KIVI NIRIA

"React To The Future"

New research developments for fast ships

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TU Delft

MARIN

Lloyd's Register

Imtech

DAMEN

BUREAU VERITAS 1828

Ministerie van Defensie

Introduction

Fast ships

Sailing at high speeds is desired

For various operations

- Search and Rescue
- Patrol
- Military

Ship type

- Fast monohull
- Limited size

Introduction

High forward speeds in head waves

Bow impacts with incoming waves

Results in

- Large vertical peak accelerations

May cause

- Fatigue and discomfort for the crew
- Structural damage at the bow
- Personal injuries

→ Limiting factor of the operability

Introduction

Following and stern quartering waves

Bow diving

- Surf-riding and plowing into the back face of next wave

Broaching

- Surf-riding coupled with loss of directional stability

Usually less intensively researched:

- Complex and costly – rare events
- Lack of suitable facilities and methods

Introduction

Hull geometry developments at the DUT

1982 - 1985

1995 - 1999

2000 - 2006

2011 - 2014

Introduction

Operational control

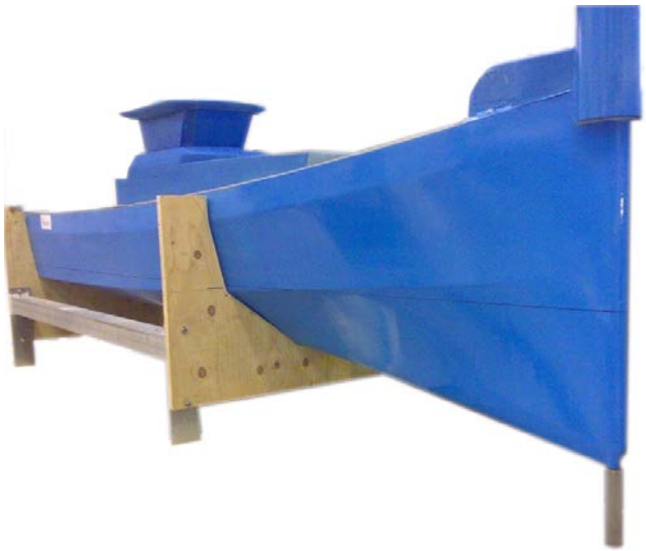
Further improvement of the operability of fast ships using active control mechanisms

Following waves

- Bow rotor

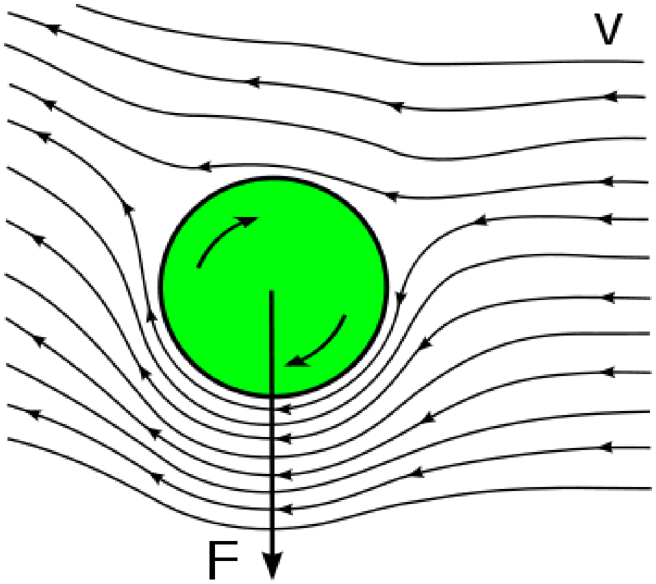
Head waves

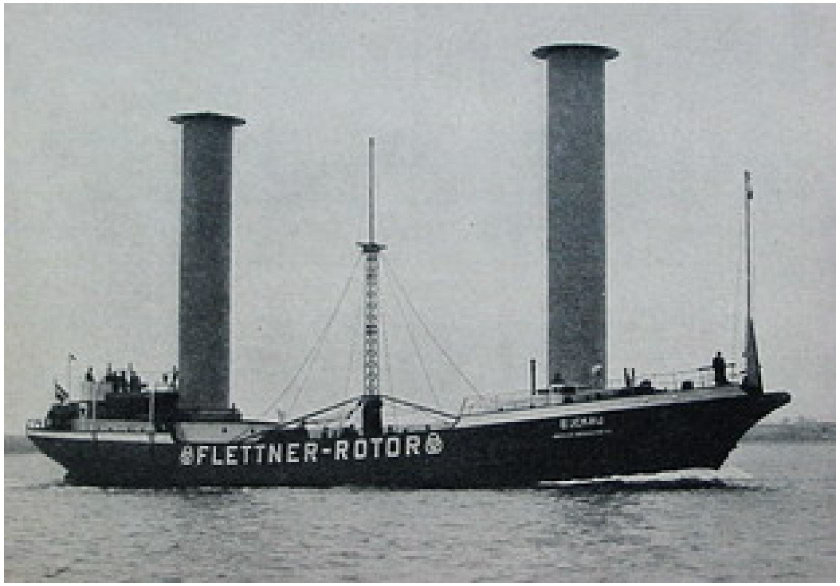
- Thrust control
- Active transom flaps / interceptors

