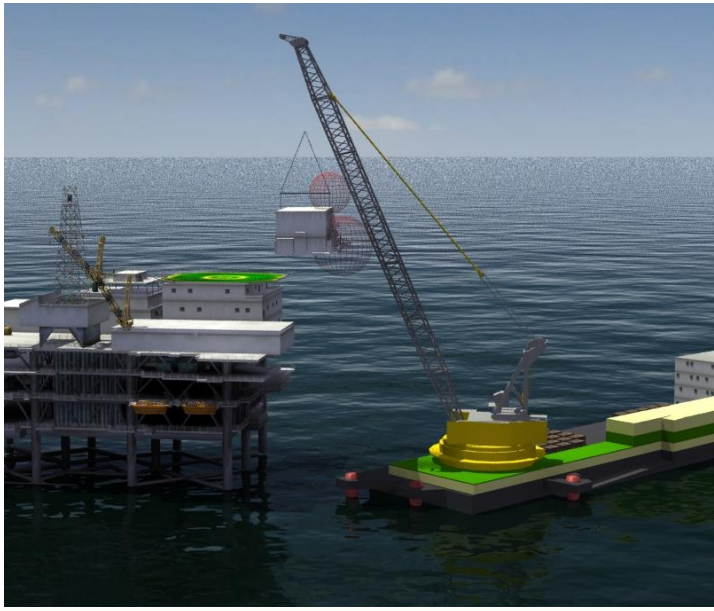


Numerical Simulation

Numerical Simulation : Fixed Platform



- **Main Parameters**
  - DP power consumption
  - Tension on lifting lines
  - Acceleration on the Top of crane
  - Relative Motion
    - Barge-Unit
    - Module-boom
  - Motions on DP control point



Numerical Simulation

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Numerical Simulation : Fixed Platform

- DP power consumption
- Tension on lifting lines
- Acceleration on the Top of crane
- Relative Motion
  - Barge-Unit
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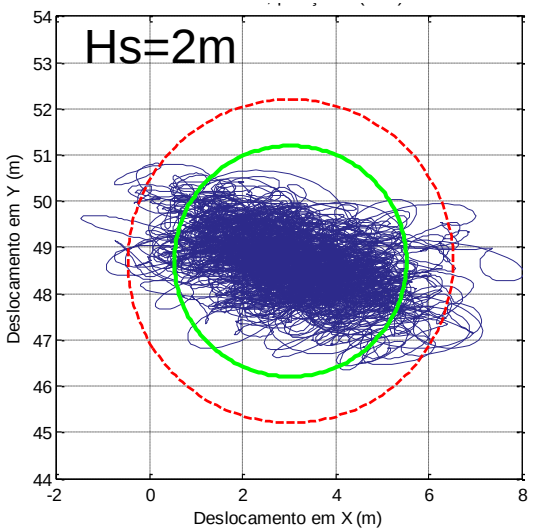

