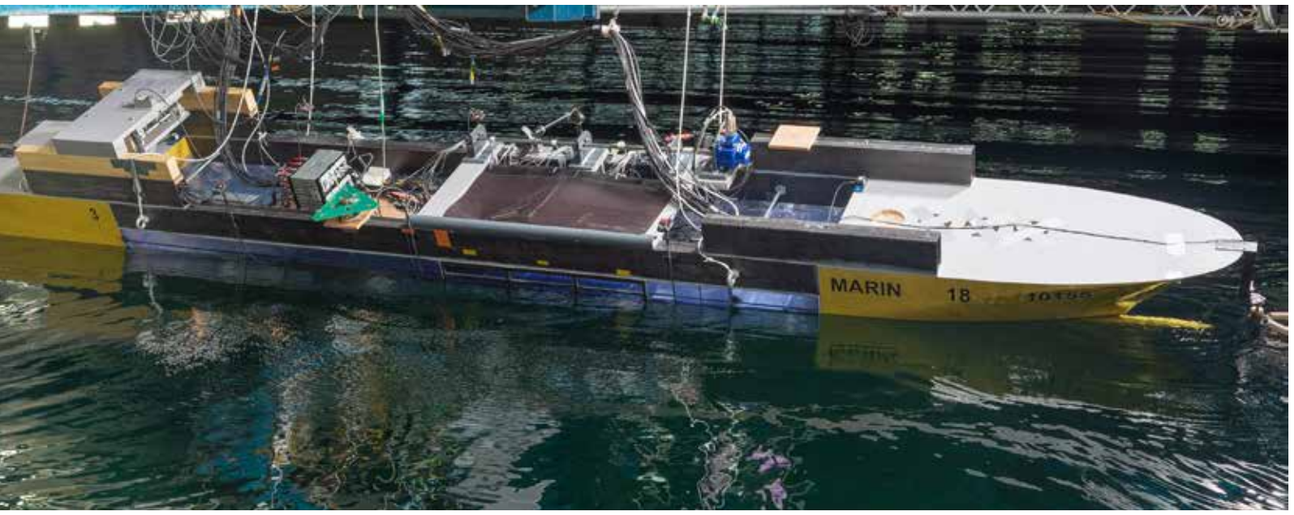


Complex flooding scenarios tested with a free floating cruise ship with a large external damage and a realistic internal compartmentation covering 6 decks

FLARE project makes significant contribution to passenger safety

We have all heard about tragic accidents and the sad stories of lost lives at sea when vessels capsize or sink, due to a collision or grounding. It does not occur that often, but when it does, the consequences can be devastating and catastrophic.

Riaan van 't Veer & Rinnert van Basten Batenburg
r.vantveer@marin.nl

Thus the question seems valid: are ships built under the present regulations really safe enough? And how do we support the crew during emergency situations, enabling them to make life saving decisions?

Beyond IMO regulations In a joint European Research project under Horizon 2020, named FLooding Accident REsponse (FLARE), 19 partners are working together with the aim of delivering a risk-based methodology (framework) for 'live' flooding risk assessment and control, which can potentially be applied to newbuildings and existing ships. The EURO 9.4 million project focuses on the safety of cruise ships and Ropax vessels.

MARIN is making a significant contribution of EURO 1.25 million to the project and is responsible for Work Package 4 concerning "Numerical Simulations and Verification". In this Work Package, model tests are conducted and numerical simulations of flooding are benchmarked. At the heart of the framework for damage stability risk evaluation is the use of dynamic flooding simulations that predict how the water progresses through the ship over time, taking into account the effect of ship hydrostatics, hydrodynamics and waves.

The outcome of the simulations enhances the designers' and operators' insight into the flooding risk quantification beyond the current IMO regulations.

MARIN has been developing dynamic flooding simulations within the FREDYN project for many years. Although the flooding equations are "just" the classical Bernoulli equations, the complexity of the ship compartmentation, with many compartments and flooding openings, and possible air entrapment in combination with large ship motions, makes dynamic flooding simulations a very challenging topic.

