Group Discussion B.2: IMO Standards and ITTC (Particularly related to Manoeuvring and Capsizing)

Group Discussion Chair: Dr. Masayoshi Hirano (Mitsui Akishima Lab.)

SUMMARY

by Masayoshi Hirano
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Scope

Regarding a possible role of ITTC at IMO, an application of consultative status to IMO to provide well-found technical advice has been discussed and recommended at the past ITTCs, namely for the manoeuvring at 20th and for the stability at 22nd ITTC.

Recently a trend can be seen at IMO towards the adoption of performance-based standards, such as Manoeuvring Standards (IMO A.751(18)) and Stockholm Agreement (IMO'95. Res. 14), in addition to (or instead of) the existing prescriptive regulations which have so far been developed basically on the basis of statistical data. This may be due to demands of more rational and more sophisticated standards applicable to wider range of ship types. It is anticipated that the role of ITTC to IMO standards is becoming much more important, because numerical simulations, physical model testing and full scale trials as well are required for the performance-based standards to demonstrate adequate performance.

In this context, the scope of the Group Discussion is to discuss relevant issues between ITTC and IMO focusing on the performance-based standards. The discussions are made mainly on the following two topics.

1. Role of ITTC as consultative status at IMO.
2. Role of ITTC in carrying out tankery work with respect to the performance-based standards.

Discussions

At IMO, issues for the manoeuvrability have been dealt with in the D&E Sub-Committee of MSC, and the concept of performance-based criteria has been introduced in the first place in the development of Manoeuvring Standards. The Standards will be mandatory from the year 2003 after 10 years interim period; during that time extensive reviews have been made in the D&E Sub-Committee. Issues for the capsizing have been dealt with in the SLF Sub-Committee of MSC at IMO. Many efforts have currently been made by the performance-based approaches with respect to such issues as the revision of ILLC, the revision of Intact Stability Code and Harmonization of Damage Stability Requirements.

Focusing on the current activities for the development of standards in both area of manoeuvring and capsizing at IMO where the performance-based criteria are to be based upon, the role of ITTC as a world-wide scientific body on the basis of physics to the IMO Standards was keenly discussed in the Group Discussion session by keynote speakers and discussers from floor as well as seen in the attached written contributions. In addition, the role of ITTC in carrying out tankery work was also extensively discussed.

As for Manoeuvring Standards, the development of procedures for the following three points may be very important issues for the mandatory application of the Standards, namely manoeuvring prediction at the initial design stage, correction of loading condition to the manoeuvrability in the sea trial and correction of external disturbances to the manoeuvrability also in the sea trial.

In the area of capsizing, physical model test has already been required for Stockholm Agreement, and very recently “Interim Guidelines for the conduct of high-speed craft model tests” (MSC/Circ. 1029) was approved in the MSC. It may also be important issues to develop and revise (if necessary) procedures for numerical simulations and model testing for these standards or guidelines for the capsizing. Thus the role of ITTC member organization in carrying out tankery work regarding IMO standards will largely be increased in near future.

Concluding remarks

Active and fruitful discussions were made in the Group Discussion session on various aspects of the relevant issues between IMO Standards and ITTC as seen in the attached written contributions, where about 70 participants attended in spite of small area of the meeting room. Conclusions obtained through the Discussion may be summarized as follows.

1. ITTC as a world-wide scientific body on the basis of physics could provide well-established technical support to IMO with respect to the performance-based standards.
2. It is recommended that discussions should be started in the governing level of structure of ITTC regarding the application of consultative status to IMO, while possible ways to satisfy the clause referring to “permanent headquarters” of ITTC should be considered (ref. the written contribution by Mr. M. Palomares of IMO).
3. Tankery work such as numerical simulations, physical model testing and in addition full scale trials should be essential tools for designed ships to meet the performance-based standards. The role of ITTC member organization in carrying out tankery work regarding IMO standards is becoming much more important than ever, and it is recommended that procedures or guidelines for the tankery work mentioned above should be developed and formulated.

LIST OF ATTACHED DOCUMENTS

[1] Dr. D. Clark: IMO Standards and ITTC. [*paper* and *slides*]

[2] Prof. K. Kijima: On some Problems in the Interim Standards on Ship Manoeuvrability in IMO. [*paper* and *slides*]

[3] Dr. J.-O. de Kat: IMO and ITTC, Safety against Capsizing and Foundering of (intact) Ships in a Seaway. [*slides*]

[4] Prof. D. Vassalos: IMO and ITTC, Damaged Stability and Survivability. [*paper* and *slides*]

[5] Mr. M. Palomares: Comments on the role of ITTC vis-à-vis IMO. [*paper*]

[6] Mr. P. Perdon: Some Thoughts about IMO Standards. [*slides*]

[7] Prof. K.-P. Rhee: On the Yaw-checking and Course-keeping Ability of IMO Standards. [*paper* and *slides*]

[8] Prof. Y. Yoshimura: Ship Manoeuvrability Standards and Role of ITTC. [*paper*]

[9] Dr. J.B. Petersen: IMO Standards and ITTC, Opinions on the IMO Res. 751 manoeuvrability criteria. [*slides*]

[10] Prof. M. Vantorre: Potential role of ITTC regarding IMO Manoeuvring Standards. [*paper*]

[11] Dr. J.J. Blok: Contribution to IMO Standards and ITTC (Manoeuvring). [*paper*]

[12] Prof. N. Umeda: What should ITTC do for review of IMO Intact Stability Code? [*paper*]

[13] Prof. Y. Ikeda: How ITTC can contribute to IMO works? [*paper*]

[14] Prof. G.F. Clauss, Mr. J. Hennig, Mr. H. Cramer: Evaluation of Capsizing Risk by Deterministic Analysis of Extreme Roll Motions. [*paper* and *slides*]

[15] Mr. D. Molyneux: Discussion to IMO Standards and ITTC. [*paper* and *slides*]

[16] Dr. J.B. Petersen: Validation Procedure for Manoeuvring Simulation Models. [*slides*]

[17] Dr. M.R. Renilson: Use of Simulation Codes for Regulations. [*slides*]

<u>IMO Standards and the ITTC</u>

by
Dr. David Clarke,
University of Newcastle upon Tyne,
United Kingdom.

ITTC Group Discussion, Venice, Italy.
Tuesday 10th September 2002.

Introduction

Good afternoon Ladies and Gentlemen, my name is Dr. David Clarke from the University of Newcastle upon Tyne, in the United Kingdom. I have been asked to lead off this Group Discussion Session on IMO Standards and the ITTC. Then Professor Katsuro Kijima will add some thoughts on revision of the Criteria and where we can go from here. Our credentials for carrying out this task are quite simply that we have both been part of ITTC for longer than we would like to be made public and we have both been representatives of our Governments at IMO, again over a long period of time.

On several occasions in the past few years it has been suggested that the ITTC, as a world-wide body, is ideally placed to act as a forum for discussion of any new standards being proposed for adoption at IMO. It must be clear to all that nothing has ever happened in this direction, which is mainly due to the fact that IMO does not recognise the existence of the ITTC, since it has no permanent headquarters and secretariat. In order to understand why this apparently intransigent stance has been taken we must understand very clearly the nature of each organisation.

The Structure of IMO

The International Maritime Organisation is in fact a subset of the United Nations Organisation. It is run along similar lines, with a permanent staff, with a Secretary General in charge, and with its headquarters in London. Therefore, those who attend IMO are representatives of the governments of the Member States. Certain other international bodies are allowed an observer status, amongst which are International Association of Classification Societies (IACS), International Marine Pilots Association (IMPA) and Oil Companies International Marine Forum (OCIMF).

The main governing body within IMO is the General Assembly, which is made up of senior representatives of the Member States. It is the General Assembly that adopts the IMO Resolutions. On the next organisational level down is the Maritime Safety Committee (MSC), who considers the draft Resolutions and forwards them on to the General Assembly. Information is passed up to the MSC from a number of Sub-Committees, one of which is the Ship Design and Equipment Sub-Committee (D&E). It is this Sub-Committee which has the subject of Ship Manoeuvrability on its agenda and when this is the case, Member Governments are invited to bring their experts to that meeting. Those interested in the Manoeuvrability agenda item are then asked to go to a separate meeting room and work on the detail of the subject matter. The Chairman of this Ad-Hoc Working Group is usually selected previously in the plenary session, and is often continuing from the previous D&E meeting, perhaps a year earlier. Those organisations with Observer status are allowed to attend the Ad-Hoc Working Group meetings and join in the technical discussions but they have no voting rights. In the past I have been the Chairman of this Ad-Hoc Working Group and so has the next speaker Professor Kijima. Furthermore, several people in this room and past ITTC Manoeuvrability Committee Members have also been members of the Ad-Hoc Committee. So in fact the ITTC has already had a lot of input to IMO in a round about way. It must be stressed that it is the various representatives of the Member States at all levels that make IMO work and make all the decisions. The permanent secretariat is there to make sure all the rules and protocols are followed and give an enormous amount of help behind the scenes.

The Structure of ITTC

Not much needs to be said about the structure of ITTC. We all know that it is a loose association of organisations who operate towing tanks, cavitation tunnels and other hydrodynamic testing facilities. In any three-year period, the next host country provides the organisation and the chairman of the Executive Committee. Effectively the home of ITTC, its headquarters and day to day running passes on to another country every three years. As such it does not fall into the category of organisation favoured by IMO. To accomplish this ITTC needs a permanent home.

The Ad-Hoc Working Group on Manoeuvrability

The Ship Design and Equipment Sub-Committee (D&E) meets in London for one week, roughly once per year. In that week the Ad-Hoc Working Group on Manoeuvrability has to consider the documents issued by the Secretariat against the Manoeuvrability agenda item, also taking into account the points raised in the briefing during the plenary session. Usually, these documents have been formally submitted by Member Governments or Observer Organisations prior to the D&E Meeting, and have been prepared by their national experts. This is normally the only way for information to enter the IMO discussions, apart from the personal knowledge of those attending the meeting.

The Ad-Hoc Working Group on Manoeuvrability has been responsible for the authorship of several important IMO documents. One of these was Resolution A.601(15) "Recommendation on the Provision and Display of Manoeuvring Information Onboard Ships", which was adopted in 1987. However the more important document was Resolution A.751(18), "Interim Standards for Ship Manoeuvrability", adopted in November 1993, together with its Explanatory Notes, issued as MSC/Circ 644.

However to make any progress, we have to consider two often asked questions. What constitutes a good manoeuvring vessel? How can adequate manoeuvrability be specified, designed for and later verified? The answers to these questions are central to the whole issue and as yet cannot be answered fully. Since the first question needs to be answered before the word "adequate" can be defined in the second question, all progress made in calculating and estimating manoeuvring characteristics appears to be meaningless, unless values can be ascribed to the manoeuvring criteria to give meaning to the word "adequate". Since values have been given to the Criteria in Resolution A.751 (18), it could be argued that the gap has been bridged, and that the ship designer has adequate measures against which to assess his design. On the contrary, others may argue that the definitive manoeuvres chosen in Resolution A.751(18) are inadequate and that the various criterion values are wholly inappropriate. The second speaker, Professor Kijima, will say more about this.

IMO Manoeuvres

The manoeuvres selected are more of less the standard manoeuvres, traditionally carried out on the shipbuilder's trials. The intention is that they should be carried out at full load, in deep water and in calm conditions. The difficulties of considering the ship behaviour in shallow water have so far been ignored, on the understanding that if the ship is made better in deep water then it is likely that some of its behaviour in shallow water will also be better. The selected manoeuvres are

- Turning Circles
- Initial Turning
- Zig Zag Manoeuvres
- Stopping Manoeuvres

IMO Criteria

The acceptance of the selected standard manoeuvres is only one half of the problem. The actual numerical measures ascribed to the manoeuvres are the other half of the problem, and are a subject of constant debate. Although the values currently required have been in use almost nine years, there is a feeling that certain values need to be amended. As the next speaker, Professor Kijima will now address this matter.

Multi-Criteria Diagram

In a recent paper Clarke and Yap [1] have shown how it is possible to amalgamate all the IMO manoeuvres into one diagram. In this diagram the design point of the ship is at the origin of the axes. It can be seen that in this case all the recognised IMO Criteria are satisfied. By increasing the Y_v' fin effect, the design point moves up the vertical axis, till eventually the turning circle criteria are not satisfied. Conversely, reducing the Y_v' fin effect moves the design point down the vertical axis until the zig-zag criteria are not satisfied. Changing the rudder Y_δ' effect moves the design point from side to side, with much less effect. The equivalence of the –5deg. phase-margin boundary and the zig-zag overshoot values is clear to see. The desirable design point would be more or less central in the white region of the diagram. When any changes or alternative values of the criteria are suggested, this diagram can make the effects of these changes immediately apparent.

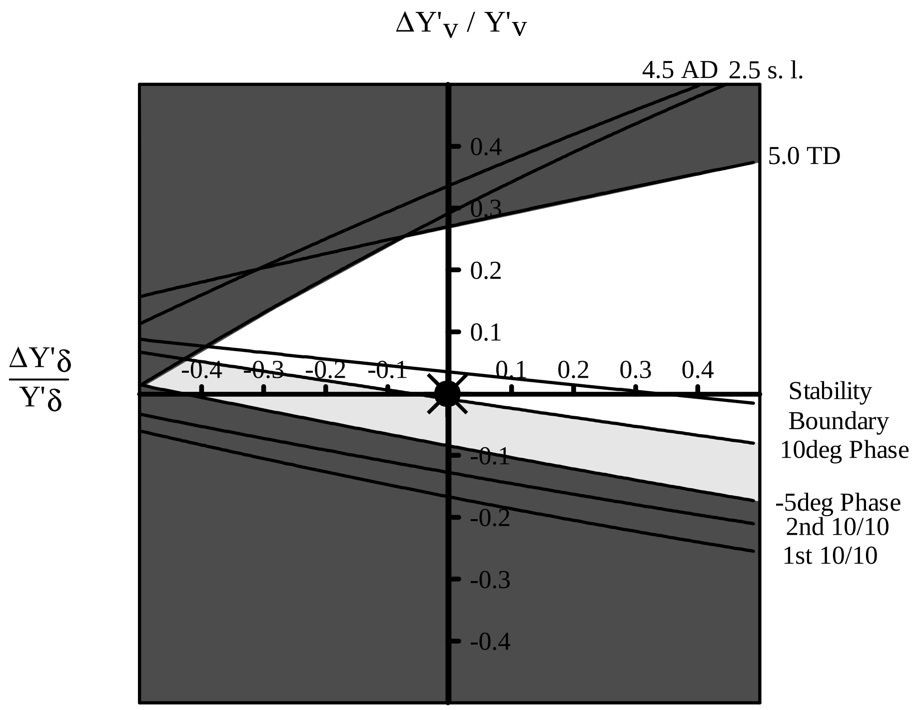

Fig. 1. IMO criteria boundaries for large tanker

Concluding Remarks

For ITTC to have any realistic representation at IMO, then it should be thinking about how to have a very simple permanent office and address. Otherwise things will have to go on as in the past, with individual ITTC members representing their respective Governments. However, it is then their duty to follow their respective government's policies, which may be at variance with the views of ITTC.

Ladies and Gentlemen, thank you for your attention.

References

[1] "A multi-criteria view of the IMO ship manoeuvring requirements", CLARKE, D. and YAP, M.L.R. Transactions of the Royal Institution of Naval Architects, Volume 143, Part A, pp. 98-110, 2001. ISSN 0373-529X.

Group Discussion B2: IMO Standards and ITTC

On Some Problems in the Interim Standards of Ship Manoeuvrability in IMO

Katsuro Kijima
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1. Preface

The Interim Standards of Ship manoeuvrability was adopted by International Maritime Organization (IMO) as assembly resolution A.751(18) for secure a safety of navigation from a view point of ship design in 1993. The Sub – Committee of Ship Design & Equipment of IMO has discussed on ship manoeuvring standards as incentive due to the “Amoco Cadiz” marine disaster in 1978.

Since the standards was adopted, many ship designer are paying attention as well as ship’s owner to the inherent performance of ship. However, this interim standard contains many problems to be solved from technical point of view.

This paper shows its problem to be investigated on the Interim Standards A.751(18).

2. Interim Standards of Ship Manoeuvrability A.751(18)

The interim standards adopted by IMO were as follows.

(1) Application condition

(1) deep, unrestricted water

(2) calm environment

(3) full load and even keel condition

(4) steady approach at the test speed

(2) Criteria

Ability	Test	Criteria
Turning Ability	Turning Test With Max. Rudder Angle (Fig.1)	Advance < 4.5*L*, Tactical Diameter < 5.0*L*
Initial Turning Ability	10°/10° Zig-zag Manoeuvring Test (Fig.2)	Track reach < 2.5*L*, by the time that 10° deviation is reached from the original heading in execution of 10° rudder angle.
Yaw Checking & Course Keeping Ability	10°/10° Zig-zag Manoeuvring Test (Fig.3)	(1) First overshoot angle · 10°, if *L*/*V* is less than 10 sec. · 20°, if *L*/*V* is 30 sec. or more. · (5+1/2(*L*/*V*)) degrees, if *L*/*V* is 10 sec. or more but less than 30 sec. (2) Second overshoot angle · values for the first overshoot angle be more than 15°
	20°/20° Zig-zag Manoeuvring Test (Fig.3)	First overshoot angle < 25°
Stopping Ability	Stopping Test (Fig.4)	Track reach < 15*L*

Since the interim standards were adopted, each country has investigated on validity of its standards. Japanese government has also examined on it in detail, and collected the sea trial data of full scale ship. By its examination, we got the result that the standards should be revised criteria on the second overshoot angle in 10/10 zigzag manoeuvring test, and also the criteria in stopping ability.

In 45th meeting of the Sub-Committee on Ship Design and Equipment of IMO, we proposed its revision, and fortunately the proposal was agreed on the second overshoot angle in 10/10 zigzag manoeuvring test. The revised version of its interim standards A.751(19) is currently as follows.

