An attempt to define critical wave and wind scenarios leading to capsize in beam sea

The IMO Weather Criterion has proven to be the governing stability criteria regarding minimum GM for e.g. small ferries and large passenger ships. The formulation of the Weather Criterion is based on some empirical relations derived many years ago for vessels not necessarily representative for current new buildings with large superstructures. Thus it seems reasonable to investigate the possibility of capsizing in beam sea under the joint action of waves and wind using direct time domain simulations. This has already been done in several studies. Here it is combined with the First Order Reliability Method (FORM) to define possible combined critical wave and wind scenarios leading to capsize and corresponding probability of capsize. The FORM results for a fictitious vessel are compared with Monte Carlo simulation and good agreement is found at a much lesser computational effort. Finally, the results for an existing small ferry will be discussed in the light of the current weather criterion.
The Effects on the Operating Condition of a Passenger Ship Retro-fitted with a Composite Superstructure

As sustainability and climate change have come on the political agenda, the shipping industry will have to be operating energy efficient ships. An appealing step to achieve this goal is by designing superstructures made out of Fiber Reinforced Plastics (FRP) aiming at the reduction of the ship's lightship weight. The benefits of a light superstructure become most prominent in large passenger ships, as the superstructures constitute a significant percentage of the lightship. Additionally, depending on the size of the ship, the superstructure may tower several decks above the weather deck, affecting the stability of the ship. In this work, the superstructure of a RoPax ferry has been redesigned using composite materials emphasizing the effects on the ship from an operational per-spective. The weight reduction has been calculated for a realistic average operating condition quantifying the effects on the stability and the fuel consumption of the retrofitted ship compared to the original design.

Small Ro/Pax Vessel stability study

In 2009 new damage stability requirements for passenger ships based on a probabilistic method were adopted by IMO and are now part of the current SOLAS Chapter II-1 regulations (SOLAS 2009). The mandate from IMO was to keep the same safety level as inherent in the old deterministic damage stability regulations in SOLAS (SOLAS 90). During the rule development prior to the adoption, it was argued that the safety level for large passenger ships should be increased, but small ro/pax vessels were only rudimentarily looked at and small vessels with very high attained index were seen as “non-representative”. Currently there is a renewed debate in IMO regarding the required damage stability safety level for passenger ships. The damage stability safety level for small ro/pax vessels has also been discussed outside of the IMO assuming that the damage stability safety level for small ro/pax designs is perhaps not sufficient, i.e. that the current safety level according to SOLAS 2009 is less than the old safety level according to SOLAS 90. In order to establish a solid foundation for the discussion, this study was made possible by a grant from The Danish Maritime Fund. The study focus on small ro/pax vessels in a range from 32 m to 100 m in length and 100 to 600 passengers/persons, and the outcome of this study is described in details in this document.
A Model for Prediction of Propulsion Power and Emissions – Tankers and Bulk Carriers

To get an idea of the reduction in propulsion power and associated emissions by varying the speed and other ship design main parameters, a generic model for parameter studies of tankers and bulk carriers has been developed. With only a few input parameters of which the maximum deadweight capacity is the primary input a proposal for the main dimensions is made. Based on these dimensions and other ship particulars which are determined by the program the necessary installed propulsion power can be calculated. By adjusting the vessel design, i.e. the suggested main dimensions, and varying the speed it is possible to estimate the influence of the different parameters on the power demand. The model is based on previously well-established power prediction methods which have been updated and verified by model test results and full-scale data, meaning that the predictions are up to date according to modern ship design standards.

The IHS Fairplay World Fleet Statistics for vessels built in the period 1990 – 2010 is used as a basis for the modeling of the main dimensions.

The model can be used to calculate exhaust gas emissions, including emissions of carbon dioxide (CO2), from bulk carriers and tankers. A calculation procedure for estimating the Energy Efficiency Design Index (EEDI) which is presently being developed by the International Maritime Organization (IMO) is also included in the model. Different ship design parameters have been varied to see the influence of these parameters on the EEDI. The paper will focus on the technical and the design measures which can improve the environmental performance and will not take into account operational measures.
environmental impact, defined as energy demand and/or emissions per transport unit, is related to the same unit for the different transport forms. For Ro-Ro passenger ferries it can be difficult to find a suitable common transport unit, as they often transport a mix of cargo, such as passengers, passenger cars, trucks, lorries, buses and other rolling transport units. In this paper a method for determination of a common transport unit for Ro-Ro passenger ships will be described.

