Seakeeping analysis and decision support tools for ship operations

Handling Waves Project

Handling Waves

Decision Support System for Ship Operation in Rough Weather

Participant	Country
RINA	Italy
Instituto Superior Técnico	Portugal
Rodriquez Cantieri Navali	Italy
Technical University of Varna	Bulgaria
Technical University of Berlin	Germany
Hamburgische Schiffbau-Versuchsanstalt GmbH	Germany
Portline	Portugal
Navigation Maritime Bulgare	Bulgaria
Grimaldi Group Naples	Italy
St. Petersburg State University	Russia

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Objective:
Develop an on-board decision support system for tactical decisions of ship handling in waves, considering in particular rough sea conditions

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Beside monitoring in real time the accelerations on the ship, the system has been developed for incorporating numerical model to:

- Relative motions at the bow and wave induced structural loads
- Probability of occurrence of large amplitude roll motions and capsizing
- Predict near term changes in motions and loads that would arise from any change in course and speed

Support to the Master

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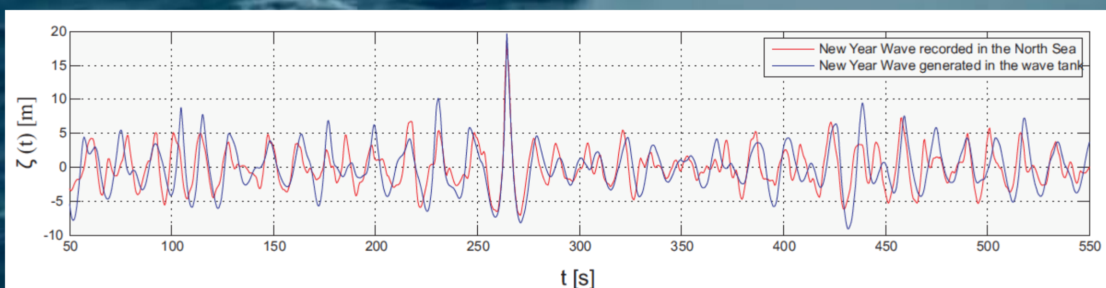
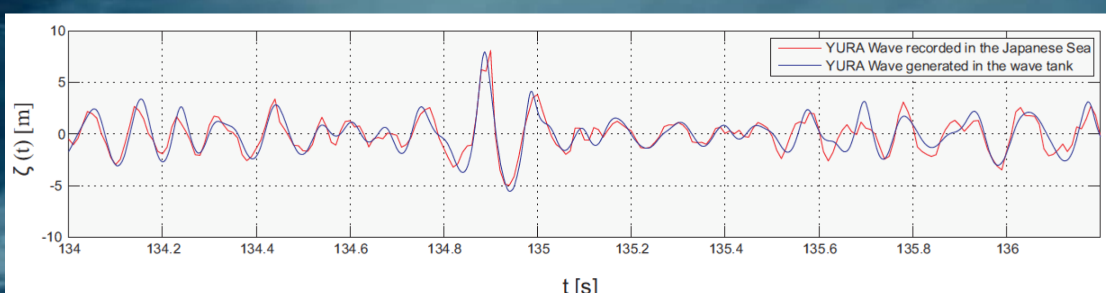
<u>Modeling rough waves in a towing tank</u>

Generation of deterministic wave sequences including rough waves for the analysis of ship behavior and structure effects



<u>New Year Wave (North Sea)</u>
Hmax = 25.63 m
Crest height of 18.5 m
Surrounding sea state Hs=11.92m
(Hmax/Hs = 2.15)



<u>Yura Wave (Japanese Sea)</u>
Hmax = 13.6 m
Crest height of 8.2 m
Surrounding sea state Hs=5.09m
(Hmax/Hs = 2.67)

