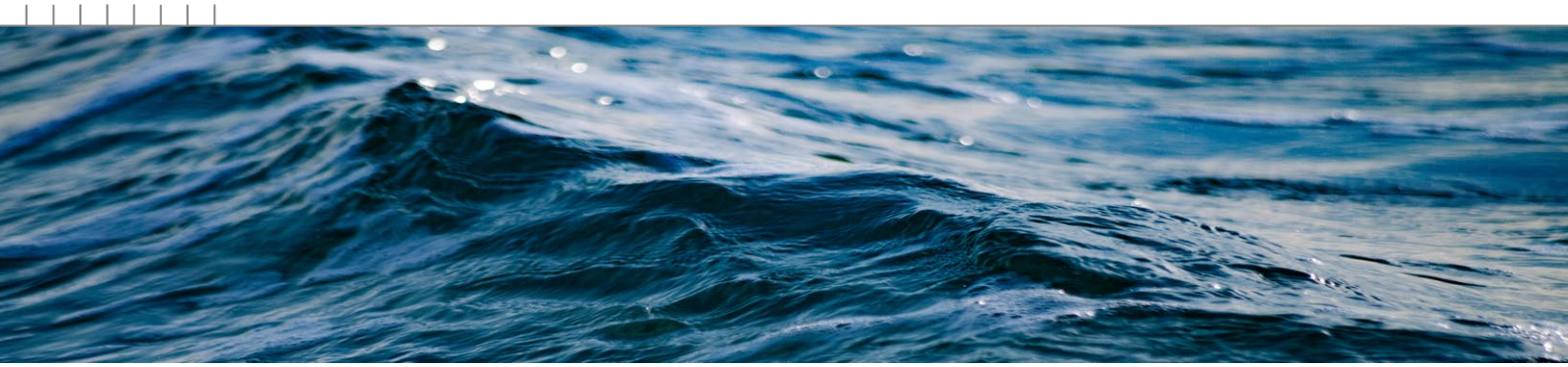


SEACAL

Seakeeping calculations: behaviour of a ship in a seaway

At MARIN the program SEACAL is available for the calculation of the behaviour of a ship in a seaway. SEACAL is a frequency domain linear 3D diffraction program. It can be used to calculate the motion response in regular waves at arbitrary speed and heading. To obtain more accurate motion predictions at forward speed, the Rankine source method is utilised in SEACAL, which is available for monohulls as well as for multihull ships. At zero forward speed, SEACAL utilises the well-known zero speed Green functions, similar as in PRECAL_R or DIFFRAC.

A number of seakeeping characteristics, such as accelerations, relative motions, added resistance and internal loads, can be derived from the motion response.

SEACAL is developed within the Cooperative Research Ships (CRS) framework, and it is basically the follow-up of PRECAL_R (which developments have stopped).

Input

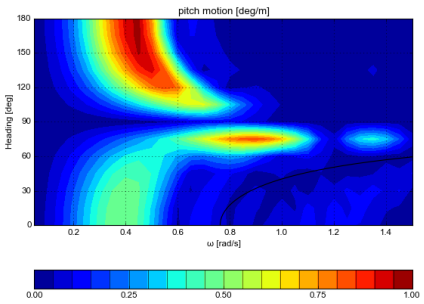
- Hull surface description in VTK format
- Mean draft, transverse metacentric height
- Mass distribution, radii of gyration
- Geometry of appendages: bilge keels, fins, rudders, skegs
- Water depth
- Ship speeds
- Regular waves: wave directions, wave frequencies

Computational approach

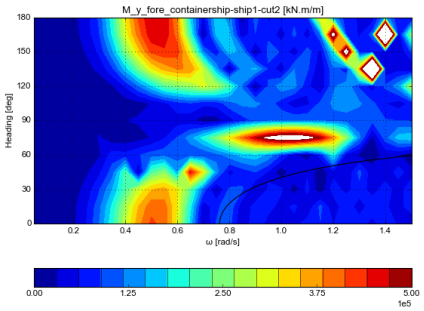
For each combination of ship speed, wave direction and wave frequency the ship-wave interaction is described as the superposition of: the forces on a fixed ship in incoming waves (the diffraction part) and the forces on an oscillating ship in calm water (the radiation part). The wave excitation forces are composed of the incoming (or Froude-Krylov) wave forces and the diffraction wave forces which are obtained by integration of the corresponding pressures over the hull surface. In the same way, the reaction forces are expressed in terms of added mass and damping coefficients. The assumption of linearity implies that in principle the results are valid for small wave amplitude and small motion amplitude only.

