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DYNAMIC POSITIONING CONFERENCE
October 9-10, 2012

DESIGN AND CONTROL SESSION

A General Approach for DP Weathervane Control

Michel R. Miyazaki, Eduardo A. Tannuri
University of São Paulo

TANQUE DE PROVAS NUMÉRICO

A General Approach for DP Weathervane Control

Michel Rejani Miyazaki
Numerical Offshore Tank (TPN)
University of São Paulo
São Paulo, SP, Brazil

Eduardo Aoun Tannuri
Numerical Offshore Tank (TPN)
University of São Paulo
São Paulo, SP, Brazil

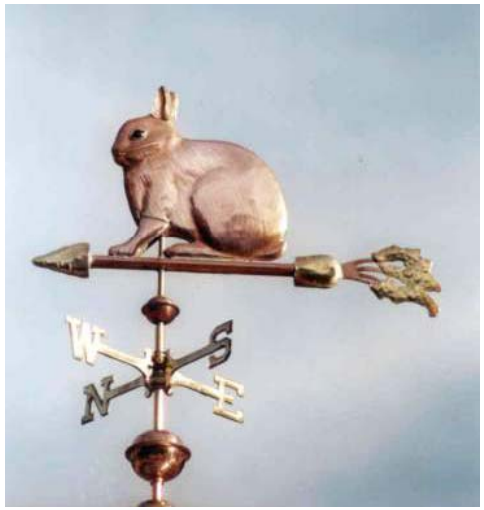
PNV USP
Departamento de Engenharia Naval e Oceânica

ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

Universidade de São Paulo

October| 2012

Introduction to Weathervane



Weathervane is an instrument for showing the direction of the wind

It is based on the principle that a body with a fore-end pivot aligns with the wind incident direction

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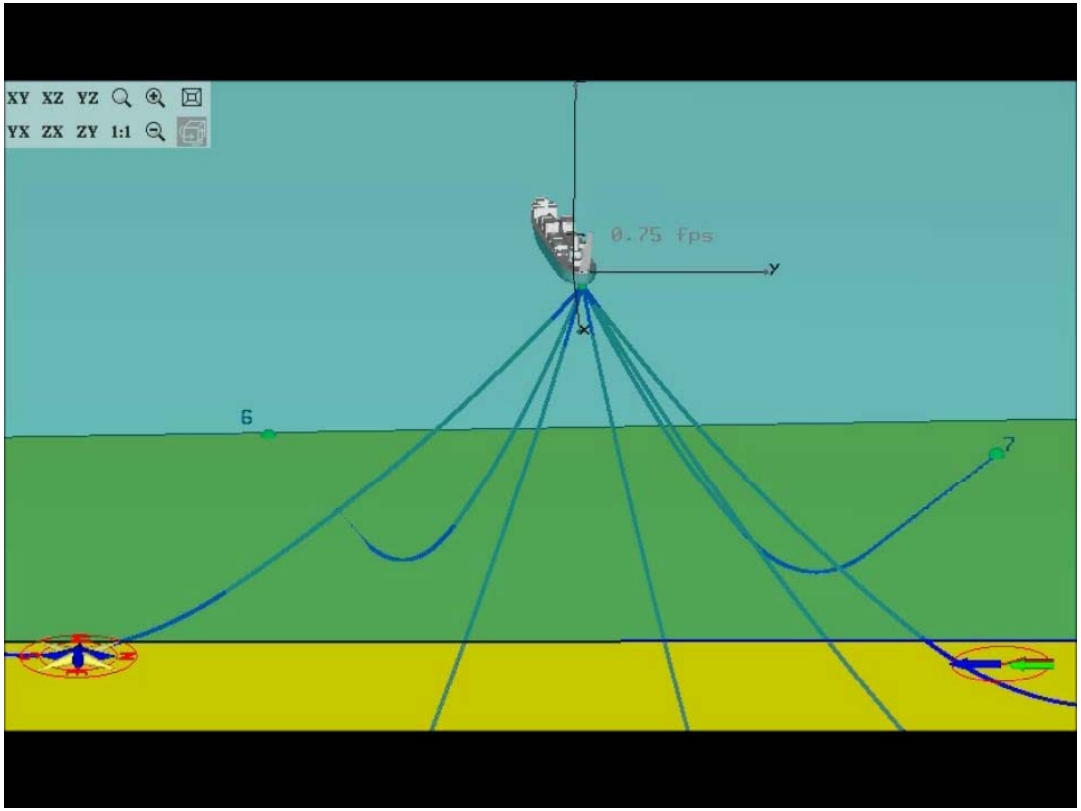
Introduction to Weathervane

This principle can be extended to a FPSO moored by a **PASSIVE turret system** at the bow



This angle garantees minimum mooring forces

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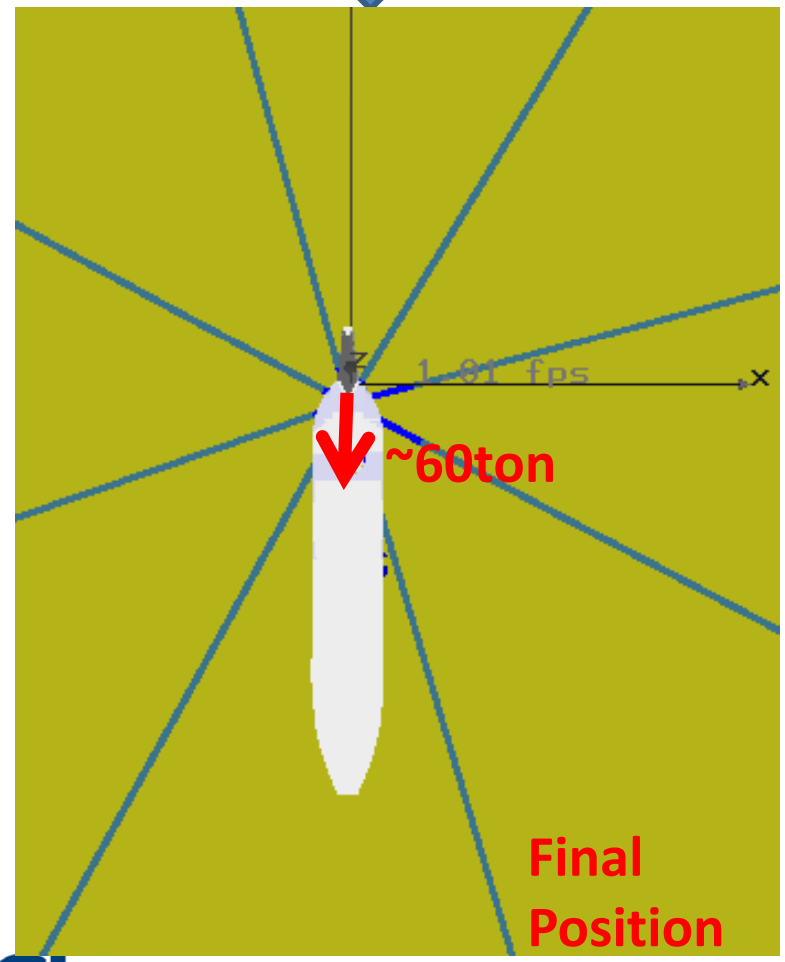
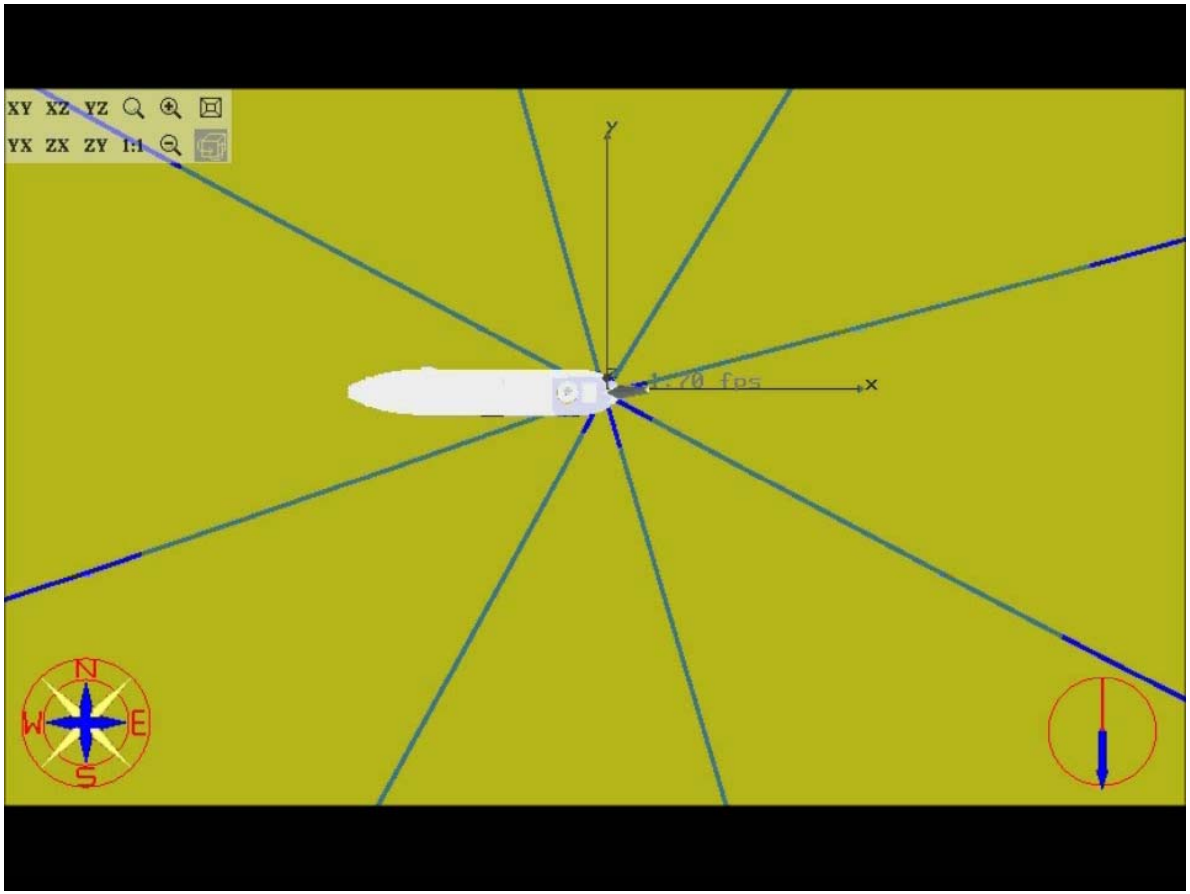
Curr



Turret at bow
Current=1.6m/s from N



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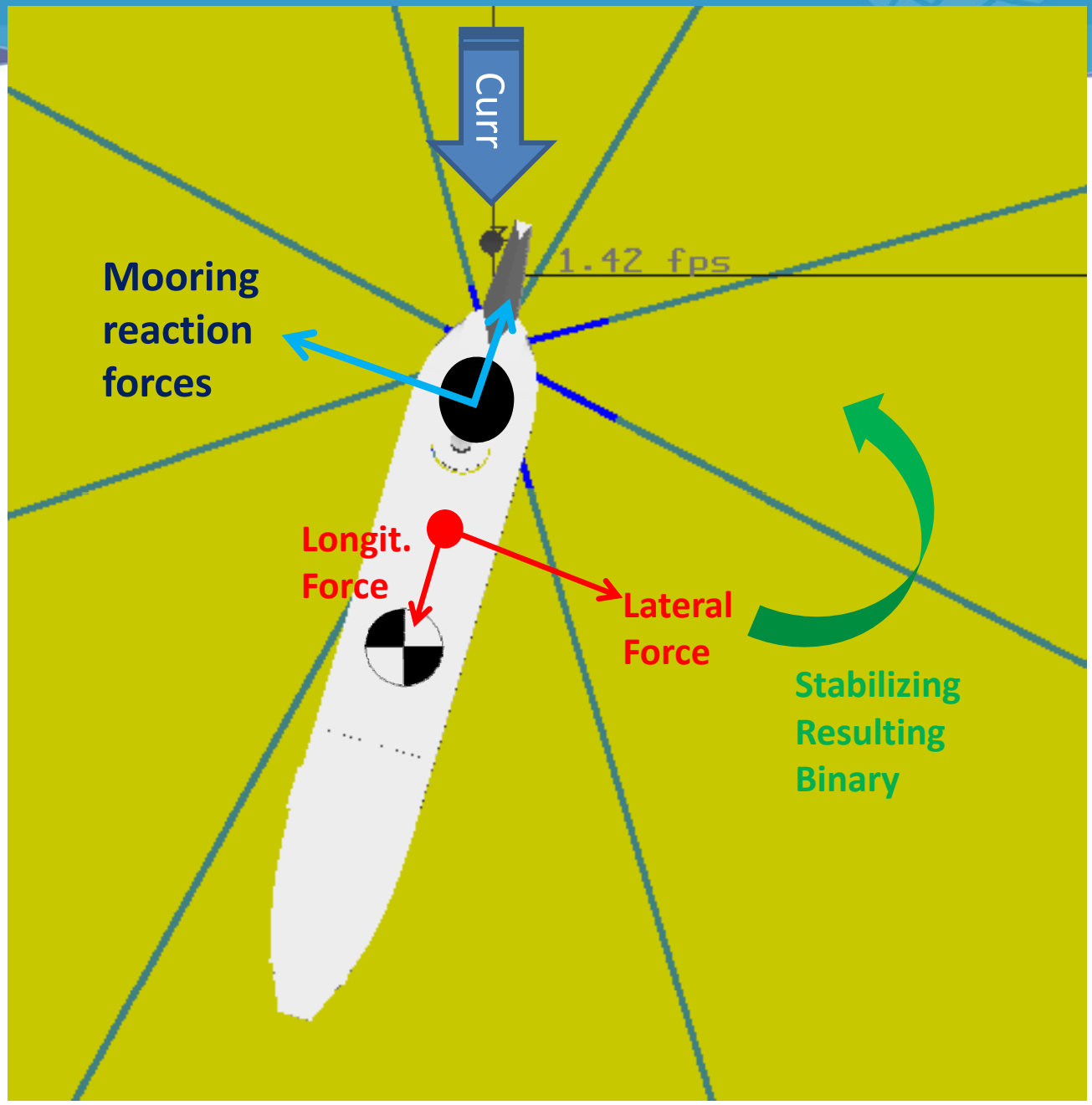
- Turret at bow
- Weathervane Basic Principle
- Stabilizing forces