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**Existing Design Trends for Tankers and Bulk Carriers - Design Changes for Improvement of the EEDI in the Future**

To get an idea of the reduction in propulsion power and associated emissions by varying the speed and other ship design main parameters, a generic model for parameter studies has been developed. With only a few input parameters of which the maximum deadweight capacity is the primary one, a proposal for the main dimensions and the necessary installed power is calculated by the model. By adjusting the vessel design, i.e. the main parameters, and varying the speed it is possible to observe the influence of the different parameters on the power demand. The model can be used to calculate exhaust gas emissions from bulk carriers and tankers, including emissions of carbon dioxide (CO2). A calculation procedure for estimating the Energy Efficiency Design Index (EEDI) is also included in the model. The IHS Fairplay World Fleet Statistics for vessels built in the period 1990–2010 are used as a basis for the generic modelling. A comprehensive regression analysis has been carried out to find the formulas to be used as a basis for the model. Furthermore, it was found during the analysis that the design trend of bulk carriers and tankers has moved in a wrong direction seen from an energy saving point of view. The block coefficient has increased during the last twenty years while the length displacement ratio (L/displ.volume1/3) has decreased over the same period. These two design changes have resulted in an increased EEDI. This development must be changed in the coming years when the EEDI shall be reduced gradually, ending in a 30 per cent reduction in 2025. An overview of the historical development and the necessary design changes will be documented here, including a complete list of the formulas for the main dimensions found by the regression analysis.

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**Model for Environmental Assessment of Container Ship Transport**

A generic computer model for systematic investigations of container ship designs is described in this paper. The primary statistical data on container ships used for the model development are also presented. The model can be used to calculate exhaust gas emissions from container ships, including emissions of carbon dioxide (CO2). A calculation procedure to estimate the newly designated Energy Efficiency Design Index (EEDI), which is under development at the International Maritime Organisation (IMO), is included in the model. Different ship design parameters have been varied to see the influence of these parameters on the EEDI. It is found possible to reduce EEDI by roughly 20 % without reducing ship speed, but only by changing some of the design parameters, such as reducing the sea margin by using a derated main engine, increasing the length of the ship by 5 %, and reducing steel weight by 3 % via steel weight optimization.

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DTU offers solution to the EEDI ro-ro conundrum

Environmental performance evaluation of RoPax ferries
Environmental performance evaluation of ro-ro passenger ferry transportation

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How do we convert the transport sector to renewable energy and improve the sector's interplay with the energy system? Background paper for the workshop on transport - renewable energy in the transport sector and planning, Technical University of Denmark, 17-18 March 2009

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State of the art report on design for X

The present State of the Art report aims at defining and reviewing the current state of the ship design process in the frame of a holistic approach, accounting for various objectives and constraints. The report addresses mainly the design of transportation carriers, though some covered aspects are also relevant to other ship types and floating devices. Design for X is herein defined as the optimization of a ship with respect to specific important performance indicators and properties, like design for safety, design for efficiency, design for arctic operations and design for production. The concept of Design for Safety was introduced and briefly demonstrated on the basis of the design of the largest cruise vessel ever built. The Design for Efficiency of Performance was reviewed with particular emphasis on recent discussions about fuel savings and the reduction of air emissions in maritime transport. Developments in the Design of ships for Arctic Operations were presented, responding to recent increased maritime transport needs in arctic areas. Finally, recent developments in the design for Production were presented, which is critical to achieving globally competitive shipbuilding business.

Cargo transport by sea and road - Technical and economical environmental factors

This paper presents the background for a method of calculating the energy demand for different ship types using only a relatively few, but important parameters. It is an empirical method, based on a statistical analysis of the main parameters of different ship types in order to establish representative relationships between the cargo capacity and the ship's main dimensions. On this basis, it has been possible to calculate the necessary propulsive power by using well-established empirical power prediction methods (Guldhammer and Harvald (1974), Oossanen (1980), and Insel & Molland (1992)). By combining the statistical analysis with a subsequent power prediction, it has been possible to develop a method which can calculate the energy consumption as a function of only 3 general parameters, namely the size of the ship (more precisely the capacity), the ship's speed and the average cargo utilization.) Having established a method for the calculation of the ships energy demand, it is relatively simple to calculate the exhaust emissions by using some well-established specific emission factors, i.e. figures for the exhaust emission pr. consumed energy unit (g/MJ). In the paper, a comparison with road transport will also be presented focusing on the energy demand and exhaust emissions per transport unit, i.e. per ton cargo per km. Finally, the energy and emission data will be used for an economical evaluation of sea transport versus land transport. This will be done by calculating the external costs to society caused by the negative effect of the different modes of transportation, i.e. costs due to air pollution, noise, accidents and congestion, which in total covers most of the external transport costs.