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INFORMATION

From:	General Secretariat of the Council
To:	Working Party on Shipping
Subject:	Preparation of IMO/SDC 12 (London, 19 - 23 January 2026) – Draft information paper by Finland – Any other business – Experiences gained on the use of the Interim Guidelines on the second generation intact stability criteria (MSC.1/Circ.1627) – A recently published study on the simplified operational guidance for parametric roll of large ships

Delegations will find attached a draft information paper by Finland in view of the 12th session of the IMO Sub-Committee on Ship Design and Construction (SDC 12) (agenda item 17).

Finland invites interested Member States to take note of/support the document.

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SUB COMMITTEE ON SHIP DESIGN AND CONSTRUCTION
12th Session
Agenda item 17

SDC 12/INF.XX
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ANY OTHER BUSINESS

Experiences gained on the use of the Interim Guidelines on the second generation intact stability criteria (MSC.1/Circ.1627) – A recently published study on the simplified operational guidance for parametric roll of large ships

Submitted by FINLAND

SUMMARY

Executive summary:	Containers are still lost at sea from ships due to excessive roll motions typically as a consequence of parametric roll resonance. The recently published interim guidelines to the second generation intact stability, MSC.1/Circ.1627, addresses this problem. New or existing ships, even if they would pass the vulnerability check in the interim guideline, may still be vulnerable to this phenomenon in unfavourable conditions. Additional calculations that can predict these potentially dangerous conditions, and guide ships in how to avoid them are therefore valuable. This document shares information on a recently published research study related to a practical methodology for predicting the parametric roll resonance failure mode.
Strategic direction, if applicable:	Not applicable
Output:	Not applicable
Action to be taken:	Paragraph 3
Related documents:	SDC 11/16/1, SDC 10/16, SDC 8/18, MSC 108/INF.7, MSC.1/Circ.1652, MSC.1/Circ.1627

Introduction

1 Recalling the invitation by SDC 8 to report experiences gained on the application of the Interim Guidelines on the application of the second-generation intact stability, and recent submissions on accidents and calculations related to the parametric roll resonance failure mode, this document presents a recently published paper on a methodology for the prediction of the parametric roll resonance failure mode for ships.

Executive summary of the study

2 The study was conducted during 2024-2025 by Aalto University and NAPA Ltd as part of a larger research project. The work includes 6 degrees of freedom (DOF) simulations in waves to validate the proposed methodology. A short summary of the study conducted is presented in the Annex, while a more detailed presentation of the applied method and results have been published in an open access journal article which can be accessed online using the following link: https://doi.org/10.1016/j.oceaneng.2025.121215

Action requested of the Sub-Committee

3 The Sub-Committee is invited to note the information provided.

ANNEX

STUDY ON SIMPLIFIED OPERATIONAL GUIDANCE FOR PARAMETRIC ROLL

Introduction

The instructions in the interim guideline on the second generation intact stability criteria (SGISC), MSC.1/Circ.1627, and its accompanying explanatory notes, MSC.1/Circ.1652, do not lay out detailed instructions for how a simplified operational guidance should be developed for all failure modes. The instructions are more on a general level (MSC.1/Circ.1627):

> *"in principle, any simple conservative estimations for the sailing conditions that should be avoided in each relevant sea state, can be used if they are shown to provide a superior safety level compared to the design assessment requirements"*

In addition, it is subsequently mentioned that the level 1 or level 2 vulnerability criteria can be utilized for this. These level 1 and level 2 checks however do not necessarily by themselves include a speed or heading component that could as such be used to produce these simplified guidelines. Consequently, a study was conducted on how the existing vulnerability check could be extended to allow for it to be used as a function of heading and speed.

Simplified Operational Guidance for Parametric Roll Resonance

The developed approach is based on the assumptions of the level 2 check 2 in SGISC, MSC.1/Circ.1627. In practice, this means that calculations are done in regular longitudinal waves, using the concept of Grim's effective wave, and the steady state roll amplitude is solved numerically from a non-linear differential equation.

For the calculation of ship motions, a hybrid approach is adopted, so that the roll motion is treated as dynamic, whereas the pitch and heave motions are considered quasi-static. This so-called 1.5-DOF (degrees of freedom) method has already been introduced by Bulian et al. (2004). In this study, direct calculation of the righting lever curve, and the corresponding pitch angle and heave motion in static waves is applied. These curves are pre-calculated at different wave crest positions, and the results are interpolated in the time-domain solution of the roll equation.

