

# **A rapid assessment tool for the evaluation of ship hard grounding**

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In recent years improved understanding of vessel response subjected to grounding became increasingly critical, primarily because of public concerns over several catastrophic accidents like environmental pollution, vessel capsizes and/or loss of human lives. Nearly 776 cases of ship grounding occur in the Baltic during 2000-2017 according to HELCOM. Owing to lack of practical tools and methods grounding accidents are understood based on limited statistical datasets, probabilistic approach, and deterministic computational crashworthiness methods like those used by the automotive industry (i.e. Non-linear Finite Element Methods). Implementation of goal-based criteria in IMO Safety of Life at Sea has not been possible, because existing methods are computationally expensive and disregards idealization of hydrodynamics, ship operation and seabed evasion. Under EU Horizons 2020 project FLARE (Flooding Accident Response - <https://flare-project.eu/>), we developed a time-domain mathematical model and computational tool for the rapid evaluation of ship grounding dynamics. Model incorporates conventional rudder propeller configuration of a twin-screw ship maneuvering in deep or shallow sea under calm-water/shortwaves and ocean currents. The tool accounts for ship geometry, structural details/arrangements, and rock details. Following crashworthiness analysis, the damage extends, deformation energy, structural forces, ship motions, and evasive maneuvers can be investigated. Our parametric studies demonstrated reasonable comparison against computationally expensive methods. The method significantly reduces computation time from several days to a few seconds. The fluid-structure interaction methods developed push forward the state of the art in ship structural crashworthiness, can help shipyards and operators mitigate risks at early design stages and accordingly suggest risk control options for use in design development. The combination of maneuvering and crashworthiness during grounding may enhance our understanding of the combined effects of structural crashworthiness on goal-based damage stability in design and operations. This is the reason why the proposed model and methods can contribute to shaping up future IMO regulations preserving the safety of life at sea.

**Keywords:** Ship safety, structural crashworthiness, Ship operation, Risk mitigation

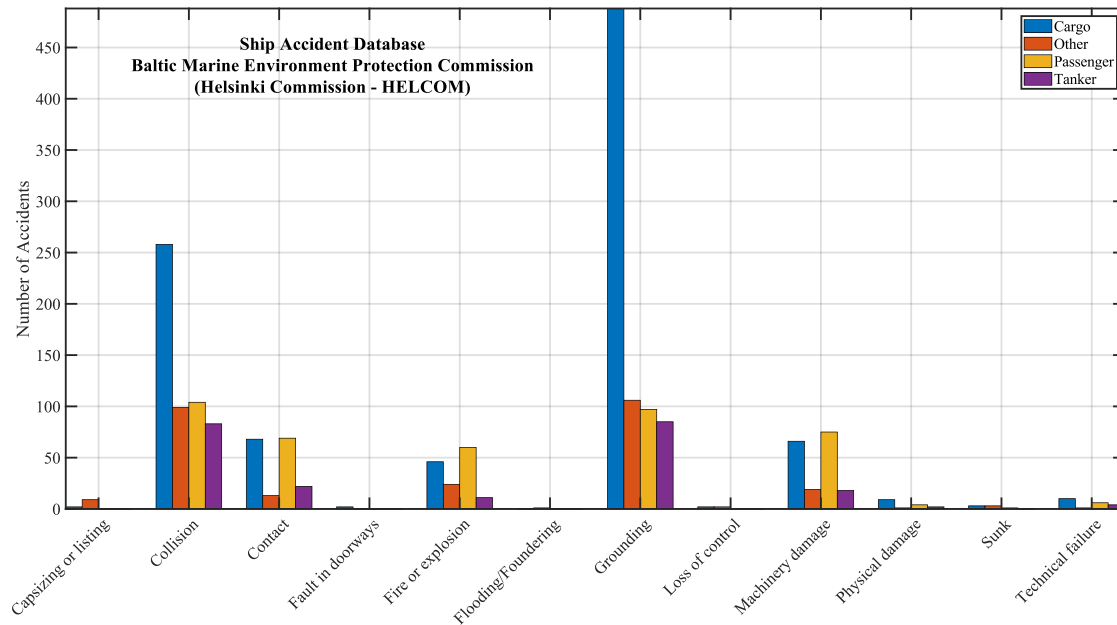


Figure 1. Baltic Sea maritime accidents database.