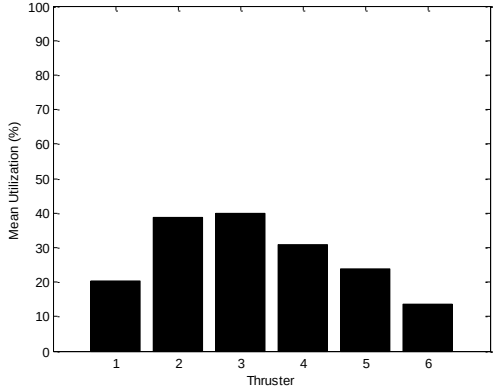

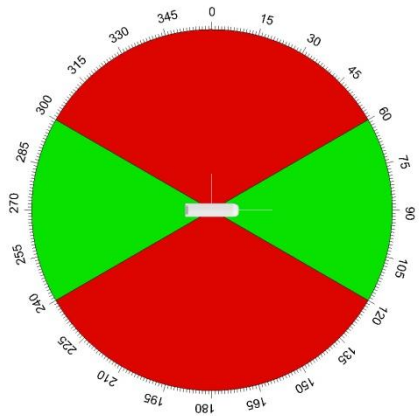

DP Drilling Vessel

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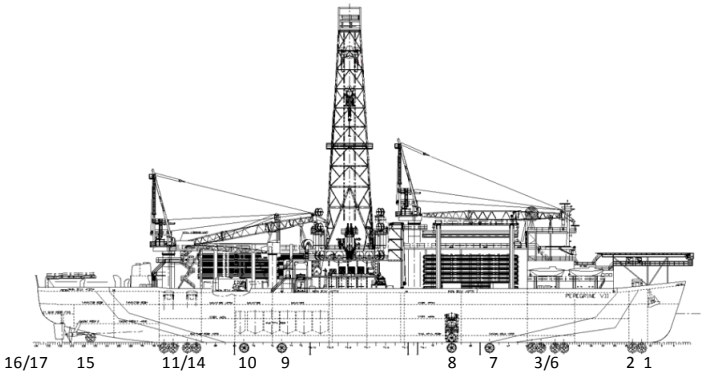
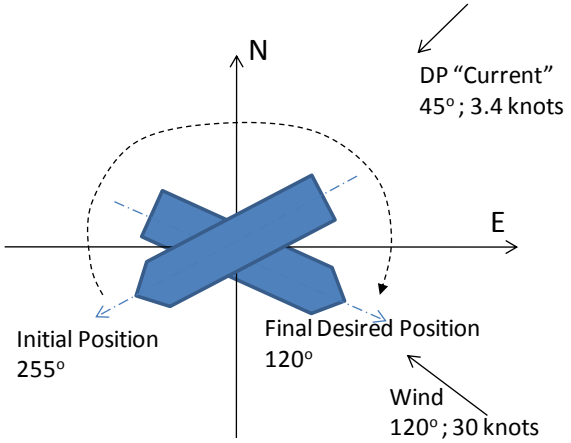
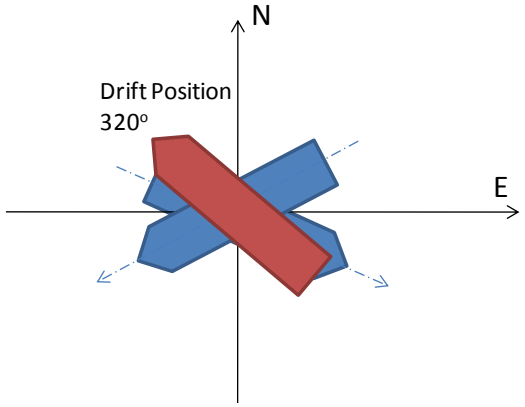