Next to the linear potential flow forces, it is possible to extend the SEACAL motion equations with (empirical and linearised) models that account for:

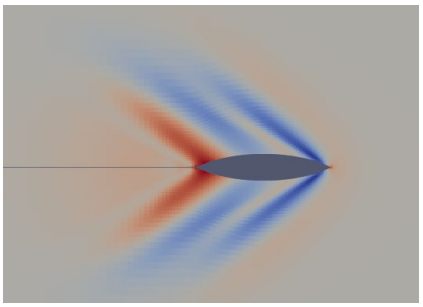
- Forces from viscous effects (skin friction, lift) by the generation of eddies around the bilge
- Forces from the bilge keels (using IKEDA, FDS (fast displacement ships) or a new CRS method)
- Forces from the rudders and/or stabiliser fins (both passive and active)
- Forces from anti-roll tanks



Pitch motion of container ship in regular waves (zero speed Green function result)



Vertical bending moment of container ship in regular waves (zero speed Green function result)



Free surface elevation around the Wigley IV at Fn = 0.20, Rankine source method.

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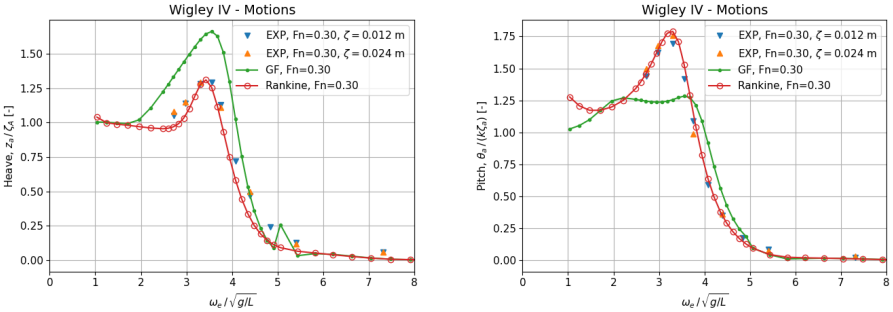
All calculation models are available at zero and forward speed wave modelling. When the Rankine method is used for forward speed calculations, the free surface mesh is automatically created by the program and can be modified by several parameters. In addition, the concept of generalised modes was used to allow both rigid body motions and flexible behaviour such as bending and torsion. Generalised modes can also be used to model multi-hull vessels (catamaran, trimaran) and multi-body configurations (side-by-side operations).

Output

- First order motions: surge, sway, heave, roll, pitch and yaw, flexural modes, effective gravity angle (EGA)
- First order wave excitation forces, added mass and damping coefficients
- Second order wave drift forces (as for instance the added resistance in waves)
- First order response at reference points: relative wave elevation, as well as, absolute motions, velocities and accelerations
- internal loads at cuts: transverse and vertical shear forces and bending moments, torsional moment

All results are available in the frequency domain. To assess and visualise the results, the MARIN program RAOViewer can be used. Within this GUI, the response statistics in irregular waves can be calculated, which include when needed a linearisation between various databases of linearised motions as function of roll motion amplitude.



Heave and Pitch RAO of Wigley IV at Fn = 0.30 (head waves), Experiments versus zero-speed Green Function (PRECAL_R/SEACAL) versus Rankine source method (SEACAL)

Applications

SEACAL is used for a wide range of applications and hull forms. The most important applications are:

- Prediction of seakeeping behaviour in initial design stage
- Seakeeping performance comparison between hull forms
- Calculation of added resistance in waves for power-speed correction
- Evaluation of roll stabiliser performance
- Optimisation of experimental programs by rational selection of heading, speed, wave height and period
- Calculation of hydrodynamic database for time domain simulations

The use of SEACAL has yielded a large volume of valuable information. In general, it can be concluded that the overall motions of various ship types in waves of limited height are predicted with fair accuracy.