CRITERIA

Ability	Test	Criteria
Turning Ability	Turning Test With Max. Rudder Angle	Advance < 4.5L, Tactical Diameter < 5.0L
Initial Turning Ability	10°/10° Zig-zag Manoeuvring Test	Track reach < 2.5, by the time that 10° deviation is reached from the original heading in execution of 10° rudder angle.
Yaw Checking & Course Keeping Ability	10°/10° Zig-zag Manoeuvring Test	(1) First overshoot angle · 10°, if L/V is less than 10 sec. · 20°, if L/V is 30 sec. or more. · (5+1/2(L/V)) degrees, if L/V is 10 sec. or more but less than 30 sec. (2) Second overshoot angle · 25°, if L/V is less than 10 sec. · 40°, if L/V is 30 sec. or more · (17.5+0.75(L/V)) degrees, if L/V is 10 sec. or more but less than 30 sec.
	20°/20° Zig-zag Manoeuvring Test	First overshoot angle < 25°
Stopping Ability	Stopping Test	Track reach < 15L Stopping distance (tack reach) should not exceed 20 L

It is scheduled that this revised version will be discussed in the meeting of Maritime Safety Committee of IMO in coming December, and finally will be expected to be adopted as assembly resolution.

3. Some problems on the Interim Standards

On the interim standards, there are some problem to be solved from a practical point of view as follows.

(1) The interim standards provide that ship's loading condition is fully loaded as application condition. But it will be very difficult to carry out

a sea trial in full load condition from a practical point of view, especially in dry cargo ship such as container ship, general cargo ship and bulk carrier etc. in case of inspection on the criteria of the standards. In the case of liquid cargo ship such as gas carrier or VLCC, it will be very easy to carry out a sea trial in full load condition. Accordingly in dry cargo ship, we have to estimate the inherent performance in full load condition from the results of sea trail condition in ballast condition. Generally speaking, it will be difficult to estimate the manoeuvring characteristics in full load condition from the results of it in ballast condition.

Therefore, we need to develop the simple and easy prediction method for ship manoeuvring characteristics in full load condition, or prediction method for manoeuvrability in full load from the results of it in the sea trial condition directly.

(2) The interim standards recommend that the sea trial should be carried out in calm environment, that is to say, in below sea state 4 and Beaufort wind scale 5. But in this sea state, the ship has not a little some effect by wind and waves. Especially, the overshoot angle in zigzag manoeuvring test will be affected by the external disturbances.

For examination of the criteria its standards, we have to develop the correction method of wind and waves for estimating real inherent manoeuvrability of ship from the results of sea trial.

4. The Items to be Supported by ITTC

As the above mentioned, the current interim standards has still some problem to be solved. In the practical application of the interim standards, ITTC will be strongly requested to support in the technical point such as the prediction method and sea trial method etc. The author proposes that we have to develop the following items:

(1) At the design stage, we want to know the inherent manoeuvring characteristics. Then if we have a simple and easy prediction method for ship manoeuvrability, it will be very useful for examination of the criteria in the interim standards. Therefore, we need to develop a simple and easy prediction method for ship manoeuvrability in all

loading condition, and ITTC also should support to develop the prediction method.

(2) On the other hands, it will be useful to develop the estimation method for manoeuvring characteristics in full load condition from the result of sea trial in such as ballast condition for examination with the criteria. But this method will be difficult to apply in all condition. We can say that the manoeuvring characteristics in full load condition will be quite different with it in ballast condition in same case.

(3) When we carry out the sea trial, we have some effects of wind and waves. In these conditions, it will be very difficult to understand real inherent ship manoeuvrability by the external disturbances, accordingly we need to correct its disturbances. Therefore it will be needed to develop the correction method for the disturbances, such as wind and waves.

Simultaneously, we need to keep the quality and accuracy of measurement of sea trial. ITTC also should support on the measurement method in sea trial.

(4) On the criteria for stopping ability, we should discuss to get more reasonable stopping distance as the criteria. Especially for VLCC, the present interim standards will be not reasonable. Fortunately, IMO, recognizing that the current standards permit the Administration to modify the test criterion for ships of large displacement, decided to amend the existing interim standards by adding the words that “in no case, the stopping distance should not exceed 20 ship lengths”. ITTC should also support to develop the easy and simple prediction method for stopping distance for use at design stage.

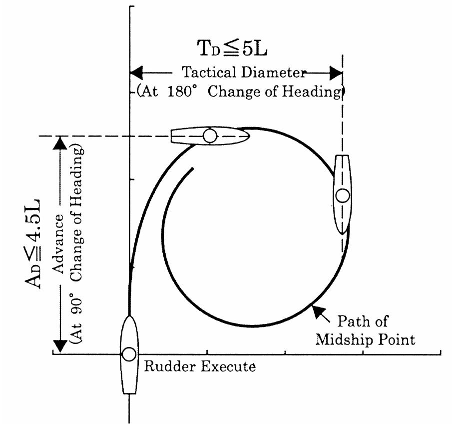


Fig.1. Turning Ability

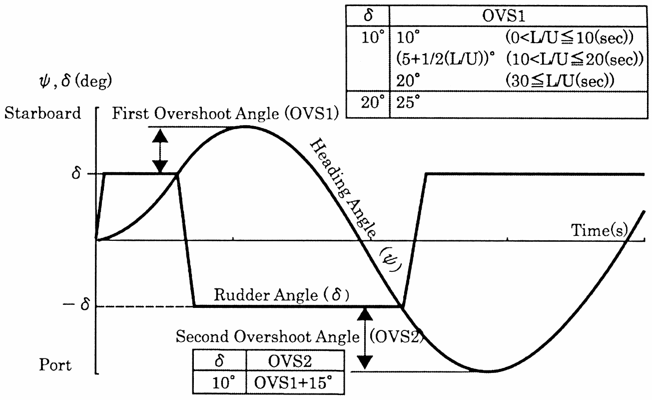


Fig.2. Initial Turning Ability

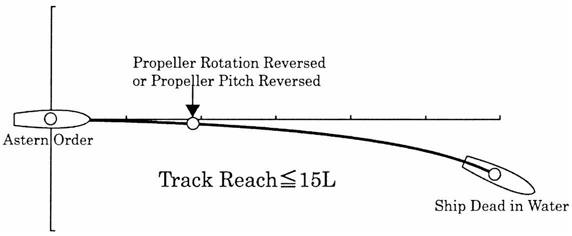


Fig.3 Zigzag Manoeuvring Test

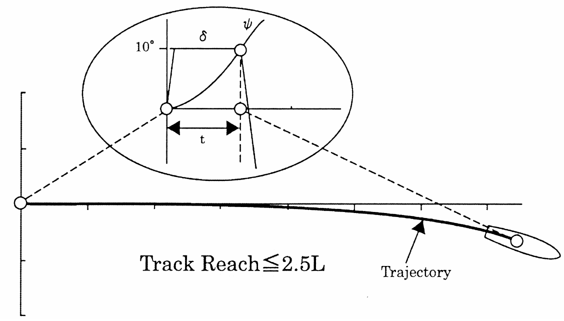


Fig.4 Stopping Distance

IMO and ITTC:
Safety against capsizing and foundering of (intact) ships in a seaway

Jan O. de Kat

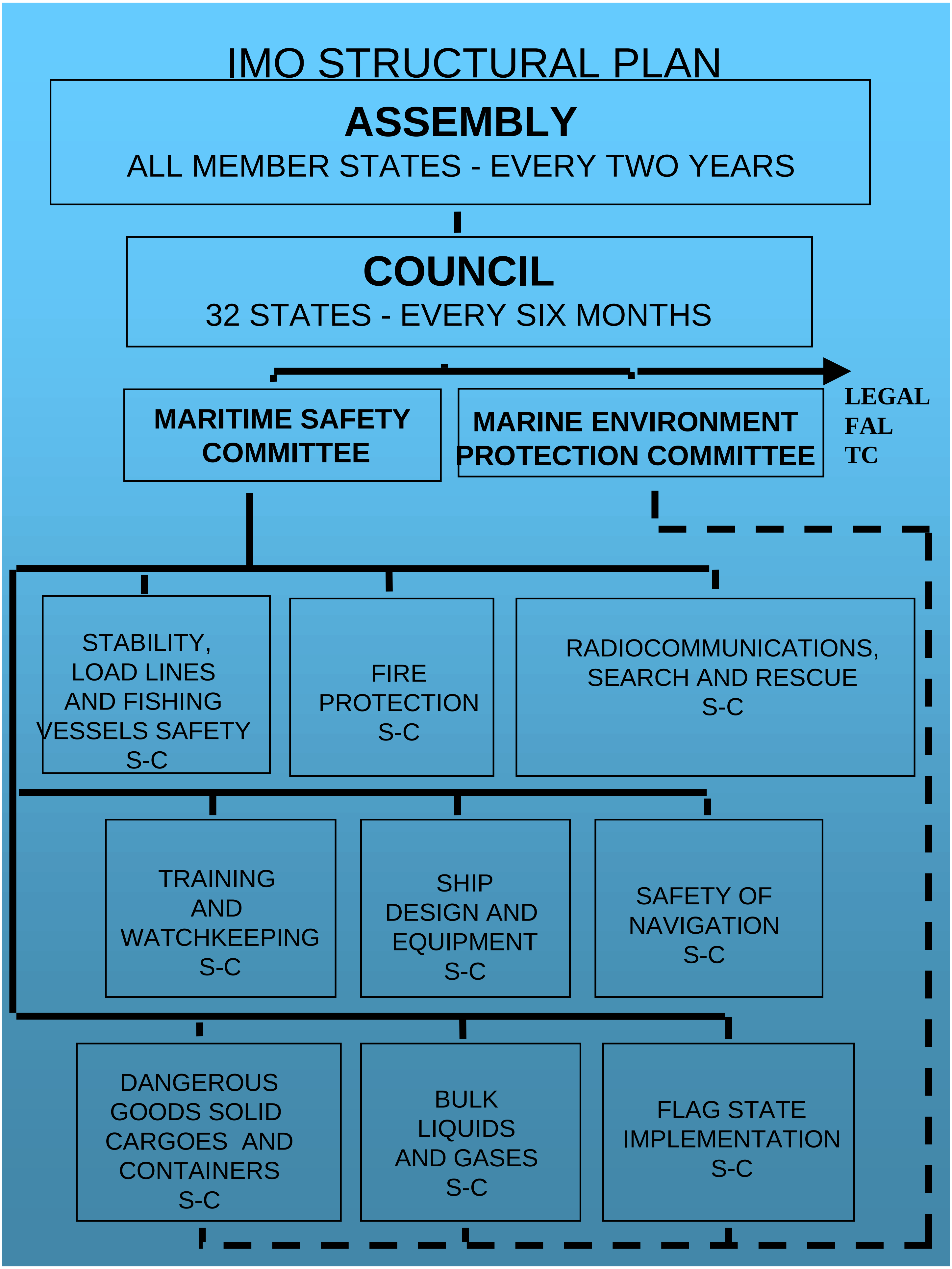
MARIN

Outline

- IMO structure
- Current developments within SLF Sub-Committee
- Technical issues relevant to ITTC
- Possible role of ITTC vs IMO

International Maritime Organization (IMO)

- *IMO has the responsibility to develop technical safety and pollution prevention global standards*
- GOVERNMENTS have the duty to implement and enforce these standards
- SHIPPING COMPANIES are responsible for applying the same standards to individual ships
- SHIPBOARD PERSONNEL have the task of putting into operation the various safety and anti-pollution measures applicable to the ship


IMO STRUCTURAL PLAN
ASSEMBLY
ALL MEMBER STATES - EVERY TWO YEARS
COUNCIL
32 STATES - EVERY SIX MONTHS
MARITIME SAFETY COMMITTEE
MARINE ENVIRONMENT PROTECTION COMMITTEE
LEGAL
FAL
TC
STABILITY, LOAD LINES AND FISHING VESSELS SAFETY S-C
FIRE PROTECTION S-C
RADIOCOMMUNICATIONS, SEARCH AND RESCUE S-C
TRAINING AND WATCHKEEPING S-C
SHIP DESIGN AND EQUIPMENT S-C
SAFETY OF NAVIGATION S-C
DANGEROUS GOODS SOLID CARGOES AND CONTAINERS S-C
BULK LIQUIDS AND GASES S-C
FLAG STATE IMPLEMENTATION S-C

MARITIME SAFETY COMMITTEE

Responsible for:

- International Convention on Load Lines (LL) 1966*
- International Convention for the Safety of Life at Sea (SOLAS) 1974 *
- International Convention on Tonnage Measurement of Ships (ITC) 1969
- International Convention on Standards of Training, Certification and Watchkeeping (STCW) 1995*
- Convention on the International Regulations for Preventing Collisions at Sea (COLREGS) 1972

* as amended

IMO STRUCTURAL PLAN

MSC Sub-Committees

MARITIME SAFETY COMMITTEE

Safety against capsizing, foundering

STABILITY, LOAD LINES AND FISHING VESSELS SAFETY
S-C

FIRE PROTECTION
S-C

RADIOCOMMUNICATIONS, SEARCH AND RESCUE
S-C

TRAINING AND WATCHKEEPING
S-C

SHIP DESIGN AND EQUIPMENT
S-C

SAFETY OF NAVIGATION
S-C

DANGEROUS GOODS SOLID CARGOES AND CONTAINERS
S-C

BULK LIQUIDS AND GASES
S-C

FLAG STATE IMPLEMENTATION
S-C

Current SLF developments

Outcome of SLF 45

- Revision of International Convention on Load Lines
  - has reached completion stage (intact, conventional ships)
- Revision of Intact Stability Code
  - just started
  - issues: (1) passenger ships; (2) parametric rolling
  - high priority: review of weather criterion
- Harmonization of Damage Stability requirements (SOLAS)
  - ongoing, target date: 2003
- Revision of model test method: SOLAS Res. 14 (‘Stockholm Agreement’) for new ships
- Safety of Large Passenger Ships; Bulk carriers; Fishing Vessels
- Container ships: partially weathertight hatch covers

IMO issues relevant to ITTC

- **International Load Line Convention**
  - influence of freeboard on extreme water on deck effects
  - loads on hatch covers

IMO issues relevant to ITTC

- **Freeboard assignment of ships with novel features**

☞ *Prevention of excessive water ingress effects*

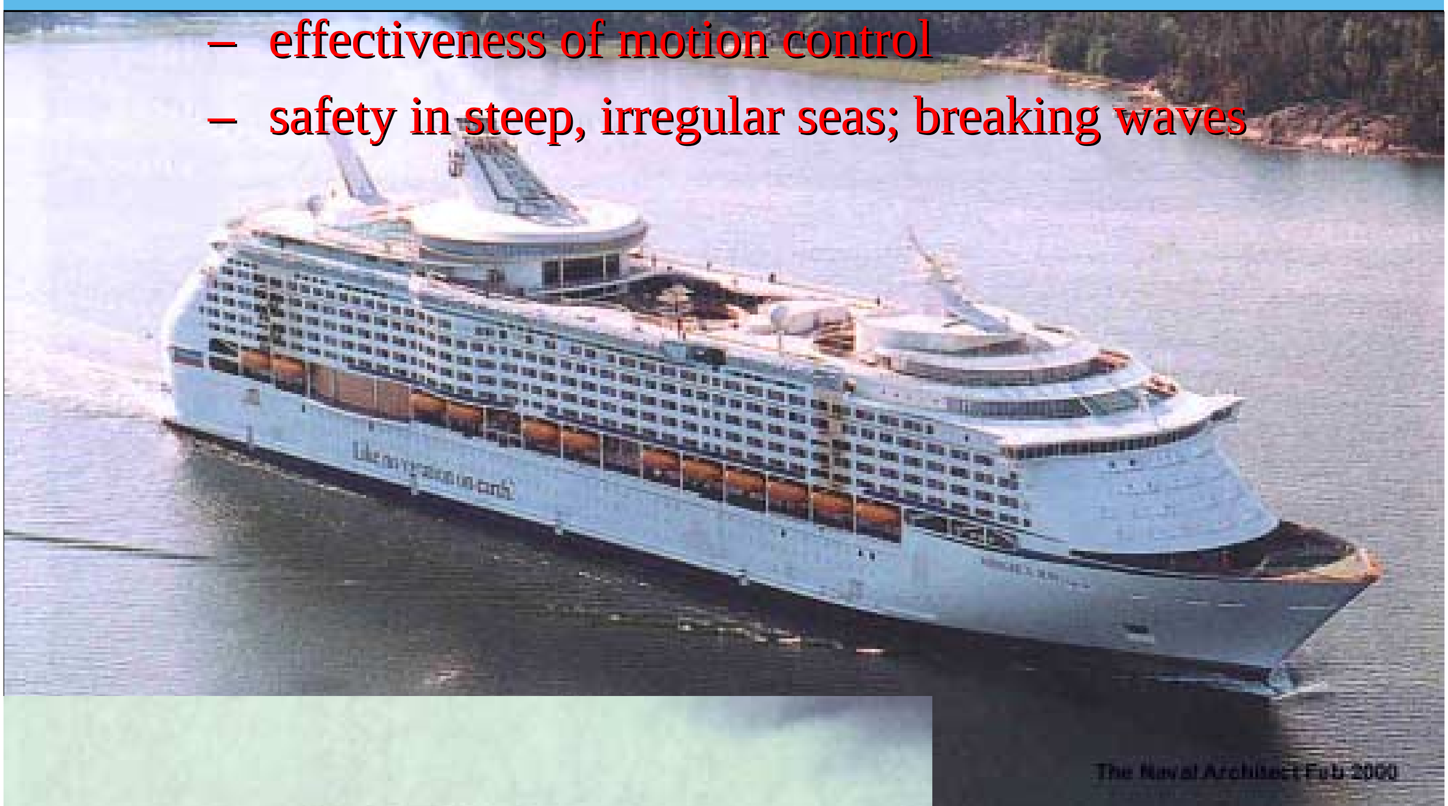
  – Open top containerships: IMO guidance for model tests exists

  – Other ships: exemption from ICLL regulations

  – Longer term: direct approach for other ships

IMO issues relevant to ITTC

- **Intact Stability**
  - longer term trend towards performance based stability standards, assessment of capsize risk
  - role of model tests, computations, full scale
  - operational guidance, e.g. operation in heavy weather
  - effectiveness of motion control
  - safety in steep, irregular seas; breaking waves