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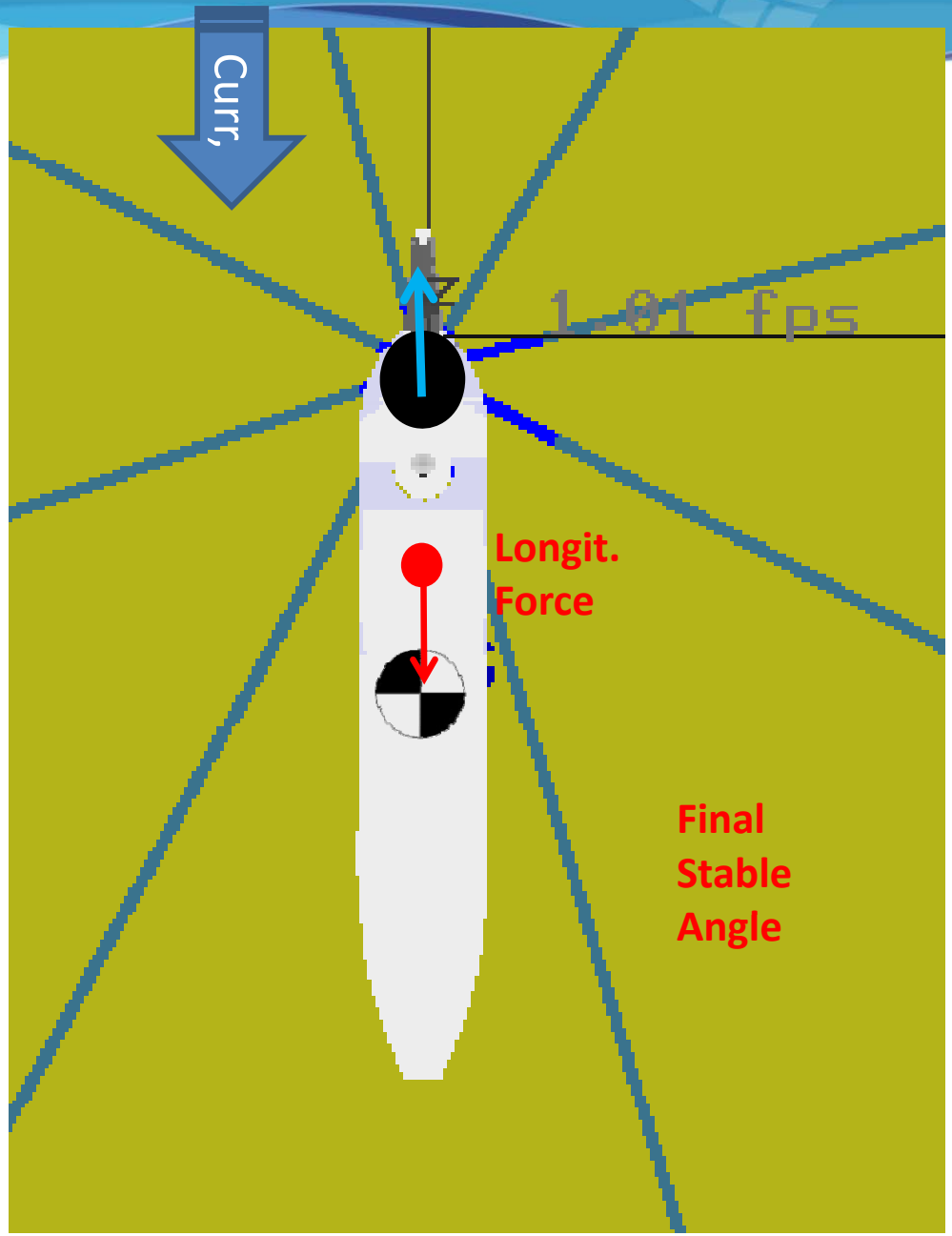
Turret at bow

Weathervane Basic Principle

Stabilizing forces



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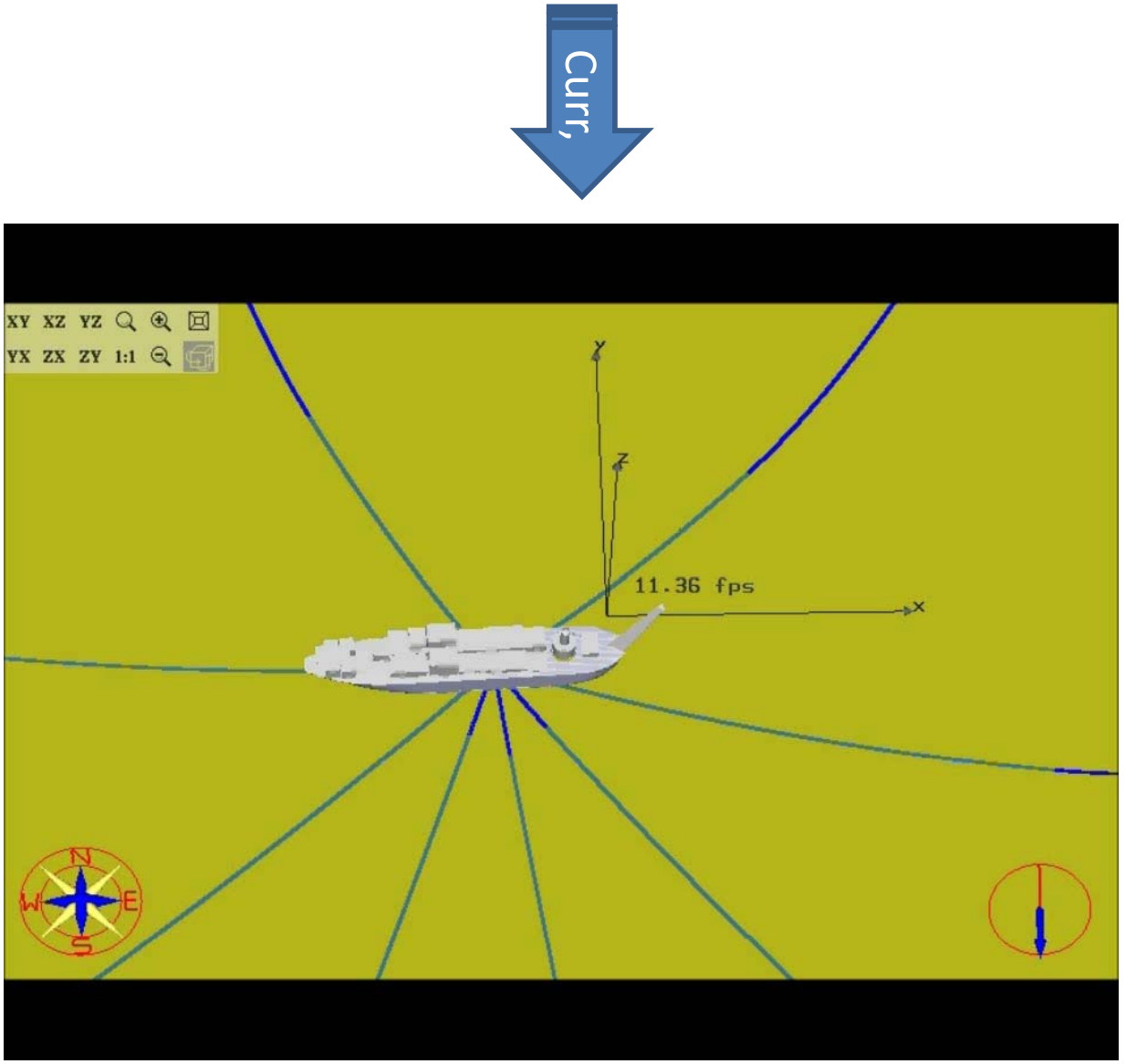
However, if the pivot point (Turret) is astern from the force application point, the equilibrium is not aligned with the environment



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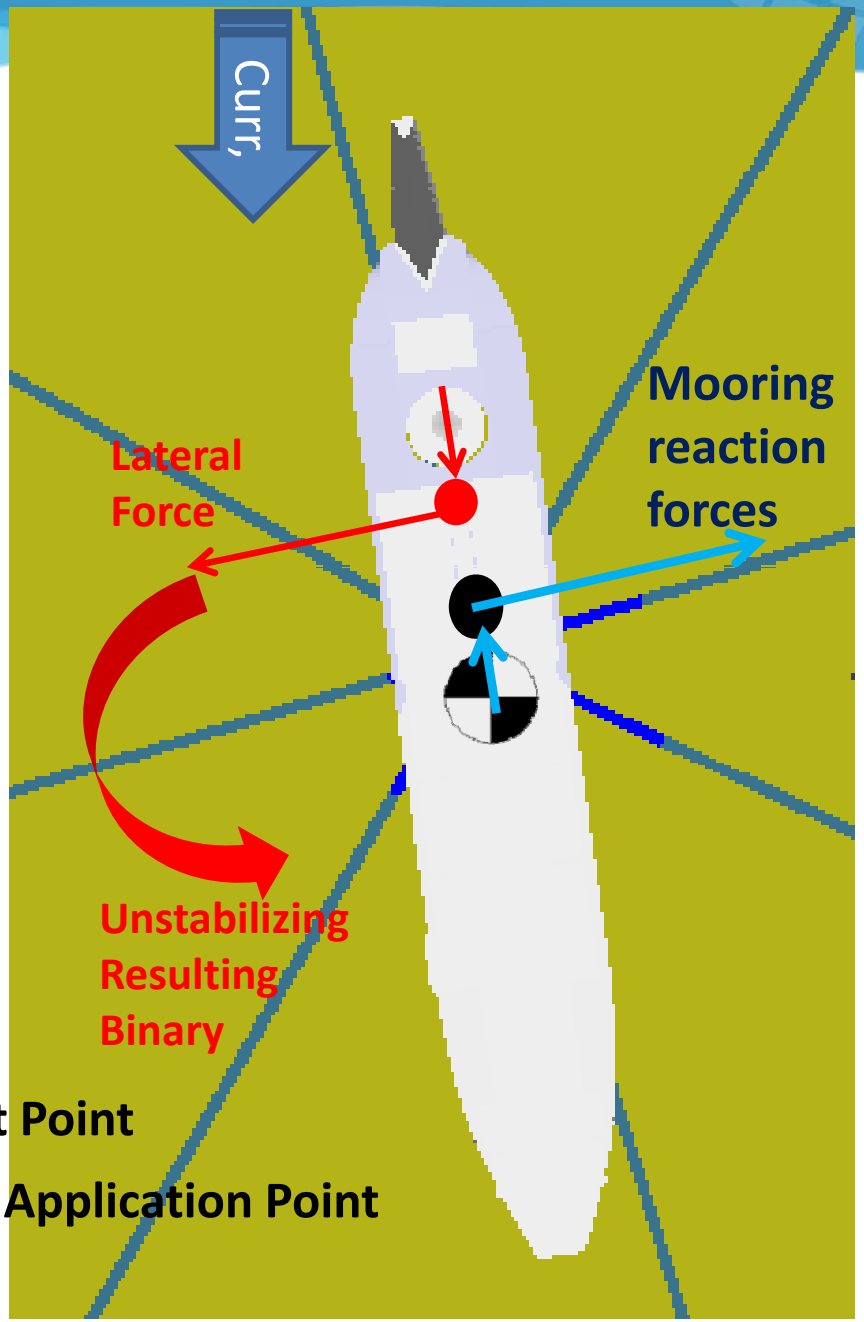

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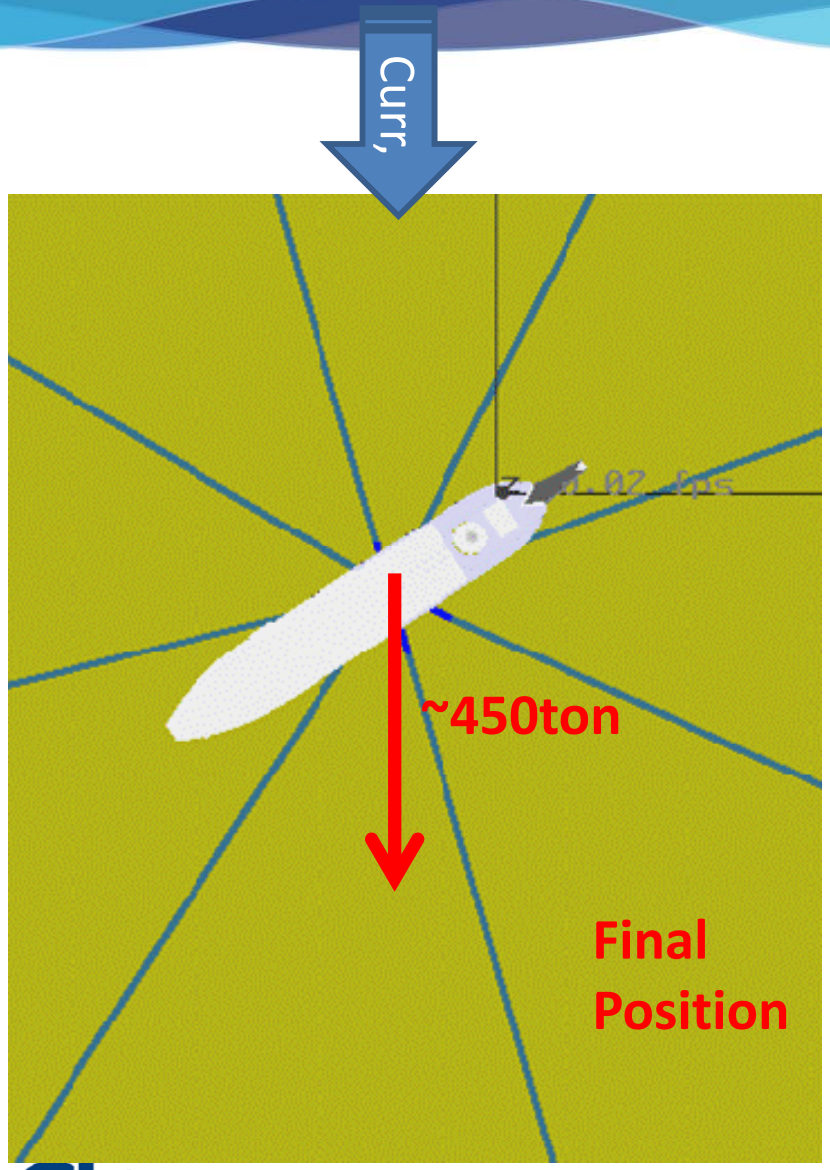
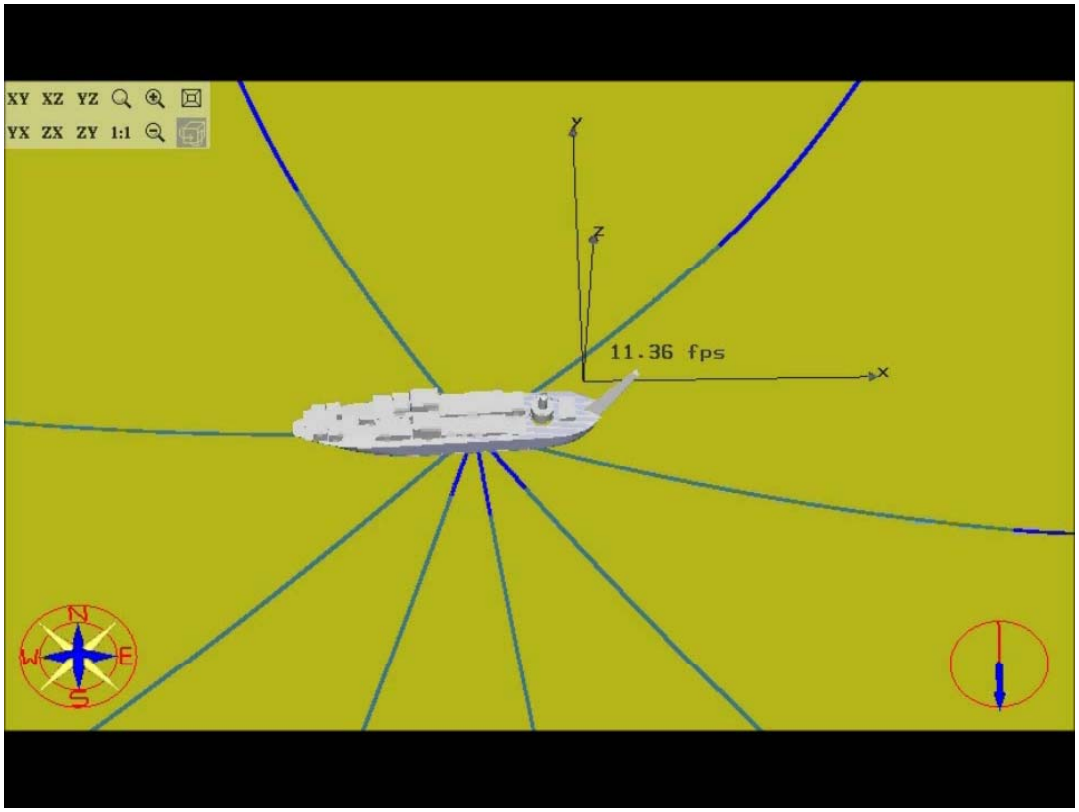