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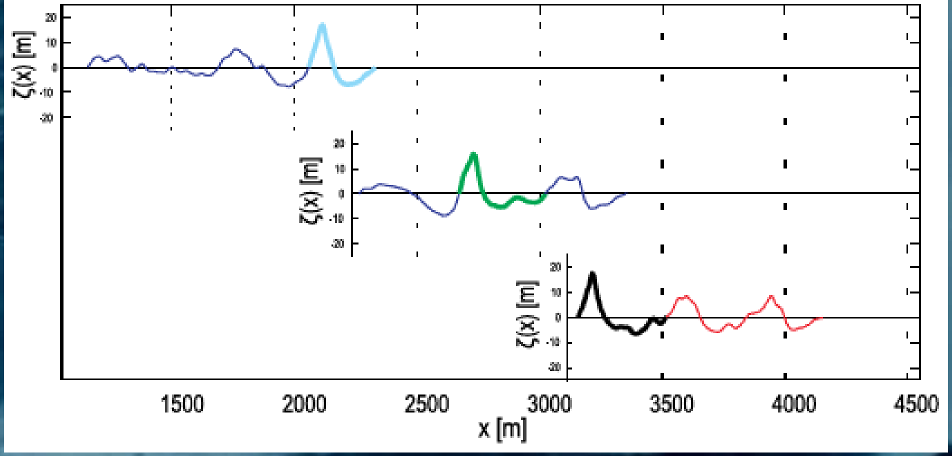
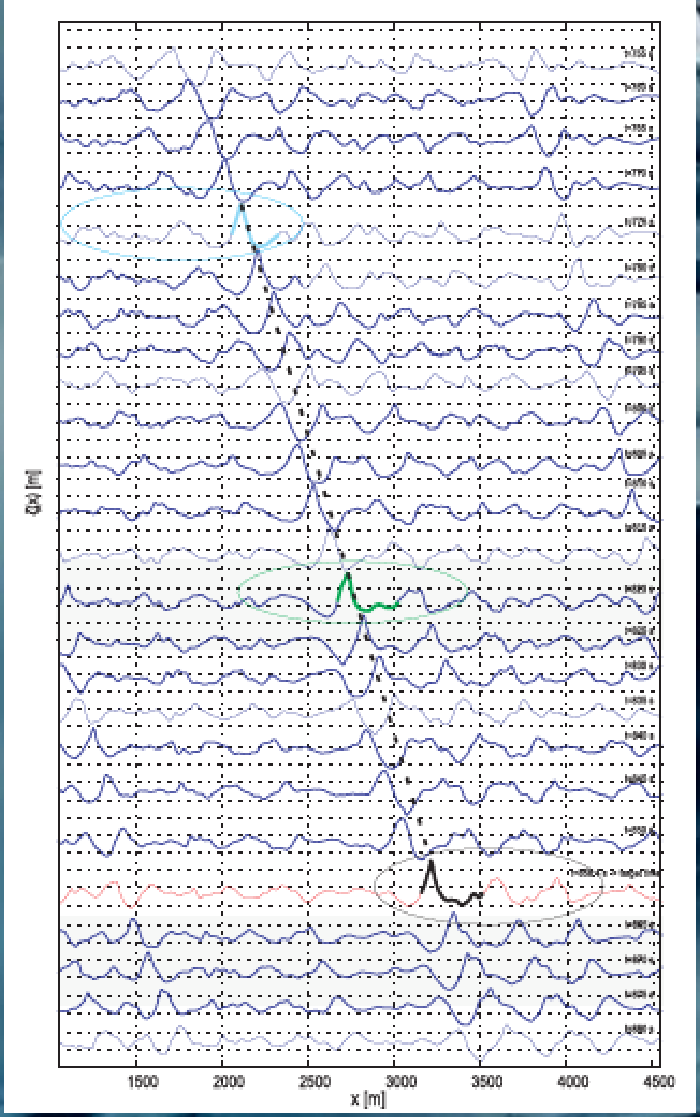
The experimental determination of rogue wave propagation





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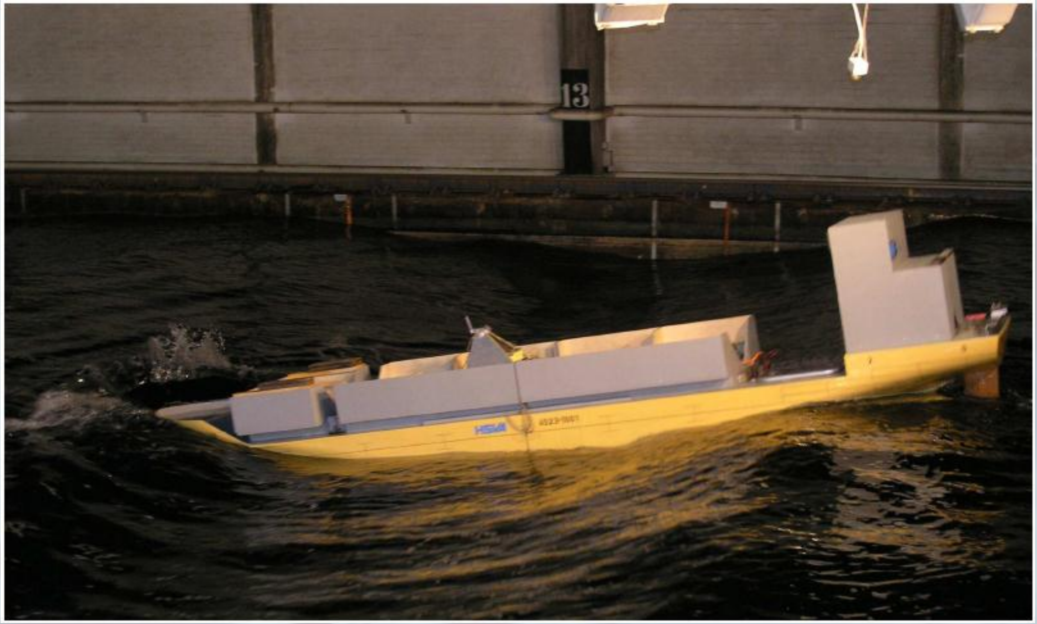
Model tests with free-running self-propelled ship models

