A GENERIC MANAGEMENT SYSTEM APPROACH TO SHIP OPERATIONAL STABILITY

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Abstract

The subject is concerned with ship stability in the operation phase of a ship's life-cycle and considers the use of a Generic Management System Approach. The paper begins by outlining why there is a need to address a ship's operational stability before reviewing how stability is implemented in practice. Basis of the Generic Management System Approach is then given with emphasis placed on the roles of the two principal components of Management System and Ship Operational Stability Scheme. Practical illustration of the approach is provided via an example. The main conclusion drawn is that ship stability information generated by the designer is not used extensively in the operational phase of the ship's life-cycle and this deficiency can be overcome by the introduction of the GMS Approach.

1. INTRODUCTION

The subject of ship stability has been of interest to all stakeholders associated with the ship ranging from ship designers and ship operators to regulatory bodies and passengers. Stability is a fundamental requirement of a ship is well accepted by everyone. It is therefore not surprising that the subject has aroused great interest amongst the naval architect profession.

In general, most attention has been placed at the design phase of a ship's life-cycle as it is at this stage that the question of stability is first given prominence in the proposed design. This in turn leads to more effort being placed on examining the main characteristic of its stability and also seeking ways of achieving an acceptable level. Over the past three decades there has been a considerable amount of research devoted to ship stability, see for example the series of international conferences on ship stability, [1] to [4], and there is no doubt the subject is now much better understood. Theoretical developments have provided methods of studying the behaviour of ships in both the intact and damaged conditions and enabled prediction methods to be introduced into design considerations.

While great strides have been made in improving the stability of ships in the design phase, less progress have been made to enable the advances made and the solutions obtained to be more readily applied to practice, i.e. at the operational phase of a ship's life–cycle. There are a number of reasons for this state of affairs and the key ones can be summarised as follows:

- Ship operation relies heavily on the experience of the on-board personnel who tend to assume the ship is well designed and their task is to ensure the ship is properly handled.

- It is quite challenging to provide sound information on a ship's stability which is also easy to understand and implement
- The ship operates in an ever changing ocean environment and stability cannot be regarded as an absolute item which is defined once for all times at the design stage.

More attention needs to be given to the stability of a ship at the operational phase because it is the longest phase of the ship' life-cycle and it is also the phase during which the ship has to satisfy the objectives for which it has been designed.

This paper focuses on a method of enhancing the interface between ship design and operation phases from the stability point of view. It begins by briefly reviewing how stability requirements are implemented in practice before outlining a management systems approach The Generic Management System(GMS) approach for ship operational stability is then described and an example is used to illustrate its application.

2. IMPLEMENTING STABILTIY IN PRACTICE

There are a number of methods of implementing the stability requirements of a ship in practice and these will now be briefly reviewed under the following headings.

2.1. Rely on statutory instruments

In this approach the practical implementation is achieved by statutory enforcement and what this means is that the ship will not be allowed to operate unless the operator meets a list of basic requirements. Examples include the loading conditions in order to establish the location of the centre of gravity and value of righting levers.

The main merits of this approach are: a common standard is adopted, lessons from past experience are incorporated, and a guide to the inexperienced on-board personnel is provided.

The main drawbacks include: need to monitor that the requirements are actually put into practice, the experience gained is not documented, the regulations can be inflexible and it takes time to amend any statutory regulations.

2.2. Provide stability information

To assist in ensuring that the on-board personnel can deal with stability in practice, it is useful to provide relevant information to which they can readily refer to in order to perform the calculation and cope with potential stability related problems. A typical example would be a stability booklet in hardcopy form or in computer file.

The main merits of the approach are: key stability information is available on board, it provides sufficient range of data to cope with many situations and it has been prepared for the ship in question.

The main drawbacks are :it is not easy to persuade practitioners to study the information when they are heavily involved with operational tasks and this is particularly true for small ships, stability information is not always presented in reader –friendly form to encourage frequent referral.

