



**IAMU 2012 Research Project**  
(No. 2012-4)

**Shipping challenges**  
**MAREM - Enhanced Management Capacity**  
**of the Maritime Industry Personnel**

By

Constanta Maritime University (CMU)

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Constanta Maritime University (CMU)**

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# Final Report for the FY2012 IAMU Capacity building Project

## Theme: Shipping challenges

### MAREM – Enhanced Management Capacity of the Maritime Industry Personnel

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**Abstract:** Safety was and still is the most important aspect of activities onboard ships. In time, due to the development of new threats against sea transport, security becomes the same importance with safety. Achieving of the present standards regarding ship, personnel, passengers and environment safety and security can be realized through a specific training. Taking in consideration actual requirements related to maritime transport safety and security, in particular at management level, Constanta Maritime University, in cooperation with Varna Naval Academy, have decided to initiate and develop a Master degree dedicated to training in these matters. In the present paper is intended to present the objectives and goals of the project entitled “MAREM – Enhancing management capacity of the maritime industry personnel”..

**Keywords:** Safety, security, enhancing, managerial skills, master degree

## 1. Introduction

Today, the safety and security of life at sea, protection of the marine environment and over 90% of the world's trade depends on the professionalism and competence of seafarers. The IMO's International Convention on Standard of Training, Certification and Watchkeeping for Seafarers (STCW), with all amendments made, is the only one internationally-agreed Convention to address the issue of minimum standards of competence for seafarers, and, in the same time, to provide effective mechanisms for enforcement of its provisions [8].

Safety on board ships has come a long way in reducing accidents, but there is still a lot of scope to improve safety. Most of the accidents at sea are due to human error, which can be reduced by proper training and motivation. Accidents mainly happen due to lack of management, taking shortcuts, complacency, attitudes, etc. The responsibilities to avoid incidents based on safety and security flow from the top management levels, from the shore establishment to onboard management officers, especially to the Master, to each and every individual onboard [9].

The dynamic nature of the regulatory environment for security in the international trade and maritime transport requires that personnel involved have to maintain an active awareness of new or evolving requirements that may apply to their vessels and operations. This means being able to integrate the latest requirements into their existing security plans, to achieve the desired level of compliance with the letter and intent of the new regulations. In this way, is required that personnel with duties on ship security to maintain an awareness of changes or additions to the expanding universe of domestic and international regulations that may have an impact on their ability to maintain a secure operating environment [7].

## 2. The “MAREM” Project objectives and goals

The complexity of modern maritime transport and the increasing risks related to safety and security lead to a significant challenge to maritime education. The growth of international maritime trade, combined with the increased threats on maritime safety and security, lead to the necessity of better trained personnel onboard ships, able to manage these new situations and satisfy the highest levels of safety and security requirements on seas.

In line with this, the overall objective of the “MAREM” project is:

A) To develop a novel approaches for maritime academic safety and security programs that meet the requirements of modern maritime industry. The idea is to achieve the objective by establishing a Master degree program in Maritime transportation safety and security. Taking into account, on one hand, that maritime transportation is international by nature, and on the other, that the International Association of Maritime Universities (IAMU) goal is to develop a comprehensive Maritime Education System for following generations, the initial Master degree program is to be established in cooperation between two maritime universities - Constanta Maritime University (Romania) and "N. Vaptsarov" Naval Academy (Bulgaria).

Therefore, the project objectives are:

B) To establish an international cooperation in the area of modern maritime education. The cooperation between maritime institutions is not completed by the involvement of two universities. The project relies on academic participation of a wide variety of representatives from the maritime community: maritime industry representatives, involved authorities, Black Sea maritime universities, members of the International Association of Maritime Universities.

In this context and taking into account the International Association of Maritime Universities (IAMU) goal for preparing and developing standardized Undergraduate Curricula and an International Certification System for Competency, the following two additional projects objectives are valid:

C) To establish a common understanding on the priorities of modern maritime education and a basis for common standards for maritime competency of the management personnel;

D) To enhance the cooperation and communication between maritime universities and maritime industry in the area of advanced maritime education and training.

### **3. Modern maritime safety and security matters and requirements to the maritime education and training**

#### ***3.1 Actual considerations on maritime safety***

The maritime safety has main objectives the reduction and elimination of accidents which involve injuries to ship' personnel and damage to property and the environment [5]. These objectives can be reached through strong principles about safety. Accidents are the last step in a chain of deficiencies. To avoid accidents is necessary to eliminate previous deficiencies. Elimination of these deficiencies is made through safety policies applied in different activity sectors onboard ship, like safety of navigation or safety of ship operations.

In the maritime field, safety has to be seen as a culture and to be applied in all activities. From this point of view, safety is of interest of all management level officers, because improving of it saves lives and as well as money. When makes references to safety culture, experts commonly describe it as the values and practices that management and personnel share to ensure that risks are minimised and mitigated to the greatest degree possible. In a way, can be said always safety is the first priority. With a true safety culture, every crew member thinks about safety, and new ways of improving it. The cause of practically every unsafe incident can be traced to some form of human or organisational error. If people think about safety continuously, many accidents simply will not happen because virtually all so called "accidents" are in fact preventable.

For the analysis of maritime safety levels, International Maritime Organisation use concepts like Human Element Analysing Process and Formal Safety Assessment. The Human Element Analysing Process is a practical and non-scientific checklist to assist regulators in ensuring that all the human element aspects related to the ship and its equipment, and the master and his crew, have been taken into consideration.

Formal Safety Assessment is a structured and systematic methodology, aimed at enhancing maritime safety, including protection of life, health, the marine environment and property, by using risk and cost/benefit assessment. This concepts can be used as a tool to help in the evaluation of new regulations for maritime safety and protection of marine environment or making a comparison between existing and possibly improved regulations, with a view to achieving a balance between the various technical and operational issues, including the human element, and between maritime safety or protection of marine environment and costs [4].

An important step for increasing safety was done with the ISM Code implementation. The ISM Code brings policies and procedures used for a more valuable safety in all ship operations. In this spirit, a proper implementation of the ISM Code should result in a safety culture onboard ship. With all of these, can be a difference between complying with the letter of the ISM Code and fulfilling its spirit, the conscious practice of an attitude to safety in which all accidents are seen as preventable, and everything reasonably possible is done to ensure that accidents are actually prevented.

The achievement of a total safety culture goes beyond compliance with the ISM Code since it can provide a means of maximising the benefits and cost savings. As seafarers, may be compelled to follow certain procedures, but, as people, cannot be compelled to believe in these procedures or to think about the safety implications of everything that they are doing [10].

In order to maintain the required levels of safety, seafarers in charge with these matters, need to address all activities undertaken in the operation of the ship together with possible situations that may arise which would affect the safety of the ship or its operation. These activities and situations will involve varying degrees of hazard to the ship, its personnel and the environment. Careful assessment of these hazards, and the probability of their occurrence, will determine the severity of the risks involved.

In the actual context of maritime activities, professional skills related to maritime safety are, but not limited to:

- maintain a safe navigational, engineering and radio watches and a general surveillance of the ship;
- manoeuvre the ship in safety conditions;
- manage the safety functions of the ship during all operations;
- perform appropriate operations for the prevention of damage to the marine environment;
- maintain the safety arrangements and the cleanliness of all accessible spaces to minimize the risk of fire;
- ensure a safe carriage of cargo during transit;
- inspect and maintain, as appropriate, the structural integrity of the ship;
- operate the main propulsion and auxiliary machinery and maintain them in a safe condition to
- enable the ship to overcome the foreseeable perils of the voyage.

For certain categories of vessel, such as tankers, are laid down special training provisions, required for this type of vessel. For this categories of vessel there are particular mandatory minimum requirements concerning the training and qualifications of seafarers serving on board these specific categories of vessel [11]. Related to safety, following matters have to be considered by seafarers, especially by those at management level:

- to provide safe practices in operation and a safe working environment;
- to establish safeguards against all identified risks;
- to maintain a continuous improvement of safety management skills, including preparing for
- emergencies related to safety and environmental protection.

### ***3.2 Best practices in maritime security***

Last years has seen a significant number of security regulations promulgated that are applicable to the maritime industry. Many of these share common imperatives, such as developing and maintaining current security plans and ensuring that appropriate training are provided. Some are specific to certain sectors of the maritime community and were developed to address deficiencies in the preventive security measures established mainly by ISPS Code [7].

All of this begs the questions of exactly who is responsible for what regulations as they apply to a specific port or vessel and how to effectively integrate these changes into the existing security structures and training curricula.

It is essential that security programs to maintain an active awareness of changes in the security regulations that pertain to their operations so that the training requirements and curriculum for the onboard personnel with designated security duties may be tailored to address both the letter and intent of the requirements. Training programs that focus solely on “checking the box” compliance for meeting the letter of the requirements, without addressing the accompanying practical components needed to achieve functional compliance, may not survive a due diligence evaluation by the agencies responsible for oversight and enforcement.

The specialised training regarding ship security is developed according to requirements stated by the International Ship and Port Facility Security Code (ISPS Code), which is a comprehensive set of measures to enhance the security of ships and port facilities, developed in response to the perceived threats to ships and port facilities [2]. In essence, the ISPS Code takes the approach that ensuring the security of ships and port facilities is a risk management activity and that, to determine what security measures are appropriate, an assessment of the risks must be made in each particular case. The Code intent to provide a standardised, consistent framework for evaluating risk, enabling responsible entities to offset changes in threat with changes in vulnerability for ships and port facilities through determination of appropriate security levels and corresponding security measures.



The Code framework for ship security includes requirements like ship security plan, ship security officer, company security officers and certain onboard equipment [3]. In addition, the following requirements are included: monitoring and controlling access, monitoring the activities of people and cargo, ensuring of availability of security communications.

Taking all of these in consideration, a person in charge with security onboard vessels have to comply with following requirements in order to protect the ship and the crew:

- to establish a framework to detect security threats and take preventive measures against security incidents affecting the ship;
- to establish roles and responsibilities for ensuring security;
- to ensure the early and efficient collection and exchange of security-related information;
- to provide a methodology for security assessments so as to have in place plans and procedures to react to changing security levels;
- to ensure confidence that adequate and proportionate maritime security measures are in place.

### ***3.3 Challenges for training in maritime safety and security***

Taking account the latest considerations about maritime safety and security, the maritime education and training have to be an active part of the maritime industry. This participation need to be made through specialised trainings, especially in these areas of interest where is most necessary. Safety and security needs in the maritime activities are in a continuous changing. New requirements are issued by international and national organisations in order to cover as much as possible all dangerous situations which can be met during ship's operation. The compliance with these requirements is reached through an adequate training.

An adequate training is based on competencies. Through competencies are reached the necessary level of knowledge in any field of activity. Maritime safety and security is one of the activities where is required a specific level of knowledge and understanding, to be able to react and minimize any possible threat on safety or security of the ship.

Related to maritime safety, the following abilities are considered as necessary to be created following to a specialised training program:

- to have knowledge of the general dangers involved in shipboard operations;
- to understand the role of the safety policies;
- to understand the importance of identifying general hazards and spreading safety awareness;
- to carry out a risk assessment procedure;
- to be able to carry out accident investigation;
- to be able to handle stress and fatigue and to understand its implications to dangerous situations and accidents;
- to be able to apply the Formal Safety Assessment methodology;
- to understand the technological progress for safety reasons;
- to know the difference between monitoring diagnostics, management and control systems;
- to be able to deal with matters involving vessel safety systems;
- to be able to deal with matters involving public safety control;
- to understand the technological progress in navigation technology;
- to be able to apply the rules of the safe navigation;
- to be able to exchange general information on safety equipment carried by ships.

For maritime security training, the following abilities have to be considered:

- to be familiarized with matters related to maritime transport;
- to be able to understand the current threats against maritime vessels;
- to be able to identify the risk factors which can lead to dangerous situations for ship;
- to know and understand responsibilities related to security matters;

- to be able to apply the relevant security policies;
- to conduct ship security and associated risk assessment;
- to be able to implement effective search mechanisms and security controls;
- to be able to identify, recognize and response to different security threats;
- to be able to take actions for ship security;
- to deal with stowaways and piracy;
- to be able to identify weapons and improvised explosives devices;
- to know the capabilities and limitations of security equipment and systems.

#### 4. Development of the Master degree curricula

As one of the main objective of the project, the master degree is developed starting from identified considerations, visions and trends in the field of maritime safety and security. The approach of these subjects will be done at a management level manner, considering practical experience and knowledge already acquired by the trainees during their previous activity on ships.

Pos.	Discipline	Semesters of 15 weeks	No of hours		Examination form	ECTS
			Lecture	Application		
1	Safety in maritime transport operations	1 <sup>st</sup> Semester	60	60	Exam	8
2	Safety based ship design	1 <sup>st</sup> Semester	45	45	Exam	7
3	Navigation safety	1 <sup>st</sup> Semester	60	60	Exam	7
4	Risk based safety	1 <sup>st</sup> Semester	60	60	Exam	8
<b>Total 1<sup>st</sup> semester</b>			<b>225</b>	<b>225</b>		<b>30</b>
5	Management of security threats	2 <sup>nd</sup> Semester	60	60	Exam	8
6	Security awareness in piracy areas	2 <sup>nd</sup> Semester	60	60	Exam	8
7	Special ships operations	2 <sup>nd</sup> Semester	60	60	Exam	7
8	Environmental engineering in maritime transport	2 <sup>nd</sup> Semester	45	45	Exam	7
<b>Total 2<sup>nd</sup> semester</b>			<b>225</b>	<b>225</b>		<b>30</b>
9	Security in financial operations	3 <sup>rd</sup> Semester	75	75	Exam	10
10	Final paper preparation	3 <sup>rd</sup> Semester		300	Project	20
<b>Total 3<sup>rd</sup> semester</b>			<b>75</b>	<b>375</b>		<b>30</b>
<b>Total Master Degree Program</b>			<b>1350 hours</b>			<b>120 ECTS</b>

*Table 1. Master degree curricula*

Considering these aspects and the European and international requirements for master degree training, present master programme is organised on three semesters of 15th weeks, with 1350 study hours, lecturers and applications. In the same time, at the end of this programme, a graduate will collect a number of 120 credits.

As structure, every semester have four courses, except the last one, dedicated mainly to final paper preparation. First semester is intended to cover subjects regarding maritime safety matters, when the second semester is more focused on security matters.

At the end of the master degree programme, the trainees will have a complete knowledge about identification of safety problems and security threats and will be able to successfully apply solutions to minimize or eliminate completely these problems.

## 5. Master degree courses

### 5.1 Management of security threats

The first course developed as part of the future master programme, was “Management of security threats”. This course was created and generated by project team members from Varna Naval Academy. This course aims to prepare new recruits for a life at sea, to give them profound knowledge and enough practical exercises considering: genesis, types and current Maritime Security Threats, methods of conducting through the analysis of the risk for the Maritime Security, the basis of the management’s risks for the Maritime Security [1]. It also aims to give a lot of examples about opposing against Maritime Security.

The expected objects of this course must be accomplished through the realization of the main tasks:

First - those who successfully complete this course will claim knowledge about:

- Current problems of the Maritime Security and basis of Strategy for Maritime Security Management;
- Legal regulation of Maritime Security – International, Allied, Regional and National regulations;
- Special features of the European requirement for Maritime Security – Directive 65 – Regulations 725;
- Politics about Maritime Security – Global, Regional, National;
- Current Maritime Security Threats – Typology and Nature;
- Definition, frames, factors for the beginning of the terrorism, piracy and armed robbery, stowaways, organized crime, internal sabotage, inter-state hostilities;
- Methods for valuation the risk of a critical marine unit’s security;
- Fundamentals of Scenario Approach in Maritime Security;
- Organization and qualities of the main parts of the National System of Maritime Security;
- Bases of the security assessment of a critical marine unit;
- Intelligence and Maritime Forces and their Role in Maritime Security;
- Mitigation Strategies for Enhance Maritime Security;
- Maritime security equipment;
- Maritime security responsibilities and authorities;
- Bases of the security of a critical marine unit;
- Maritime Security Administration;
- Ship and Port Security Contingency Planning;
- Organization of the tuition of opposing against Maritime Security Threats;
- Methods for conducting tuition and trainings considering the Maritime Security;
- The meaning of the computers in the Maritime Security trainings.

Second - those who successfully complete this course will be able to:

- Defining the frames of analysis of each threat against the Maritime Security – historical, geographical, legal;
- Identification of potential main points of the Maritime Security Threats;
- Revealing the connection of actual Maritime Security Threats;
- Making analysis of Maritime Security Threats;
- Making valuation of the situation in the Mediterranean-Black sea region
- Prognosticating the development of the main Maritime Security Threats in the Mediterranean-Black sea region;
- Extraction of useful lessons from past Maritime Security Threats;
- Fulfillment of the main steps of the methods of security assessment of a critical marine unit;
- Application of Scenario Approach in Maritime Security Threats;
- Applications of Scenario Approach in Maritime Security Vulnerabilities;
- Orientation in the mission, functions, tasks and the organization of a National Maritime Search

- and Rescue Coordinative Center;
- Using of the main Maritime Security Equipment;
- Putting the main points from the different plans of security into practice;
- Organizing the interaction between the National Institutions with responsibilities of the Maritime Security;
- Reacting in different situations of Maritime Security.
- After the successful completion of the course of education the recruits could:
  - Work as an expert in National Governmental or Non-Governmental organizations, connected to the and the Maritime Security and Safety.
  - Work as an expert in International, European and Regional structures, connected to the Maritime Security and Safety.
  - Work as an expert analyzing the risk in recognized organization for Maritime Security.
  - Work as an officer or expert of Security in the National Maritime and Port Administration.
  - Work as an officer or expert of Security in the Ship Company.
  - Raise his qualification as an officer from Naval Forces in the Naval Coordination and guidance of shipping as a tool of Maritime Security.

The teaching programme satisfies completely the demands of the National Standards for preparation of different officials, considering the questions of the Maritime Security. After taking the necessary exams in the National Maritime Administration, the student could be certificated as an Officer of the Security of the Company, port facility equipment, or if the officer is a certificated seafarer as an Officer of the Security of a ship for International Sailing considering the ISPS Code and the Manila Supplements of the STCW Code. An additional advantage for the trainees, successfully taken the course, is the knowledge about ATP-2 vol II, given them effective knowledge for their interaction with the Naval Forces.

## **5.2 Safety based ship design**

Second course scheduled was “Safety based ship design”, created by lecturers from Constanta Maritime University, members of project teams.

Safety based ship design aims at a systematic integration of safety risk analysis in the design process with prevention and reduction of risk to life, property and environment, embedded as a design objective, alongside standard design objective such as speed, cargo capacity, passenger capacity, and turnaround times. This implies the adoption of a methodology that links safety risk prevention/reduction measures to ship performance and cost by using relevant tools to address ship design and operation [12]. This can be considered a radical shift from the current treatment of safety, as a design constraint imposed by rules and regulations. The present concept offers freedom to the designer to choose and identify optimal solutions to meet safety targets. For safety based ship design to be realized, safety must be treated as a life cycle issue, which in turn implies focus on risk-based operation and need for a safety-based regulatory framework.

Safety based ship design is expected to satisfy the international maritime industry need to deliver ever more innovative and competitive transport solutions to their customers as well as a wider societal need for increasingly safer transport. Is expected this concept to deliver the foundation for the maritime sector to sustain world-leadership on safety-critical and knowledge-intensive ships, maritime services, products, equipment and related software.

Having successfully completed the course, the student will be able to demonstrate knowledge and understanding of:

- Tools and methodologies used in ship design process
- Statutory and regulatory requirements in ship design
- Needs to integrate safe design and operation within the ship design process
- Safety assessment methodology and risk acceptance criteria in ship design
- Concept of reliability based design in ship building
- Design principles and criteria
- High-level approval process for novel and risk and safety based design

- Operation of safety based designed ships
- Role of safety based ship design in collision and grounding
- Ship damage stability and survivability
- Safety based design for fire, explosion and evacuation in these situations

Having successfully completed the course, the student will be able to:

- Apply design tools and synthesise safety information
- Apply the methodology and tools used in the ship design process
- Interpret and apply statutory regulations and classification rules
- Estimate suitable dimensions according with the safety requirements, carry out checks on ship capacity, mass balance and compliance with statutory regulations, including assessment of ship economic viability
- Ensuring the arrangement meets the requirements for layout, capacities, choice of deck equipment and machinery, safety and statutory regulations

## 6. Conclusions

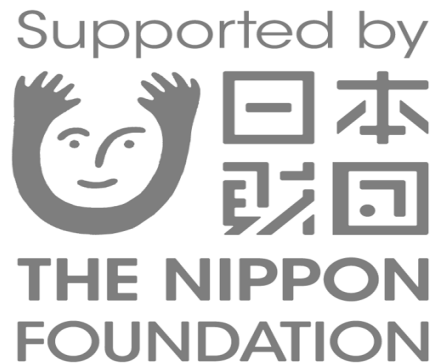
From the beginning, the maritime transport was the most profitable way for goods carrying, and the safety and security of this have to be treated as an important part. Problems related to ship safety and security affect the entire personnel, but, main responsibility for these are at management level.

