CONTRIBUTIONS OF SAFETY MANAGEMENT TO SHIP STABILITY

Chengi Kuo, University of Strathclyde, Glasgow, Scotland c.kuo@strath.ac.uk

ABSTRACT

The address offers me an opportunity to give my views on ship stability. It begins by highlighting a brief history that led to the first STAB conference in 1975 before giving some insight into early efforts on understanding ship stability. Comments are then made on the stability developments before outlining advances in ship safety management. Suggestions on how these advances can contribute to ship stability are given. The address ends with a discussion on some key issues. Main message is that ship stability can benefit from progress made and experience gained in safety management

Keywords: *safety, management system*

1. INTRODUCTION

I am greatly honoured to be giving this address at STAB 2009 in St. Petersburg, Russia. I like to thank the Organising Committee for their kind invitation.

It will not surprise many of you that I will be sharing personal thoughts on the stability of ships and ocean vehicles coupled with the area where I have been devoting most of my research efforts in recent years. If some of the ideas and suggestions I put forward are too thought provoking or too biased, I make no apologises because that was what I expected from these addresses when I was a young researcher and I hope you will take same attitude. Pick up the things you find useful and interesting and listen to others you may disbelieve but let them be an experience. You may find them helpful at a future date.

For me there is an added pleasure for being here in St. Petersburg. I always wanted to visit Hermitage Museum because of my interest in art and what a wonderful opportunity to be able to combine a technical conference with something I enjoy greatly!

1.1 Background to stab conference 1975

My first contact with ship stability practice really started with a meeting in the late 1960's with the late Mr Harry Bird of UK Board of Trade when I was giving a course on CAD for shipbuilding. He explained that he has the responsibility for looking after the ship stability regulations and attended meetings on the behalf of UK government at IMCO- an inter-governmental body before it later became IMO. He told me that in other countries like Japan, Germany and Russia their work were supported by senior academics. No UK academic seemed to be interested in the subject. He then asked me a question in a most causal manner:

"I know this is not your area, but would you like to get involved in ship stability?"

I took the bait although my knowledge of stability was only at undergraduate level and my interest was mainly to pass the examination on the subject! The first task I help them was to verify which computer programs they should approve for static stability calculations. What they were doing was to give interim approval to computer programs which generated GZ curves for their reference design close to the average values of GZ curves of all the submitted programs! I was lucky in having a good batch of undergraduates that year to assist me and got them to work on calculating, by hand, static stability of known geometrical forms from fundamental considerations. The results were then used to compare the submitted computer programs.

Later I worked on using equations of motion to study ship stability with a number of researchers and friends in other disciplines such as applied mathematics. We tried various methods and sought to relate ship stability to other types of stabilities. What I learnt was computer programs must be verified vigorously by other independent methods such as experiments and back up by practical experience. We also recognised that we knew little about the work of others and this turn led to the international conference on stability of ships and ocean vehicles to be held in Glasgow in 1975 with the support of friends from Germany, Japan, Poland, Russia, UK and USA.

1.2 What is ship stability?

Stability is something appreciated by every one associated with ships whether they are ship designers, operators or passengers. In the back of their minds stability is concerned with the ship floating upright. Thus the physical concept of ship stability can be readily interpreted as whether a ship will float upright or upside down. However, to translate this phenomenon into a process for design or operation is a much more difficult task. The earlier proposed definition or explanation can be stated for a ship in calm water, as follows:

"A ship, floating in an upright and equilibrium position, is considered to be stable if it is heeled to one side and returns to its initial position after a short interval of time."

This implies that the influencing parameters are the heeling and restoring moments and time. Thus, for long time it was the restoring lever and the two moments that were used as measure of ship stability, see for example (IMO, 1968 and Sarchin & Goldberg, 1962).

This representation is of course not adequate because ship is not stationary and sea will not always be calm. Thus the attentions of researchers were directed towards introducing ship motions and effects of waves- initially regular waves and later random seas. Examples of progress made can be seen from the paper published in the proceedings of STAB conferences over the years. There are two features worth mentioning here.