Turret at mid-ship
Current=1.6m/s from N

The non-weathervane angle leads to high loads in the mooring system



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Introduction to Weathervane

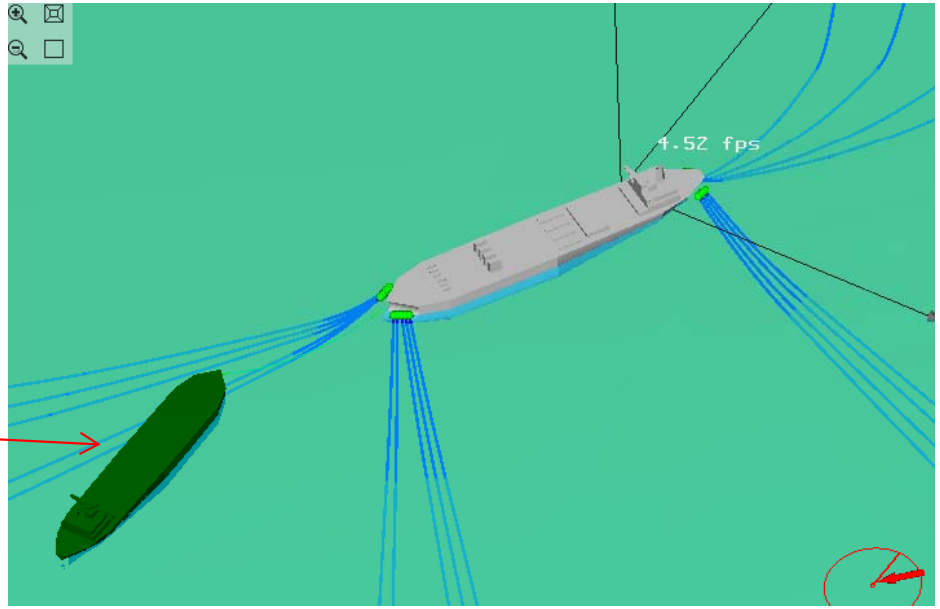
The same principle can be extended to a **ACTIVE DP** vessel

Passive Turret Mooring

with weathervane capacity

Active DP Shuttle

with weathervane capacity



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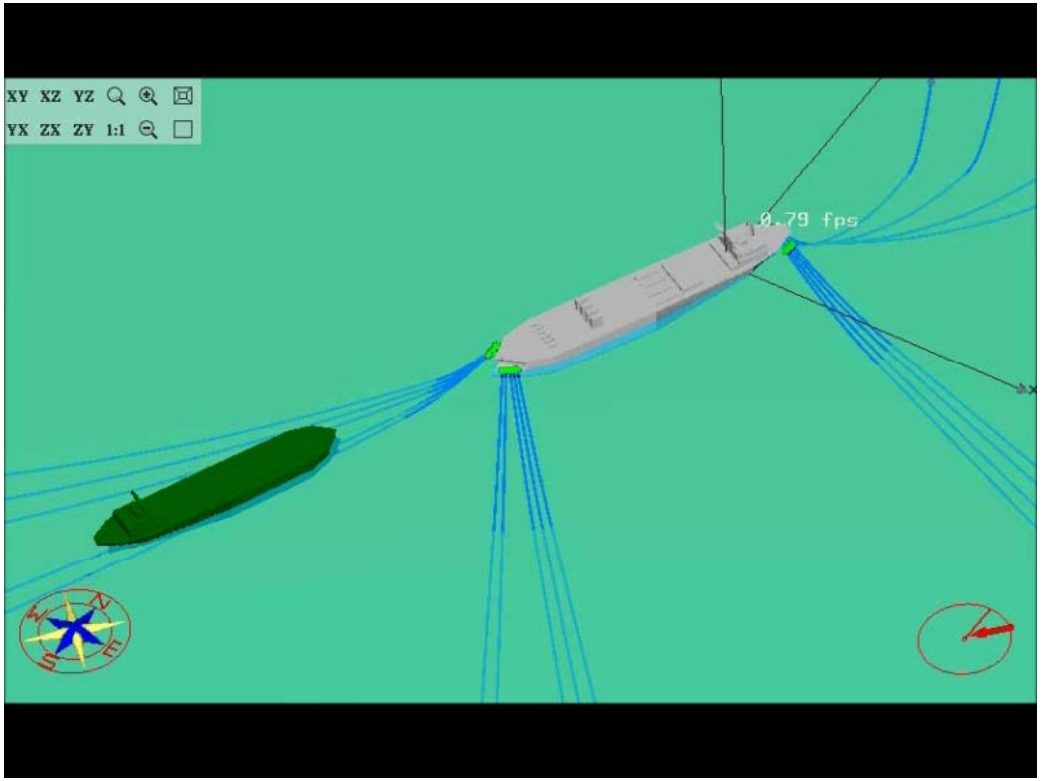
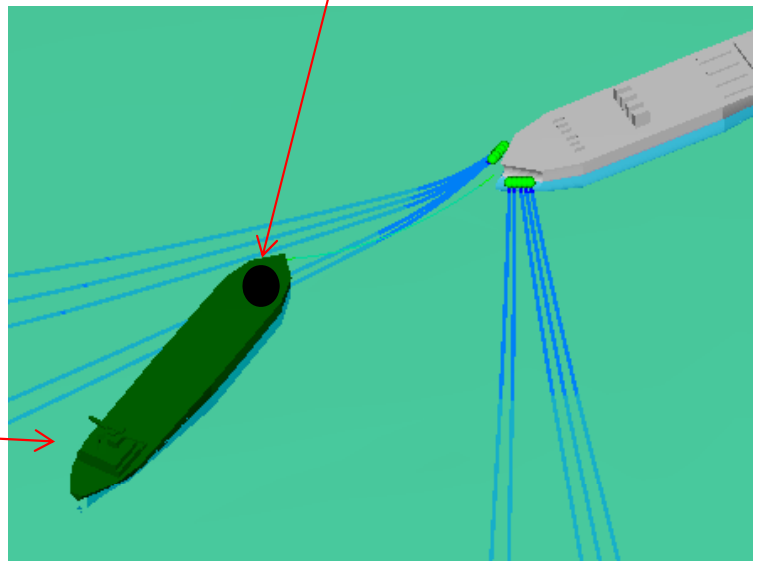
Simulation of a environmental Direction variation



Control Reference Point

Close to the bow

"artificial" Pivot Point



Active DP Shuttle

with weathervane capacity

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Introduction to Weathervane

This idea was introduced by **J.A. Pinkster and U. Nienhuis** (OTC, 1986)

They proposed only one propeller at the bow, and to control a reference point close to the forward end of the vessel

No heading control !
Maybe dangerous

Unstable behavior for reference control point close to the midship

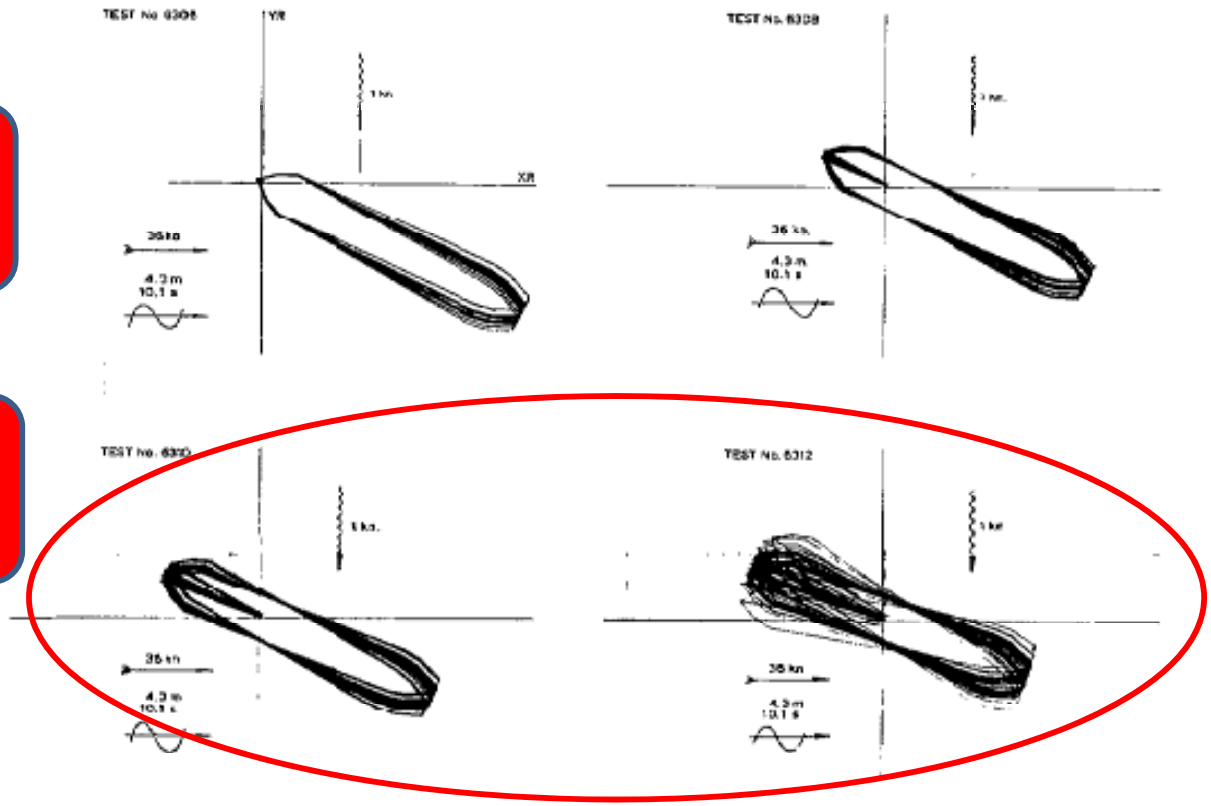

Fig. 8—Contour plots of model tests.

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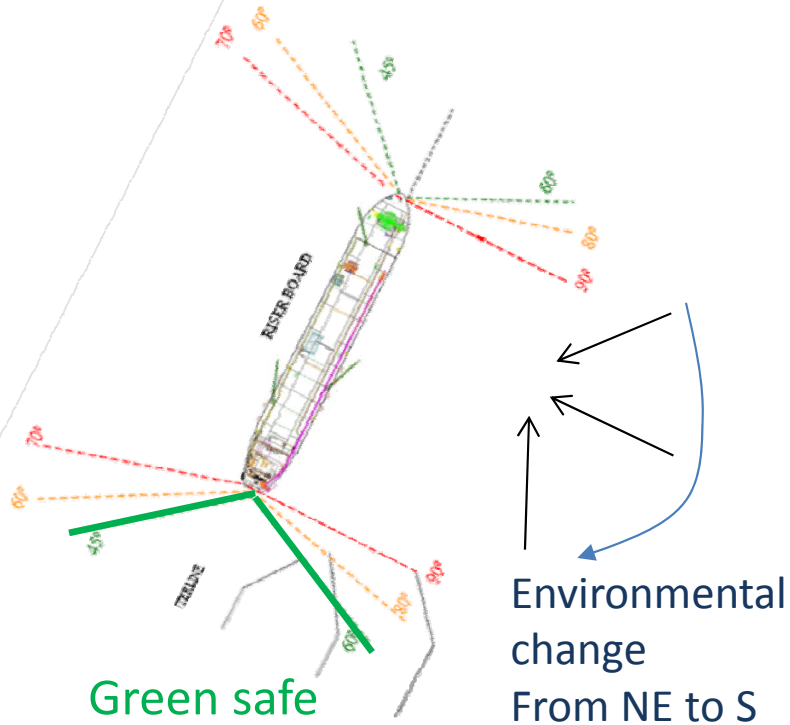
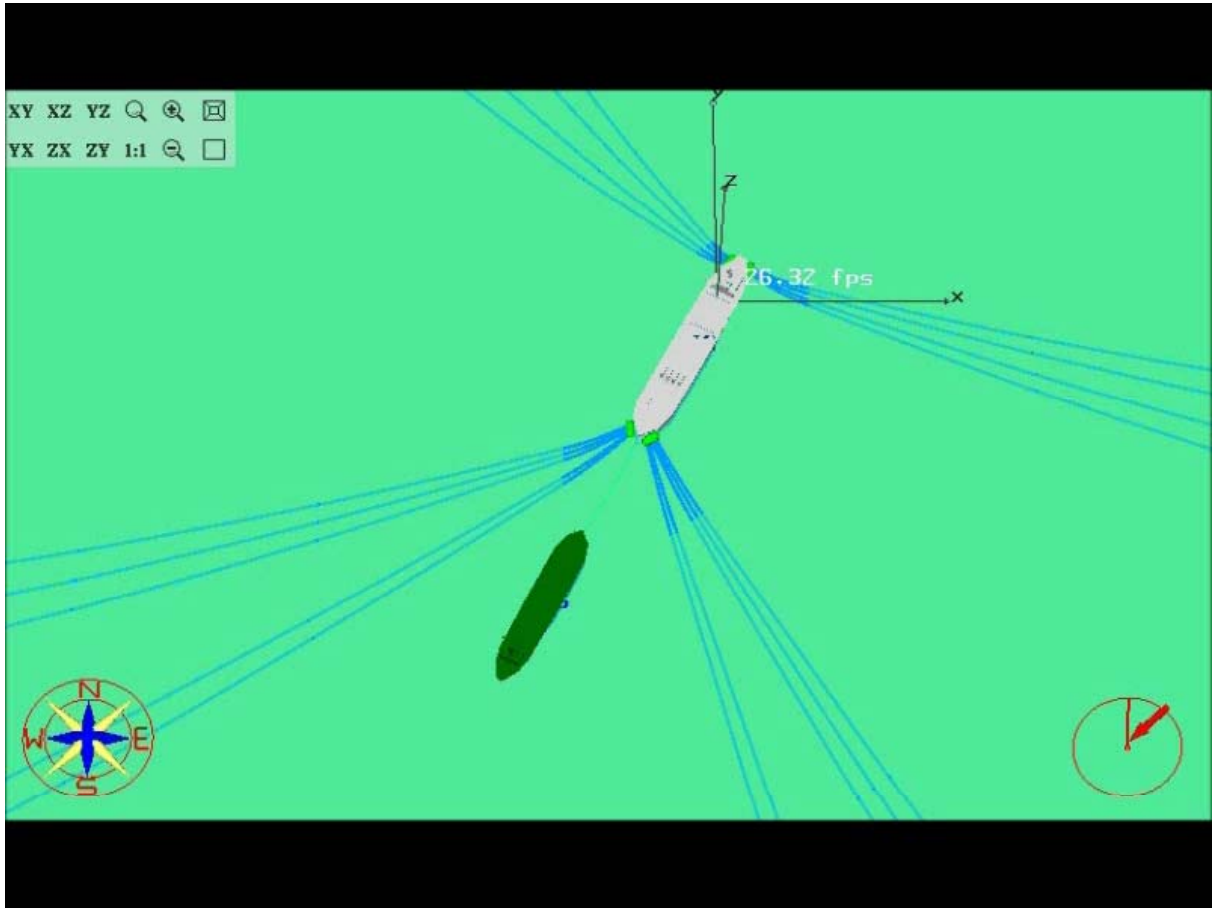
No heading control !
Maybe dangerous



