INTERNATIONAL MARITIME ORGANIZATION

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MARITIME SAFETY COMMITTEE
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Agenda item 18

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ANY OTHER BUSINESS

Update on the progress of the MARIN Top Tier Joint Industry Project (JIP) on securing container safety

Submitted by Australia, Denmark, Germany, Netherlands, Singapore, IUMI and WSC

SUMMARY

Executive summary:	The document informs the Committee of the progress of the TopTier JIP on securing container safety and draws attention to a Notice to Mariners produced by the JIP.
Strategic direction, if applicable:	4
Output:	4.4
Action to be taken:	Paragraph 31
Related documents:	MSC 104/17/4 and CCC 8/11

Introduction

1 Recent incidents with modern large container vessels operated by reputable shipping companies suggest that the existing cargo stowage and securing approach does not sufficiently cover the relevant aspects for the newest classes of ultra large container ships. Container cargo is planned to maximum safe allowable loads and there is limited redundancy and margins for error and uncertainty. A better understanding of the operations, physics and hazards is necessary.

2 The Maritime Research Institute Netherlands (MARIN) set up the Top Tier Joint Industry Project (JIP) on securing container safety. The project is a follow-up of the earlier Lashing@Sea JIP that addressed cargo securing safety in the period of 2006-2009. The initiative responds to changes in container shipping practice over the past decade, and reported incidents involving losses of containers overboard, for example as outlined in document MSC 104/17/4 (Australia et al). The project began in May 2021 and will run for three years.

3 The primary objectives of the JIP are to identify and recommend improvements for transport, stowing and securing containers and related matters, and provide the technical understanding that is needed for safe designs and innovations into the future. Top Tier addresses these objectives together with a wide consortium of stakeholders from both the

shipping industry and authorities responsible for overall safety to ensure the required expertise and to achieve leverage for acceptance of findings. Industry wide uptake of findings and recommendations is sought by cooperating with high-level bodies as WSC, IMO, IACS, and ISO through submitting results and requesting follow-up actions. Annex 1 contains the project information leaflet in addition to the following link:
https://www.marin.nl/en/jips/toptier#downloads

Status

4 The TopTier project started in 2021 with the initial focus being on bringing together an industry wide consortium to support and conduct the project. By mid-2022, the project is supported by 40 participants including three national authorities, 10 major carriers, seven class societies, and five lashing manufacturers. In addition to the following link, annex 2 contains a list of participants: https://www.marin.nl/en/jips/toptier

5 Phase 1 reviewed current practice and incidents and identified gaps. Multiple well attended meetings took place and three reports were submitted for review:

.1 review current practice;

.2 review of container loss incidents; and

.3 gap analysis in container cargo securing.

6 Phase 1 was concluded with three early deliverables to alert mariners to the particular phenomena of parametric roll in following seas conditions after having noted that:

.1 multiple incidents with high profile container losses during winter 2021 could be explained by parametric roll in a following sea condition;

.2 container ships are more vulnerable/exposed to this phenomenon at present because of low GM in full laden conditions and low speeds in relation to port congestion; and

.3 parametric roll in following seas is less known than the head seas version and thus might occur without crews being aware of any pending or raising threat.

7 A Notice to Mariners titled "Beware of parametric rolling in following seas", was published in January 2022. A two-page document to highlight the particular phenomena, suggests how to recognize tell-tale conditions and take mitigating actions. The Notice was circulated around the world fleet to have immediate effect and can be accessed from https://www.marin.nl/en/jips/toptier#notice. Annex 3 contains a copy of the Notice to Mariners.

8 An Excel tool to assist crews in the interpretation of wave conditions with respect to hazard for parametric rolling conditions before the actual onset of large motions can also be accessed from https://www.marin.nl/en/jips/toptier#notice. Annex 4 contains an example of the tool workings.

9 A video to illustrate the specific characteristics of parametric rolling in following seas conditions can also be accessed from https://www.marin.nl/en/jips/toptier.

10 By mid-2022, work has shifted to phase 2 of the project. Six working groups are undertaking detailed technical research and investigations. The working groups contribute to the overall project goal with targets that are complementary. The outputs will be combined into practical safety improvements during phase 3 of the project.