To avoid problems generated by the missings of ship safety or security systems, need to exist specialized training for those in charge with these aspects. This was one of the reasons for designing and realization of the master degree programme in maritime safety and security.

At graduation, trainees will be able to understand risks and threats for ship safety and security and will be able to manage in a right manner these situations to protect ship, personnel, passengers and the environment.

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- [12] [www.eramar.net](http://www.eramar.net), “Safer EURORO II” Thematic Network



MAREM – ENHANCING  
MANAGEMENT CAPACITY OF THE  
MARITIME INDUSTRIES PERSONNEL

*Modern maritime safety and security matters and  
requirements to the maritime education and training*

The complexity of modern maritime transport and the increasing risks related to safety and security lead to a significant challenge to maritime education. The growth of international maritime trade, combined with the increased threats on maritime safety and security, lead to the necessity of better trained personnel onboard ships, able to manage these new situations and satisfy the highest levels of safety and security requirements on seas.

Today, the safety and security of life at sea, protection of the marine environment and over 90% of the world's trade depends on the professionalism and competence of seafarers. The IMO's International Convention on Standard of Training, Certification and Watchkeeping for Seafarers (STCW), with all amendments made, is the only one internationally-agreed Convention to address the issue of minimum standards of competence for seafarers, and, in the same time, to provide effective mechanisms for enforcement of its provisions.

Safety on board ships has come a long way in reducing accidents, but there is still a lot of scope to improve safety. Most of the accidents at sea are due to human error, which can be reduced by proper training and motivation. Accidents mainly happen due to lack of management, taking shortcuts, complacency, attitudes, etc. The responsibilities to avoid incidents based on safety and security flow from the top management levels, from the shore establishment to onboard management officers, especially to the Master, to each and every individual onboard.

The dynamic nature of the regulatory environment for security in the international trade and maritime transport requires that personnel involved have to maintain an active awareness of new or evolving requirements that may apply to their vessels and operations. This means being able to integrate the latest requirements into their existing security plans, to achieve the desired level of compliance with the letter and intent of the new regulations. In this way, is required that personnel with duties on ship security to maintain an awareness of changes or additions to the expanding universe of domestic and international regulations that may have an impact on their ability to maintain a secure operating environment.

## ACTUAL CONSIDERATIONS ABOUT MARITIME SAFETY

The maritime safety has as main objectives the reduction and elimination of accidents which involve injuries to ship' personnel and damage to property and the environment. These objectives can be reached through strong principles about safety. Accidents are the last step in a chain of deficiencies. To avoid accidents is necessary to eliminate previous deficiencies. Elimination of these deficiencies is made through safety policies applied in different activity sectors onboard ship, like safety of navigation or safety of ship operations.

In the maritime field, safety has to be seen as a culture and to be applied in all activities. From this point of view, safety is of interest of all management level officers, because improving of it saves lives and as well as money. When makes references to safety culture, experts commonly describe it as the values and practices that management and personnel share to ensure that risks are minimised and mitigated to the greatest degree possible. In a short way, can be said that safety is always the first priority. With a true safety culture, every crew member thinks about safety, and new ways of improving it. The cause of practically every unsafe incident can be traced to some form of human or organisational error. If people think about safety continuously, many accidents simply will not happen because virtually all so called "accidents" are in fact preventable.

For the analysis of maritime safety levels, International Maritime Organisation use concepts like Human Element Analysing Process and Formal Safety Assessment. The Human Element Analysing Process is a practical and non-scientific checklist to assist regulators in ensuring that all the human element aspects related to the ship and its equipment, and the master and his crew, have been taken into consideration.

Formal Safety Assessment is a structured and systematic methodology, aimed at enhancing maritime safety, including protection of life, health, the marine environment and property, by using risk and cost/benefit assessment. This concepts can be used as a tool to help in the evaluation of new regulations for maritime safety and protection of marine environment or making a comparison between existing and possibly improved regulations, with a view to achieving a balance between the various technical and operational issues, including the human element, and between maritime safety or protection of marine environment and costs.

An important step for increasing safety was done with the ISM Code implementation. The ISM Code brings policies and procedures used for a more valuable safety in all ship operations. In this spirit, a proper implementation of the ISM Code should result in a safety culture onboard ship. With all of these, can be a difference between complying with the letter of the ISM Code and fulfilling its spirit, the conscious practice of an attitude to safety in which all accidents are seen as preventable, and everything reasonably possible is done to ensure that accidents are actually prevented.

The achievement of a total safety culture goes beyond compliance with the ISM Code since it can provide a means of maximising the benefits and cost savings. As seafarers, may be compelled to follow certain procedures, but, as people, cannot be compelled to believe in these procedures or to think about the safety implications of everything that they are doing.

In order to maintain the required levels of safety, seafarers in charge with these matters, need to address all activities undertaken in the operation of the ship together with possible situations that may arise which would affect the safety of the ship or its operation. These activities and situations will involve varying degrees of hazard to the ship, its personnel and the environment. Careful assessment of these hazards, and the probability of their occurrence, will determine the severity of the risks involved.



In the actual context of maritime activities, professional skills related to maritime safety are, but not limited to:

- to maintain a safe navigational, engineering and radio watches and a general surveillance of the ship;
- to manoeuvre the ship in safety conditions;
- to manage the safety functions of the ship during all operations;
- to perform appropriate operations for the prevention of damage to the marine environment;
- to maintain the safety arrangements and the cleanliness of all accessible spaces to minimize the risk of fire;
- to ensure a safe carriage of cargo during transit;
- to inspect and maintain, as appropriate, the structural integrity of the ship;
- to operate the main propulsion and auxiliary machinery and maintain them in a safe condition to enable the ship to overcome the foreseeable perils of the voyage.

For certain categories of vessel, such as tankers, are laid down special training provisions, required for this type of vessel. For this categories of vessel there are particular mandatory minimum requirements concerning the training and qualifications of seafarers serving on board these specific categories of vessel. Related to safety, following matters have to be considered by seafarers, especially by those at management level:

- to provide safe practices in operation and a safe working environment;
- to establish safeguards against all identified risks;
- to maintain a continuous improvement of safety management skills, including preparing for emergencies related to safety and environmental protection.

## BEST PRACTICES IN MARITIME SECURITY

Last years has seen a significant number of security regulations promulgated that are applicable to the maritime industry. Many of these share common imperatives, such as developing and maintaining current security plans and ensuring that appropriate training are provided. Some are specific to certain sectors of the maritime community and were developed to address deficiencies in the preventive security measures established mainly by ISPS Code.

All of this begs the questions of exactly who is responsible for what regulations as they apply to a specific port or vessel and how to effectively integrate these changes into the existing security structures and training curricula.

It is essential that security programs to maintain an active awareness of changes in the security regulations that pertain to their operations so that the training requirements and curriculum for the onboard personnel with designated security duties may be tailored to address both the letter and intent of the requirements. Training programs that focus solely on “checking the box” compliance for meeting the letter of the requirements, without addressing the accompanying practical components needed to achieve functional compliance, may not survive a due diligence evaluation by the agencies responsible for oversight and enforcement.

The specialised training regarding ship security is developed according to requirements stated by the International Ship and Port Facility Security Code (ISPS Code), which is a comprehensive set of measures to enhance the security of ships and port facilities, developed in response to the perceived threats to ships and port facilities. In essence, the ISPS Code takes the approach that ensuring the security of ships and port facilities is a risk management activity and that, to determine what security measures are appropriate, an assessment of the risks must be made in each particular case. The Code intent to provide a standardised, consistent framework for evaluating risk, enabling responsible entities to offset changes in threat with changes in vulnerability for ships and port facilities through determination of appropriate security levels and corresponding security measures.

The Code framework for ship security includes requirements like ship security plan, ship security officer, company security officers and certain onboard equipment. In addition, the following requirements are included: monitoring and controlling access, monitoring the activities of people and cargo, ensuring of availability of security communications.

Taking all of these in consideration, a person in charge with security onboard vessels have to comply with following requirements in order to protect the ship and the crew:

- to establish a framework to detect security threats and take preventive measures against security incidents affecting the ship;
- to establish roles and responsibilities for ensuring security;
- to ensure the early and efficient collection and exchange of security-related information;
- to provide a methodology for security assessments so as to have in place plans and procedures to react to changing security levels;
- to ensure confidence that adequate and proportionate maritime security measures are in place.

## CHALLENGES FOR TRAINING IN MARITIME SAFETY AND SECURITY

Taking account the latest considerations about maritime safety and security, the maritime education and training have to be an active part of the maritime industry. This participation need to be made through specialised trainings, especially in these areas of interest where is most necessary. Safety and security needs in the maritime activities are in a continuous changing. New requirements are issued by international and national organisations in order to cover as much as possible all dangerous situations which can be met during ship's operation. The compliance with these requirements is reached through an adequate training.

An adequate training is based on competencies. Through competencies are reached the necessary level of knowledge in any field of activity. Maritime safety and security is one of the activities where is required a specific level of knowledge and understanding, to be able to react and minimize any possible threat on safety or security of the ship.

Related to maritime safety, the following abilities are considered as necessary to be created following to a specialised training program:

- to have knowledge of the general dangers involved in shipboard operations;
- to understand the role of the safety policies;
- to understand the importance of identifying general hazards and spreading safety awareness;
- to carry out a risk assessment procedure;
- to be able to carry out accident investigation;
- to be able to handle stress and fatigue and to understand its implications to dangerous situations and accidents;
- to be able to apply the Formal Safety Assessment methodology;
- to understand the technological progress for safety reasons;
- to know the difference between monitoring diagnostics, management and control systems;
- to be able to deal with matters involving vessel safety systems;
- to be able to deal with matters involving public safety control;
- to understand the technological progress in navigation technology;
- to be able to apply the rules of the safe navigation;
- to be able to exchange general information on safety equipment carried by ships.

For maritime security training, the following abilities have to be considered:

- to be familiarized with matters related to maritime transport;
- to be able to understand the current threats against maritime vessels;
- to be able to identify the risk factors which can lead to dangerous situations for ship;
- to know and understand responsibilities related to security matters;
- to be able to apply the relevant security policies;
- to conduct ship security and associated risk assessment;
- to be able to implement effective search mechanisms and security controls;
- to be able to identify, recognize and response to different security threats;
- to be able to take actions for ship security;
- to deal with stowaways and piracy;
- to be able to identify weapons and improvised explosives devices;
- to know the capabilities and limitations of security equipment and systems.



MAREM – ENHANCING  
MANAGEMENT CAPACITY OF THE  
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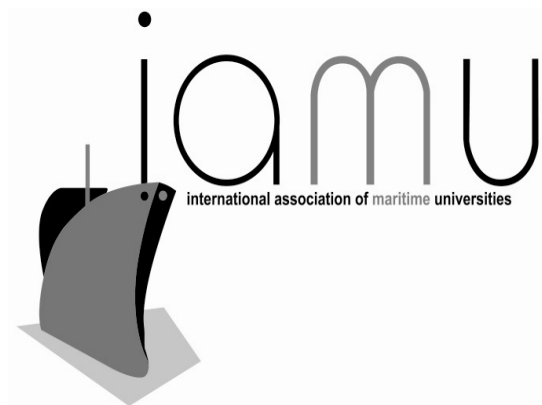
*MARITIME TRANSPORTATION SAFETY  
AND SECURITY*

MASTER DEGREE PROGRAM

CURRICULA

**Master Programme: Maritime safety and security**  
**Level: Management**

Pos.	Discipline	Semesters of 15 weeks	No of hours		Examination form	ECTS
			Lecture	Application		
1	Safety in maritime transport operations	1 <sup>st</sup> Semester	60	60	Exam	8
2	Safety based ship design	1 <sup>st</sup> Semester	45	45	Exam	7
3	Navigation safety	1 <sup>st</sup> Semester	60	60	Exam	7
4	Risk based safety	1 <sup>st</sup> Semester	60	60	Exam	8
	<b>Total 1<sup>st</sup> semester</b>		<b>225</b>	<b>225</b>		<b>30</b>
5	Management of security threats	2 <sup>nd</sup> Semester	60	60	Exam	8
6	Security awareness in piracy areas	2 <sup>nd</sup> Semester	60	60	Exam	8
7	Special ships operations	2 <sup>nd</sup> Semester	60	60	Exam	7
8	Environmental engineering in maritime transport	2 <sup>nd</sup> Semester	45	45	Exam	7
	<b>Total 2<sup>nd</sup> semester</b>		<b>225</b>	<b>225</b>		<b>30</b>
9	Security in financial operations	3 <sup>rd</sup> Semester	75	75	Exam	10
10	Final paper preparation	3 <sup>rd</sup> Semester		300	Project	20
	<b>Total 3<sup>rd</sup> semester</b>		<b>75</b>	<b>375</b>		<b>30</b>
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MAREM – ENHANCING MANAGEMENT  
CAPACITY OF THE MARITIME INDUSTRIES  
PERSONNEL

*Maritime security threats*

*Teaching Syllabus*

*The materials and data in this publication have been obtained through the support of the International Association of Maritime Universities (IAMU) and The Nippon Foundation in Japan.*

## **Aims**

This course aims to prepare new recruits for a life at sea, to give them profound knowledge and enough practical exercises considering: genesis, types and current Maritime Security Threats, methods of conducting through the analysis of the risk for the Maritime Security, the basis of the management's risks for the Maritime Security. It also aims to give a lot of examples about opposing against Maritime Security.

## **Objective**

The expected objects of this course must be accomplished through the realization of the main tasks:

First - those who successfully complete this course will claim knowledge about:

- Current problems of the Maritime Security and basis of Strategy for Maritime Security Management;
- Legal regulation of Maritime Security – International, Allied, Regional and National regulations;
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- Maritime security equipment;
- Maritime security responsibilities and authorities;
- Bases of the security of a critical marine unit;
- Maritime Security Administration;
- Ship and Port Security Contingency Planning;
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- Applications of Scenario Approach in Maritime Security Vulnerabilities;
- Orientation in the mission, functions, tasks and the organization of a National Maritime Search and Rescue Coordinative Center;
- Using of the main Maritime Security Equipment;



- Putting the main points from the different plans of security into practice;
- Organizing the interaction between the National Institutions with responsibilities of the Maritime Security;
- Reacting in different situations of Maritime Security.

After the successful completion of the course of education the recruits could:

1. Work as an expert in National Governmental or Non-Governmental organizations, connected to the and the Maritime Security and Safety.
2. Work as an expert in International, European and Regional structures, connected to the Maritime Security and Safety.
3. Work as an expert analyzing the risk in recognized organization for Maritime Security.
4. Work as an officer or expert of Security in the National Maritime and Port Administration.
5. Work as an officer or expert of Security in the Ship Company.
6. Raise his qualification as an officer from Naval Forces in the Naval Coordination and guidance of shipping as a tool of Maritime Security.

The teaching programme satisfies completely the demands of the National Standards for preparation of different officials, considering the questions of the Maritime Security. After taking the necessary exams in the National Maritime Administration, the student could be certificated as an Officer of the Security of the Company, port facility equipment, or if the officer is a certificated seafarer as an Officer of the Security of a ship for International Sailing considering the ISPS Code and the Manila Supplements of the STCW Code. An additional advantage for the trainees, successfully taken the course, is the knowledge about ATP-2 vol II, given them effective knowledge for their interaction with the Naval Forces.

### **Training facilities and equipment**

For the training purpose are use an ordinary classroom with overhead projector and multimedia equipment for use of audiovisual material such as videos and slides.

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- W3 CIA Official site [www.cia.gov](http://www.cia.gov)
- W4 CIA World Factbook USA [www.cia.gov](http://www.cia.gov)
- W5 EMSA Official site [www.emsa.europa.eu](http://www.emsa.europa.eu)
- W6 EUROPOL Official site [www.europol.europa.eu](http://www.europol.europa.eu)
- W7 IACS International Association of Classification Societies [www.iacs.org](http://www.iacs.org)
- W8 INTERPOL Official site [www.interpol](http://www.interpol)
- W9 ILO International Labour Organization [www.ilo.org](http://www.ilo.org)
- W10 ICC International Maritime Bureau (IMB) [www.iccwbo.org/ccs/menu\\_imb\\_bureau](http://www.iccwbo.org/ccs/menu_imb_bureau)
- W11 IMO Official Site [www.imo.org](http://www.imo.org)
- W12 ISL Shipping Statistics and Market Review (SSMR) [www.isl.org](http://www.isl.org)
- W13 ISO International Organization for Standardization [www.iso.org](http://www.iso.org)

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- W18 NATO Review [www.nato.int](http://www.nato.int)
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## Course Outline

Knowledge, understanding and proficiency	Lectures, discussions, seminars, practical works, games - approximate time (hours)
<b>MODULE 1. CURRENT MARITIME SECURITY THREATS</b>	
<b>1. INTRODUCTION TO THE COURSE</b> 1.1 Aims of the course. 1.2 Actuality of problematic the topic being studied. 1.3 Organization of the course. 1.4 Review of the used methods of teaching.	Lecture 2,0
<b>2. CONTEMPORARY PROBLEMS OF MARITIME SECURITY</b> 2.1 Historical aspect of the maritime security problem. 2.2 Ship and port operations. 2.3 Legal frameworks for maritime security. 2.4 Maritime security policies.	Lecture 2,0
<b>3. MARITIME TRANSPORTATION SYSTEM WITHIN THE CONTEXT OF MARITIME SECURITY</b> 3.1 Public policy and maritime responsiveness to commerce. 3.2 Economic dependence on maritime transportation. 3.3 A renewed emphasis on security ships and ports. 3.4 A need for partnership between governmental institutions and business organizations in managing maritime security.	Lecture 2,0
<b>4. CURRENT MARITIME SECURITY THREATS AND THEIR NATURE</b> 4.1 Categories of maritime security threats. 4.2 Threats of the maritime security. 4.3 Analysing each threat of the maritime security – historical, geographical, legal frames. 4.4 General model of a Maritime Security Threat. 4.5 Connection between threats – The „Four Circles“ Model.	Lecture 2,0
<b>5. TERRORISM AND COMMERCIAL MARITIME TRANSPORTATION</b> 5.1 The legal definition of terrorism. 5.2 Historical, geographical and legal aspects of phenomenon terrorism. 5.3 Characteristics of contemporary maritime terrorism. 5.4 Subjects of the terrorist threat. 5.5 Typical examples.	Lecture 2,0
<b>6. PIRACY AND ARMED ROBBERY</b> 6.1 The legal definition of piracy and armed robbery. 6.2 Historical, geographical and legal aspects of	Lecture 2,0

