

Time Domain Analysis of Multi Body Dynamics for Offshore Operations

aNySIM

Multi-body time domain simulation tool

MARIN has been developing, using and selling hydrodynamic simulation software for many years. Specialised tools were developed for specific areas: coupled mooring analysis, Dynamic Positioning, multiple-body lifting operations, riser dynamics, offloading operations, etc. Developments in the offshore industry in recent years showed the need for a more integrated and flexible tool. Therefore, MARIN decided to develop the new modular 'aNySIM' code. It brings together the capabilities of the different software packages and has become MARIN's main in-house hydrodynamic toolbox. Various modules can be coupled to the central N-body time domain simulation module. As an example, this makes possible studying a DP heading controlled moored FPSO with a shuttle tanker behind it, including all the hydrodynamic and mechanical interactions.

In 2006 MARIN started with the development of the new time domain program aNySIM. aNySIM can simulate the coupled motion behaviour of multiple floating bodies including effects such as mooring systems and hydrodynamic interactions. The program integrates the equation of motion taking into account the own inertia, added inertia, wave loads, damping loads and hydrostatic restoring forces:

$$\sum_{j=1}^{6N} (M_{kj} + m_{kj}) \ddot{x}_j + \int_{-\infty}^t R_{kj}(t-\tau) \dot{x}(\tau) d\tau + C_{kj} x_j = F_k(t)$$

where:

- x_j = motion in j-th mode
- $F_k(t)$ = arbitrarily in time varying external force in the k-th mode of motion
- M = inertia matrix
- m = added inertia matrix (frequency independent)
- R = matrix of retardation functions
- C = matrix of hydrostatic restoring forces




The inertia matrix consists of the mass of the ship and the distribution of the masses with respect to the centre of gravity (radii of inertia).

The right-hand side forcing function F includes the following forces:

- Wind forces.
- Current forces.
- Wave forces (first order).
- Mean wave drift forces.
- Slowly varying wave drift forces.
- Viscous damping forces.
- Restoring forces of mooring system.
- Restoring forces of lifting arrangement.
- Thruster forces.
- Rudder forces.

Computational approach

The mathematical model is based on a time-step solution of the system of coupled differential equations of motion in which the fluid reaction forces are described with convolution integrals according to the Cummins' formulation. The program uses linear diffraction data, wave forces, added mass and damping. In this way arbitrary hull forms can be accounted for.

Frequency dependent added mass and damping coefficients are transformed into inertia coefficients, retardation functions and response functions, such as described in the formula on the left. The instantaneous first and second order wave forces can be taken into account. These are the wave forces for the actual position of the vessel.

Modular approach

aNySIM was developed by implementing the functionalities step by step making sure that every step is validated and benchmarked against model tests and previous time domain software. At present the following modules are available in aNySIM:

- Time domain integration of equation of motion.
- Wave forces (1st and 2nd order).
- Current forces.
- Wind forces.
- Fenders.
- Lines.
- Anchor lines (quasi static and dynamic).
- Thrusters and rudders.
- Kalman filter.
- DP controllers.

User defined module

aNySIM offers an interface through which external subroutines can be called. In this way the user can extend the functionality of aNySIM by developing additional modules in FORTRAN90. The interface is such that data from the other modules is available for the user to compute additional signals. For example the current loads on the truss of a spar can be computed by requesting the current velocities at various water depths along the truss and then multiplying them by the Cd values.

Input

Typical input parameters that are needed to run a simulation are:

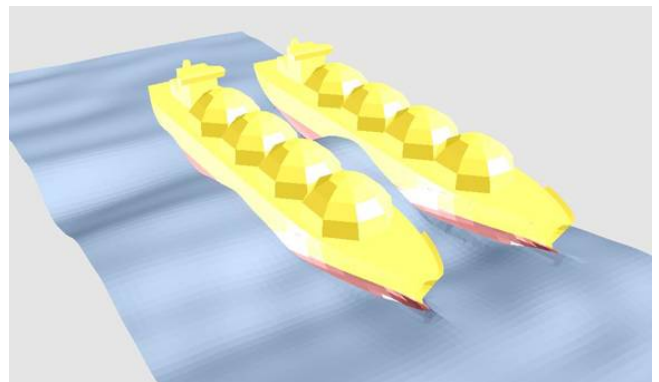
- Geometry, inertia and stability of floating bodies.
- Loading conditions and draughts.
- Water depth and diffraction data.
- Wind, wave and current conditions.
- Mooring arrangement.
- Propulsion arrangement.

Output

The standard output option consists of time traces of the motions in the centers of gravity, crane tip motions, mooring loads, fender forces,

relative motions etc. Additional output records may be defined by the user as functions of all available state variables in the user interface algorithm. This is a module where user defined forces can be programmed.

aNySIM concludes with a concise statistical analysis yielding extreme and mean values and standard deviations of all selected output signals. aNySIM output (including the diffracted wave field) can be visualized using the in-house visualisation tool Neptune as shown below.



Batch runs

The aNySIM program is equipped with a batch functionality that allows running large batches on MARIN's computer network. With this approach it becomes feasible to perform workability analyses for long term environmental data in limited simulation time. (Up to 10.000 runs is feasible in a few days)

Project based version for clients: aNySIM-pro

A project based version of aNySIM is now also available for clients. Further information about this software can be found on the aNySIM-pro leaflet. A demo version of the program can be obtained through the contact details below.

For more information please contact the Maritime Simulation & Software Group;

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