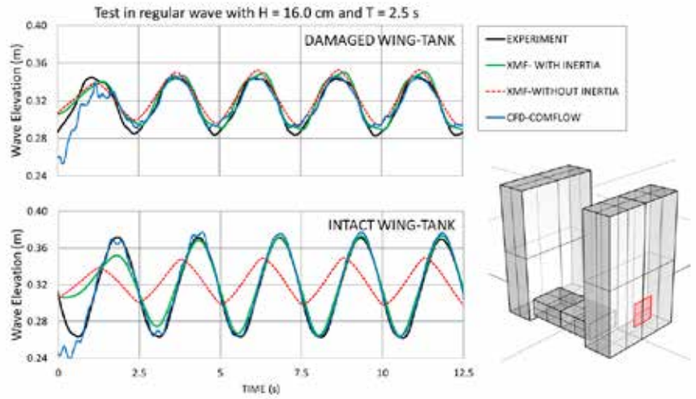


Figure 1: Flooded Wing-tank-cross-duct configuration exposed to regular waves. Experiments, COMFLOW and XMF simulations with fluid inertia and without fluid inertia effects accounted for.

New benchmark Over the last year a new and improved flooding model was developed under MARIN's well-known XMF framework. This flooding model accounts for flow inertia effects when present, and surpasses the (steady) Bernoulli equations. Inertia effects play a role in the flooding of a cross-flooding duct for example, used to provide the necessary equalisation of flood water through the ship in order to decrease the heel angle after damage has occurred. The highlights of the numerical model and the first results were published at the International Conference on the Stability and Safety of Ships and Ocean Vehicles (STAB 2021) and showed improved correlations compared to the Bernoulli-based flow simulations.

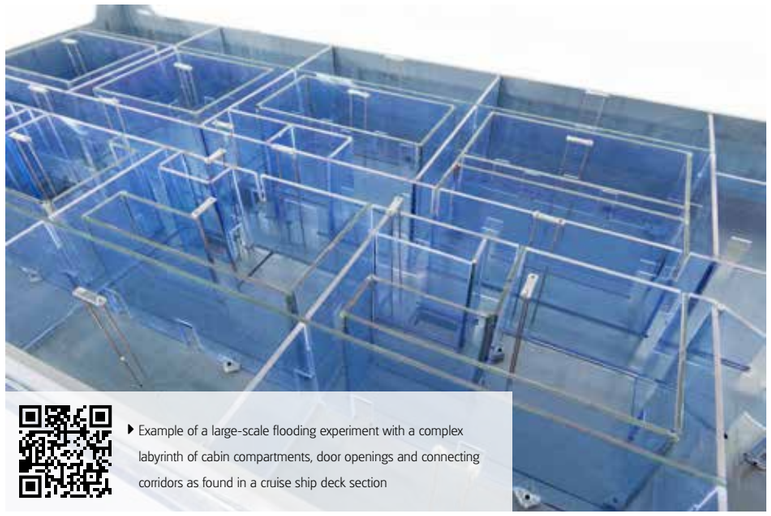
To provide a new benchmark dataset for flooding simulations, MARIN and the Hamburg Ship Model Basin HSVA conducted extensive model test programmes with varying levels of flooding complexity in a cruise ship (MARIN) and Ropax vessel (HSVA).

Large-scale captive flooding tests MARIN conducted unique, large-scale captive flooding tests to assess the flooding of several typical compartment configurations, covering in-, down-, up- and cross-flooding. The effect of air scaling was covered by executing the tests over a range of atmospheric pressures with closed or open ship vent pipes in the Depressurised Wave Basin.

Complicated flooding scenarios were tested in the Seakeeping and Manoeuvring Basin with a free-floating cruise ship with substantial external damage and a realistic internal compartmentation covering six decks. Tests were executed in irregular waves up to 7 m high. Typical hydrodynamic aspects such as the roll damping of a damaged ship and the effect of drift velocity were investigated. Experimental test techniques were optimised to open the ship breach at a dedicated time during the test by means of a remotely-controlled magnetic sheet.

First results The first results of the benchmark study demonstrated that existing dynamic flooding simulations are able to predict the capsize phenomena rather well. However, the timescale on which water progresses through the ship, and the accuracy of water levels in specific compartments shows a wider variation between the different simulation tools. Further publications will follow soon, covering even more complex flooding of the large cruise ship and Ropax vessel tested.

Being in its final year, the FLARE project is organising a series of webinars to update you on the progress of the project and is preparing proposals for the revision of the relevant IMO regulations, thereby significantly contributing to ship passenger safety. The consortium website www.flare-project.eu can be consulted for more information.



Example of a large-scale flooding experiment with a complex labyrinth of cabin compartments, door openings and connecting corridors as found in a cruise ship deck section