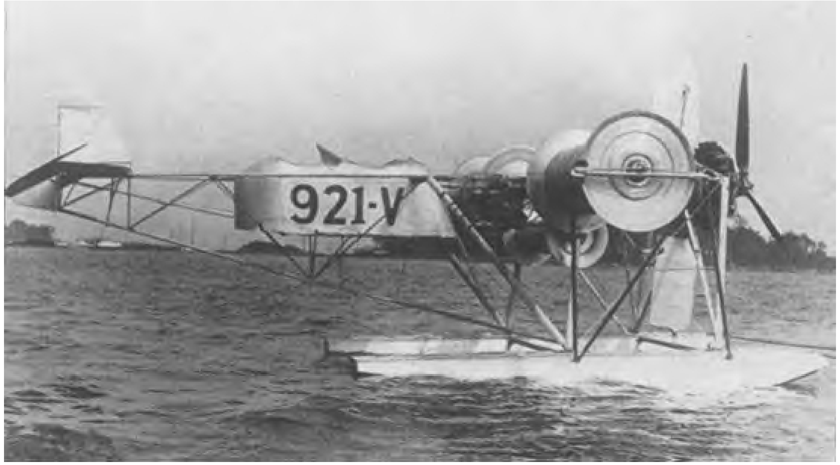


Bow rotor

Magnus effect

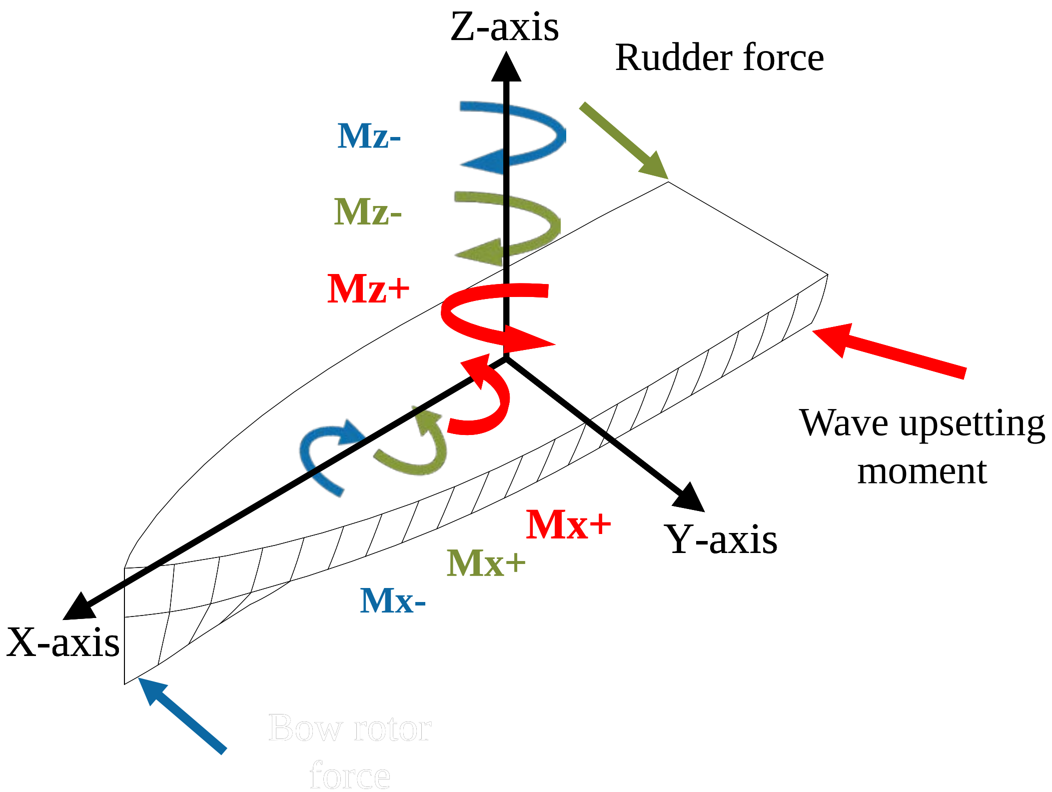






Bow rotor

Principle

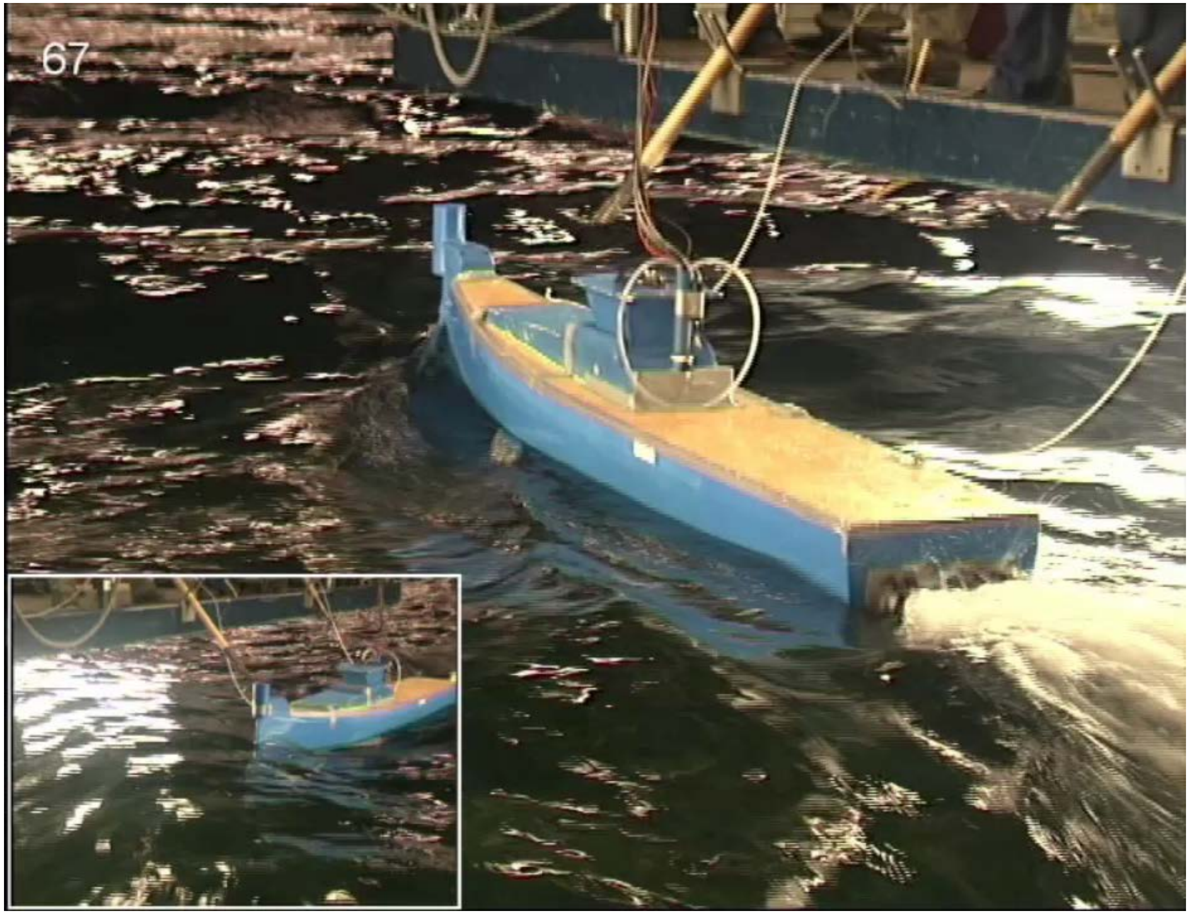


Bow rotor

Without rotor - Hs = 3.5 m, Vs = 20 kn, μ = 315°

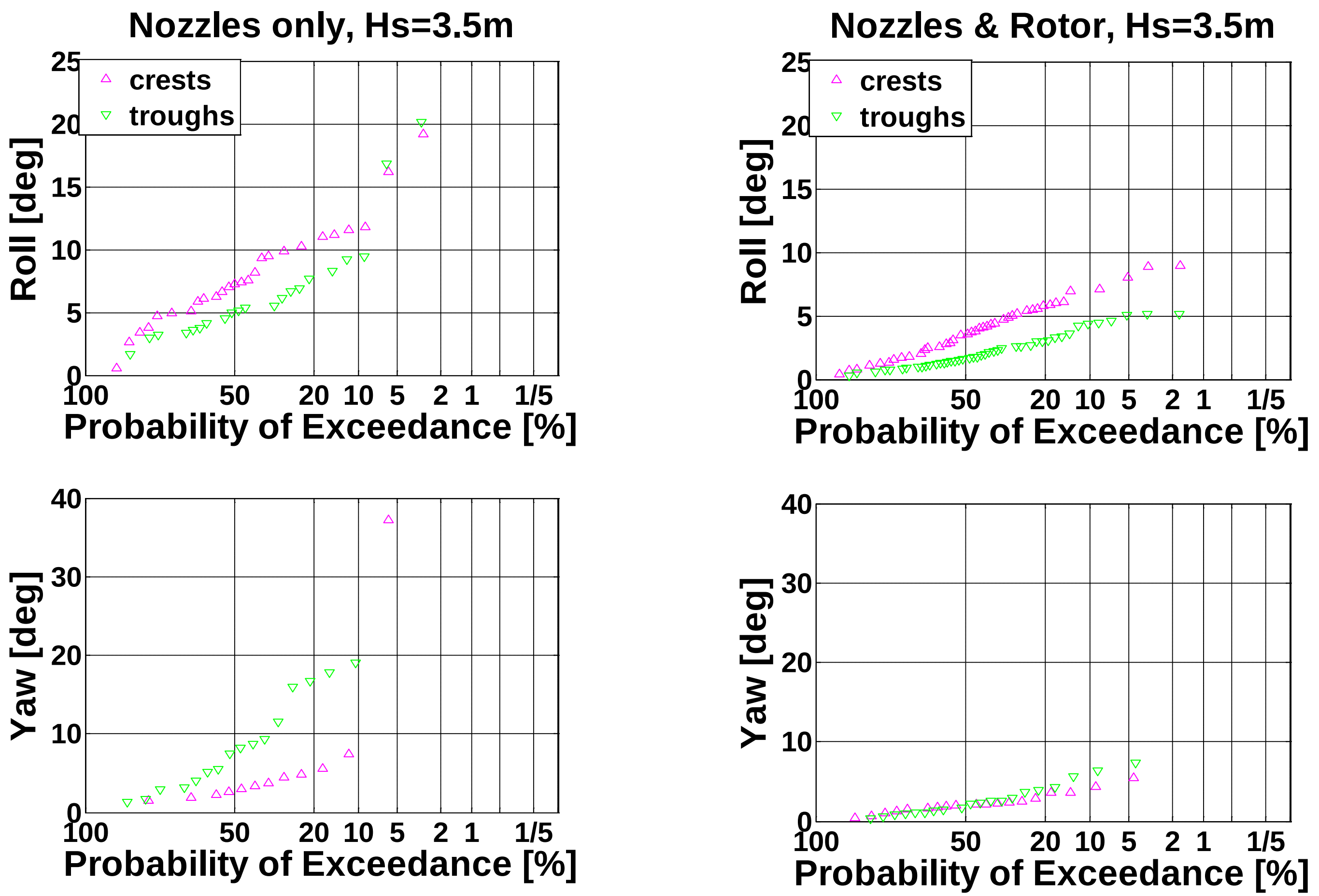
Bow rotor

With rotor - Hs = 3.5 m, Vs = 20 kn, μ = 315˚



Bow rotor

Results



Bow rotor

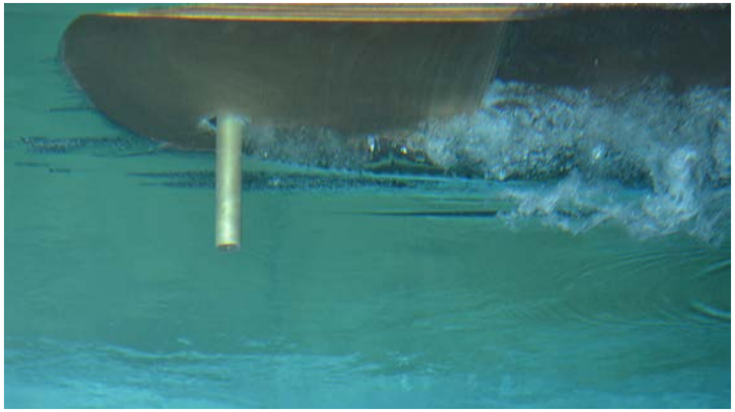
Further developments

General rotor research

- Reynolds number
- Dynamic effects
- Surface roughness

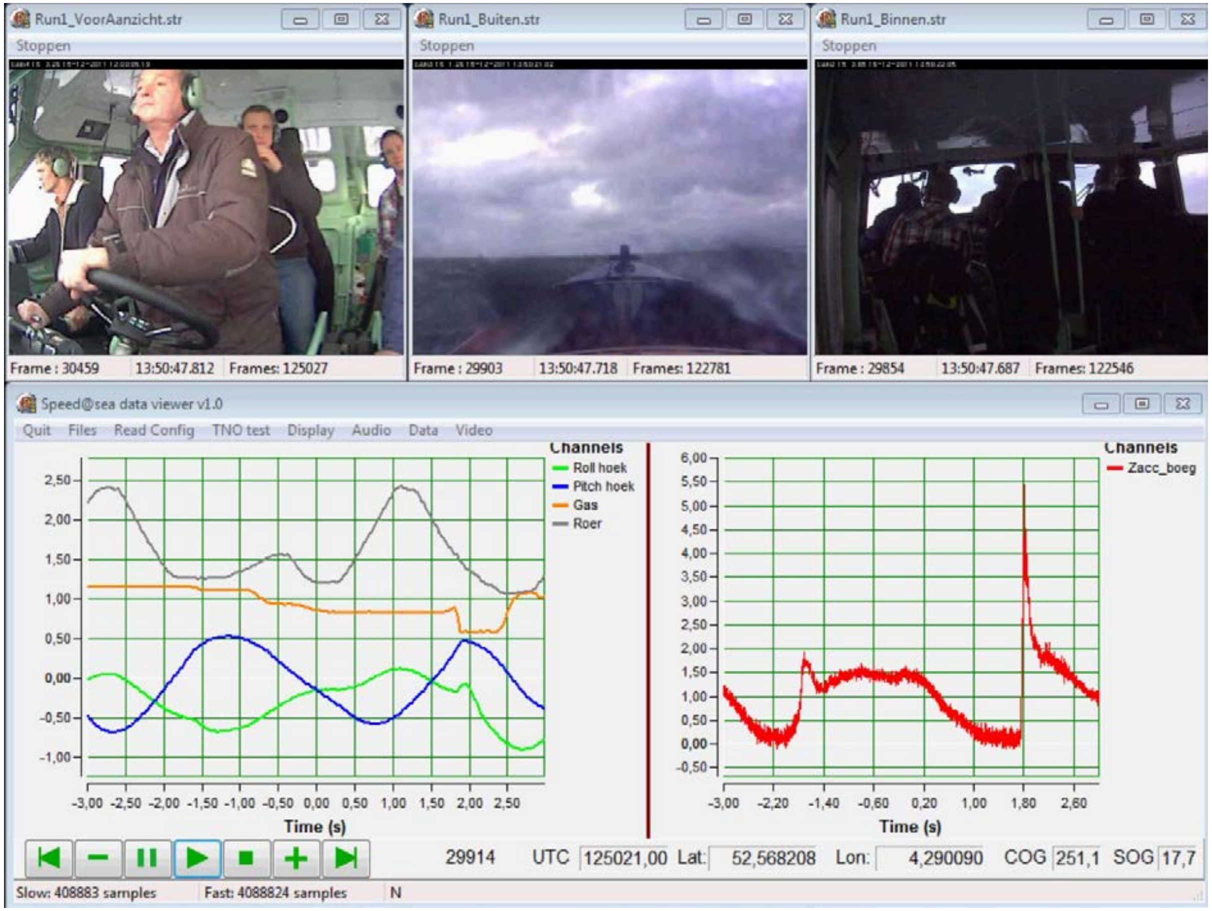
Applications

- A 22 meter patrol boat with a retractable bow rotor is currently under construction
- Wind assisted ship propulsion



Proactive control

Full scale trails in head waves (Speed@Sea)



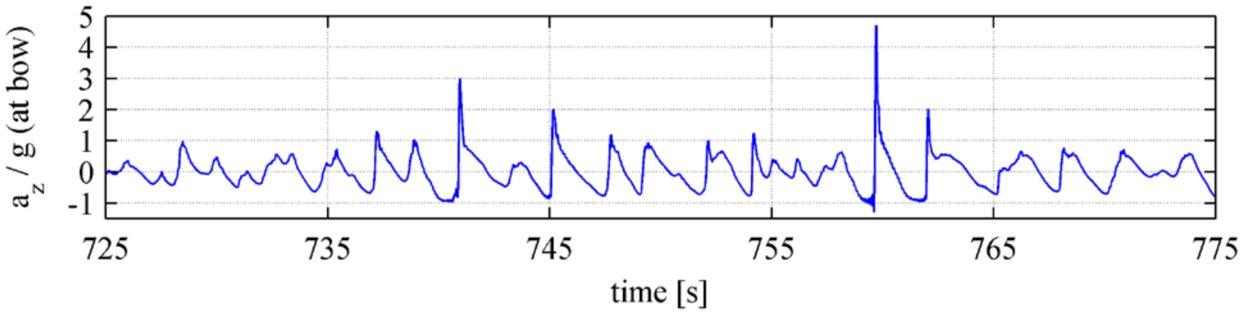
