MARIN

Challenging wind and waves

Linking hydrodynamic research to the maritime industry

## Simulation of the motions of a submersible

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# SUBSIM

The computer program SUBSIM provides a time domain simulation of the behaviour in six degrees of freedom of deeply submerged streamlined bodies equipped with all sorts of foil shaped appendages. The program is intended to be used in the initial design stage if model test data are not available. It uses the geometry of the hull and the appendages as input.

## Computational approach

In the first part of the program the hydrodynamic characteristics are calculated by means of empirical methods. This part can be used separately if only a prediction of the hydrodynamic coefficients is required. The formulae in this empirical method do not only concern the hydrodynamics of a streamlined hull but also the appendages (sail and planes) and the interaction effects between these elements. In this way all hydrodynamic aspects of the entire ship can be approximated.

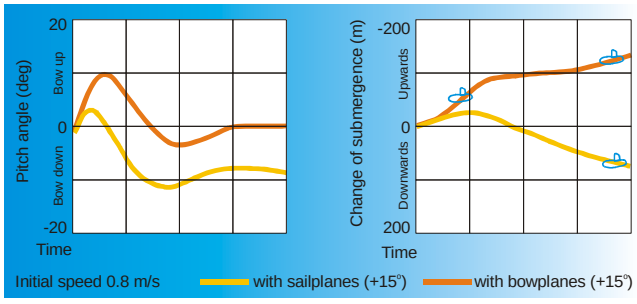
In the actual simulation part the hydrodynamic characteristics are used to establish the excitation forces on the submersible. The mathematical model uses a modular approach; the ship is divided into the hull and a number of foil shaped elements. The forces on the hull and on each element are calculated separately as a function of the local velocities. These forces are added to the interaction forces between the various elements. The total forces are substituted in the equations of motion by means of which the accelerations are derived.
Integration of the accelerations provides the ship's velocities after which a second integration leads to the ship's position at each moment of the manoeuvre.

## Applications

SUBSIM has been developed for assessing the stability and manoeuvring behaviour of submersibles with a limited amount of input.

The program offers three modes:

- The test mode in which the force and moment of the hull and the appendages are calculated
- The stability mode in which the coefficients of the linearised mathematical model are calculated. These coefficients determine the stability of the vessel
- The simulation mode in which the real simulation of manoeuvres is done




*Diving manoeuvre at high speed due to 15 deg. rotation of forward planes for two hull configurations*

## Input

Input are the following data:

- Geometry of the hull and appendages
- Propeller characteristics
- Revolution rate of the propeller
- Speed range for the stability assessment
- Initial position and velocities of the submersible
- Initial settings of the fin angles
- Type of manoeuvre (turning circle, overshoot, meander, see-saw and automatic pilot control). The manoeuvre can be performed interactively
- Rudder executes to realise the specified manoeuvre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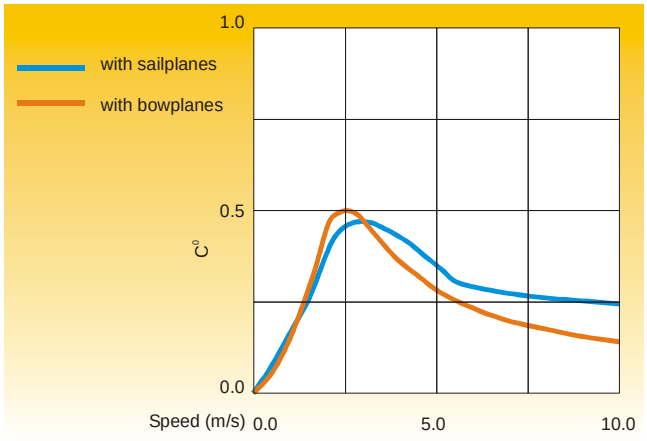
## Output

The output includes:

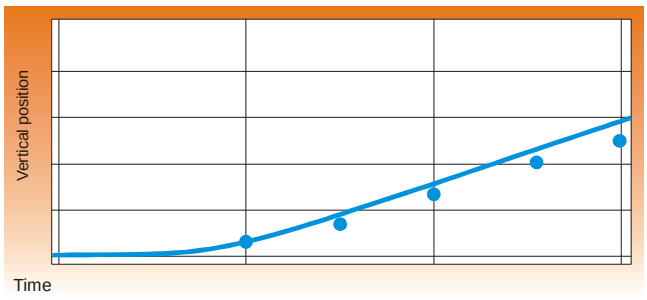
- The vertical plane stability roots and damping
- The neutral point in the vertical plane
- The critical speed of the forward planes
- At each time step of the manoeuvre the position of the ship and the steering planes
- The ship's velocity components and the force contributions




*Dimensionless critical damping C of the vertical behaviour of two hull configurations*

## Accuracy

SUBSIM has been evaluated for slender main hulls (length/diameter ratio between 4 and 12) at small lateral velocities relative to the forward speed so that the angles of attack remain smaller than about 30 degrees. For such conditions the results agree acceptably well with full scale measurements.




*Vertical manoeuvre at a constant angle of the stern planes*

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