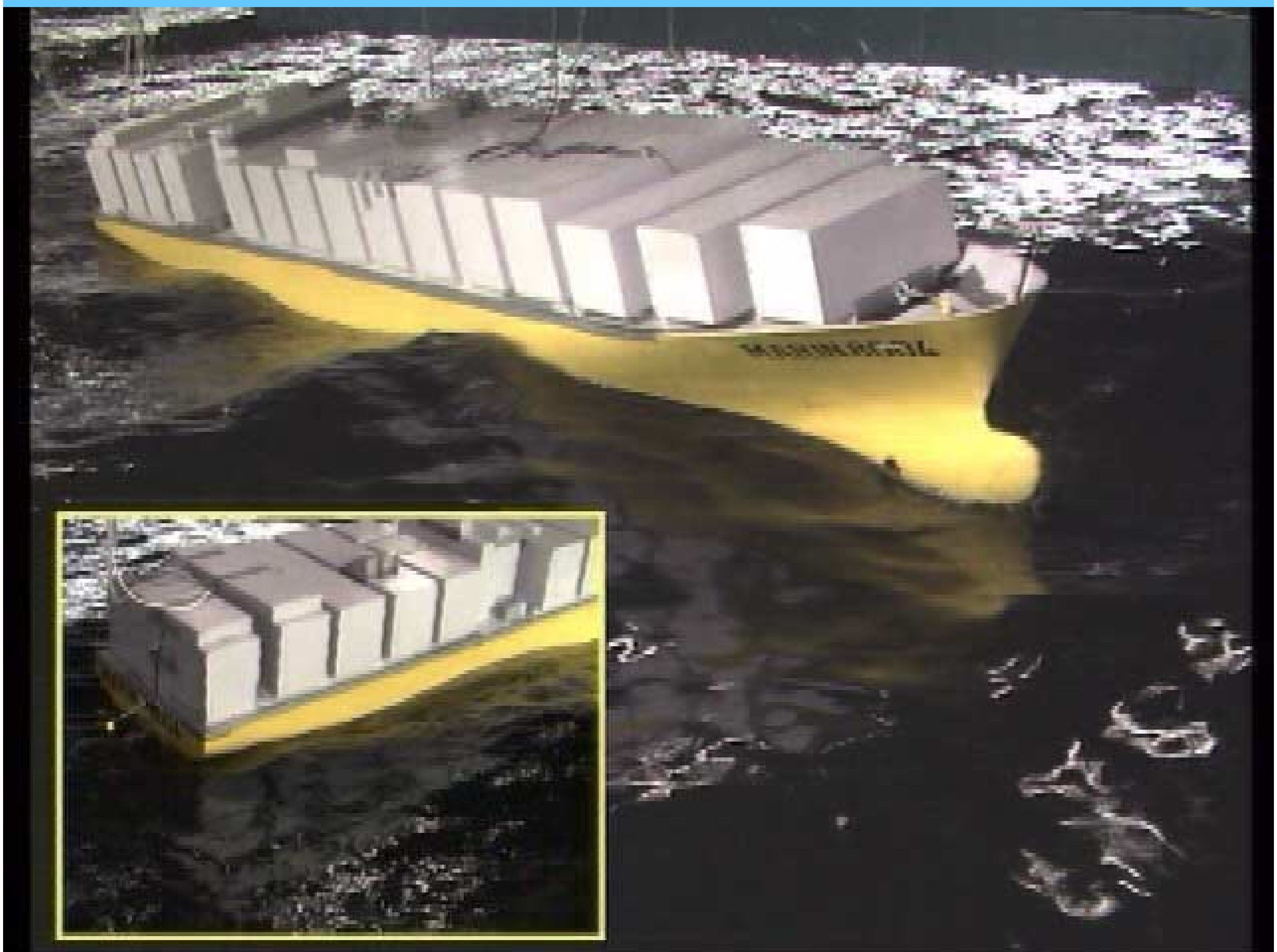


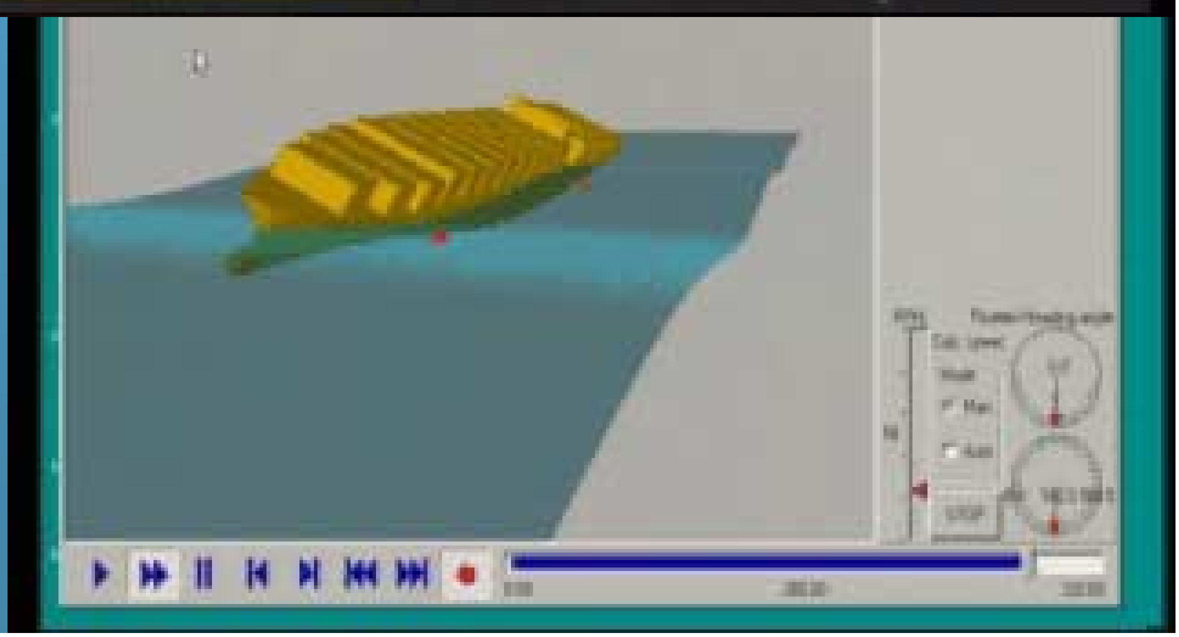
IMO issues relevant to ITTC

- Capsize model test procedures

High speed broach and capsize (NRIFE)

Parametric rolling





IMO issues relevant to ITTC

- **Stability and safety of High Speed Craft: HSC 2000 Code**

  ☞ *Prove equivalent safety through full scale tests, model tests or mathematical simulations:*

  –directional instability (roll, pitch)

  –broaching and bow diving in following seas

  –loss of transverse stability

  –resonant rolling

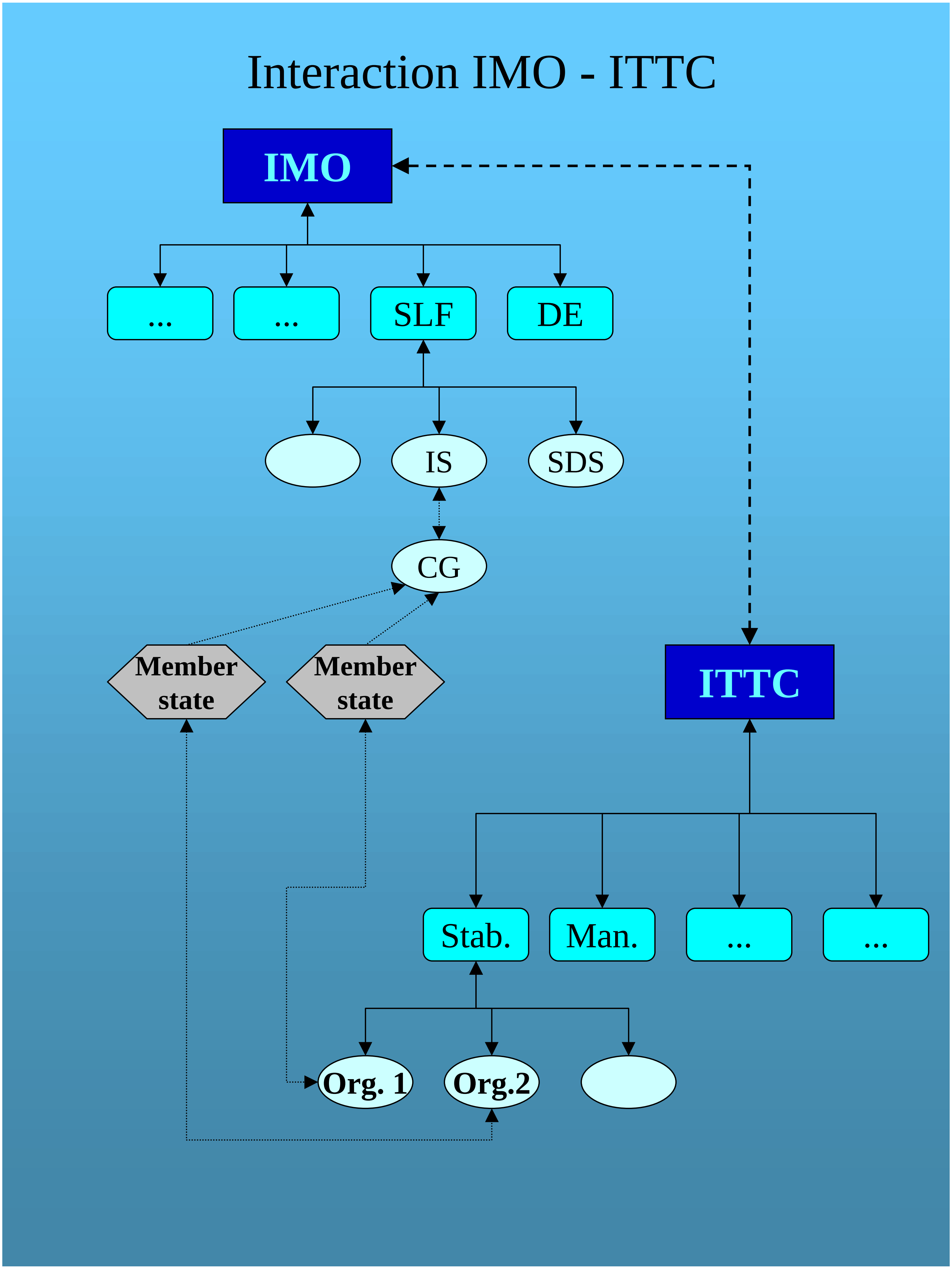
  –porpoising of planing hulls, chine tripping, ...

Role of ITTC vs IMO

- IMO: development of technical safety standards
- Current trend: performance based standards, probabilistic aspects and FSA techniques
  - need for good understanding of relevant physics
  - need for reliable safety assessment procedures

- ITTC: provider of technical expertise
  - understanding of physics
  - expertise: hydrodynamics, structural behaviour, ...
  - development and evaluation of model test procedures
  - databases with model test data: validation
  - standards for numerical simulation tools

- What is needed: mechanism for interaction between ITTC and IMO


Interaction IMO - ITTC
IMO
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...
SLF
DE
IS
SDS
CG
Member state
Member state
ITTC
Stab.
Man.
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...
Org. 1
Org.2

IMO and ITTC – Damage Stability and Survivability

By Professor Dracos Vassalos
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The Universities of Glasgow and Strathclyde

Presented at the ITTC Meeting - Venice 10 September 2002

IMO regulations have seen a gradual shift from prescriptive to performance-based criteria. This shift is taking place in order to provide ship designers with greater flexibility and to be more broadly applicable to changing and novel ship designs that were not envisioned during earlier regulatory development. In order to properly apply performance-based criteria there is a need to develop standard techniques and guidelines for assessing ship safety using first principles analysis.

IMO's regulation of ship damage survivability has been at the core of IMO activities in the recent past. There are three broad categories of survivability and damage stability standards:

- Deterministic (SOLAS standards, Stockholm Agreement)
- Probabilistic (A.265 1974, SOLAS B-1 1992, EU Project HARDER, Harmonization)
- Performance-based (SOLAS '95 Resolution 14)

It is noted that the development of the A.265 criteria in the 1970's and the more recent developments of the HARDER and Harmonization standards have all involved significant model testing of damaged ships. The SOLAS '95 standards, in particular, directly permit the demonstration of compliance using a model test. Two other activities related to damage survivability that have recently been considered by the IMO relate to:

<u>Large passenger ship safety</u>
The principal areas of interest for large passenger ship damage survivability are the "time to sink" as it relates to safe abandonment, and the structural integrity of the ship after damage. While the final fate of the ship might be adequately predicted by hydrostatic analysis, prediction of the evolution of flooding and estimation of the time to capsize necessitates the use of modern time-domain numerical simulation tools.

<u>High speed craft</u>
Regarding high speed craft (HSC), due to the continuous introduction of state-of-the-art technology and innovation in the developments to HSC design and operation, the recent developments of the HSC code have incorporated safety equivalence-based alternatives and performance-based criteria. Examples of performance-based criteria for high speed craft are the model test alternatives for exemption of the inner bow door, for which IMO has directly requested help from ITTC.

On the basis of available evidence it can be concluded with justification that the need to understand extreme behaviour of ships in heavy seas is becoming progressively more important to provide cost-effective safety and regulatory levels. The role of ITTC in co-ordinating theses efforts internationally (fundamental to the development of universally accepted rules and regulations) and in fostering the development of rational performance-based standards at IMO (procedures, benchmarking, validation) is now becoming more important than ever. Attempts by ITTC to attain observer status at IMO so that it can contribute to the scientific evolution of the subject most effectively (pro-actively and by responding to emerging needs) must now be given serious consideration. Taking the above into account, together with the fact that stability issues have been at the core of IMO activities in the recent past and are likely to remain as such in the foreseeable future, ITTC ought to recognise the need for a longer term agenda within a General Committee for Ship Stability in Waves.

IMO and ITTC
Damage Stability and Survivability

by

Professor Dracos Vassalos
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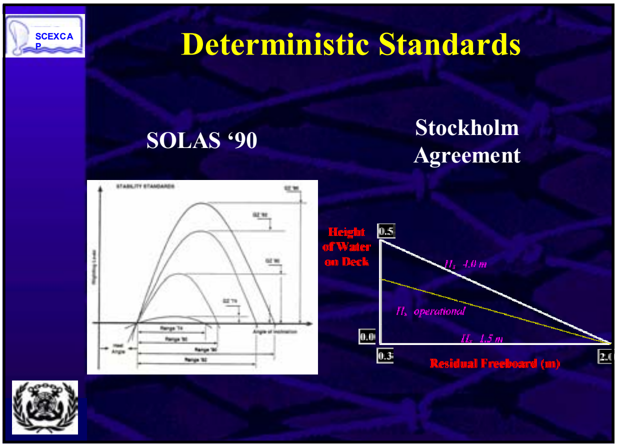
VENICE
10 September 2002

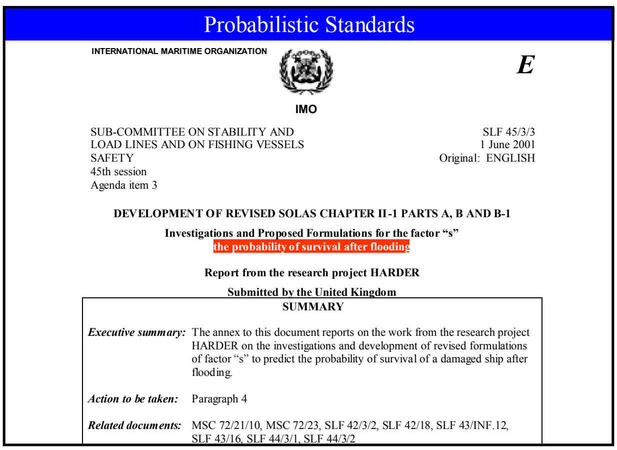
Presentation Outline

- Background
- Current Developments within SLF Sub-Committee of relevance to ITTC:
  - ⇒ Harmonisation of damage stability standards
  - ⇒ Large Passenger Ships Safety
  - ⇒ HSC Code – Guidelines for the conduct of model tests
- Conclusions and Recommendations

Background

- The shift from prescriptive to performance-based approaches and the implied need to develop standard techniques and guidelines for assessing safety (against capsizing) from first principles is now seen as the key to rapid implementation of technological innovation.
- IMO responded through the adoption of "Alternative Design and Approaches" and of "Safety Equivalence" to facilitate developments in this direction. This, in turn led to three broad categories of damage stability standards:
  - ⇒ Deterministic (SOLAS standards, Stockholm Agreement)
  - ⇒ Probabilistic (A.265 1974, SOLAS B-1 1992, HARDER)
  - ⇒ Performance-based (SOLAS '95 Resolution 14)





Probabilistic Standards

INTERNATIONAL MARITIME ORGANIZATION

IMO

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SUB-COMMITTEE ON STABILITY AND LOAD LINES AND ON FISHING VESSELS SAFETY
45th session
Agenda item 3

SLF 45/3/3
1 June 2001
Original: ENGLISH

DEVELOPMENT OF REVISED SOLAS CHAPTER II-1 PARTS A, B AND B-1

Investigations and Proposed Formulations for the factor "s"

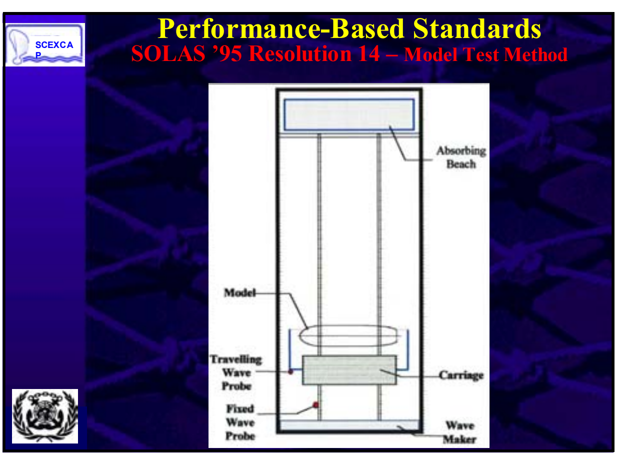
the probability of survival after flooding

Report from the research project HARDER

Submitted by the United Kingdom

SUMMARY

Executive summary:	The annex to this document reports on the work from the research project HARDER on the investigations and development of revised formulations of factor "s" to predict the probability of survival of a damaged ship after flooding.
Action to be taken:	Paragraph 4
Related documents:	MSC 72/21/10, MSC 72/23, SLF 42/3/2, SLF 42/18, SLF 43/INF.12, SLF 43/16, SLF 44/3/1, SLF 44/3/2



Performance-Based Standards

INTERNATIONAL MARITIME ORGANIZATION

IMO

E

SUB-COMMITTEE ON STABILITY AND LOAD LINES AND ON FISHING VESSELS SAFETY
45th session
Agenda item 10

SLF 45/10
12 March 2002
Original: ENGLISH

REVISION OF THE MODEL TEST METHOD SPECIFIED IN THE 1995 SOLAS CONFERENCE RESOLUTION 14

Note by the Secretariat

SUMMARY	
Executive summary:	This document contains comments by the Secretariat concerning the procedure for approving/adopting the eventual revised model test method and associated guidance notes
Action to be taken:	Paragraph 6
Related documents:	SLF 44/18, section 13; 1995 SOLAS Conference resolution 14

Performance-Based Standards

INTERNATIONAL MARITIME ORGANIZATION

IMO

E

SUB-COMMITTEE ON STABILITY AND LOAD LINES AND ON FISHING VESSELS SAFETY
45th session
Agenda item 8

SLF 45/8/2
10 June 2002
Original: ENGLISH

LARGE PASSENGER SHIP SAFETY

Outcome of MSC 75

Note by the Secretariat

SUMMARY	
Executive summary:	This document reports on the outcome of MSC 75 with regard to large passenger ship safety.
Action to be taken:	Paragraph 11
Related documents:	MSC 75/24, section 4; MSC 75/WP.12

Large Passenger Ships Safety

SCEXCAP

Regulatory gap: Characterize the designed survivability of the ship
to consider how an analytical relationship between the “time to sink” and residual damage stability could be developed for all damage cases in which the survivability index "s" is less than 1. The methodology should make use of probabilistic principles as necessary to be compatible and used in conjunction with the future probabilistic harmonized stability calculation methods;

Regulatory gap: Structural integrity of the ship after damage
to propose a methodology to consider structural integrity after damage that accounts for additional loads due to flooded spaces and hull structural degradation, in terms of damage stability, longitudinal strength and local strength for prevention of progressive flooding. The methodology should account for the effects of sea state. For future ships, the methodology would integrate the structural integrity criteria with stability criteria. For existing ships, the methodology would provide operational guidance.

