Dynamic Positioning Committee

Marine Technology Society

Thrusters

Thrust Degradation in DP Operations

DP Model Test of an Aframaz Shuttle Tanker – Methods Results, Operations

Reinert Nordtveit - ***Teekay Corporation***

Bjørn Nygård - ***Kongsberg Maritime AS***

Egil Jullumstrø - ***MARINTEK***

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Dynamic Positioning Conference – Houston, 2007

Thrust Degradation in DP Operations

DP Model Test of an Aframax Shuttle Tanker

by

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TEEKAY – THE MARINE MIDSTREAM COMPANY®

Introduction

- DP model test of an IMO Class 2 Shuttle Tanker
- Focus on
  - Thrust degradation effects
  - Environmental design criteria
  - DP performance and design evaluation
- R&D project with the partners:

  Teekay, Kongsberg Maritime and Marintek

TEEKAY CORPORATION

KONGSBERG

MARINTEK

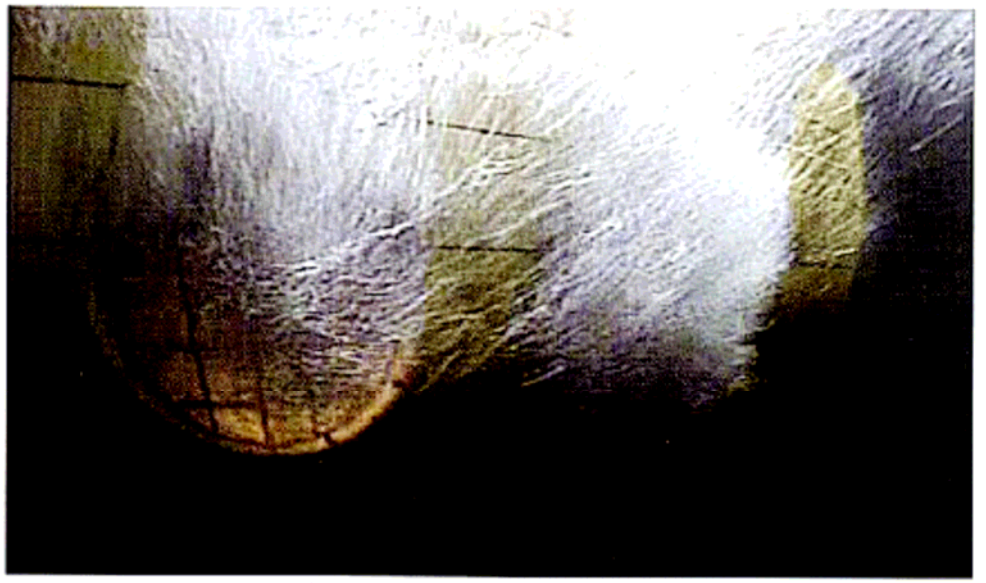
Teekay Corporation

- Transports more than 10 percent of the world's seaborne oil
- Operates more than 190 vessels / 41 DP shuttle tankers
- Global organization / 17 countries / 6,300 employees
- More than 19.000 cargo lifts carried out by shuttle tankers during the past 25 years
- Offshore loading using DP control is a safe and reliable operation
- Continuous focus to improve design and operational excellence

Project Incentive

- Experience from operations in harsh weather conditions have shown indications of lower margins on the vessel's station keeping performance than calculated by theoretical analyses such as DP capability plots
- A lack of industrial practices on how thrust degradation effects and environmental design criteria are defined and incorporated in DP capability analyses in general has been identified
- The main drivers are to further improve the safety, efficiency and regularity of offshore loading operations

Dynamic Positioning - Force Balance Exercise

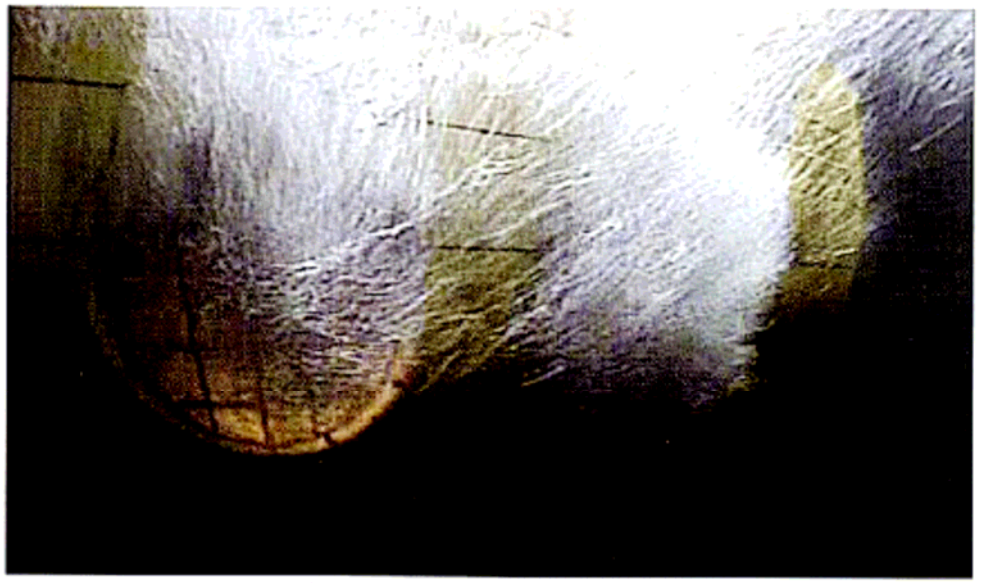


An extreme ventilation event of tunnel thrusters in waves.