11 The scope of work in phase 2 is aiming at six different aspects, each addressed in a separate working group:

.1 true strength limits and safe (design) working loads for lashings and container gear;

.2 effects of reliability/uncertainty in planning and loading process information;

.3 extreme motion and acceleration design values, and avoiding off design conditions;

.4 reliability/uncertainty of cargo securing load planning calculations;

.5 maximizing human factor performance by raising awareness and decision support; and

.6 review of regulatory framework and how to integrate recommended good practice.

12 The contributions of these working groups are intended to improve the understanding of different aspects of the problem and to reduce uncertainty. In phase 3 of the project the findings of these efforts will be combined to identify and verify a clear "safety criterion" for container cargo stowage and securing. Such a safety indicator will serve as a guideline to ensure a minimum safety level. Its development should be transparent and auditable to ensure that constraints used in the planning calculations are matched in operational practice. Presently a harmonized approach for that purpose does not exist.

13 An outline of work plans for each working group in the JIP are summarized below.

Working Group 1 – Limits and safety margins

14 Stow planning for container cargo aims to maximize intake with the constraint of ship stability, and the expected securing loads to stay inside safe working limits of ships own lashing gear and ISO rated container frames. At present the age or condition of lashing gear and containers is not accounted for in these safe working loads. Working Group 1 will review the true limits of containers and lashing gear as function of time, wear and tear. The objective of Working Group 1 is to develop a validated numerical model to determine the sensitivity of limit state load cases of different age equipment. This will allow assessment of existing safety factors as a function of the equipment design and age.

Working Group 2 – Reducing uncertainty of process input information

15 Container cargo intake is planned and maximized to safe working loads under the assumption that the input data is accurate. The objective of Working Group 2, is to determine uncertainty and impact raised by the container / planning / ship / terminal process "as is" and to make recommendations for improvements. Variation between the on "deck" and "stow planned" container configuration was surveyed on six vessels. It is found that a significant percentage of containers are not stowed at their designated positions. The impact of these mis-stows on actual loads and safety will be determined.

16 Action points that have yet to be scheduled pertain to:

.1 evaluate/confirm the positive effect of mandatory VGM requirements;

.2 review ISO standards on container ID codes, load ratings;

.3 consider options to streamline data flow between container data bases, carrier and terminal planners, the vessel and the terminal; and

.4 examine compliance of lashing gear and containers to existing condition standards.

Working Group 3 – In and out of design motions

17 Load planning is done for "in design" extreme motions and accelerations which implies that worse case "off design" conditions are to be avoided by operational decisions. Working Group 3 addresses how to define "in design" motions and accelerations and validates if and how "off design" conditions can realistically be avoided. Outputs will include recommendations for objective and reliable decision parameters and algorithms.

18 On board measurements are used to determine the nature and character of different loading mechanisms on board such as rigid body motions, effects of hull girder deflections such as whipping, springing and hatch cover motions. The extrapolation of quantitative design values requires dedicated desk, and model test research.

19 Numerical calculations are being undertaken and seakeeping model tests were performed to determine the sensitivity of a 10,000 TEU container vessel for extreme roll motions under varying loading conditions. In particular parametric roll in following sea conditions was found to have unexpected impact at low GM. This triggered the drafting of a notice to mariners to raise attention on this phenomenon. Focus is on the validation of tools (frequency domain for resonant roll, time domain for parametric roll and Computational Fluid Dynamics (CFD) for roll damping). Interaction with Second Generation Intact Stability Criteria (SCISC) vulnerability criteria (level 1 to 3) will be assessed here. Thereafter, voyage simulations including rerouting will be done to identify in/off design behaviour.

20 In the fall of 2022, a representative 15,000 TEU vessel will be chosen for which the same calculation scope is anticipated. Seakeeping model tests for this vessel are scheduled in early 2023, to validate the calculations and address remaining questions on off-design behaviour such as stability loss. For the moment the tests will be done with a rigid model.