Proactive control

Operability

Increase of the operability requires a reduction of the vertical peak accelerations

Characteristics vertical peak accelerations

- Nonlinear
- Low frequency of occurrence
- Short time duration



→ Incentive for the design of a proactive control system

Proactive control

Approach

Concept

- Change the state of the vessel before a wave impact event

Control parameters

- Thrust control (PhD project *A.F.J. van Deyzen*)
- Motion control mechanisms

Control devices

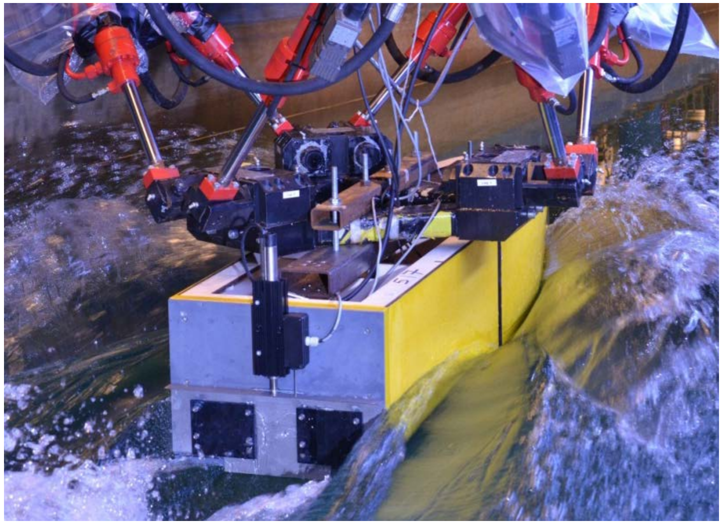
Experiments

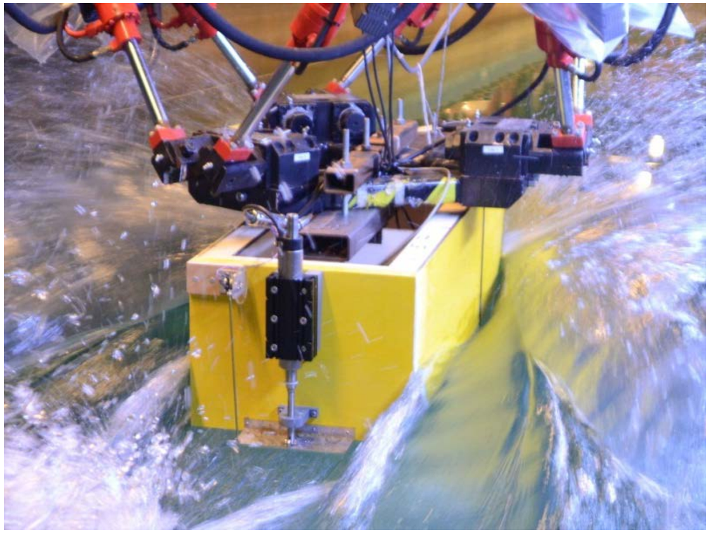
Model configuration

- Interceptor
- Transom flap

Objectives

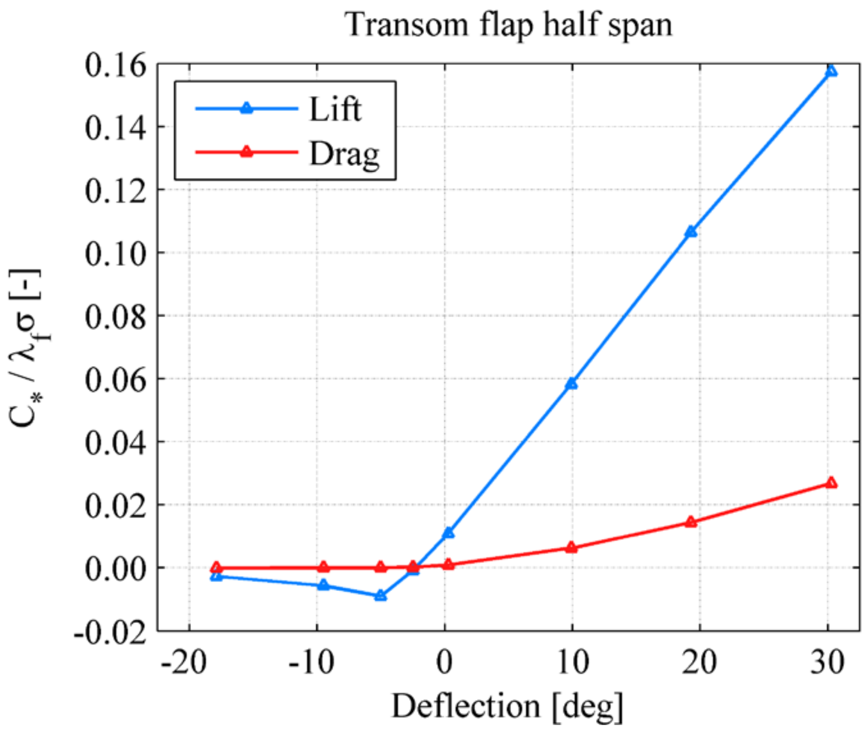
- Stationary characteristics of control devices
- Hydrodynamic behaviour of (fast) oscillating control devices