Green safe zone

Environmental change
From NE to S



Weathervane control must be switched off by the DPO

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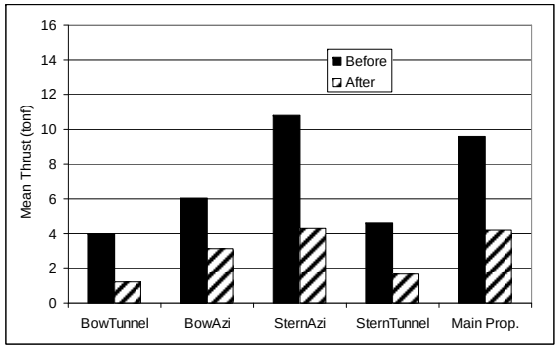
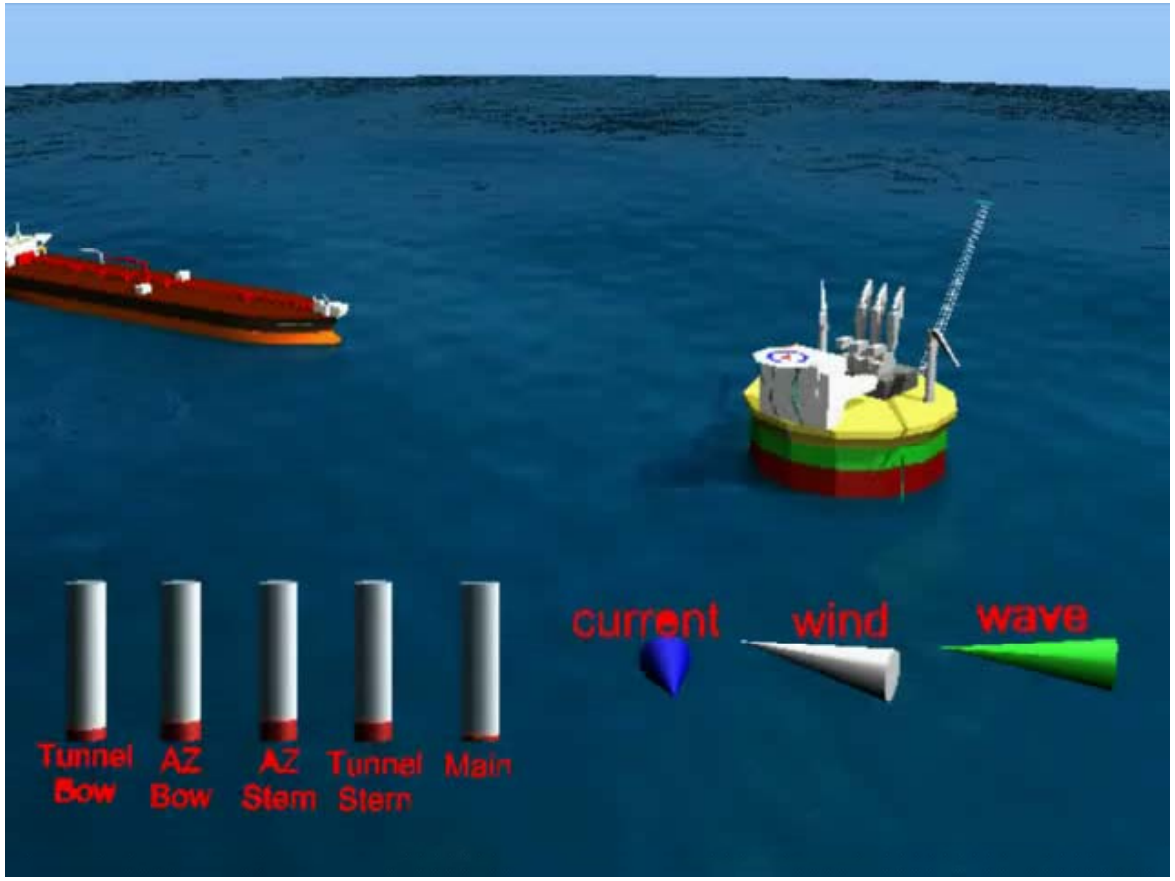
Solution - "Manual" Weathervane control based on DPO Experience





Actual Operation
2009 (Brazilian Basin)

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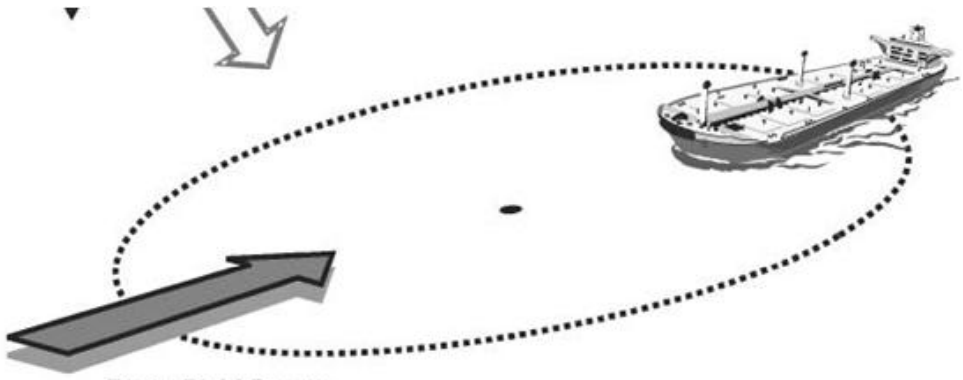
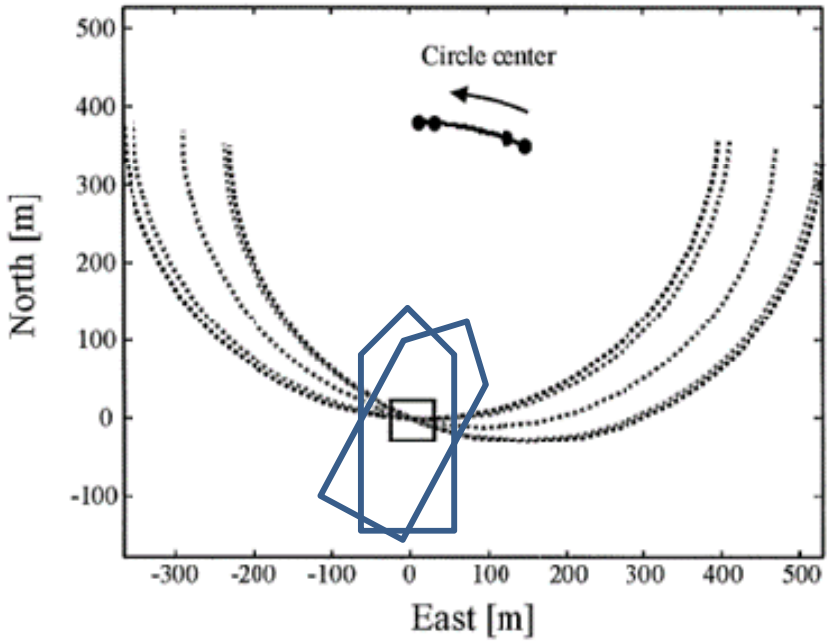
Introduction to Weathervane

T.I. Fossen and J.P. Strand (Automatica, 2001)

They proposed the Wheather Optimal Heading Control (WOHC) **ABB Patented**

Control of a forward bow point





Circle reference point is changed to keep position of vessel reference point

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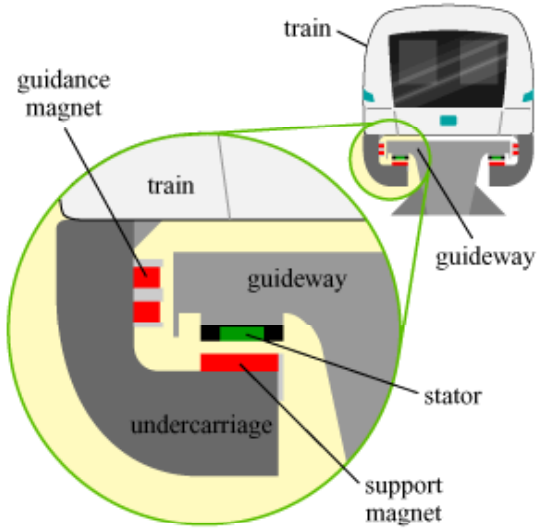
Zero Power Control Weathervane

- This work presents a novel methodology for weathervane control.
- It is based on the Zero Power Control Technique
- Originally developed for Maglev Magnetic Levitation



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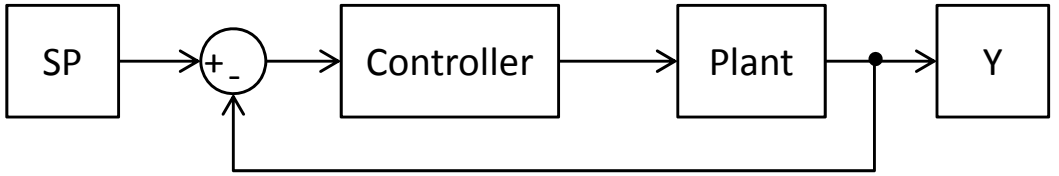
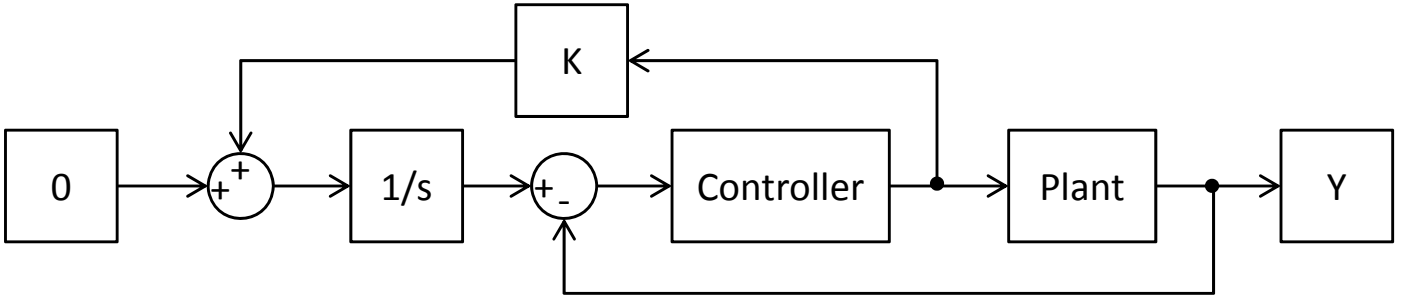
Zero Power Control

Traditional control:
Monitoring the system output



Zero Power Control:
Monitoring the controller output and the system output



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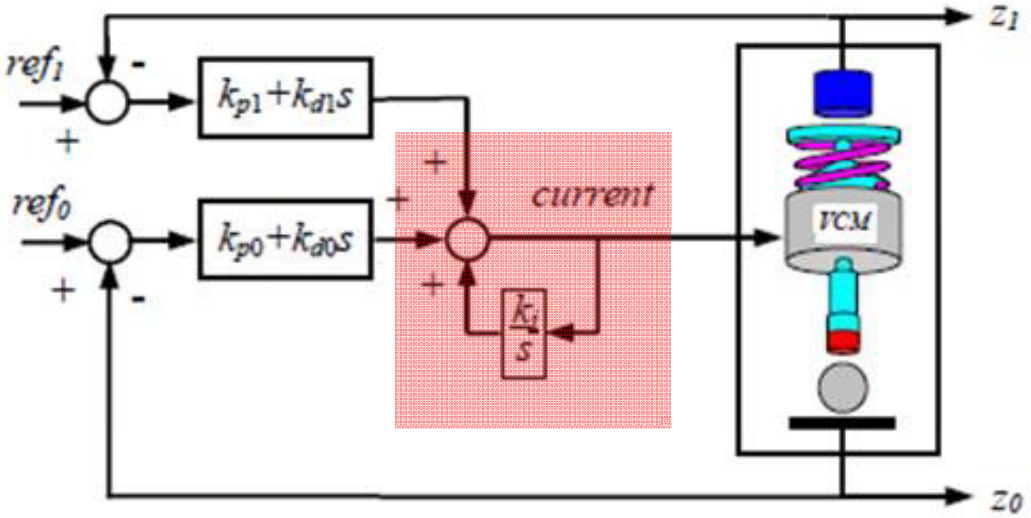
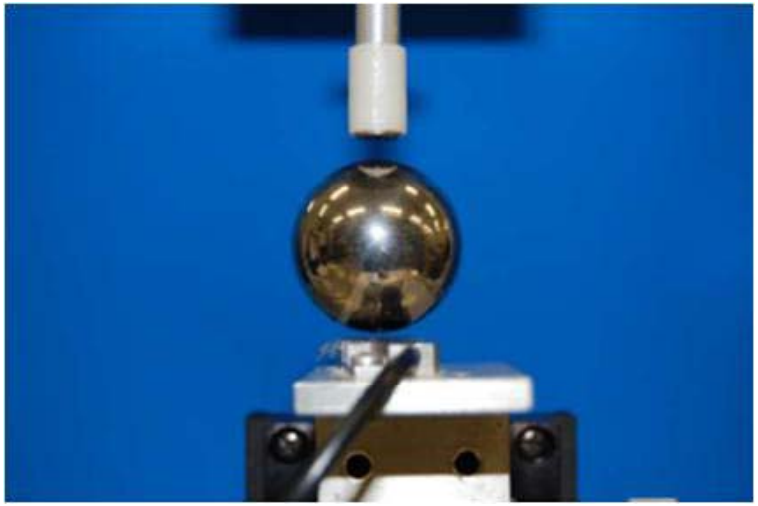
Zero Power Control Weathervane

- How it works?