Working Group 4 – Cargo securing load calculations

21 The objective of Working Group 4 is to verify the performance of securing load calculation algorithms used in the stow planning stage. A model test program is scheduled to provide a reference data set in controlled conditions for comparison against the numerical models. The model tests are designed to match a realistic configuration as far as possible to allow direct comparison.

22 A 1:6 container stack scale model is engineered with realistic container stiffness, strength, cargo weight, lashing and twist lock representation. Benchmark tests will be conducted on an earthquake simulator facility in Japan.

23 Class societies in the project are invited to submit securing load predictions using production lashing arrangement solvers as used in stow planning. The variation between the various predictions and the benchmark tests will be used to review the existing safety margins and understand/confirm the physics that dominate stack forces.

24 First milestones are initial tests with a single row to take place in early September 2022. A second period with tests on three adjacent rows is planned towards the end of 2022 to investigate the effect of multi row (dynamic) behaviour in relation to single row behaviour.

Working Group 5 – Operational decisions & human factors

25 The objective of Working Group 5 is to document whether there is a need for specific additional information to assist operational decision making, outline the nature of that information, recommend options to convey it intuitively to operators, and validate if such can be accepted on board and whether it improves safety by means of a demonstrator.

26 Feedback was obtained from crew questionnaires. 1000+ responses were received both for "prior to departure" and "in transit conditions" surveys. The findings substantiate the concerns on board about; controllability of the loading process, condition of containers and lashing equipment, limited feedback and awareness for actual loads and allowable limits at sea, difficulty to choose options when motions are high and outside view on waves is limited (at night from bridge at +50 m elevation).

27 Further efforts will be aimed at recommending the type of additional data needed, the options to convey that to operators, and working out how to demonstrate the merits of the additional data as needed to substantiate recommendations regarding such solutions.

Working Group 6 – Regulatory Framework

28 Working Group 6 is analysing the reported gaps in the current practice, and the actions and expected timeline of delivery of the JIP results with the objective to raise attention for the future project findings and to get feedback and support at an early stage, where possible and appropriate.

29 Working group discussions are centred around main questions, i.e. what aspects need to be improved and how to bring about changes. The central question is how to deal with the increasing complexity in container cargo securing and agree on an approach to reduce uncertainties on the input side and maximize certainty of the operational procedures to stay inside an acceptable minimum safety envelope.

30 Key points coming forward in working group sessions are container and gear maintenance schemes / compliance codes to existing standards, validity of minimal standards (ISO), training, and (re)distribution of responsibilities in relation to the complexity of the container planning, loading and transport chain. A communications plan is in preparation to run along the duration of the project to publish expected findings and recommendations to the industry and regulatory entities.

Action requested of the Committee

31 The Committee is invited to note the information provided.

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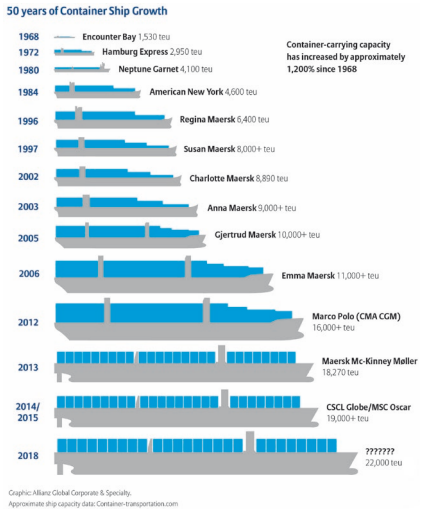
TopTier Joint Industry Project

Securing container cargo safety

Container transport is essential for modern world economy. Although incident rates are percentage wise extremely low, the absolute numbers are too high. Annually around 1,000 containers are lost to sea and multiple lives are lost in cargo handling operations. Severe damages to coastal marine environments have raised a public and political concern about the safety and environmental impact of modern container ships. Both politics and industry are urged by the press to act on uncertainties in container securing. Joint Industry Project TopTier is initiated to lower the probability of loss of containers at sea, working together with a wide consortium of stakeholders.