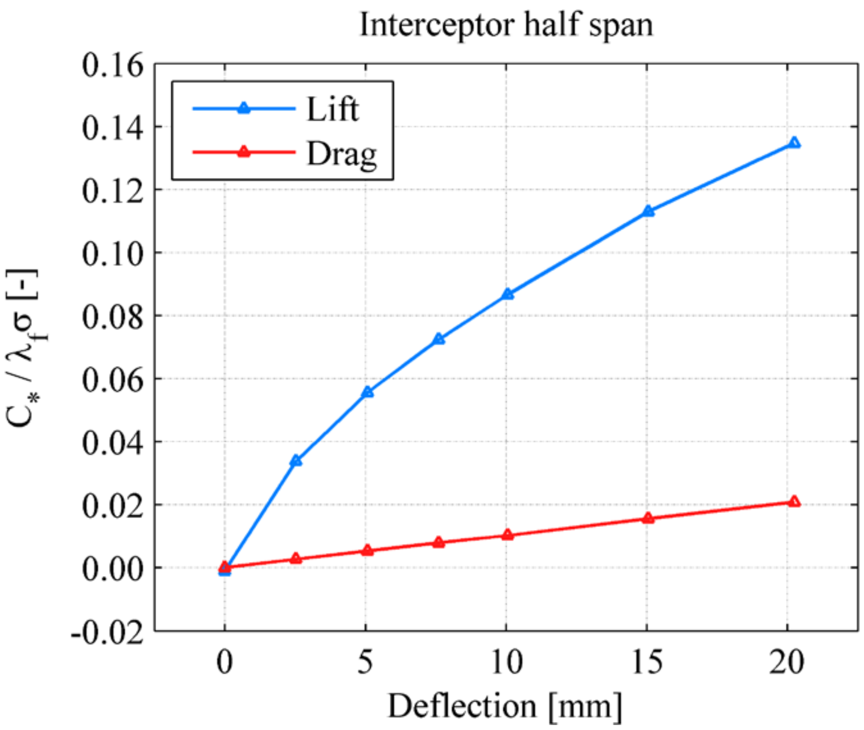




Control devices

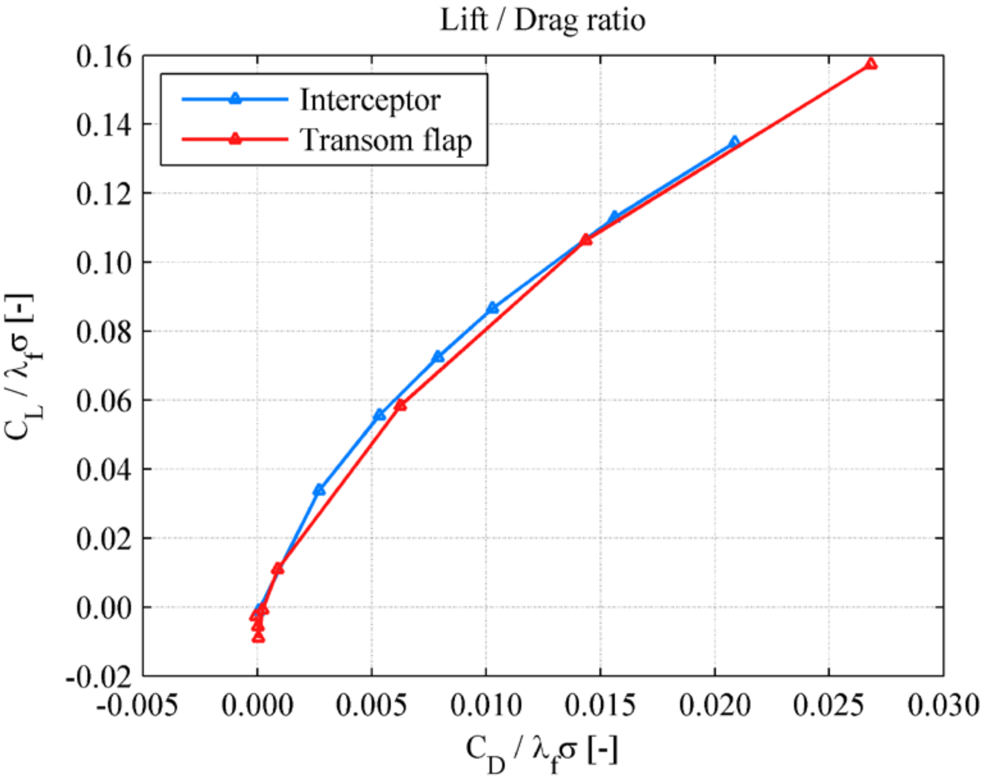
Results - stationary tests





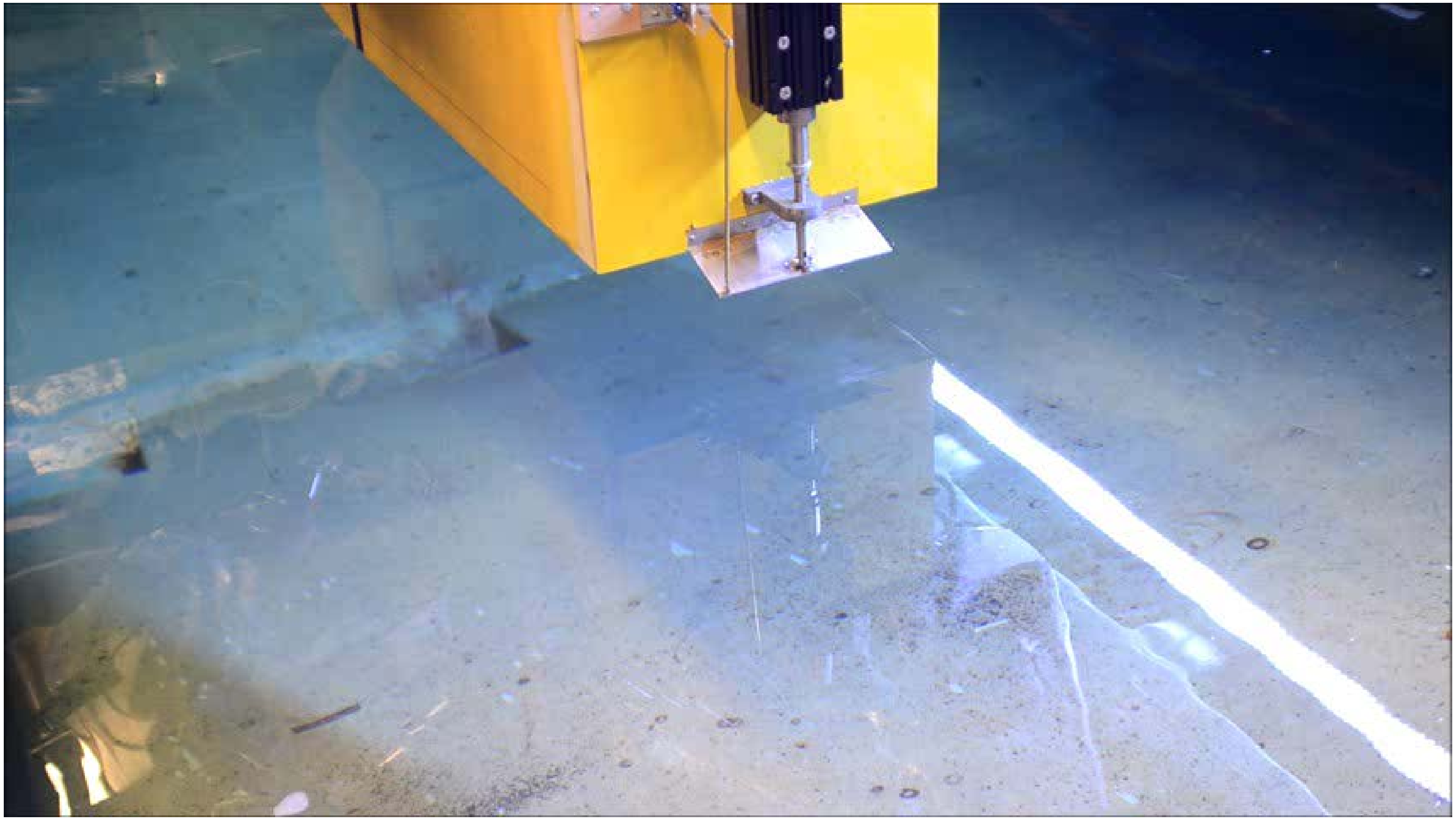
Control devices

Transom flap vs. interceptor efficiency



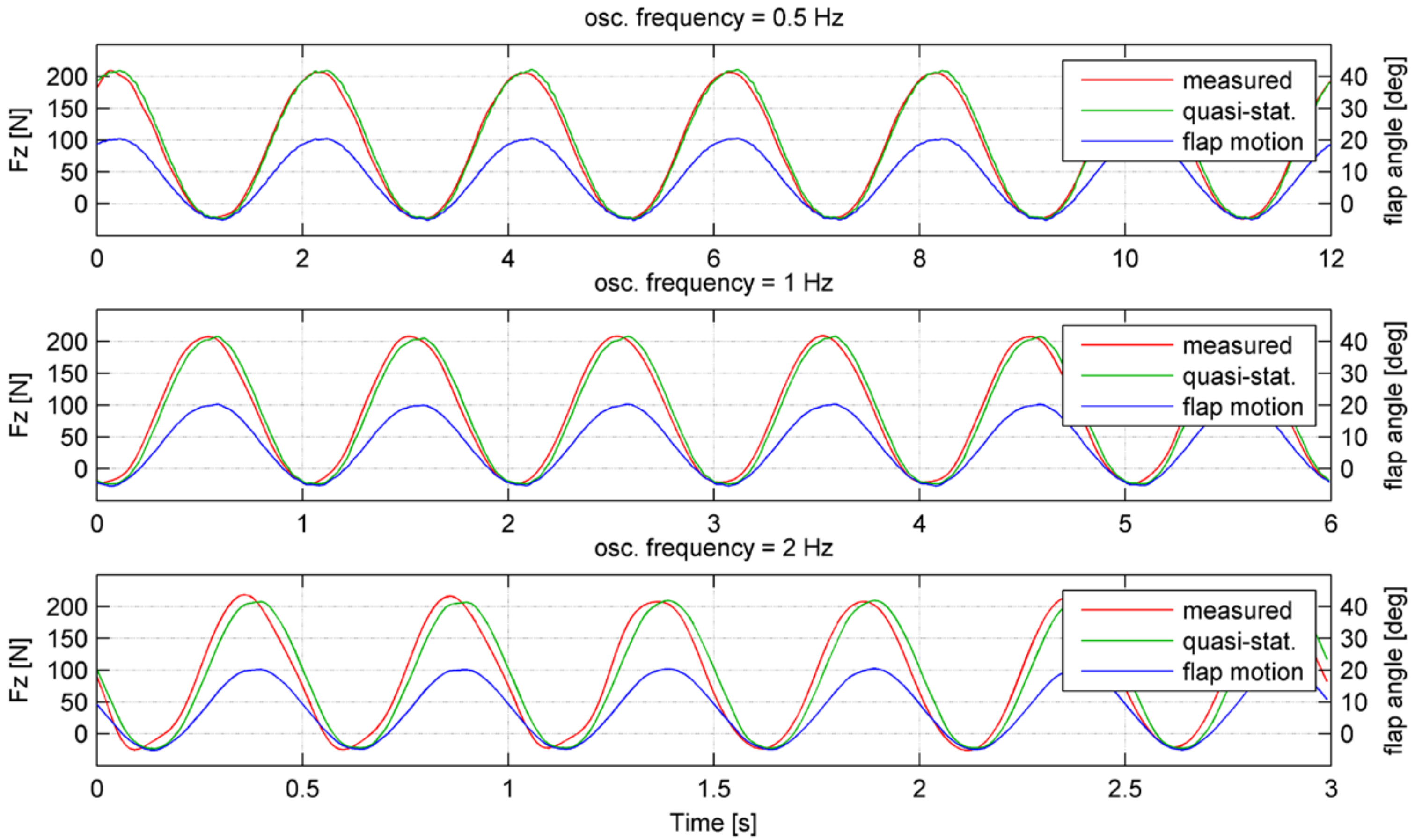
Control devices

Oscillation transom flaps



Control devices

Results – oscillation tests



Proactive control system

Design

Proactive concept

- Anticipate on future vertical peak accelerations address them before they actually pose a problem

Components ship application

- Wave measurement system
- Real-time simulation model
- Control system that intervenes when it detects a disturbance

Control objectives

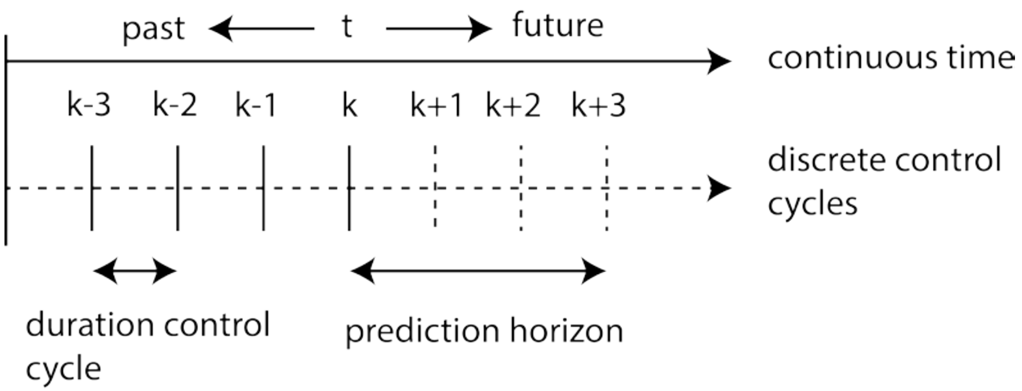
- Limit the peak accelerations to a particular threshold value