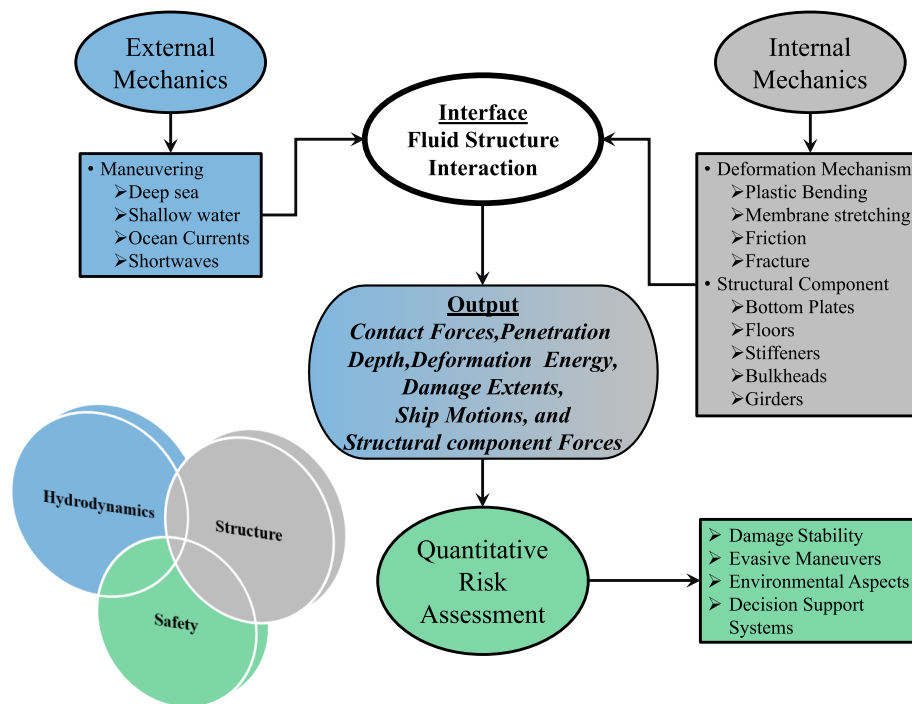


Figure 2. Methodology of a rapid Fluid-structure interaction model for quantitative risk assessment of ship grounding and evasiveness

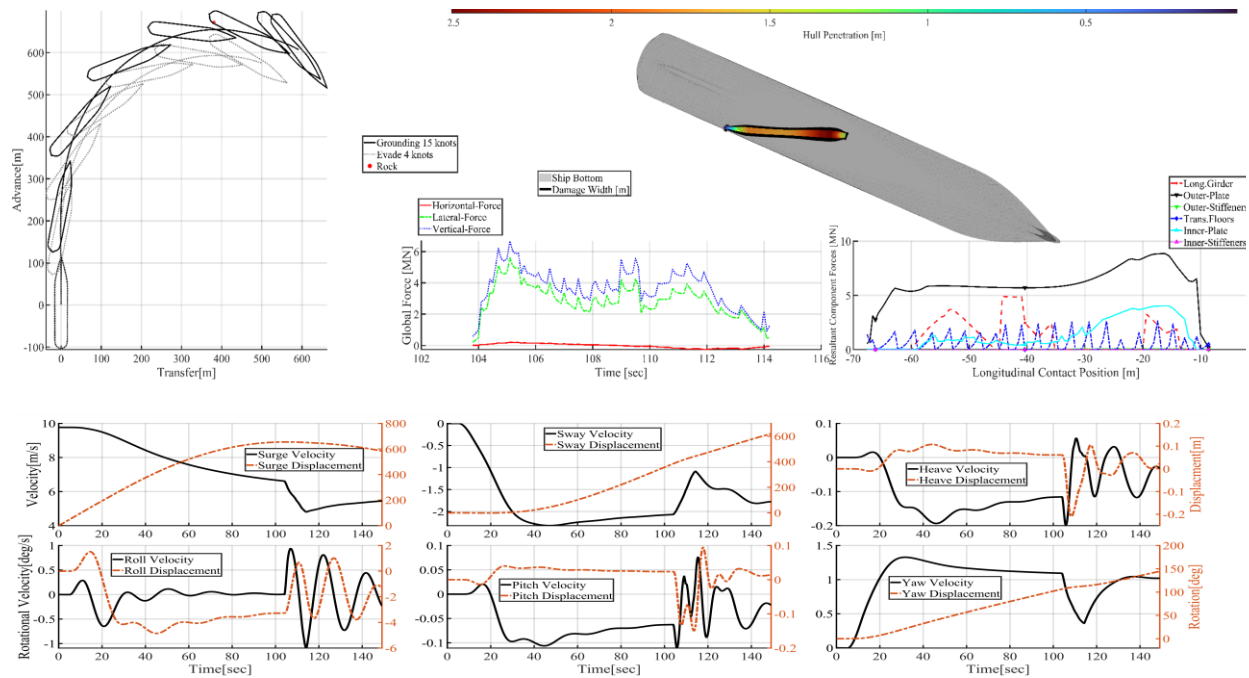


Figure 3. Results of ship operation. Ship turning manoeuvre, representing grounding and evasive action at different speeds. Evasive speed 4 knots and grounding speed 15 knots, both with 35° starboard turn. Top left evasive and grounding trajectory. The remaining plots are of grounding damage extent, resistance forces, and 6-DOF translational and angular ship motion.