Firstly, when ship motions were described by differential equations some researchers came up with the idea for relating stability of the equations of motion to ship stability, (Kuo & Odabasi, 1975). The idea was attractive but no practical solutions were obtained because ship stability is a physical phenomenon would not be readily related to a "stability" that is non-physical. However, in the last two decades, there has been a lot of progress stemming from advances in dynamic systems theory, improvements in numerical modelling and abundant computing power. May be one day a link would be found between ship stability and non-physical stability to overcome the early failures.

Secondly, capsizing was considered to be a sudden behaviour change from a stable state to an unsafe state. Thus it was thought valuable to explore the use of the "catastrophe theory", see (Zeeman, 1974). While some progress has been made, there was extra work and complexity involved in comparison with the static stability approach and has therefore not made the desired acceptance.

It is thus interesting to ask why these attempts have been unsuccessful. There are many possible reasons which may range from inadequate modelling representation to difference between physical stability and non-physical stability. The suggestion I like to share with you is that we lack a proper definition for the stability of a ship operating in random sea. We need a global but practical and achievable definition that can help to focus our research attention.

2. DEVELOPMENTS IN TREATING SHIP STABILITY

Significant advances in the treatment of safety of a system usually follow major disasters when there are large numbers of fatalities and public outcries. The investigation would then produce recommended solutions that are intended to avoid recurrence of similar accidents. Shipping is no exception to this trend. For example, it is well known that sinking of the liner Titanic led to the SOLAS (Safety Of Life At Sea) regulations, (IMO, 1974). For ship stability the major disasters which had most influence was the capsizing of The Herald of Free Enterprise, (Sheen, 1987) and later the loss of Estonia, (Joint Accident Investigation Commission, 1997). Although the public inquiry clearly pinpointed failure of management as the key cause of the accident, it was technical aspects of the Ro Ro ferry that received most of professional attention, e.g. the effects of water on car deck on capsizing, design of barriers to confine free surface, methods of increasing buoyancy cost-effectively, computer simulations of capsize and stability of ships in seaways.

2.1 Some examples of positive development

Risk based techniques: There is now greater awareness and skills in applying risk based methods to ship stability problems and leading to incorporating of these techniques in regulations.

IMO actions: In the past, progress in introducing new safety measures at IMO have been “slow” because of the need to balance the national interests of main players in shipping. To-day, this has changed with IMO willing to examine initiatives and take actions to implement the preferred ones. For example, the modification to SOLAS Part II has allowed equivalence to be adopted.

Internet facilities: The development and embracement of internet and email technologies have opened up vast opportunities for ready access of information on ship stability and communication between interested parties. Provided an information overload is avoided, the facilities can play a most valuable role in progressing ship stability research.

2.2 Some examples of missed opportunities

Physical interpretation of computer results: As computer technology advances there is an increased tendency to go to lot more details and obtain greater accuracies. It is not uncommon to see comparison between two stability solutions being based on data calculated to double digit decimal places with input information reliable only to one decimal place. Little or no attempt is made to give a physical interpretation of the results. If this trend continues, it can be regarded as a disservice to the efforts directed at improving ship stability.

Failure to benefit from advances in safety management: Although management failures play key role s in accidents and have indirect influence on ship’s stability, little attempt is made to explore what can be learnt and adopted from safety management and instead assumes that it is the responsibility of the IMO’s International Safety Management Code, (ISM, 1994) which has no direct link to research interests or efforts.

In summary, there has been better understanding of the mechanism of stability and good progress made on computer simulations of ship behaviour in seaways. However, really useful contributions to practice will only be made when technological advances are integrated with safety management. The next sections will make an attempt to do this.

3. ADVANCES IN SHIP SAFETY MANAGEMENT

While ship stability has received focused attention via STAB conferences, significant advances have been made in ship safety management following some major disasters associated with offshore hydrocarbon exploration and production, see (Alexander Kjelland, 1981 and Ocean Ranger, 1984). The most important disaster was the explosion of oil production installation Piper Alpha in the North Sea in July, 1988. It is after this accident that the Cullen inquiry made 108 recommendations including the replacement of prescriptive regulatory approach by the safety case approach based on the goal setting principle, (Cullen, 1990). Piper Alpha was not a floating structure but the Cullen recommendations affected ships working in the offshore oil industry and maritime industry also unofficially used this method for appropriate activities and situations. I therefore believe the significant advances in safety management can contribute to enhancing ship stability research and application. These will now be considered under the following headings.