Propeller forces counteract drifting forces

- Propeller forces delivered by
  - Main propellers and high lift rudders
  - Tunnel and azimuth thrusters

Dynamic Positioning - Force Balance Exercise



An extreme ventilation event of tunnel thrusters in waves.

Propeller forces counteract drifting forces

- Drifting forces determined by
  - Environmental conditions
  - Vessel's main particulars

Environmental Design Criteria

- Environmental design criteria for offshore loading
- Corresponding to Halten area – Norwegian Sea

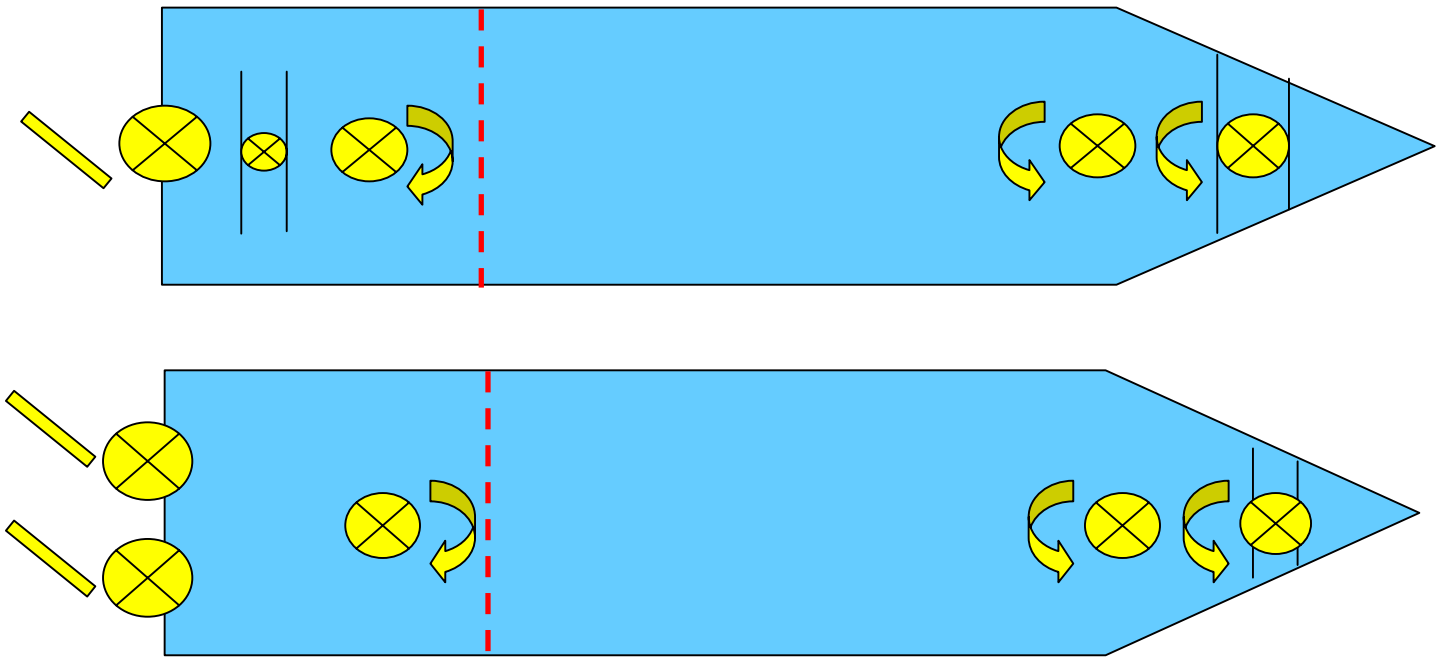
	Connection	Disconnection
Significant wave height [Hs]	4.5 m	5.5 m
Wind speed [U10]	31knots	38 knots
Current speed [Cv]	1 knot	1knot
Wave spectrum peak period [Tp]	11 Seconds	12 Seconds
Wave spectrum	JONSWAP	JONSWAP
Peak enhancement factor [γ]	1.8	1.8

Thrust and Propeller Forces

Nominal thrust – Thrust degradation = Thrust available

- Thrust degradation $\tau = \frac{T}{T_{nom}}$
- Thrust degradation affected by
  - thruster-hull interactions (Coanda)
  - thruster-thruster interactions
  - sea current
  - wave effects
  - ship motions
  - thruster ventilation

Model and Thruster Configuration



- Two aft ships; single and twin screw
- Interchangeable forebody
- Model scale 1:25, L ≈ 10 m , Displ. ≈ 6.9 mt

Model and Thruster Configuration

Thrust Loss Model Test

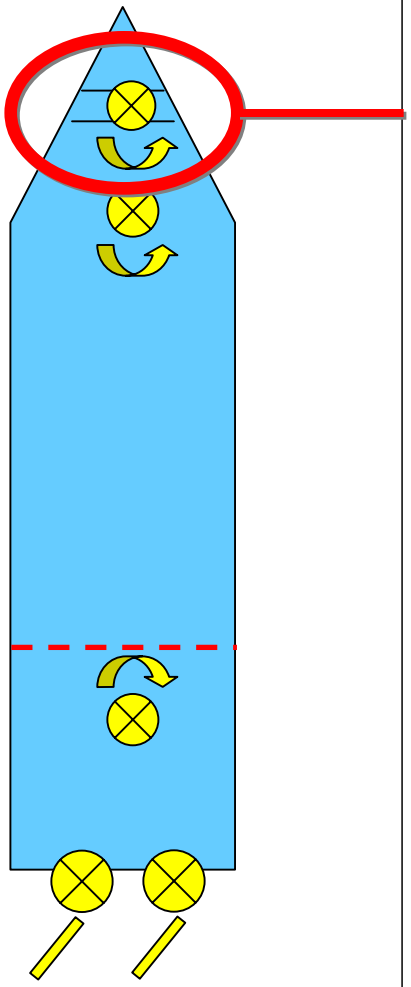
- Measurement of thrust degradation for
  - Main propellers and rudders - single and twin screw
  - Tunnel thrusters - fwd and aft
  - Azimuth thrusters – fwd and aft
- Loading conditions
  - Ballast
  - Loaded
- Environmental Conditions
  - Calm water
  - Offshore loading criteria; connection and disconnection
  - Corresponding to Halten Area in the Norwegian Sea

