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Preface

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In the study of ship dynamics the assumption is often made that excitation and response are related linearly. This has not been very helpful in the efforts to understand the fundamental aspects of ship motions in extreme environments because the assumption of linearity is often inappropriate there. In recent years, however, the tide seems to have changed as the ideas of nonlinear systems have started to enjoy increased popularity among the scientists of the field. The new potential generated has raised hopes for developing deeper knowledge and explanations about various phenomena of instability whose existence has been known for a long time. Perhaps the best-known success story of the application of the nonlinear methodology in ship dynamics concerns the rolling behaviour of ships in waves: significant new insights have been developed about the mechanism of ship *capsize*, the most fearful of all types of ship instability. Yet, the influence of nonlinearity on the dynamic response of a ship is not confined only in the roll direction.

Nonlinearities have also been shown to play an important role in the horizontal- as well as in the vertical-plane dynamics. A number of phenomena of dynamic instability—such as *broaching* (the sudden loss of control that triggers a forced turning motion, often ending with capsize), *surf-riding* (the capture of a ship by a single wave), and *porpoising* (the self-sustained pitching and heaving at high speed)—have been explained as constituting manifestations of some local or global bifurcation. That is, a sudden and often dramatic change in the pattern of the response at a critical value of some parameter of the ship or of its environment. Moreover, *parametric* and *internal resonance* phenomena have now well-established relevance to ship motions; and recently we have also seen growing evidence for *chaotic* ship responses, sometimes robust enough to be reproduced relatively easily in the laboratory.

In spite of these remarkable developments, however, there should be no sense of complacency, as the behaviour of a ship in the ocean can be inextricably complex. The researcher has to deal not only with the intricacies of nonlinear systems but also with the highly intractable nature of the hydrodynamic problem, the existence of couplings and the apparent lack of regularity of the excitations produced in the marine environment. There is no doubt that many theoretical challenges lie ahead, as we are still experiencing the infancy of ship dynamics research. Indeed, it will be many years before a proper methodological framework is established, which would allow all matters to be treated in a coherent and scientifically rigorous manner. However, with concerns about ship safety as compelling as ever, there is a lot to be learned through exploitation of the main strength of nonlinear analysis, namely the ability to capture and explain in simple terms the underlying structures that govern apparently complex processes.

In the announcement for this Theme Issue, we invited contributions for the following areas: ship capsize, broaching, asymmetric large amplitude motions, surf-riding, instabilities at high speed, porpoising, parametric and internal resonances, nonlinear motions with 'water-on-deck', problems of mathematical modelling and sources of nonlinearity, coupling effects, the wave environment and the excitations, computational tools and experimental verification of nonlinear behaviour. We are pleased

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that most of these areas have been addressed in the accepted papers. We hope that the publication of the Theme will make the exciting new developments taking place in the field of nonlinear ship dynamics more easily accessible by the practising naval architects. For this reason we have included an extended overview of the field as an opening article. We hope also that the current Theme will serve as a source of inspiration for further interesting and relevant research.

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