Three ship models:

- Bulk Carrier
- Containership
- RoRo



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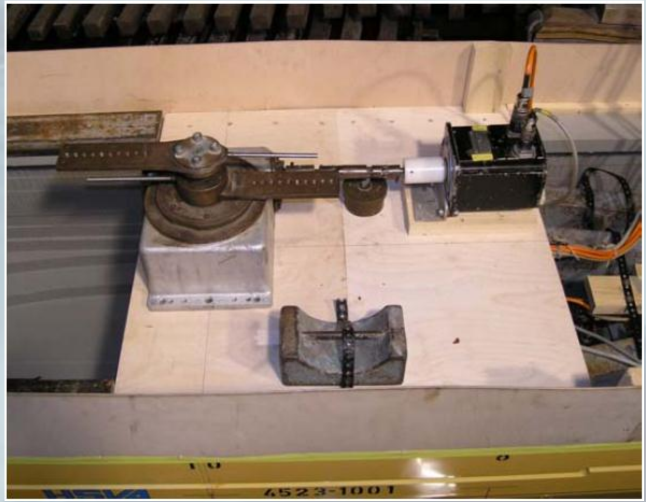
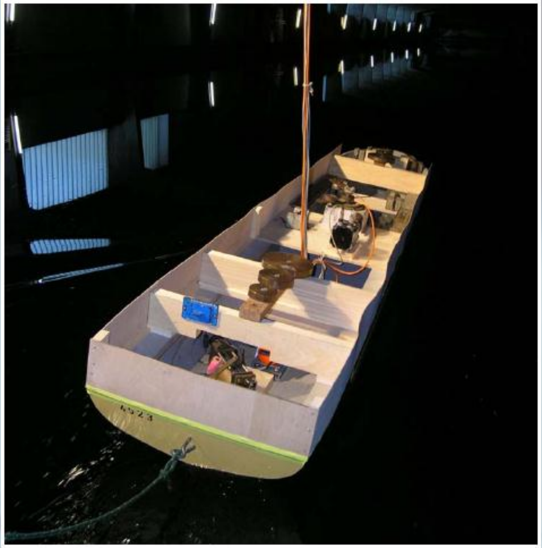
Forced roll motion tests in order to study the roll damping characteristics -> to be included in the numerical model

Model equipped with two contra-rotating arms for harmonically excite roll motion





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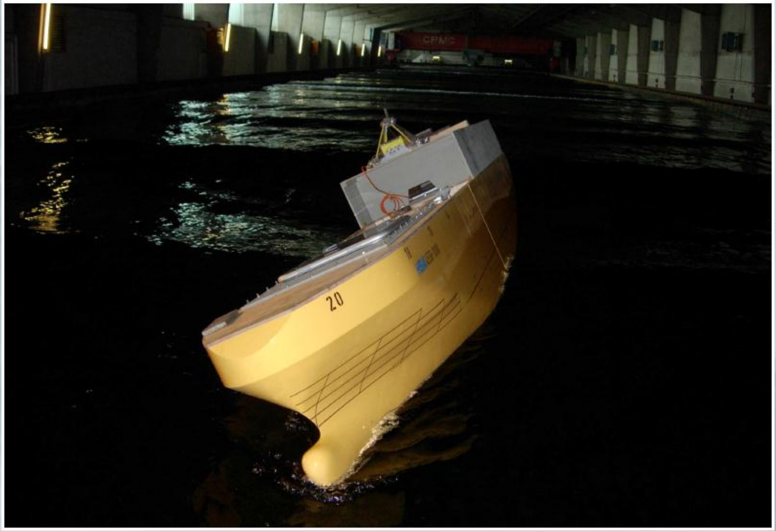
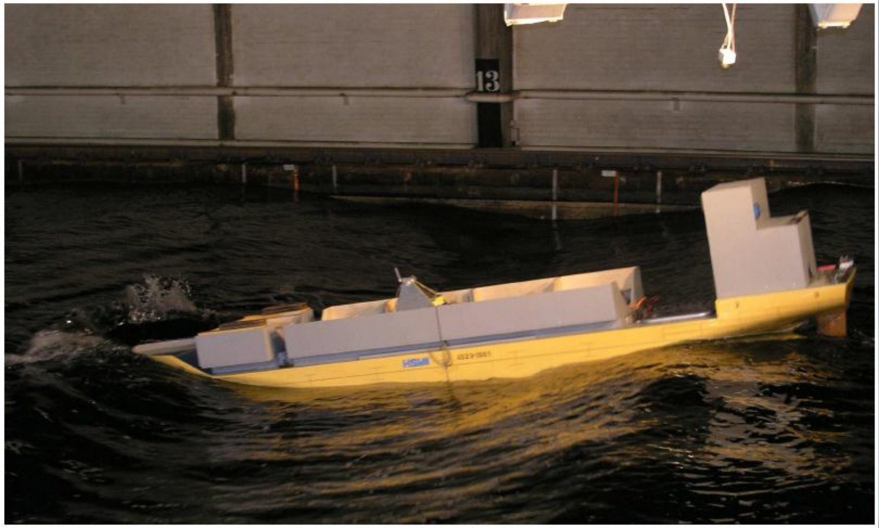
Seakeeping tests in order to study the motion behavior, global ship loads and risk of capsizing -> Base for the validation of numerical models for predicting ship motions, loads and parametric rolling in adverse sea conditions