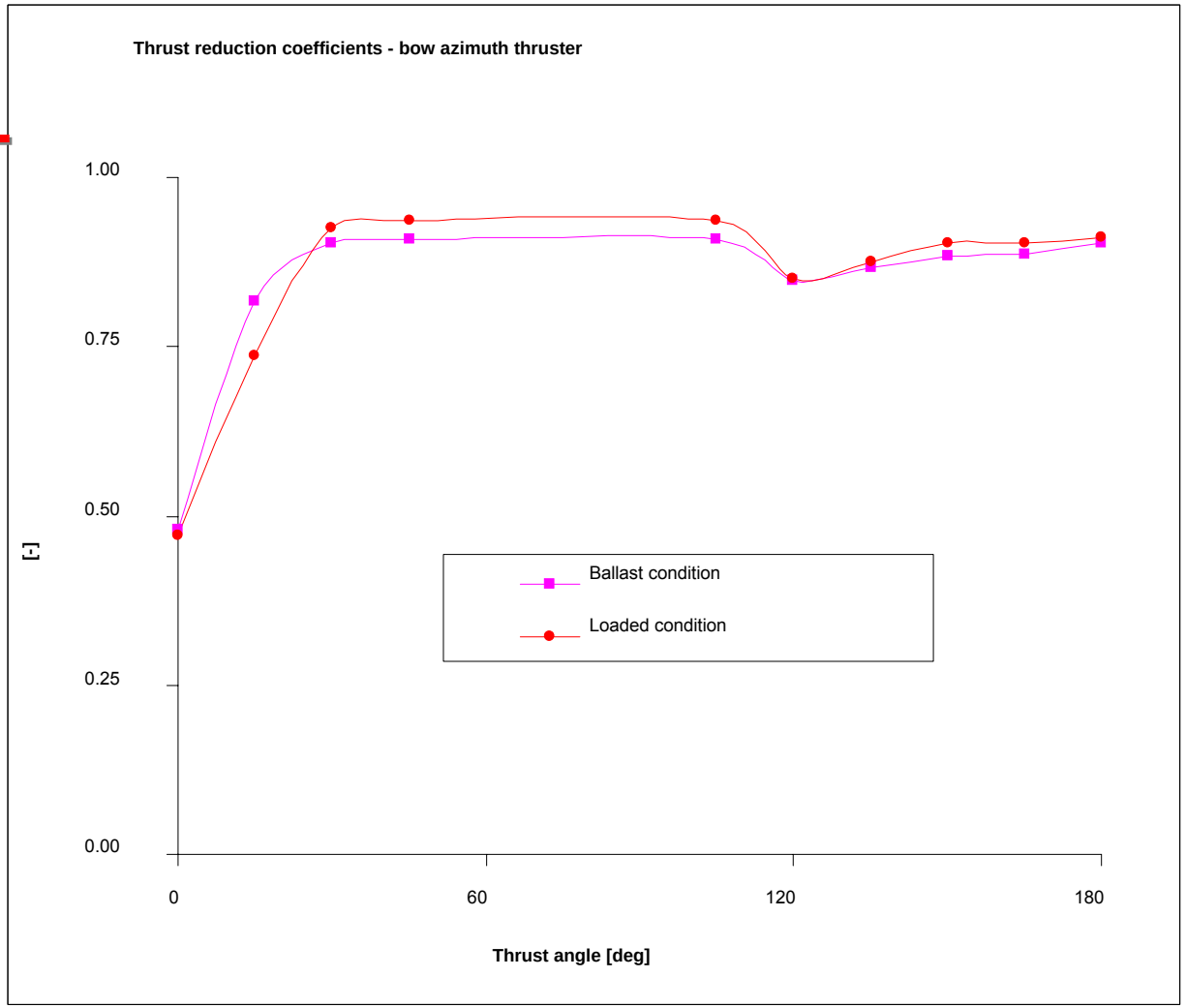
Thrust Loss Model Test

- Thrust degradation measurement program comprised the following
  - Open water characteristics for all propeller and thruster units
  - Thruster – thruster interactions
  - Thruster – hull interactions
  - Thruster – rudder interactions
  - Tunnel thruster losses
  - Thrust degradation due to current
  - Thrust degradation due to waves
  - Thrust degradation due to ventilation

