A SIMULATION PLATFORM FOR SHIP DESIGN

PETER SLINNING TENFJORD AND MARTIN ØKSDAL BAKKE

SUPERVISOR: PROF. STEIN OVE ERIKSTAD

CO-SUPERVISOR: PHD CAND. ENDRE SANDVIK

NTNU
Norwegian University of Science and Technology

BACKGROUND & OBJECTIVE

Most vessels that are built in Norway today are costly and rarely copies of previous vessels. The ship design process is extensive and time consuming. The unique nature of each design makes it hard to benefit from scale effects. It is difficult to test new designs prior to production, and prototyping is too costly. To make the process more efficient, simulation is introduced as a tool.

Simulation of vessel operation can be imagined as a real life test of the vessel, providing insight into how it will perform. It works by running the vessel through its assigned operations, and subjecting it to external influences such as meteorological and oceanographic conditions (MetOcean). This ensures that the operational profile captures the complete spectrum of realistic operating conditions.

Three important aspects that are important in achieving the objective of building a simulation platform are identified

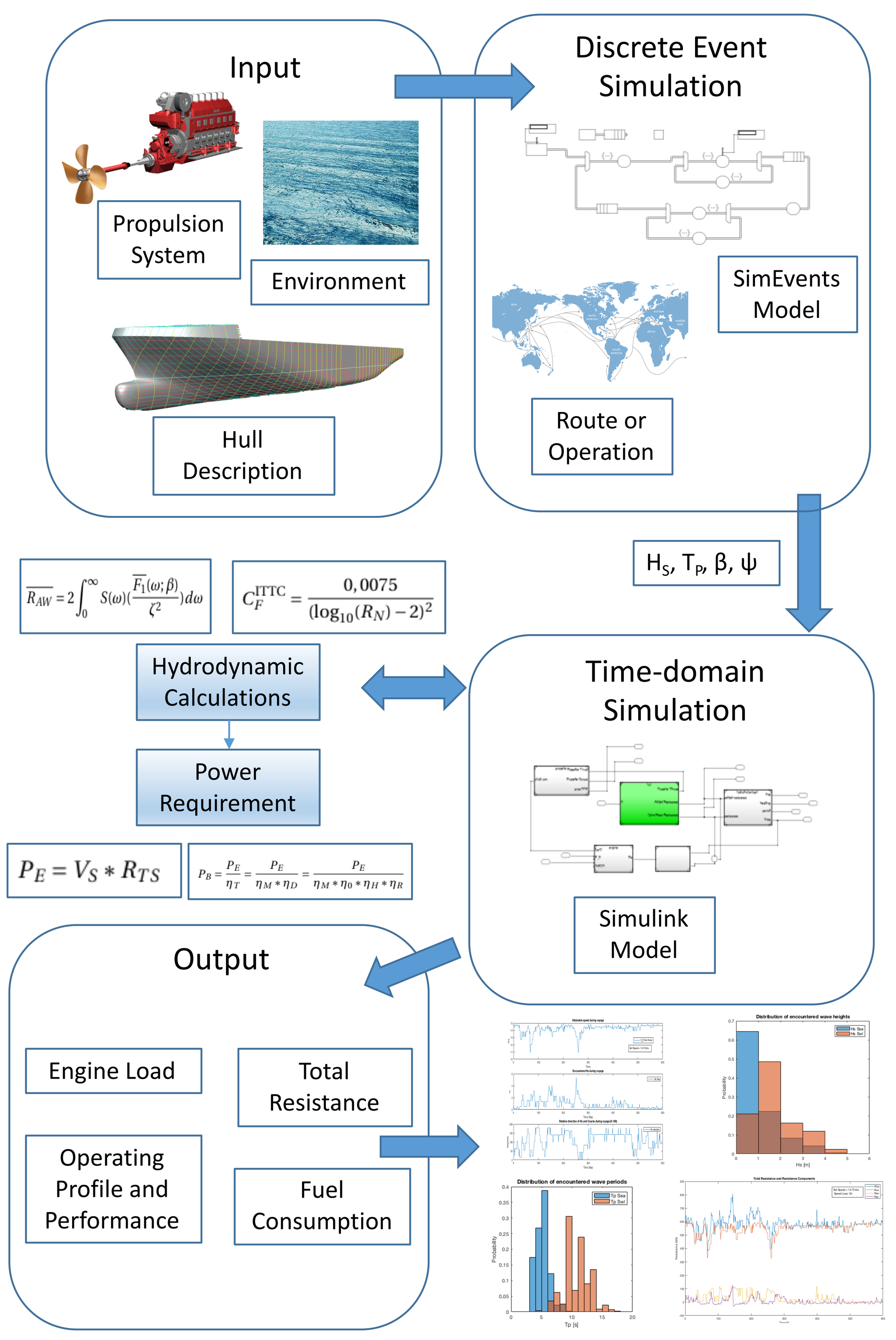
1. The complex interactions of a vessels sub-systems (e.g., machinery, hull)
2. Including stochastic variables (e.g., MetOcean data)
3. Fidelity level and level of accuracy

