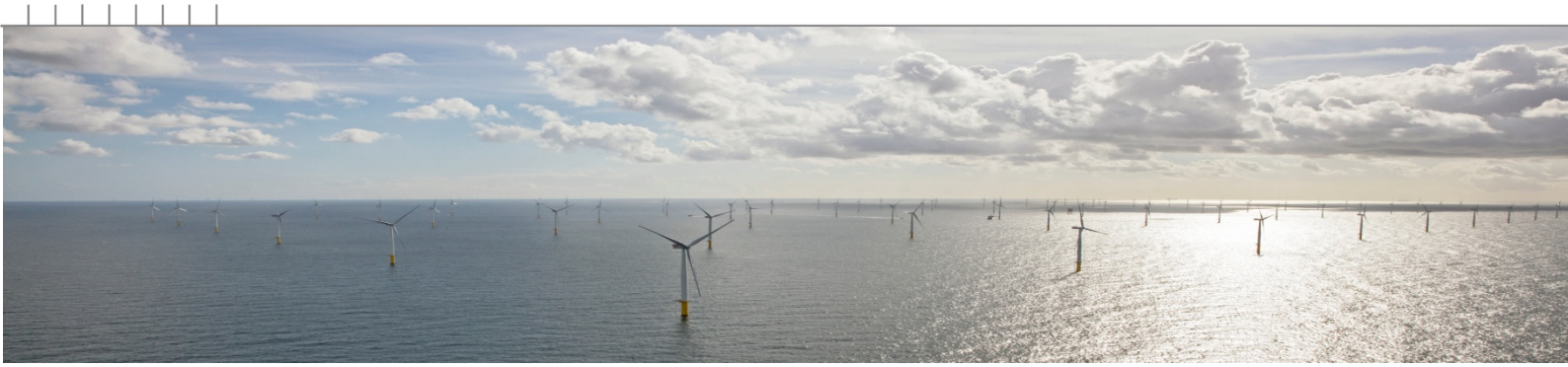
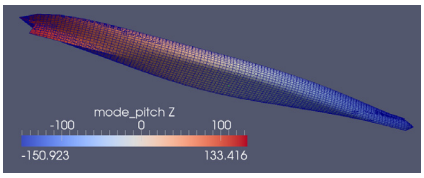


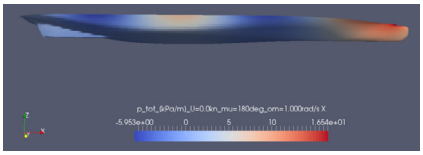
PRECAL_R

Seakeeping calculations: behaviour of a ship in a seaway

At MARIN the program PRECAL_R is available for the calculation of the behaviour of a ship in a seaway. The program is based on the well-known frequency domain linear 3D diffraction theory. It can be used to calculate the motion response in regular waves at arbitrary speed and heading. A number of seakeeping characteristics, such as accelerations, relative motions, added resistance and internal loads, can be derived from the motion response. PRECAL_R was developed within the Cooperative Research Ships (CRS) framework.



Pitch mode



Hull pressure distribution

The workflow in PRECAL_R is split up into three parts:

- HYDMES generates the 3D hull surface description with panels and calculates the hydrostatics.
- HYDCAL calculates the hydrodynamic pressures and velocities on the hull surface.
- RESCAL calculates the wave excitation forces, the added mass and damping coefficients, the roll damping due to viscous effects and eddies, the forces generated appendages and anti-roll tanks. Then the equations of motion are solved, yielding the motion response of the ship in waves.

Computational approach

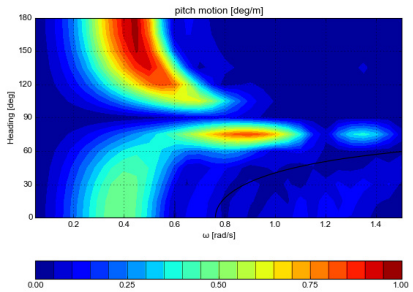
For each combination of ship speed, wave direction and wave frequency the ship-wave interaction is described as the superposition of the forces on a fixed ship in incoming waves (the diffraction part) and the forces on an oscillating ship in calm water (the radiation part).

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.

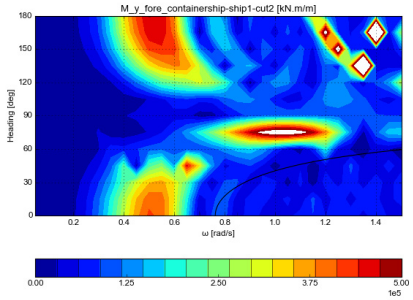
The assumption of linearity implies that in principle the results are valid for small wave amplitude and small motion amplitude only.

Although the potential theory underlying PRECAL_R neglects viscous flow effects and vortices in the flow around the ship, the equations of motion are solved with account of the following effects:

- hull damping due to viscous effects (skin friction, lift) and the generation of eddies around the bilge
- viscous and turbulent flow around bilge keels and skegs
- viscous flow around fin and rudder stabilisers (both passive and active)
- nonlinear forces from anti-roll tanks



Pitch motion of container ship in regular waves



Vertical bending moment of container ship in regular waves

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).

Input

- hull surface description in VTK format
- mean draft, transverse metacentric height
- mass distribution, radii of gyration
- appendages: bilge keels, fins, rudders, skegs
- water depth
- ship speeds
- regular waves: wave directions, wave frequencies

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 (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. In parallel with PRECAL_R, the program RAOViewer was developed to facilitate the visualisation of these results and to assess the ship seakeeping performances in given irregular sea states. In addition, PRECAL _R was coupled to OperabilityViewer to efficiently perform operability analysis based on sets of operational criteria.

Applications

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

- prediction of seakeeping behaviour in initial design stage
- comparison of hull forms
- evaluation of roll stabiliser performance
- optimization of experimental programs by rational selection of heading, speed, wave height and period

The use of PRECAL_R 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.

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