Thrust Loss Model Test - Results

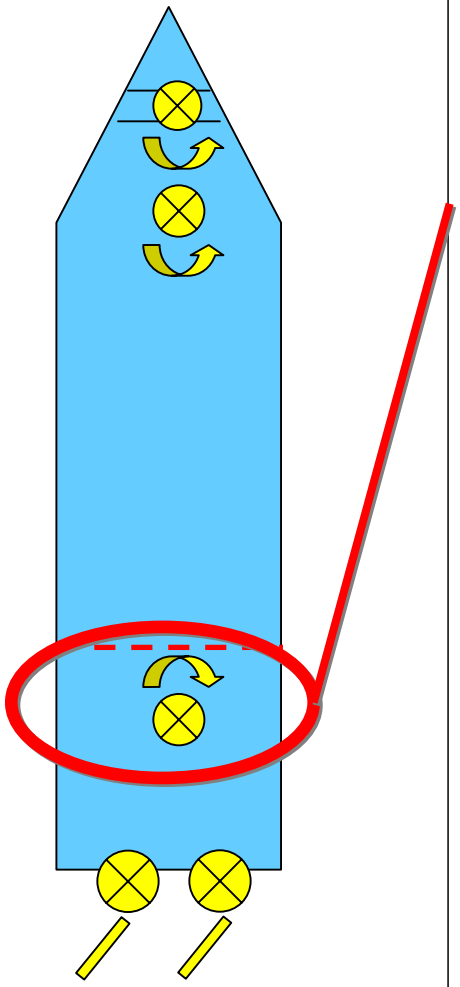
- Thrust degradation measurements for bow azimuth thruster

