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Editorial

Safety of maritime transportation

The maritime industry is experiencing one of its longest and fastest period of growth. The past 10 years has seen an annual growth rate of 3.8% in transport volume, and in the past 3 years this growth rate has almost doubled. This correlates strongly with the growth in the world economy and trade. The world order book contains about 4 times as many deadweight (DWT) as the average in the period 1991–2002, and is now at 331 million DWT (up from 79 in 1991–2002). At the same time there is almost no scrapping, which is a natural result of the rather extreme profits, which in some cases has been close to 10 times the operational costs and 3–5 times the operational costs for long periods.

The ship types that dominate, when measured in tons of DWT (Tankers, Bulk Carriers and Container) are now for a large part (about 2/3) built in Asia (China, Korea and Japan), but the European yards that build higher value advanced ships (e.g. Offshore and Cruise) also have full order books for the next years and, as explained by Pil et al. [6], the market of LNG ships is booming. Europe is also giving high priority to fast transportation making the market of high-speed ships an interesting one. However, the operation of these ships brings new problems concerning their safety, as discussed by Antão and Guedes Soares [1].

This market development is taking place at the same time as sustainable development and the global heating due to green house gas emissions is on top of the agenda, demanding reduction in the consumption of fossil fuel, and thereby reduction in the need for e.g. oil tankers and offshore supply vessels. It will be interesting to see which measures are implemented. Shipping people seems to be fairly optimistic, as ships are environmentally friendly transport compared with alternatives, it is not likely that shipping is affected more strongly than other means of transport or other industries in general.

In these times of extremely high activity, we felt it would be appropriate to prepare a special issue dealing with safety of maritime transportation but it has been difficult to convince researchers to contribute with papers in view of their high pressure of work. In addition to market pressures, a large activity is also in regulatory reform and the demand for justification and transparency in regulations is also high on the agenda. This is at least partly reflected in the papers included.

Use of probabilistic methods and formal methods for risk assessment is not new to shipping. For example, the probabilistic damage stability regulations, was an important input to the amendments to SOLAS approved by the International Maritime Organization's (IMO) Maritime Safety Committee in December 2004. This work can be traced back to the late 1960s, when Prof. Wendel of Hannover/Hamburg Universities outlined his ideas on the "Subdivision of Ships". Subsequent work by a specialist IMO group used his basic ideas to develop a new set of subdivision regulations. The outcome of this work was the "Equivalent Passenger Ship Regulations", based on probabilistic analysis, and allowing freedom for the designer as long as the conditional probability of surviving a collision is acceptable. Though the basic concept is universal and still valid today, there were several assumptions and parameters to be validated based on the evolution of ship types and traffic routes.

Very little was done to derive new and updated statistics on damage extent following a collision. The new regulation, developed mainly by ship stability experts/researchers in the HARDER project, is now fully probabilistic, with a well-defined method for doing the analysis and with certified software. The required survivability of the ship in a collision is also given in the regulation. The paper by Papanikolaou and Eliopoulou [3] is explaining more details of the development of the new damage stability regulations. The main point for the designer is the large freedom on how to subdivide the ship, and is an example of a goal and risk-based regulation and design method that are now debated at IMO as a general approach to regulation. For example, while probabilistic damage stability deals with probabilities of water flowing into the ship, probabilistic oil outflow analysis deals with the potential pollution of oil flowing out of a damaged vessel. A new regulation based on this approach was decided upon by IMO in 2003.

The most important trend on implementing risk assessment as a basis for regulation in shipping is represented by the development and use of Formal Safety Assessment (FSA), as exemplified in brief in the paper by Vanem et al. [5]. The FSA initiative was taken by the British maritime authorities at IMO in 1995, following Lord Carver's 1992 report on maritime safety. It had been realized that the work at IMO was largely initiated by ship losses, and little systematic preventive work was being done. Bulk-carrier

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losses were intolerably high during the early 1990s, and many questioned the efficiency of IMO and the classification societies in dealing with the problem. After the first introduction of FSA, risk-analysis expertise was soon mobilized in many organizations. The International Association of Classification Societies (IACS) established an internal working group to contribute to the IMO FSA guidelines, and contributed by the full content of the human reliability analysis. While work on these IMO guidelines was still in progress, DNV carried out a FSA on bulk-carrier integrity, which was the basis of IACS' decision to strengthen the bulkheads between the two foremost cargo holds on such vessels in 1997. The decision was based on cost-effectiveness and a parameter later referred to as "Net Cost of Averting a Fatality" in the subsequent IMO Guidelines. The bulk-carrier report was widely distributed and helped make FSA understandable to many in the shipping industry. Later studies have included an extensive FSA on Bulk Carrier Safety, Free Fall Lifeboats, Helicopter Landing Areas on Cruise Ships, Navigation of Large Passenger Ships, and introduction of Electronic Chart Display and Information System as a mandatory requirement.

The paper by Trucco [2] is detailing the use of Bayesian Network techniques, a method used in the last two of these FSAs, which both relates to Navigation and therefore the risk models contain many dependencies between the technical systems and the human element. For these types of modeling challenges, Bayesian Network models have proven very useful. It is also confirmed by many studies that the human operator is increasing the contribution to ship accidents, as also explained by Antão and Guedes Soares [1], further increasing the relevance of these modeling techniques.