2.3. Use of hardware devices

This approach can be regarded as a method of providing helpful information that has stability implications through installing of extra equipment or electronic devices. An example would be the SAFE device linked to the GPS on board trawlers and in this case the device is used to detect presence of offshore oil production equipment on the seabed during fishing so as to avoid snagging of the nets, see [5].

The merits of this approach: an extra dimension is provided to the on-board personnel, and it can be used to improve the operation.

The main drawbacks are: extra cost is involved and additional training is needed

While these approaches have ensured that ship stability is implemented in practice there is considerable scope for improvement. Indeed, there is a need to introduce an approach which can meet some of the following desirable features:

- Improve the interface between design and operation
- Focus on the most critical stability situations
- Ensure documentation of practical procedures
- Encourage the development of a positive ship stability culture
- Allow improvements to be continuous
- Adopt systematic ways of gathering operational experience
- Enable performance to be measured and reviewed.

It is believed that a generic management systems approach can meet most of the requirements

3. BASIS OF THE GMS APPROACH

The background to the Generic Management System (GMS) approach can be found in [6], which is made up of two principal components. One component is a Management System (MS) and the other component is a specific Scheme. In the present case the scheme is the Ship Operational Stability (SOS) Scheme.

The MS part involves the five basic elements, and brief discussion will be given in Section 4. SOSS has six elements and a brief discussion is given in Section 5.

A graphical illustration of the two components of the GMS approach for Ship Operational Stability is given in Figure (1).

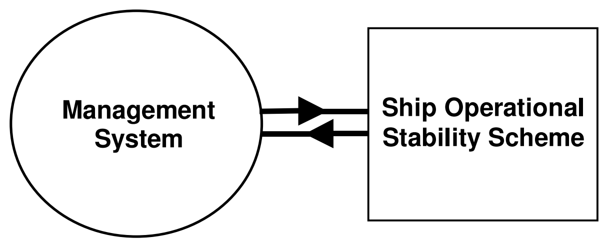

Figure 1 Basis of GMS for Ship Operational Stability

It will be noted the GMS approach has been used in other situations such as evaluating the safety of a system using the Safety Case Concept via the Safety Case Scheme, [7], and performing ship design via the Ship Design Scheme, see [8].

4. MANAGEMENT SYSTEM AND ITS ROLE

To understand what is meant by the term "management system", it is useful to treat it in stages beginning with definitions of "management" and "system". There are many interpretations of the term "management" and it can be generalised as follows:

"The process that co-ordinates activities and resources to meet an objective"

The important points to note are there is an objective to be satisfied and human, physical and financial resources are to be co-coordinated. The term "System" can be defined as follows:

"An arrangement or network that has four inter-connected components of input, output, processor and feedback"

The main steps of a management system are as follows:

Step 1: DEFINE: The objective and acceptance or performance criteria

Step 2: ORGANISE: The resources and plan to ensure the objective can be met

Step 3: IMPLEMENT: The plan in practice

Step 4: MEASURE: The performance criteria and the process by independent methods

Step 5: REVIEW: The lessons learnt and feedback

By arranging these steps along a circuit, see Fig.(2), results in a management system which can be applied to all activities and tasks. There are two features which deserve attention. Firstly, the "measure" step enables the activities and resources to be assessed in an intelligent way in order to establish if the acceptance or performance criteria are satisfied. Secondly, by placing the steps on a circuit that can revolve the refinement would be continuous. It should be noted, however, that refinement does NOT mean a never ending demand for higher and higher standards. In the present case, refinement means achieving the agreed standard more cost-effectively e.g. less effort is needed.