- Maximise the average forward speed of the ship

Proactive control system

Control strategy

Model predictive control

- Discrete control cycles
- Prediction horizon



Principle

- Sample the state of the ship and the incident wave
- Response prediction during the prediction horizon
- Determine the consequences of various control actions
- Implement a ‘tailored’ solution

Proactive control system

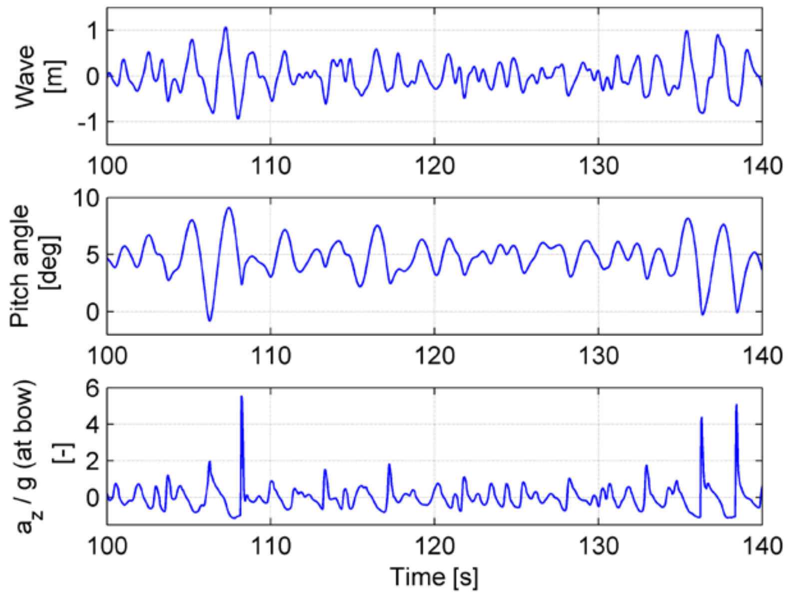
Simulation model FASTSHIP

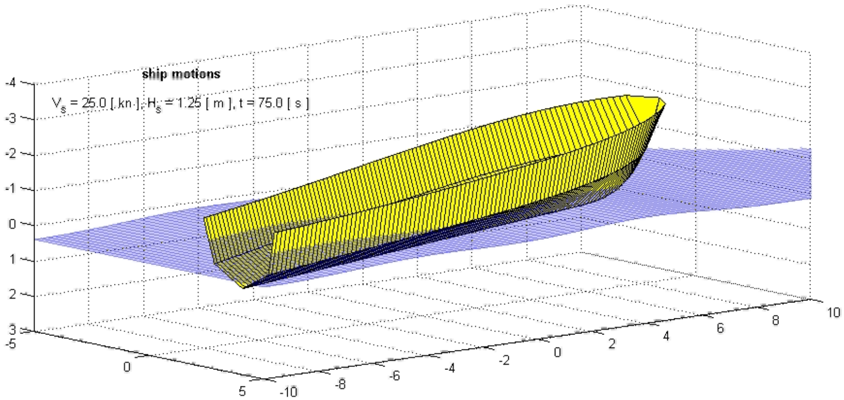
Background

- Simulation program for motion predictions of fast ships

Properties

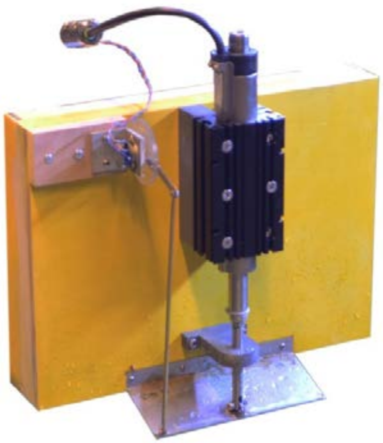
- Head waves
- Deals with nonlinear acceleration levels
- Short CPU time (real-time applications)