3.1 Role of management in safety

Naval architects and engineers tend to have an aversion or arms-length relationship with “management” in that they regard it as not having direct influence on safety or other technological subjects. To give you evidence, I have always asked participants to the safety management workshops to select three factors they most closely associate with safety out of a list of 24 items. They make the three selections before workshop starts and at the end of the workshop. A typical set of results is given in Figure 1.

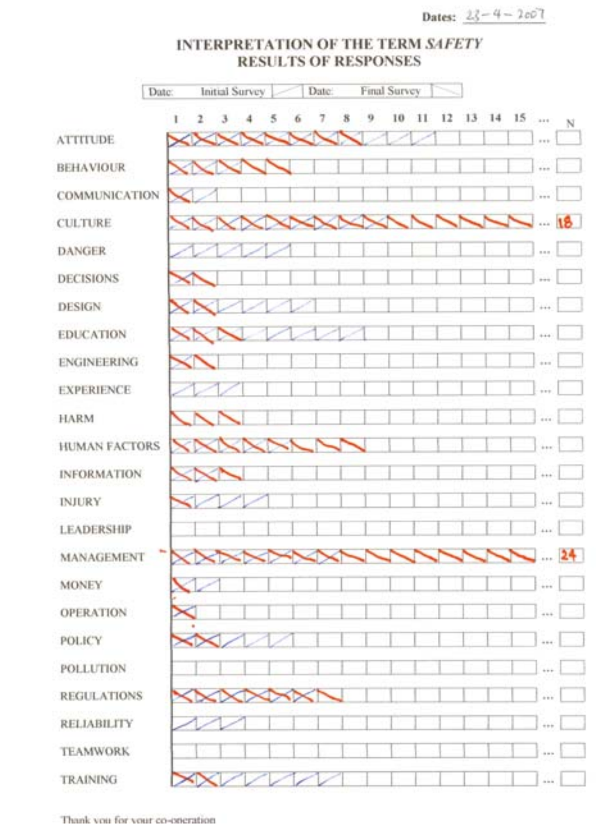

Figure 1. Views of three features most closed associated with safety.

It can be seen that few associate management with safety at the beginning. This trend is similar from data gathered in my first workshop at the Royal Institution Naval Architect, London in 1993 to the latest one held in 2009 at Malaysia. In fact in one country, not a single one of the 30 participants selected management at the start!

Yet it is the management that is responsible for the design, attitude of the people, communication methods, availability of information and use of resources. Indeed, the key findings of The Herald of Free Enterprise disaster was “The management of the company was rotten to the core”, (Sheen, 1987). For this reason, good safety in a ship's life-cycle has to be properly managed so that an acceptable safety standard can be achieved at all levels.

3.2 Safety is not absolute

Ship stability has been treated by prescriptive regulatory approach where both the requirement and method of solution are prescribed. While the approach has merits and is effective for routine and well understood situations, it treats safety as something absolute but every one's perception of what is safety or not safety is different. I was asked to reflect this feature in a short and practical definition of safety, (Kuo, 2007), and this is given as follows:

"A quality used by humans to judge perceived harm"

Because safety is not absolute, the safety requirement would not be absolute either but expressed in a form that include a demonstration that good management practice and mechanism are in place to meet the required safety standard.

3.3 What is safety management?

Having argued that management has the key role in treating safety, it would be useful to define what is meant by the term safety management as applied to the operations of system, situation or activity:

"The process, used by people vested with responsibilities, for co-ordinating the activities and resources effectively in order to ensure a given safety standard can be satisfied while aiming to minimise the perceived harm".

It will be noted that different people at various levels can have responsibility to co-ordinate activities and resources under their control. Safety management can therefore be implemented throughout the organisation.

3.4 Treating a non absolute entity with a management system circuit

Once it is recognised and accepted that safety is not an absolute entity, there is a need to have a technique for treating it. Having searched various possibilities I devised a method I gave the name Generic Management System Circuit approach or GMSC approach, see (Kuo, 2007).