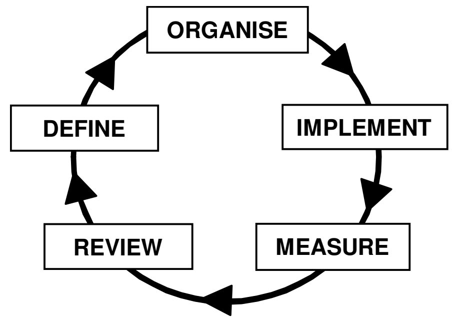

Figure 2. A Typical Management System

The key benefits of a management system can be summarised as follows:

a) <u>Capable of dealing with non-absolute items</u>: Ship operational stability is not an absolute item in a similar manner to quality, design, safety and a management system is needed to ensure the correct balance is achieved at given circumstances.
b) <u>Continuous improvement</u>: It is very difficult to reach the correct standard or level immediately in an activity with no absolute "right" or "wrong" answer and some form of iteration is needed. This is done via continuous refinement via feedback.
c) <u>Independent measurement</u>: All activities require means of assessing how well the acceptance or performance criteria are met and using truly independent methods will ensure proper assessments are done.
d) <u>General applicability</u>: The five basic steps are needed in any activity regardless whether they are technical or non-technical. A management system is needed to "get things done" and controlled within the agreed limits.

Thus a formal definition of a management system can be stated as follows:

"*An arrangement that co-ordinates activities and resources to meet an objective involving main components of input, output, processor and feedback*"

5. ELEMENTS OF THE SHIP OPERATIONAL STABILITY SCHEME

There are six basic elements in the Ship Operational Stability (SOS) and each will now be briefly considered using the coding of OS Element 1 to represent Operational Stability's Element 1 and so on.

OS Element 1: ACQUIRE
Data concerning the operations of the ship and its stability parameters.. Typical examples of the types of information include: operational areas, sea states on the routes, loading conditions and rolling restoring capabilities.

OS Element 2: IDENTIFY
Situations in which the ship's stability can be affected leading to large angle rolling or possibility of capsizing. It is helpful to call these situations as hazards defined here as " something which can lead to undesired outcome in meeting the objective". In the present context the objective is to operate the ship with minimum likelihood of capsizing and anything that can prevent the achievement of this goal would be a hazard. The reason for treating it in this way is because established techniques are available to perform tasks associated with this element. For example, Brainstorming technique would involve a number of experienced on-board ship personnel and ship designer working in a team to identify these hazards.

OS Element 3:ASSESS
The significance of the identified hazards include a mixture of past experience, methods that combine likelihood of occurrence and consequence if the hazard is realised in practice. Once again there are established techniques to perform the work of this element using what is known as qualitative and quantitative methods. It is useful to note that this element is commonly known as 'Risk Assessment".

OS Element 4: REDUCE
Selected risk level of the hazards obtained from the previous element by addressing both the likelihood of occurrence and consequences using a combination of management, engineering and operational methods.

OS Element 5: PREPARE:
For unexpected or emergency situations, e.g. severe listing of the ship and large resonating rolling . While this is often a most likely event, it is essential to have a contingency plan if such accidents should occur.

OS Element 6: OUTPUT
The results obtained from the previous elements. This is essential to have the results in a form which is usable for operational personnel on board ships and be readily interfaced with other activities of the ship.

The elements of the SOS Scheme can be illustrated graphically in Figure (3).

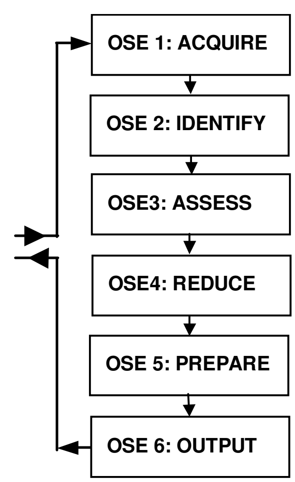

Figure 3. Elements of Ship Operational Stability Scheme

6 PRACTICAL APPLICATION OF THE GMS APPROACH

The practical application of GMS for Ship Operational Stability can be shown graphically in Figure (4). In using this approach it is assumed that in the ship's operational phase there are a number of activities to be performed and stability is one of them. For this reason ship operational stability would be considered as a part of the ship operation process. It is usual to start be defining the goal of ship stability to be achieved and the performance criteria before organising the activities and resources, both human and financial, to ensure the goal can be achieved. The next task would be to implement the Ship Operational Stability Scheme involving the six elements. Once the results are obtained there is a need to ensure they are applied in practice. Measurements are then done to check how well the performance criteria have been met before reviewing the lessons learned and comparing with benchmarks. It should be noted that the elements of the management system lie on a revolving circuit so as to ensure improvements are continuous