Knowledge, understanding and proficiency	Lectures, discussions, seminars, practical works, games - approximate time (hours)
piracy and armed robbery. 6.3 Characteristics of contemporary piracy and armed robbery. 6.4 Subjects of piracy and armed robbery: 6.5 Typical examples	
<b>7. STOWAWAYS</b> 7.1 The legal definition of stowaways. 7.2 Historical, geographical and legal aspects of stowaways. 7.3 Characteristics of phenomenon stowaways – motivation. 7.4 Tactics and techniques used by stowaways.	<b>Lecture</b> <b>2,0</b>
<b>8. TRANSNATIONAL ORGANISED CRIME – part 1</b> 8.1 The illicit trade in hazardous materials. 8.2 The illicit trade in small arms and light weapons. 8.3 Human trafficking.	<b>Lecture</b> <b>2,0</b>
<b>9. TRANSNATIONAL ORGANIZED CRIME – part 2</b> 9.1 Illegal drug origins and production. 9.2 Maritime smuggling routes and trends – Balkans. 9.3 Drug smuggling methods and techniques.	<b>Lecture</b> <b>2,0</b>
<b>10. INTERNAL CRIMINAL CONSPIRACIES</b> 10.1 Cargo theft. 10.2 Other matters about maritime security. 10.3 Commercial conspiracies.	<b>Lecture</b> <b>2,0</b>
<b>11. INTER-STATE HOSTILITIES</b> 11.1 Defining, varieties, identical signs. 11.2 Historical, geographical, legal frames – typical examples for international arguments in the sea. 11.3 Factors, heightening the threats in the sea. 11.4 Subjects of the threat.	<b>Lecture</b> <b>2,0</b>
<b>12. ACTUAL SITUATION OF MODERN PIRACY</b> 12.1 Trends in modern piracy. 12.2 Somali piracy case 12.3 The linkage between piracy, transnational organized crime, narcotics traffickers, terrorism and authority corruption.	<b>Discussion</b> <b>4,0</b>
<b>13. CONTEMPORARY PROBLEMS OF MARITIME SECURITY</b> 13.1 Contemporary situation in the maritime security. 13.2 Current maritime security threats and their nature. 13.3 Comparative analysis of the current piracy and terrorism at sea. 13.4 The connection between the threats of the maritime security.	<b>Seminar</b> <b>4,0</b>

<b>Knowledge, understanding and proficiency</b>	<b>Lectures, discussions, seminars, practical works, games - approximate time (hours)</b>
<b>14. DEFINING THE FOCUS OF THE THREATS TO MARITIME SECURITY IN THE MEDITERRANEAN BLACK SEA REGION</b> 14.1 Game organization 14.2 Game concept 14.3 Scenario 14.4 Master Event List 14.5 Game Initiating Conditions	<b>Game 4,0</b>
<b>MODULE 2 ANALISING THE RISK OF THE MARITIME SECURITY</b>	
<b>15. METHODS OF ASSESSMENT THE RISKS OF THE SECURITY OF A CRITICAL MARINE UNIT</b> 15.1 Basics of analyzing the risks. 15.2 Methods used while calculating the risk. 15.3 Assessment the risk based on two factors. 15.4 Assessment the risk based on three factors. 15.5 Assessment the threats and vulnerability. 15.6 Assessment the gravity of the consequences.	<b>Lecture 2,0</b>
<b>16. SHIP SECURITY ASSESSMENT</b> 16.1 Introduction to the SSA. 16.2 Organizing the SSA. 16.3 Inspecting the security. 16.4 Documenting the SSA	<b>Lecture 2,0</b>
<b>17. DISCUSSING THE METHODOLOGY OF THE SSA OF THE NORWEGIAN SHOPOWNERS' ASSOCIATION</b> 17.1 Structure of the methodology. 17.2 Review of the methodology step by step. 17.3 Tools of the methodology. 17.4 Review of similar methodologies.	<b>Discussion 2,0</b>
<b>18. PORT FACILITY (PORT) SECURITY ASSESSMENT</b> 18.1 Introduction to the PFSA (PSA) 18.2 Organizing the PFSA (PSA) 18.3 Inspecting the security. 18.4 Documenting the PFSA.	<b>Lecture 2,0</b>
<b>19. DISCUSSING THE METHODOLOGY OF PFSA OF ABS CORPORATION</b> 19.1 Structure of the methodology. 19.2 Review of the methodology step by step. 19.3 Tools of the methodology. 19.4 Review of similar methodologies.	<b>Discussion 2,0</b>
<b>20. OFFSHORE FACILITY SECURITY ASSESSMENT</b> 20.1 Introduction to the OFSA. 20.2 Organizing the OFSA.	<b>Lecture 2,0</b>

<b>Knowledge, understanding and proficiency</b>	<b>Lectures, discussions, seminars, practical works, games - approximate time (hours)</b>
20.3 Inspecting the security. 20.4 Documenting the OFSA.	
<b>21. FUNDAMENTALS OF SCENARIO APPROACH IN MARITIME SECURITY</b> 21.1 Characteristics and parameters of scenario approach. 21.2 Forms of presentation of scenario approach – strengths and weakness. 21.3 Descriptive form of presentation. 21.4 Matrix form of presentation 21.5 Tree form of presentation	<b>Lecture 2,0</b>
<b>22. APPLICATION OF SCENARIO APPROACH IN MARITIME SECURITY THREATS</b> 22.1 Choice of priorities in scenario approach of maritime security threats. 22.2 Choice of applicable forms in scenario approach of maritime security threats. 22.3 Methods of limiting uncertainty in scenario approach of maritime security threats. 22.4 Possibilities of this type scenario approach application.	<b>Lecture 2,0</b>
<b>23. APPLICATION OF SCENARIO APPROACH IN MARITIME SECURITY VULNERABILITIES</b> 23.1 Choice of priorities in scenario approach of maritime security vulnerabilities. 23.2 Choice of applicable forms in scenario approach of maritime security vulnerabilities. 23.3 Methods of limiting uncertainty in scenario approach of maritime security vulnerabilities. 23.4 Possibilities of this type scenario approach application.	<b>Lecture 2,0</b>
<b>24. ROLE AND PLACE OF SCENARIO APPROACH IN CONTEMPORARY MANAGEMENT OF MARITIME SECURITY</b> 24.1 Usage of scenario approach in contemporary management of maritime security. 24.2 Scenarios approach and creation of risk mitigation strategies.	<b>Discussion 4,0</b>
<b>25. RISK ASSESSMENT OF MARITIME SECURITY</b> 25.1 Methods for assessing the risk of a critical marine units. 25.2 Computer-based methods for risk assessment of maritime security. 25.3 The MSRAM methodology of the US Coast Guard.	<b>Seminar 4,0</b>

Knowledge, understanding and proficiency	Lectures, discussions, seminars, practical works, games - approximate time (hours)
25.4 The scenario as an instrument in the risk assessment of maritime security. 25.5 Maritime security assessment. 25.6 Characteristics of the maritime security assessment for different types of critical marine units.	
<b>26. FORMATION AND GAMING OF VARIOUS FORMS OF PRESENTATION OF SCENARIO APPROACH</b> 26.1 Formation of various forms presentation of scenarios. 26.2 Gaming of various forms presentation of scenarios. 26.3 Analysis of outcomes of gaming scenarios.	<b>Game 6,0</b>
<b>MODULE 3. MANAGEMENT OF THE RISKS OF THE MARITIME SECURITY</b>	
<b>27. MARITIME FORCES AND SECURITY OF MERCHANT SHIPPING</b> 27.1 Naval Coordination and Guidance for Shipping. 27.2 Operation Active Endeavour. 27.3 Other Allied Maritime Security Operations. 27.4 Information Exchange in the Red Sea, Arabian Sea, and Arabian Gulf.	<b>Lecture 2,0</b>
<b>28. INTELLIGENCE IN MARITIME SECURITY</b> 28.1 Role of intelligence in maritime security. 28.2 The intelligence cycle.	<b>Lecture 2,0</b>
<b>29. THREAT MITIGATION STRATEGIES (CRIMINALS)</b> 29.1 Types of behavior and activities of criminals to pose a security threat. 29.2 Types of behavior and activities of terrorists to pose a security threat.	<b>Lecture 2,0</b>
<b>30. HOSTAGE SURVIVAL AND RESCUE</b> 30.1 Hostage survival techniques. 30.2 Properly reactions to possible rescue operations.	<b>Lecture 2,0</b>
<b>31. MARITIME SECURITY EQUIPMENT</b> 31.1 General equipment used by maritime security. 31.2 Solutions for increasing the maritime security. 31.3 Systems and security equipment. 31.4 Using the maritime security equipment.	<b>Lecture 2,0</b>
<b>32. MARITIME SECURITY RESPONSIBILITIES AND AUTHORITIES</b> 32.1 Governments' responsibilities 32.2 Responsibilities of Recognised Security Organisations. 32.3 Maritime security responsibilities of the company, the ship and the port facility.	<b>Lecture 2,0</b>

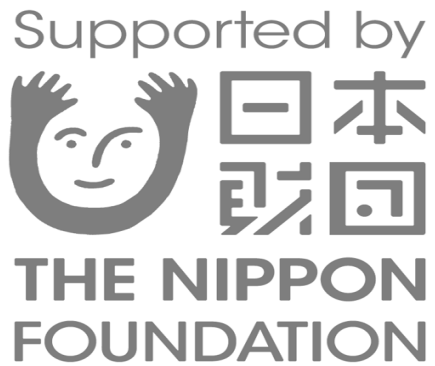
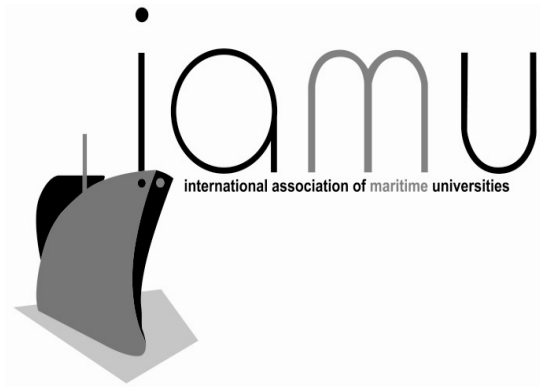
<p align="center"><b>Knowledge, understanding and proficiency</b></p>	<p align="center"><b>Lectures, discussions, seminars, practical works, games - approximate time (hours)</b></p>
<p>32.4 Responsibilities of the security officers of the ship, company and port facility. 32.5 Responsibilities of the crew members and port facility personnel.</p>	
<p><b>33. SECURITY'S RESPONSIBILITIES OF THE MERCHANT SHIP</b> 33.1 Perimeter security of the merchant ship. 33.2 Control of access to the merchant ship 33.3 Basic security procedures considering the of the merchant ship. 33.4 Special features of the security of different types of merchant ships.</p>	<p><b>Lecture 2,0</b></p>
<p><b>34. INTERACTION BETWEEN THE MERCHANT SHIP AND THE PORT FACILITY IN SECURITY'S INTEREST</b> 34.1 Organization of the security of the port and its aquatory. 34.2 Control and management of the access. 34.3 Features of the interaction.</p>	<p><b>Lecture 2,0</b></p>
<p><b>35. IDENTIFICATION, RECOGNITION AND REACTION OF THREATS FOR MARITIME SECURITY</b> 35.1 Uncovering and recognizing weapons, dangerous substances and devises. 35.2 Techniques used in detouring the security measures. 35.3 Methods of searching and unostentatious inspections - realization and coordination of searches. 35.4 Psychological portraits of the types of violators of the maritime security.</p>	<p><b>Discussion 4,0</b></p>
<p><b>36. MARITIME SECURITY PLANS</b> 36.1 Purpose and contents of the maritime security plans. 36.2 Purpose and contents of the port facility security plan. 36.3 Implementation of maritime security plans into practice. 36.4 Maitenance and change in the maritime security plans. 36.5 Maritime security procedures.</p>	<p><b>Seminar 4,0</b></p>
<p><b>37. MARITIME SECURITY ADMINISTRATION</b> 37.1 Levels of maritime security administration – International, European, National. 37.2 Documentation of the security of a critical marine</p>	<p><b>Lecture 2,0</b></p>

Knowledge, understanding and proficiency	Lectures, discussions, seminars, practical works, games - approximate time (hours)
unit. 37.3 Making a report about accidents considering the security of the ship. 37.4 Audits and inspections of the security of the ship. 37.5 Verification and certification of the ship and port facility. 37.6 Voluntary ship and port facility security assessment.	
<b>38. MAINTENANCE OF THE SECURITY OF CRITICAL MARINE UNITS</b> 38.1 Keeping the security of the ship. 38.2 Necessary actions considering the different levels of security. 38.3 Maintenance of the interaction between the ship and the port.	<b>Discussion 2,0</b>
<b>39. SHIP AND PORT SECURITY CONTINGENCY PLANNING</b> 39.1 Contingency planning – a critical part of ship and port security management. 39.2 Getting the maritime community excited about contingency planning. 39.3 Sources and standards of contingency planning. 39.4 Focus on Integration and Cooperation.	<b>Seminar 2,0</b>
<b>40. COOPERATION ENHANCEMENT BETWEEN MARITIME INSTITUTION AT MARITIME SECURITY LEVEL 3</b> 40.1 Game organization 40.2 Game concept 40.3 Scenario 40.4 Master Event List 40.5 Game Initiating Conditions	<b>Game 4,0</b>
<b>MODULE 4. TRAINING FOR OPPOSITION TO THREATS FOR MARITIME SECURITY</b>	
<b>41. FUNDAMENTALS OF TRAINING FOR OPPOSITION TO THREATS FOR MARITIME SECURITY</b> 41.1 Basic security knowledge and skills for those who work in the maritime industry. 41.2 Techniques for training. 41.3 Types of training – traditional and computer assisted. 41.4 Scenario as a tool of the security training.	<b>Lecture 2,0</b>
<b>42. METHODOLOGY FOR CONDUCTING MARITIME SECURITY TRAINING AND DRILLS</b> 42.1 Maritime security training and drills.	<b>Lecture 2,0</b>

Knowledge, understanding and proficiency	Lectures, discussions, seminars, practical works, games - approximate time (hours)
42.2 Planning, preparation and conducting maritime security training and drills. 42.3 Evaluation of the maritime security training and drills. 42.4 Reporting for the maritime security training and drills.	
<b>43. METHODOLOGY FOR CONDUCTING MARITIME SECURITY EXERCISES</b> 43.1 Maritime security exercises. 43.2 Planning, preparation and maritime security exercises. 43.3 Evaluation of the maritime security exercises. 43.4 Reporting for the maritime security exercises.	<b>Lecture 2,0</b>
<b>44. PROBLEMS OF THE TRAINING FOR OPPOSITION AGAINST THE THREATS FOR THE MARITIME SECURITY</b> 44.1 Methodical preparation of the managing staff in the maritime industry. 44.2 Trained people's motivation. 44.3 Planning, preparation and practicing the security of the crew of an important maritime units. 44.4 Characteristics of the used computer programs in the training for opposition against the threats for the maritime security. 44.5 Opportunities for realizing a national/regional computer financing for the maritime security.	<b>Seminar 4,0</b>
<b>45. DISCUSSING THE CAPABILITIES OF THE NAVAL FORCES IN TAKING PART IN THE STABILIZATION OF THE MARITIME SECURITY IN THE REGION</b> 45.1 Legal basis for using the Naval Forces for stabilization of the Maritime Security. 45.2 Doctrinal basics for stabilization of the maritime security. 45.3 International and regional partnership in interest of the maritime security. 45.4 Using the naval coordination and guidance of shipping as a tool of maritime security.	<b>Discussion 2,0</b>
<b>46. DISCUSSING THE CAPABILITIES OF THE NATIONAL LAW ENFORCEMENT STRUCTURES IN TAKING PART IN THE STABILIZATION OF THE MARITIME SECURITY IN THE REGION</b> 46.1 Legal basis for their use in the consolidation of the Maritime Security. 46.2 Capabilities of the Maritime Administration and	<b>Discussion 2,0</b>



<p align="center"><b>Knowledge, understanding and proficiency</b></p>	<p align="center"><b>Lectures, discussions, seminars, practical works, games - approximate time (hours)</b></p>
<p>Ministry Interior. 46.3 Review of the past experience of the US Coast Guard in applying the interagency approach. 46.4 International and regional partnership in interest of the Maritime Security.</p>	
<p><b>47. INTRODUCTION TO THE POSSIBILITIES OF THE MAIN ELEMENTS OF THE NATIONAL SYSTEM FOR MARITIME SECURITY</b> 47.1 Familiarization to the mission, functions, tasks and the organization of the Maritime Rescue Coordination Centre. 47.2 Familiarization to the opportunities of VTMIS, AIS, LRIT and discussing their use in the interest of the Maritime Security of the Republic of Bulgaria/Republic of Romania. 47.3 Familiarization to the plans for reaction in different levels of security in a Maritime Company. 47.4 Discussing the interaction between the institutions with responsibilities in Maritime's Security interest of the Republic of Bulgaria/Republic of Romania.</p>	<p><b>Practical work in institutions 8,0</b></p>
<p align="center"><b>TOTAL</b></p>	<p align="center"><b>120</b></p>
<p align="center"><b>REVIEW AND ASSESSMENT</b></p>	



MAREM – ENHANCING MANAGEMENT  
CAPACITY OF THE MARITIME INDUSTRIES  
PERSONNEL

*Maritime security threats*

*Instructor Manual*

*The materials and data in this publication have been obtained through the support of the International Association of Maritime Universities (IAMU) and The Nippon Foundation in Japan.*

# Chapter I

## Introduction to the course

### 1.1 Aims of the course

#### 1.1.1. Aims

This course aims to prepare new recruits for a life at sea, to give them profound knowledge and enough practical exercises considering: genesis, types and current Maritime Security Threats, methods of conducting through the analysis of the risk for the Maritime Security, the basis of the management's risks for the Maritime Security. It also aims to give a lot of examples about opposing against Maritime Security.

#### 1.1.2. Objective

The expected objects of this course must be accomplished through the realization of the main tasks:

First - those who successfully complete this course will claim knowledge about:

- Current problems of the Maritime Security and basis of Strategy for Maritime Security Management;
- Legal regulation of Maritime Security – International, Allied, Regional and National regulations;
- Special features of the European requirement for Maritime Security – Directive 65 – Regulations 725;
- Politics about Maritime Security – Global, Regional, National;
- Current Maritime Security Threats – Typology and Nature;
- Definition, frames, factors for the beginning of the terrorism, piracy and armed robbery, stowaways, organized crime, internal sabotage, inter-state hostilities;
- Methods for valuation the risk of a critical marine unit's security;
- Fundamentals of Scenario Approach in Maritime Security;
- Organization and qualities of the main parts of the National System of Maritime Security;
- Bases of the security assessment of a critical marine unit;
- Intelligence and Maritime Forces and their Role in Maritime Security;
- Mitigation Strategies for Enhance Maritime Security;
- Maritime security equipment;
- Maritime security responsibilities and authorities;
- Bases of the security of a critical marine unit;
- Maritime Security Administration;
- Ship and Port Security Contingency Planning;
- Organization of the tuition of opposing against Maritime Security Threats;
- Methods for conducting tuition and trainings considering the Maritime Security;
- The meaning of the computers in the Maritime Security trainings.

Second - those who successfully complete this course will be able to:

- Defining the frames of analysis of each threat against the Maritime Security – historical, geographical, legal;
- Identification of potential main points of the Maritime Security Threats;
- Revealing the connection of actual Maritime Security Threats;
- Making analysis of Maritime Security Threats;
- Making valuation of the situation in the Mediterranean-Black sea region
- Prognosticating the development of the main Maritime Security Threats in the Mediterranean-Black sea region;

- Extraction of useful lessons from past Maritime Security Threats;
- Fulfillment of the main steps of the methods of security assessment of a critical marine unit;
- Application of Scenario Approach in Maritime Security Threats;
- Applications of Scenario Approach in Maritime Security Vulnerabilities;
- Orientation in the mission, functions, tasks and the organization of a National Maritime Search and Rescue Coordinative Center;
- Using of the main Maritime Security Equipment;
- Putting the main points from the different plans of security into practice;
- Organizing the interaction between the National Institutions with responsibilities of the Maritime Security;
- Reacting in different situations of Maritime Security.

### ***1.2 Actuality and problematic of the topic being studied***

The economy of each country depends in a great stage of the maritime transport. About 90% of their general volumes are food supplies and raw material. During the past years there has been an increase with high rates in the volume of the oil and oil products (about 10% per year). There is a transport distribution: oil and oil products – 55%, iron ore – 10%, grain and coal – 5%, manure – 3%, wood material, sugar and bauxite – 1.5 – 2.0%, about 25% dump and container cargo. Assimilation of The World Ocean has always been connected with ensuring the safety and the security of the navigation as there are different kinds of threats considering sailing. Regardless of the efforts undertaken from The World Community, during the past years there has been a dramatic rise in the intensity of the incidents, connected with the security. Nowadays The Global Logistics process is the main focus of the current maritime security.

Among the acts, directed against the maritime security, that are on the focus of public attention, are maritime terrorism, piracy and armed robbery, stowaways, transnational organized crime, internal criminal conspiracies. They are performed on the ships or against them, on critical marine units or against them, and also against crucial interests, considering the usage of the sea, often in valuation of the International Law. These acts give the so called incidents, connected with the maritime security, content. Each one of them is a unique event, which specification often does not allow disclosure of the information available to them. Because of mainly economic reasons (loss of prestige, clients and cargo), the companies and administrations sometimes dodge that kind of information.