Pollution in sensitive areas due to loss of containers (photo: ANP)



Increase in container ship size over the years (from: worldshipping.org)

Background

Container lines strive for economic operations by maximizing efficiency inside playing field boundaries for safety as defined by (flag state) administrations and class societies. Unsafe situations occur if these boundaries are too low, if they are not respected, or if process uncertainties have so much impact that assumed safety margins are insufficient.

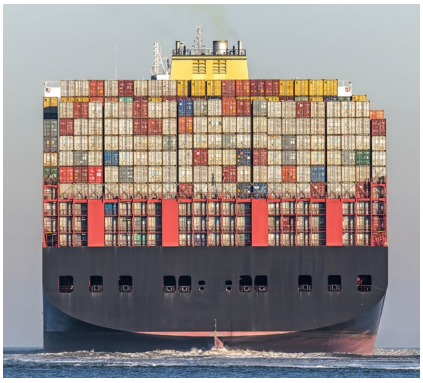
Limited experience with new ship sizes, their operating conditions and loading mechanisms in the case of extreme events, increased such uncertainties. Investigation into recent incidents (OVV report June 2020) suggest that present-day limits do not sufficiently cover all factors in play for the newest classes of ultra large container ships. A better understanding of these conditions and the working mechanisms is therefore necessary.

MARIN organised the Joint Industry Project Lashing@Sea (2006 - 2009) with wide consortium from shipping industry and flag state administrations worked together to review the current practice and hazards to the container shipping sector at that time. Many process uncertainties were identified and recommendations for improvements were formulated and submitted to IMO.

Now, ten years later, part of these recommendations are implemented, but some uncertainties still remain. Vessel dimensions in the meantime have increased from around 10 kTEU to 20+ kTEU. A series of recent incidents suggest that scale effects and increased economic pressure may have strained practice beyond safe boundaries.

Stakeholders:

- Ship operators
- Flag state administrations
- Coastal state representatives
- Class societies
- P&I clubs
- Lashing gear manufacturers
- Port and terminal operators
- Workers representatives, ILO
- Port authorities
- On board system developers
- Independent research institutes



Present-day ULCC (from: fleetmon.com)

Open for participation

A first meeting is scheduled for September 2020 to discuss the project plan. All stakeholders are invited to participate and contribute Please inform us of your interest.

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Objective

The Joint Industry Project 'TopTier' is defined to follow up on Lashing@Sea. The objective is to lower the probability of loss of containers at sea. The project will identify and recommend improvements for the coming decade that are supported by both shipping industry and authorities responsible for overall safety. As such, the project contributes to a safe and level playing field.

TopTier is organised as a Joint Industry Project to ensure wide representation and combine sufficient experience and capabilities, as needed to create an effective impact of project findings. Results and costs will be shared with all participants.

Scope of work

The TopTier JIP is structured in five tasks. The first task will identify the anno 2020 most relevant aspects in cargo stowage and securing on containerships by means of review of current practice through interviews and questionnaires with e.g. shipping lines, ship crews, terminal workers, surveyors and P&I.

The second task will focus on how to deal with current practice cargo securing design values and probabilities from the regulators point of view. This requires a large reference base line set of ship motion statistics as function of size, load condition and wave condition. A simple setup will be developed and installed on a series of ships to collect these data from in service measurements. This will enable class societies to relate their ship rules to a shared and agreed reference. The working group together will use the data to define an approach how coastal safety requirements can be related to class rule individual ship safety requirements and vice versa.

In the third task, the fidelity of cargo securing design practice is improved by including presently unaccounted effects. In particular the dynamics of high tier container stows under dynamic loads from ship motions and flexible hull deformations by whipping, springing and in particular horizontal bending and torsion. These effects will be investigated by a combination of in-service measurements, model tests and numerical studies.

The fourth task aims to increase awareness and proactive abilities of ship crews and stow planning departments in their role to prevent incidents by not exceeding (presently mostly invisible) maximum safe operation limits. Aspects to be included are; feedback on actual operating conditions in comparison to used design values; likelihood and occurrence of extreme motions, parametric roll, loss of stability and green water damages; and stow optimisations taking into account effects of offloading along the voyage on GM, and dynamic row interactions due to unfavourable weight distributions.