HSC Code

Mitigating Factors

- Light displacement provides for a large reserve of buoyancy in relation to displacement
- More stringent navigational and operational requirements (e.g., categories A & B craft, Safety Certificate, Permit to Operate, etc.)
- Introduction of active risk management and reduction measures (accommodation arrangements, active safety systems, restricted operation, quality management and human factors engineering)
- 4-yearly revision of HSC Code (1977; 1994 – 96; 2000)
- Continuous introduction of state-of-the-art technology and innovation developments to HSC design and operation (safety equivalence-based alternatives)
- Introduction of performance-based criteria.

HSC Code

SUB-COMMITTEE ON STABILITY AND LOAD LINES AND ON FISHING VESSELS SAFETY
44th session
Agenda item 7

SLF 44/7/xx
xx June 2001
Original: ENGLISH

GUIDELINES FOR THE CONDUCT OF HSC MODEL TESTS

Proposed Interim Guidelines

Submitted by the United Kingdom

SUMMARY

Executive summary:	The Code of Safety for High -Speed Craft (2000) incorporates a model test option when an Administration is considering an exemption from the requirement for such bow loading craft to have an inner bow door. As requested at SLF 43, this paper proposes a revised text for such guidelines.
Action to be taken:	Paragraph 10
Related Documents:	MSC 72/21/8 SLF 43/12 SLF 43/16

Conclusions and Recommendations

- The need to understand extreme behaviour of ships in heavy seas is becoming progressively more important in the strife to cater for safety provision cost-effectively.
- The role of ITTC in co-ordinating efforts internationally (fundamental to the development of universally accepted rules and regulations) and in fostering the development of rational performance-based standards at IMO (procedures, benchmarking, validation) is becoming much more important than ever.

Conclusions and Recommendations

- Attempts by ITTC to attain observer status at IMO so that it can contribute to the scientific evolution of the subject most effectively (pro-actively and by responding to emerging needs) must now be given serious consideration.
- Taking the above into acount together with the fact that stability issues have been at the core of IMO activities in the recent past and are likely to remain as such in the foreseeable future, ITTC ought to recognise the need for a longer term agenda within a General Committee for Ship Stability in Waves.

Comments on the role of ITTC *vis-à-vis* IMO

By Miguel Palomares, IMO

In the field of maritime safety, the International Maritime Organization is nowadays placing increasing emphasis on performance-based standards, rather than taking the prescriptive deterministic route. Thus, some regulations may offer the possibility of satisfying compliance with certain prescriptions either by calculation or model testing.

This philosophy may be, and in some cases already is, applied in the areas of manoeuvrability, intact stability (e.g., capsizing-weather criteria; parametric rolling), damage stability (e.g., ro-ro ships under resolution 14 of the 1995 SOLAS Conference), seakeeping (especially bulk carriers), load lines (freeboard of unconventional ship types), inner bow door on ro-ro high-speed craft and others.

In this connection, it is worth mentioning that the Maritime Safety Committee (MSC), at its seventy-fifth session (15 to 24 May 2002), approved MSC/Circ.1029 on Interim Guidelines for the conduct of high-speed craft model tests and noted that the SLF Sub-Committee, in agreeing to the draft Interim Guidelines, had regard to the following recommendations:

.1 the Interim Guidelines should be applied with a view to verification and further development in the light of experience, and these should be revisited after a period of time not exceeding four years following the date of entry into force of the 2000 HSC Code (1 July 2002);

.2 comparative model tests should be conducted and the results of such tests should be submitted to the Organization, so as to validate and further refine the Interim Guidelines; and

.3 Member Governments should undertake to seek comments on, and evaluation of, the Interim Guidelines from the International Towing Tank Conference (ITTC) and, subsequently, collect information from the ITTC, in particular the results of their experience, and submit it to the Organization for consideration with a view to improving the Interim Guidelines.

IMO might, therefore, benefit **directly** from ITTC expertise in formulating and developing the relevant model test and other related procedures if ITTC were to offer it in the first place and, subsequently, if the IMO Council, following consideration of an application from ITTC for "consultative status", decided to grant it in accordance with the IMO Rules governing relationship with non-governmental international organizations.

Referring to the above Rules with a possible ITTC application for consultative status in mind, it should be noted that Rule 5 – "Constitution and structure of the non-governmental organization" states, *inter alia*, that "consultative status may not be granted to any non-governmental international organization unless it has a permanent headquarters, a governing body and an executive officer…" The ITTC might, therefore, consider possible ways of satisfying the clause referring to "permanent headquarters", in consultation with the IMO Secretariat (External Relations Office), before an application is submitted.

Some thoughts about IMO standards

P. Perdon

Impact of the adoption of IMO standards

- Beneficial impact
  - More attention is paid to manoeuvrability
- Detrimental impact
  - Manoeuvrability characteristics of ships is now limited to 6 or 7 criteria

Beneficial impact

- The hydrodynamic community is asked to propose efficient and validated prediction tools
- The standardisation of criteria imposes a standardisation of procedures

⇨ *in line with actual ITTC purpose*

Detrimental impact

- Satisfaction of IMO criteria does not ensure that the ship exhibits an overall acceptable behaviour
- 35° turning circle or zigzag in deep water are not normal operational manoeuvres performed by ships.

Challenges for the future

- Improve the prediction capability of manoeuvring properties
  - Model test techniques, calculations
- Promote a "mission" oriented approach to define and and verify performance criteria
  - A NATO specialist team is now conducting such a work for navy ships
  - For commercial ships, harbour manoeuvring capacity requirements should be developed

On the Yaw-checking and Course-keeping Ability of IMO Standards

Key Pyo Rhee, Professor,
Dept of Naval Architecture and Ocean Engineering,
Seoul National University, Korea

International Maritime Organization (IMO) adopted the interim standards for ship manoeuvrability for the purpose of preventing the marine disasters. This accelerated the researches on ship’s manoeuvrability. Most of researches were done by using model test, and on the estimation of the ship’s manoeuvrability at the early design stage. Only several papers dealt the manoeuvring standards.

Reviewing Group on IMO Interim Standards for Ship Manoeuvrability in Korea collected the ship manoeuvring data of 75 ships launched at Korean shipyards in recent 5 years. And based on these data, the IMO’s standards on yaw-checking and course-keeping ability are reviewed from the viewpoint of practical navigational difficulty. The IMO’s Standards use overshoot angles of zigzag test as criteria of on yaw-checking and course-keeping ability of a ship. Two approaches are tried to investigate the correlation between overshoot angles and safe navigation; one is through an auto-tracking simulation, the other is through a ship-handling simulator experiments.

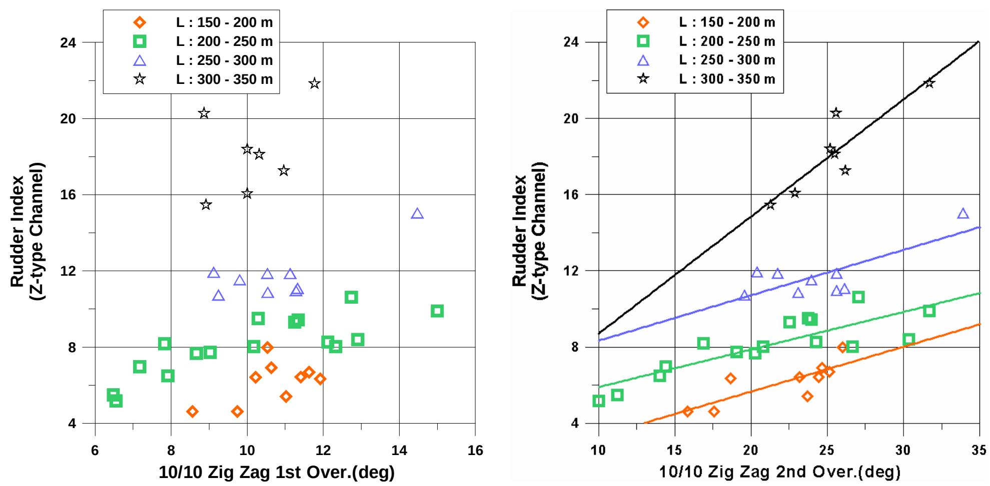


Figure 1. Rudder Index vs. first and second overshoot angles of 10/10 Z manoeuvre

Auto-tracking simulation of ships along 10 and 30 deg.-bent courses and Z-type course is carried out using the first order Nomoto’s linearized manoeuvring equations with PD controller, under the assumption of full speed, deep water, no disturbance and no speed control. The controller gains are determined by the linear control theory. Rudder index, which is defined as the time integration of the absolute value of the rudder angle during the auto-tracking simulation, is adopted to evaluate the navigational difficulty.

$$RudderIndex = \frac{1}{T_{Cf} - T_{C0}} \int_{T_{C0}}^{T_{Cf}} |d(t)| \; dt$$

where Tcf and Tc0 mean time when control ends and starts, respectively, and d(t) is rudder angle Ships with poor manoeuvrability have larger value of rudder index.

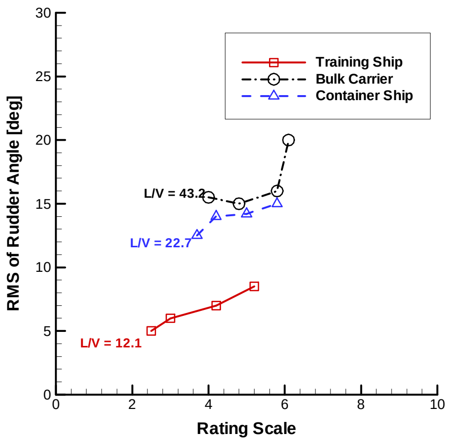


Figure 2. Averaged subjective rating scales vs. averaged RMS values of applied rudder angle

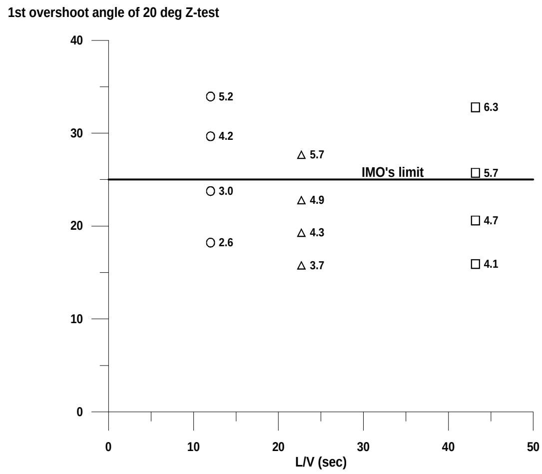


Figure 3. Averaged subjective rating scale marked on IMO standard diagram (1^{st} overshoot angles of 20/20 zigzag test)

We can find that ships with shorter length are maneuverable with less difficulty than ships with longer length although they have same overshoot angles

Simulator experiment is executed under the real situation of navigating in a curved, narrow waterway. 12 series ships are generated systematically to have different course keeping ability by changing rudder area and linear manoeuvring coefficients. Five pilots with more than 15 years' experience evaluate the subjective rating scale on the series ships.

The mission to shiphandling is 1) passing along the waterway centerline as far as possible, 2) keeping propeller RPM constant as that of harbor full speed, and 3) only rudder command is allowed and pilot issues orally the order to helmsman. Evaluation is carried out by pilots immediately after every simulations based on skill required, difficulty of task and stress level felt by pilot during simulation. Larger rating scale means more skill required, more difficulty in task and higher stress level. Through these, we can find that even though some small ships do not satisfy IMO’s standards, pilots feel relatively easy in passing through in curved, narrow waterway.

There is clear correlation among the rudder index, overshoot angles and the manoeuvring difficulty felt by the pilots. Furthermore, we can find that size of a ship is also an important factor for safe navigation. That is, pilots feel much easier when they navigate the smaller ships than larger ones although the ships have same overshoot angles.The current interim standards that are varying with L/V ratio should be reconsidered. Ships with smaller L/V would have better maneuverabilty than those with larger L/V although they have larger overshoot angles

References

K. P. Rhee, et al, 2001, “Review of IMO Manoeuvring Standards in View of Manoeuvring Sea Trial Data,” Mini Symposium on Prediction of Ship Manoeuvring Performance, Tokyo, Japan

K. H. Sohn, et al, 2001, “A Simulator Study on Validation of IMO’s Ship Manoeuvrability Standards with Particular Reference to Yaw-checking and Course-keeping Ability,” Mini Symposium on Prediction of Ship Manoeuvring Performance, Tokyo, Japan

Y. Yoshimura, “Investigation into the Yaw-checking Ability in Ship Manoeuvrability Standard.” Mini Symposium on Prediction of Ship Manoeuvring Performance, Tokyo, Japan

On the Yaw-checking and Course-keeping Ability of IMO Standards

Key Pyo Rhee

Reviewing Group on IMO Interim Standards for Ship Manoeuvrability in Korea

Contents

- Ship Manoeuvring Data (complete dataset of 75 ships)
- Review of IMO Interim Standards from the viewpoint of practical navigational difficulty
- An auto-tracking simulation, and

  A Ship-handling Simulator Study

  to investigate the correlation btn overshoot angles and safe navigation

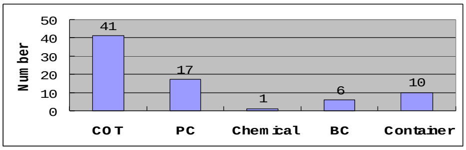
Manoeuvring Data : Kind of Tests

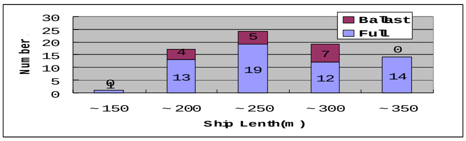
Kind of Tests	Turning			
	Advance/L		Tactical Diameter/L	
	PORT	STBD	PORT	STBD
Design Load Condition	44	44	44	44
Full Load Condition	15	15	15	15
Ballast Condition	16	16	16	16

Kind of Tests	Zig-zag					
	10/10				20/20	
	1st Overshoot Angle		2nd Overshoot Angle		1st Overshoot Angle	
	PORT	STBD	PORT	STBD	PORT	STBD
Design Load Condition	7	43	8	43	7	41
Full Load Condition	1	14	1	14	2	14
Ballast Condition	4	6	3	6	3	12

Kind of Tests	Stopping
	Track Reach/L
Design Load Condition	44
Full Load Condition	15
Ballast Condition	16

Manoeuvring Data : Ship Type & Length



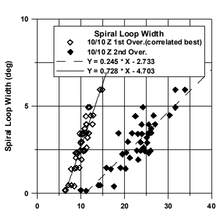


Investigate the relation between overshoot angles and navigational safety

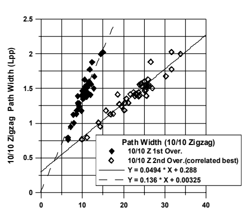
Carried out

- standard manoeuvring simulation and
- auto tracking simulation for ships in DB.
- A Ship-handling Simulator Experiments

Relation of Overshoot Angles with Spiral Loop Width & Zig-Zag Path Width



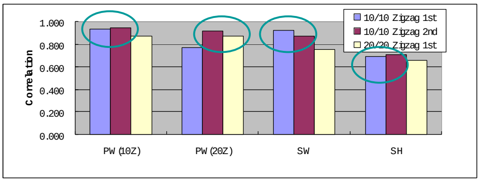
Overshoot angles
vs.
Spiral Loop Width



Overshoot angles
vs.
Zig-Zag Path Width

Correlation Between Overshoot Angles(OSA) and Zig-Zag Path Width & Spiral Characteristics

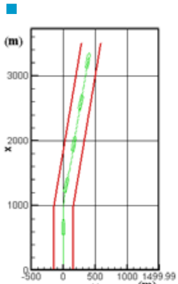
- Higher Correlation of 10/10 Zig-Zag 1st and 2nd OSA
- Relatively Lower Correlation of 20/20 Zig-Zag 1st OSA



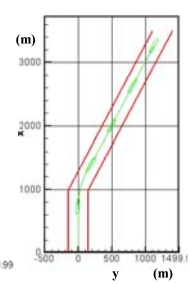
Auto Tracking Simulation

- **Test Condition**
  - Navigation by auto tracking
  - At deep water
  - With full speed
  - No wind, wave, current
- **Autopilot**
  - PD control for rudder
  - No speed control (constant rpm)
  - Tracking the predetermined course

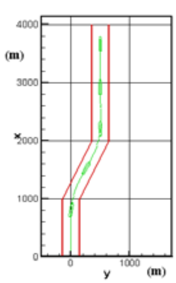
Predetermined courses



- **10°-bent Course**



- **30°-bent Course**



- **Z-type Course**

Navigational Difficulty Index

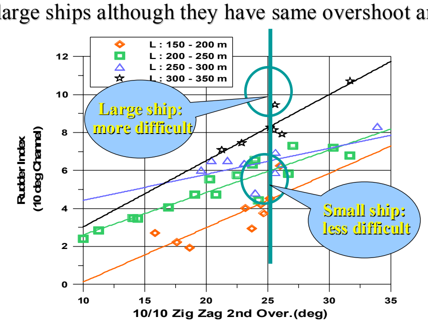
- **Rudder Index**
  - How much rudder angles were used during navigation in averaging sense
  - Ships with poor manoeuvrability have larger value of rudder index.

$$RudderIndex = \frac{1}{T_{Cf} - T_{C0}} \int_{T_{C0}}^{T_{Cf}} |\delta(t)| \; dt$$

Tcf : Time when control ends
Tc0: Time when control starts
δ(t): rudder angle

Navigational Difficulty and Ship Length

- Small ships are maneuverable with less difficulty than large ships although they have same overshoot angles.