The piracy and armed robbery are connected not only with attacks and armed robberies, but with blackmailing, documentaries and insurance fraud, illegal immigration, trafficking of weapons, people and drugs. Cross-border criminal structures and their general economic interests bound in a common system all crimes including the Marine terrorism. Despite the different kind of motivation of the used techniques, tactics and procedures, these crimes are very close.

Every marine expert must be familiar with the traditional threat, inter-state hostilities, that after the Cold War has been still, but hides a serious negative potential for many regions.

Today the elements of the Marine Transport System are not only viewed as an object of attacks of terrorist organizations or as a source of their financing, but as a means of dissemination of the threat, and the ships are a weapon for its immediate realization. In the contemporary conditions the seas have been hard to control. The ships are transnational subjects and the terroristic activity is hard to be identified over background, made by the piracy, armed attacks and other crimes in the sea.

### ***1.3 Organization of the course***

The teaching programme must include the following modules:

1. CURRENT MARITIME SECURITY THREATS
2. ANALISING THE RISK OF THE MARITIME SECURITY
3. MANAGEMENT OF THE RISKS OF THE MARITIME SECURITY
4. TRAINING FOR OPPOSITION TO THREATS FOR MARITIME SECURITY

#### ***1.4 Review of the methods used for teaching***

The course makes provision to use the following academic teaching forms:

- Lectures – the students must gain profound knowledge and clear understanding for the current problems of the Maritime Security, the basis of the Strategy for Maritime Security Management, the organization and main elements of the National Maritime Security System;
- Discussions – the students must gain skills for making and defending their own opinion over current problems of the Maritime Security, to demonstrate abilities for independent studying of a vital for the Maritime Security document;
- Seminars – the purpose of the seminars is to see how the students assimilate the knowledge being taught and their ability to interpret them in a rival environment;
- Games – important practical form in which the students are in a realistic situation and must, independently or in a team, to complete different tasks, as an example to prognosticate the development of the main Maritime Security Threats; extracting useful lessons from their activities; application of Scenario Approach in Maritime Security Threats and Vulnerabilities, etc.;
- Practical work in maritime institutions – introduction to the mission, functions, tasks and the organization of the National Search and Rescue Coordinative Center, studying and working with Maritime Security Equipment; using different kind of security plans; organizing the interaction between the National Institutions with responsibilities considering the Maritime Security.

## Chapter II

### Contemporary problems of maritime security

#### 2.1 Historical aspects of the maritime security problem

The word *security* can actually be understood as a stable, relatively predictable environment in which an individual or group may go about its business without disruption or harm and without fear of disturbance or injury. Security can also be viewed as a system or orderly method for establishing conditions and procedures for stability. The system of security is arranged so that all aspects of the organization are functioning as planned. Security can also relate peoples' comfort levels with respect to their environment. This *sense of place* describes a feeling people have as they interact with their environment. As the environmental conditions change, a person's sense of place changes, and the degree to which people increase or decrease their security plans changes. If the mission of an organization is to provide a safe and secure environment for people to operate a business, then the security manager's risk is to establish a secure sense of place for the relative community. It becomes important for the manager to understand these dynamics and to integrate security concerns at various levels in the organization in order to meet the mission challenges.

There is evidence that during the Mycenaean Age in Greece, from around 1600 to 1100 BC, large fortress-like palaces were constructed, designed no doubt to enhance the security of inhabitants by protecting them from invaders or perhaps from warring opponents intent on subjugating the populace. The sense of place is improved by a facility design and plans that eliminate or reduce the chance of harm. Crime-prevention programs and strategies today often employ CPTED (*crime prevention through environmental design*) principles to take advantage of environmental conditions to improve security. A classic example is a CPTED strategy called *territorial reinforcement*, in which users assert control over an environment by defining lines and distinguishing private spaces from public spaces using landscape plantings, pavement designs, and natural fences such as shrubbery, trees, and water. The effort is designed to not only reduce risk of given threats, but to lead to behavior that encourages people to keep an eye out for one another in what is hopefully a safer, and more livable, community.

The Romans, known for the development of early locks and keys, recognized the relative importance of incorporating security into the development of management systems in the conduct of commerce and trade. After the Norman invasion and domination of England by William the Conqueror in 1066, feudalism, though not recognized by this term until the 1600s, provided a substantial level of security for individuals and groups. This is evidence that societies adapted management systems using their surroundings to mitigate the risks associated with their environment, such as predators, thieves, opposing forces, and the like. During the Middle Ages in Europe, the movement of an agrarian people to the cities created conditions of considerable poverty and hardship. In England these conditions prompted the development of the night watchman, or *wait*. Other developments during this time included the formation of private police agencies, individual merchants hiring men to guard their property, and the hiring of agents to recover stolen property. The basic theories of protection have changed little over the past centuries, but the challenges faced by society and its organizations continue to evolve, with the threat of terrorism taking precedence within the past few years.

The threat of acts of terrorism has become a driving force for the strengthening of the security of much of our infrastructure, and seaports have unprecedented level of scrutiny, at least if one considers the historically unregulated environments that most ports have operated in. Global acts of terrorism now highlight the diverse vulnerabilities of seaports and emphasize the importance of strong protective measures and activities designed to deter terrorist acts. In addition to terrorism, seaports are vulnerable to a variety of international and domestic criminal activities. The smuggling of drugs, weapons, and illegal migrants through seaports represents a constant threat to safety and security. Other forms of criminal activity include environmental crimes, cargo theft, and the unlawful export of controlled goods, munitions, stolen property, and drug proceed.

## 2.2 Ship and port operations

Ports primarily managed for the handling of cargo or raw materials will have facilities and equipment such as container yards, cargo sheds, storage tanks, pipelines, cranes, loaders, and towing vehicles. Ports that are managed primarily for the handling of passengers will have facilities and staff to handle both people and/or vehicles transferring on to and off vessels such as ferries, recreational vessels, and passenger cruise ships. The term *seaport* is often used to describe a port that primarily serves ocean-going vessels. A *river port* is one that handles vessels trafficking on rivers such as barges and transport vessels that are capable of operating in shallower waters. *Inland ports* on lakes, rivers, and canals may have access to larger bodies of water. *Fishing ports* are primarily used to service and manage a fleet of vessels engaged in the fishing industry. A *dry port* describes a facility used to store cargo containers or break bulk cargo. A security manager in a port facility may have much more than the ships themselves to consider in terms of risk mitigation.

The intermodal nature of the cargo shipping business suggests that transportation costs for merchandise have gone down as the world has bought into the cargo container shipping system. “The efficiencies associated with global specialization inevitably lead to increasing interdependence. This poses vulnerabilities which could be exploited by terrorist groups. The security challenge is to protect the nation from terrorism without unduly restricting the flow of international commerce”.

## 2.3 Legal frameworks for maritime security

A port is the developed interface between waterborne vessels and land adjacent to a body of water. It can be a facility for managing the transfer of cargo, raw materials, and/or people between the land and the water.

### - Freedom of the Seas

Beginning in the seventeenth century, the world’s nations essentially operated under the Freedom of the Seas doctrine, or *Mare Liberum*, as advanced in a 1609 treatise by the Dutch Jurist Hugo Grotius. *Mare Liberum*’s major position was that the world’s oceans were a resource that all nations could use as they like. The doctrine limited each country’s jurisdiction to a relatively narrow three-mile strip of water along a nation’s coastline. The rest of the world’s oceans were open to all nations and be claimed by none.

### - International Convention for the Safety of Life at Sea.

In 1914, the first version of the International Convention for the Safety of Life at Sea (SOLAS) was adopted in the aftermath of the *Titanic* disaster. This disaster, still regarded as one of the worst peacetime maritime disasters, presaged changes in maritime practices and ship design, such as the establishment of ice patrols, 24-hour radio watches, and lifeboat regulations.

The SOLAS Convention came to be regarded as an important international treaty concerning the safety of merchant ships. After the adoption of the 1914 form, successive amendments were made in 1929, 1948, and 1960. The 1960 convention was the first task for the IMO after its creation as far as modernizing maritime regulations and maintaining currency with technical developments in the shipping industry. The 1974 convention has been updated and amended many times and is often referred to as SOLAS, 1974, as amended. The convention addresses minimum standards for ship construction, equipment, and operation. Flag states ensure compliance, and contracting governments may inspect ships of other contracting states.

### - United Nations Convention on Law of the Sea

Additional evidence of global efforts to effect regulations within the maritime sector was the United Nations Convention on the Law of the Sea. UNCLOS is an international agreement that resulted from the third United Nations Convention on the Law of the Sea, 1973 – 1982. Even though the Freedom of the Seas doctrine prevailed well into the twentieth century, many countries began to extend claims over offshore resources. Concerns relating to the depletion of coastal fish stocks by long-distance fishing fleets, the treat of pollution from ocean-going ships and oil tankers, and the



growing naval presence of many nations' military organizations around the world contributed to a global consensus that the world's oceans were being exploited and manipulated. To date, 155 countries and the European Community have joined in the convention.

#### **- International Ship and Port Facility Security Code**

Global fears of the terrorist threat after September 11 spurred the IMO to critically review its agenda concerning vessel and port facility security, and resulted in the adoption of the International Ship and Port Facility Security (ISPS) Code.

As a new security regime for international shipping implemented in July 2004, the ISPS Code is designed to counter acts of terrorism, drug smuggling, cargo theft, and other forms of cargo crimes. It establishes an international framework for cooperation between most of the world's governments, government agencies, and the shipping and port industries to detect security threats.

### ***2.4 Maritime security policies***

Maritime operators have to put into maintaining ISPS compliancy for their existing fleet or facilities, and into getting certificates of approval for new vessels and sites, both global and local regulatory authorities also continued to strive to secure homelands, supply chains, and trade. This has led to the introduction of amendments to, or new, maritime and supply-chain security regulations such as the Maritime Transportation Security Act of 2002 (MTSA), the Advance Manifest System (AMS/24 hour rule), the Container Security Initiative (CSI), the Technology Asset Protection Association (TAPA), the U.S. Customs-Trade Partnership Against Terrorism (C-TPAT), and the Smart and Secure Tradelane (SST) program, to name a few. Bilateral and regional initiatives such as Free and Secure Trade (FAST) between the United States and Canada, the EU Customs Security Program (CSP) and Authorized Economic Operator (AEO) were adopted too.

Together with regulations and awareness of the importance of being able to protect, monitor, and control operations worldwide, came the introduction of all kinds of electronic tools into the maritime industry to "enhance" security. Examples of these tools are the Automatic Identification System (AIS), the Ship Security Alert System (SSAS), electronic seals for containers, biometric identification systems, and radio-frequency identification (RFID) (as control devices for tracking of goods and activities around cargo). Other features and measures included high-voltage fences and long-range acoustic devices to mitigate waterborne attacks. Some of these techniques have found their way into the everyday life of sailors and ship operators, where others still have a long way to go to be accepted as a valuable resource in the fight against maritime terrorism and other waterborne criminal threats such as piracy.

The World Custom Organization (WCO) has taken a position on supply chain security, due to its belief that international trade is an essential driver for economic prosperity. The global trading system is vulnerable to terrorists' exploitation and therefore capable of damaging the global economy. The WCO believes that customs organizations are uniquely qualified and positioned to provide increased security to the global supply chain. Also due to the international of commerce, the WCO believes that its organization should endorse a strategy to assist in securing the movement of global trading. The WCO "Framework" sets forth the principles and standards, while presenting them for adoption as a minimal threshold of what be done by WCO members – this being the customs agencies of individual states.

The World Custom Organization has been working with the International Organization for Standardization (ISO) to establish a step-by-step supply chain management *certification standard*. The ISO has many different types of certifications, and growing percentage of international business will not contract vendors or suppliers unless they have the relevant ISO certifications. Establishing an ISO certification standard for supply chain management will go a long way toward progressively forcing supply chain security policies and procedures though the whole cargo supply chain – and this works in-hand with WCO goals.

## Chapter III

### Maritime transportation system within the context of maritime security

#### 3.1 *Public policy and maritime responsiveness to commerce*

Public policy is made by a legislature in the form of laws, which are enforced by the executive branch. The laws and regulations that surface as public policy establish fees that can be charged, set standards of service, and control the activities of industries in the public interest. Private organizations are not typically subject to outside scrutiny. They exist to satisfy their clients. Internal operations are their own business and not that of the general public. It is when the activities within the private sector intersect with the general well-being and safety of the public that government steps in to effect controls in managing private sector operations. Much of public policymaking in government must be accomplished with the collaboration of numerous private groups and individuals. Public-private partnerships are essential for progress in achieving social goals. Much public policy is formalized as an outcome of the public and/or private sector's concept of the appropriate values, which are then translated into effective programs and funding. The problem with values in society is that they may be in conflict. The political system is the societal mechanism for resolving questions of values. The government is responsible for ensuring that the side effects of market transactions do not harm the public good. This is the framework for law and order and economic stability.

Security, which used to receive consideration as a necessary but uncomfortable overhead expense, is now seen as not only a necessary component a business but a value-added feature that can maximize profits through the mitigation of risks and costs associated with harm.

Maritime business and port interests responsible for the movement and storage of cargo, as well as cruise lines and ferry operations responsible for the safe transportation of paying passengers, understand the need for security and have spent a lot of money to enhance their own security.

The challenge for government and business is to recognize and implement risk management and security-planning processes that engage maritime assets and their end users cooperatively in driving maritime security.

#### 3.2 *Economic dependence on maritime transportation*

The fact that the world depends on the free movement of trade by vessels, combined with the significant growth in trade by shipping, suggest that the threat of global terrorism in this economic sector is cause for concern the perspective of maritime security management. The economic impacts of terrorism can be understood in three ways:

1. The costs of the attack itself;
2. The costs of security in mitigating the threat of future attacks as well as the associated indirect costs, such as increased wait times for security searches;
3. The costs resulting from behavioral changes as a result of the fear of future attacks, such as a decreased demand for goods and services.

There is good reason for public policy direction in the maritime and port security realm to be driven by a desire to mitigate, not only the immediate physical threats from terrorism, but the long-term economic threats that could befall the industry, the nation, and world markets.

The safety and security of the world's passenger vessel services whether for recreation or for transportation, require similar, and perhaps even higher, considerations from a security management perspective. A recent study on maritime terrorism risk suggests the following:

- Cruise and ferry vessels need more protection against terrorist attacks that could kill and injure many passengers and cause serious financial losses.
- Maritime attacks could result in mass casualties, severe property damage, and commercial disruptions.

- Independent commercial defendants may be held civilly liable for damages caused by terrorist attacks.
- Risk-management approaches must include securing nuclear materials at their points of origin.
- Passenger ferry scenarios include on-board bombs and USS *Cole*-style improvised explosive device attacks.
- Maritime attacks could target port facilities or inland locations.

Supply chain disruptions could initiate contractual and tort disputes.

Transnational organized crime is a very old phenomenon that has evolved and intensified over the years. It has captured the world's attention in the past thirty or forty years particularly in connection with the illicit drug trade and narcotic black market that emerged as a result law enforcement efforts to suppress trafficking. A huge aspect of organized crime is a network of violence and corruption perpetuated by drug cartels in order to protect their financial interests in trafficking illegal narcotics. Organized crime typically engenders activities such as illicit trafficking in drugs, small arms and light weapons, corruption, money-laundering, prostitution, human trafficking all of which are linked to increased incidents of violent crime within national borders. Moreover, as its name suggests, this network of violence and crime is highly organized and spans a broad global spectrum among powerful cartels and crime syndicates. The reach of power of these crime organizations has so grown over time that they are believed to have financial and other stakes in virtually all of the security threats.

### ***3.3 A renewed emphasis on security ships and ports***

The important dynamic to focus on is the need to develop joint initiatives and relationships between the private and public sectors in securing port and shipping interests from the threats of terrorism and criminal activity. Given that port and shipping may be targets for extremists, security management must give new gravitas to the possibilities that the people who come in and out of ports every day – the seafarers, truck drivers, vendors, dock workers, secretaries, even security and law enforcement agents – may be using their ability to access critical infrastructure and vessels to contemplate or plan harm them.

It is given in the security profession that the mitigation of risk begins with controlling access to port facilities and vessels. An International Maritime Bureau report suggested that maritime certificate fraud was a growing threat to the international maritime community. The possibility that terrorists could pose as legitimate ship's crew member surfaced in view of the apparent ease of obtaining forged crew travel documents. Some especially significant figures compiled by a 2001 IMO report indicated that of thirteen thousand false certificates identified, 90 percent of cases were reported in the Philippines. Perhaps most distressing: "in 10 of the 13 countries visited, it was evident that forgery was more than a backroom business ... It was typically well-organized, with effective links to maritime administrations, employers, manning agents, and training establishments". It should come as no surprise that the impetus for government policies mandating more stringent maritime, port and employee documentation and access requirement is the fear that those individuals who might do harm to people and assets in this environment should not have ready and certain access to port facilities and vessels.

### ***3.4 A need for partnership between governmental institutions and business organizations in managing maritime security***

The momentum for comprehensive and focused management of maritime security has been strengthened by governmental policy response to the threats posed by terrorists and other criminal elements to the maritime transportation sector. Although no business operating in this environment wishes to turn a blind eye to the growing security needs, the complexities of commercial enterprises in this sector demand sound management practices for planning the security of maritime transport. There

are no unlimited budgets for security managers. As a business must continue to operate and thrive to support its shareholders, clients, and customer base, a realistic approach to planning maritime security must transcend a fortress mentality. A balanced approach, one that develops and employs rational methods to risk mitigation yet remains cognizant of both common sense and compliance with governmental policies, is essential. In making improvements to securing an efficient global supply chain, one study has suggested three interconnected strategies:

1. Government-driven policies strengthening the global container supply chain
2. Multi-sector efforts to improve container shipping system security
3. Research and development on new technologies for low-cost, high-volume remote sensing and scanning

Most problems have been encountered at the national level. These relate to the provision of physical security for ships and ports as well as to security in the maritime surroundings and of inbound cargoes. The staffs of national maritime administrations have expanded to meet the demands of managing and implementing new strategies. More agencies are now involved in providing some type maritime security than was case previously. Regardless of the size of the country, there is a premium on the effectiveness of interagency coordination.

Seafaring has become less attractive as a career, and some seafarers of the Muslim faith have been laid off by shipping companies as a consequence of the additional constraints imposed on their ships when they visit American ports. Any possible manning shortage, as shipowners scrape around to find properly trained and experienced crews, could in the long run pose a greater threat to the safety and security of shipping than any threat from terrorism. Paradoxically, the shortage is occurring at a time when there are increased concerns about the human factor as a cause of maritime accidents and of the need for increased standards of competence among seafarers.

There is a challenge with providing maritime security against the threat of maritime terrorism in finding the right balance between assessments of risk on the one hand and realistic costs on the other. It is not just a matter of identifying threats and possible scenarios, but there is also the need to assess risk probabilities to guide policy and achieve a realistic allocation on resources.

It is a normal practice for government departments to bid for more resources than their government's budget can allow. In defense organizations, exhaustive analytical processes test new acquisition proposals. However, due to doubt about perceptions of an urgent need following 9/11 to make major improvements in maritime security, there seems to have been little testing, at least initially, of maritime security risk assessments and maritime counterterrorism measures. These were simply asserted by the government, and the private sector had to comply.

At an international level, the situation becomes more complicated with issues of globalization and equity coming into play between the developed and developing worlds. However, the same basic principle applies – the one who gets the benefit of enhanced maritime security should meet the costs of that additional security.

By expecting industry to bear the full costs of the new security measures, a government is treating these measures as though the benefits accrue only to the shipowners, shipper, or port or port facility operator. But it is the community at large that is ultimately being made more secure. At least in part, the new maritime security measures display many of the characteristics of a “public good” whose benefits are indivisible. If the measures are treated solely as “private goods” with benefits only for industry, then inevitably industry will tend to do the minimum possible to ensure compliance with regulations.

At the global level, the situation is more difficult. It is still a matter of burden sharing, but arguably the greatest beneficiaries of the new security measures are the developed countries. Generally, developing countries have been less concerned about the terrorist threat, but they are also facing increased costs with upgrading port facilities to comply with the ISPS Code; in making their national flag ships compliant with the code; and in providing new government machinery to oversee the new arrangements, including those for oversight of the training and licensing of seafarers. Certainly, there are large costs for the developed countries as well, but they are also the major beneficiaries.