METHOD & SOFTWARE

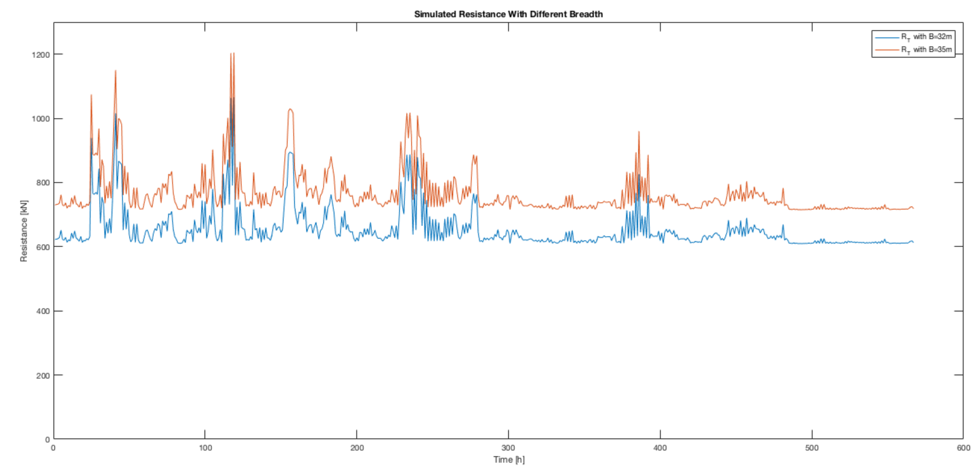
MATLAB's add-on Simulink is used as simulation software, with the plug-and-play feature it illustrates the complex interaction between the sub-systems in a clear way.

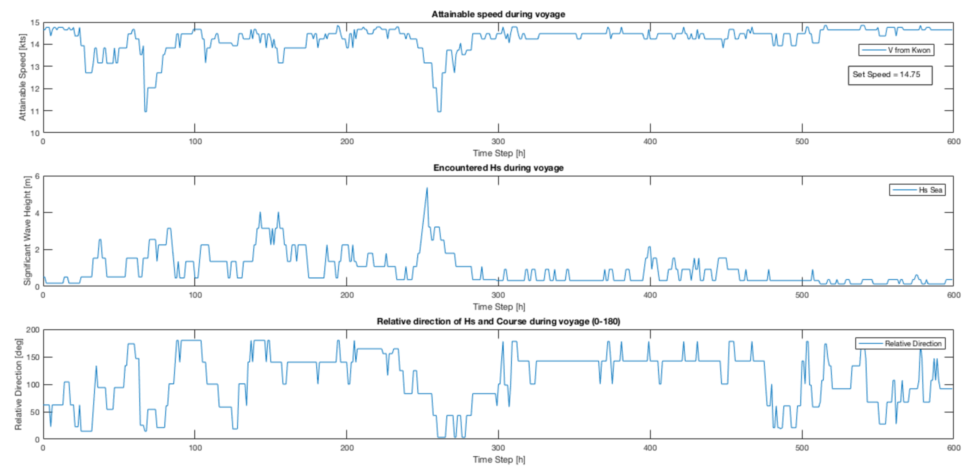
To achieve accurate results, external programs have been applied. For the hydrodynamic part of the simulation model, ShipX have been applied, offering plug-ins such as Wave Resistance and Vessel Responses, calculating calm water and added resistance operators (coefficients), respectively.

