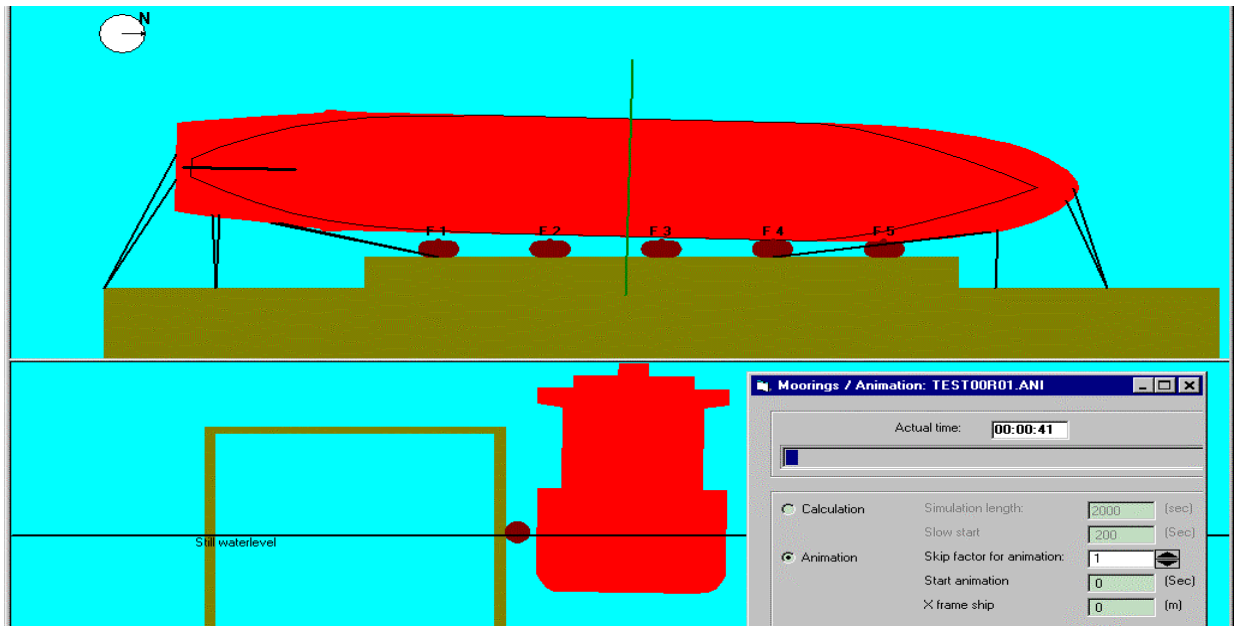
design of mooring systems

determination of motions of moored vessels and other floating objects



For harbours, marine terminals, floating terminals and offshore structures, optimising the mooring system is important for **improving safety** and **minimising downtime**.

Moored objects are subject to external forces in the form of wind, waves, current and interaction effects from passing ships. These forces may have various impacts, including:

- hampering the cargo handling operations due to large motions (downtime)
- damaging the moorings due to large loads and endangering ship's crew and terminal personnel

Optimising the mooring system is a cost-effective measure to reduce these negative impacts. In order to do this a thorough knowledge and efficient tools in the field of moored ship dynamics are required. ALKYON's experts have much experience in designing and testing of mooring systems. They have been involved in many mooring system designs, including over 35 projects since 1990.

For the assessment of the downtime and the optimisation of mooring systems ALKYON has available the moored ship computer simulation program **SHIP-MOORINGS**. This is a tool capable of simulating the behaviour of a ship moored to fixed structures (quays, jetties) as well as floating structures (single point or spread mooring systems).

SHIP-MOORINGS models the ship response as a function of:

- irregular waves from multiple directions, modelling includes long waves, seiches and drift forces
- wind, including gusts
- current flow (including dynamic effects) and water-level (tide)
- water motions induced by passing ships (water level depression, return flow)
- hydrostatic and hydrodynamic (added mass, damping) reaction forces
- proximity effects of other (floating or non-floating) objects
- non-linear characteristics of mooring lines, fenders and anchors

The results are presented as time-plots of motions and mooring-line and fender forces. They are also analysed spectrally and statistically. Motions, velocities and accelerations are computed and analysed for any location on the ship. The vessel motions are also monitored visually on screen.

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special features

SHIP-MOORINGS has been designed such that it is also possible to be used for the design of a safe berth at mooring locations where the environmental conditions are harsh. Special features allowing this are:

- the forces on the ship are dependent on the actual ship's location and orientation (commonly moored ship models assume the motions of the ship to be small and keep the relative direction of external forces constant)
- fender forces are applied at the correct point-of-contact in the three-dimensional space (commonly this is not the case, see above)
- forces also depend on the slowly varying ship motions themselves
- motions, velocities and accelerations are computed and analysed for any location on the ship
- the program produces an animation of the ship motion, which is especially important for analysing the behaviour of vessels moored to SPM-like terminals.
- the program allows for the application of special fender constructions and winch layouts

Technical Specifications

Input Data:

- Ship data
  - Ship's Geometry
  - Ship's mass and inertia data
  - Hydrostatic and hydrodynamic data
  - Coefficients for hull shapes
  - Wave force coefficients
  - Wind force coefficients
- Environmental data
  - Bottom schematisation – Water depths in a user defined rectangular grid
  - Wave field's for Sea and Swell waves – Wave heights and wave directions in a user defined rectangular grid for both Sea and Swell.
  - Current schematisation – U- and V-components of the current velocity in a user defined rectangular grid.
  - Wind schematisation – U- and V-components of the wind speed in a user defined rectangular grid.
  - Wave parameters – Spectral parameters, wave direction and significant wave height for wave systems.

  Note: An user defined grid is defined by its origin, increment size in X- and Y-direction and the number of cell's in both directions. The grid can be different for each of the quantities above.
- Mooring data
  - Location of fenders – X-, Y- and Z-location in world co-ordinates.
  - Location of Mooring lines – Position on the shore in world co-ordinates and position at the ship in ship co-ordinates.
  - Fender characteristics – Type of fender
  - Mooring line characteristics – Line type, material, pretension, diameter of line, length of line.

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Output Data:

- Printed output
  - Ship's motions in six degrees of freedom
  - Ship' velocities (u, v and r)
  - Wind forces
  - Wave forces
- Post-processing data
  - Motions in six degrees of freedom at each desired location on the ship
  - Velocities and accelerations at each desired location on the ship
  - Line forces
  - Line extensions
  - Fender forces
  - Fender impressions
  - Spectral analysis of motions, velocities and accelerations
  - Spectral analysis of line forces and fender forces
  - Exceedance distributions of motions, velocities and accelerations
  - Exceedance distributions of line forces and fender forces
- Animation data
  - Ship motions - x-y motion and y-z motion at each desired cross-section

Simulation process:

- Integration module based on Gear's BDF method with
  - Good opportunities for stiff systems
  - Self computing timestep – The timestep is computed such that the required error level is achieved. So good results are obtained with a minimum of computational effort.
  - Solving of the system of equations each timestep.
  - Error analysis each timestep.
- Time varying conditions for
  - Wind-, Wave- and current conditions
  - Waterdepth (Tide simulation)
- Each timestep evaluation of
  - Environmental conditions, dependant on the ship's actual position
  - External forces like line forces, fender forces, wave forces, wind forces
- Generating output data at fixed time intervals

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