## Chapter IV

### Current maritime security threats and their nature

#### 4.1 Categories of maritime security threats

##### 4.1.1. According to the direction of the "vector" of impact:

- External - terrorism, piracy, organized crime, amateur criminals, extremists, "stowaways";
- Internal - disgruntled crew members (employees) or forced / recruited to cooperate with a criminal organization or rivals, representatives / helpers of the above groups, employees with criminal tendencies, aggressive staff, mentally disturbed individuals;
- Combined – it is particularly dangerous option terrorists to get control of the other categories.

##### 4.1.2. According to the reasons:

- Maritime terrorism – political reasons (opposition to the political system), ideological or religious (in opposition to the conventional social views), symbolic, inducing fear;
- Piracy and armed robbery - economic motives;
- Stowaways - illegal emigration, human trafficking, economic motives;
- Transnational organized crime - economic motives – smuggling, trafficking;
- Internal criminal conspiracies - economic motives, smuggling rivals;
- Inter-state hostilities – diversion;
- Riots or civil disobedience - sabotage or vandalism.

Knowing the people who are employed is very important, because in this way different motives are combined in various combinations and evaluation of security becomes extremely complicated.

#### 4.2 Threats of the maritime security

Today it is very difficult to trace a leading trend in the development of these threats, because the official statistics is not complete, companies do not always report all incidents. Potential focus of maritime security threats:

- For terrorist groups: people's sense of security, ensuring shipping, continuity of the global logistics process, the exchange of goods and ideas – i.e. progress of civilization;
- For piracy and armed attacks - hijacking ships for ransom for the sailors, seizure of offshore installations and kidnapping of workers;

Geographic focus:

- Nine critical points in the world are located in geographic areas where there are terrorist groups associated with Al-Qaeda. A successful closure of the Strait of Hormuz achieved by attack and sinking a supertanker would lead to crisis in the world economy - 90% of the oil from Saudi Arabia and 100% from Kuwait and Iraq would not reach customers;
- Mega-ports and connected with them megalopolises – attack on them with WMD may cause damage not only locally but also could paralyze a large area and affect the global economy;

**Smuggling** - it can lead to great financial loss to the ship-owner whose vessel is used by smugglers. Often drugs are smuggled by putting them into the transported goods and might be brought onboard through a variety of ways, such as in the luggage, in the shipping supplies, in electronic equipment or in the body of a man. Weapons are also often smuggled and are carried in cargo containers, for example.

**Drug trafficking** is a serious crime that is associated with **maritime transport system** -the two most common drugs are:

- Heroin - poppy cultivation, heroin production from opium and transportation from the Golden Crescent (Iran, Pakistan, Afghanistan) , the Golden Triangle (Myanmar, Thailand, Laos) and Latin America (Colombia, Guatemala, Mexico);
- Cocaine - production in Central America (Colombia, Venezuela, Bolivia) and transportation to the U.S. and Europe by sea.

**Cargo thefts** – century-old problem for the maritime industry, which is still current nowadays and which leads to enormous financial losses. Prevention is usually the most effective method to deal with this threat. Although it may not be connected with violence or with political consequences, the threat has serious economic, social and community impacts. Cargo theft is only one of several threats to the security of cargo.

### **4.3 Analysing each threat of the maritime security – historical, geographical, legal frames**

#### **4.3.1. Geographical frameworks – For Bulgaria and Romania**

According to the IMB, traditional areas of piracy are: Somalia, South China Sea, Nigeria, Malacca and Singapore Straits, Bangladesh, South America, Indonesia, Caribbean. In recent years the piracy center shifted to Somalia and Nigeria. The focus is Somalia with the longest coastline in Africa - more than 3000 km. Pirate threat in South America includes the territorial sea of Peru, Brazil, Colombia, Costa Rica, Ecuador, Haiti and Venezuela.

Potential areas of terrorist threat are around the so called "Shock points" - the most vulnerable parts of the main delivery channels that terrorist may try to block by acquisition, directing or hijacking a tanker and subsequent sabotage. Closure that would significantly affect world trade, especially for the supply and price of oil –The Bosphorus Strait, Suez Canal, the Strait of Bab-el-Mandeb, and English Channel, the Strait of Gibraltar, Panama Canal; Danish straits; Strait of Hormuz, Malacca and Singapore straits.

**Human trafficking** - from areas with high migration:

- Kurdish populated northern Iraq and eastern Turkey;
- North Africa by sea to Europe, mainly Italy;

The regional maritime security is described in two formats:

- The first one includes the Black Sea region, the Mediterranean region and their approaches;
- The second one is directly connected with the security of Black Sea and its basin, with a special attention to the Danube river;

This helps us to see the link between:

- “close” format: the Straits of: Gibraltar, Bosphorus and the Channel of Suez;
- “far away” format: the Straits of: Malacca, Bab-el-Mandeb, Hormuz.

#### **4.3.2. Historical frameworks**

„Sea countries” are usually connected with: shipping and trade; sea territories reclamation; enrichment (legal or/and illegal); protection of interests.

Since the very beginning of the mankind, the Piracy is well known as: *a social phenomenon related to the re-distribution of wealth*; a possible way for Sea Power maintenance; a method to achieve Control of the Sea.

The most famous ancient seafarers – the **Phoenicians** discovered new territories; maintained the world trade; maintained the slave trade. They established a model for enrichment through violence and robbery.

In ancient **Athens** the Community of pirates law legalised by a law which regulates their activities and responsibilities. The pirates had to provide help in wartime and to protect Athens’ sea lines of communications.

The analysis of the ancient piracy reveals - the countries sustain pirates in order to protect the borders; the pirates rules all sea territories of “weak” states; during ancient times sea was an area for asymmetric war.

#### **4.3.3. Legal framework**

The MarSec *legal framework* is provided by:

- International convention for the safety of life at sea, 1974 (SOLAS-74) chapter XI-1 and XI-2;
- International Ship and Port Facility Security (ISPS Code);
- Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation, 1988 (SUA-88) and addition 2005;
- Protocol for the Suppression of Unlawful Acts against the Safety of Fixed Platforms located on the Continental Shelf, 1988 (Protocol).

#### **4.4 General model of a Maritime Security Threat**

The model of the threat includes - an entity (organization, people, motivation, base), funding, techniques, tactics and procedures (TTP), abilities (doctrine, weapons and training).

The following TTP are used:

- Power - the use of force, violence, damage or destruction of protective systems;
- False / demonstration - imitating an authorized activities during which the terrorist penetrate the important marine object;
- Hidden - attempt actions to remain unnoticed;
- A hidden conspiracy;
- Hidden in disguise;
- Combined.

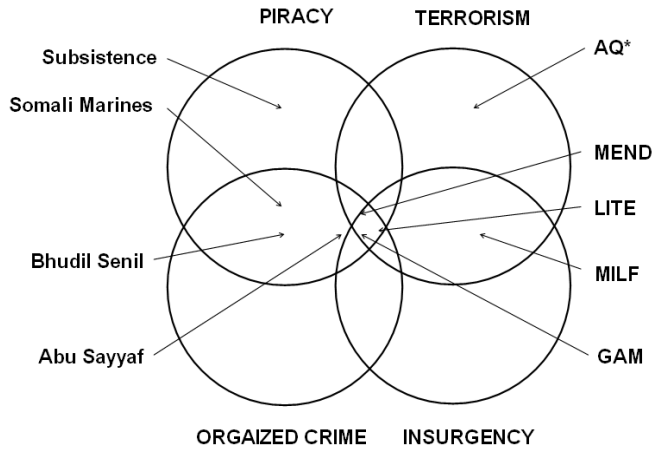
*Location and directions* of attack - the quay, at anchor or at sea, depending on the tactical situation, the attack can be done - by the sea, underwater, from the air or on / in the information space.

*Armament* – close-in weapon systems (CIWS – Vulkan Phalanx, AK-630, Goalkeeper, etc.), large caliber machineguns, man-portable air-defense systems (MANPADS), short-range antiship systems and rocket-propelled grenade (RPG) launchers, sea mines, high explosives, modern means of C2, optoelectronic observation systems, radar and sonar, navigation equipment. It is possible for them to carry nuclear, chemical and biological weapons.

*Objects of attack* - elements of critical maritime infrastructure (production platforms, installations, oil refineries), objects from MTS (merchant ships, PFs, assemblies of marine communications, maritime buoyage system, lighthouses, etc.)

#### **4.5 Connection between threats – The „Four Circles“ Model.**

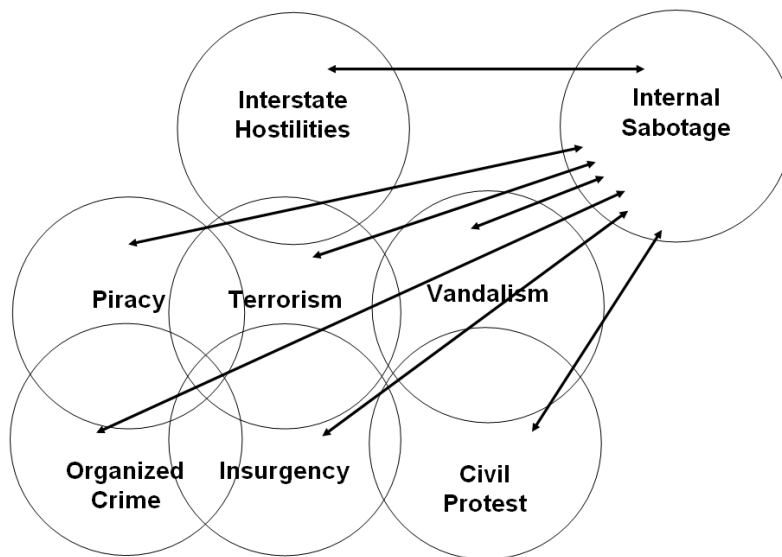
The scheme illustrates one of the most popular models, which shows the connection between the main threats to maritime security. In the analysis should be taken into account the specific conditions of the particular region and other external factors that require maintaining a good database.



*Source: Lloyd's MIU Handbook of Maritime Security, Edited by Rupert Herbert-Burns, Sam Bateman and Peter Lehr*

**The "Four Circles" Model**

The diagram below shows the connection of the possible threats to the security of an offshore facility.



*Source: Mikhail Kashubsky, Offshore petroleum security: Analysis of offshore security threats, target attractiveness, and the international legal framework for the protection and security of offshore petroleum installations, University of Wollongong, 2011*

**Offshore Security Threats Nexus**



## Chapter V

### Terrorism and commercial maritime transportation

#### 5.1 The legal definition of terrorism

The definition of terrorism utilized by the U. S. National Counterterrorism Center defines it as follows:

[P] *remediated, politically motivated violence perpetrated against noncombatant targets by subnational groups or clandestine agents.*

Terrorism is the use of force or violence against persons or property in violation of the national criminal laws for purposes of intimidation, coercion, or ransom. Terrorists often use threats to create fear among the public, to try to convince citizens that their government is powerless to prevent terrorism, and to get immediate publicity for their causes. The types of violence which may constitute a terrorist incident include the following:

- Physical harm, injury, or death to persons (assassination, kidnapping, hijacking, bombing with casualties);
- Physical damage or destruction of property, conveyances, facilities or assets (for example, the bombing of an oil pipeline, electrical station, unoccupied religious center).

In actuality, terrorist operations often are a combination of the actual act and the intended impact. While the tactical target may be a small group of victims, the strategic target may be the entire nation, i.e. the real audience. Terrorists seek to gain attention to their cause by creating fear and intimidation.

#### 5.2 Historical, geographical and legal aspects of phenomenon terrorism

The use of terror to influence or achieve political and/or religious change is not new. One early terrorist group, the Assassins murdered the religious and political leaders of Sunni Islam. Hence, the word *assassin* comes from the secret Muslim Order. The word *terrorism* comes from the French Revolution's "Reign of Terror" (1793-1794) when 12,000 people were executed for being suspected enemies of the revolution. Over the next 100 years, anarchism (antigovernment causes) arose in the United States, Russia, and Europe, and were highlighted by the assassination of Tsar Alexander in 1881, the attempted assassination of steel magnate Henry Frick in 1892, and the assassination of President William McKinley in 1901. An act of terrorism – the assassination in 1914 of the Archduke Franz Ferdinand – was one of the catalysts leading to the outbreak of World War I. The assassin had sought to win the independence of Bosnia from Austrian rule. The early and mid-20<sup>th</sup> century were marked by native people using terrorism to free themselves from colonial powers, in countries such as Algeria, Vietnam, and Egypt. It was at the beginning of the second half of the 20<sup>th</sup> century that "modern terrorism" emerged and the targeting of innocent civilians and business became commonplace. This has been seen in the operations of terrorist organizations such as Spain's Basque-separatist group ETA, Colombia's FARC and ELN, Ireland's IRA, and Palestine's PFLP and Hamas. Terrorist groups and incidents have continued to swell during the past 20 years, and the reach of the groups has become truly global. While many organizations still profess political goals, the attacks have become increasingly violent and indiscriminate, and in the case of Islamic terrorists there is a perceived religious mandate. The groups are very organized in their recruitment, training, and operations, including the preparation of manuals for training and torture. Terrorist organizations such as Islamic Jihad, Hezbollah, and al Qaeda exemplify this phenomenon, as their operations stretch across the globe, their desire to slaughter innocent civilians appears insatiable, and their declared motivations are political and religious (doing "God's work").

Over 10,000 terrorist attacks occurred in 2011, affecting nearly 45,000 victims in 70 countries and resulting in over 20,000 deaths. The total number of worldwide attacks in 2011, however, dropped by almost 12 percent from 2010 and nearly 29 percent from 2007. Although the 2011 numbers represent five-year lows, they also underscore the human toll and geographic reach of terrorism. The Near East and South Asia continued to experience the most attacks, incurring just over 75 percent of the 2011 total. In addition, Africa and the Western Hemisphere experienced five-year highs in the number of attacks, exhibiting the constant evolution of the terrorist threat.

### ***5.3 Characteristics of contemporary maritime terrorism***

An excerpt of the July, 2012, Bureau of Counterterrorism, United States Department of State “Country Reports on Terrorism 2011” lists the key observations of the worldwide terrorism as follows:

- Over 10,000 terrorist attacks occurred in 2011, affecting nearly 45,000 victims in 70 countries and resulting in over 20,000 deaths. The total number of worldwide attacks in 2011, however, dropped by almost 12 percent from 2010 and nearly 29 percent from 2007. Although the 2011 numbers represent five-year lows, they also underscore the human toll and geographic reach of terrorism. The Near East and South Asia continued to experience the most attacks, incurring just over 75 percent of the 2011 total. In addition, Africa and the Western Hemisphere experienced five-year highs in the number of attacks, exhibiting the constant evolution of the terrorist threat.
- The Near East and South Asia suffered 7,721 attacks and 9,236 deaths. The majority of those occurred in just three countries—Afghanistan, Iraq and Pakistan—which, together, accounted for 85 percent of attacks in these regions and almost 64 percent of attacks worldwide. While attacks in Afghanistan and Iraq decreased from 2010 by 14 and 16 percent, respectively, attacks in Pakistan increased by 8 percent.
- Africa experienced 978 attacks in 2011, an 11.5 percent increase over 2010. This is attributable in large part to the more aggressive attack tempo of the Nigeria-based terrorist group Boko Haram, which conducted 136 attacks in 2011—up from 31 in 2010.
- Attacks in Europe and Eurasia fell 20 percent from 703 in 2010 to 561 in 2011. The greatest decline occurred in Russia where terrorist attacks were down from 396 in 2010 to 238 in 2011. In contrast, Turkey experienced a spike in terrorist attacks, rising from 40 in 2010 to 91 in 2011. Together, Russia and Turkey suffered almost 70 percent of all 2011 terrorism-related deaths in Europe and Eurasia.
- The number of terrorist attacks in East Asia and the Pacific declined for the fifth consecutive year, falling 25 percent from 724 in 2010 to 543 in 2011, and 62 percent from the peak of 1,423 in 2007. Thailand and the Philippines continued to be the primary terrorist targets in the region.
- Terrorist attacks in the Western Hemisphere rose nearly 40 percent from 343 in 2010 to 480 in 2011, the vast majority of which were ascribed to the Revolutionary Armed Forces of Colombia (FARC).

Sunni extremists accounted for the greatest number of terrorist attacks and fatalities for the third consecutive year. More than 5,700 incidents were attributed to Sunni extremists, accounting for nearly 56 percent of all attacks and about 70 percent of all fatalities. Among this perpetrator group, al-Qaeda (AQ) and its affiliates were responsible for at least 688 attacks that resulted in almost 2,000 deaths, while the Taliban in Afghanistan and Pakistan conducted over 800 attacks that resulted in nearly 1,900 deaths. Secular, political, and anarchist groups were the next largest category of perpetrators, conducting 2,283 attacks with 1,926 fatalities, a drop of 5 percent and 9 percent, respectively, from 2010.

Armed attacks and bombings constituted nearly 80 percent of all terrorist attacks in 2011. Suicide attacks accounted for just 2.7 percent of terrorist attacks last year but 21 percent of all terrorism-related fatalities, a fact that underscores their extreme lethality. IEDs were the most frequently used and deadliest terrorist weapon employed.

Over 12,000 people were killed by terrorist attacks in 2011. The overall number of victims killed, however, decreased 5 percent from 2010. More than half of the people killed in 2011 were civilians and 755 were children. Although terrorism deaths decreased, the number of government representative and security force fatalities increased significantly. Muslims continued to bear the brunt of terrorism, while attacks targeting Christians dropped nearly 45 percent from a five-year high in 2010.

Over two-thirds of all terrorist attacks struck infrastructure or facilities. Of those, transportation assets and public places were the most frequently targeted. Transportation facilities—such as vehicles, buses and transportation infrastructure—incurred damage in about 27 percent of the attacks, while public places—including communal areas, markets, polling stations, religious institutions, schools and residences—incurred damage in about 21 percent of the attacks.

#### ***5.4 Subjects of terrorist threat***

The targeting and attacking of ships and ports by terrorist organizations has escalated considerably in the past 10 years. Moreover, small vessels are being used as the primary platform for launching or conducting the attacks. A growing concern is that terrorists may wish to gain control of maritime conveyances for the purpose of using them as a delivery for weapons weapon of mass destruction. Alternatively, terrorists could take control of a large tanker or cargo vessel for the purpose of ramming it into the Liquid Natural Gas (LNG) or Liquefied Petroleum Gas (LPG) storage tanks or pipes located on the docks of seaports. Many seaports are located adjacent to major cities, so loss of life may well be significant.

#### ***5.5 Typical examples***

Some of the recent key incidents of terrorists targeting ships and ports are:

- In 1985, four Palestinian terrorists, led by Abu Abbas, boarded the cruise ship *Achille Lauro*, which had over 400 passengers and crew onboard. The terrorists demanded the release of some 50 Palestinian terrorists being held prisoner. After a 2-day standoff, during which time 69-year-old paraplegic Leon Klinghoffer (American) was killed and his body dumped overboard, the terrorists were given free passage on an Egypt Air flight. However, once in the air, the aircraft was intercepted by two USN F-14s and forced to land at Sigonella, Sicily, and the terrorists were then turned over to Italian police.
- On January 16, 1996 in the Turkish port Trabzon, the Panamanian passenger ship *Avrasia* hijacking, by a Chechen terrorist group consist of nine Chechens and Turkish-Georgians from Abkhazia. The conflict, which resolved by the Turkish Navy and Coast Guard mediation, emphasizes on the one hand the Chechens will to attract people’s attention towards “the Chechen Cause” and on the other hand their initial intention to sabotage the two suspended bridges over the Bosphorus Strait.
- On October 12, 2000, the USS *Cole* was berthed in the port of Aden, Yemen, for bunkering and loading ship’s stores when two Yemeni terrorists drove a small inflatable with 400 pounds of high explosives into the side of the Navy ship. When the smoke cleared, there were 17 dead sailors and 37 injured. The USS *Cole* sustained extensive damage. Several Yemenis and Egyptians with ties to al Qaeda were arrested but later escaped.
- On October 6, 2002, the MV *Limburg* was anchored off the coast of Yemen awaiting a pilot when a small vessel came alongside and detonated its load of explosives. The explosion left the tanker of 397,000 barrels of crude oil damaged and a massive fire underway. One crew member was killed in the blast, and the others were rescued. The terrorist attack was claimed by al Qaeda. It is suspected that terrorists utilized a remote-control motorboat loaded with explosives to blow a hole in the side of the tanker. Another potential use of vessels for an attack platform was reported in the *Economist* on October 2, 2003. The press report indicated that a total of 10 tugboats had mysteriously disappeared throughout

Indonesia ports. Tugboats are much larger and more powerful than a pilot boat, zodiac, or other small launch and could carry a huge quantity of explosives for attacking a ship or port facility.

