ABSTRACT

The subject of this dissertation concerns the safety of maritime transportation with a particular focus on ship collision avoidance problems in encounters with both vessels underway and stationary obstacles. Despite the constant technological development, the automation of the marine industry, and finally the introduction of autonomous ships, maritime accidents of a navigational nature still occur. Moreover, their consequences are usually disastrous for both human life and the marine environment.

The scientific literature offers a large number of solutions proposed to increase the level of navigation safety. Many of them can be used in the case of both ship collision and allision. However, to date, the vast majority of the solutions proposed have some conceptual limitations. These include, for instance, a lack of a link between the proposed safety indicator and an evasive maneuver, omitting ship dynamics, the presence of environmental disturbances, or a lack of consideration of the ship's maneuverability in the collision avoidance process. These disadvantages cause difficulties in the effective utilization of the proposed solution by the navigator, both during routine ship encounters, as well as in close-quarters situations.

To address the identified issues, this dissertation proposes the improved and developed concept of the *Collision Avoidance Dynamic Critical Area* (CADCA) along with the procedure of its determination. The proposed simulation method is based on the geometric solution of the encounter situation and takes into account the physics of objects' motion. This has been achieved, due to the utilization of an external source of ship motion data used as an input to the proposed method of the CADCA determination. The concept of the critical area allows the navigator to obtain direct information about the distance, at which the execution of the last chance maneuver for the set of boundary conditions should be made. Additionally, the utilization of an external ship motion model allowed for reproducing ship maneuvers in various operational and environmental conditions. The proposed solutions make both the proposed CADCA concept and the method of its determination of a utilitarian nature.

The proposed method of determining CADCA was verified through a large simulation study. The obtained results were analyzed with regard to the impact of selected operational (initial ship speed, a magnitude of rudder angle, planned course alteration) and environmental factors (significant

wave height, angle of wave attack), on the size and shape of CADCA. Based on the conducted simulation study, the dynamic nature of the CADCA concept has been proved, as the size and shapes of the areas were significantly affected by the considered simulation parameters. Based on the results obtained, several potential applications of the CADCA concept have been proposed. These include onboard and shore-side solutions dedicated to manned ships, autonomous vessels, as well as vessel traffic services.