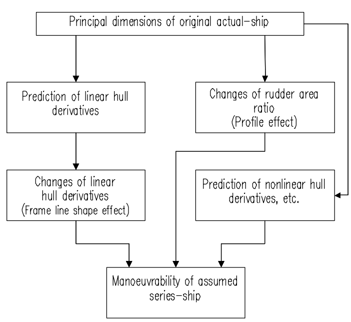
A Ship-handling Simulator Experiments

- **Simulator Study**
  - Using 12 series ships which are generated systematically with different course keeping ability
  - At the waterway of Incheon Harbor in Korea
  - By 5 pilots with more than 15 years' experience
- **Examine the correlation between overshoot angles and degree of manoeuvring difficulty felt by pilots.**

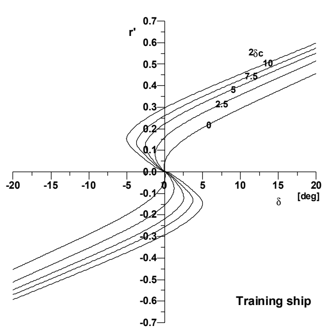
Principal Dimensions of Original Actual-Ships

			Training ship (3,700 GT)	Container ship (4,300 TEU)	Bulk carrier (207,000DWT)
Length bet. per.	L	(m)	93.0	274.0	300.0
Breadth	B	(m)	14.5	32.25	50.0
Depth	D	(m)	7.0	21.7	25.7
Draft	d	(m)	5.2	13.5	18.0
Block coeff.	C_B		0.604	0.65	0.8388
Design Speed	V	(kt)	15.0	23.5	13.5

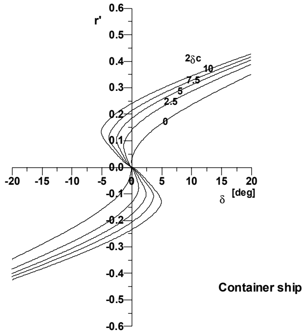
Generation of Series Ships : 12 ships



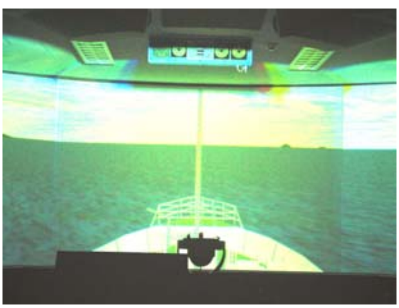
Series Training Ships and Spiral Characteristics



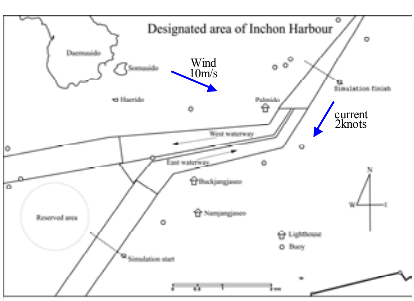
Series Container Ships and Spiral Characteristics



Simulator : Actual View



Game Area : Waterway to Inchon Harbor



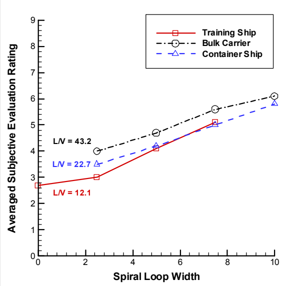
Mission to Shiphandling

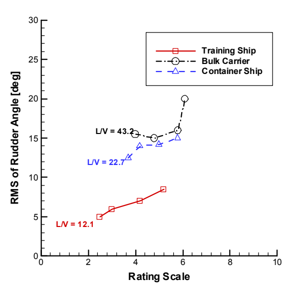
- Passing along the waterway centerline as far as possible
- Keeping propeller RPM constant as that of harbor full speed
- Only rudder command is allowed and pilot issues orally the order to helmsman.

Evaluation by Pilots

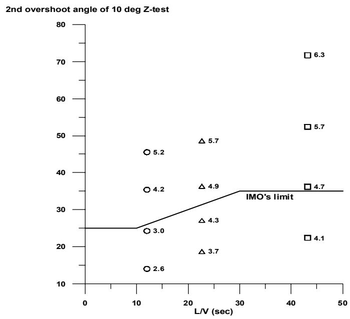
- Evaluate by pilots after simulations immediately
  - Skill required
  - Difficulty of task
  - Stress level
- Rating scales
  - Level ranges from 0 – 9
  - Larger values mean more skill required and more difficulty in task and more stress level

Averaged subjective evaluation rating scales felt by pilots during the simulations

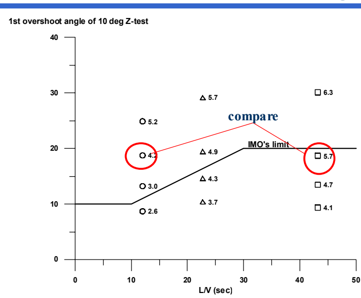




Averaged subjective evaluation rating scales marked on IMO's standard diagram



Averaged subjective evaluation rating scales marked on IMO's standard diagram



Pilots felt that ships with smaller L/V are maneuverable easier than a ship with larger L/V although they have same overshoot angles

Summary

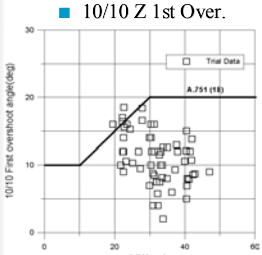
- Ships with shorter length are manoeuvrable with less difficulty than ships with longer length although they have the same overshoot angles.
- Even though some small ships do not satisfy IMO's standards, pilots feel relatively easy in passing through in curved, narrow waterway.
- IMO's standards need to be revised considering practical navigational difficulty.

The Other Maneuvering Indices for Course Keeping & Changing Ability

- **Spiral Width**
  - Related with the directional stability
  - Index for course keeping ability
- **Zig-Zag Path Width**
  - Related with the safety in channel navigation
  - Index for yaw checking ability
- **Correlation between over shoot angles and spiral width and zig-zag path width ?**

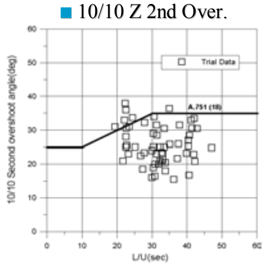
Trial Data : Course keeping & Yaw checking ability (Full & Design Load)

- 10/10 Z 1st Over.



Sub-stand. : 4 (6.8%)

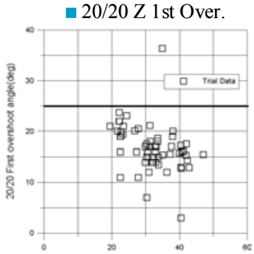
- 10/10 Z 2nd Over.



Sub-stand. : 7 (11.9%)

Trial Data : Course keeping & Yaw checking ability (Full & Design Load)

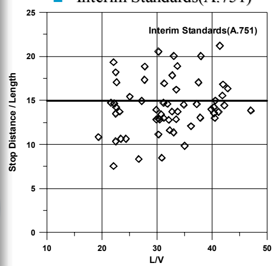
- 20/20 Z 1st Over.

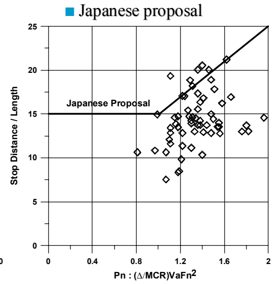


Sub-stand. : 1 (1.7%)

Trial Data : Stopping ability (Full & Design Load)

- Interim Standards(A.751)
- Japanese proposal

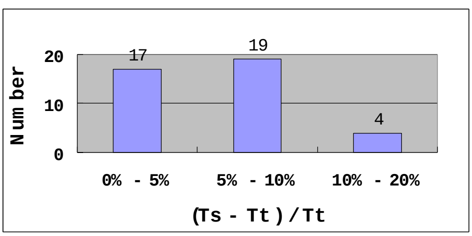




Sub-stand. : 19 (32.2%)

Sub-stand. : 7 (11.9%)

Trial Draft and Scantling (Full load)Draft



Ts : Scantling draft , Tt : Trial draft

Correction Methods

- **Method Option I in Explanatory Notes**

  Vs = Vss / Vst * Vt

  Vs : performance at the scantling draft condition

  Vt : measured performance at the trial draft condition

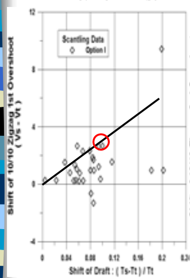
  Vss : estimated performance at the scantling draft condition,

  Vst : estimated performance at the trial draft condition.

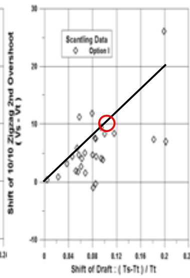
- **Estimating performance**
  - Mview : program for predicting maoeuvring performance at initial design stage

Corrected overshoot angles

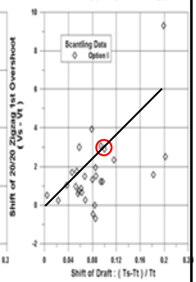
- 10/10 Z 1st



- 10/10 Z 2nd

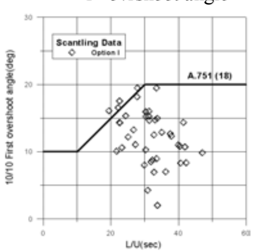


- 20/20 Z 1st



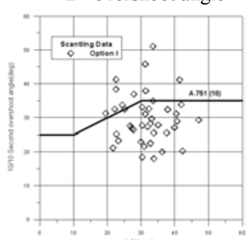
Corrected Data at Full Load : 10/10 zig-zag overshoot angles

- 1st ovrshoot angle



Sub-stand. : 4 (10%)

- 2nd overshoot angle



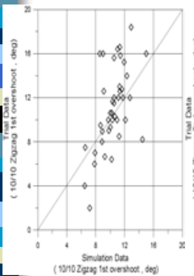
Sub-stand. : 11 (27.5%)

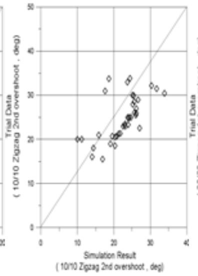
Summary(1)

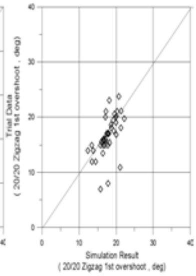
- Complete ship manouvring data of 75 ships are investigated.
- The following criteria are believed to be too severe to satisfy.
  - Track reach in stopping test
    => 32 % of substandard ships
  - 2nd overshoot angles in 10/10 Zig-Zag test
    => 28 % of substandard ships at full load

Prediction of Trial Data

- 10/10 Z 1st
- 10/10 Z 2nd
- 20/20 Z 1st

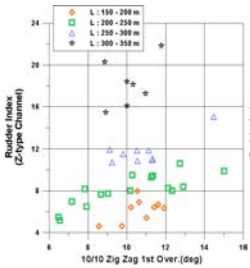


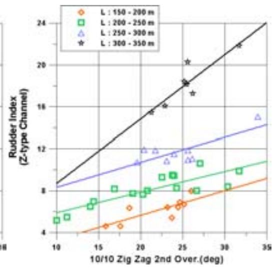




Correlation Between Overshoot Angles(OSA) and Rudder Index

- Necessity of <u>criteria on 10/10 Z 2nd overshoot angle</u>

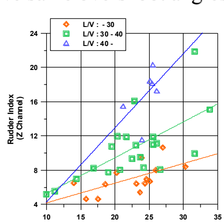


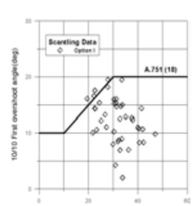


- Z-type Course (10 Z 1st Over.)
- Z-type Course (10 Z 2nd Over.)

IMO standards should vary with L/V ?

- Ships with smaller L/V are maneuverable with less difficulty than ships with larger L/V although they have same overshoot angles

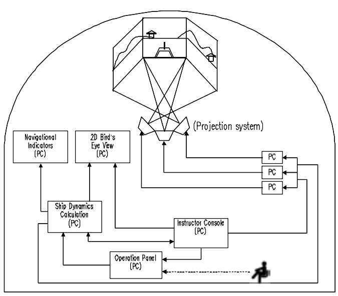




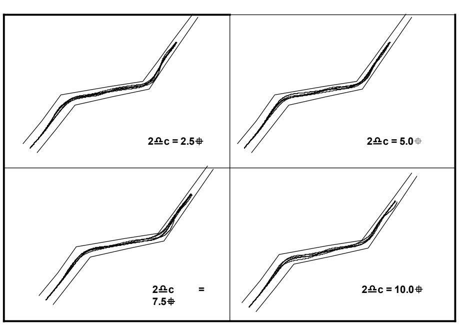
Summary(2)

- 1st and 2nd overshoot angles for 10/10 zig-zag test are good indices for course keeping and changing ability of a ship
- If 1st and 2nd overshoot angles for 10/10 zig-zag test are adopted as criteria for course keeping and changing ability of a ship, 1st overshoot angle for 20/20 zig-zag test is not necessary to be included additionally as an criterion.
- The current interim standards which are varying with L/V ratio should be reconsidered. Ships with smaller L/V would have better maneuverabilty than those with larger L/V although they have larger overshoot angles

Simulator : System



Trajectory of Bulk Carrier

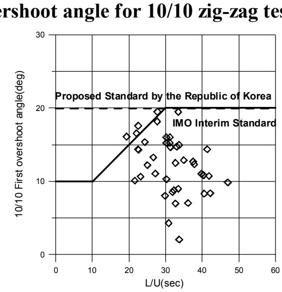


Proposal for yaw checking and course keeping ability standard (1)

- **The criterion of 1st overshoot angle for 20/20 zig-zag test is not necessary**
  - 1st and 2nd overshoot angles of 10/10 zig-zag test are sufficient to evaluate the yaw checking and course keeping ability (Annex 1)
  - To reduce required expenses for unnecessary tests.

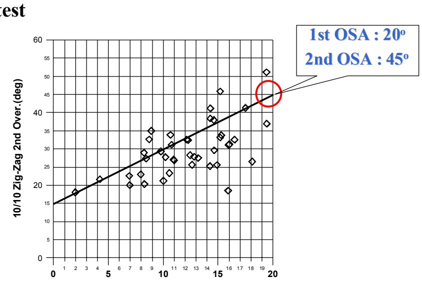
Proposal for yaw checking and course keeping ability standard (2)

- **1st overshoot angle for 10/10 zig-zag test**



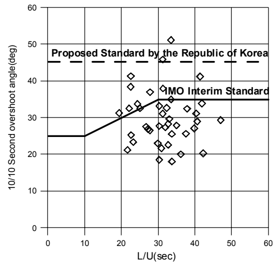
Proposal for yaw checking and course keeping ability standard (3)

- **Relation between 1st and 2nd overshoot angle for 10/10 zig-zag test**



Proposal for yaw checking and course keeping ability standard (4)

- 2nd overshoot angle for 10/10 zig-zag test



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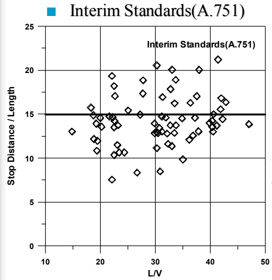
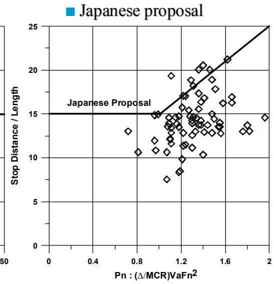
Trial Data : Stopping ability

- Interim Standards(A.751)



Sub-stand. : 21 (28%)

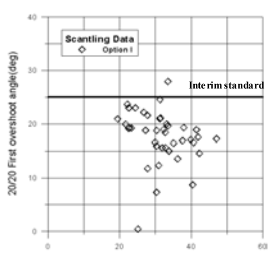
- Japanese proposal



Sub-stand. : 7 (9.3%)

44

Corrected Data at Full Load : 20/20 zig-zag 1st overshoot angles



Sub-stand. : 1 (2.5%)

45

Substandard Ships

- Number of substandard ships increases largely as the trial draft condition changes from design load to full load.