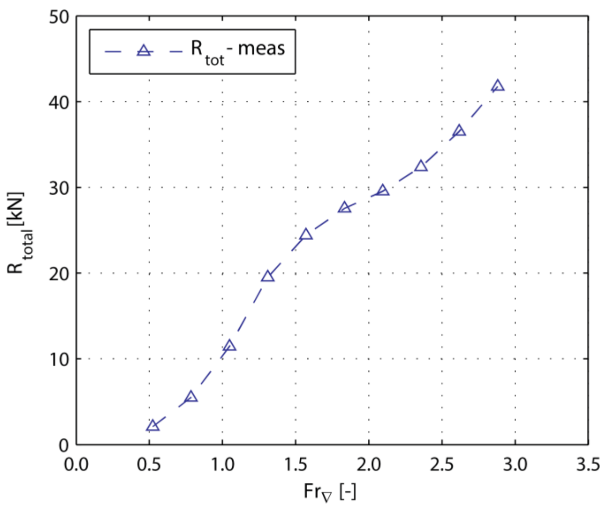


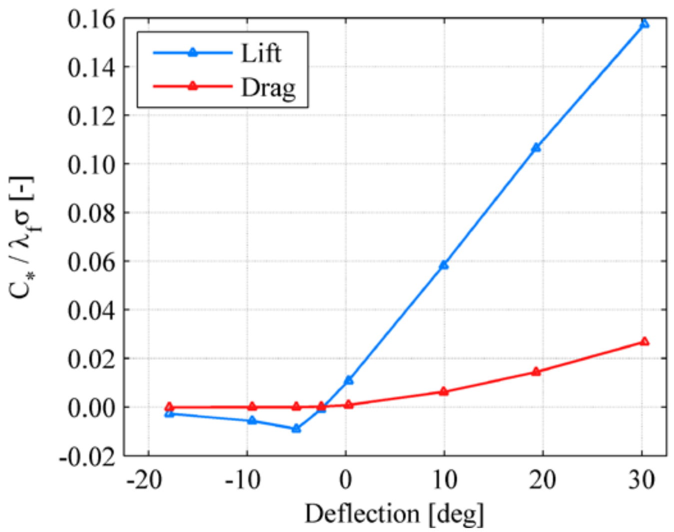


Proactive control system

Control parameters





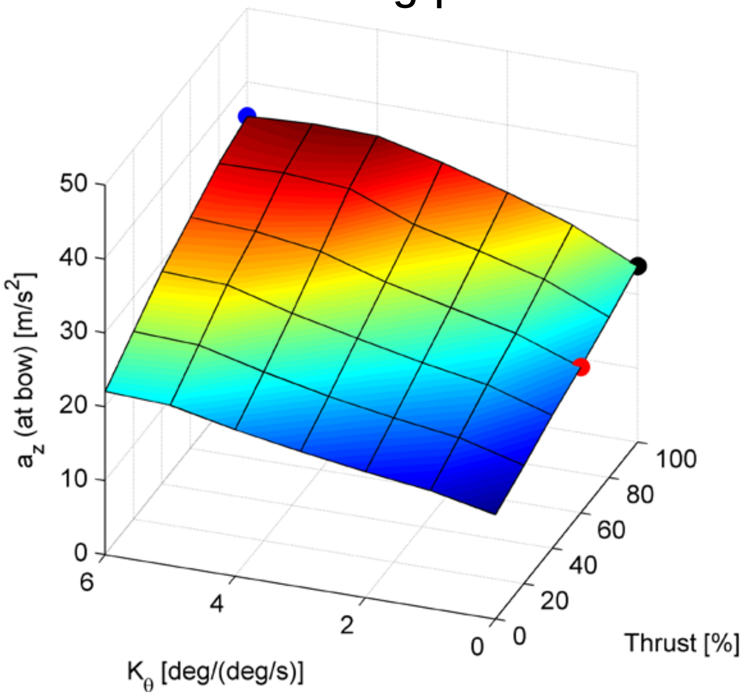


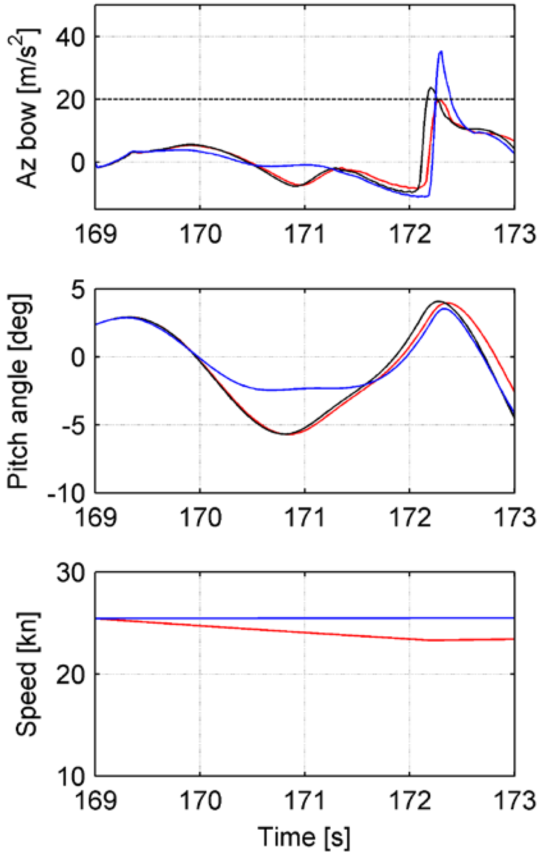
Proactive control system

Results of various control actions

Performance matrix

- Collection of 42 predictions
- Decision making process





Proactive control system

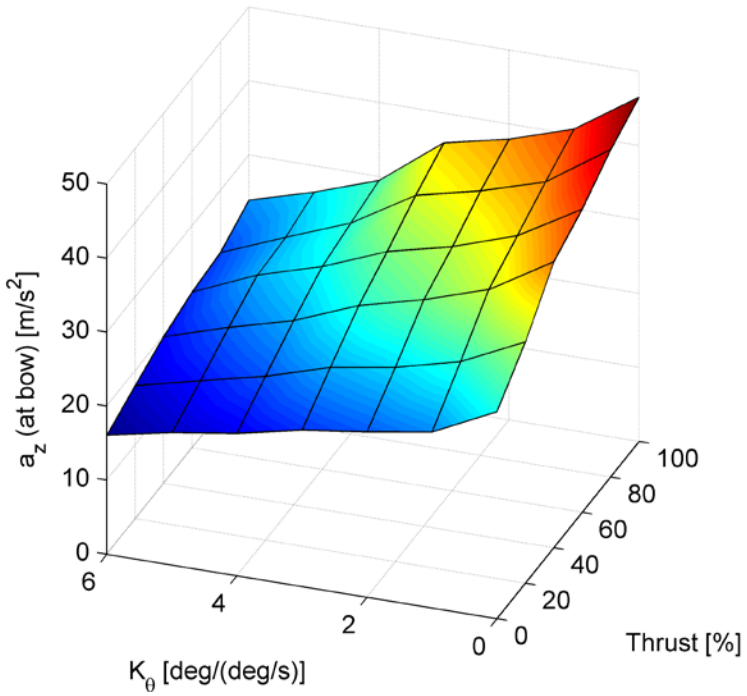
Real-time application

Processing delay

- Reduces the prediction horizon
- Affects the accuracy of the predictions

Minimisation of the processing time

- Parallelization
- Processing time 0.3 ~ 0.4 seconds

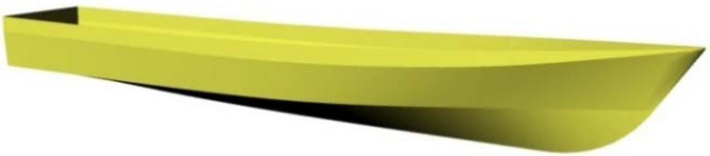


Simulations

Test case

Specifications

- Ship length 22 meters
- Two transom flaps
- Speed range 18 – 26 knots

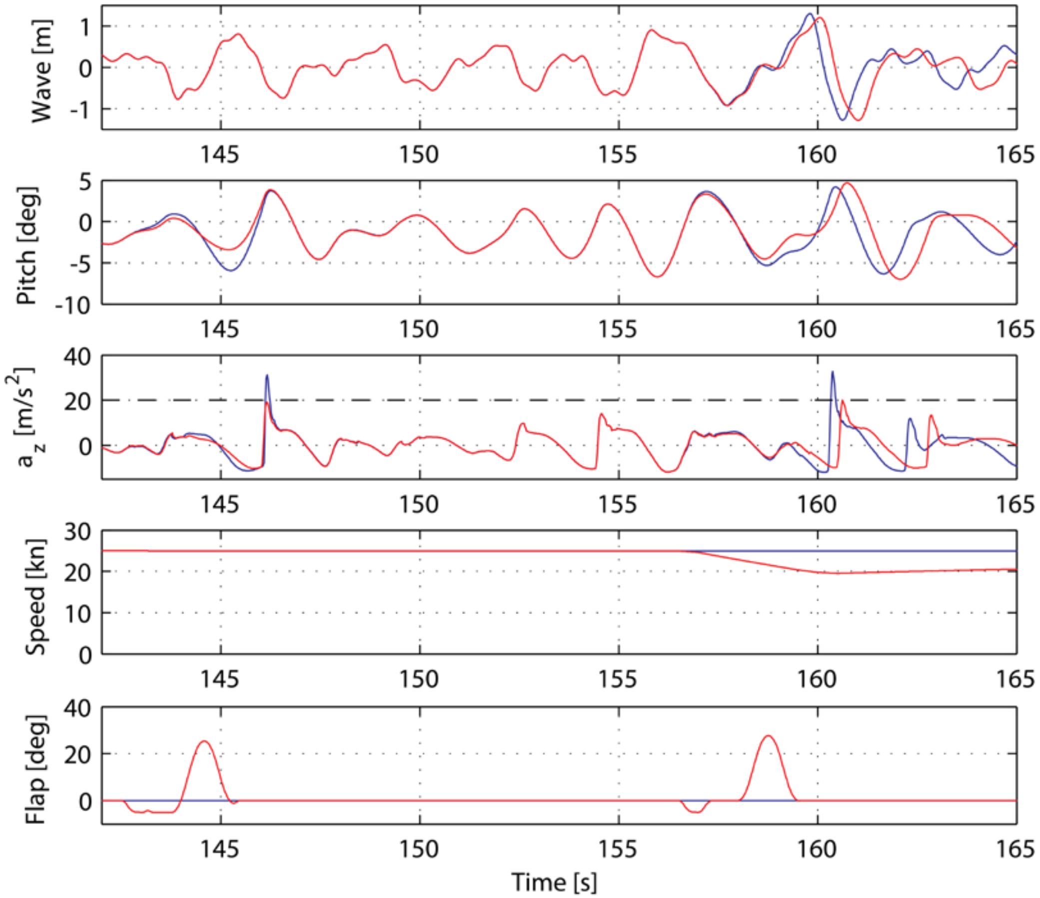


Objective

- Indicate the performance of a proactive ride control system with two control parameters