- In June 2003, Philippine-based terrorist group Abu Sayaaf kidnapped a resort maintenance engineer. Upon his release, the man, certified scuba diving instructor, reported that Abu Sayaaf had specifically targeted him because of his scuba skills. This report mirrors a similar report from Kuala Lumpur, where a dive shop owner reported that several local Muslim youth had inquired about scuba classes but were interested only in learning how to dive deep and not about issues of decompression or lifesaving technique. These two reports suggest a potential interest in terrorists to strike ships via motorized underwater sleds, hull-attached mines or human torpedoes. This concern is supported by a statement made by captured al Qaeda operative Omar al-Faruq, in Indonesia on June 5, 2002, confessing to planning scuba attacks against U.S. warships.
- In 2004, at the port Ashdod, Israel, 10 persons were killed and more than 15 injured when two suicide bombs detonated. A subsequent inspection in the port identified an empty container with five grenades, weapons, clothing, and a mattress. Gate logs revealed that the container had entered the port 4 hours prior to the suicide attack.
- In November 2005, terrorists deployed an explosives-laden unmanned launch at the port of Buenaventura, Colombia, and guided into berths 10 and 11. While the launch was alongside the berth, Navy personnel attempted to board. Explosives detonated, killing two Navy officers and injuring seven other persons. Subsequent arrests by police in reference to the attack also netted information on the construction in progress of a 5-meter long homemade torpedo made by terrorists and designed to carry a large amount explosives.

## Chapter VI

### Piracy and armed robbery

#### 6.1 *The legal definition of piracy and armed robbery*

Piracy and stowaways, the former of which can be traced back to 1200 b.c., continue to be costly scourges for the commercial maritime industry and involve the use of various tactics and platforms which present a challenge to ships and ports. Equally concerning, though, is the trend which points to an ever-increasing potential for violence.

The International Maritime Bureau (IMB) defines piracy and armed robbery as follows: an act of boarding or attempting to board any ship with the apparent intent to commit theft or any other crime and with the apparent attempt or capability to use force in the furtherance of that act.” Article 101 of the 1982 United Nations Convention on the Law of the Sea defines piracy as:

- (a) *any illegal acts of violence or detention, or any act of depredation, committed for private ends by the crew or the passengers of a private ship or private aircraft, and directed*
- (i) *on the high seas, against another ship or aircraft, on against persons or property on board such ship or aircraft;*
- (ii) *against a ship, aircraft, persons or property in a place outside the jurisdiction of any State;*
- (b) *any act of voluntary participation in the operation of a ship or of an aircraft with knowledge of facts making it a pirate ship or aircraft;*
- (c) *any act of inciting or of intentionally facilitating an act described in subparagraph (a) or (b).*

Armed robbery at sea, on the other hand must be distinguished from piracy as the definition of piracy is very narrow. The commission of an act of piracy necessarily involves the attack being launched from another ship on the High Seas and the attack must be launched for private ends. Armed robbery, however, is defined as “any illegal act of violence or detention or any act of depredation, or threat thereof, other than an act of “piracy”, committed for private ends and directed against a ship or against persons or property on board such a ship, within a State’s internal waters, archipelagic waters and territorial sea and any act or intentionally facilitating on act described above.” Accordingly, there is no requirement for the involvement of at least two ships or any limitations in respect of the motivation behind armed attacks.

#### 6.2 *Historical, geographical and legal aspects of piracy and armed robbery*

The first acts of piracy can be traced back over 3000 years. The earliest act of piracy was pioneered by a group called “The Sea Peoples”. These seafaring raiders lived around 1200 b.c. and sailed to the eastern shores of the Mediterranean, causing political unrest, and attempted to enter Egyptian territory during the late 19<sup>th</sup> dynasty and during 8 Year 8 of the reign of Ramesses III of the 20<sup>th</sup> dynasty. Most memorable in more recent history were the two centuries from 1500 to 1700 when buccaneers Sir Francis Drake, Captain Kidd, and Captain Morgan sacked galleons and coastal cities, and Edward “Blackbeard” Teach and Bartholomew “Black Bart” Roberts terrorized the seas and became icons of piracy.

Some 200 years ago, piracy was even a military tactic in the early days of the United States. During the American Revolutionary War, colonial ship owners took part in a concept called *privateering*. This allowed privately owned vessels to attack and seize British vessels and keep a substantial share of the profits. Over \$16 million in British maritime assets were seized by these privateers during the Revolutionary War. John Paul Jones, the founder of the American naval tradition, was referred to as a “pirate” by the British Navy. His tactics included flying British flags in order to sneak up on British Ships and raiding the British coast, seizing three ships, spiking the guns of a fort, and setting fire to a ship in port and attempting to kidnap a British dignitary.

Such a scourge it was then that it was regarded as a *jus cogens* crime, subject to the penal jurisdiction of all States. This classification remains today but the problem has much reduced. Still, there are areas that have been identified as hotspots. The main areas are the South China Sea, the Strait of Malacca, West Africa and Somalia. Currently the greatest number of incidents of piracy and robbery at sea, and certainly the most disruptive is shown to occur off the coast of Somalia. These crimes occurring off the coast of Somalia have occupied a great deal of media attention in recent times due to the frequency of attacks, their impact on the international shipping industry and international trade.

### **6.3 Characteristics of contemporary piracy and armed robbery**

More than half of all pirates attacks reported to the Baltic and International Maritime Council (BIMCO) take place while the vessel is at anchorage. Stationary vessels are more vulnerable to attacks launched from the shore by pirates in motorboats, and most attacks occur under the cover of darkness. This prevents faster response from police and security patrols. Also, while vessels are at anchorage, the crew is busy preparing for upcoming cargo operation.

Piracy attacks usually involve boarding the ship from one or more high-speed small boats, using a rope with a grappling hook (for hooking to the deck side rail or deck floor), or lightweight ladder (single or double pole and with hooks at the top). If the vessel is at anchor and the hawse cover is not in place and secured, the pirates also may climb up at anchor chain to gain access to the ship. In cases in which the crew makes the serious mistake of not retracting the Pilot ladder, this provides a means access for pirates (as well as terrorists, stowaways, and contraband smugglers). According to OSS Maritime Security Team supervisors – who have repelled dozens of pirate attacks over the past 17 years – if a pirate is attacking a vessel while underway, it is generally accomplished by the high-speed small craft approaching from an angled position and sweeping in along the hull, at the aft. Once the craft is alongside, a ladder is raised to the deck or a grappling hook thrown up and hooked. Agile pirates can be on deck in only a few minutes. Pirates will not hesitate to shoot, as a means to escape once detected, or to coerce the vessel into stopping.

On container ship and freighters, the pirates may plan to steal cargo electronic and navigation equipment, valuables from unsecured crew accommodations, and money from the captain's safe. In the case of a bulk vessel, especially in Southeast Asia and Africa, it is most likely that the target is the entire ship.

The attackers are usually armed with knives, machetes, or handguns, but is very common for pirates to have rifles. The use of machine guns and rocket-propelled grenades is popular off the coast of Africa.

### **6.4 Subjects of piracy and armed robbery**

The IMB Piracy Reporting Centre (IMB PRC) has recorded 439 incidents of piracy and armed robbery in 2011, compared to 263 in 2007. A total of 177 incidents have been reported in the first six months of 2012, compared to 266 266 incidents for the corresponding period in 2011.

In 2011, 45 vessels were hijacked, 176 vessels boarded, 113 vessels fired upon and 105 vessels reported attempted attacks. A total of 802 crew members were taken hostage, ten kidnapped and eight killed as a direct result of incident.

Somali pirates account for more than half of the 2011 attacks. Whilst the overall number of Somali incidents has increased from 219 in 2010 to 237 in 2011, the number of successful hijackings has decreased from 49 in 2010 to 28 vessels in 2011.

Up to 3<sup>rd</sup> December 2012 are reported following worldwide piracy incidents:

- Total Attacks – 278;
- Total Hijackings – 27

Piracy incidents reported for Somalia:

- Total Incidents – 71;
- Total Hijackings – 13;

-Total Hostages – 212.

The attacks have also reportedly extended to the EEZ of the Seychelles. Many of attacks have taken place in the Somali EEZ as it was last declared, which has complicated enforcement options of the international community that Somalia is effectively a failed State with no central Government or overarching rule of law. As such, the nature of the piracy problem in the Gulf of Aden is one particular surrounding circumstance thus requiring a certain approach.

The decrease in the overall number is welcomed and primarily due to a noticeable decline in Somali piracy activity. The reduction of reported Somali piracy incidents is the result of the efforts of international navies, effective deployment of Best Management Practices, ship hardening and particularly the increased use of Privately Contracted Armed Security Personnel (PCASP). The number of vessels employing and reporting the carriage of PCASP has increased. The regulation and vetting of PCASP still needs to be adequately addressed. Until such time as a comprehensive legal framework is in place, owners and Masters should follow the IMO and industry guidelines on the carriage of PCASP. The preemptive and disruptive tactics – including the first land based attack – employed by the navies have played a vital role in deterring the pirates. Naval assets are essential to region-wide counter piracy tactics, including interdicting mother-ships before they can get into a position to threaten merchant vessels.

The decline in Somali piracy, however, has been offset by an increase of attacks in the Gulf of Guinea, where 32 incidents, including hijackings, were reported in 2012, versus 25 in 2011. In Nigeria alone there were 17 reports, compared six in 2011. Togo reported five incidents including a hijacking, compared to no incidents during the same time 2011.

In Nigeria, three vessels and 61 crew members were taken hostage. Seven vessels were boarded, six fired upon and one attempted attack was reported. The report further showed that attacks by armed pirates in skiffs were occurring at greater distances from the coast, suggesting the possible use of fishing or other vessels to reach targets. On 30 June 2012 alone, three vessels were fired upon, including a tanker and a container vessel within a five-minute period, approximately 135 nautical miles from Port Harcourt.

The increase in pirate activity off Togo has also been attributed to Nigerian pirates. The five reported incidents all occurred in April 2012, culminating with the hijacking of a Panamax product tanker by the month's end.

Attacks elsewhere in the world have mainly been armed robberies. Indonesia accounts for almost 20% of the global numbers, with 32 reported incidents compared to 21 over the same period in 2011. Twenty-eight of the vessels targeted were boarded, including 23 anchored vessels, two berthed and three that were underway. Guns have been reported on one occasion.

## **6.5 Typical examples**

Over the past 20 or so years, as evidenced in case history, piracy has become more brazen, more violent, and has utilized more advanced weaponry in their attacks. Let's review some selected cases:

- On 24 November 2009, a Liberia flagged Tanker Cancale Star was attacked armed robbers, around 18,5 nm off Cotonou, Benin at approximately 0120 UTC. Eight to nine robbers armed with guns and knives boarded an anchored tanker. The robbers boarded via the poop deck and attacked the poop deck watchman and forced the watchman to the bridge. Robbers demanded ship's cash, crew cash, and personal belongings. Robbers were aggressive and they beat up the master and other crew. Few crewmembers hands were tied with ropes and forced to lie on deck. The 3<sup>rd</sup> officer activated ship's alarm and SSAS alert. Hearing the alarm the robbers panicked and tried to escape. As they escaped they shot and killed the chief officer. One of the robbers was caught by the 2<sup>nd</sup> and 3<sup>rd</sup> officer and handed over to the Benin police. Most of the money was recovered from the robber who was caught.
- On 20 October 2010, a Hong Kong flagged Container Marianne Schulte was attacked by pirates, around 15 nm South of Tin Can Island Fairway Buoy, Lagos, Nigeria. Eight pirates

armed with guns boarded the drifting ship. 2/O raised alarm and tried to contact the port control but received no response. SSAS activated. Pirates took hostage three crewmembers, went to the Master's cabin and attempted to break Master's door with extinguisher and gun. Master opened the door and under gun threat handed over the ship's cash to the pirates. The pirates ordered the Master to muster all the crew, including the bridge watchkeepers to his cabin. The pirates ransacked the crewmembers cabins. Before escaping the pirates ordered five crewmembers to carry out all the stolen items to the deck and lower it into their waiting boat.

- On 15 November 2011, a Panama flagged Product Tanker BW Danube was attacked by eight pirates in two skiffs chased the tanker underway, around SE of Salalah, Oman at approximately 0418 UTC. Master raised alarm, and increased speed. All crew except bridge team mustered in the citadel. The security team onboard fired flares as a warning towards the skiffs. The pirates fired upon the tanker and finally aborted the attempted attack and moved towards a mother vessel.
- On 15 October 2012, a Luxemburg flagged Supply Vessel MV Bourbon Liberty 249 was attacked by armed pirates while underway, around 40 nm south Brass, Nigeria at approximately 1130 UTC. Around seven armed pirates attacked and boarded the anchor handling tug supply vessel via a speedboat launched from a mother ship. They stole vessel's properties and crew valuables and personal effects, kidnapped seven crew members and escaped. The remaining nine crew members were safe onboard.
- On December 2012, a Danish flagged Product tanker MT Torm Cristina was attacked by armed pirates while underway, (about 80 nm NW of Muscat, Oman), off Somalia at approximately 1458 UTC. The pirates approached and opened fire at the tanker. The Master immediately raised the alarm, commenced evasive manoeuvres, contacted UKMTO, sent distress alerts via VHF and SSAS and all crew retreated into the citadel. Navies in the vicinity responded to the distress and a naval boarding team was sent to rescue the crews. On boarding the tanker, no pirates were found and the crew regained control of their vessel and continued passage.



## Chapter VII

### Stowaways

#### *7.1 The legal definition of stowaways*

The Convention on Facilitation of International Maritime Traffic, 1965, as amended (The FAL Convention – IMO), define stowaway as “A person who is secreted on a ship, or in cargo which is subsequently loaded on the ship, or in cargo which is subsequently loaded on the ship, without the consent of the shipowner or the Master or any other responsible person and who is detected on board the ship after it has departed from a port, or in the cargo while unloading it in the port of arrival, and is reported as a stowaway by the master to the appropriate authorities.”

The International Maritime Organization strongly encourages that appropriate measures be taken to reduce risks of unauthorized persons boarding ships. The FAL Convention has clear ship/port "Preventive measures" and recommended practices on the "Treatment of stowaways while on board" and "Disembarkation and return of a stowaway".

The Facilitation Committee, at its thirty seventh session (FAL 37), in 2011, adopted resolution FAL.11 (37) in "Revised guidelines on the prevention of access by stowaways and the allocation of responsibilities to seek the successful resolution of stowaway cases". This resolution is particularly addressed to Member Governments which are not contracting Governments of the FAL Convention and to those Member States which find it impracticable to comply with the relevant Recommended Practices of the FAL Convention.

The Facilitation Committee invited IMO Member Governments and international organizations in consultative status, through Circular FAL.2/Circ.50.Rev.2, to provide the Organization with information on stowaway incidents. The information is collated and issued quarterly as a FAL.2 Circular.

Taking into account that incidents of stowaways represent a serious problem for the shipping industry and that no signs of improvements have been seen regarding the reduction of stowaway cases, the International Maritime Organization strongly encourages Member States to fully implement the International Convention for the Safety of Life at Sea (SOLAS), chapter XI-2 on measures to enhance maritime security, and the ISPS Code, which also contain clear specifications on access control and security measures for port facilities and ships.

#### *7.2 Historical, geographical and legal aspects of stowaways*

The evolution of the stowaways and human smuggling from the single person, unaided, and stowing away on a freighter to today’s organized stowaway operation has changed the methods and techniques used by stowaways and, unfortunately, has placed the human cargo in a greater risk of death. Webster’s defines stowaway as “a person who hides aboard a ship, airplane, etc. to get free passage, evade port officials, etc.”

Notwithstanding the individual stowaway who, without additional assistance, manages to stow onboard a commercial ship, the majority of stowaway incidents are actually organized human smuggling operations and managed by local or transnational human trafficking organizations. According to OSS and Phoenix Group Vessel Security Teams which have captured in excess of 500 stowaways during the past 15 years, in some ports in poor countries – such as Colombia, Ecuador, Haiti, Honduras, and Dominican Republic – a port security guard or police officer makes his “real” pay collecting bribes and generally must pay his supervisor for the opportunity to be positioned closer to the dock. Because the closer he is to the dock, the greater the opportunity for increased number of bribes and those which are of larger amounts (for cargo theft, drug smuggling, etc.). This also includes

bribes paid by individual stowaways and, more importantly, bribes paid by stowaway organizations. In these ports, it is an open secret who runs the stowaway organizations.

### ***7.3 Characteristics of phenomenon stowaways - motivation***

The overwhelming majority of stowaways are looking for economic opportunity and a better life for themselves and probably their families. While there are many exceptions to the rule (specifically Chinese stowaways), a general profile of a typical stowaway is as follows:

- Male;
- 15-35 years old;
- Economically poor;
- May have some type of national identification but no passport;
- Carries a minimal amount of water, food, and clothing;
- Has point-of-contact information in the country of destination;
- Paid for the opportunity (e.g., professional human trafficking organization, security guard at gate, crew member on ship, etc.);
- May be trading right of passage for smuggling a modest amount of illegal narcotics;
- Has made multiple prior attempts;
- Is nonviolent (will immediately try again if caught so there is no need for violence).

Stowaway and human smuggling organizations tend to function like an effective “cargo shipping agent.” These organizations have an infrastructure within the port and contacts developed within the port entities, such as port police, stevedores, local security guard deployed onboard the ship, container and seal checkers, etc. The would-be stowaway pays a flat fee for the right of passage and to cover the logistics and bribes necessary. In many cases, the stowaways do not have the money to pay, so they may offer to become *mulas* (drug couriers) for all or part of the payment. The success of the agreement is “guaranteed” in that the stowaway is given, if necessary, repeated opportunities to get to his intended destination. All persons involved in the operation at the port of embarkation – and in many cases in the destination port – share in the fee. The fees for transit to the United States vary from U.S.\$4,000 per stowaway in the port of Limon Costa Rica, to U.S.\$60,000 per stowaway in a port in China. This is big business. Imagine, one kilo of cocaine at a source country port can be purchased for \$2,000 – basically the same price as what a stowaway pays. In fact, human smuggling organizations view their clients as just another commodity. The person who directs the tactical portion of the operation, i.e., organizing and placing the stowaways inside the container or supervising the small boat transporting the stowaways to the anchored ship, is called a *coyote* or *snakehead*.

### ***7.4 Tactics and techniques used by stowaways***

Stowaways utilize many techniques and tactics to gain access to the vessel including via authorized and unauthorized vessel access points, in containers, or in cargo. The typical load on/load off (LO-LO) container ship (as well as roll-on/roll-off [RO-RO], tanker, and general cargo vessels) provides many points of access for stowaways. The most common points of access for stowaways are as follows:

- The gangway serves as authorized access point for stevedores, crew, government officials, and visitors. However, it is very common for stowaways, generally with the assistance of stevedores, to pose as legitimate stevedores (in uniform and with fake or real stevedore IDs), day laborers etc., and try to enter to vessel.
- Not fully retracted Jacob’s or Pilot ladders present an opportunity for stowaways arriving by small launches or for swimmers. Some swimmers use the infamous “stowaway pole”. This bamboo pole has metal hook attached to the top for hooking on to the deck rail and handholds fashioned from pieces of rubber tied at intervals along the pole. The bamboo has natural air pockets, so it will float in the water, which serves two purposes: (1) this makes it

somewhat easier to swim with, and (2) it provides its own projection capability. As in the case of pirates and drug couriers, stowaways boarding from small crafts generally use a grappling hook attached to a rope, a lightweight ladder, or a knotted rope tossed down to the waterline by a participating stevedore, crew member, or security officer. Also, stowaways use supply and bunker vessels – which frequently tie up on the waterside of the ship – as a platform to access the target ship’s waterside.