The basis of the methodology involves a management system circuit (MSC) and a process scheme (PS) as given in Figure 2.

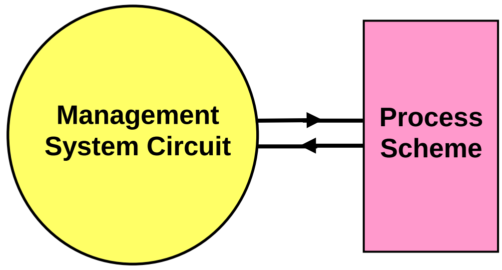

Figure 2. Basic unit of GMSC.

The management system circuit (MSC) has five basic elements and it is used to ensure that the tasks are performed as planned. The five elements are as follows:

Element 1: **Define:** the goal and performance criteria

Element 2:**Organize:**the resources & activities and plan

Element 3: **Implement:** in practice components of process scheme in practice

Element 4: **Measure:** the results obtained and against performance criteria

Element5:**Review:** the experience, lessons learnt, benchmarking before feeding back to Define

By having these elements placed on a revolving circuit, the management system circuit enables iteration to be introduced and continuing improvement to be achieved. The formulations would have essential features which are needed to treat any entity which is not absolute. Examples include: safety with safety scheme, quality with quality scheme, teaching with teaching scheme and research with research scheme.

The process scheme can take any form depending on the circumstances and in general it is made up of a series of components representing the tasks to be performed. In the safety context, there are four components involve identifying the hazards in a system or activity, assessing the risk level of the hazards, reducing risk of those with significant or intolerable risk level and lastly preparing for emergencies should an accident becomes a reality.

In addition to the principal merit of this approach for treating any entity that is not absolute, it can be readily linked to other management system circuits that exist in an organisation. For example, a company would have management system circuits for addressing its business, quality, design, production, maintenance, operation, research and training. Because the management system circuits are in the same form with the individual functions being different, the communication, information handling and decision making would be greatly enhanced.

3.5 GMSC approach and the safety case approach

From the previous section, it may be noted that there is some similarities between GMSC approach and the safety case approach. However, there is a significant difference, see (Kuo, 2007). GMSC approach starts with the management system circuit and implements a safety scheme or any appropriate scheme. In this way, the objective and performance criteria are first defined before implementing the safety scheme.

In the safety case approach, the starting point is the safety scheme in absence of objective and once the four components are processed they are controlled by a safety management system (SMS). This SMS can be in any form without having the facility for treating a non absolute entity.

4. SCOPE FOR CONTRIBUTING TO SHIP STABILITY

From the discussion given in the previous section, there is no reason why ship stability should not benefit from the advances in ship safety management. The three key areas are as follows:

4.1 Non absoluteness of ship stability

From the arguments presented earlier, there is a strong case to suggest that ship stability is also a non absolute entity and this is not surprising because ship stability is a subset of ship safety. By recognising this feature it may lead to researchers coming up with fresh methods for assessing ship stability.

4.2 Using the management system circuit approach

For assessing the stability of new ship concepts or ascertain the stability of ship in special operations from fundamental considerations, it is now possible to use the management system circuit approach in the same way the safety of offshore hydrocarbon installations are being assessed.

4.3 Fresh interpretation of ship stability

Once it is recognised that safety is not absolute, fresh criteria for addressing safety emerged that are also not absolute. For example, the safety requirement of an offshore installation can be stated as follows:

"The risk level of major hazards associated with safety should be tolerable and managed to as high as reasonably practicable standard"

Likewise this approach could be applied to ship stability and a suggested interpretation of the term stability is now given here:

"A ship is said to be stable in a given sea state, if on heeling from its position of equilibrium, it returns to that position within the most appropriate wave period selected for the specific operational region and that the risk of capsizing should be tolerable and managed to as high as reasonably practicable standard"

It is therefore interesting to test whether this interpretation is something which can be used in conjunction with modern methods of addressing ship stability.