For the SGISC level 2 check 2 criterion, Grim's effective wave with a wave-length equal to the ship length is used. The height of the effective wave depends on the significant wave height and zero crossing period, and the weight factors for different sea states are obtained from wave statistics. For producing SOG, this concept needs to be extended to also account for the wave encounter direction ($\bar{\chi}$). This wave direction influence on the Grim's effective wave height (H_{eff}) is considered using a method initially suggested by Umeda and Yamakoshi (1993). In addition to the effective wave height, the wave encounter direction also affects the mean wave encounter frequency ($\overline{\omega_e}$), as presented by Sakai et al. (2019).

In the developed SOG method, the stability variation is calculated in a longitudinal wave, based on Grim's effective wave, extended to oblique seas. However, instead of using the dispersion relation, the velocity of the wave along the ship hull is calculated based on the effective wave encounter frequency.

The roll damping coefficients are estimated with the simplified Ikeda's method, as presented in SGISC Explanatory Notes, MSC.1/Circ.1652. Parametric roll is a resonance phenomenon, and therefore, it is crucial that the natural roll period (T_r) is estimated with a good accuracy. Therefore, especially for large ships, the alternative formula to estimate the roll period based on the metacentric height (*GM*) and main dimensions of the ship, presented by Japan in MSC 108/INF.7, is considered more suitable for SOG than the formula in the current IS 2008 Code.

To make results easy to use onboard by the crew, graphical representations, such as polar charts are effective. The procedure for preparing the polar chart data for a given loading condition of the ship in a given sea state is presented in Figure 1. Similarly to the level 2 check 2, only parametric excitation is considered, while direct wave excitation which is important in beam seas, is ignored.

procedure POLARCHART(H_s, T_z, d, GM)
    estimate natural roll period T_r based on GM
    for each mean wave encounter angle $\overline{\chi}$ **do**
        calculate Grim's effective wave height $H_{eff}(H_s, T_z, \overline{\chi})$
        calculate GZ curves at different wave positions along the hull
        for each ship speed V_s **do**
            calculate roll damping coefficients with the simplified Ikeda method
            calculate mean wave encounter frequency $\overline{\omega}_e\left(H_s, T_z, V_s, \overline{\chi}\right)$
            calculate relative wave velocity V_w along hull, from the encounter frequency
            solve steady state roll amplitude
        end for
    end for
end procedure

Figure 1: Procedure for preparing the polar chart data for parametric roll for a ship with draught (d), metacentric height (GM) and natural roll period (T_r) in a sea state with significant wave height (H_s) and zero-crossing period (T_z), adopted from Ruponen et al. (2025).

Detailed results from validating the developed method against experimental data from model tests are presented by Ruponen et al. (2025). The test cases include both regular and irregular waves, in both head and following sea conditions.

Calculation Example

The well-documented accident of the Maersk Essen (DMAIB 2022 and SDC 10/16) is used to demonstrate the presented method for preparing SOG polar charts for parametric roll. The hull form of the ship is not publicly available, so a similar hull form, the DTC (Duisburg Test Case), Moctar et al. (2012), was used instead. The natural roll period of 42.8 s, as specified in the accident investigation report, was used in all calculations.

In order to investigate the applicability of the presented method for generating polar charts for the risk of parametric roll, comparative 6-DOF simulations were done with the LaiDyn code (Matusiak, 2021). A comparison of the maximum roll amplitudes is presented in Table 1. The results from the presented SOG approach are consistent with the direct stability assessment using the 6-DOF LaiDyn simulation code. The measured roll amplitude onboard Maersk Essen was slightly larger, but it should be noted that the simulations in the study were also conducted with a slightly different hull form. A comparison of the simulated time histories for roll and pitch angles are presented in Figure 2. The outcome of the calculation for the DTC hull form and the comparison data from the LaiDyn code is presented as a polar chart in Figure 3. The polar chart shows a good agreement between the results from the two methods used in longitudinal and quartering seas.

Table 1: Comparison of maximum roll amplitudes for the Maersk Essen condition with the DTC hull form.

Measured onboard Maersk Essen	26°
LaiDyn (maximum from 15 h simulation)	24.2°
LaiDyn average of 5 maxima from 3h simulations	22.9°
NAPA (presented new method for SOG)	24.7°

