Cooperative Research Navies develops new FREDYN software

In 2010 the Cooperative Research Navies (CRN) group celebrated its 20th anniversary. Report showcases CRN's activities and working groups, together with the very latest FREDYN software developments.

Figure 3. Snapshot of the view through the bridge simulator window.

Frans van Walree
f.v.walree@marin.nl

The CRN consortium was established to study the mechanisms of capsizing and to develop guidelines for safe ship design and operation at sea. MARIN provides the CRN chairmanship and secretariat, as well as overall project management, while participants contribute their expertise and technology and have access to www.crnav.org.

Background Navy ships have been designed and operated for the past 50 years in accordance with empirically-based stability criteria which were originally derived for wall-sided and flared monohull vessels of World War II vintage.
Existing ship stability criteria do not adequately address dynamic stability, nor do they address the stochastic nature of the wave environment. These criteria are typically based on hydrostatics and include margins that only provide an approximate means of accounting for ship dynamics. The stability criteria do not account for a ship's dynamic behaviour in extreme seas. Even modern hull forms may experience substantial roll angles in moderate sea conditions, (see Figure 1).

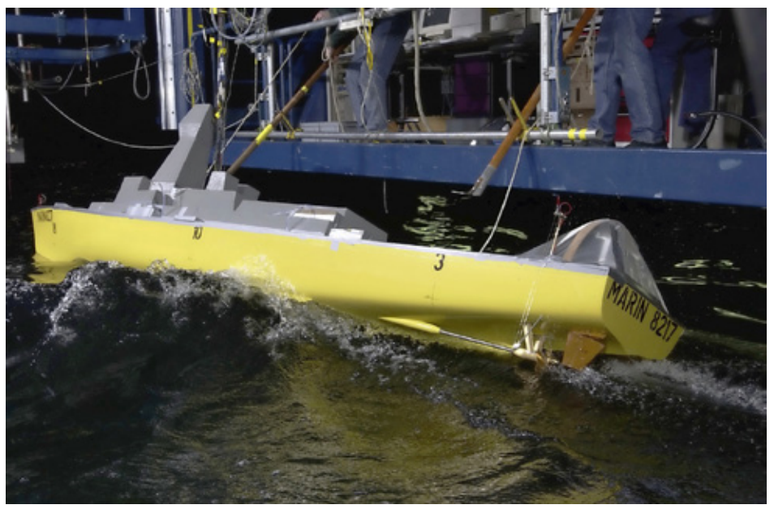

Figure 1. Frigate model in sea state 6

Dynamic Stability Simulation As warships must be able to operate in high sea states and at high speeds, this problem is of particular concern to navies. Stability requirements can have a major impact on design decisions. The objective of the Dynamic Stability Simulation project is to develop physics-based stability criteria for intact and damaged ships based on realistic and validated computer modelling. This is in order to assess the capsize risk associated with new ship design. The Naval Stability Standards Working Group provides the framework for CRN with regard to the development of design criteria.

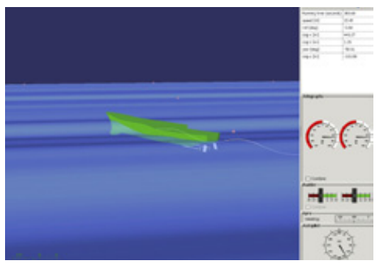

Figure 2. FREDYN animation of a destroyer in waves

The safe operation of a ship in extreme seas, in combination with the highest possible speeds and various loading conditions, requires sound knowledge of the expected dynamic behaviour of the vessel. Operational procedures will benefit from the knowledge gained about the dynamic stability related risk in various operational environments.
The Operator Guidance and Training Working Group provides input for the research aimed at improving operational issues. FREDYN is the principal simulation tool developed by CRN. FREDYN is a nonlinear simulation method in six degrees of freedom. Initial modules of the FREDYN code were programmed in Fortran 77, while more recent modules were programmed in Fortran 90.

FREDYN10 emerges FREDYN software was in need of modernisation to remove obsolete methods and coding and to allow FREDYN to easily be linked to other simulation hardware and software. Modernising the software also improves the flexibility of used modules and methods, as well as reducing maintenance costs. The Phoenix project was initiated within CRN to restructure the FREDYN software accordingly. After three years of work at MARIN FREDYN10 emerged, with a completely recoded core in C++. Figure 2 shows an animation snapshot of FREDYN10.

The restructuring of FREDYN has already proved its worth when at the request of the OGTWG last year, QinetiQ successfully linked FREDYN10 to an advanced bridge simulator in the UK. Figure 3 shows a frigate at heel while sailing in heavy seas and wind. Although how the simulator represents a real ship at sea needs to be enhanced, the combination of FREDYN with an advanced bridge simulator environment offers unique opportunities for heavy weather training for naval officers.

Another example is the use of the new FREDYN module for flooding calculations. DSTO-Melbourne used the flooding capability of FREDYN to support the investigation into the loss of HMAS Sydney in World War II. Although the cruiser was believed to have been engaged in a battle with the much more lightly armed German raider Kormoran, the reasons for the loss of the Sydney have remained a mystery. The wreck was found in March 2008 off the Western Australian coast, at a depth of 2,500 m. Observations with an ROV showed extensive shell and torpedo damage. FREDYN simulations for the damaged ship in the hindcast sea state showed it was plausible that the ship would sink in a couple of hours and that due to the extreme motions experienced it was highly unlikely that the crew would be either able to undertake any damage control procedures or even evacuate.
Present FREDYN developments enhance its nonlinear seakeeping capabilities by implementing methods for nonlinear irregular waves, nonlinear strip theory and roll damping for large amplitude roll motions.

The CRN group comprises:

- Canadian Navy (DMSS, Ottawa and DRDC-Atlantic, Dartmouth)
- French Navy (DGA, Val de Reuil and Paris)
- Defence Science and Technology Organisation (Department of Defence, Melbourne)
- Royal Netherlands Navy (Department of Defence, The Hague)
- Royal UK Navy (UK MoD, Bristol and QinetiQ, Haslar)
- U.S. Coast Guard (Surface Forces Logistics Center, Baltimore)
- U.S. Navy (Naval Surface Warfare Center, Bethesda and NAVSEA, Washington DC)
- MARIN (Wageningen, the Netherlands)