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Investigation of conditions leading to large roll angles or even capsizing for vessels running in bow or following waves.

Mainly three phenomena are known:

- Parametric rolling:
  - Caused by oscillation of the righting levers in waves. Parametric roll generally occurs if the encounter period in is roughly equal to half the natural roll period of the ship (or equal to the natural period itself)
- Pure loss of stability:
  - Sudden occurring non-oscillatory phenomenon which can lead to capsizing, due to a significant reduction of the righting lever on the wave when the encounter period is very large
- Broaching:
  - Unintentional change in the horizontal plane kinematics (loss of directional stability). Capsizing can occur when energy is transferred into roll direction

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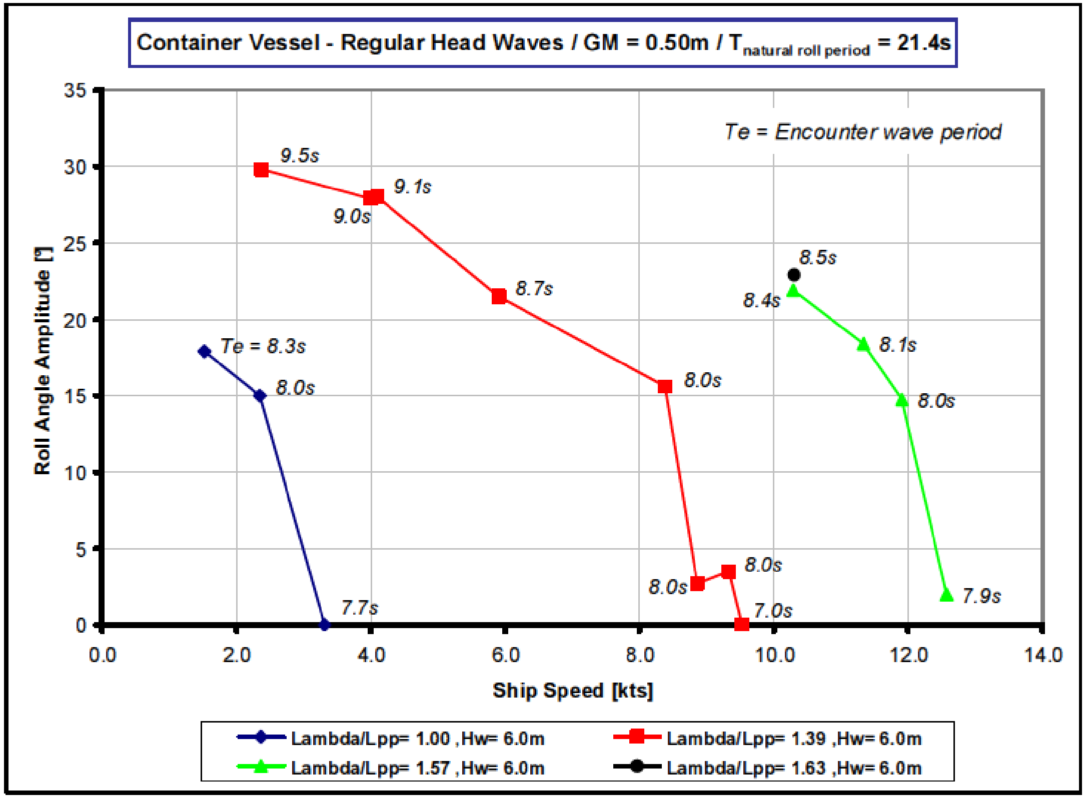
During the tests large roll motions have been recorded, but no capsizing occurred.