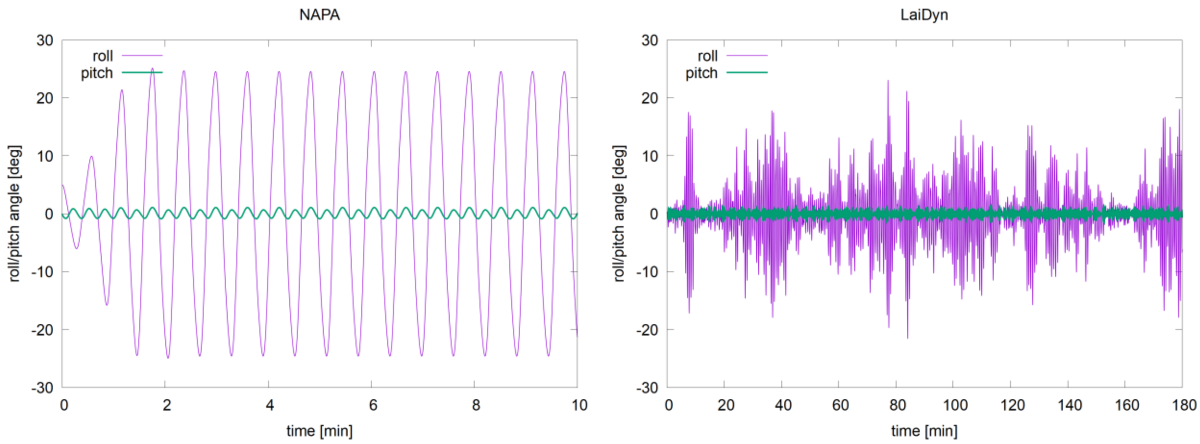

Figure 2: Time histories for roll and pitch angles for the DTC hull form in the Maersk Essen accident condition with the new 1.5-DOF method (NAPA) and with the 6-DOF LaiDyn code, adopted from Ruponen et al. (2025).

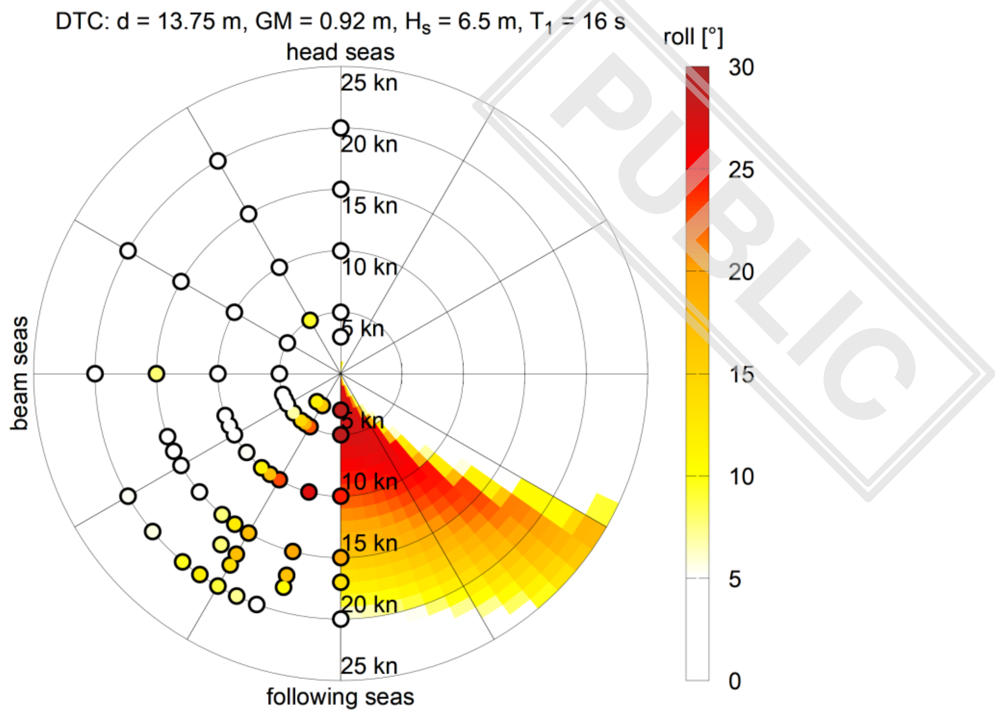

Figure 3: Comparison of parametric roll polar charts with the 6-DOF method in LaiDyn (left side) and 1.5-DOF SOG method in NAPA (right side), showing a high risk of parametric roll in following and stern-quartering seas, adopted from Ruponen et al. (2025).

Conclusions

A new practical method for simplified operational guidance for avoiding parametric roll has been developed, based on the SGISC level 2 check 2 method, with extensions to properly consider also oblique seas. The results can be presented graphically for easy use by the crew onboard.

The methodology was compared against 6-DOF simulations in waves using the LaiDyn code, and showed good agreement in conditions with parametric roll. The calculations are relatively fast to perform and therefore suitable for simplified operational guidance use.

It is noted that the presented approach considers only parametric roll excitation (in longitudinal or quartering seas), whereas direct wave excitation, which is dominant in beam seas conditions, is ignored. This means that the polar charts only indicate a risk of parametric roll, not excessive roll motion in general. Furthermore, the research has focused on large container ships, and in the future, the presented method should be validated also for smaller vessels.

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