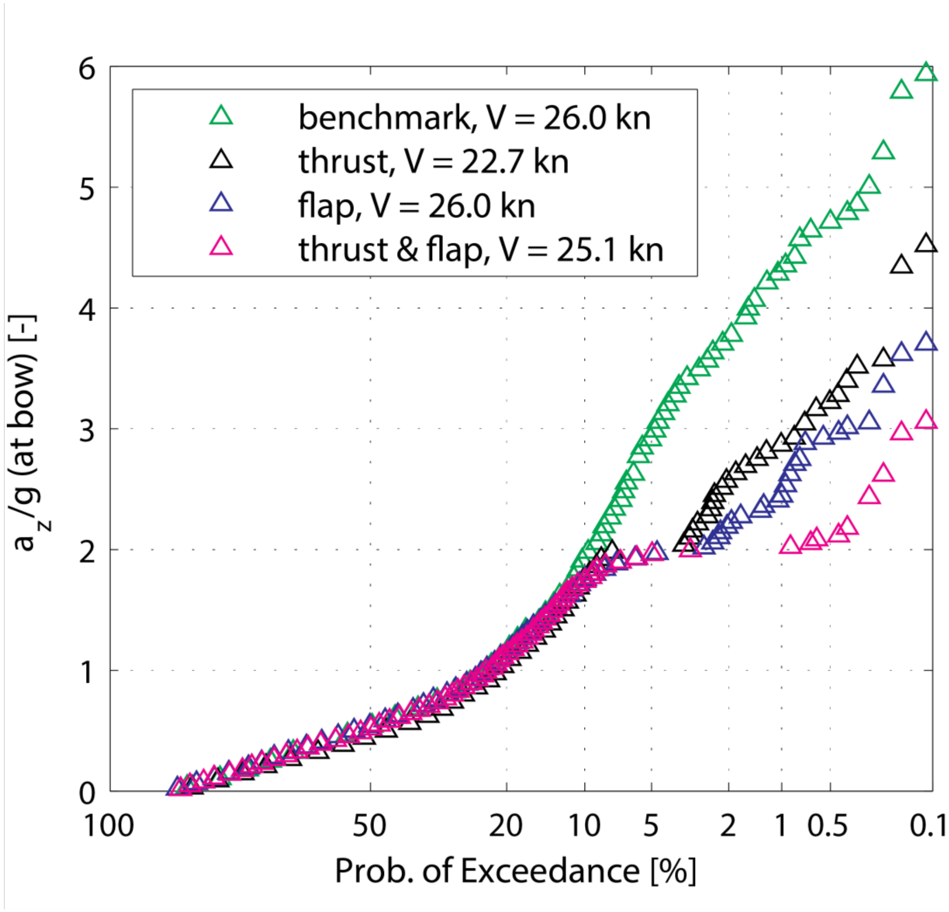
Simulations

Results proactive ride control system



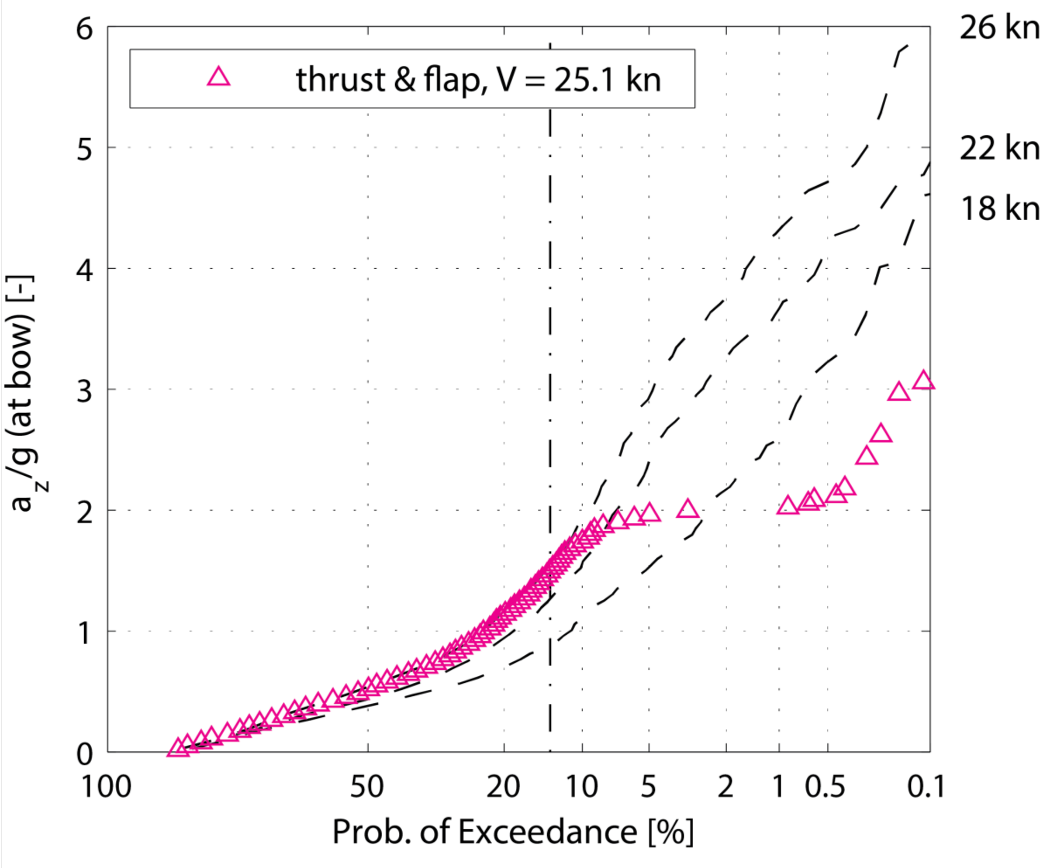
Simulations

Results control variables



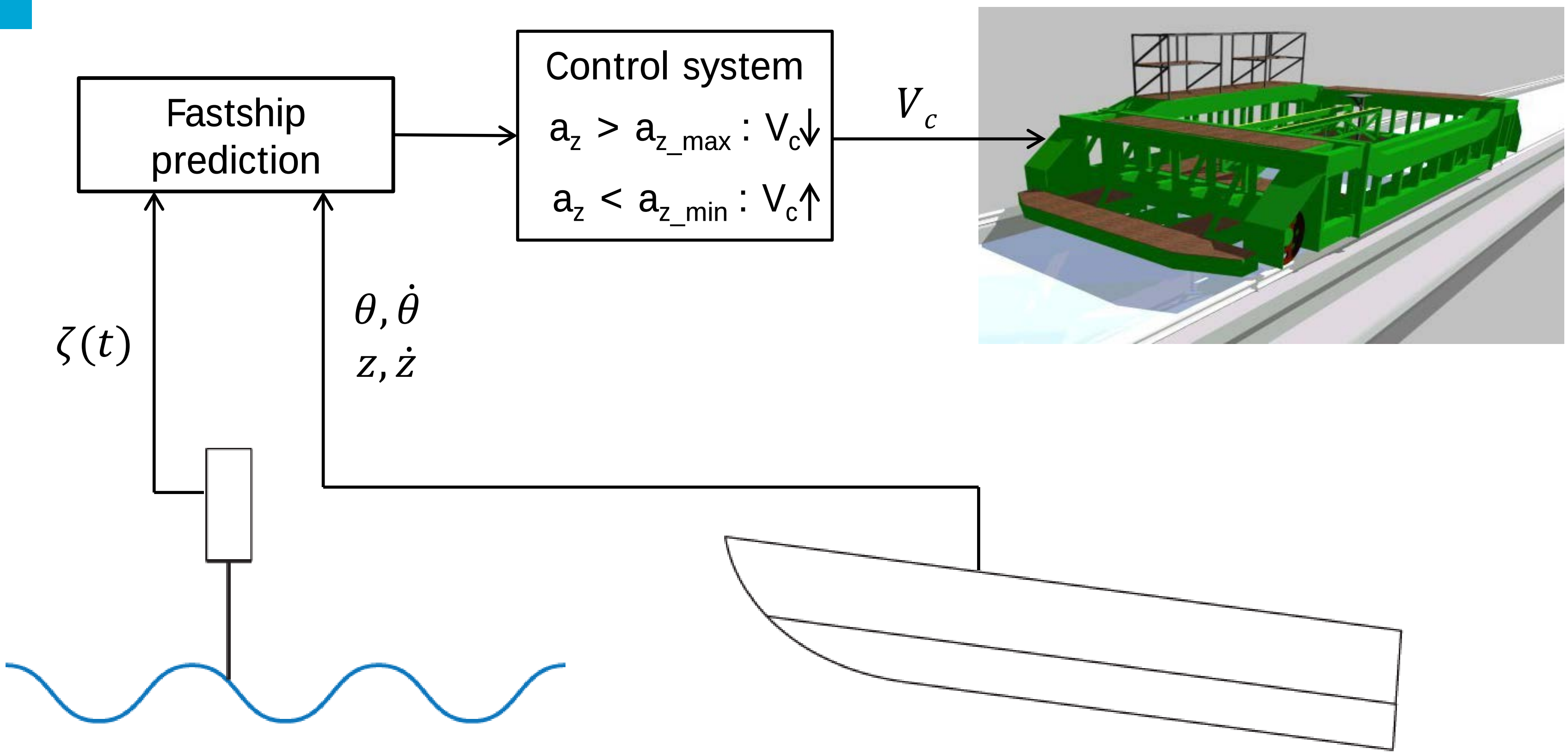
Simulations

Results operability



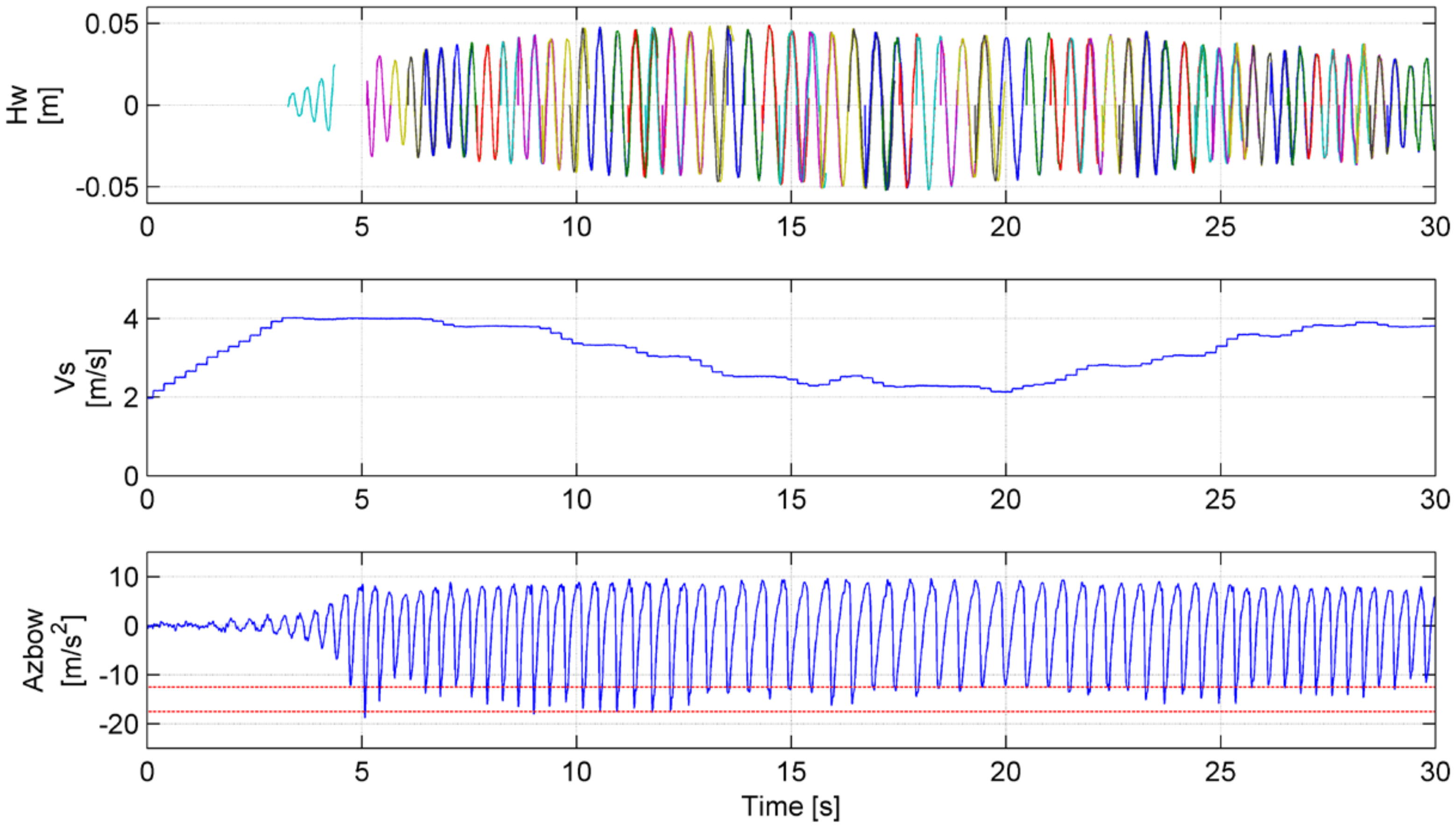
Proof of concept

"Proactive Speed Control" on model scale



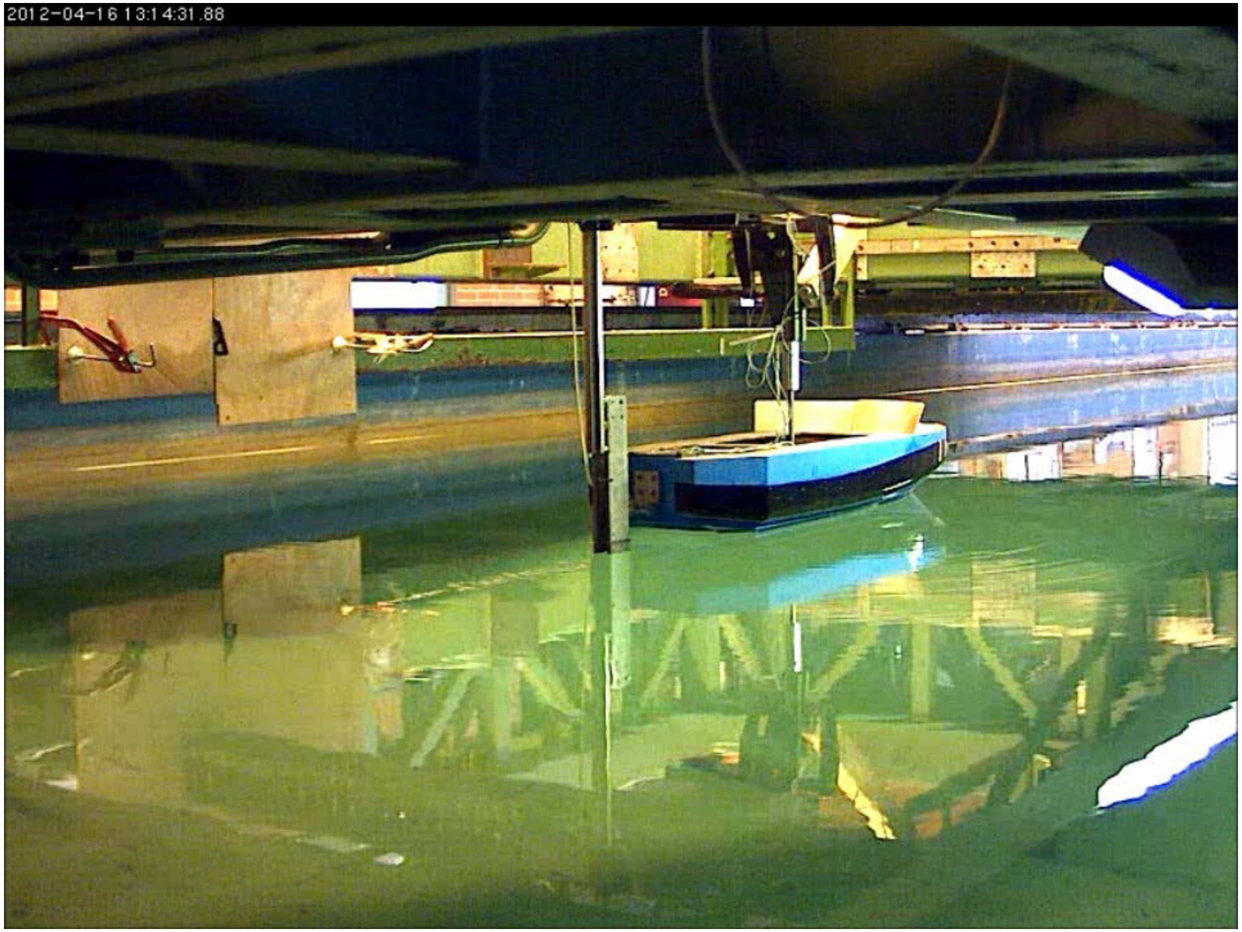
Proof of concept

"Proactive Speed Control" time traces



Proof of concept

“Proactive Speed Control” model experiments



Proof of concept

Outlook

Extension "proactive speed control"

New experiments:

- Irregular waves
- Speed control
- Interceptor

Objectives

- Demonstrate performance and feasibility of the proactive control method in a model test environment

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