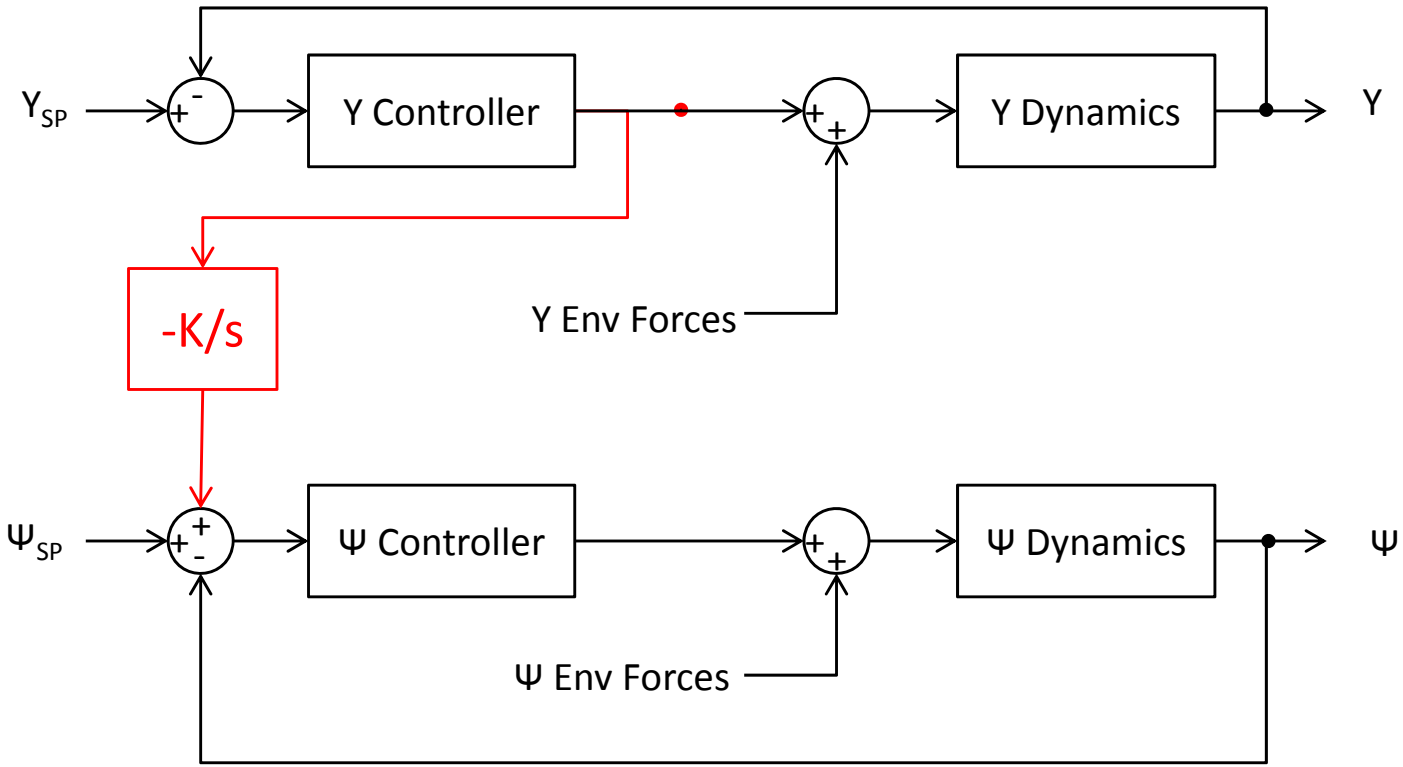




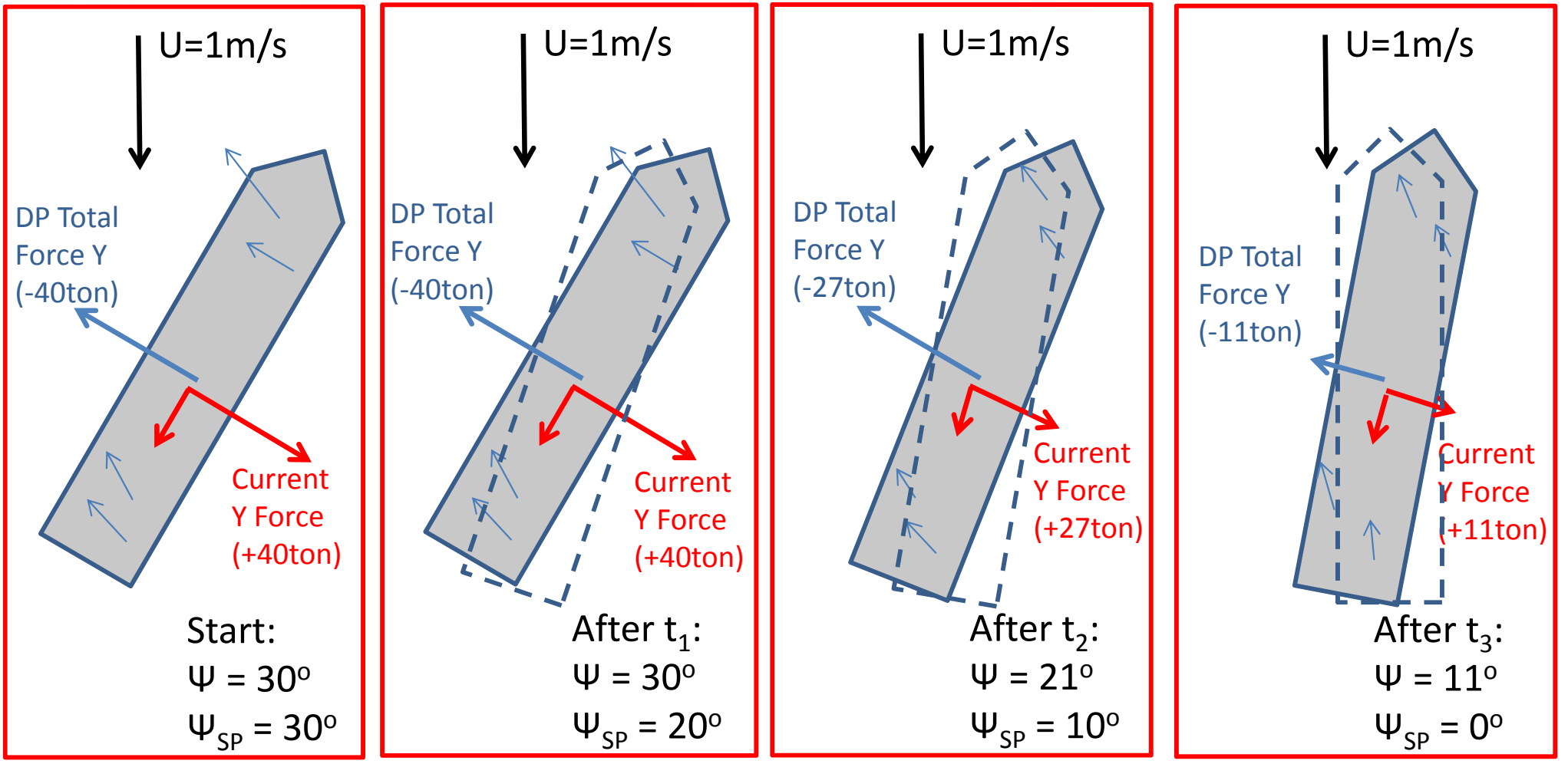
Control Action is used to change the position, seeking the minimum consumption

Zero Power Control Weathervane

- Application to DP System: **Sway Control Force is used to change the Heading Set-point**



Zero Power Control Weathervane



Speed of set-point change depends on K1

Zero Power Control

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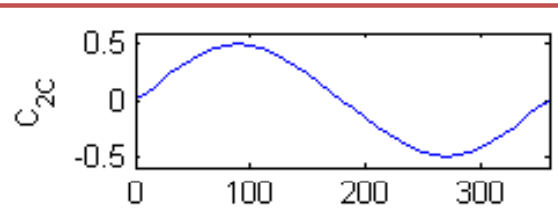
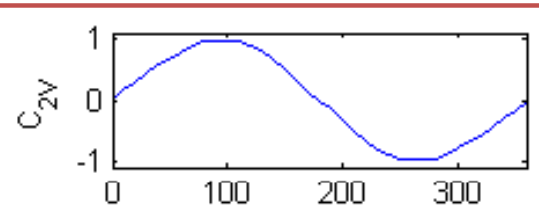
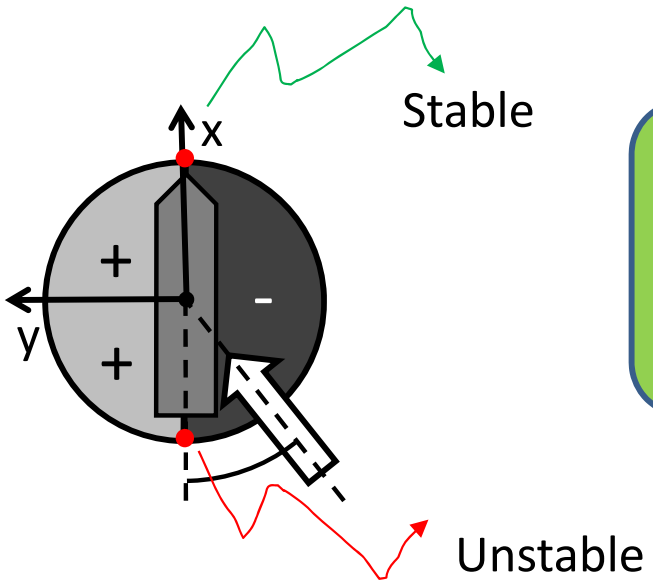
Current



Wind





2 equilibriums

Bow incidence is stalble

Stern Incidence is unstable

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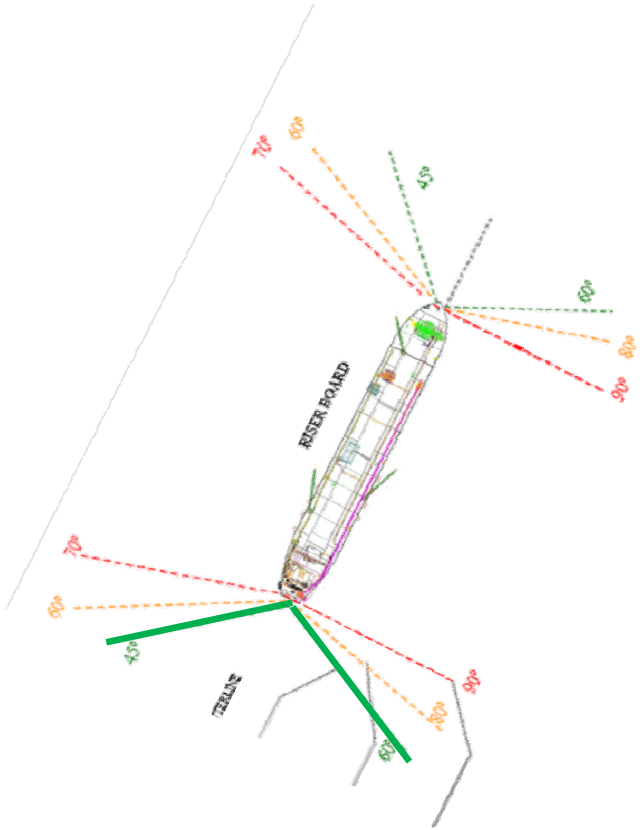
Advantages of ZPC Weathervane control

- Can control any reference point
- Heading is controlled, so limits can be imposed
- All horizontal plane controllers maintain the same control structure and same tuning



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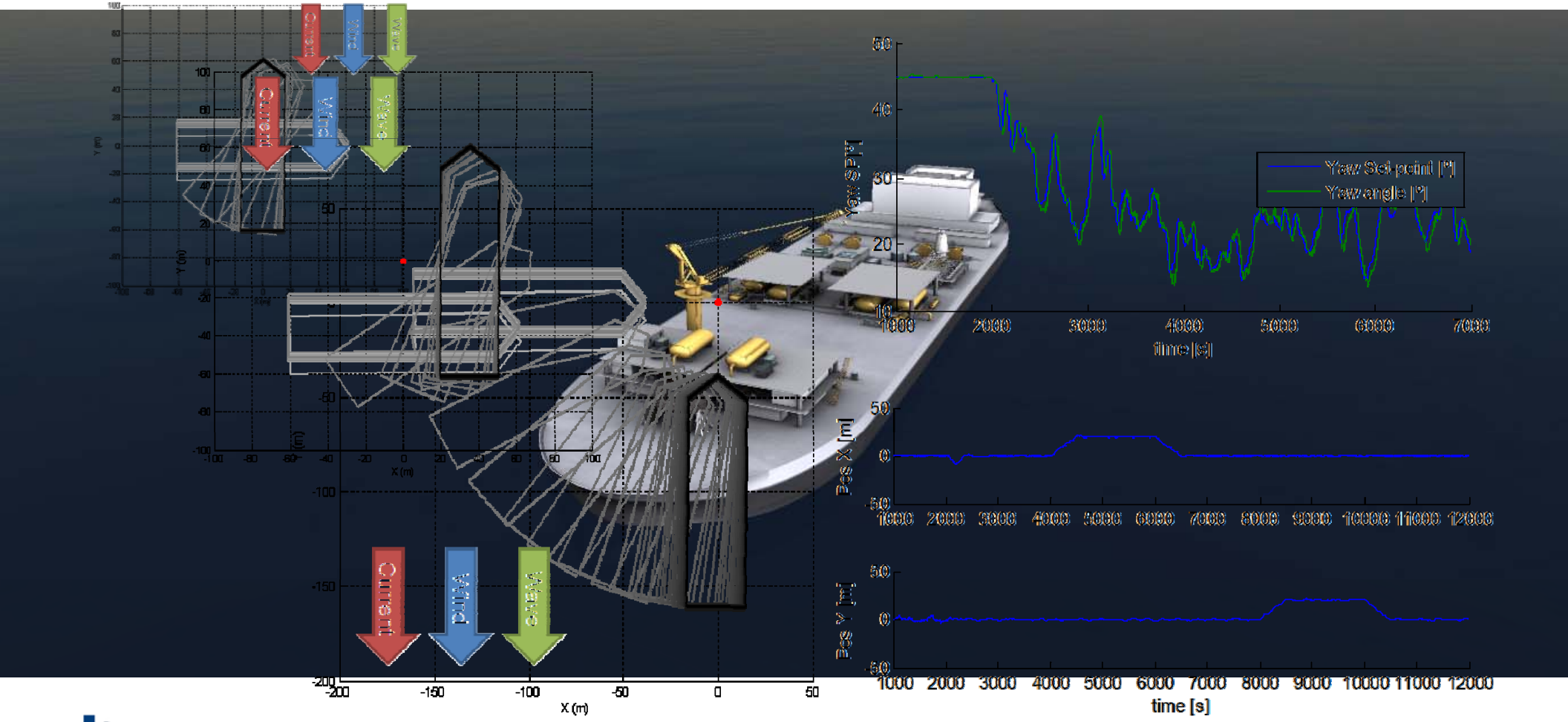
Numerical Results