The outcome of the project will be brought to the attention of relevant authorities as IMO, ILO in order to aim for top down implementation for a continued level and safe playing field both at sea and on shore.

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ANNEX 2

TOP TIER PARTICIPANTS

Flag States

Australia Germany Netherlands

Recognised Organisations

American Bureau of Shipping
Bureau Veritas
Lloyds Register
Nippon Kaiji Kyokai
Korean Register
Det Norske Veritas
China Classification Society

Non-Governmental Organisations

World Shipping Council (WSC)
International Group of P & I Clubs
Hamburg University of Technology (MUHH)
German Insurance Association (GDV)
Bureau International des Containers (BIC)
Monohakobi Technology Institute
China Ship Scientific Research Centre (CSSRC)

Industry Participants

Maersk
Evergreen
CMA-CGM
Nippon Yusen Kabushiki Kaisha (NYK)
German Lashing
SEC Container Securing
RADAC Wave monitoring
GBMS
DTN
NSY
Mediterranean Shipping Company (MSC)
Hapag- Lloyd
Ocean Network Express (ONE)
Macgregor
LOX Container Technology
Samsung Heavy Industries
NAVIS
TNO
ABB

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Notice to Mariners

Beware of parametric rolling in following seas

A series of incidents with exceptional container losses occurred during the winter season 2020-2021. The TopTier project was put in place by industry to find ways to avoid similar incidents in the future, and initial results show that parametric rolling in following seas was especially hazardous. This notice describes how container vessel crew and operational staff can plan, recognize and act to prevent parametric rolling in following seas.

Hazard & rationale

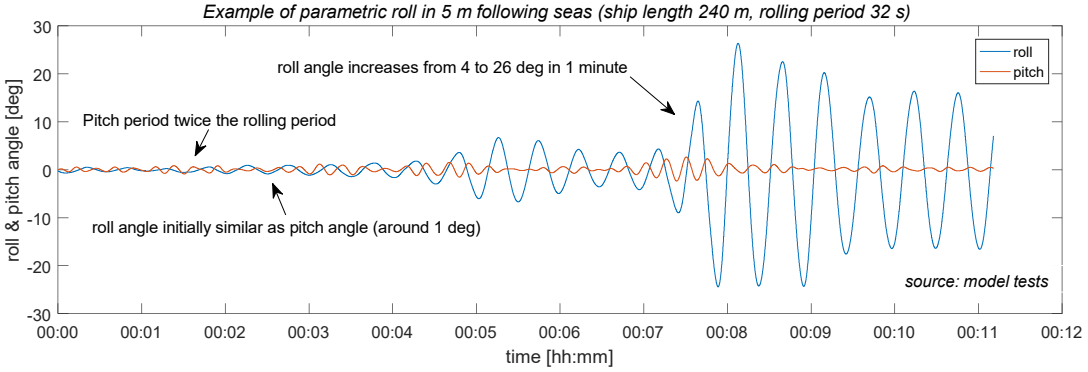
Container ships are also vulnerable to parametric rolling in following sea conditions. Unfavourable combinations of rolling period, vessel speed, heading, and wave conditions, can trigger sudden and extremely rapid increase of roll motions to hazardous levels, threatening the safety of vessel, crew and cargo. This can happen in relatively mild wave heights.

What is parametric rolling?

Parametric rolling can occur when:

- The rolling period is twice the wave encounter period
- Wave lengths are in the range of the vessel length

In these conditions the passing waves cause a variation in waterplane area that can trigger vessel instability in roll. This is most common in heavy head seas, but can occur also in following seas, when the rolling period is long. Even a few high waves after each other may trigger unexpected large roll motions, as shown by the measured time traces of roll and pitch motions in the figure below. In the example, the ship is 240m long with a natural roll period of 32s and is sailing in a 5m following sea.



When to be alert?

Ships at low GM are vulnerable to parametric rolling in following seas, especially when there are waves with a long length from the stern quarter. Long term routing and short term vessel handling should consider the risk of parametric rolling in following seas when:

- Vessel rolling period is long because of low GM (rolling periods in excess of 20s for ships with length above 250m). The rolling period should be measured after departure, as rules of thumb based on GM are not always accurate.
- Following sea conditions (or close to) are expected or experienced.
- The rolling period is twice the wave encounter period. The wave encounter period is equal to the pitching period and can be measured with a stopwatch.
- Wave lengths are longer than two-thirds of the ship length.