No phenomena like loss of stability or broaching could be observed, but the occurrence of parametric rolling was extensively investigated.

Results of tests in regular head waves - Containership



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Segmented models (two or more segments) have been employed for measuring hull girder wave loads

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Time domain weakly non-linear approach

- Radiation and diffraction forces assumed to be linear and derived from frequency domain calculations
- Radiation forces in the time domain represented by
  - convolution integrals of impulse response functions
  - infinite frequency added masses and radiation
- Hydrostatic and Froude-Krilov pressures integrated over the instantaneous wetted surface of the hull
- Other effects, like for instance green water on deck, can be modeled

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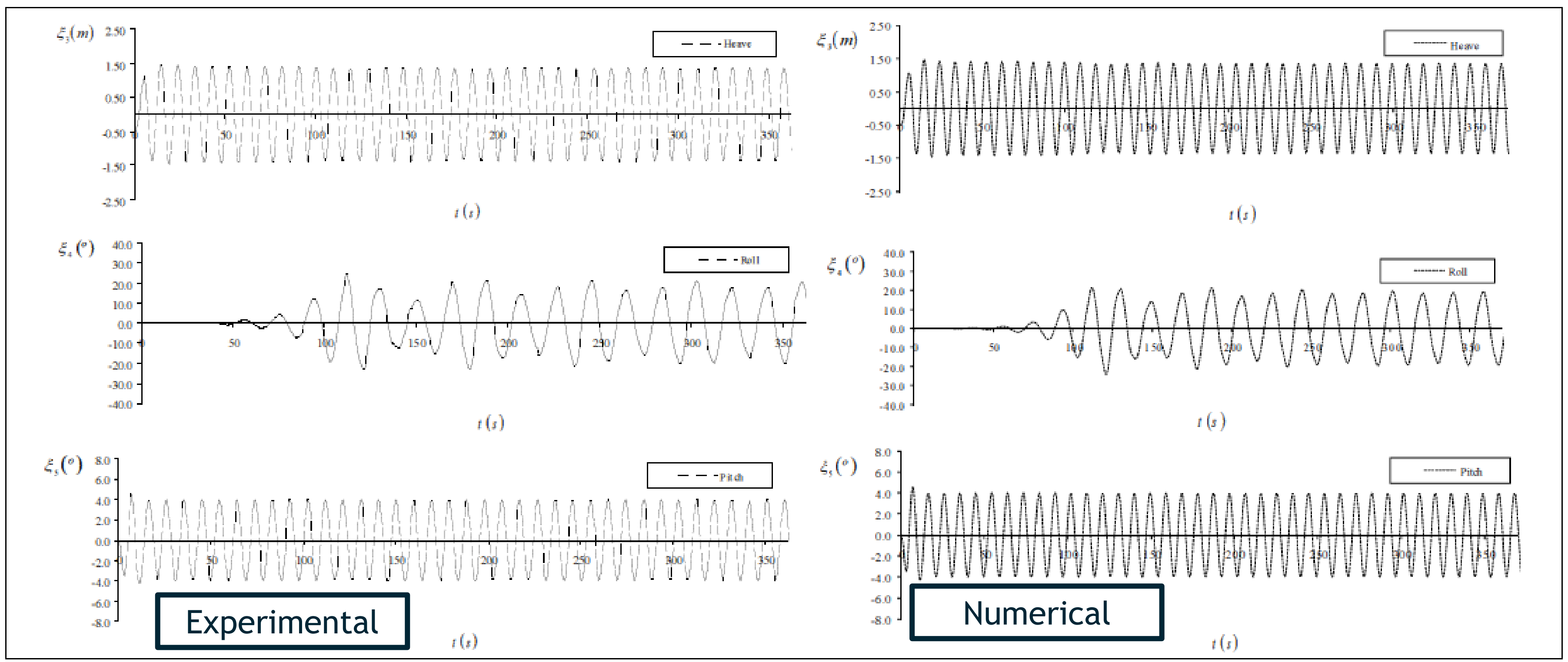
Parametric rolling in regular head waves (H = 6 [m] and T = 10.23 [s])