- Mooring lines and anchor chain present additional means of entry into the vessel by stowaways. During the nighttime unmonitored mooring lines, especially if the vessel is at low tide and heavy with cargo (which lowers the vessel in relation to the dock), permit stowaways to climb hand-over-hand from the dock to the vessel. The anchor chain, especially if the hawse cover is not secured, is the primary access point for stowaways to board ships while at anchorage. On some ships, the distance from the water to the top of the anchor chain is very short, and the angle of the chain from the ship to the water denies easy observation from on deck. Both of these factors make the access via the ship’s anchor chain an inviting target for stowaways, as well as other criminal elements. Another method used by human smuggling organizations is the “love boat”. In high volume ports and waterways that have active anchorages, is not uncommon for water taxis and launches filled with prostitutes to visit commercial cargo ships while waiting at anchorage. Frequently, these love boats also carry stowaways and drug couriers.
- There has been much written, in alerts from Protection and Indemnity (P&I) Clubs, Customs and Border Protection (CBP) bulletins, and news reports, about stowaways (and drug smugglers) accessing the rudder compartment and traveling inside this compartment and travelling inside this compartment to the port destination. This is a very risky technique because the constant loud noise, regular spray of ocean water (which damages any unprotected food), and the movement of the ship can easily create dangerous situations. This tactic has been especially popular via tankers and break-bulk vessels from ports in Africa, Venezuela, and Colombia.

When stowaways successfully enter the vessel, some of the commonly used locations include the following:

- Inside ventilation shafts and crawlspaces within the cargo bays/hatches;
- Behind or inside coiled mooring lines and other equipment in unsecured storage lockers;
- Between and on top of containers in the hatches, including wedging between containers that are stacked four or five high (a risky method);
- Inside unsecured empty containers or loaded ragtops (push back the tarp cover);
- On the main (poop) deck, between and on top of containers, hiding in unsecured equipment rooms and crane compartments;
- Inside life boats and the smoke stack access hatch;
- In the engine room, steering room, engineering, and spare parts locker (including submerged in oily water under the raised floor in the engine room and breathing through a straw or narrow plastic tube);
- In unsecured crew accommodations, hospital room, and passenger/pilot rooms;
- In linen lockers, food storage areas, and other common areas.

The other primary means that stowaways utilize are hiding inside break-bulk and palletized cargo and via containers and related equipment:

- Stowaways hide inside pallets of cargo – boxes of fruit, vegetables, etc. – generally with the assistance of persons at the packing station. With this technique, a void is created by extracting several boxes from the finalized pallet. The stowaway sits in a ball position, while only box ends are used to build the façade. To the untrained eye, it looks like a normal pallet of bananas. Due to the small space, the stowaway can carry only a limited amount of water and food for voyage.

- Empty containers/trailers and open-top (ragtop) containers are frequently targeted by stowaways. Empty containers and trailers offer the stowaways adequate space for supplies, movement, and additional air to breathe if the container becomes boxed in, and because empty containers hold no cargo, they are typically left unsealed in the port (easy access) and earn a low level of interest. Ragtop containers are designed to hold some types of bulk cargoes and large pieces, such as heavy generators, engines, etc., that need to be moved by crane which are not well suited for a conventional container. However, the canvas top easily can be pulled back or tie rope cut, stowaways inserted, and the rope retied. Also, because these containers generally are stowed on deck (and not in the closed bays) and have a very porous canvas top, there is regular access to fresh air.
- Human smuggling organizations utilize loaded containers and *supposedly* loaded containers to transport stowaways. In the Dominican Republic and Haiti, thousands depart each year either as stowaways in containers or onboard cargo ship or in boats crossing the Mona Passage to Puerto Rico in the hope of reaching the shores of the United States. Dominican authorities estimate that as many as 100 of these persons die each month trying to accomplish this goal – mostly in boats that sink attempting to cross the treacherous Mona Passage. However, it is also all too common for Dominican and Haitian stowaways to perish inside cargo bays and containers. Generally, human smuggling in 807 cargo containers (the 807 designation refers to the value-added duty provisions under Section 807 of the Tariff Schedules of the United States, which offer significant tax incentives for having fabrics manufactured/cut sewed at the *maquillas* in the Caribbean and Central America) is performed by loading the stowaways to the front of the container, with a wall of cargo to the rear – providing adequate concealment for visual inspections. Another technique utilized is to build a false wall one-half or two-thirds into the container, with the stowaways and their provisions loaded in the empty space and cargo fully loaded to the rear.
- Stowaways also are found hiding on the undersides of trailers, mafis, and chassis equipment. Mafis are very low to the ground, and it is difficult to observe the undersides. Also, the structural design creates hidden pockets in corners where stowaways and drug couriers can easily hide themselves. Typically, stowaways suspend themselves under mafis, trailers, and chassis utilizing ropes and harnesses to maintain their bodies as close as possible to the underside and decrease the opportunity for observation by security.

## Chapter VIII

### Transnational organized crime

#### 8.1 *The illicit trade in hazardous materials*

Transnational organized crime is a very old phenomenon that has evolved and intensified over the years. It has captured the world's attention in the past thirty or forty years particularly in connection with the illicit drug trade and narcotic black market that emerged as a result law enforcement efforts to suppress trafficking. A huge aspect of organized crime is a network of violence and corruption perpetuated by drug cartels in order to protect their financial interests in trafficking illegal narcotics. Organized crime typically engenders activities such as illicit trafficking in drugs, small arms and light weapons, corruption, money-laundering, prostitution, human trafficking all of which are linked to increased incidents of violent crime within national borders. Moreover, as its name suggests, this network of violence and crime is highly organized and spans a broad global spectrum among powerful cartels and crime syndicates. The reach of power of these crime organizations has so grown over time that they are believed to have financial and other stakes in virtually all of the security threats.

Increased law enforcement action against the drug trade created a need on the part of traffickers to protect their interests in the extremely lucrative trade and to maneuver around legal systems. As a consequence, traffickers became more organized and savvy in terms of their operations and clear hierarchy of power or chain of command developed within criminal organizations. This level of organization and development was also aided by the vast resources acquired on account of the drug trade which has also cultivated a contiguous culture of violence and intimidation mainly through the use of firearms and other weapons to resist interference from law enforcement authorities as well as rival drug traffickers. In order to fully profit from the proceeds of crime, criminal organizations required a way to "legitimize" their funds, hence the money-laundering aspect of organized crime. Corruption and bribery of public officials also became a tool for thwarting law enforcement efforts against criminal activity and for increasing the power base of cartels. With increased power bases and huge financial resources criminal organizations were able to diversify their portfolios. Human trafficking, prostitution, and migrant smuggling which are all very lucrative illegal trades and some of which have a parallel connection with the drug trade, are also associated with organized criminal operations. As demand and markets for illicit trades grew globally, so did the global network of crime syndicated. This level of criminal organization evolved to create inter-organisational cooperation among cartels in different regions of the world, hence further developing the transnational aspect of organized crime.

Criminal organizations more easily conduct these operations in regions where poverty is relatively high, social stability is relatively low and/or where borders and porous with lax or few controls attending them, as these conditions are conducive to corruptible public officials, disaffected youth that may be attracted to the financial gains of organized criminal activity, as well as easy access to territories from the air and particularly from the sea. Organized crime syndicates also act to create or exacerbate these conditions where possible. They are known to fund internal conflicts in vulnerable regions of the world maintaining, or in some cases, increasing the demand for drugs and weapons. In other cases, social destabilization occurs as a natural consequence of the violence and crime that accompanies organized criminal activity, discouraging valuable revenue derived from tourism and foreign investment. In a nutshell, organized criminal activity weakens rich countries and devastates poor ones.

The United Nations Convention against Transnational Organized Crime (hereafter referred to as "CTOC") is the main international convention addressing this problem. It aims to combat organized crime through, *inter alia*, global cooperation in matters relating to confiscation of property, extradition, mutual legal assistance, and technical assistance and training. It also requires States Parties to

implement domestic measures to achieve, *inter alia*, criminalization of the various aspects of organized crime, including illicit trafficking in arms, drugs and persons; international law enforcement cooperation; the adoption of new frameworks for mutual legal assistance; extradition; and provision for technical assistance and training. Its three Protocols<sup>1</sup> make similar provision in respect of human trafficking, smuggling of migrants at sea, and the illicit manufacture and traffic of firearms. The United Nations Office on Drugs and Crime (hereafter referred to as the “UNODC”) is the United Nations agency that works with Governments, regional organizations and civil society to achieve full and effective national implementation of CTOC and its Protocols.

The threat of international terrorism has highlighted the risk posed by hazardous materials that, aside from their obvious threats to environmental safety, can be converted into weapons of mass destruction. On a regular basis, ports are the conduit for legal substances such as chemicals, fuels, and other hazardous materials. The control and security of the transportation and storage of these materials is increasingly a concern for seaports due to the destruction that can be caused by mishandling or criminal intent.

## **8.2 The illicit trade in small arms and light weapons**

As indicated, the illicit trade in small arms and light weapons (SALW) is heavily linked to the illicit drug trade. As such its impact is as hard-hitting and far-reaching as the illicit drug problem. There is a distinction to be made however between the illicit trade in weapons and the secret trade thereof. Governments supplying arms secretly to groups in foreign countries are not necessarily acting illicitly, although, if the proper procedures of the receiving state have not been followed that state may well regard the action as illicit in the context of interference in its domestic affairs. The illicit traffic in weapons as it is referenced herein is generally understood to cover “that international trade in conventional weapons which is contrary to the laws of states and/or international law”.

The demand for illicit arms and weapons is due to a number of factors but is in many cases directly proportional to the demand for illegal narcotics. In others it is fuelled by internal conflict and civil war. Traffickers in this respect tend to be exiled groups and private arms dealers whose motives are politically driven, or drug traffickers and organized crime elements whose motives are for profit. Excessive accumulations of small arms and light weapons are generally the source of weapons peddled on the illicit market. Some of these are surplus from newly manufactured weapons while others are surplus from the Cold War and therefore much older. The illicit trade therefore largely consists in practical terms of excessive accumulations of legally produced weapons circulated throughout the target market with destabilizing effects on the countries and regions that receive them.

The illicit traffic in weapons plays a major role in the current increases in violence in many countries and regions, whether as a result of internal armed conflicts or increases in violent crime, and consequently the destabilization of societies and governments. The illicit traffic or circulation of arms has also been linked to the fostering of terrorism, mercenary acts and the violation of human rights. These effects are further exacerbated by the lack of national controls of arms production, exports and imports in a number of countries that receive illicit weapons as well as poorly trained or corrupt border personnel. Differences in legislation and enforcement mechanisms of states for the import and export of weapons has been identified as a facilitating factor in the circulation and illicit transfer of SALW, along with lack of state cooperation in this area. This lack of cooperation and coordination has also been identified as facilitating the excess accumulation of SALW.

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<sup>1</sup> The three Protocols are: (1) Protocol to Prevent, Suppress and Punish Trafficking in Persons, especially women and children, supplementing the United Nations Convention against Transnational Organized Crime; (2) Protocol against the Smuggling of Migrants by Land, Air and Sea, supplementing the United Nations Convention against Transnational Organized Crime; and (3) Protocol against the Illicit Manufacturing and Trafficking in Firearms, their Parts and Components and Ammunition, supplementing the United Nations Convention against Transnational Organized Crime.

The most influential document on this issue is the *Program of Action to Prevent, Combat and Eradicate the Illicit Trade in Small Arms and Light Weapons in all its Aspects* (PoA). This non-binding instrument adopted in July 2001 sets out measures to be taken at the national, regional and international levels in respect of, *inter alia*, legislation; confiscated, seized or collected weapons; and technical and financial assistance to States which are otherwise unable to adequately identify and trace illicit arms and light weapons. Since 2001 there have been a number of Regional follow-up conferences regarding implementation of the PoA. The PoA remains the main framework document with which many States and regions work in relation to implementing measures to address the problems of SALW.

### **8.3 Human trafficking**

Human trafficking is internationally regarded as “the recruitment, transportation, transfer, harboring or receipt of persons, by means of the threat or use of force or other forms coercion, of abduction, of fraud, of deception, of the abuse of power or of a position of vulnerability or of the giving or receiving of payments or benefits to achieve the consent of a person having control over another person, for the purpose of exploitation”.<sup>2</sup>

In general pattern that human trafficking has been found to follow is that victims are recruited or taken in the country of origin, transported through transit territories, and exploited in the country of destination. Based on reported cases of human trafficking, typical areas of origin, transit and destination have been identified. The major regions of origin have been identified as Western Africa, Asia, particularly South East Asia, Latin America and the Caribbean, and Central and South East Europe. On the other hand, Central and South East Europe is reportedly a main transit sub-region. Major destination regions have been identified as Western Europe and North America. In the case of intra-regional trafficking Western Africa has been identified as the main destination sub-region for victims trafficked for Africa. Within Europe, Central and South East Europe are the major origin sub-regions with Western Europe being the main point of destination. In Asia certain countries rate highly as countries of origin while others are largely destination countries.

As this data is based on reported information, the picture it paints is probably not entirely representative of the trafficking situation worldwide but does give a general idea of the demand and supply trends throughout the market for trafficked persons. Women and children are most frequently and most acutely affected but men are also trafficked, more often for forced labor purposes than for the purposes of sexual exploitation which tends to most affect women and young girls. Besides being physically, psychologically and emotionally destructive and affront to human rights as a whole, human trafficking affects societies in a variety of ways. As a result of its links to organized crime, human trafficking tends to be accompanied by drugs, arms and increased criminal activity, namely at the transit phase and destination phase in cases where victims are trafficked for the purpose of sexual exploitation. In this respect, its prevalence can lead to social degradation which has economic consequences from the perspective that legitimate local and foreign investment may suffer and decline.

### **8.4 Illegal drug origins and production**

The huge global demand for illegal drugs is the fundamental driving force behind the illicit trade. The source of illegal drugs is typically poor farmers in developing countries for whom the cultivation of their traditional or new food crops is far less profitable than cultivation of illicit drugs. Globalization has, in this respect, been said to have contributed to the nurture of the drug trade, for as displaced farmers seek alternative ways to eke their living the cultivation of narcotics for illicit sale and

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<sup>2</sup> See article 3(a) of Protocol to Prevent, Suppress and Punish Trafficking in Persons, Op.cit.n 10. “Exploitation” includes, at minimum, the exploitation of the prostitution of others, or other forms of sexual exploitation, forced labour or services, slavery, or practices similar to slavery, servitude or the removal of organs.

distribution becomes a tempting solution despite the incumbent risks and dangers. The organized criminal organizations that employ these farmers, at one time, also ensured that the supply reached the demand, thereby exerting control on drug operations from beginning to end but this absolute control has waned in recent years due to law enforcement efforts. The global drug trade has been valued by the UNODC at \$320 billion per year, comparable to the gross national product (GNP) of a State such as Sweden at \$358 billion. Accordingly, it is greater than the world market for tobacco, wine, beer, chocolate, coffee and tea combined. The cocaine whole-sale market covers more than one quarter the value of the entire illicit drug trade while the heroin market alone has been valued at \$57 billion. Two billion dollars of this go to farmers while most of the remainder ends up with professional criminals, insurgents, terrorists and street retailers.

These sums of money allow drug syndicates to buy the weapons, access and influence required to get illicit drugs to the market, thereby providing them with dangerous economic, political and paramilitary leverage. All this has devastating consequences for human security and social stability. In some cases destabilization is deliberate with drug traffickers funding insurgencies and internal strife while in others the violent consequences of the trade ward off tourists and foreign investors which are crucial to economic development in poorer countries. As such, the global drug problem is viewed as a serious threat to public health and safety, to the well-being of humanity, and to the national security of States, consequently undermining socio-economic and political stability as well as sustainable development. The 1988 Convention on the other hand deals directly with State legislative and maritime law enforcement cooperation is the key component.

Latest available data indicated that there has been no significant change in the global status quo regarding the use, production and health consequences of illicit drugs other than the return to high levels of opium production in Afghanistan after a disease the opium poppy and subsequent crop failure in 2010. But while the troubled waters of world's illicit drug markets may appear to be stagnant, shifts and changes in their flows and currents can be observed below the surface. These are significant and also worrying, not because of how they currently impact on the data but because they are proof of the resilience and adaptability of illicit drug suppliers and users and because of the potential future repercussions of those shifts and changes in the world's major drug markets.

The extent of global illicit drug use remained stable in the five years up to and including 2010, at between 3.4 and 6.6 per cent of the adult population (persons aged 15-64). However, some 10-13 per cent of drug users continue to be problem users with drug dependence and/or drug-use disorders, the prevalence of HIV (estimated at approximately 20 per cent), hepatitis C (46.7 per cent) and hepatitis B (14.6 per cent) among injecting drug users continues to add to the global burden of disease, and, last but not least, approximately 1 in every 100 deaths among adults is attributed to illicit drug use.

The majority of illegal drugs smuggled from their points of cultivation and/or production to transnational markets of consumption is transported via maritime cargo, containers and vessels, and this criminal activity presents a significant challenge to the targeted seaports and commercial vessels. The surge in production of opium and coca in the past few years has likewise increased the amount of illegal drugs available for shipment. The methods and techniques used to smuggle drugs via maritime cargo and conveyances are extensive, difficult to detect, and ingenious in design and variation.

Opioids continue to be the dominant drug type accounting for treatment demand in Asia and Europe and also contribute considerably to treatment demand in Africa, North America and Oceania. Treatment for cocaine use is mainly associated with the Americas, while cannabis is the main drug causing treatment demand in Africa. Demand for treatment relating to the use of amphetamine-type stimulants (ATS) is most common in Asia.

The two most widely used illicit drugs are cannabis and ATS. Total production and cultivation of coca is known to be stable, while the production of opium has returned to levels comparable to 2009.

With estimated annual prevalence ranging from 0.6 to 0.8 per cent of the population aged 15-64, the use of opioids (mainly heroin, morphine and non-medical use of prescription opioids) is stable in all of the main markets. After a blip in global production in 2010, caused by a disease of the opium poppy in Afghanistan, production has now more or less returned to its 2009 level. Average wholesale and retail



prices in the most regularly monitored markets for opiates, in Western and Central Europe and the Americas, have also shown little change since 2009, but this does not reflect the situation seen in much major opium-producing countries such as Afghanistan and Myanmar where, despite an increase in opium production, farm-gate prices continued to rise in 2010 and 2011.

Although large quantities of heroin continue to be trafficked along the main Balkan route, leading from Afghanistan to Western and Central Europe via South-Eastern Europe, declining seizures were reported in most of the countries in those regions in 2010. However, the coastal markets of Africa are reporting increasing seizures, as are countries of South-East Asia. Whether this implies that traffickers are seeking alternative routes or that heroin use is on the increase in those places, the lack of available data makes it impossible to draw definitive conclusions. But one thing is clear: the opiate market continues to be extremely flexible and adaptable.

The major markets for cocaine are North America, Europe and Oceania (mainly Australia and New Zealand). North America has seen a marked decline in cocaine use, mainly due to a decline in the United States, from 3.0 per cent (2006) to 2.2. per cent (2010) among adults aged 15-64; however, there has not been such a decline in Europe, when cocaine use stabilized over the same period. Latest data from Australia show an increase in cocaine use.

An additional factor influencing the availability of, and overall demand for, cocaine in different regions is the emergence of new, albeit small, cocaine markets in, for example, Eastern Europe and South-East Asia. There is also some evidence that cocaine trafficking through West Africa may have had a spillover effect on countries in that sub-region, with cocaine emerging as a drug of major concern, along with heroin. Some data indicate an expansion of the cocaine market, particularly of “crack” cocaine, in some countries of South America.

The relative importance of cannabis resin and herb varies by region, with cannabis resin being dominant in the Near and Middle East and South-West Asia, cannabis resin and herb markets being comparable in size in North Africa and Europe. The rest of the world, including the United States, where production continues to be high, is dominated by cannabis herb. Data for Africa is hard to come by but seizure data suggest that herb is also the dominant form of cannabis in that region, except in North Africa where resin is predominant.

### ***8.5 Maritime smuggling routes and trends - Balkans***

Since the beginning of the cocaine craze of the 1970s and 1980s, Peru and Colombia have alternated as the largest producers of the coca plant, while Bolivia produces a lesser, but still significant quantity. Previously, cocaine was mainly shipped to the United States, but as the European and Asian markets continue to grow, trafficking routes to these parts of the world have become increasingly important.