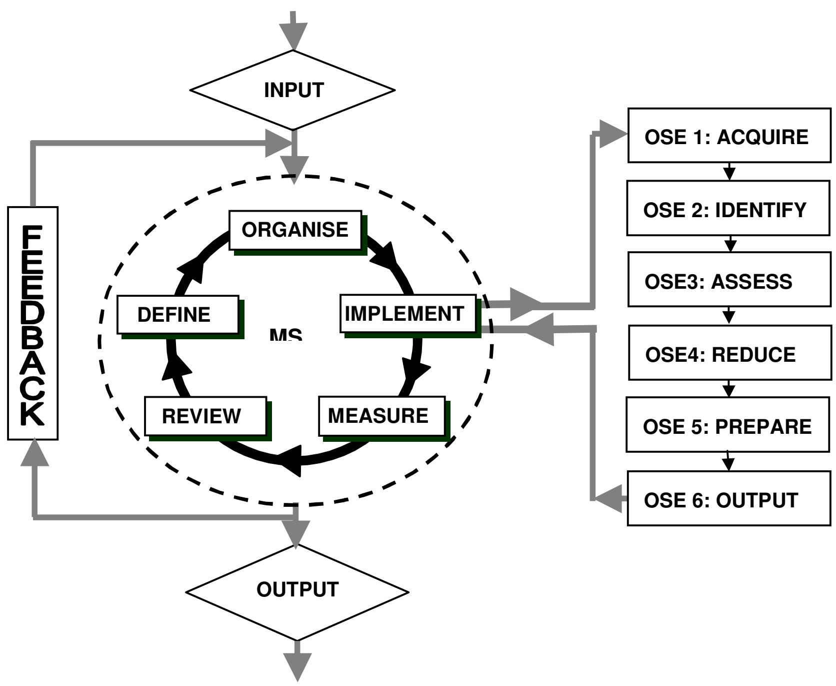

Figure 4. GMS for Ship Operational Stability

7 AN ILLUSTRATIVE EXAMPLE

An example is selected to highlight how the GMS approach for Ship Operational Stability can be applied and these would be considered under the following headings.

7.1. Background

The operational stability situations being considered are for passenger Ro-Ro ships and concern their intact stability. It is assumed the weather conditions can be heavy leading to possibility of capsizing. The ships are designed to satisfy the intact stability regulations.

7.2. The Steps of GMS for Ship Operational Stability

The tasks associated with the five elements of the Management System are:

DEFINE: Tasks include:
The goal

(i) To operate ship in intact conditions that minimise the exposure to capsizing hazard
(ii) To achieve safe passages in the seaways

The performance criteria

(i) The percentage of rolling above 20 degrees should, on average, be less than 5% of recorded rolls.
(ii) Corrective actions should be as soon as possible and within 10 minutes from the onset of exceedence.

ORGANISE: Tasks include:
For the Crew

(i) Briefing on the route is given via "route planning"
(ii) Information on the ship's stability characteristics is provided
(iii) Training, using simulators, on handling of the ship is performed

Actions relating to Hardware

(i) To install appropriate devices for measuring roll amplitudes or provide information of rolling motion
(iii) To interface roll measuring devices with ship's other equipment

On Communication

(i) Establish communication methods on board and with shore
(ii) Formalise documentation of experience relating to operational stability

Use of Computer Programs

(i) Install appropriate computer programs for performing calculations on ship's stability conditions
(ii) Ensure results are presented in user friendly manner

IMPLEMENT: Tasks include:

(i) OSE1: ACQUIRE information on stability characteristics of the ship, its route and environmental conditions
(ii) OSE2: IDENTIFY hazards relating to operational stability, e.g.