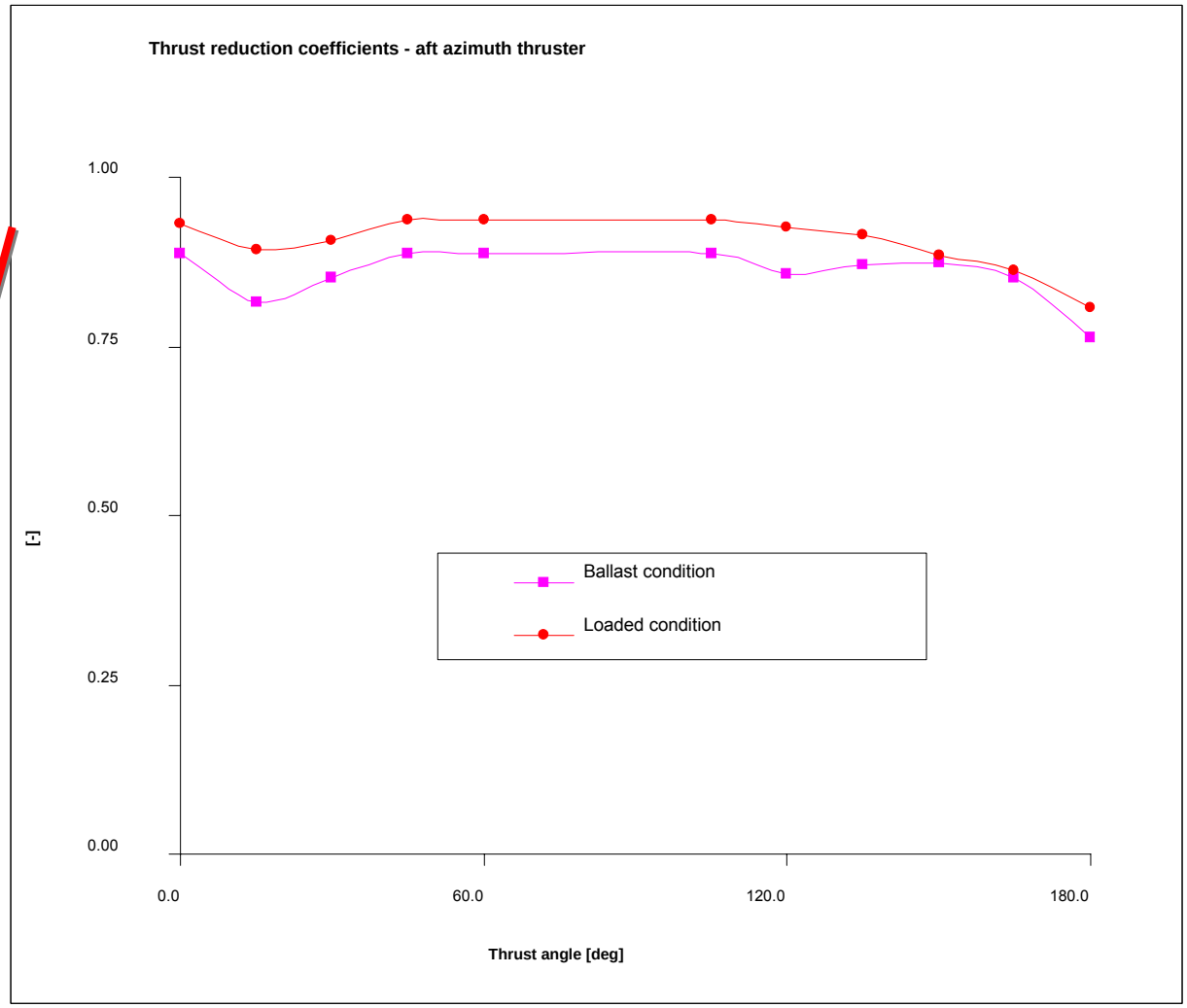




Thrust Loss Model Test - Results

- Thrust degradation measurement for aft azimuth thruster





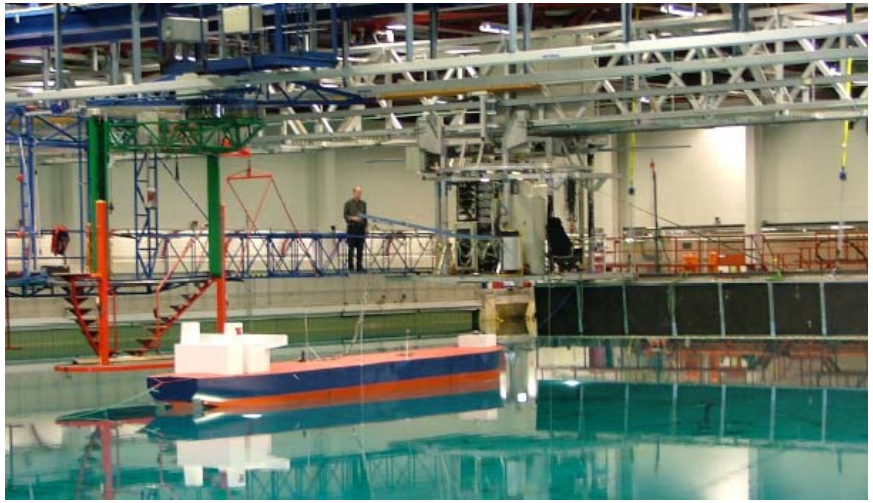
Thrust Loss Model Test - Results

- Thrust degradation measurement for main propeller and tunnel thrusters

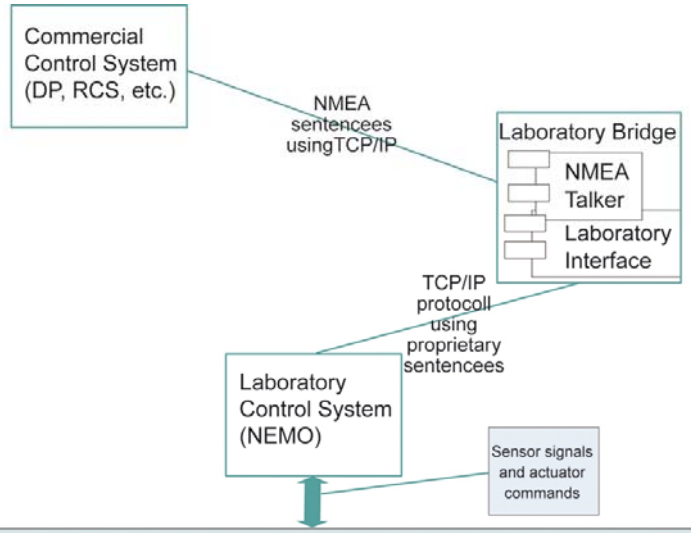
Thrust degradation coefficients – Main propeller and tunnel thrusters		
	Ballast condition	***Loaded condition***
Main propeller single-screw	**0.75**	**0.85**
Main propeller twin-screw	**0.75**	**0.87**
Tunnel thruster – bow	**0.65**	**0.80**
Tunnel thruster - aft	**0.65**	**0.80**

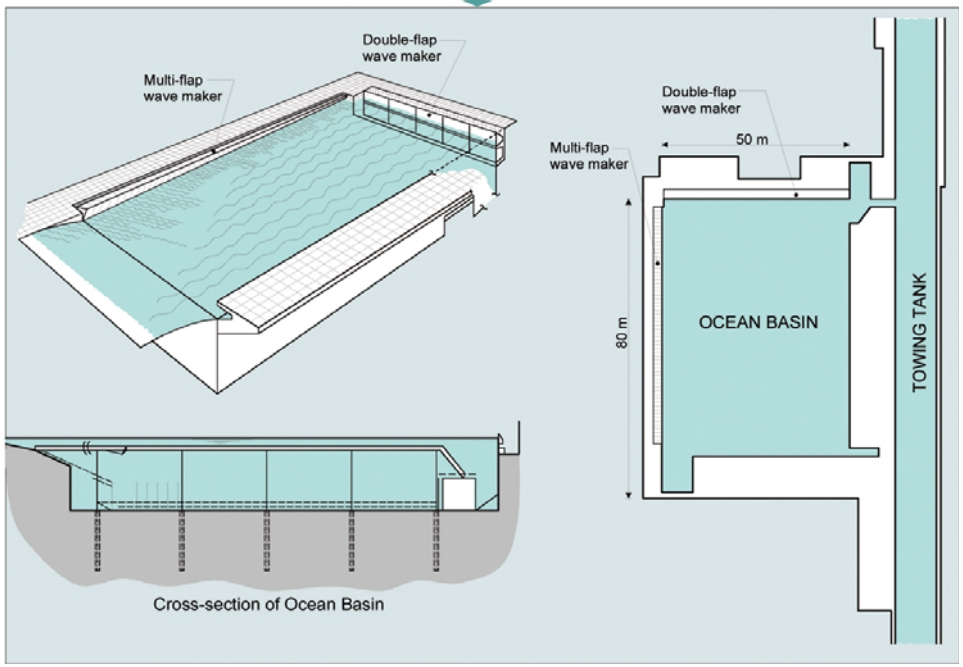
DP Model Test

- Marintek Ocean Basin, 80m x 50m x 10m
- “Off-the-shelf” DP software
- North Sea environmental conditions
- Ballast and loaded conditions
- Intact and failure mode
- Various power settings for thrusters
- Test duration; 1 hour full scale time / 12 minutes model scale time