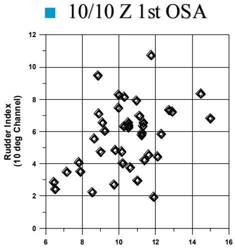
Criteria	Trial Draft Condition (Total : 59 ships)		Scantling Draft Condition (Total : 40 ships)	
	Number	%	Number	%
10 Z 1st Overshoot	4	6.8	4	10.0
10 Z 2nd Overshoot	7	11.9	11	27.5
20 Z 1st Overshoot	1	1.7	1	2.5

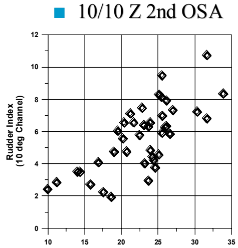
Simulation Program

- **Mview**
  - Program for predicting standard manoeuvring performance at initial design stage.
  - Developed based on HPMM data of 25 series ships and Free Running data of 8 ships
  - Validation with sea trial data of 21 ships

Correlation Between Overshoot Angles(OSA) and Rudder Index

- 10/10 Z 1st OSA
- 10/10 Z 2nd OSA

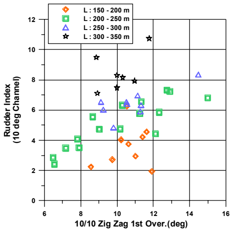




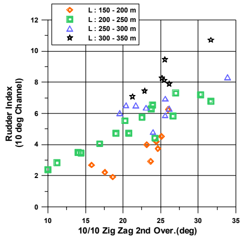
- 10°-bent course

Correlation Between Overshoot Angles(OSA) and Rudder Index

- 10/10 Z 1st OSA



- 10/10 Z 2nd OSA

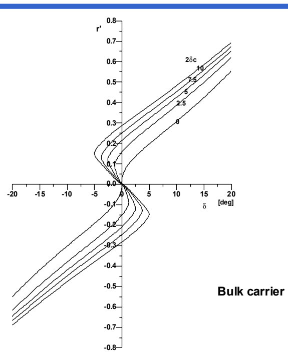


- 10°-bent course

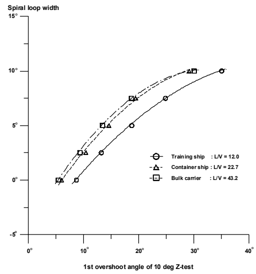
Correlation Between Overshoot Angles (OSA) and Rudder Index

	10°–bent channel	30°–bent channel	Z–type channel
10/10 Zig-Zag 1st OSA	0.405	0.175	0.193
10/10 Zig-Zag 2nd OSA	0.716	0.510	0.525
20/20 Zig-Zag 1st OSA	0.334	0.088	0.084

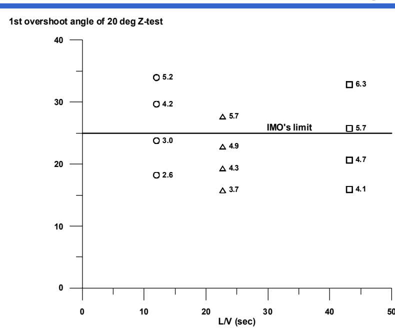
Series Bulk Carriers and Spiral Characteristics



Relation between spiral loops and the 1st overshoot angle of 10 deg Z-test

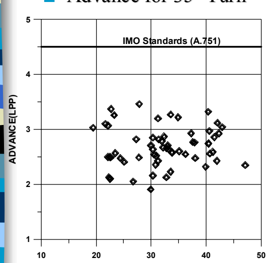


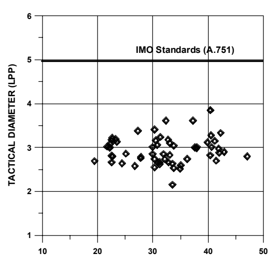
Averaged subjective evaluation rating scales marked on IMO's standard diagram



Trial Data : Turning Ability (Full & Design Load : 59 ships)

- Advance for 35° Turn
- Tactical dia. for 35° turn.





Ship Manoeuvrability Standard and Role of ITTC

Yasuo Yoshimura
Hokkaido University, JAPAN

1. Demand of Manoeuvrability Prediction

International Maritime Organisation (IMO) adopted the interim standards for ship manoeuvrability [1] for the purpose of preventing the marine disasters. It has been accelerating to establish the standard prediction method of ship manoeuvrability.

When designing the ship hull form and rudder, it must be judged whether the manoeuvrability complies with the IMO's standard or not. If the manoeuvrability does not comply with the standard, the designed particulars should be altered until it complies with the standard. In this process, the designer tries to predict the manoeuvrability with the pre-settled ship particulars. For this purpose, the following prediction methods will be applied.

1) Based on performance database
2) Based on free-running model test in tank
3) Based on numerical simulations using captive model test results or theoretical calculation

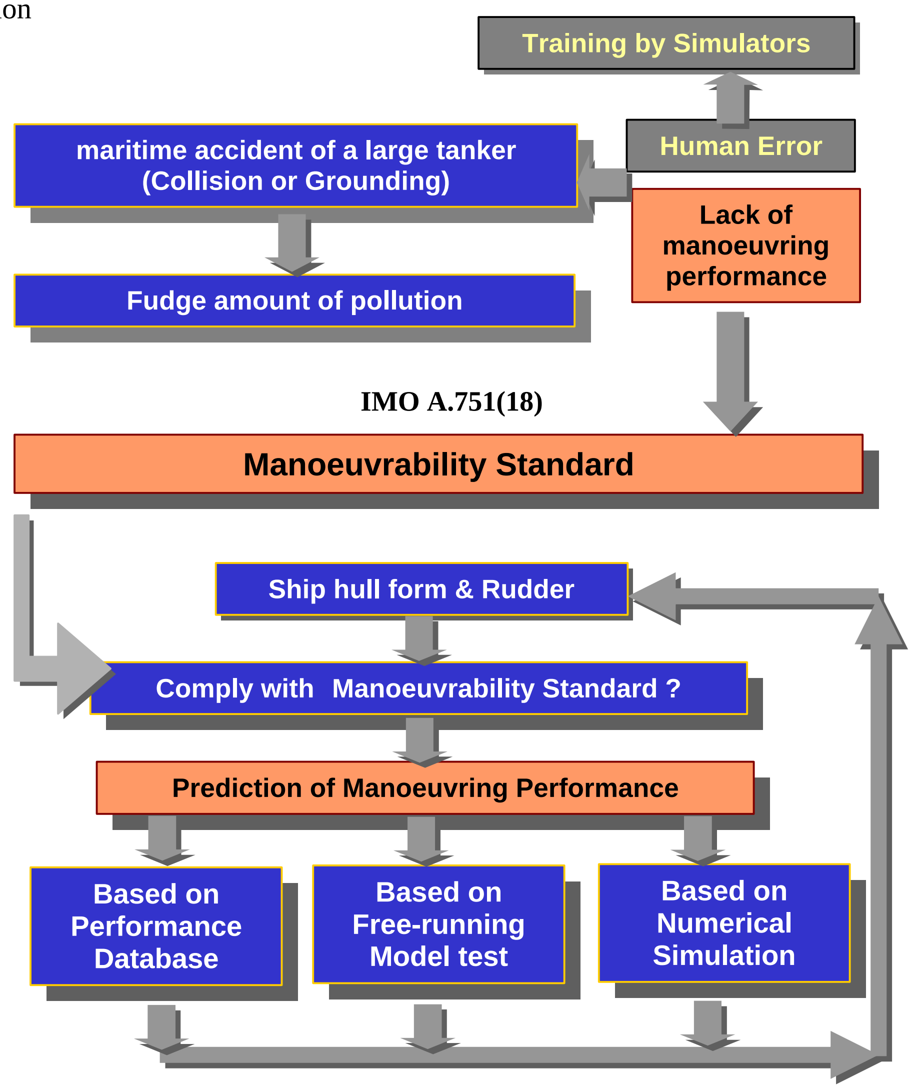


Fig.1 Demand and method of manoeuvrability prediction in the ship design stage.

2. Problems in the Prediction

The prediction methods however, have the following problems.

Free-Running Model Test	Effect of Model Size (Model Scale) Effect of Propeller Load
Captive Model Test	Different Procedure Different Hydrodynamic Model Effect of Propeller Load
Simulation	Different Mathematical Model Different Hydrodynamic Data Not enough Validation

The following manoeuvrability [2] of full load condition becomes quite different, although that of ballast condition is almost the same in each other. In this case, the prediction of manoeuvrability becomes very difficult, because the conventional predicted results become the same [3] since they have the same principal dimensions as shown in Table 1. The stern frame line is just different as shown in Fig.2 between two ships.

Table 1 Principal Dimensions of SR221-A, B Model (Full Load)

	Ship Model-A	Ship Model-B
L_{pp} (m)	3.5000	3.5000
B (m)	0.6344	0.6344
d_m (m)	0.2111	0.2111
Cb	0.8045	0.8018
Cp	0.8084	0.8057
Cw	0.8879	0.8567
$Lcb(\%L_{pp})$	-2.45	-2.61
$A_R/L_{pp}d_m$	1/74.1	1/74.1

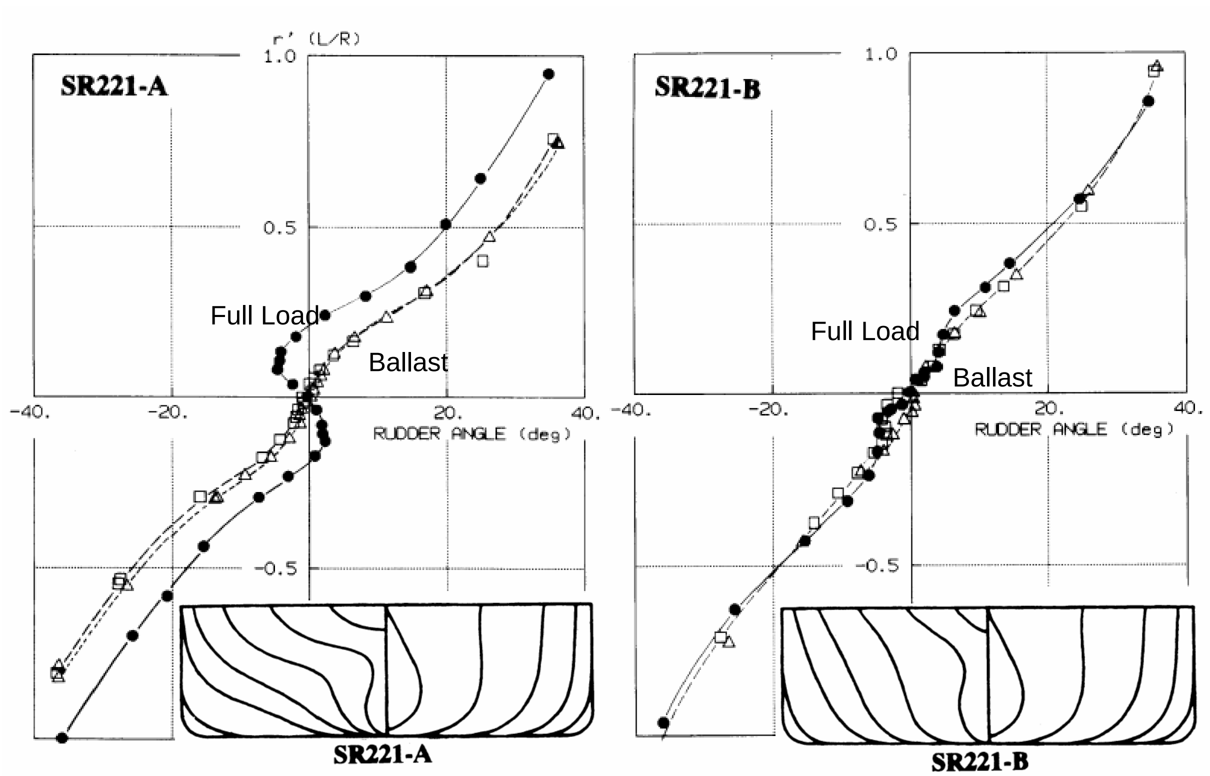
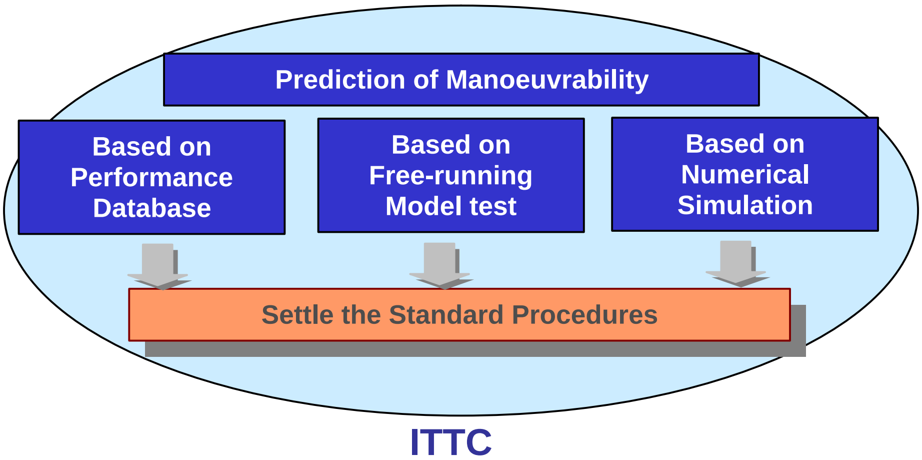


Fig.2 Comparison of spiral curves between two ship models.

3. The Role of ITTC

In order to become the manoeuvrability standard effective, the proper prediction method shall be established particularly for unstable ships whose manoeuvrability becomes critical against the standard. For this purpose, “Esso Osaka” is not suitable for the validation as well as the comparative study because its manoeuvrability is not unstable.

As the results, ITTC has to prepare and settle the standard procedures for the manoeuvrability prediction as well as the model test.



REFERENCES

[1] IMO, "Interim Standards for Ship Manoeuvrability", Resolution A.751 (18), Dec. 1993.

[2] Yoshimura, Y. "Prediction of ship manoeuvrability of SR221 series model with full load and ballast conditions", *Proceedings of Workshop on Ship Manoeuvrability in Kyushu University*, 1998.

[3] Kijima, K., Tanaka, S. and others, “On a Prediction Method of Ship Manoeuvring characteristics”, *Proceedings of MARSIM93, Oct. 1993*, pp285-294

IMO standards and ITTC

Opinions on the IMO Res. 751 manoeuvrability criteria

By
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IMO Res. 751 criteria

- From a safety point of view, there is a need to have some criteria
- It is necessary that the manoeuvres are easy to understand and easy to perform in full scale
- Present standards are ok as a starting point, except the stopping manoeuvre for large ships
- In case of problems with overshoot angles, a larger rudder or a faster rudder rate often solve the problem

IMO Res. 751 criteria and the safety issue

- Purpose of the criteria: reduce risk
- Risk is (sometimes) defined as probability multiplied by consequence
- How much do we reduce the probability of a powered grounding or a collision with the suggested criteria?
- Different ships have different consequences

IMO Res. 751 criteria and the ITTC institutions

- More focus on manoeuvrability means more work, which is good!
- There is a desperate need for more benchmark data to validate our prediction methods, especially for ships which perform close to the criteria
- Data bases of full scale ship manoeuvres are needed but...... we need published ship data together with the manoeuvre results
- Correlate the criteria with first the probability of an accident and next to the risk to be able to quantify the effect

Question:

- The course keeping in beam wind at slow speed is an important manoeuvre, perhaps missing?

Potential role of ITTC regarding IMO Manoeuvring Standards

Contribution to

Group Discusssion B.2 "IMO Standards and ITTC"

by

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Flanders Hydraulics, Antwerp (B)

Introduction. In the Report of the 20th ITTC Manoeuvrability Committee, it was recommended that the ITTC should seek an observer status at IMO: "If ITTC has observer status at IMO, it could give such assistance by providing an international pool of experts in a given discipline (in this case, manoeuvring) to help in the interpretation and application of the deliberations of the various IMO Working Groups.

It is the discussor's opinion that, if an observer status for ITTC in IMO is considered to be of interest for the ITTC community, this should be reflected in the tasks of the general committees – and in particular the Manoeuvring Committee – or in the establishment of specialist committees. Indeed, the former committees have – according to their tasks – restricted themselves to a review of the literature on IMO Standards related topics; more thorough work was not systematically carried out. Therefore, I would like to formulate some suggestions for tasks to be fulfilled by the committees in order to allow the ITTC to fulfil its status as observer as adequately as possible.

Review of manoeuvring criteria. In the first place, a general review of research on manoeuvring criteria and related topics should be carried out, in order to provide a broad theoretical base. Much information has been published, but the collection of these data into a consistent ITTC document would strengthen the position of the organisation. Following items should be included:

- a broad theoretical base,
- an inventory of existing criteria with relevancy for manoeuvring and steering behaviour,
- the relation between these criteria and the present IMO manoeuvring standards;
- an inventory of existing trials.

Some of these tasks were already initiated by the present Manoeuvring Committee. Paragraph 4.7 (Dynamic stability) contains a modest overview of manoeuvring indices; while rewriting the 14th ITTC trial code, an effort was made to associate manoeuvres with handling characteristics.

Manoeuvring criteria prediction. An inventory of and guidelines for the use of methods predicting standard trial results in a design phase should be developed. This document should also contain a methodology for estimating the accuracy of the results and an indication of the sensitivity to inaccuracy of input data. As an example, the effect of errors on experimentally determined coefficients in a mathematical manoeuvring model on the accuracy of the predicted trial results can be mentioned; the Esso Osaka specialist committee performed some work in this field.

Trial correction methods. Trial results must be corrected for external disturbances (wind, waves, current) and loading conditions (draft, trim, GM). The ITTC could take some action to develop guidelines for avoiding or minimising these effects, and for correction of trial results, e.g. through simulation.

Some efforts of the 23rd ITTC Manoeuvring Committee on this topic are published in paragraph 6.1 of the Report.

Shallow and restricted water effects. As ship manoeuvrability characteristics are of most importance in restricted areas, IMO will probably focus on manoeuvring in shallow and restricted waters. The efforts of the 23rd ITTC Manoeuvring Committee should therefore be continued and extended.

Concluding remark. The suggested actions will provide the ITTC with a scientifical, experience based background which is required for its potential observer status within IMO, and which will be beneficial for all member organisations involved.

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23rd International Towing Tank Conference

Contribution to: **Group Discussion B2**
IMO standards and ITTC (Manoeuvring)
Chaired by Dr. M.Hirano

Contribution by: **Dr.ir.J.J.Blok, MARIN The Netherlands**

We welcome the initiative towards a closer cooperation between ITTC and IMO in order to extend the currently very limited set of manoeuvring performance criteria.

A subject that is probably more than anything in need of urgent attention is concerned with the "criteria" to be adopted for the performance of a ship in shallow (and confined) waterways. The IMO criteria currently in use are all very well for deep water and open ocean, and for large ships, but it is in the congested approaches to the harbor, when sailing at reduced speed on small underkeel clearance, that the steering and manoeuvring performance of the ship is really put to the test and where it should really meet certain standards.