The combination of above conditions should be avoided already in route planning by calculating the wave encounter period and wave length using the vessel speed, the forecasted wind and swell wave periods and direction (see next page for details).

How to recognize the first signs or increasing risk?

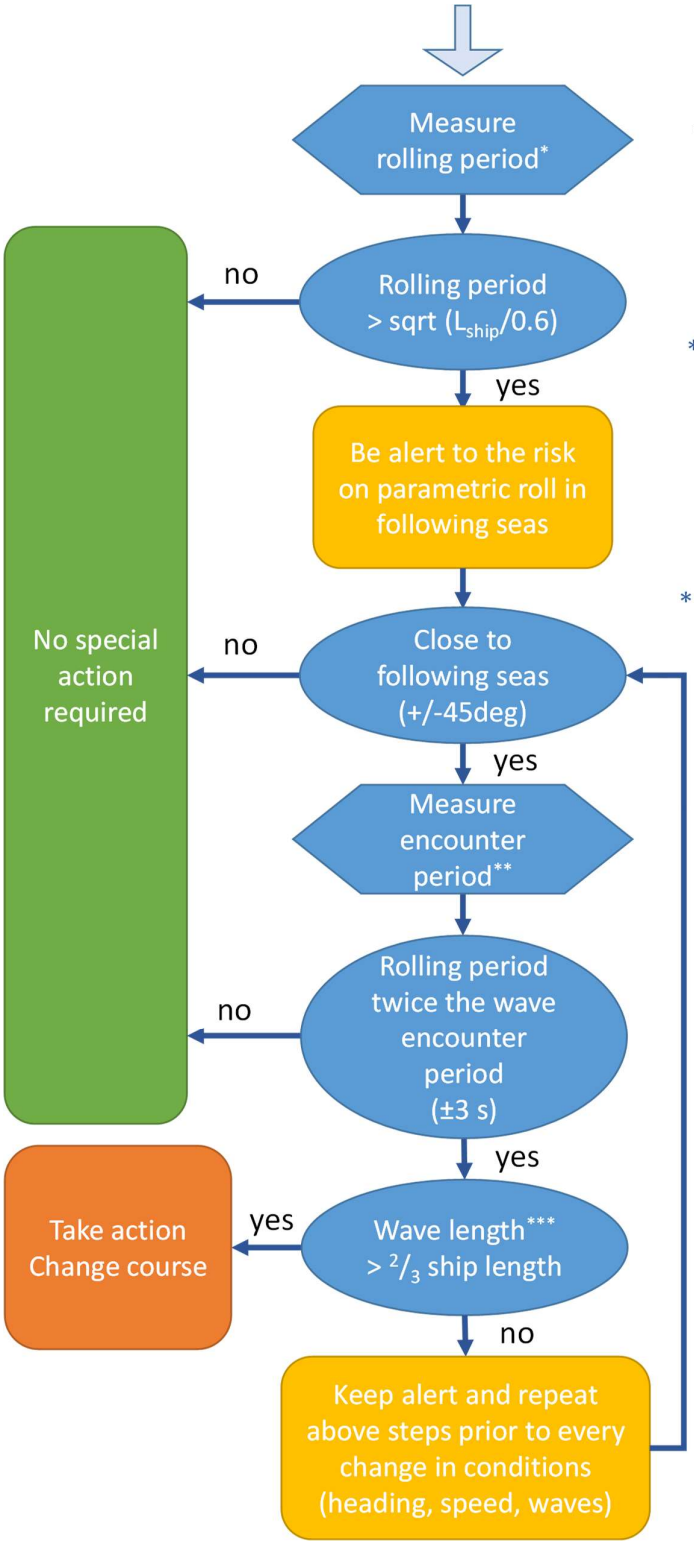
A vessel can go into parametric rolling very suddenly and unexpectedly. To prevent it, crew should therefore learn to recognize the conditions and danger signs at an early stage. Tell-tale behaviour is the synchronisation between the gentle roll and pitch motions as waves pass underneath, especially when the vessel starts rolling alternatingly from port onto starboard shoulder in perfect sync with successive pitching cycles. This indicates that wave encounter periods are close to half of the roll period and in this condition parametric rolling can happen at any time if waves are high enough.