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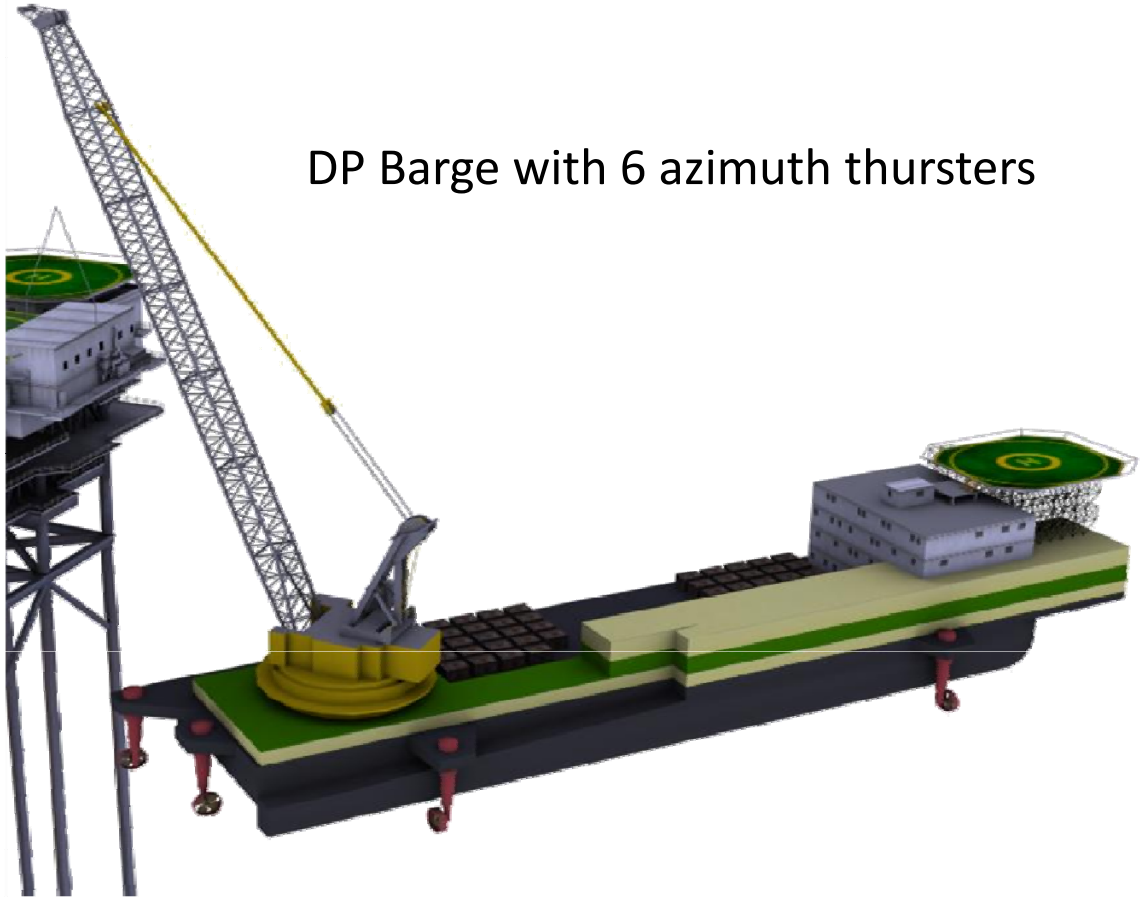
Numerical Results

Property	value
Total length (m)	121.92
Length entre perpendiculars L_{pp} (m)	121.92
Beam B (m)	30.48
Draft T (m)	5.18
Mass M (ton)	17092
Moment of Inertia I_Z (ton.m^2)	2.4×10^7



DP Barge with 6 azimuth thursters

Numerical Offshore Tank – TPN Simulator

Time Domain Simulator

Condition 1 - Aligned

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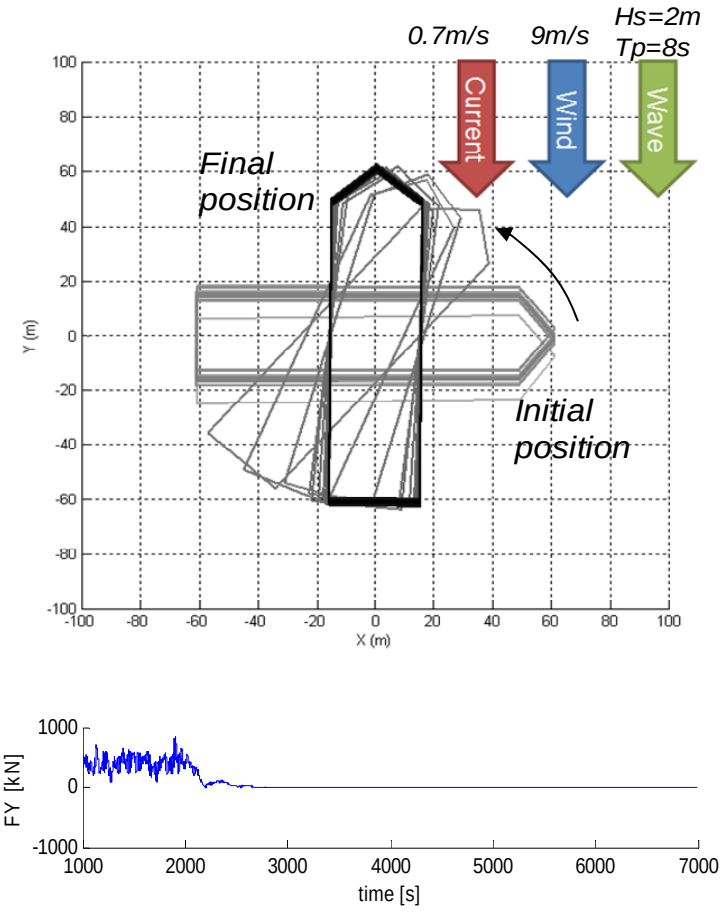
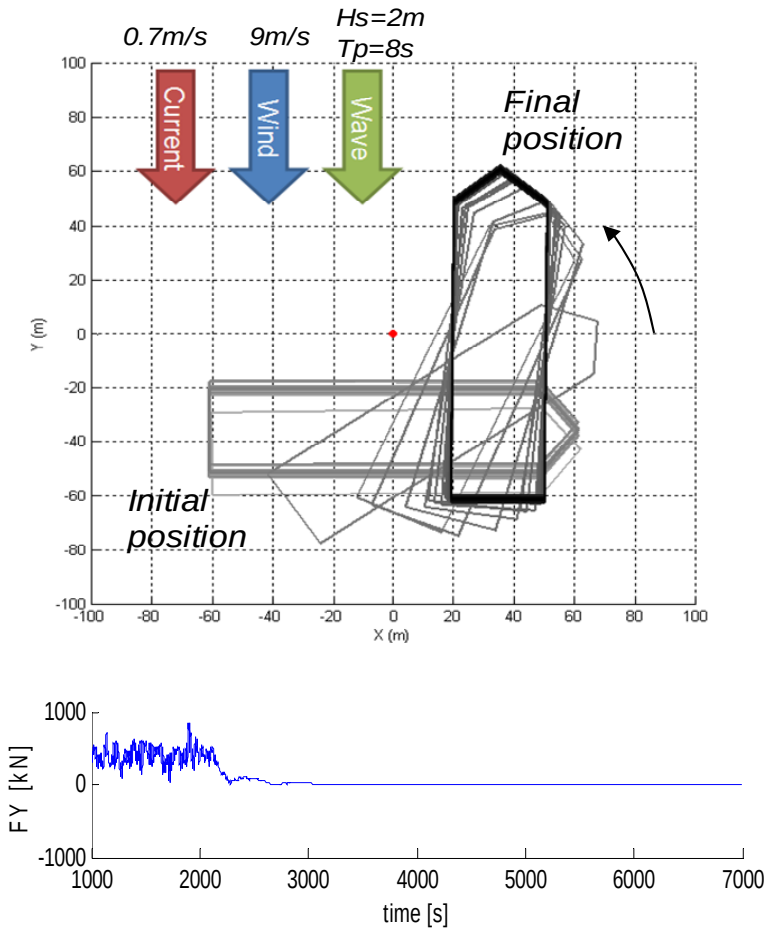


Midship control



Side-point control

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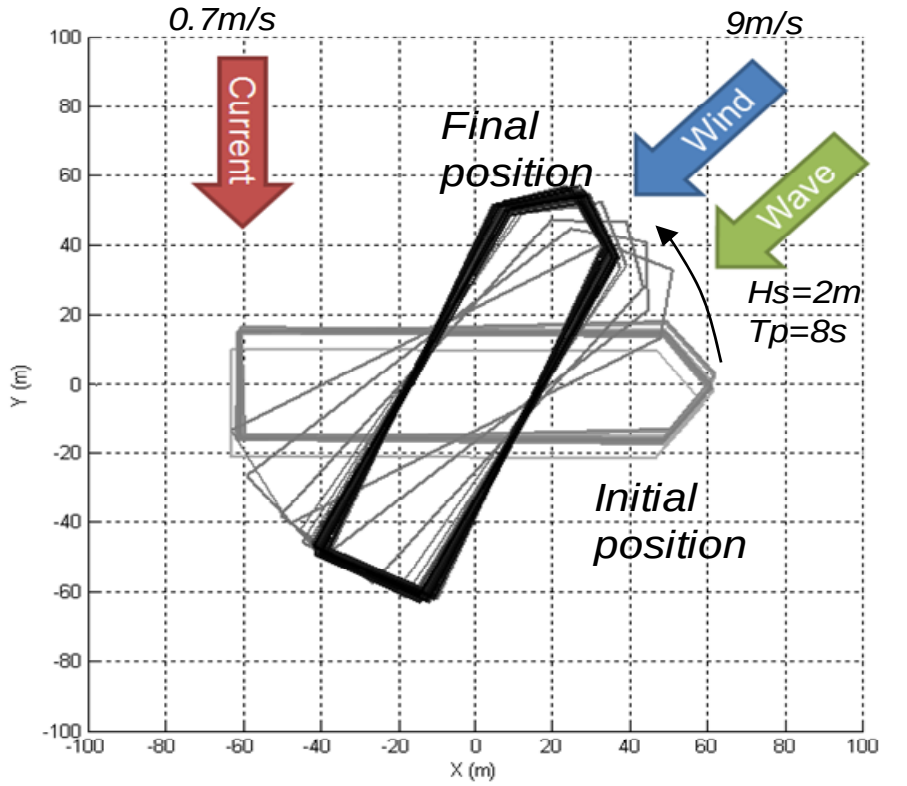
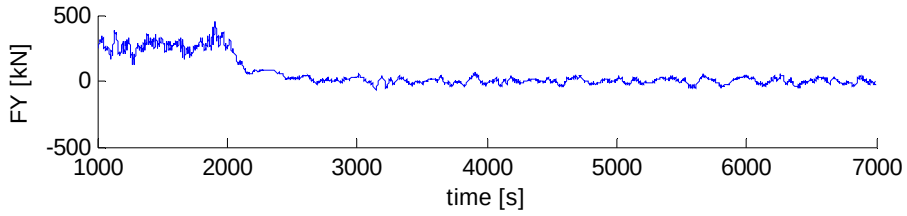
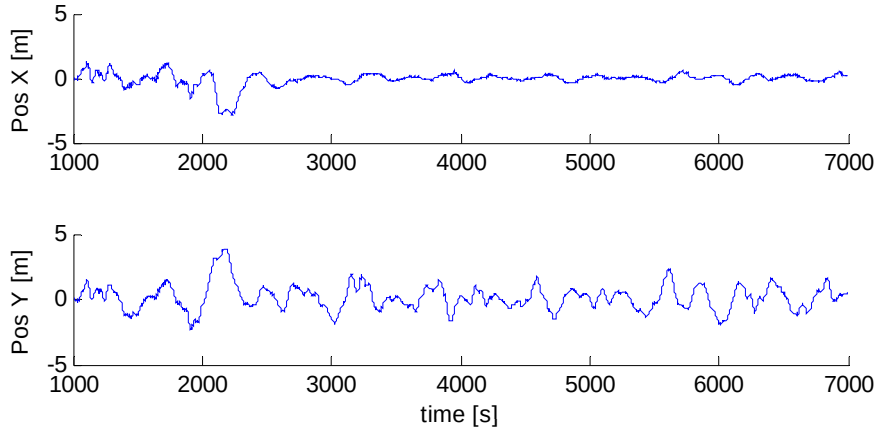
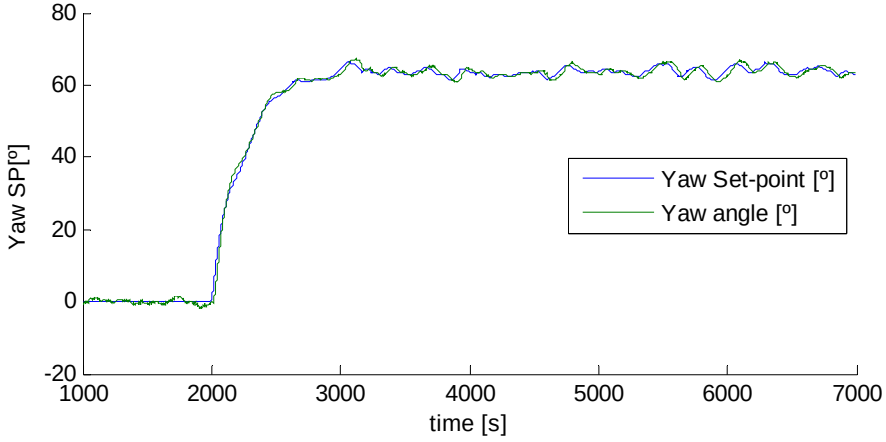
Simulation: Brazilian Typical Environment #1









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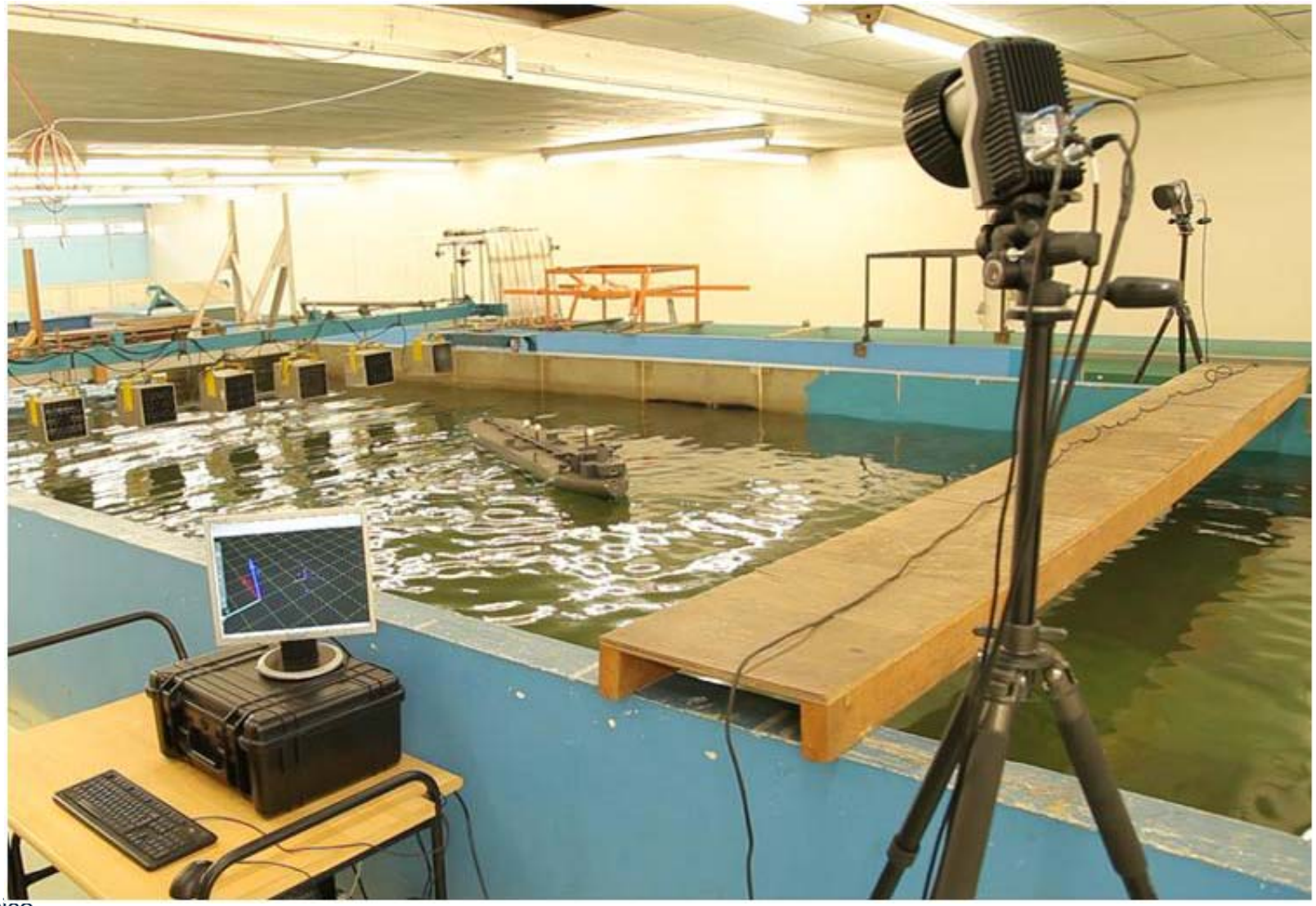
Experimental Results