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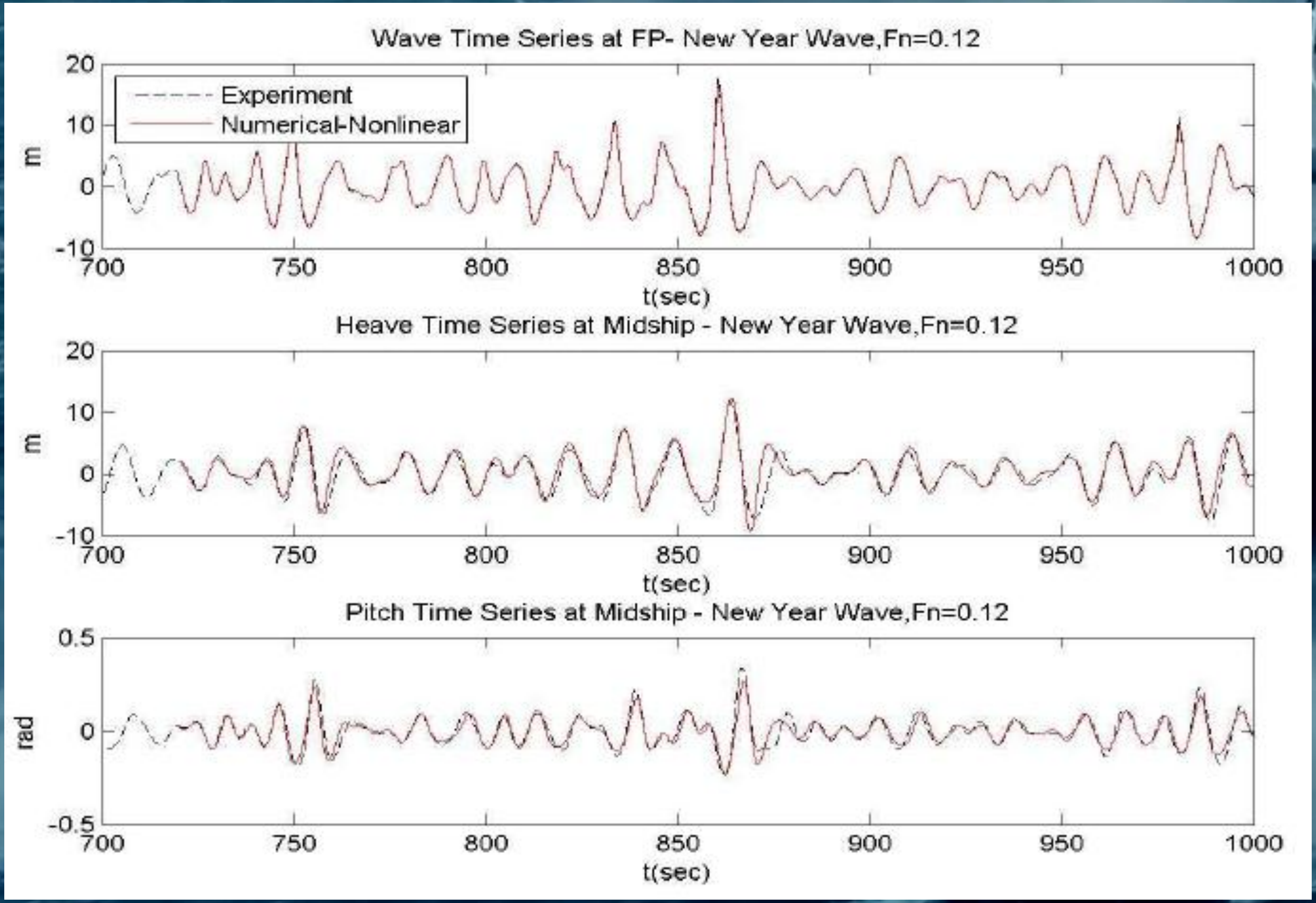