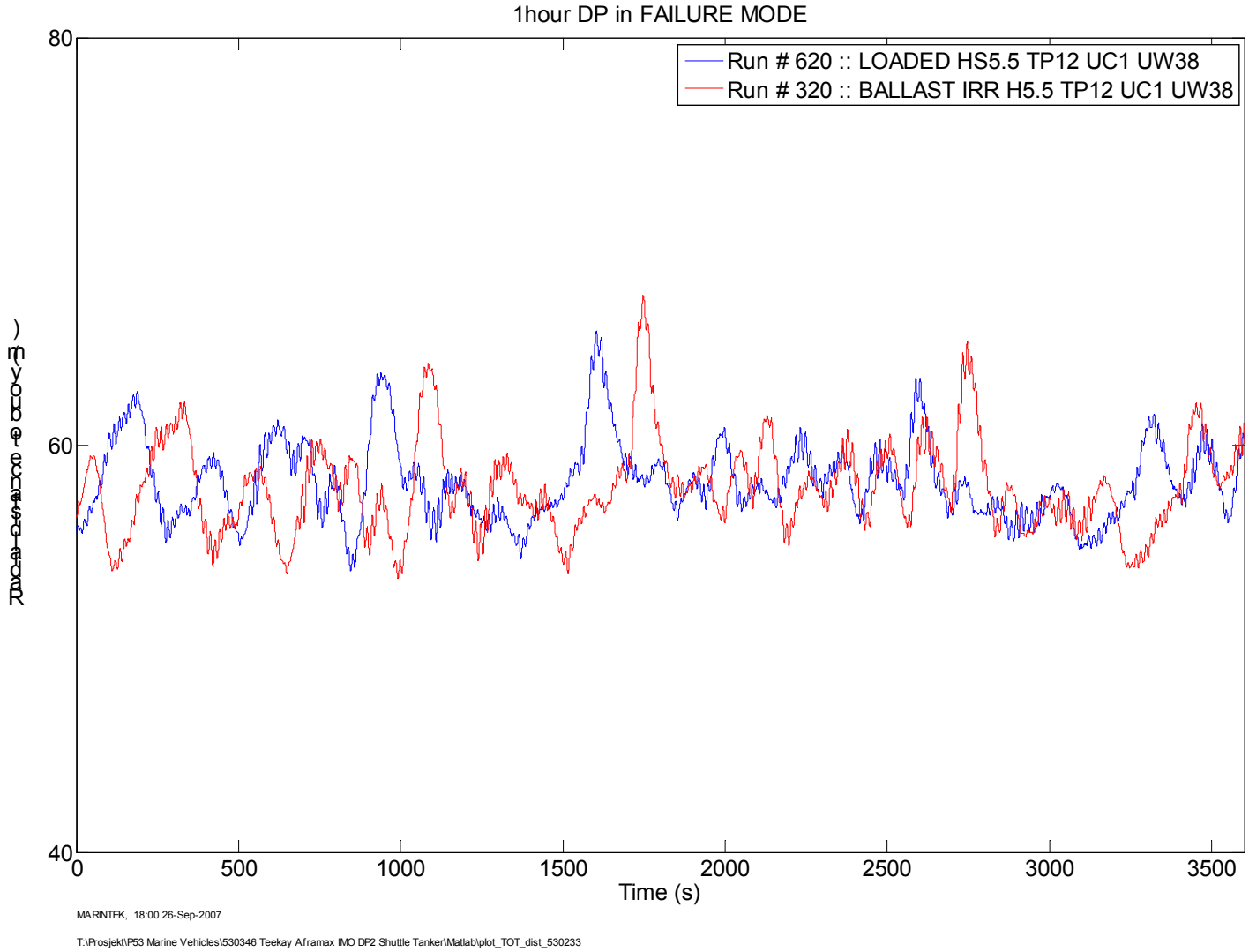


DP Model Test



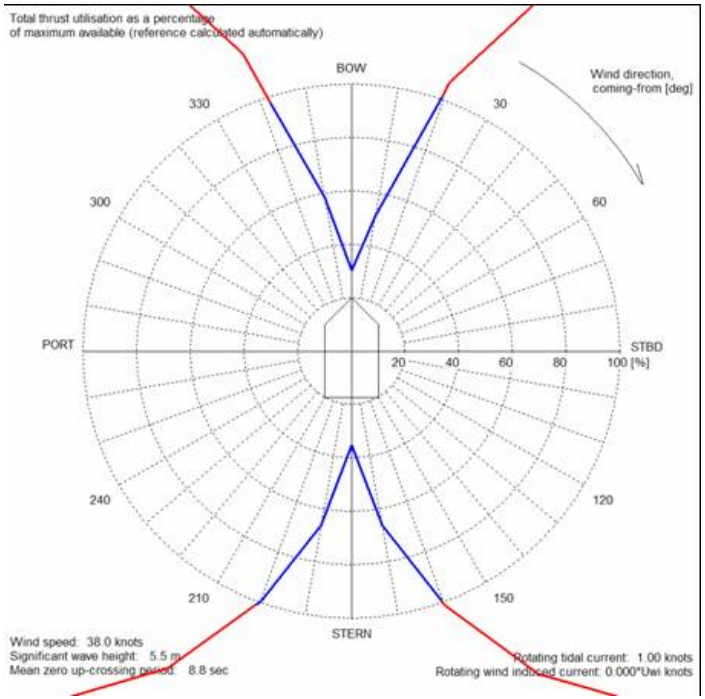


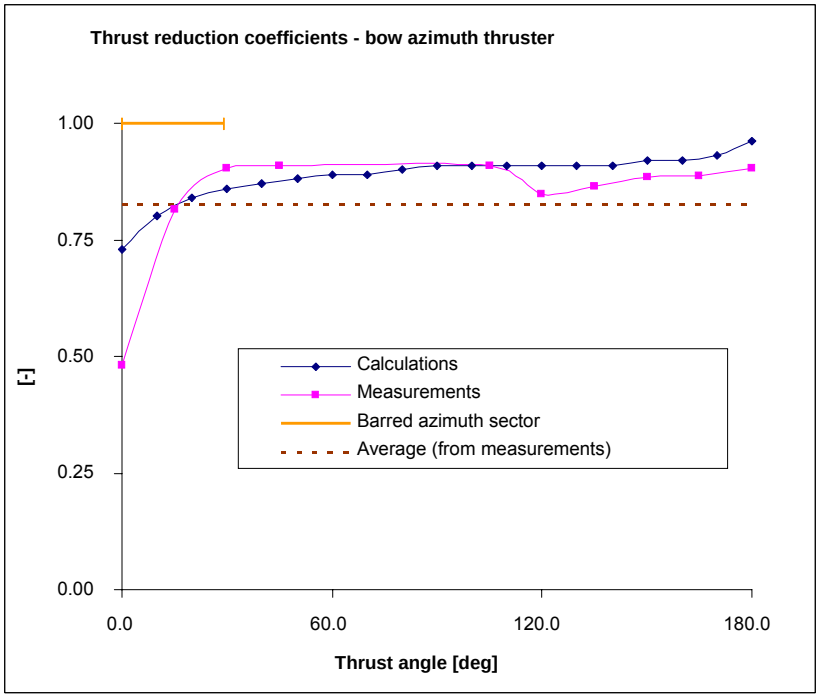
DP Model Test - Results



DP Capability Plot

- Static force balance
- Auto position mode is assumed
- Tandem offshore loading is a “weather vane” operation
- Sector around the bow of relevance for shuttle tankers
- Thrust degradation calculation included in StatCap

