HANDLING WAVES

Decision-Support System for Ship Operation in Rough Weather

Funding: European (6th RTD Framework Programme)
Duration: Jan 2007 - Jul 2010
Status: Complete with results
Total project cost: €2,939,628
EU contribution: €1,699,964

Background & policy context:
Reliability of the service, in terms of punctuality, operability and availability of ships, is the attribute that contributes the most to the efficiency of waterborne transport. The aim of the project was to improve ships' performance, and thus its efficiency, by addressing those operational factors that are connected to operability and availability of the ship itself.

The effect of waves in rough weather is one of the key factors that degrades the ship's efficiency. The development of an on-board decision support system for tactical decisions of ship handling in waves would enable the master to improve ship performance while minimising the likelihood of structural damage. Besides monitoring the actual ship responses in real time, such a system would predict the near term motions and structural loads due both to weather changes and to possible changes in course and speed by the ship master.

Objectives:
The objective of the project was to develop an on-board decision support system for tactical decisions of ship handling in waves, considering in particular rough sea conditions. Besides monitoring in real time the accelerations on the ship, the system incorporated numerical models to:

- Estimate actual relative motions at the bow and wave induced structural loads,
- Estimate probabilities of occurrence of rogue waves and their effects on the ship motions and structural loads,
- Estimate probabilities of occurrence of large amplitude roll motions and capsizing,
- Predict the near term changes in motions and loads that would arise from any change in course and speed by the shipmaster.

The project would also carry out in service pilot applications in three ships.

Methodology:
The activity of the project has been organised into six technical work packages which objectives are described in the following:

Work package 1 - Analysis and modelling of rogue waves
The objectives of this task included:

- Improving the understanding of the mechanisms of generation of the rogue waves, of their geometries and of the probability of occurrence in wave records
- Improving the methodology to generate experimentally in a seakeeping tank deterministic rogue waves and extreme wave groups.
Generating in a seakeeping tank a set of tailor-made wave groups that include rogue waves for posterior experimental analysis of rogue wave kinematics and the effects of rogue waves on ship structures.

Improving the existing probabilistic models to account for the probability occurrence of rogue waves in a synoptic scale

Work package 2 - Ship capsizing in rough seas
The objective of this task was to investigate experimentally conditions that lead to the loss of ship stability and capsizing of ships and also to unexpected large roll motions.

Work package 3 - Waves induced loads in rough seas
The objective of this task is to carry out a program of experimental tests with three models of ships in deterministic wave sequences that include rogue waves and extreme wave groups.

Work package 4 - Numerical assessment of ship response to extreme waves
This task dealt with the development and application of methods for numerical calculation of ship responses.

Work package 5 - On board decision support system
The onboard decision support system was developed in this task. The objective of the system is to improve the ship performance at sea by informing the shipmaster on the level of various ship responses to the waves, comparing the actual ship responses with safety and comfort criteria, and advising on the best route.

Work package 6 - Pilot applications on board
Demonstrate the applicability of the system through pilot applications on different ship types, namely a Bulk Carrier, a Ferry and a Container ship.

Parent Programmes:
FP6-SUSTDEV-3 - Global Change and Ecosystems

Institute type: Public institution
Institute name: European Commission
Funding type: Public (EU)

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Key Results:

The main results by WPs are as follows:

Work package 1 - Analysis and modelling of rogue waves
The software for stochastic simulation of wave-records with incorporated freak waves was developed. The software was tested on the selected subset of HIPOCAS hindcasting data. The analysis of wave data to determine statistics of the larger waves has been done. The possibility to use the directional wave spectra for characterization of the wave-making conditions (where the rogue waves arising are possible) is the result of better knowledge of the wave generation and propagation process, which has been implemented in various wave modelling packages.

WP 2 - Ship capsizing in rough seas
In Wp2 ship models for capsizing test have been prepared. A numerical model of ship motion in waves has been validated by direct contrast and comparison with the experimental results. In this study a non-linear numerical model is utilized to simulate roll responses in regular and irregular beam waves.

Wp3 - Waves induced loads in rough seas
The wave tank of the Technical University of Berlin has been upgraded with equipment for properly measuring the motions of the models. The models (Container Vessel, Ro/Ro-Ship, Bulk Carrier) are manufactured and equipped with strain gauges. Synchronisation of the wireless motion measurement systems with the established electronic measurement system of the TUB has been done.

Wp4 - Numerical assessment of ship response to extreme waves
The existing method to calculate green water on deck and the related effects on the global structural loads was improved and a procedure to calculate slamming loads and the related transient hull response was tested. A comprehensive analysis has been carried out by amplifying the relative motion at the bow in the numerical calculations, with a method based on previously obtained experimental data, to assess the effects on the vertical bending moment. Direct comparisons have been carried out for many abnormal wave conditions tested in the tank, and it was concluded that the prediction of the largest sagging peak improves significantly. A database with histories of motions and wave induced loads in the time domain has been developed based on ship motions simulations and structural loads calculated with the program developed in the previous task. Numerical tests have been performed. These tests have been successful and indicated that some additional spectral smoothing

Documents:
- Publishable Final Activity Report (Final report)
**STRIA Roadmaps:** Vehicle design and manufacturing, Network and traffic management systems

**Transport mode:** inland

**Transport sectors:** Passenger transport, Freight transport

**Geo-spatial type:** Network corridors