Real drift-off event





DP Drilling Vessel

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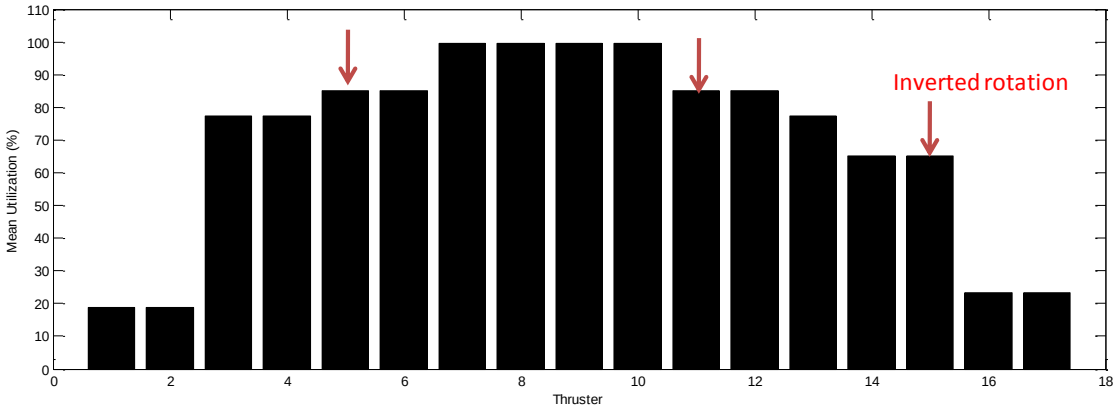
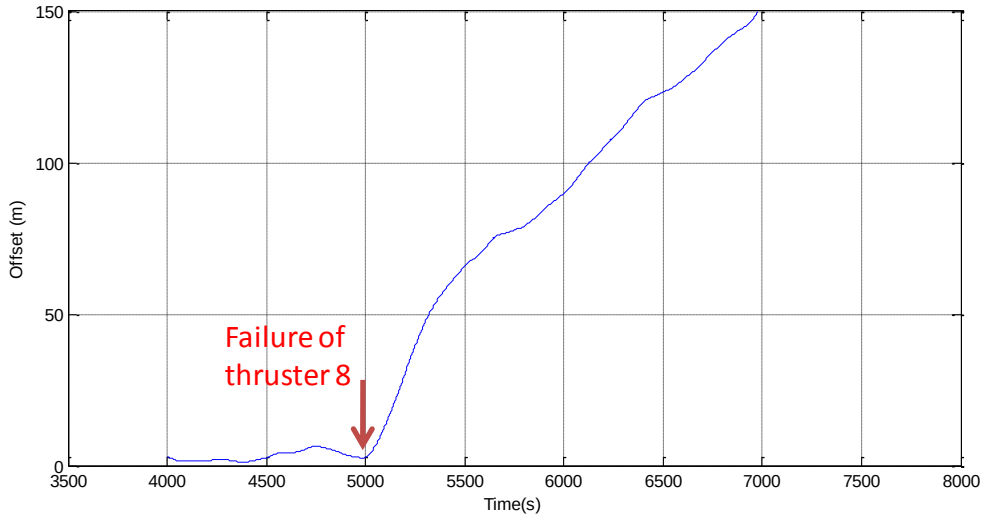


Simulations



DP Shuttle Tanker

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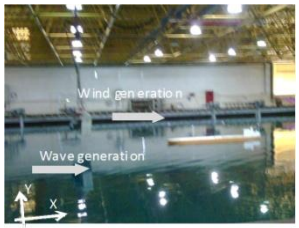
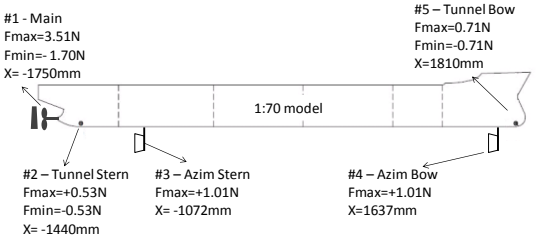
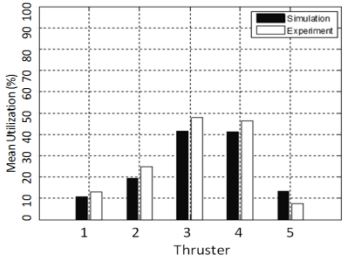
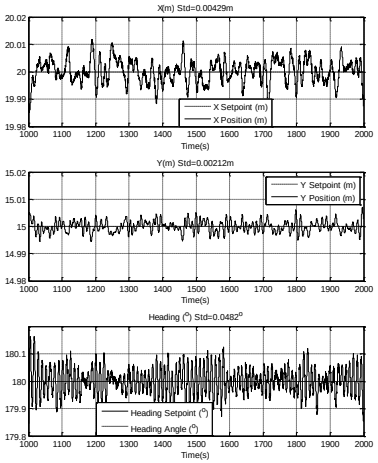


