MARIN

Challenging wind and waves

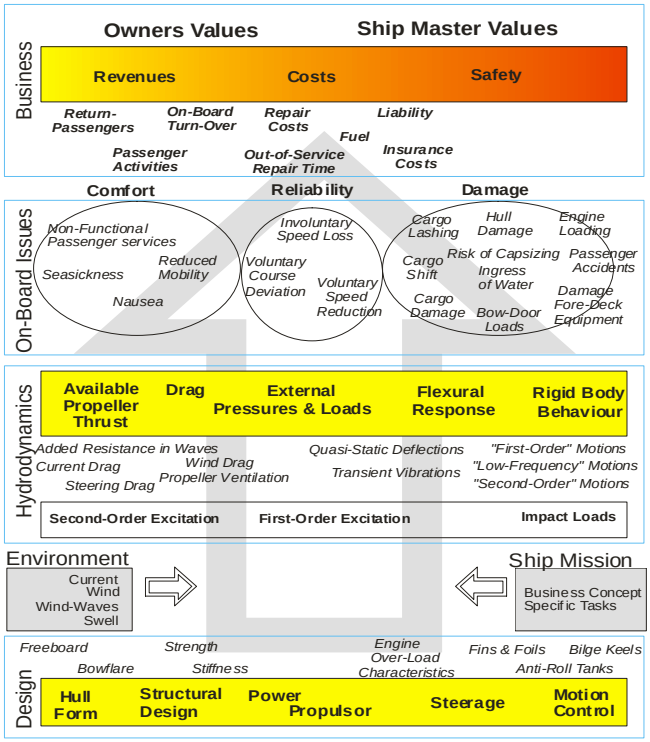
Linking hydrodynamic research to the maritime industry

Ship route scenario simulations

MARIN internal use only

GULLIVER

At MARIN the program GULLIVER is available for so-called ship route scenario simulations. It simulates the operation of a ship on a fixed route over a long period. The basic elements are the ship's calm water and seakeeping characteristics, the environment (wind, waves, current) and an operational scenario representing the captain's reaction to actual and predicted conditions.



Weather impact on a ship's earning capacity

Backgrounds and motivation

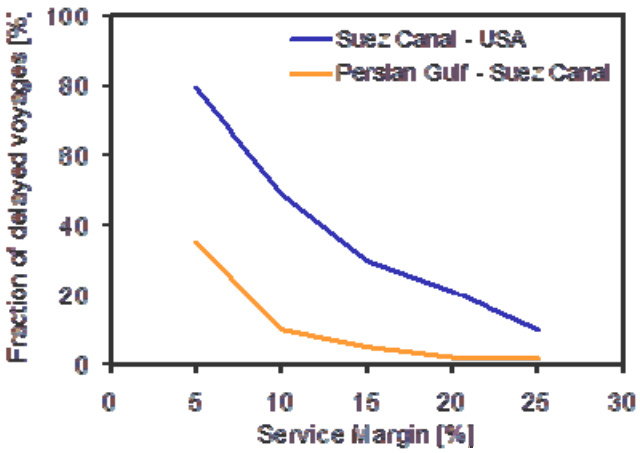
A well-balanced design for service leads to a competitive edge for both the ship builder and the ship owner. A problem with this balance is the complexity of the performance assessment.

This should encompass a complete description of:

- The hydrodynamic characteristics of a design
- The environmental conditions on the route
- A scenario for the captain's reaction to the encountered conditions

For a long time the lack of a practical evaluation tool for this mixture of complex issues (see figure above) and lack of insight into the impact of seakeeping on the in-service economy have been major obstacles in design for service. This situation changed with the introduction of improved numerical models for ship hydrodynamics and wind-wave interaction, fast computer facilities and advanced programming techniques. Combination of these developments in the GULLIVER software facilitates simulation of ship performance in unprecedented detail over a long period of service.

The application of GULLIVER is not limited to detailed performance assessments of new designs. A careful reproduction of existing ship and fleet performance yields valuable insight into the impact of seakeeping on shipping economy.



Risk on delay as function of service margin and route

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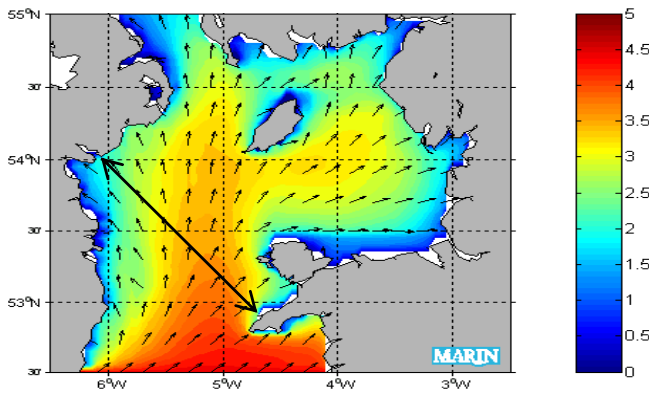
Time domain approach

A practical way around the problems and limitations of a statistical approach is based on a deterministic step-wise simulation of a given "mission". The use of hind cast data as input for wind and waves solves the problem of accounting for the right coherence between wind and waves and the varying spectral characteristics of the waves. Such a time domain approach accounts for the persistence of adverse weather and the reaction of the master on past and future ship behaviour.

Environmental conditions

Within GULLIVER, wave and wind parameters on open ocean routes are available from various sources and comprise wind sea and swell parameters and the wind speed. The complete wave spectrum is reconstructed from these parameters by adding assumptions on the spectral shape and the directional spreading. Waves in the coastal zone can be represented by two-dimensional wave spectra at arbitrary time steps. The figure below shows a typical example: the wave field on the Irish Sea driven by the local wind and swell from the south. Ocean and tidal currents are obtained from multi-parameter models.



Significant wave height and direction on Irish Sea

Scenario

A common way to characterise the motion characteristics is based on the use of linear and quadratic transfer functions. The transfer functions are stored in a RAO-database, containing the rigid body motions and the relative water motion, local accelerations, shear forces and bending moments.

The involuntary speed loss is obtained by comparing the total resistance, from calm water, wind and waves, with the available thrust. In GULLIVER, four different engine settings are available; constant power, constant torque, constant RPM and a controllable pitch propeller (CPP) setting.

Commonly used operational scenarios are "just in time", "constant power", "constant speed" and scenarios related to comfort and/or safety.

Output

GULLIVER generates long term statistics for virtually any quantity:

- Environmental parameters, e.g. significant wave height, wind speed, current speed
- Ship behaviour, e.g. (relative) motions, local accelerations, bending moments, green water and slamming
- Trip duration, sustained speed and voluntary speed reduction
- Engine load, fuel consumption
- Crew and passenger comfort e.g. MIR, VDV, MSI and MII

Output is generated in the form of animations, time traces, (polar) histograms, probability of exceedance diagrams and tabulated form. Scatter diagrams of all environmental parameters can be generated as well.

Application

GULLIVER has been used in a wide variety of projects, for example:

- Service reliability and comfort study for a large cruise vessel
- Service margin study for an LNG carrier
- Safety study for a sea-river ship
- Comfort study for a passenger ferry

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