What to do when it happens?

Break the synchronization between the roll period and the encounter period. The most direct way to do this is to change heading to beam or bow quartering seas. Avoid abrupt steering. The heading change can be combined with a speed increase but only if it does not increase the risk of other hazards. Changing course may seem counterintuitive but is the only way to reduce the risk of parametric rolling in following seas.

This notice to mariners in an initiative of the TopTier JIP. The Joint Industry Project TopTier is initiated to address the loss of containers with active participation of major stakeholders. More explicit guidance on the hazard of parametric rolling in following seas is work in progress. For more information https://www.marin.nl/en/jips/toptier

When to be alert on parametric rolling in following seas?

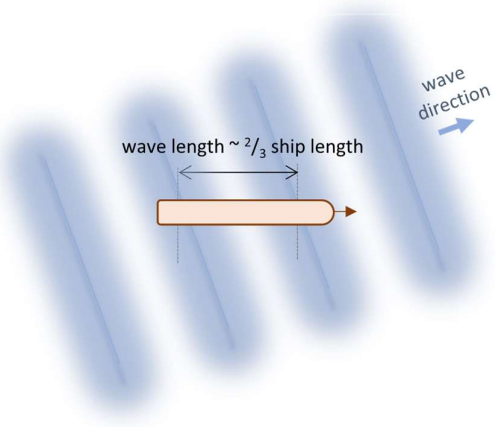


*) Measure roll period:
Use a stopwatch to measure the time of 10 complete roll motion, divide measured time by 10.

**) Measure wave encounter period:
Use a stopwatch to measure the time of 10 complete pitch motions, divide measured time by 10

***) Estimate the wavelength:

The wave length can be estimated in comparison with the ship length.



= measurement / calculation
= decision point
= notice / alert

Calculating the rolling period

An accurate assessment of the rolling period is preferred but may not yet be available during voyage preparation. In that case, you can use the formula below, adding an estimate for the encounter period and wave length.

$$T_{roll} = \frac{0.86B}{\sqrt{GM_{fluid}}} \qquad T_e = \frac{3T_w^{\,2}}{3T_w + V\cos(\alpha)} \qquad L_w = \frac{1.56T_w^{\,2}}{\mathrm{abs}(\cos(\alpha))}$$

Where:

T_{roll}	=	Estimated rolling period of ship in [seconds]
B	=	Beam of ship in [meter]
GM_{fluid}	=	Transverse stability including free surface correction in [meter]
L_w	=	Wave length in [meter]
L_{ship}	=	Ship length [meter]
T_w	=	Wave period in [seconds]
α	=	Ship fixed wave direction (α=0° means head seas) in [degrees]
T_e	=	Wave encounter period in [seconds]
V	=	Ship speed in [knots]
abs	=	Absolute value
sqrt	=	Square root

* * *

ANNEX 4

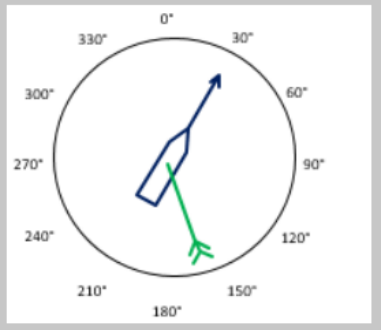
ROLL RISK ESTIMATOR

Introduction

Below is an example of a vessel 310 m long, doing 10 knots following a course of 030 degrees. The wave direction is from 160 degrees, with a mean wave period of 10.5 seconds.