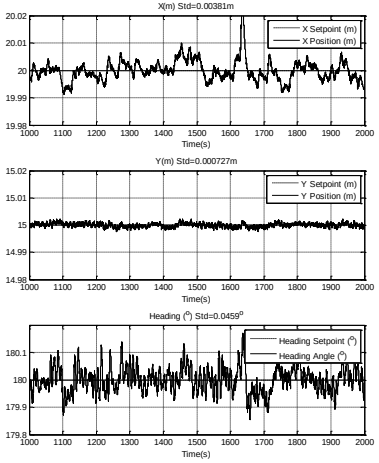


Small Scale Experiments





Simulation



Experiment

DP Shuttle Tanker

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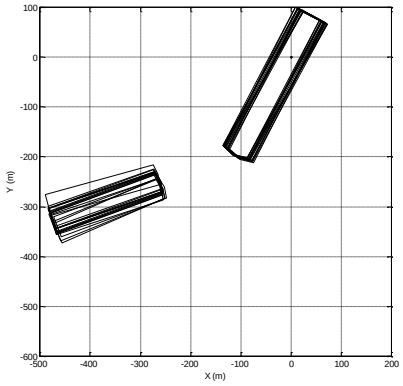
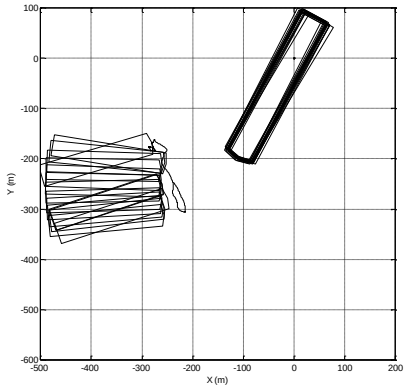
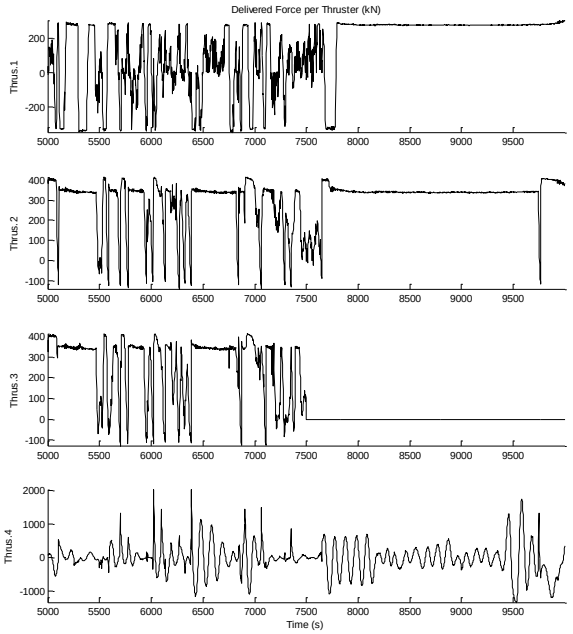
Failure simulations