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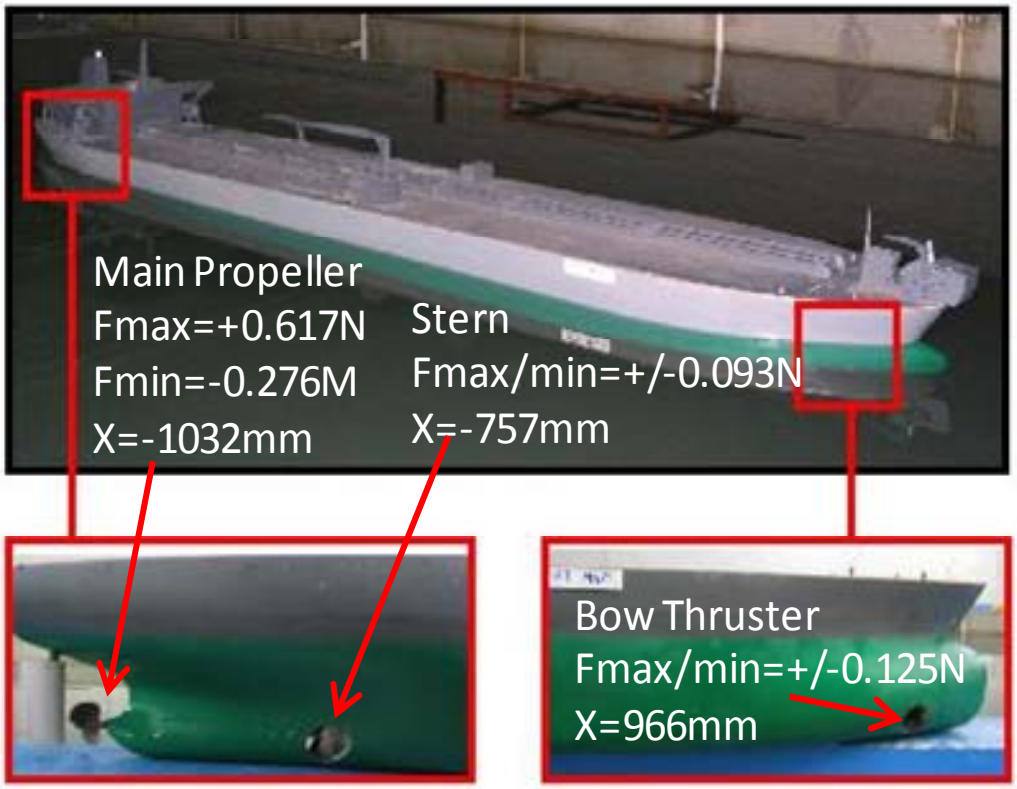
Vessel Properties



1:125 Reduced Scale
DP Tanker

Property	Real value	Model Value
Total Length	277m	2.22m
Length between Perpendiculars [L_{PP}]	262m	2.10m
Beam [B]	46m	0.37m
Draft [T]	8m	0.064m
Mass [M]	80,617 ton	41.3 kg
Inertia [I_z]	4.85 x 10^7 ton m^2	1.59 kg m^2

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Laboratory Facilities

Wind Generation System:

- Adjustable Angle
- Adjustable Speed

Wave Generation System:

- Adjustable Frequency
- Adjustable Height

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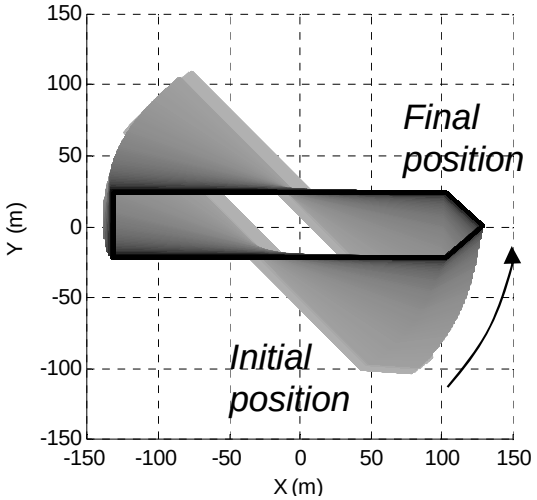
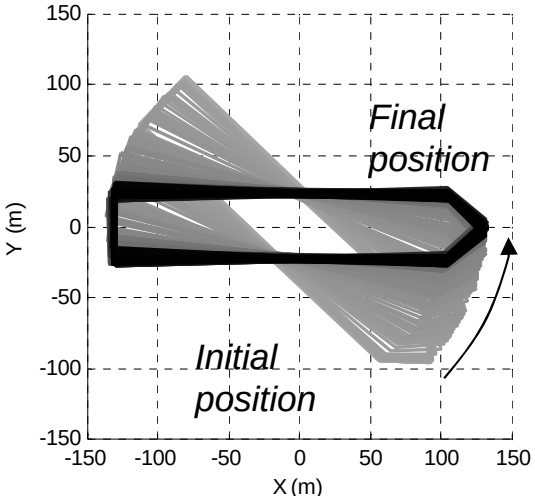
Comparison: Midship control

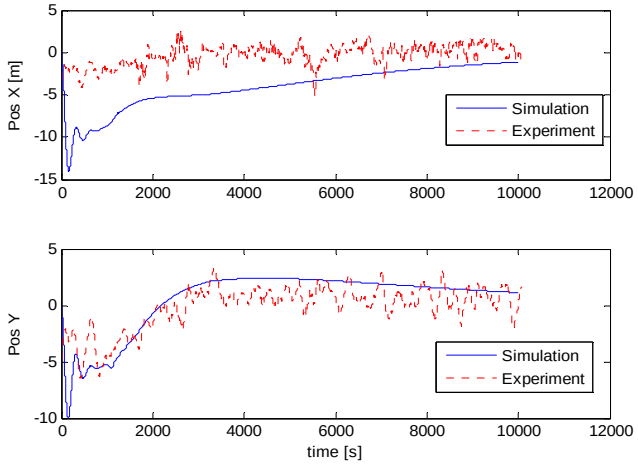
Simulation

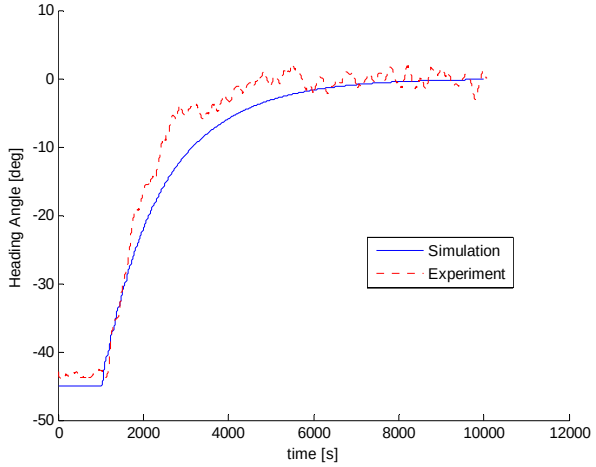


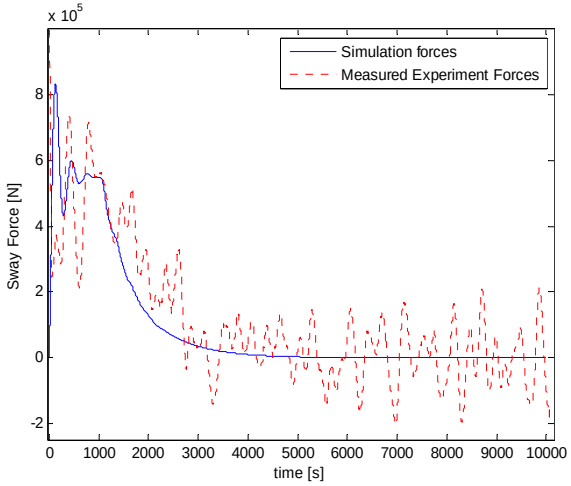
Experiment



Wind 22m/s







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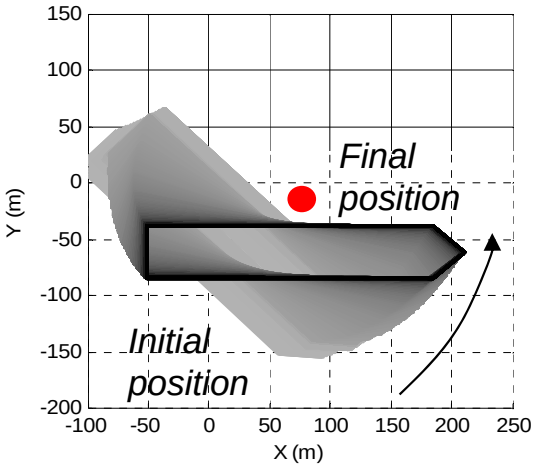
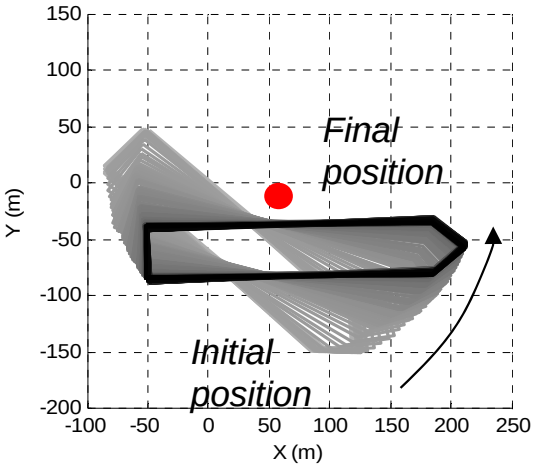
Comparison: Port side control

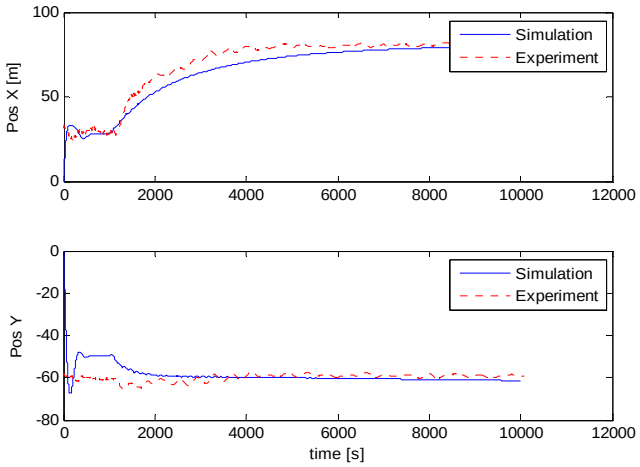
Simulation

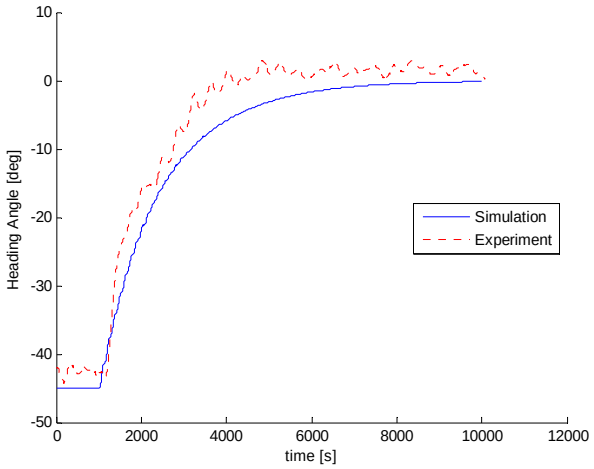


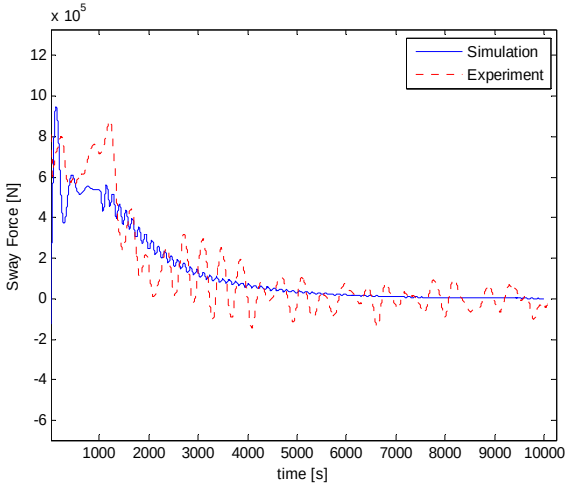
Experiment



Wind 16m/s







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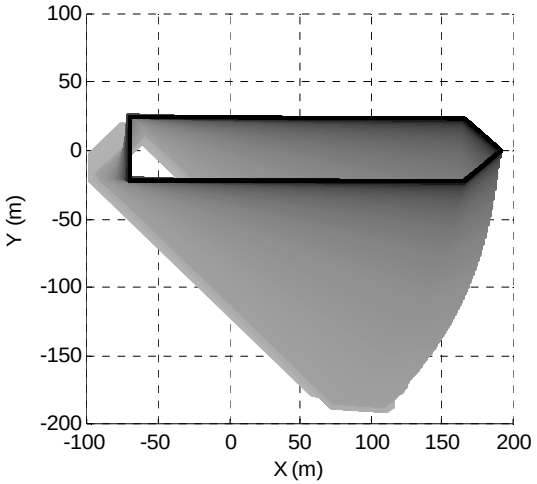
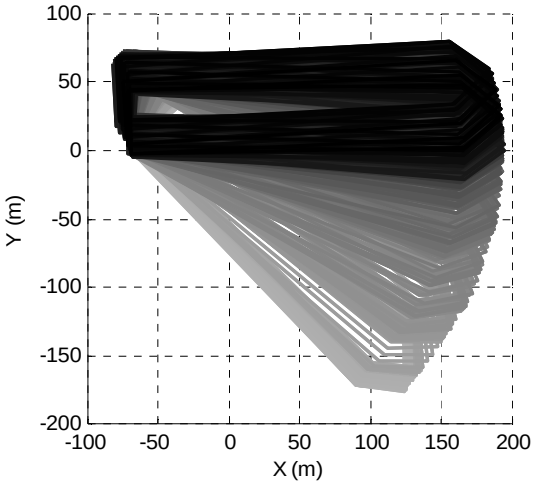
Comparison: Stern control

