SHOPERA PROJECT
(Energy Efficient Safe SHip OPERAtion)

Funded under: FP7-TRANSPORT

Project Context and Objectives:

The 2012 guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships (MEPC.212(63)) represent a major step forward in implementing the REGULATIONS ON ENERGY EFFICIENCY OF SHIPS (resolution MEPC.203(62)) through the introduction of a series of specifications for calculating the EEDI for various types of ships. There are, however, serious concerns regarding the sufficiency of propulsion power and of steering devices to maintain the manoeuvrability of ships in adverse conditions, hence the safety of ships, assuming that the ship marginally passes the relevant EEDI criterion. This gave reason for additional considerations and studies at IMO (MEPC 64/4/13 and MEPC 64/INF7). Furthermore, whereas present EEDI regulations concern the limitation of toxic gas emissions by ship operation, what may be understood as a new constraint in ship design and operation, it is urgent to look holistically into integrated ship design and operational environments and implement multi-objective optimisation procedures optimising ship's powering while ensuring safe ship operation, but at the same time looking for the right balance between ship's efficiency and economy, safety and greenness.

To this end, the SHOPERA consortium was put together representing the whole spectrum of stakeholders in the maritime industry and with superior expertise and scientific know-how in hydrodynamic tools development, validation of software tools, experimental techniques and expertise in ship design and international maritime rule making.

Project SHOPERA aims to address the above raised, urgent regulatory issues by:

- ✓ Further development and refinement of existing high fidelity, hydrodynamic simulation software tools for the efficient analysis of the seakeeping and manoeuvring performance and safety of ships in complex environmental and/or adverse sea/weather conditions (including the consideration of winds and extreme sea events). The efficiency of steering devices and the effect of restricted waterways in port areas will be considered. Extensive use will be made of state-of-the-art numerical simulation tools available to the consortium, which will be adapted to the needs of the project and be supported by a comprehensive model testing programme.
- ✓ Performing seakeeping/manoeuvring model tests in combined seaway/wind environment by use of a series of prototypes of different

ship types (offshore supply vessel, bulk carrier, tanker, containership, RoRo ferry), to provide the required basis for the validation of employed software tool and the results obtained by numerical simulations. Full scale measurements available to the consortium will be exploited for the validation of tools and scalability of model tests. Integrating validated software tools for the hydrodynamic/manoeuvrability assessment of ships in adverse seaway/weather conditions into a ship design software platform and set-up of a multi-objective optimization procedure in which ship's performance is assessed holistically, thus, looking for the minimum powering requirement to ensure safe ship operation in adverse seaway/weather conditions, while keeping the right balance between ship economy, efficiency and safety of the ship and the marine/air environment.

- ✓ Putting together design teams that comprise designers, shipyards, owners and class societies to conduct investigations on the impact of the proposed new guidelines for the assessment of the minimum propulsion power to maintain manoeuvrability in adverse conditions (MEPC 64/4/13) on the design and operational characteristics of various ship types. To investigate in parallel the impact on EEDI by implementation of the developed integrated/holistic optimisation procedure in a series of case studies. Herein, to assess in addition ship types currently not covered by the EEDI provisions, like tugs and Offshore Support Vessels.
- ✓ Developing new guidelines for the required minimum propulsion power and steering performance to maintain manoeuvrability of ships in adverse environmental conditions.
- ✓ Establishing minimum propulsion power and likely new EEDI requirements ensuring safe operation for various types of ships. Preparing and submitting to IMO a summary of results and recommendations for further consideration (end of project, October 2016).

Project Results:

In the 2013 Interim Guidelines environmental conditions have been proposed for the assessment of the manoeuvrability of ships in adverse conditions. A thorough review of these adverse environmental conditions has been carried out. The analysis includes seaway joint statistics across the North Atlantic and in European coastal areas, relevant seaway spectra, critical sea states parameters and shallow-water aspects of wave dynamics.

Information from various sources has been collected to provide a database with reliable information about accidents related to the manoeuvrability of ships under adverse weather situations. The statistical analysis enabled the identification of ship types and sizes in greater risk. The collected data were analysed in order to study how the prevailing weather conditions relate to the accidents, and how the various ship types are affected. The risk related curves that resulted from the risk analysis were used to determine the risk levels of every ship type of varying size.