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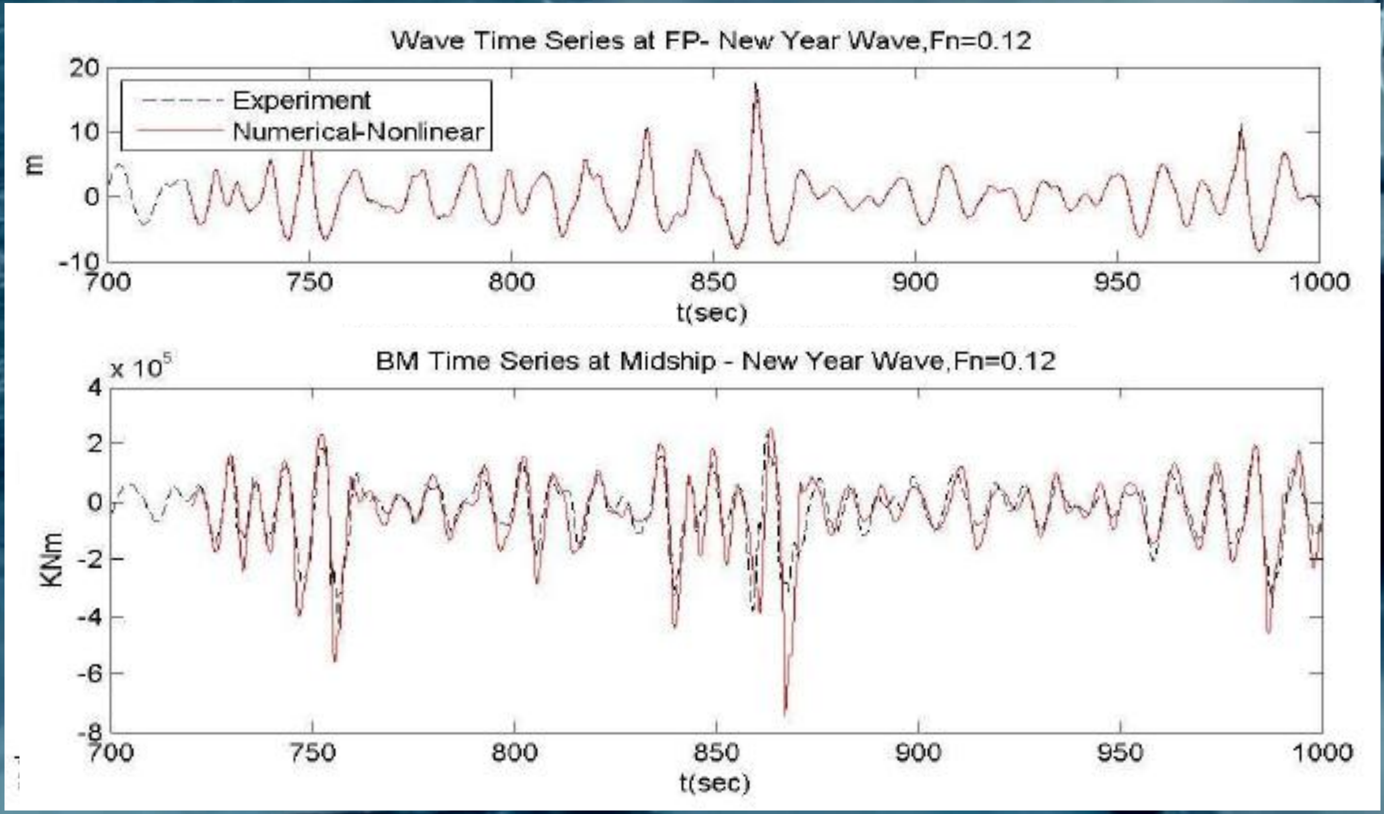

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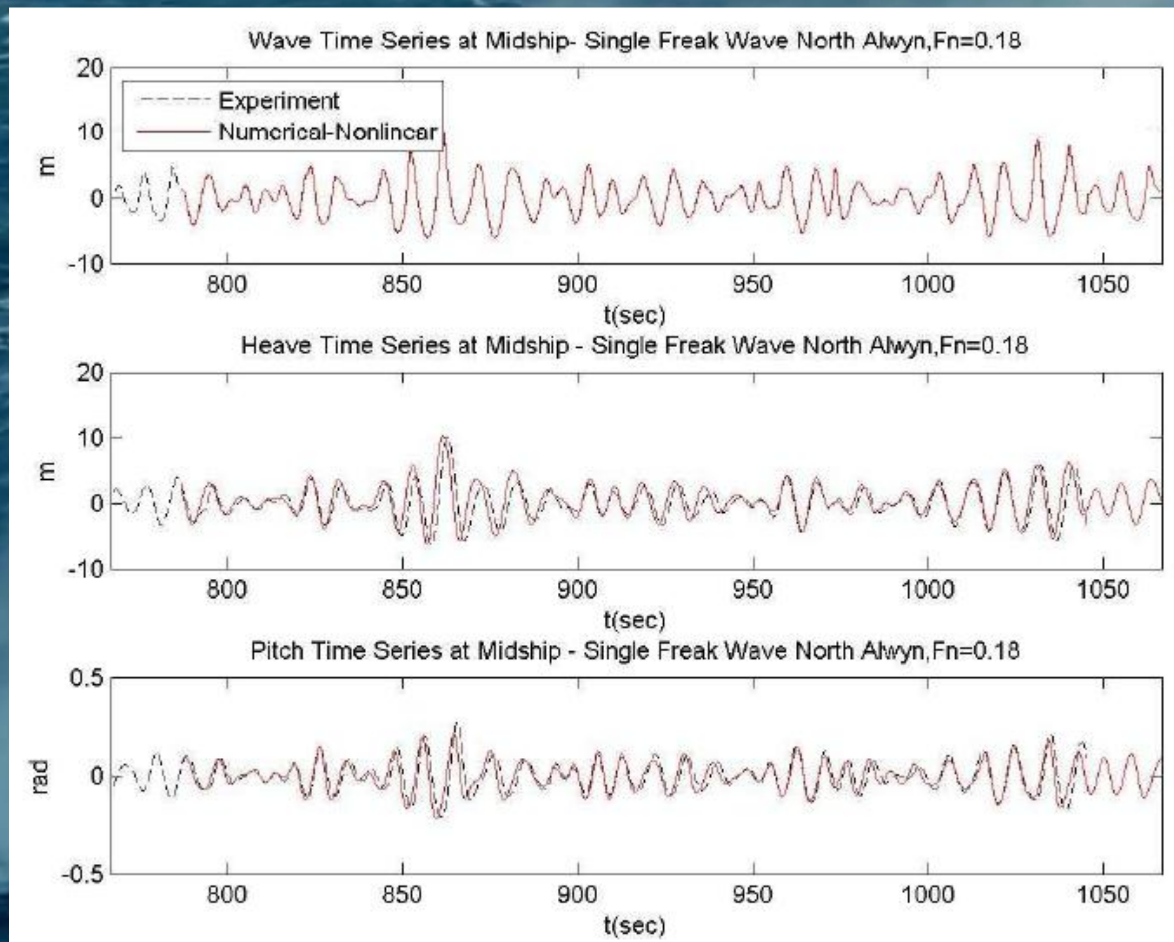