Input *V1.1 (28 July 2022)*

Vessel length in [meter]	310
Roll period in [seconds] or enter	34
Uncertainty in roll or wave period [seconds]	3
Vessel speed in [knots]	10
Course of ship in [degrees]	30
Wave direction in [degrees]	160
Mean wave period in [seconds] **or enter**	10.5
Wave encounter period in [seconds] **and** Effective wave length in [meter]	

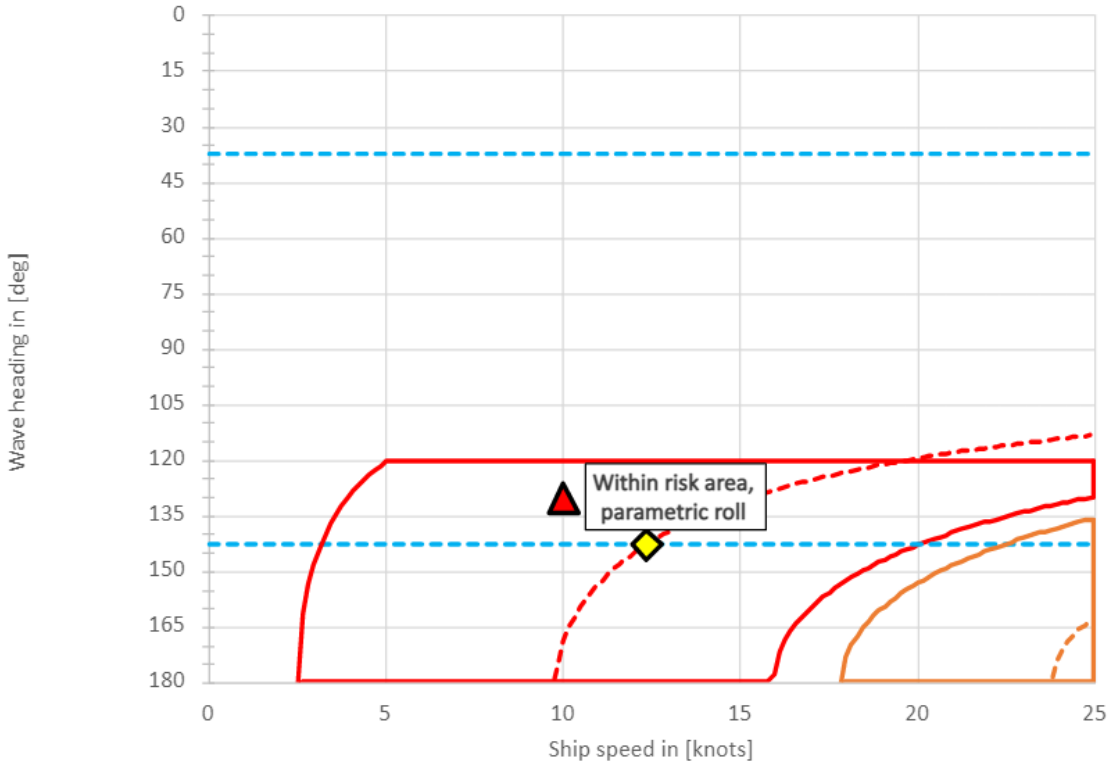


Risk evaluation*

Risk on resonant roll	No
Risk parametric roll in (close to) head seas	No
Risk parametric roll in (close to) following seas	Yes

Results

Ship fixed wave direction in [degrees]	130	Effective wave length in [meter]	384
Peak wave period in seconds	12.6	Rolling period / Encounter period ratio	2.2
Wave encounter period in [seconds]	15.2	Wave length / Ship length ratio	1.2



** Note that the purpose of this sheet is to provide information and assistance in addition to MSC.1/Circ.1228 and other guidelines/rules for the safe operation of ships. It indicates combinations of speed, heading and wave period that result in unfavourable tuning of roll motions that should be avoided. It does not give indication of the maximum roll motion and at which wave height the vessel is vulnerable to adverse rolling must be judged by the master's experience. In addition it does not address other dangerous ship behaviour like e.g. large vertical accelerations, shipping green water and slamming*

*** When the present condition is inside the red risk area for parametric roll or the orange risk area for resonant roll,* ***A direct but gradual change of heading (and/or speed) is strongly advised to get outside the risk area.***

**** The closer the present condition to the yellow point, the higher the risk on parametric roll*

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