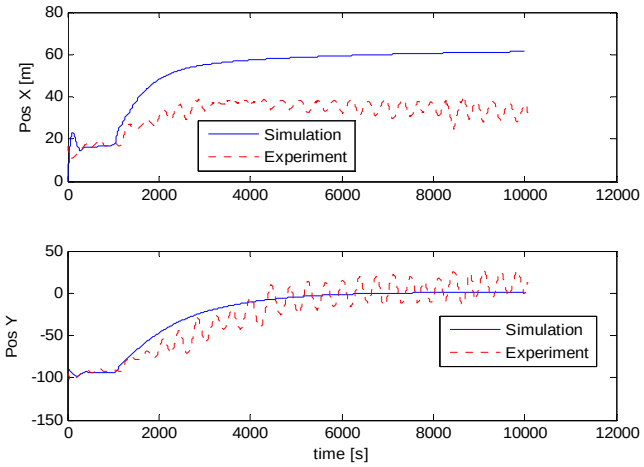
Simulation

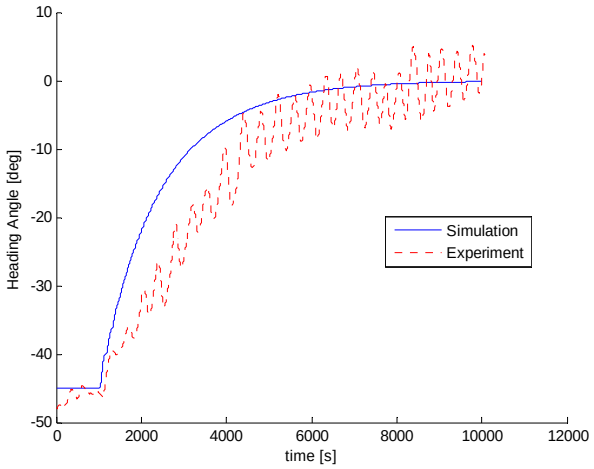


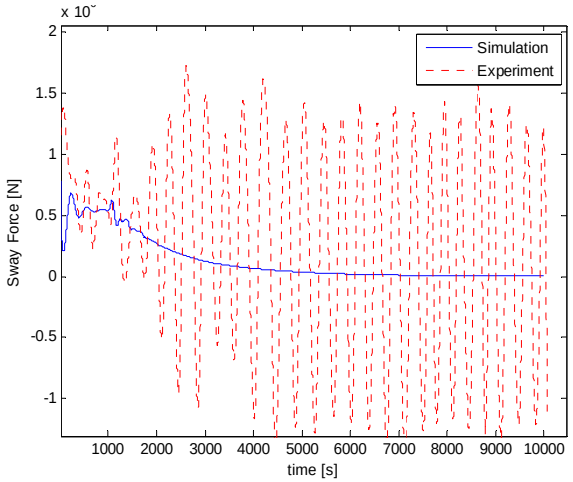
Experiment



Wind







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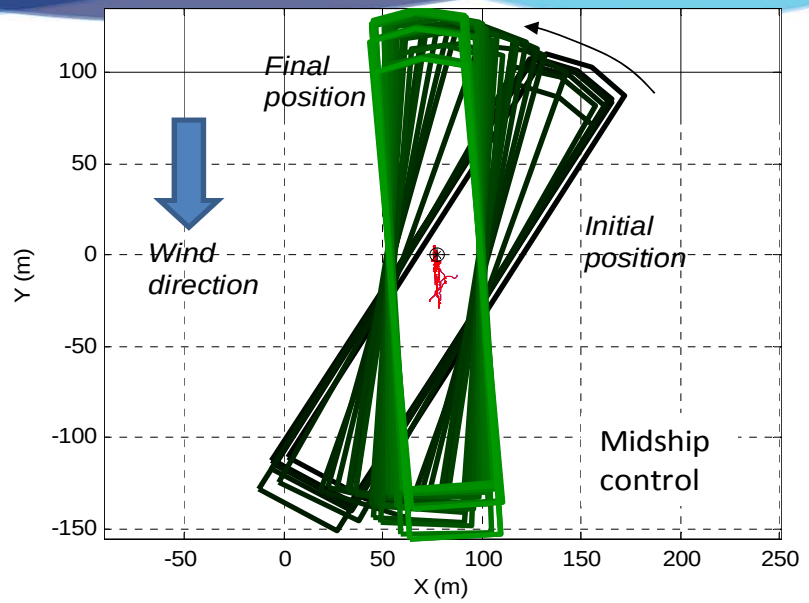
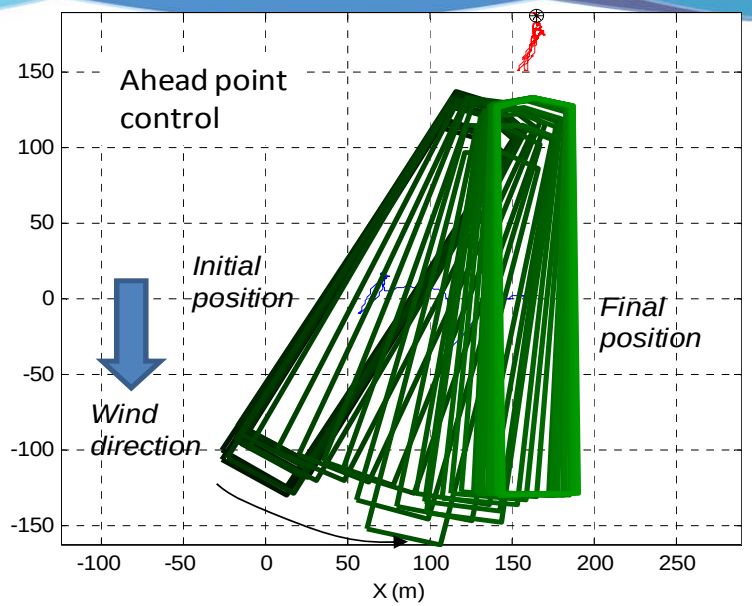
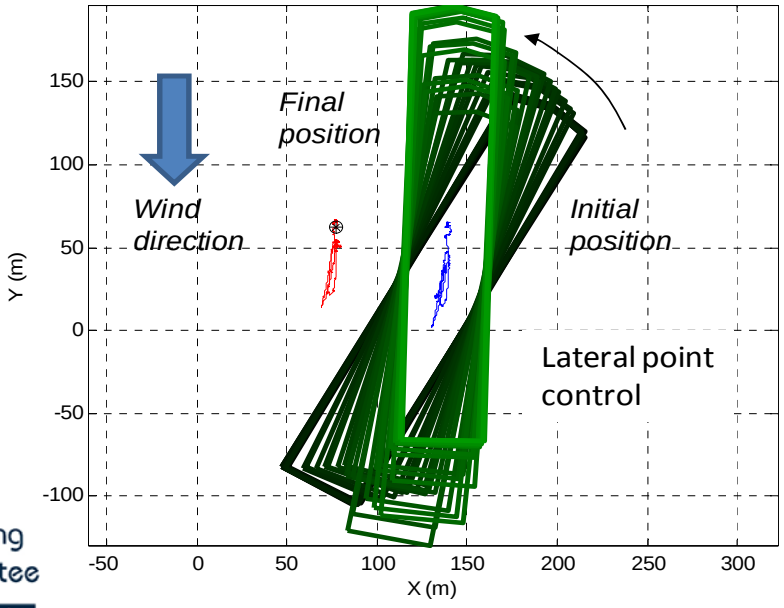
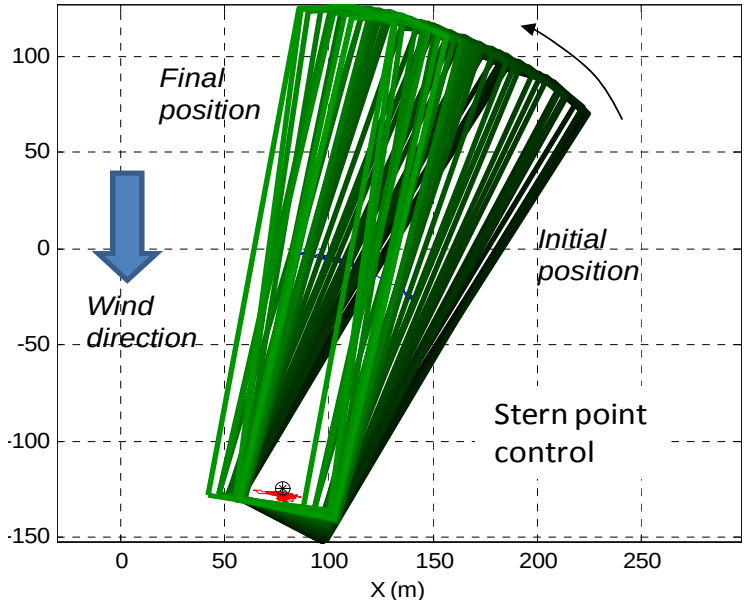
Experiments Summary









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Midship control

Bow control

Port side control

Stern control

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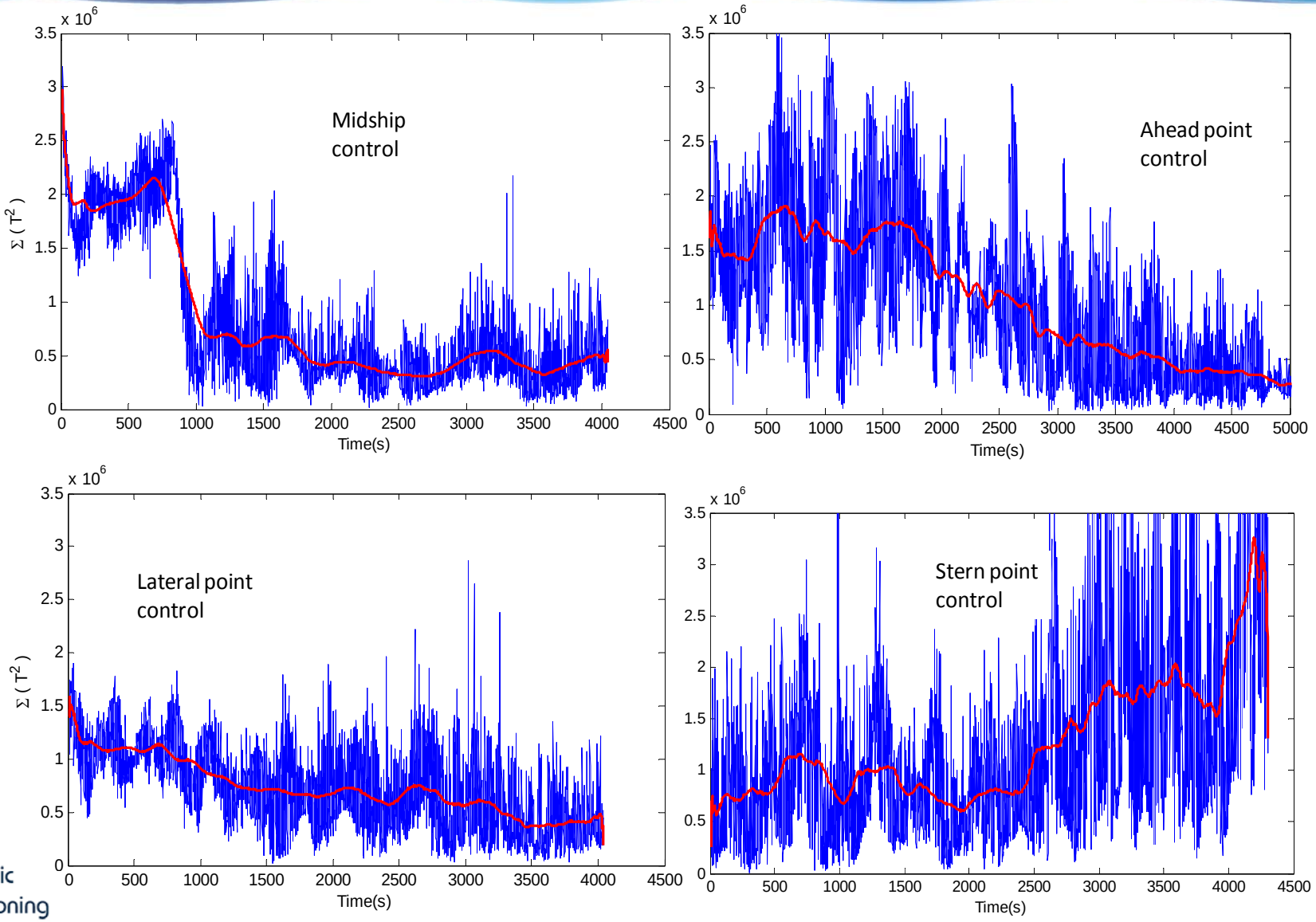
Experiments Summary



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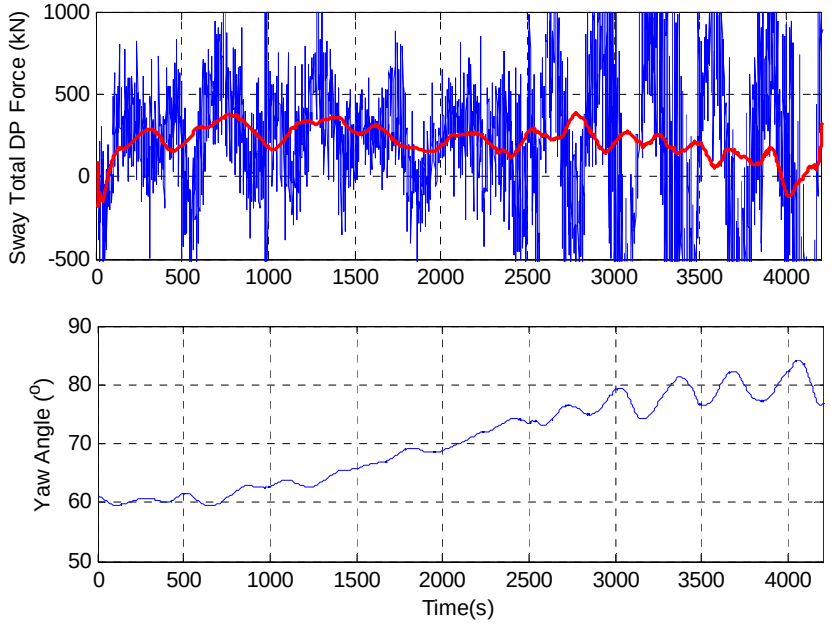
Analysis

- For the stern control point, the large heading oscillation is responsible for the power amplification. The Figure shows that the average DP sway force reduces after the ZPC-W is turned on. So, the weathervane action is working properly, and the oscillation problems may be mitigated by a fine tuning of the control gains.



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CONCLUSIONS

- Satisfactory results so far, decreasing DP utilization (Except stern control)
- Successfully controlled the vessel bow, midship and port side and variable environment condition
- More studies need to be conducted, but the results of this paper shows that this controller is commercially viable, with great advantages over simpler weathervane controllers, specially for offshore applications

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FUTURE WORK

- More simulations
- Deeper stability analysis
- Real time simulation
- Implementation

TPN-USP Real Time Simulator

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THANKS

eduat@usp.br

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