Before failure of azimuth bow thruster



After failure of azimuth bow thruster



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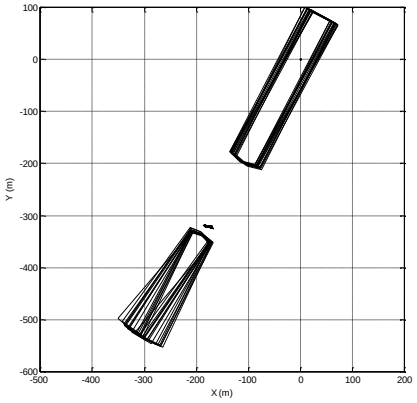
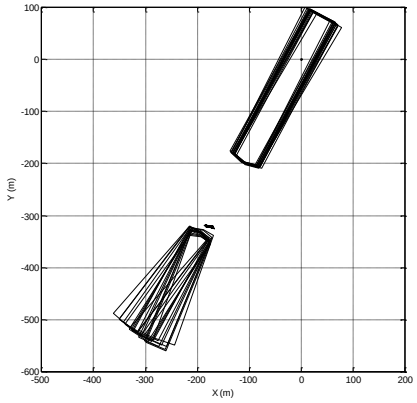
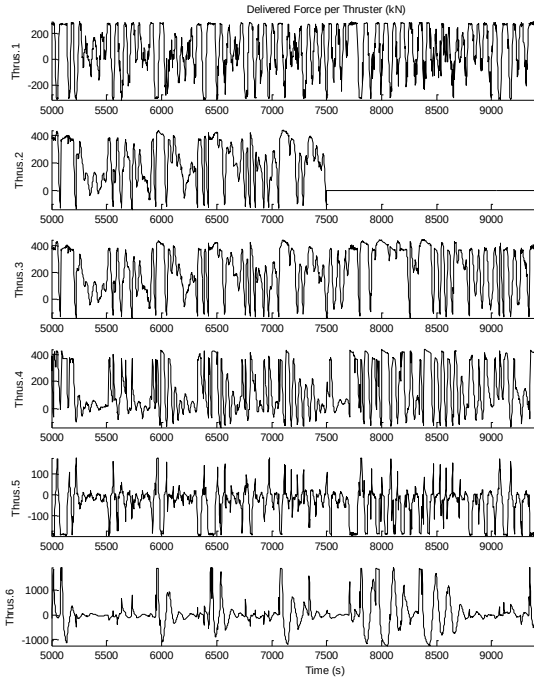
Failure simulations



Before failure of azimuth bow thruster



After failure of azimuth bow thruster



DP Shuttle Tanker

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Static Analysis

Equilibrium equation

- Mean current force
- Mean drift (wave)
- Mean Wind Forces

Dynamic Analysis

Time domain simulation

Static effects +

- Current oscillation
- Slow drift (wave)
- First order motions (wave)
- Wind Gusts
- Propeller dynamic response
- Transient motions

Downtime analysis

DP Shuttle Tanker

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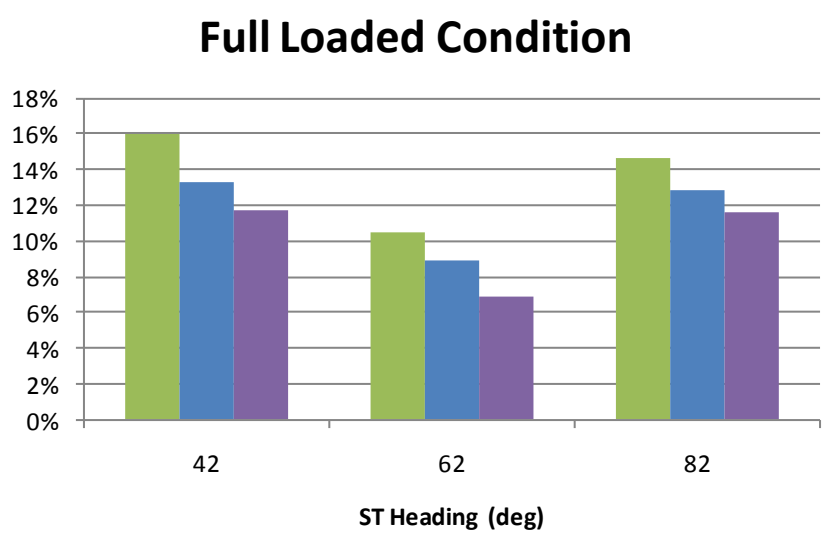
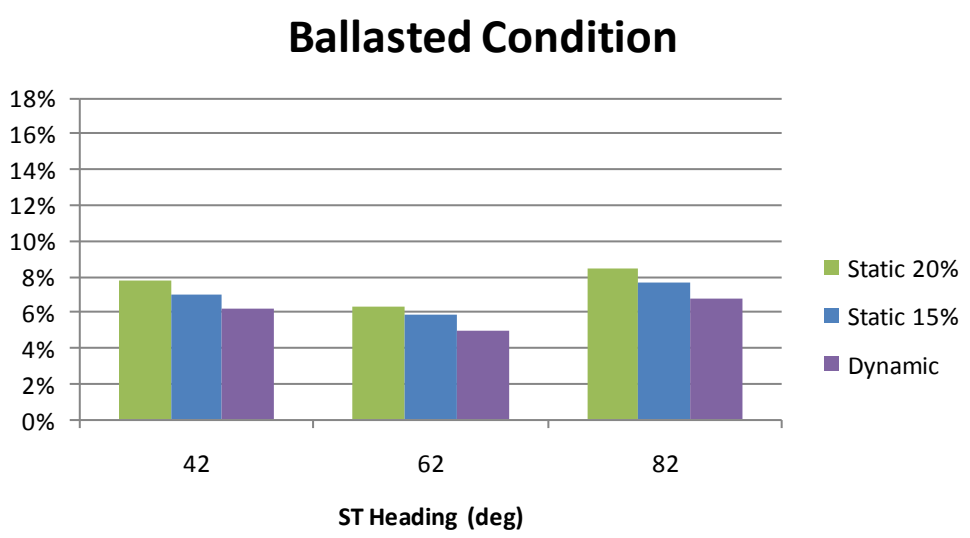
Downtime analysis