OVERVIEW OF MODEL



RESULTS





Emphasis has been put on presenting results that are of use early in the design phase. The platform presents summaries of encountered sea and weather conditions, and the associated vessel performance. Encountered scenarios can be reproduced in order to compare different design configurations. This approach gives important information that may assist in decision making.

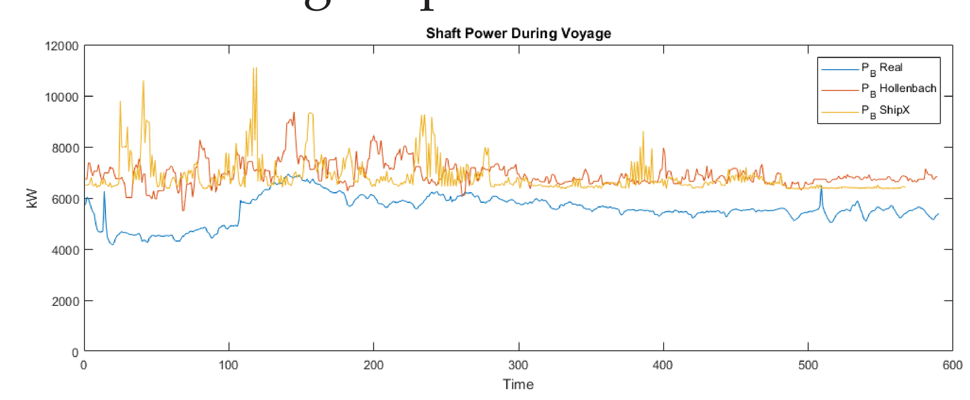
Running simulations while changing the main dimensions of the vessel have contributed to validate the results from the model. When changing the beam of the vessel, the resistance could be seen to increase accordingly.

The results also show the difficulties in the numerical estimation of added resistance in waves, and emphasis should be placed on creating a good ShipX model. The empirical methods yield reasonable results, in light of the low computational time and limited user input requirement. The accumulated operating profiles gives the user good insight into encountered weather conditions, especially compared to traditional information used in the early design phase.

CASE STUDY

In order to validate the simulation model a case study was performed. A 60,000 dwt general cargo carrier was chosen as the case vessel. The ship data log contained vessel coordinates, speed, main engine load and more. In order to replicate the sea conditions, the voyage was divided into legs, and historical wave data from the location of each leg was used to create weather models.