A critical analysis of the regulatory framework has been carried out to identify intrinsic safety issues regarding minimum propulsion power to maintain the manoeuvrability of ships under adverse conditions. Operational experience from ship operators is also gathered and studied. The results of the investigations are used to propose relevant safety criteria for manoeuvrability in adverse conditions.

Among the types of codes considered in the project are potential flow seakeeping codes for the prediction of added resistance and loss of stability in waves and for manoeuvring predictions in waves or in confined waters. Other codes are based on field (CFD) methods. Many applications of these codes have the objective of determining off-line data bases for second-order wave forces, manoeuvring hull forces in shallow water, rudder forces behind the propeller etc. These data bases are meant to augment the manoeuvring potential codes, improving their prediction ability while keeping the computation time within acceptable limits. Other applications aim at direct predictions of ship motions.

A comprehensive test program of more than 1,300 model tests for three ship hulls has been conducted. The hull types encompass two standardized, public domain designs, namely the KVLCC2 tanker and the DTC container ship as well as a RoPax ferry design. The results of the experimental studies serve the validation of the seakeeping and manoeuvring codes developed and refined in SHOPERA, but the data measured for the public domain hulls stands for itself and is a valuable contribution and important extension of public benchmark data.

Models of varying complexity are being developed for the modelling of the main engine's dynamics and of the forces acting on the rudder(s). A simplified engine model based on the engine diagram was developed to be used in a "steady approach" for the assessment of the manoeuvrability of ships considering only time-average forces, moments and other variables. A dynamic model for the engine-propeller interaction by accounting for shaft dynamics is also considered, to be used for direct CFD simulations of manoeuvring motions in waves. The simplified rudder model may be used for the calculation of rudder forces in the propeller slip stream. Semi-empirical formulas are developed for the estimation of the added resistance and powering in waves.

The impact of guidelines to be developed in SHOPERA for the assessment of manoeuvrability in adverse conditions will be investigated by a formalized optimization procedure. Macros and software tools for the automated elaboration of a ship's basic design are under development. These tools will be linked with an optimization platform, facilitating the set-up of complex optimization problems, the integration of software tools, and the analysis of the results.

A series of case studies are carried out by a team comprising designers, classification societies, yards, universities, operators and ports. The investigation on the impact of the proposed new guidelines will be undertaken through careful identification of the case studies of the different ship types.

The dissemination of the obtained results is being accomplished by a series of publications in scientific journals, conferences and workshops. A project-specific web site (http://shopera.org/) has been created. One public workshop has been already organized by SHOPERA and three more are planned.

Potential Impact:

The SHOPERA project aims to provide a substantial contribution to the knowledge and State of the Art in the area of ship's safety and manoeuvrability in adverse weather conditions.

The main expected results from the elaboration of the project are:

- Further development and refinement of existing high fidelity, hydrodynamic simulation software tools for the efficient analysis of the seakeeping and manoeuvring performance and safety of ships in complex environmental conditions.
- Elaboration of seakeeping/manoeuvring model tests in combined seaway/wind environment to provide the required basis for the validation of the employed software tools and the results obtained by numerical simulations.
- Integration of software tools for the hydrodynamic/manoeuvrability assessment of ships in adverse seaway/weather conditions into a ship design software platform and set-up of a multi-objective optimization procedure in which a ship’s performance is assessed holistically.
- Elaboration of case studies to investigate the impact of the proposed new guidelines for the assessment of the minimum propulsion power to maintain manoeuvrability in adverse conditions on the design and operational characteristics of various ship types.
- Development of new guidelines for the required minimum propulsion power and steering performance to maintain manoeuvrability in adverse conditions. Establishing minimum propulsion power and likely new EEDI requirements ensuring safe operation for various types of ships.
- Upon completion, submit results for consideration by IMO. The project SHOPERA will contribute to energy efficient, environmental friendly and safer shipping assuming that project results will be submitted for consideration to IMO and be implemented in due course. The project addresses the compelling need for ensuring ship’s safety, while looking into green maritime transport solutions, which is currently an issue of highest priority at IMO-MEPC in relation to the introduction of EEDI, as of January 1, 2013.