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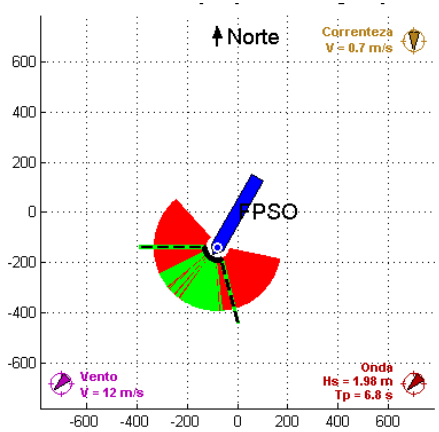
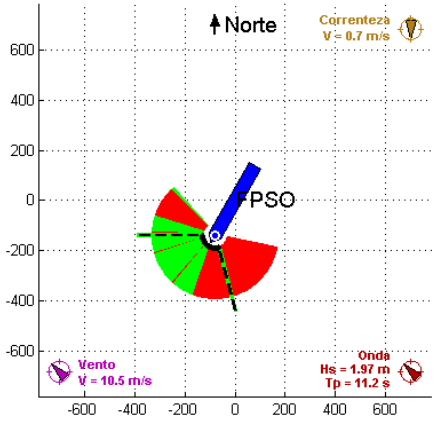
Downtime analysis





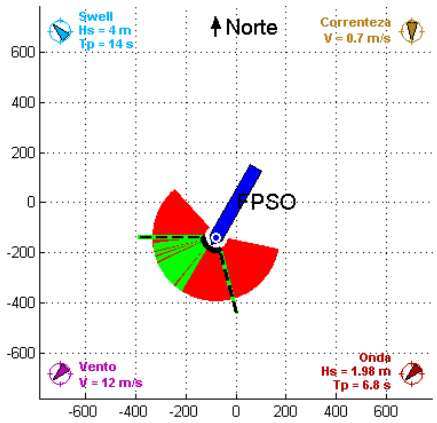


Table 1. Downtime results for DP1-Enhanced ST

Type of offloading station active	Downtime
Total (Bow or stern operation)	5.3%
Stern Operation Only	62.0%
Bow Operation Only	21.5%

Thanks!

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Acknowledgments:

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FAPESP

CNPq

Conselho Nacional de Desenvolvimento Científico e Tecnológico