We think the maritime industry is really in need of manoeuvring performance criteria in this field, perhaps different criteria for different ship types, becauses of the wide variation in deployment. This would provide a more rational basis for the choice of manoeuvring devices, it would allow harbor authorities to make a better distinction between the good and the bad ships, and would also give them a basis to enforce tug assistence, rather than leave it up to the 'gut feeling' of the master.

In the 1980's there has been an initiative in the USA of combining the experimental research in laboratories with mathematical modelling and finally the full-mission bridge manoeuvring simulator in order to ascertain whether or not a certain ship could negotiate a standardized 'test track', the ABC harbor. Although also in the world of bridge simulators there continues to be an apparent lack of solid criteria this would at least also include 'human factors' into the judgement of the performance of the ship. However, the idea was abandoned.

It is interesting to observe that for virtually all other vehicles in existence, from automobiles, trucks, motorcycles to airplanes, even military helicopters, the standardized test track approach has been adopted. For ships there may in practice be some additional difficulties, time frame, weather-window, that justify a somewhat different approach, yet then the simulator could be put to good use.

In the 1990's there has been an investigation, initiated in the USA and entailing a world-wide survey of bridge simulators, that lead to the rather depressing conclusion that basic research in this field, on human factors, on effects of ship characteristics, on the pro's and con's of some manoeuvring devices was just non-existent; all simulation work being undertaken on a practical heuristic basis. This situation persists up to the present day.

In conclusion, we think it is high time for a renewed and concerted initiative towards "harbor and shallow water manoeuvring criteria", not only because ships characteristics and manoeuvring devices are changing, but also the bridge and the conning process is rapidly changing into a PC workshop, and finally and most importantly, also because society is becoming less and less prepared to accept any mishap as: 'Oh well these things happen from time to time'.

The experience with IMO regulations have shown that in those cases where the scientific community could provide them with their research findings supported by solid data, the IMO was more than prepared to consider these as an interim standard. So why not take the lead here as ITTC and create a research network and initiate and undertake the necessary technical research, rather than be observer to their IMO game. The latter should be done anyway, but by undertaking joint research towards a common goal the ITTC would extend its role as being solely a scientific body and would also become a knowledge body showing responsiveness to the needs of society.

Written discussion to 23rd ITTC Group Discussion on '*IMO Standards and ITTC*'

What should ITTC do for review of IMO Intact Stability Code?

by Naoya Umeda (Osaka University, Japan)

At Sub-committee of SLF 45 of IMO, the review of Code on Intact Stability of All Types of Ships Covered by IMO Instruments, IMO Resolution, A. 749 (18), started this July as one of high-priority agenda items. The code itself was adopted in 1993, which covers all recommended intact stability criteria, such as A. 167 based Rahola's work and A. 562 as the weather criterion based on Japanese and Soviet rules. And major parts of this code are used as mandatory for a ship with a length of 24 m and above within IACS UR L2. Obviously this is a matter of IMO, governments and classification societies. However, once this review will open a door for routes to model tests for approval, ITTC member organisations will be forced to be related with this work. On this occasion, it might be true that ITTC, consisting of towing tanks with their sufficient expertise on physical and numerical experiments, is a more appropriate body than IMO, consisting of governments, for standardising test procedures.

SLF 45 agreed to conduct the review of this code for two different targets in parallel, e.g. short term target and long term target. The former should be reached within 1-2 years; the latter should be done for 5 years.

Short term target

The short term target highlights revision of current weather criteria but allows us to use alternative tools for estimating coefficients in the weather criteria. As closely relevant matters to the ITTC activities, this work requires

1) Standard procedures for estimating the roll period and roll damping in full and model scales.
2) Standard procedures for estimating wind heeling moment in a wind tunnel.
3) Standard procedures for estimating roll amplitudes in random beam waves at a towing tank.
4) Examination of safety level that the current criteria indirectly assume, probably with calculation of capsizing probability.

Long term target

The long term target includes introduction of direct stability assessment with model tests and numerical simulation as alternative routes to prescriptive rules. As closely relevant matters to the ITTC activities, this work requires

1) Standard procedures for capsizing model tests under all wave directions.
2) Standard procedures for capsizing numerical simulation under all wave directions.
3) Methodology for specifying safety level that our society could accept.

Opinions of the discusser

Finally, to realise the above within the specified target date, the discusser presents the following opinions;

1) Statements from ITTC should be based on scientific evidences.
2) Standard procedures of model tests should be feasible in existing tanks of relevant member organisations of ITTC.
3) Accuracy of existing numerical simulation techniques should be extensively examined with model experiments, preferably at ITTC.
4) Concepts of safety equivalence with capsizing probability or equivalent should be established in wider communities including ITTC.

Written discussion to 23rd ITTC Group Discussion on IMO Standards and ITTC

How ITTC can contribute to IMO works?

Yoshiho Ikeda
Osaka Prefecture University

The main role of IMO is to develop technical safety standards and to maintain them. To establish a standard, right understanding of physics of the dangerous problem under consideration and determination of appropriate safety level should be done.

For understanding of physics, ITTC could make some contributions from technical and scientific points of view. The serious problems for IMO, however, sometimes appear suddenly, like the deck water problem for a RORO ship due to the ESTONIA disaster and the bulk carrier safety problem, and public opinion, sometimes overheated, does not allow spending enough time for research works. IMO should solve quickly within very limited period. This may rarely cause inappropriate standards, like Stockholm Agreement, which could not be globally accepted. ITTC may not be a suitable organization to do such argent tasks for IMO although some technical committee of ITTC can supply some technical information about the problems.

Determinations of appropriate safety levels in IMO are sometimes political issues as well as technical issues. The safety levels should be accepted not only by users, operators and shipbuilders but also society. Each country in IMO has different opinions depending on situations of their own marine industries and public opinion. Usually various compromises are needed for establishing a standard. Some countries do some research works to support their insistence in IMO if necessary. Therefore, it seems to be difficult for ITTC to keep neutral position.

For the works for maintenance of the standards, for examples revisions by using more modern and reliable theories and expansion for new-type ships, ITTC can play an important role. ITTC should watch the developed experimental procedures and simulation methods by ITTC members, and report them to IMO for supporting the works to establish or revise the standards.

Performance-based standards may be one of important trend of IMO standards in near future. Then, many ITTC members will make experimental works for their customers according to the standard procedure of IMO. ITTC can play an important role to evaluate and revise the standard procedures from technical points of view.

CONTRIBUTION TO 23rd GROUP DISCUSSION ON IMO-STANDARDS AND ITTC

Chairman: Dr. Masayoshi Hirano

Evaluation of Capsizing Risk by Deterministic Analysis of Extreme Roll Motions

by G. F. Clauss, J. Hennig, Technical University Berlin,
and H. Cramer, Flensburg Shipyard

Demand for Intact Stability Criteria

At present, the assessment of ship stability – intact or damaged – is confined to the fulfilment of empirical criteria related to the static lever arm curve for still water condition only. The IMO intact stability criteria (Resolution A 749, IS-Code) are prescriptive rules based on practical experiences quite some years ago.

Innovative measures for improving the dynamic intact stability of a design are scarcely rewarded or even punished by current rules, even if model tests or direct dynamic simulations show a clear improvement. This is not surprising, as due to market demands ship designs change very rapidly and the current criteria (based on the static lever arm curve for still water condition) are easy to handle neglecting the (dynamical) physical characteristics of modern vessels.

Some of the large Container ships recently suffered from parametric excitation, loosing and/or damaging cargo even with the risk of capsizing. Modern designs are susceptible to parametric excitation, not only Container ships, but also RoRo-, RoPax-, Ferry and Cruise vessels, but luckily most of them have not yet encountered such a dangerous situation - or we have not heard about it. Also quite a few vessels are endangered by pure loss of stability or combinations of parametric excitation as well as loss of stability. Currently the intact stability rules do not cover these dangerous mechanisms and other unfavourable seakeeping characteristics. Ship operators often complain about very short roll periods leading to high accelerations, especially if combined with insufficient roll damping as well as insufficient course-keeping capabilities of vessels in rough weather.

Due to these problems with the current IS-Code a revision process has started at the last IMO-SLF meeting. It has been decided that next to some short term amendments the code should be completely revised with two major aims:

1. all new criteria shall be formulated as performance based criteria
2. alternative direct assessments via model test and/or numerical simulations shall be possible

Consequently the following steps have to be performed in the revision process:

- Identification of safety related situations/mechanisms endangering the intact ship
- Collection of existing knowledge and further research related to physical phenomena endanger-

ing ship stability and safety as well as the assessment of ship performance in dangerous situations

- Development of a framework of performance, based on intact stability criteria
- Definition of criteria with appropriate standards

Direct Assessment

In many areas of ship design and approval direct assessment is accepted to prove sufficient safety or strength (e.g. stress analysis in structural design or evacuation). With respect to the intact stability approval, there are so far no alternative approaches established next to the "simple" fulfilment of the current empirical criteria with its already mentioned deficiencies.

Meanwhile, numerical tools have been developed and successfully tested which allow the evaluation of dangerous and even fatal scenarios. Söding (1987) investigated the loss of the "E.L.M.A. Tres", and France et al. (2001) investigated the problem of parametric excitation of C11 Class Container ships. The use of a "design for safety methodology" – based on direct numerical simulations and a qualitative assessment – allows an increase of ship safety in severe seas without impeding their economical performance (Cramer and Krüger (2001)). Despite the known deficiencies of the presently available numerical tools they can be applied to assess ship safety when being used appropriately.

Still, next to approval problems with most national authorities there is one basic problem when developing or applying direct approaches today: it is unknown what kind of safety level the existing empirical rules represent and which safety level would reach international acceptance. In order to allow a quantitative direct assessment of a ship's intact stability it is therefore necessary to develop methodologies for those alternative approaches and to estimate the internationally tolerable safety level. Those developments are indispensible for the future ship approval and design, as empirical formulations will never be able to provide a sufficiently broad and fair evaluation basis to cover all possible new design developments. This is also reflected in the IMO's decision towards performance based criteria and alternative direct assessments.

Deterministic Seakeeping Tests

For analyzing the mechanism of large roll motions with subsequent capsizing of stationary offshore structures or cruising ships a seakeeping model test technique has been developed which uses deterministic (response based) wave sequences embedded in irregular seas.

The parameters of the model seas - transient wave sequences consisting of random seas or regular wave trains with an embedded deterministic high transient wave - are systematically varied to investigate the ship model response with regard to metacentric height, model velocity, and course angle for different ship types (Kühnlein and Brink (2002), Clauss and Hennig (2002)). The wave elevation at the position of the ship model in time and space is calculated (and controlled by registrations during model tests) in order to relate wave excitation to the resulting roll motion.

Fig. 1 presents a model test with a RO-RO vessel (GM=1.36 m, natural roll period T_R=19.2 s, v=15 kn) in extremely high seas from astern (ITTC spectrum with H_s=15.3 m, T_P=14.6 s, Z-manoeuvre: target course $\mu = \pm 10°$). The upper diagram presents the registration at a stationary wave probe. As the waves are quite high the associated crests are short and steep followed by flat and long troughs. In contrast, the cruising ship – see wave elevation at ship center (moving frame)– apparently experiences extremely long crests and short troughs with periods well above 20 s as the vessel is surfing on top of the waves. Consequently, the ship broaches, and finally capsizes as the vessel roll exceeds 40° and the course becomes uncontrollable (Fig. 2).

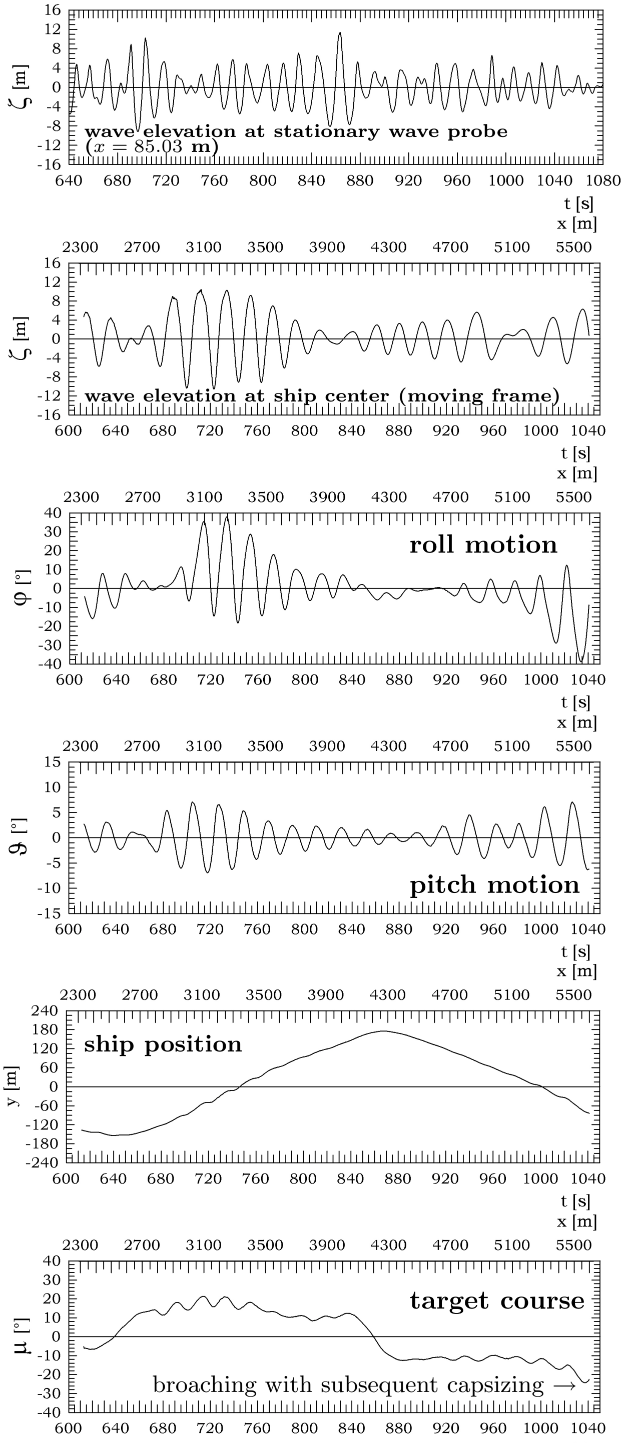

Figure 1: Broaching of the RO-RO vessel (GM=1.36 m, v = 15 kn, Z-manoeuvre at $\mu = \pm 10°$) with subsequent capsizing in harsh seas (T_p = 14.6 s, H_s = 15.3 m).

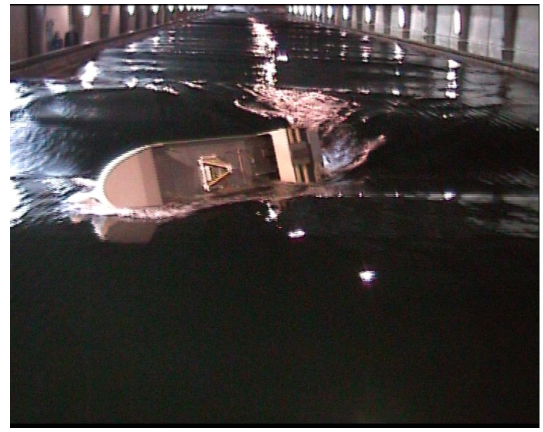

Figure 2: RO-RO vessel in a severe model storm.

Note that the wave characteristics, i. e. wave elevation and the associated pressure field as well as the acceleration and velocity distribution in time and space refer to the moving frame at the center position of the cruising ship, and can be directly correlated to the ship motions by magnitude and phase. As a consequence, the seakeeping behaviour and even the mechanism of capsizing can be evaluated on the basis of non-linear cause and effect chains (Clauss (2002)).

Non-linear Evaluation of Capsizing Risk

Based on systematic experimental tests of this type a non-linear numerical method for simulating ship motions in extreme seas has been developed. With this program polar plots are determined presenting limiting wave heights for capsizing of a vessel depending on its speed and course (Clauss et al. (2002)): As shown in Fig. 3 – left hand side – the most critical regions of resonance motions as well as of parametric rolling are identified. Only a change of trim by 1 m to stern (see right hand side) reduces the capsizing risk considerably. Consequently, the assessment of the seakeeping behaviour of a floating structure requires a highly complex procedure combining non-linear numerical simulation methods validated by deterministic seakeeping tests. As a result, safer ships can be designed and loading conditions optimized, improving ship operation and navigation significantly.

Conclusions

In conclusion, the application of deterministic wave sequences for the evaluation of wave/structure interactions is recommended as an additional tool in numerical wave tank investigations and physical model tests. Aiming for response based design we may assume critical extreme waves and wave sequences, and the analysis will reveal whether we really succeeded in finding the "extreme wave environment", i. e. systematic variations are inevitable.

- In detail, the method can be used as a tool to analyze the mechanism of the structure behaviour in waves because the non-linear cause and effect chains are deduced from deterministically given wave field characteristics like pressure field, particle accelerations and velocities as well as non-linear wave elevation in space and time.
- Wave trains can be designed individually to investigate a specific structure at a certain tank position, i. e. some dedicated regular waves can precede an extremely high wave or wave group for simulating memory effects. By stretching or compressing the peak wave the associated frequency and slope can be tuned accordingly. Also phase relations between incident wave and structure motions can be selected and varied deterministically. Any test can be repeated identically if a specific effect is analyzed.
- Observed wave registrations, like the extremely high New Year Wave Sequence (Fig. 4) can be generated in a wave tank at a selected model scale. Thus, the genesis of extreme events in such wave groups can be analyzed in space and time. Also, the seakeeping behaviour of any structure can be evaluated in such extreme environments.
- Finally, non-linear numerical methods can be developed and validated by dedicated seakeeping model tests in deterministic wave sequences. By systematic simulations even the most critical wave groups may be identified.
- These developments can be used for improving evaluation methods for capsizing risks and – as a consequence – stability criteria.

Acknowledgements

The authors are indebted to the German Federal Ministry of Research and Education (BMBF) for funding the project *ROLL-S* in the framework of which the presented results have been achieved.