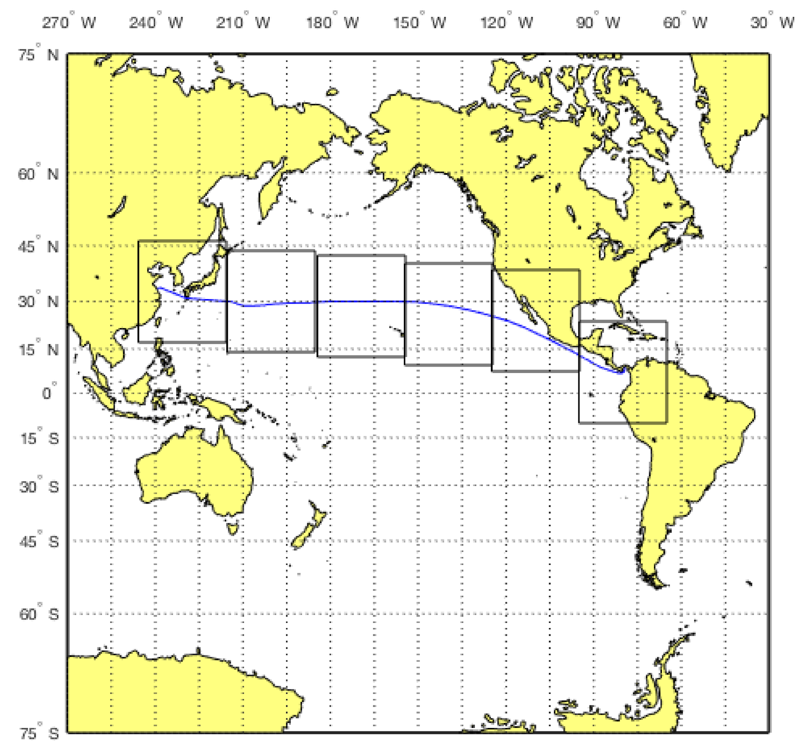
The speed set in the case study is the design speed of 15 kts, and the speed loss in actual sea conditions is found by Kwon's empirical method. Below is a comparison between the break power from the data log, from simulation using Hollenbach's method for calm water resistance prediction together with Kreitner's formula for added resistance from waves, and from simulation using ShipX' Waveres and Veres.



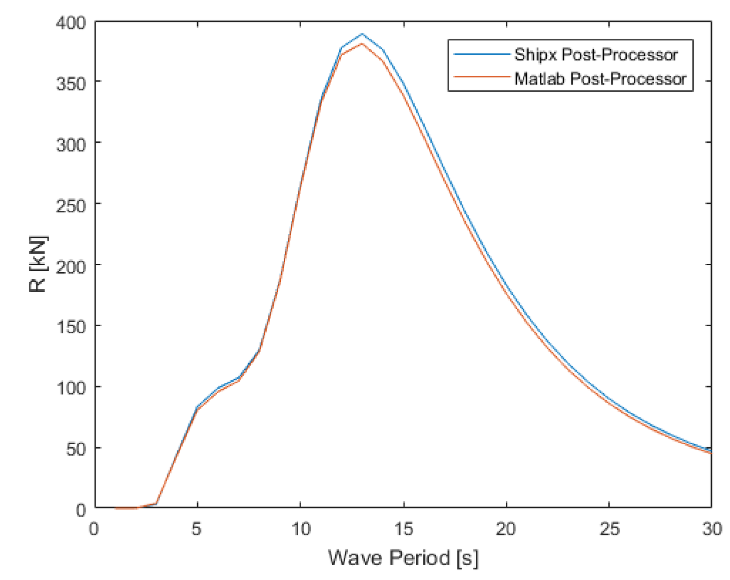
The results indicate that the model may overestimate the propulsive powering need. Note that for the first part of the case voyage, the ship is operating at lower speed than the design condition, whilst in the simulated voyage, the speed is constant. This contributes to the large differences at the first part of the voyage.

OPERATING CONDITIONS

Operating conditions, i.e. MetOcean, have a large impact on a vessels performance. We have chosen to generate operating conditions using Markov Chains where the transition matrices are based on historical data for given locations. The route is divided into legs where each leg has similar conditions.



To calculate added resistance in an irregular seaway a Pierson-Moskowitz wave spectrum is generated and combined with Shipx responses to produce a response spectrum for the vessel at given periods.



FUTURE WORK

Inclusion of more operating modes is a natural next step for the simulation platform. Especially the ability to simulate dynamic positioning as part of a voyage, while including operability factors based on weather conditions.

The ability to optimize should be an included feature in future simulation models. This could include parameters at early stages; e.g. main dimensions, or for later stages; optimization of the propulsion system, e.g. choosing fuel type or engine compositions.

CONCLUSION

The platform has shown great promise with regards to interchangeability between modules, depending on fidelity level, as well as the ability to change parameters for a given vessel.

It is also an advantage that we now can see the effect that one change has on the entire system, giving the ability to find the best solution for the entire system, which can be different from the best solution for the sub-system.