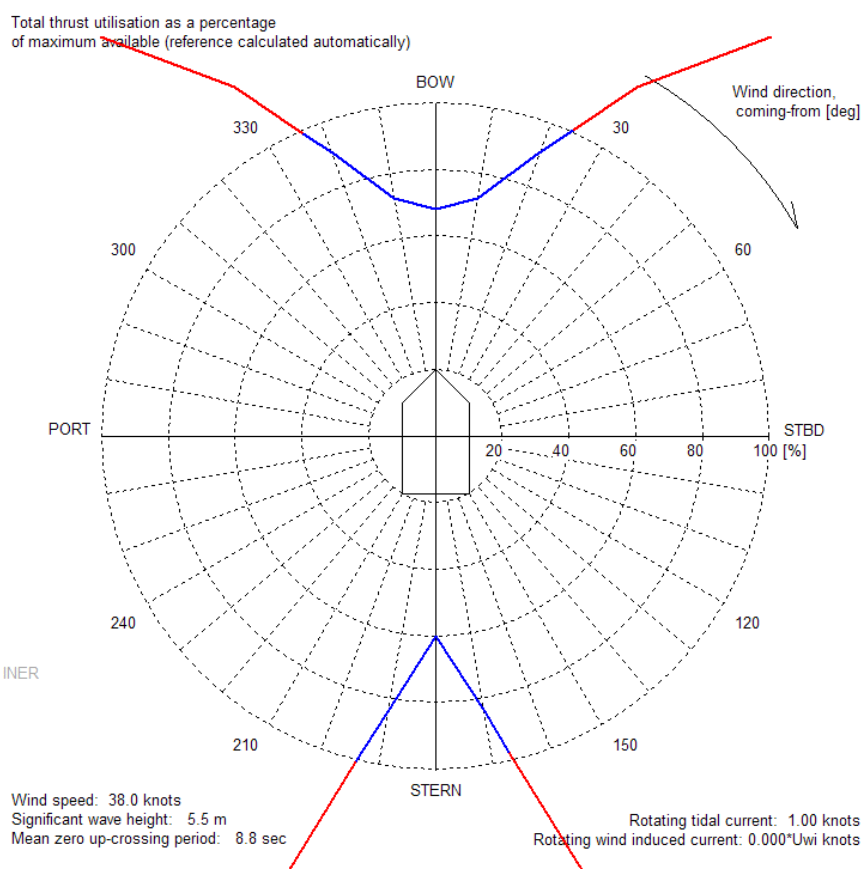




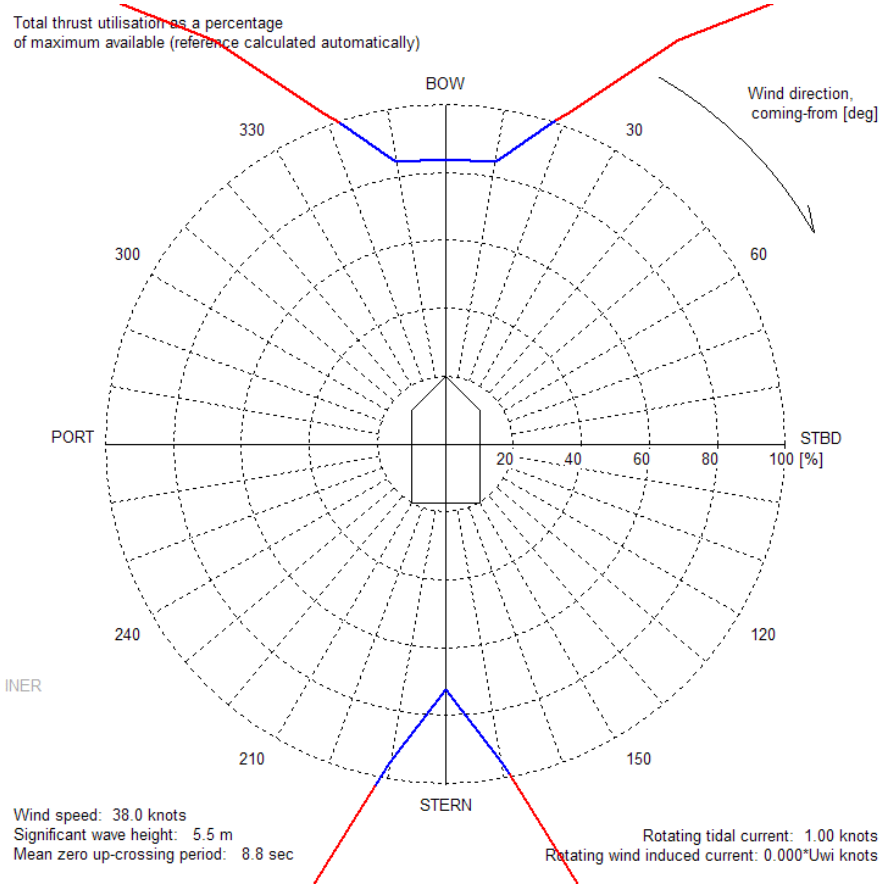
DP Capability Plot - Example

- Worst case single failure for a DP2 single screw shuttle tanker
- North sea environmental design conditions - ballast

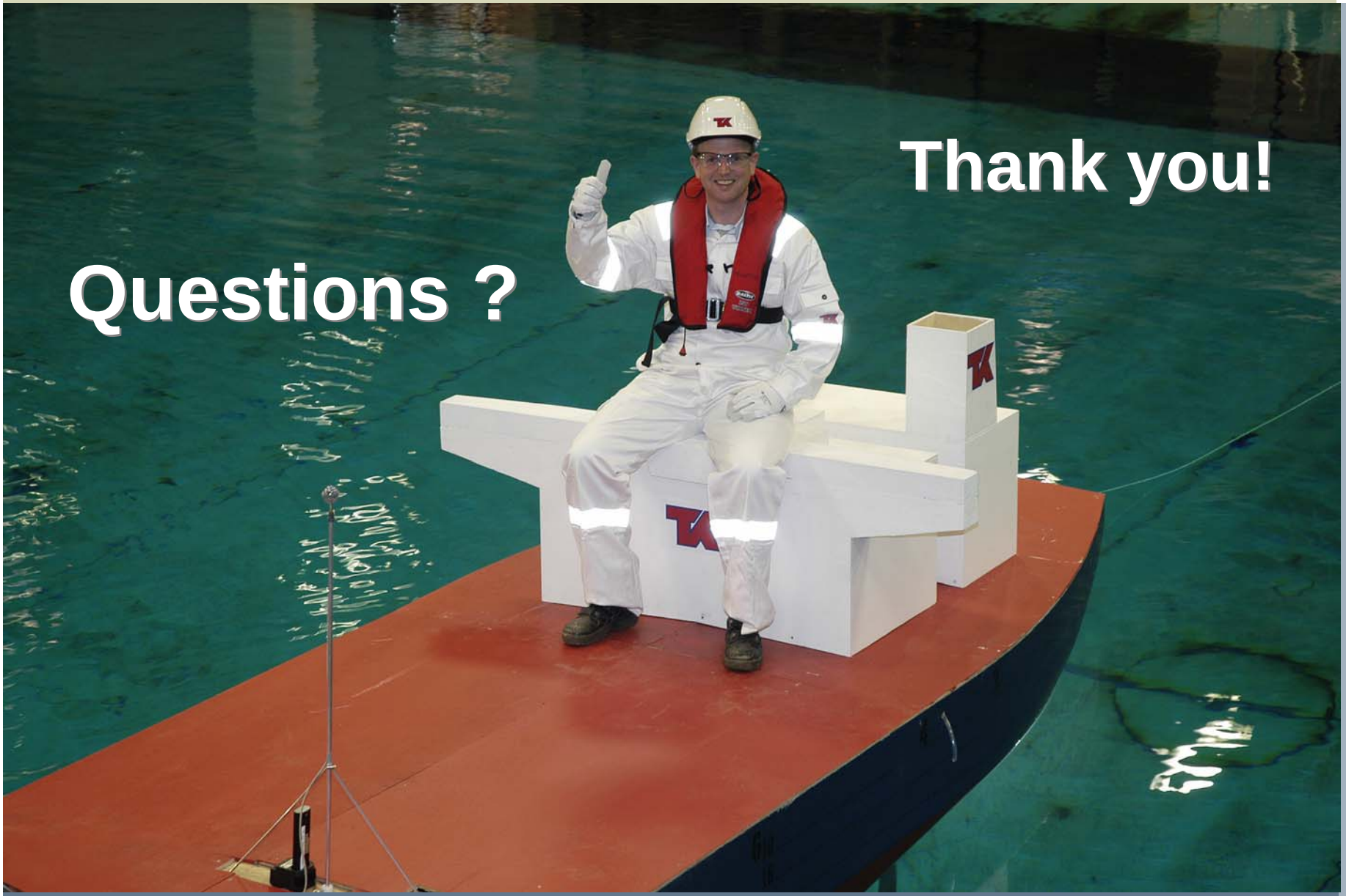
Plot 1: Thrust degradation not included



Plot 2: Thrust degradation included



Conclusions

- Thrust degradation effects are of significant importance for all types of DP vessels
- Thrust degradation effects should be accounted for in design and operation of DP vessels
- Magnitude depends on vessel design, operation and environmental conditions
- Thrust degradation calculations have been included in software for DP capability analysis; KM StatCap
- Calculations correspond reasonably well with model test measurements for a shuttle tanker
- Results from DP capability analysis (capability plot) correspond well with shuttle tanker operational experience

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