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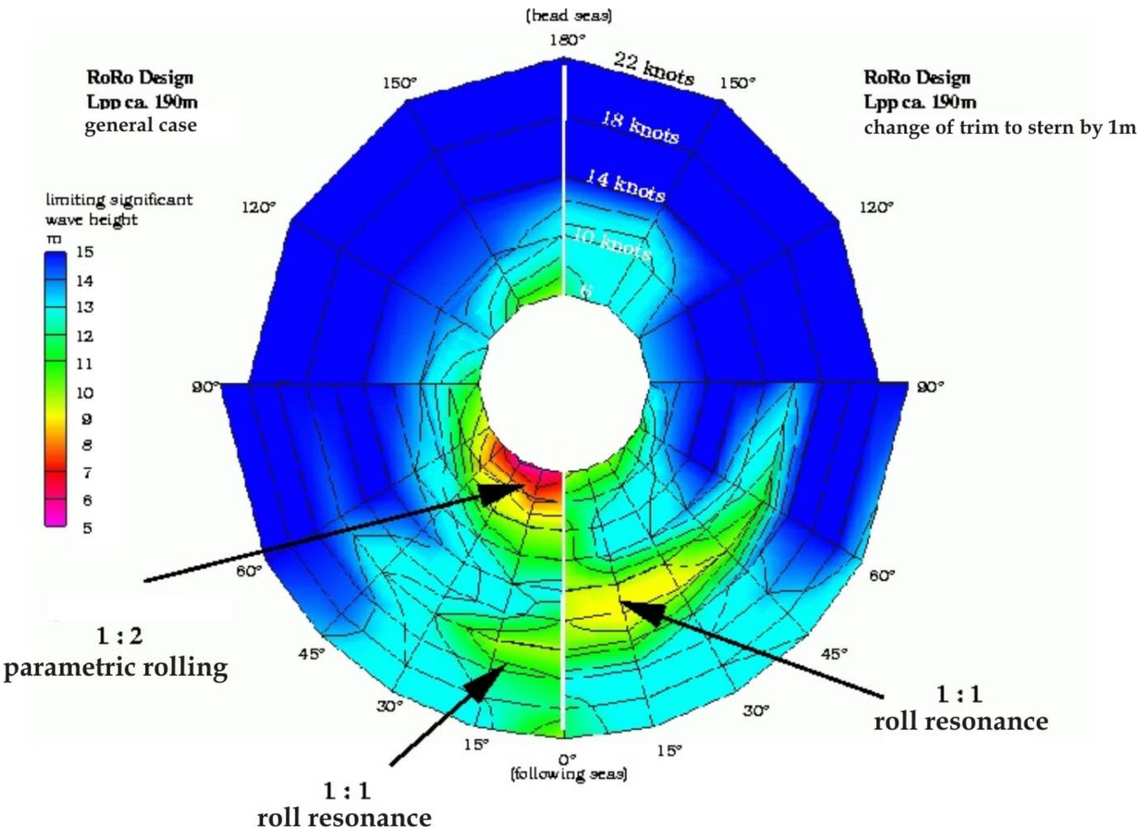


Figure 3: Polar plot with limiting wave heights for a RO-RO design - based on nonlinear calculation methods.

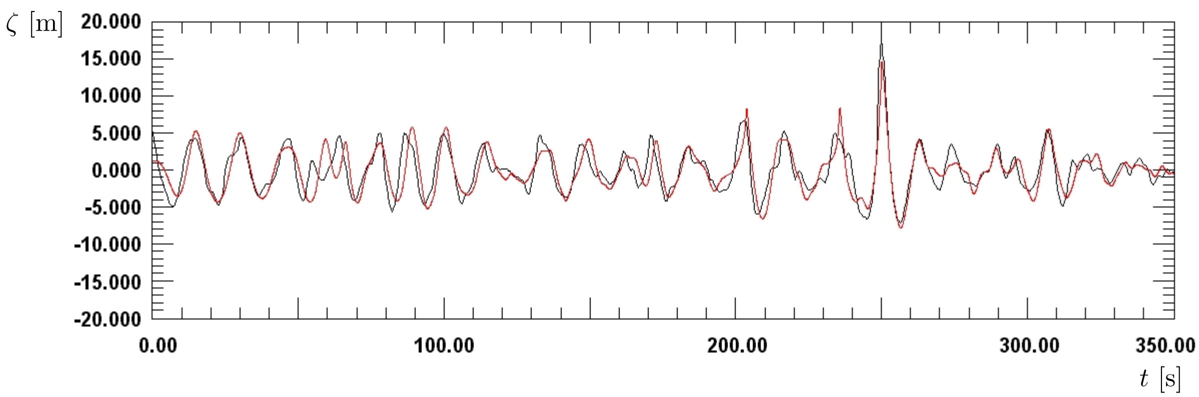


Figure 4: Draupner New Year Wave: Full scale data and wave tank generation (scale 1:81).

Evaluation of Capsizing Risk by Deterministic Analysis of Extreme Roll Motions

Prof. Dr.-Ing. Günther Clauss
Dipl.-Math. techn. Janou Hennig
Technical University Berlin

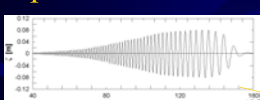
Dipl.-Ing. Heike Cramer
Flensburg Shipyard

Investigation of roll and capsizing processes

- Extreme wave height and steepness
- Wave groupiness
- Propagation velocity and direction
- Loss of stability at the wave crest
- Resonant excitation, parametric excitation
- Broaching due to course instability

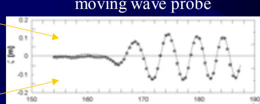
Correlation wave excitation – ship motions
High demands on capsizing test procedure

Non-linear transformation of measured wave trains to the position of the moving ship

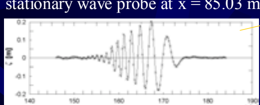


stationary wave probe at x = 8.74 m

moving wave probe

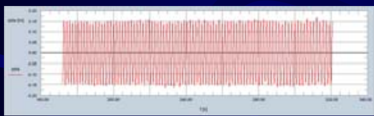


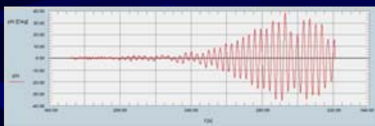
stationary wave probe at x = 85.03 m



velocity of towing carriage
v = 1.65 m/s

Parametric excitation of the RO-RO vessel at regular head seas



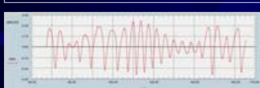


$L/L_{PP} = 1.2$
$H = 11.9$ m
$\mu = 177°$

Video

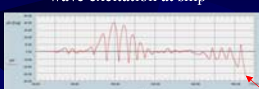
RO-RO vessel at severe seas from astern

GM=1.36 m, v=15 kn, μ=10°, Tp=14.6 s, H_S=15.3 m



wave excitation at ship

course



roll angle > 40°

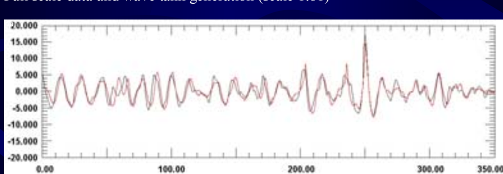
broaching

y(x)

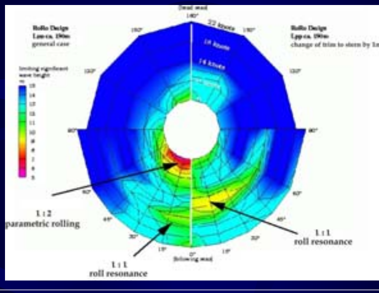
Video

New Year Wave

- Measured on 01/01/95 in the Norwegian sector of the North Sea (Draupner)
- 20 min wave record
- H_s = 11.92 m
- H_{max} = 25.6 m ⇨ H_{max}/H_s = 2.15
- Water depth = 70 m
- Data kindly provided by Statoil
- Full scale data and wave tank generation (scale 1:81)



Evaluation of safety of ship designs: example RO-RO ship



23rd International Towing Tank Conference

Discussion to

IMO Standards and ITTC (Particularly related to Manoeuvring and Capsizing)

David Molyneux
Institute for Marine Dynamics, National Research Council, Canada

The adoption of Resolution 14 at the 1995 SOLAS Convention was a major milestone in the links between model experiments and safety regulation. It allowed model experiments carried out to a prescribed process to be used as an alternative to the classical approach of determining the hydrostatic stability of a damaged passenger ship. The procedures were developed by experts in ferry safety, and followed best practice, based on model experiments carried out prior to 1995. In 1999, the ITTC adopted a procedure for carrying out experiments to determine the survivability of intact and damaged ships in waves. These procedures were developed by experts in model testing and they provided much more detail on model construction, experiment and analysis procedures. In 2001, revisions to the IMO procedures were proposed by Sweden, which reflected practical experience gained between 1995 and 2001. The ITTC Prediction of Extreme Motions and Capsize Committee has also proposed some small revisions to the ITTC methods based on experience.

From an analytical point of view, it makes a lot of sense to study a complex, hydrodynamic problem, such as flooding a damaged ship, with physical models rather than hydrostatic analysis. Modeling provides the opportunity include the complex dynamics resulting from the combinations of ship structural arrangement, freeboard, mean heel, dynamic roll angle and period and wave amplitude and period on the flooding and draining of the deck. But, like all models of a process it includes some inherent simplifications and omissions, which must be fully understood, before reliable conclusions about system performance can be drawn.

Some obvious simplifications in the ro-ro ferry case are the open deck, the wave direction and the simplified damage shape and location. A lot of valuable work has been carried out to try and understand how each of these factors influences the results of experiments. Also there are numerical approaches to the problem, which make similar assumptions and have been well validated against model experiments. However, we must be aware that a pass or fail of the experiment is for regulatory purposes only and does not necessarily mean that the equivalent ship will survive a real collision. As such the results should be considered a performance index, rather than an absolute measure of survivability. Clearly the two have to be related, but how much data do we have on which to make decisions that will stand up against strong legal challenges that might result from an accident in the future?

Whilst there has been discussion on the merits of the technicalities of the different procedures within the ITTC and amongst the experts within its membership at forums such as the International Workshops on Stability and Operational Safety of Ships, there has not been a lot of discussion on the philosophical changes required of ITTC members and the IMO if this type of procedure is widely adopted as an alternative to the classical analysis of a ship's design information. I would like to focus my discussion on how the two organizations might work together in the future to provide rational standards for ship safety.

I propose that we reconsider the process for developing the regulations, with more collaboration between the IMO (and other professional or regulatory bodies) and the ITTC to develop, robust state of the art procedures for evaluating ocean-going systems whose safety depends on complex hydrodynamics.

Firstly, IMO appointed experts and an ITTC appointed group should jointly review the safety regulations and determine which situations would benefit from detailed hydrodynamic modeling (using physical or numerical models). For each of these situations, the IMO must specify the criteria to be met (e.g. 30 minute survival time in 95 percentile highest sea state). Next, the ITTC experts should develop interim guidelines based on literature reviews of related topics and past experience in the field. The next logical step would be to investigate the sensitivity of these guidelines. This is potentially a large amount of work, well beyond the typical good will of member organizations. The ITTC has functioned in the past as a research organization using the funds of its member organizations and their clients. Whilst this might be appropriate for 'established' technologies such as powering and seakeeping, it is much less appropriate for the development of performance-based regulations. This is where organizations such as the IMO must recognize their responsibilities, and fund some of this work directly. Obviously funds should be levered as much as possible with national authorities, national facilities and funders of university research. As a result of this research revised guidelines can be prepared, with a full understanding of their limitations, based on the findings of the research. These guidelines then become the ones adopted by the IMO, subject to periodic revision as required.

It has been observed that discussion on the technical merits of different approaches can highlight the uncertainties of the problem. A high level of disharmony between experts can produce uncertainty in the minds of the regulators. If we recognize this, an organization like the ITTC, which represents a wide diversity of members, can be a harmonizing agent, whereas national delegations may be subject to the strong-minded views of their own particular expert. The consultative process will also give a chance for technical and regulatory experts to discuss their problems outside of the very public forum of IMO.

Some potential problems will exist with this approach. There is always a high degree of interdependency between the experiment method and the facilities at a particular organization. This is something that must always be addressed within the preparation of guidelines, but might be particularly problematic in areas where only a few organizations have been working.

The proposed approach also raises some issues around the legal status of the ITTC. Up to now, it has functioned essentially as a consultative organization, for the purpose of distributing information to members on the state of the art in relevant technologies.

Procedures have been developed for various tests, but member organizations have been free to adopt and adapt as they see fit. If the requirement is for meeting model performance under a specified standard procedure, as in the case of ro-ro ferry survivability, then the legality of an ITTC standard under these circumstances is questionable. However, an IMO standard can be adopted easily by subscribing nations. Any agreement between the IMO and the ITTC should also address liabilities of the member organizations in the event of a model tested to the appropriate standard surviving, but a ship capsizing or sinking.

In conclusion, the development of safety assessments based on performance data from model tests is an exciting opportunity for ITTC members. Up to now, the ITTC has been reactive towards developments in safety regulations. We must respect the IMO for producing guidelines that represented the state of the art at the time under very difficult circumstances. However, the ITTC should be able to quickly assemble committees of experts in any area of model testing ships or offshore structures and would seem to be the natural place to look for a group of experts to develop the technical background to any model test guidelines. The IMO should be more active in supporting the research behind these guidelines, so that there is a full understanding of the implications of the specified elements in the procedure on the accuracy, reliability and cost of a prescribed model test program. I would like to recommend that the ITTC Executive Committee and the IMO jointly investigate their respective roles in the development of new performance-based standards for ship safety.

IMO Standards and ITTC: Discussion

David Molyneux

National Research Council
Institute for Marine Dynamics

NRC · CNRC

Framework for IMO & ITTC Collaboration

- Joint review of ship safety issues dependent on complex hydrodynamics
  - –Flooding & damage
  - –Capsize
  - –Maneuvering
  - –Drop tests (lifeboats)
- IMO specified criteria
- ITTC interim guidelines
- Sensitivity and uncertainty studies carried out by ITTC members
- ITTC/IMO joint procedures

NRC · CNRC

Challenges

- Funding for sensitivity and uncertainty studies so that procedures are rigorous and well understood
- Minimize interdependence of facilities and experiment methods on expected results
- Legalities and liabilities for ITTC members
- Technical debate highlighting uncertainties can make legislators uncomfortable

NRC · CNRC

Recommendations

- ITTC members are becoming responsible for model tests to assess safety of marine systems and ITTC must recognize this
- ITTC must work with IMO to develop rigorous standard experiment procedures which benefit the largest number of member organizations
- Research in this area must be funded since it is beyond the resources of member organizations normal commitment to ITTC

NRC · CNRC

Validation procedure for manoeuvring simulation models

Two types :

• Models for prediction of ship manoeuvrability (IMO manoeuvres)

• Models for use in simulators

Focus on practical guidelines

Steps to be validated:

- Prediction of hydrodynamic forces
- Modelling of forces in mathematical models (derivatives, coefficients,tables, direct simulation of forces)
- Mathematical model structure
- Integration method
- Simulation software
- Simulated manoeuvres

Extract of procedure (1):

- The report should include an adequate ship description
- The expected accuracy of the predicted hydrodynamic forces should be addressed
- The method of scale effect compensation should be documented

Extract of procedure (2):

- For captive tests: It should be documented that the mathematical model can represent the measured forces
- For free sailing/system identification: Validate that the predicted model is able to predict other manoeuvres than the performed free-sailing manoeuvres
- For each documented manoeuvre, a minimum set of required state variables have been defined

Validation

- The applied method should be validated against benchmark data for *at least* one test case
- Uncertainty analysis difficult due to huge amount of input data (captive model test procedure)
- Next best thing; perform uncertainty analysis on input parameters of the applied method

Conclusion

- Practical approach to the problem (how to do in easy steps)
- A ”first version” now exist
- Difficult, must cover many different methods, mathematical models and a lot of parameters
- Recommendation: Adopt the procedure as an intermediate procedure, next committee should continue the work.

QinetiQ

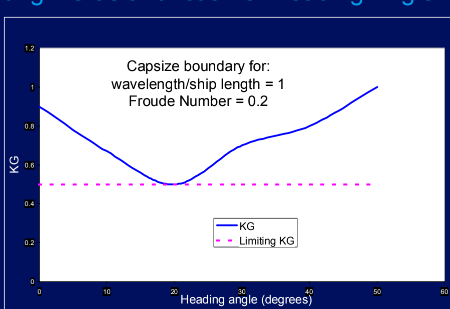
Use of simulation code for regulations

» Irregular or Regular waves?

- Irregular:
  - Statistical, can require long simulation time.
- Regular:
  - deterministic, hence short run time. Can be non-linear.
- Variables:
  - h/λ; λ/L; ψ; Fn $\Rightarrow$ Limiting KG_f

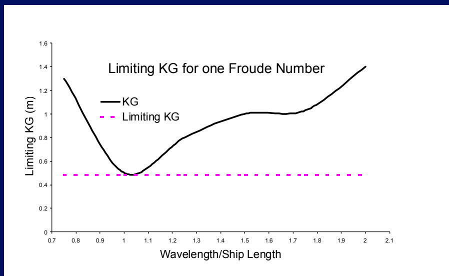
QinetiQ

Limiting KG as a function of Heading Angle

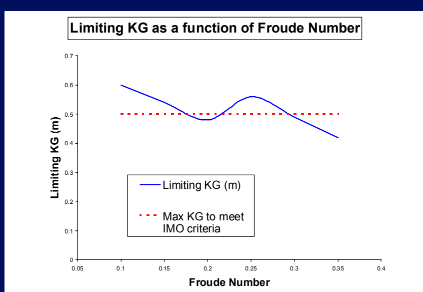


QinetiQ

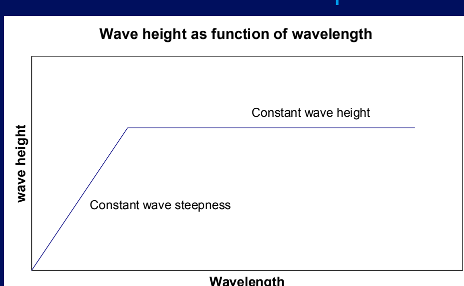
Limiting KG as a function of λ/L



Use of simulation code for regulations



Choice of wave steepness



Use of simulation code for regulations