H1: Loss of stability on wave crest
H2: Parametric rolling
H3: Broaching in following seas
H4: Shifting of cargo

(iii) OSE3: ASSESS the risk levels of the hazards using qualitative methods, e.g.

The risk levels of hazards are:

H1: Tolerable
H2: Intolerable
H3: Intolerable
H4: Negligible

(iv) OSE4: REDUCE the risk level of intolerable hazards, e.g.
Possible risk reduction methods include:

H2: Alter ship's heading and change ship's speed; output alarm when critical point is exceeded
H3: Detect following sea situations, alter ship's heading and change ship's speed

(v) OSE5: PREPARE for emergencies, e.g.

- Provide advanced simulator training to deal with potential emergencies
- Analyse past experience and devise future operational procedures

(vi) OSE6: OUTPUT information and results, e.g.
- Data related to the performance of operational stability
- Procedure for dealing with the hazards

MEASURE: Tasks include:

(i) Check the operational performances are within criteria
(ii) Ascertain the effectiveness of the management system process

REVIEW: Tasks include:
(i) Benchmarking with other similar ships
(ii) Compile the lessons learnt
(iii) Document experience in fresh procedures
(iv) Feed back the relevant refinements to the DEFINE element.

8. DiSCUSSION

There are a number of issues deserving brief discussion under the following headings:

8.1. Main merits of GMS for Ship Operational Stability

It is helpful to summarise the main merits of the approach as follows:

(i) A formalised method of implementing operational ship stability for practical usage and it is hoped that experience gained can be documented and be available for future use.
(ii) The ship operational stability scheme enables attention to be focused on the most important hazards which have the strongest influence on its operational stability
(iii) The approach also introduced the concept of risk and risk based techniques to operational stability and thus benefit from the advances in this area
(iv) When ship operational stability is based on management system principles, it can readily be interfaced with other activities such as Safety Management System, Design Management System.
(v) The approach encourages ship operational stability to be thought in a similar manner to other aspects of a ship's life-cycle and this in turn will improve overall effectiveness and communication.

8.2. Link to the Educational Programmes for Ship Officers

In the past, as far as ship's operational stability is concerned, the ship's officers were respected for their practical experience. However, in recent years the courses of ship's officers have included modules on ship stability, see for example Ship Stability 1 of the Higher National Unit Specification [9]. The module covered included: loading calculations; interpretation of the righting arm (GZ) curve, understanding "stiff" and "tender" vessels and angle of loll, changes in stability during voyage, effects of free surface and applying relationships of draft, trim, weights and their positions.

The implications of the change would lead to ship officers having both theoretical knowledge and practical experience. There is therefore an opportunity for ship designers to achieve stronger interface with ship officers so that the desirable features of ship's operational stability can be implemented in practice. It is now possible for ship designers and ship officers to jointly perform the ship's operational stability scheme and to encourage the officers to address critical stability hazards in a systematic manner.

8.3. Future Development

The use of Generic Management System Approach to address the ship's operational safety will help to improve safety of ship without increasing the cost of ship operation. The main steps deserving attention include:

(i) Introduce the GMS concept to students of both naval architecture and nautical studies so that there is an early understanding of the subject
(ii) Select a type of ship which is more sensitive to operational stability and is large enough to involve more than a small number of crew, to try out the GMS for operational stability
(iii) Document the experience gained so that procedures are available for other to use in the future

9. CONCLUSIONS

Based on the work outlined in the paper, the following conclusions can be drawn:

(a) Ship stability information generated by designers is not used extensively in the ship operational phase and this deficiency can be overcome with the introduction of General Management System Approach for ship's operational stability
(b) Application of the ship operational stability scheme in practice will enable critical ship stability scenarios which affect operations to be given focused attention
(c) With increase in the knowledge of ship's officers on ship stability, there is a good opportunity for improving the interface between ship designers and ship operations.

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11. ACKNOWLEDGEMENTS

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