Probabilistic and risk-based methods are important in the maritime industry today, as these methods are considered the basis for the long-term development of Goal-Based Standards (GBS), an activity which was initiated at IMO in 2004. The basic idea with GBS, or more correctly Goal-Based Regulations (GBR) is to better organize the regulations following a functional approach. The functional requirements and safety requirement are made part of the IMO conventions but allows for different prescriptive standards or rules that are verified to comply with the conventions. In the process it is also the intention to verify the rules of the classification societies. These ideas are expressed by the current definitions of GBS.

IMO Goal-Based Standards are:

- broad, over-arching safety, environmental and/or security standards that ships are to meet during their lifecycle;
- the required level to be achieved by the requirements applied by class societies, administrations and IMO;
- clear, demonstrable, verifiable, long-standing and achievable irrespective of ship design and technology;
- specific enough in order not to be open to differing interpretations.

The structure of the regulations is described in Fig. 1.

The current GBS debate is focused on the relationship between IMO and the Classification Societies, and the IACS Common Structural Rules, the topic also of the paper by Parunov and Guedes Soares [4], are used to test the current verification procedure, which is the topic of the contribution. Currently, IMO and the Flag States are not much involved in defining the structural strength standards for ships. This is in practice defined by the Classification societies, and followed up by Class surveys during the operational life of the ship. IACS has argued, and demonstrated that a Structural Reliability Analysis (SRA) is a perfect tool for justifying that the rules are in compliance with the IMO risk acceptance criteria. Therefore the analysis following a similar approach as in the paper by Parunov and Guedes Soares [4] can be used as justification, and the verification according to GBS will be a standard verification of a structural code calibration based on SRA, and obviously the industry is very much interested in knowing consequences of the re-calibrated rules in terms of steel weight and costs, as discussed in [4].

For the high value ships and in order to facilitate innovation in ship design, there are also many activities to develop a regulatory system that allow for more direct use of risk analysis in design. This design approach is usually referred to as risk-based design. Also, this development will be easier if the regulations also were risk based, and justified by FSA and SRA, as risk (and reliability/availability) information used to justify the regulations was available and could be referred to as target reliabilities, availabilities or risks for the innovative designs. It has been a challenge to set acceptance criteria at a functional or system level that are consistent with the acceptance criteria at the ship level, largely because of the lack of comprehensive FSA studies. The paper by Ruud and Mikkelsen [8] is an example illustrating an approach using the FSA ideas applied to setting target safety level. This approach, which is generally applicable, is linking the Safety Integrity Level and Barrier Integrity Level concepts used in IEC 61508 to the IMO FSA

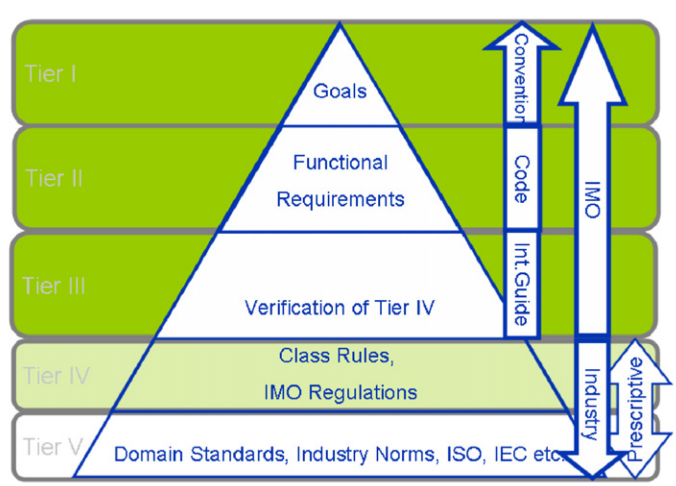

Fig. 1. Scope of goal-based design.

risk acceptance criteria. The risk acceptance criteria for safety are now documented in the IMO FSA Guidelines, and for environmental risk a criterion has been proposed along the lines briefly documented in Vanem et al. [7]. This example in [7] is therefore a good example on how domain standards like IEC standards may be used in the regulatory system for ships in a consistent and transparent way, and in accordance with the GBR principles.

In a Special Issue dealing with Maritime Transportation, it can be appropriate to include an historical note about the word "*risk*".

Dictionaries confirm that the Latin word comes from a Greek navigation term rhizikon, rhiza ($\rho\iota\zeta\alpha$) that meant "root, stone, cut of the firm land" and was a metaphor for "difficulty to avoid in the sea". The term is used in Homer's Rhapsody M of Odyssey "Sirens, Scylla, Charybdee and the bulls of Helios (Sun)". Odysseus tried to save himself from Charybdee at the cliffs ($\rho\iota\zeta\alpha$) of Scylla. The Latin (resicum, risicum, riscus: cliff, récif, Felsklippe) is the direct formal origin for Italian (risico, risco, rischio), Portuguese risco, Spanish riesgo and French risque. English borrowed it from Portuguese or Italian, German from Italian and both were confirmed by the French risque of the 18th century.

These lexical borrowings happened in the end of the middle-ages, when mentalities woke up and people dared to discover the world, so that from the 16th century on, the term got a benefit meaning, for example the German 'Rysigo' became a technical term for business, with the meaning "to dare, to undertake, enterprise, hope for economic success". But, the origin of the term seems to be related to ships' risk of grounding on a cliff ($\rho\iota\zeta\alpha$).

With this historical note, we hope that this series of papers related with maritime transportation may provide an overview about how the application of the probabilistic-based methods is allowing the progress in that sector.

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Rolf Skjong
Det Norske Veritas, Norway

C. Guedes Soares
Technical University of Lisbon,
Instituto Superior Técnico, Portugal
E-mail address: guedess@mar.ist.utl.pt