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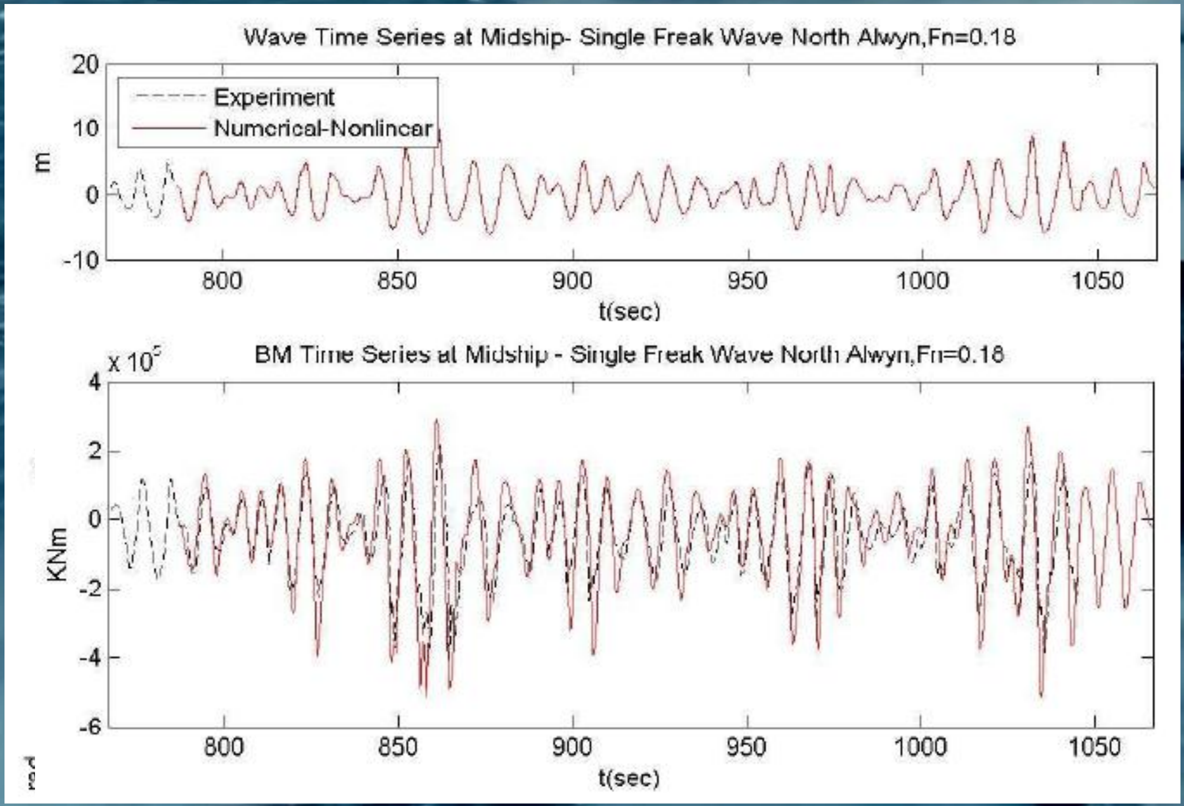

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Estimation of sea spectra from motion time histories.

Employment of artificial neural networks to obtain estimates of wave-induced vertical bending moment and shear force from sway, heave, roll, pitch, heading and yaw measurements have been developed.
The data used to calibrate and validate the neural network model obtained through time-domain simulations.

Development of a simplified model for determining the actual maximum admissible loads to be compared with the loads determined by the monitoring system and the fatigue damage rate.

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A system prototype has been installed on 3 ships