5. DISCUSSION

5.1 Future challenges

There are many problems needing research attention and some of the more significant challenges include:

a) Comparing ship stability standard for different types of ships: For every one associated with shipping such as operators, designers and legislators, the ability to compare how different design/ships will perform from stability point of view in various sea states would be a most valuable contribution to safety. Use should be made of the relevant advances once they have verified.

b) Increasing comfort of passengers: As technologies advance it is possible to achieve higher and higher speeds of travel. The limiting factor is not the technology but human comfort. While anti rolling devices are becoming more sophisticated, the challenge is to reduce rolling by cost-effective anti-rolling devices which are applicable broader types of ships.

c) Effective integrating design and operation with external environments: Facilities are becoming available that can measure wave properties in real time over an area around a moving ship. There is therefore a case for integrating the gathered data with ship's performance characteristics so that the operation can minimise the roll motions. Put it another way, to devise a system that can link optimum stability with the auto–pilot onboard. Of course more work is needed to link the motion and stability of the ships to the region and as the ship moves to other regions it would be necessary to input fresh values of significant wave for the new regions.

5.2 Role of education and training

For ship stability to fully benefit from advances in safety management there is a need to give a high priority to education and training. Education is needed to change the mindset because a majority of technically trained persons who tend to be wary about management. Training is required so that the individuals can become proficient at using the techniques related to management. Both can achieve optimum results with teaching methods that put emphasis on interactivity and sharing of knowledge and experience. There are many methods delivering and these range from formal classes and interactive training CD, to distance e-learning methods. Since individual gain knowledge by different methods, it would be difficult to state which method is more effective and generally a combination of methods are needed. However, to be successful two fundamental criteria should be satisfied.

Firstly, it is essential to involve students or participants in the learning process. There is a Chinese proverb which can be stated as follows: "You tell me, I forget. You show me, I understand. You involve me, I learn." Secondly, the performances of the participating students must be measured so that some indications can be obtained on the effectiveness of the education and training programmes.

6. CONCLUSIONS

Based what I have presented, the following conclusions are drawn:

a) Our understanding and knowledge of ship stability and application of the developed techniques have advanced considerably since 1975 and yet there are still lot more research to be done in the future.

b) Stability of ship and ocean vehicles is also something that is not absolute like safety and the Generic Management System Circuit approach offers a suitable methodology for achieving an acceptable ship stability standard while being managed to as high as reasonably practicable.

c) One of the major challenges in the future for managing ship stability is to have techniques for comparing stability of different ships operating in various ocean environments.

7. REFERENCES

Cullen, 1990, “The Public Inquiry into the Piper Alpha Disaster (The Cullen Report)” HMSO Cm: 1310.

Estonia, 1997, “Final report on the MV ESTONIA disaster of 28 September 1994”, Joint accident investigation commission of Estonia, Finland and Sweden. December 1997. The Governments of the Republic of Estonia, Finland and Sweden.

IMO, 1968, Assemble resolution A167 Recommendation for intact stability of passenger and cargo ships with length under 100metres. November 1968.

IMO, 1974, “SOLAS (Safety of Life at Sea)” IMO Regulations.

IMO, 1994, “International Safety Management Code (ISM Code)”. IMO Publication, 186E.

Kuo, C and Odabasi,A.Y ,1975, “Application of dynamics systems approach to ship and ocean vehicle stability” Proc. of International Conf on Stability of ships and Ocean Vehicles, Glasgow, 1975.

Kuo,C, 2007, “Safety management and its maritime application” The Nautical Institute, ISBN 1 870077 83 0.

Norwegian Commission, 1981, “The Alexander L. Kielland accident”, Report of a Norwegian Public Council in 1981 ISBN B0000ED27N.

Royal Comm, 1984, “Report one: The loss of the semisubmersible drill rig Ocean Ranger and its crew”, Royal Commission Report 1984, The government of Canada, Council for Publication citation, Ottawa.

Sarchin, T.H. and Goldberg, L.L, 1962, “Stability and buoyancy criteria for US naval surface ships”, Trans. SNAME, 70.

Sheen, Justice, 1987, “MV Herald of Free Enterprise – Fatal Accident Investigation (Sheen Report)”. Report of Court No.80, 74. UK Department of Transport, HMSO.

Zeeman, E.C., 1974, “A catastrophic model for the stability of ships” Proc Esc Latin-Americas Math, Brazil, 1974.