In everyday life we commonly observe the oscillatory motions of numerous objects in the surrounding world. The blades of grass sway in the breeze, the pendulum of the clock oscillates around its equilibrium position, the children's swing moves rhythmically up, down and up again. Those motions are forced by external forces, and the observed effects are more or less regular. The same is true of the waves in the water that one can observe while spending time on the beach. When there is a floating object on the waves, for example a ship, it will also move. In general, the motion takes place in six degrees of freedom, i.e., the ship experience linear motions: forward and backward, to the right and left, and up and down, which are called surge, sway and heave. Furthermore, the rotary motions around the longitudinal, transverse and vertical axes coexist. The impact of external forces, in this case caused by the waving sea, will be reflected in the response of the considered ship.

The literature review and centuries of experience of seafarers, naval architects and scientists, reveal that rolling is the most interesting, and also the most important from the point of view of ship safety mode of motion. The rolling ship experiences instantaneously varying angles of heel and the associated accelerations that are an extremely interesting phenomenon in itself. In addition, this phenomenon sometimes has an unexpected impact on the environment and human life, since, due to excessive rolling occasionally seagoing ships accidentally drops containers overboard or pollute sea environment by spilling fuel that can suddenly overflow through the tank vents. For this reason, there is no doubt that scientific research aimed at the best understanding of the ship rolling phenomenon is justified and interesting. Many aspects related to the rolling of ships have been studied through years of research conducted worldwide. However, the occurrences of chaotic rolling have not yet been comprehensively investigated, and there is a limited number of papers published on this subject.

The goal of this scientific project is to significantly expand knowledge on the interdisciplinary borderline of fluid mechanics and solid state mechanics that are, in the context of waterborne transport, aggregated within the framework of the ship theory. The proposed project aims at examining the ship's rolling in conditions of super-resonant excitation, in which a chaotic object response may occur, in particular at high rolling amplitudes. Systematized scientific description of chaotic rolling will expand the existing field of understanding of the phenomena accompanying the motion of a ship when in rough seas. For excitation with sub-resonant frequency, contemporary models describe the observed rolling well. However, for super-resonant excitation frequencies, the results of observations cannot be sufficiently explained on the basis of contemporary knowledge in conditions where the rolling becomes chaotic. The problem to be solved is to study the chaotic rolling and the conditions of its occurrence, both in terms of the characteristics of the object subjected to the roll motion and the excitation characteristics.

The concept of the research includes inducing forced rolling of ship models and recording the response in the form of time series describing the resultant oscillatory motion. The research will be carried out in the model basin at the Gdańsk University of Technology for all test series for zero forward speed. Then, the tests will be run in a large lake reservoir, to perform measurements with non-zero forward speed of the model. This will aim at studying the effect of velocity-induced added masses on rolling characteristics in the context of the chaotic response. For this purpose, at least two ship models on a scale that allows testing in the basin will be designed and built, each of them with a different hull geometry. Then one larger self-propelled and remotely controlled model will be built, for the use during the lake tests. The common feature of the models is the ability to precisely adjust their displacement and moments of inertia. The response time series will be captured by the optical system in the model basin, and with the use of accelerometers and inclinometers in the open water, after their prior calibration in the model basin. Then, the de-noised time series presenting all recorded components of the motions, in particular rolling, will be subjected to frequency-amplitude analysis and correlation to the motion excitation moment. Furthermore, each recorded series will be assessed in terms of meeting the characteristics of chaotic rolling, using a criterion developed for this purpose.

The expected results of the research will allow for the further in depth development of the ship theory by supplementing the description of the ship rolling phenomenon for super-resonant excitation frequencies at large response amplitudes. It is expected that the obtained results will contribute to a more comprehensive description of the ship roll motion, which is currently widely studied, both in linear and non-linear terms, though without focusing on chaotic motions. For sub-resonant excitation frequencies, such chaotic rolling does not occur, while for super-resonant frequencies there is a gap in the contemporary knowledge. The obtained results shall fill this gap. The expected research results may also significantly contribute to the current approach to the ship roll damping, which remains an important field of research within the ship theory. The expected demonstration of the inseparability of damping and the impact of added masses might suggest the need for revision of contemporary damping models, and may also explain the reasons for their observed deficiencies in super-resonant excitation conditions.