Venezuela and the Caribbean islands serve as primary launching points for thousands of maritime and areal routes to Europe. In recent years, West Africa has also turned into an important stopover in the cocaine trade, mostly due to weak border enforcement, as well as high levels of corruption, which create a haven of impunity for traffickers.

**Bulgaria** is a transit country for heroin, as well as a minor producer of illicit synthetic narcotics. Bulgaria’s location astride Balkan heroin transit routes makes it vulnerable to international trafficking organizations transporting narcotics into the European Union. Organized crime groups operating in Bulgaria have increased their influence and involvement in the international narcotics trade. These groups are sophisticated, well-financed, and entrenched within Bulgarian society. Bulgaria’s Black Sea ports continue to be exploited by drug traffickers to smuggle cocaine from South America to Europe and heroin from Turkey and Iran to Europe.

The only illicit drug crop known to be cultivated in Bulgaria is cannabis, primarily for domestic consumption. Bulgaria continues to be a source of some synthetic drugs, though production has declined in recent years.

**Romania** is not a major source of illicit narcotics, but continues to be a significant transit country for narcotics and lies along the well-established Northern Balkan Route for opium, morphine base, heroin,

and chemical precursors moving to and from Afghanistan, Central and Western Europe. The largest cocaine seizure in all of Europe in 2009 (over 2 metric tons) took place in Constanta, its largest port city. Romania and other Black Sea Eastern European countries are becoming increasingly popular among international cocaine traffickers looking for alternative entry points into Western Europe's lucrative cocaine markets. Romania's long Black Sea coastline and its large deep-water port of Constanta likely are being used as secondary cocaine entry points into Europe. The global economic crisis continued to impact on all Romanian government agencies, and resources for counternarcotics units were more scarce than usual. Romania is party to the 1988 UN Drug Convention. Romania is party to the UN Convention against Transnational Organized Crime and its three protocols, and the UN Convention Against Corruption.

**Ukraine** is not a major drug producing country; however, it is located astride several important drug trafficking routes into Western Europe, and thus is an important transit country. Ukraine's numerous ports on the Black and Azov seas, its extensive river transportation routes, its porous northern and eastern borders, and its inadequately financed and under-equipped border and customs agencies make Ukraine an attractive route for drug traffickers into the bordering European Union's profitable illegal drug market. Narcotics, primarily heroin, move from Afghanistan through Russia, the Caucasus, and Turkey and then pass through Ukraine, destined for Western Europe. New routes for Latin American cocaine are also taking hold, as confirmed by three large seizures in the Odesa sea port in 2010 of 152 kilos of cocaine concealed in deck planks, 1,193 kilos hidden in blast furnaces, and over 582 kilos disguised in metal scrap. The shipments came from ports in Bolivia and Venezuela. But as frequently occurs in transit countries, drug addiction appears to be growing in Ukraine itself. Analysts are almost unanimous in the opinion that Ukraine is increasingly being viewed not only as a transit country, but also as a drug market in its own right.

In several recent years, experts have noted an increase in heroin traffic from Turkey into Ukraine by sea, or into Russia and then into Ukraine across its south-eastern border, and further by land across Ukraine's western border into Western Europe. Experts believe that traditional Balkan drug traffic routes have become saturated and criminals are looking for new trafficking channels. Drug traffic from Asia is controlled by well-organized international criminal groups of Afghan, Pakistani, and Tajik origin that use citizens of the former Soviet republics as drug couriers.

So when the shipping line opened up this route and linked these two ports, one penetrated by Colombia narcotics traffickers and the other by the Russia Mafia, an opportunity presented itself for paramilitary forces need of arms and with access to large quantities of drugs. The shipping line's route for legitimate cargo directly influenced the planning, operations, and seaports utilized by narcotics smuggling organization.

A similar situation may occur when a new major seaport is built or existing clientele change. The construction of a new seaport, especially transshipment port, where there not a port before may change the dynamics because now there may be drug production or transit locations. Or, a port may sign a contract with a shipping line that has a history of drug seizures or significant penetration by narco organizations or whose vessels call on ports in drug in drug production/transit countries. Either of these two scenarios affects the drug smuggling threat for the seaport, as well as the seaports up and down the cargo supply chain.

Narcotics smuggling organizations constantly analyze changes in vessel routing, seaport commercial activities, and commercial shipping agreements for opportunities to exploit vulnerabilities and ship their product via the most efficient and secure method.

## **8.6 Drug smuggling methods and techniques**

The techniques and methods used by drug smugglers continue to evolve, traverse the globe, and are limited only by the imagination and determination of the narcotics smuggling organizations. While some involved in counter-narcotics law enforcement may profess the adage "there's nothing new under the sun" with regard to drug smuggling methods, this belief is not fully accurate because the

drug smugglers constantly are revising or modifying the old techniques and methods. Additionally, it is interesting to note that a new or revised smuggling or concealment method discovered in, for example, Colombia will most assuredly be discovered a few months later in bordering countries or in ports up the supply chain and literally circle the globe over a period of time.

#### **Drug Smuggling via Cargo**

Drug smugglers conceal their consignments inside the cargo, in lieu of the cargo, fabricated with the merchandise, mixed with the cargo, and within the structure of the packing/pallet. Tremendous ingenuity, imagination, money, and the effort are dedicated to constantly “looking for a better mousetrap”.

#### **Drug Smuggling via Containers**

The ingenuity, effort, and persistence expended in the designing and implementing of drug smuggling techniques via cargo are equaled or surpassed by these techniques utilized in the smuggling of drugs via containers and associated equipment. Secret compartments, fabricated inner structures, and the disassembly and reassembly of container structures are common techniques and tactics.

#### **Drug Smuggling via Vessels**

Drug smuggling via the commercial vessel, her crew, or drug couriers presents special challenges to the vessel master, crew, and shipping line. While the quantities may be smaller than drug loads found in containers and cargo, there is an increased risk that when drugs are seized onboard the vessel by law enforcement agencies, the vessel may be delayed, detained, or a fine assessed by government authorities. Additionally, drug couriers – who are transporting very valuable cargo – may become desperate or violent if confronted by crew members.

The ever-increasing production of and demand for illegal drugs – specifically heroin, cocaine, and marijuana – ensures that commercial vessels, their cargoes, and seaports will remain a target for drug smugglers. Moreover, the ship crews and port security forces will continue to be challenged by the innovative and varied smuggling methods and techniques.

## Chapter IX

### Internal criminal conspiracies

#### 9.1 Cargo theft

The “container revolution”, which has increased transportation efficiency and spawned the rapidly growing intermodal freight transportation industry, may have inadvertently encouraged increased organized criminal presence in freight transportation. Traditionally (before the 1960s), high-value cargo was moved using break-bulk packaging and shipping techniques. During the “break-bulk” era, high-value cargo was packaged in cases or pallets for shipment and loaded and unloaded on piece-by-piece or pallet-by-pallet basis. Easy access encouraged the theft of electronics, appliances, clothes, engine parts, liquor, cosmetics, and cigarettes from terminals (including warehouses, docks, and transfer points) and during loading, unloading, and shipment. When first introduced, containers successfully reduced pilferage. Estimates indicated that during the early years of the container revolution, theft of containerized cargo dropped to less than one-tenth of 1 percent of all cargo shipped in containers. Unfortunately, “after an initial honeymoon period, during which criminals adjusted to the new container system, other patterns of theft developed”.

Organized crime recognized the potential for big business. Containers stacked in terminals, could be stolen as a whole, opened and made subject to pilferage, or serve as a conduit for drug smuggling. “Much larger “packages” containing higher value cargoes could now be spirited away with comparative ease and the spoils made it worth using more elaborate methods of deception and daring. Whereas, previously ten televisions might go missing because that was all thieves could carry or secret, now two hundred could be stolen at a go in container”. For example, computer laptops, cellular telephones, perfume, and wearing apparel are among the top items stolen and could be worth from hundreds of thousands of dollars to millions of dollars per container load. A pallet of these devices can command upwards of \$250,000. Sixty-four pallets can be loaded into a single 40-foot container, with a new value of \$16 million.

Containerized cargo theft is carried out primarily as an organized criminal conspiracy. Substantial evidence supports the hypothesis that most theft of containerized cargo is systematic in method. Often, criminals act with apparent information about cargo manifest, suggesting that collusion is occurring with transportation employees. Cargo terminals are particularly vulnerable to employee penetration at intermodal transfer points, warehouses, rail yards, and docks. In its *Ports of the World: a Guide to Cargo Loss Control*, the SIGMA Corporation reports that the majority of cargo loss claims “involve cargo taken from transportation facilities by personnel authorized to be there and on vehicles controlled or similarly authorized by management”.

This immense network of importers, wholesalers, freight brokers, truckers, and dock workers create problems for law enforcement and transportation operations in pinpointing instances of bribery, extortion, or “purchased” information. Estimates indicate that “well over 80 percent of all theft and pilferage of transportation cargoes is accomplished by, or with the collusion of, persons whose employment entitles them access to the cargo that is stolen”.

Criminals use a variety of methods to steal cargo, including:

- Opening containers stacked at terminal yards or transfer facilities, removing goods, and transporting them from ports or intermodal facilities by personal automobile or delivery trucks.
- Falsely claiming that a truck was hijacked leaving a port or warehouse, when the driver is actually complicit in the crime, and receiving a cut of the profits.
- Dismantling containers, removing key merchandise, re-sealing containers and continuing shipment.
- Relying on an organized network for spotting, stealing, and fencing merchandise.
- Driving off in a loaded tractor trailer via fraudulent paperwork.
- Speeding through fences and security checkpoints.

- Stealing loaded trucks off the street or from storage yards.

Once stolen from a terminal, the cargo merchandise is quickly repackaged in a nearby warehouse or facility for transportation to an out-of state fencing location or out of the country. These goods may re-enter the country and be sold at a discount, providing an effective way to legitimate illegal profits (referred to as transshipment). The law enforcement estimates that most stolen cargo remains in the possession of those who stole it for less than twenty-four hours.

Organized criminal groups are becoming transnational, facilitating theft of containerized cargo in one country and trafficking of stolen goods in another. Transnational criminal operations use the entire shipping cycle, in particular, the maritime and trucking transportation shipping system and the freight-forwarding sector, to support stolen merchandise trafficking. Organized criminals enjoy the same efficiencies and economies of scale as legitimate transnational business, but can elude national efforts to restrict their activities.

The most common form of cargo theft is pilferage, which is most often perpetrated by employees. The practice of handlers pilfering cargo has long been an institution in the shipping industry. Manufacturers have been known to over-ship cargo to allow for the “strinkage” that occurs due to pilferage. In the case of containerized cargo, access is achieved through the following methods:

- After offloading from the ship while the container is idle awaiting pickup/delivery in the terminal yard.
- While the cargo is undergoing consolidation or de-consolidation either at the terminal or an off-site freight forwarder.
- Anywhere along a trucking or rail route where the shipment is idle.

Instances occur in which high-value, high-technology equipment is deliberately “sidetracked” inside a carrier’s terminal by employees. When it fails to arrive at the consignee, it is treated as a loss. After a period of time it legally belongs to the carrier; and, after appropriate arrangements are made between the perpetrators and associated liquidators, the shipment is sold at a fraction of its value.

The value of computer hardware and components makes such shipments an attractive target of theft. Exchanges now take place where cocaine shipments bound for the United States are traded for computer chips stolen from cargo shipments. In this scenario, both commodities have the capacity for significant increase in value as they are passed along. Further, as an alternate method to shipping drug profits (that are in the form of cash) out of the United States, those profits are invested in stolen cargo purchased at a fraction of its value (computer hardware, memory chips, etc.) and shipped overseas as legitimate cargo, thus maximizing the capital generation of illicit activity.

One means for pilfering cargo is by removing the contents of one container and placing all or part of the contents into an adjacent container (for example, one that is empty or carrying low value cargo) that will not be monitored. Thieves have devised several ways of gaining access into shipping containers, some of which involve removal and replacement of all or part of the door hardware fasteners so that the seals and locks will not appear to have been disturbed. Once transferred, the perpetrator can arrange for removal and delivery of the stolen goods with minimal risk.

The potential theft of cargo in transit is a significant concern that will occupy the time and resources of all individuals engaged in port security, whether as an PFSO for the port or as the security manager for a cargo terminal. Worldwide, the theft of goods in transit likely approaches \$50 billion or more annually. Law enforcement agencies estimate that more than half of all cargo theft is not reported, suggesting that the true amount of stolen cargo worldwide probably exceeds \$100 billion a year. The fallout is not merely the loss of the cargo itself, but the costs associated with reproduction, reshipment, insurance, lost time and material, and many other internal or external costs to business. The International Cargo Security Council estimates the annual cargo losses in the U.S. to be about \$ 10 billion; however, this does not take into consideration the indirect losses to companies, i.e. costs related to expediting the replacement goods, disruption of customer service, claim processing, insurance premium increases, and damage to the company reputation. Indirect losses may be five times those of the direct losses. The collection of data on cargo theft, up to now spurious and woefully inadequate. Protecting cargo from pilferage and illegal conversion while transiting seaports is a major

concern for security. The need to deter theft at seaports has resulted in the development and implementation of processes such as gate pass systems and technological advancements in closed-closed television systems, cargo container scanning, and container integrity monitoring, which can help ports maintain controls on the goods being shipped and stored.

## **9.2 Other matters about maritime security**

The willful destruction of the property of others constitutes the crime of vandalism. Criminal activities may result in vandalism to seaport property, vessels, and private property owned by port tenants and employees.

Stowaways attempting to enter the country by hiding onboard vessels are a concern for both seaports and vessels, which requires cooperation among port facilities, terminal operators, and security personnel.

Seaports risk exposure to higher levels of crime and infiltration by internal conspiracies if the personnel responsible for port security have inadequate training. Developing the appropriate knowledge, skills, and abilities among security personnel is an essential component of reducing risks to seaports.

Protecting individuals who work and travel on board vessels is a responsibility of not only the vessel but also the seaport. The increasing need for cooperation and coordination between port facilities and vessels with respect to security is also driven by the mutual need to protect the public safety in and around seaports.

Competition within the private sector may result in efforts by some to steal trade secrets or compromise business practices to obtain economic advantage. Seaports may be targeted locations for espionage activities due to the influence of private sector trade, transportation, and import/export interests.

## **9.3 Commercial conspiracies**

The smuggling of contraband out of a country is a significant risk unique to seaports. The transfer of illegal, stolen, or unauthorized goods through the regular cargo transportation systems can proliferate, because many nations depend on large volumes of cargo shipments to sustain their economies. The movement of controlled goods, munitions, stolen property, drug proceeds, and other forms of trade fraud provide a number of risks for port security management that must be considered in developing mitigation and response strategies for security. Many non-drug-import crimes go undetected at seaports because only a very small fraction of cargo is physically inspected. This rate may vary at targeted ports and has actually increased significantly since the terrorist attacks of 2001. Challenges related to trade fraud and commercial conspiracies include the following:

- Diversion of imported or in-bond merchandise into the country's commerce
- Textile trans-shipments to avoid quotas
- Undervaluation, double invoicing, or false description of merchandise imported into the country
- Importation, transportation, and distribution of counterfeit goods subject to trade and copyright
- Importation, transportation, and transshipment of items that pose a threat to consumers or environment, such as tainted or prohibited foodstuffs, medicines and unapproved drugs

Thus, while the PFSO will certainly be occupied by the perhaps more immediate threats from terrorism, challenges associated with commercial criminal activities must also receive attention. The truth is, there will be many competing security challenges in the port environment. Port managers responsible for the security organization must develop a broad sense of what constitutes risk. Even a relatively small port must consider its role as part of the larger community and transportation networks it intersects with. Understanding the scope of the challenge is the preliminary step to understanding and managing risk.

## Chapter X

### Inter-state hostilities

#### *10.1 Defining, varieties, identical signs*

Illegal behaviour and actions of some countries related to the usage of military or paramilitary forms of force may be seen as threatening of the navy security (safety).

Oil providing installations are usually attractive military aim during wars and hostilities. The destruction of the enemy's petrol installations might lead to the shortage of energetic supplies, which are in a great demand during wars and to paralyze the country's economy. During the Second World War shortage of oil made Hitler to redirect a part of his armies acting mainly towards the Northern part of the USSR, in order to obtain access to the Caspian oil fields. Nazi Germany didn't succeed in this goal and thus, at the end of 1942 cascade effects began leading to the full military failure.

These attacks against petrol installations are also a great factor in the Iran-Iraq war from 1980 to 1981. Petrol installations are the main target since the beginning of the conflict, as Iran and Iraq attacked almost all refineries, stores, offshore cargo terminals and other platforms in the Persian Gulf. During the war Iran confiscate offshore platforms in an oil field run by NIOC and at the end of the war before Iran gives back the control over them, the fields was made useless. In March 1983 Iraq planes destroyed Iran's offshore platform and started a great fire in the sea.

Another example for hostilities of countries against oil providing offshore installations are the American attacks in 1987 and 1988 against Iran's offshore platforms. On 19<sup>th</sup> October 1987 the American navy attacked two Iran oil offshore platforms in an answer to an Iran rocket attack. On 18<sup>th</sup> April 1988 USA destroys two Iran offshore petrol platforms in an answer to the blowing off of the American frigate by an Iran mine. Meanwhile Iraq destroys some petrol platforms in the North of the Persian Gulf. The estimated economy loss of the Iran offshore industry is about 1 billion USD. As well as, during the Iraq invasion and occupation of Kuwait in 1990-91 almost the whole petrol industry of the country was paralyzed - petrol fields and infrastructure objects. During the last days of the occupation the Iraq army deliberately set hundreds of fires detonated and damaged about 75% from petrol wells in Kuwait. It took almost a year for the fires to be put out and it took other 3 years for the oil industry to be restored.

Offshore installations could be a potential military aim even in times of piece as we can see in the incident on 22<sup>nd</sup> August 2002 when the Iran Navy invade and occupied Orizont offshore drilling facility, belonging to a Romanian petrol company with 26 Romanian workers in the Salman field in the Iranian waters. This incident is a typical example for unsolved argument on a contract between petrol companies and a country.

During the last years there are a lot of examples which indicates that arguments for offshore petrol fields and navy boundaries may turn into direct military conflicts between neighbouring countries which to lead to regional instability. There is an obvious increasing concern that conflicts related to disputable control over resources in some offshore areas is likely to escalate in near future, because petrol storage on the continent are almost run out and more and more attention is paid on the reserves in the offshore zone. Increasing demand of oil products and their supply is possible to make the countries to try and increase their energy independence which is sensible reason for alert for the safety of the seas.

Terrorist actions done in a name of a country are also considered a threat for oil drilling offshore installations. In a case of international confrontation it is possible that some countries attack petrol installations of their rival with terrorist groups and at the same time possibly deny taking part in such an illegal act. For example, in Iran-Iraq war from 1980-88 Iran widely uses undercover actions against petrol tanks and offshore petrol devices in the petrol gulf, performed by groups of religious extremists. Even if there isn't any intercountry conflicts and navy boundary, some countries gave asylum to

criminals a terrorist, as a base of operations for export of illegal acts in the sea in the other parts of the world. There are countries which supply with weapons, ammunitions, military technique, equipment and hardware as well as army expertise and military preparation of separatist movements and terrorist groups. "Broken" or "bankrupt" countries are good base for pirates and terrorists because they gave them convenient asylums and free access on sea to potential targets. For example, the blowing up of the French agents and sunk of Rainbow Warrior in the port of Auckland, New Zealand on 10 July 1985, is regarded by many New Zealanders as State terrorism.

## ***10.2 Historical, geographical, legal frames - typical examples for international arguments in the sea***

Since ancient times potential threat against the navy safety have appeared in the form of inter-state armed conflicts and wars at the sea, maritime boundary disputes, and State Terrorism. "Inter-State hostilities" may lead to serious disrupt in the navy transport system and damage the exploitation of different sea resources (fish, oil, gas, etc.). More and more actual become problems with security of increasing and enhancing drilling offshore installations.

Countries and international oil companies are in a race to get an access to the offshore oil resources. When the UNCLOS become legal in 1994, there was a great fight for taking the control over the rich of oil aquatories. Some costal countries claim their wish to increase their economy zone up to 200 sea miles, as well as the regions on the continental shelf to a maximum distance of 350 sea miles from the baselines of 100 sea miles of over 2500m depth of the water, in which they are supposed to have the exclusive rights to exploit the resources of oil and gas from the sea bottom. The increasing rivalry for exploiting the offshore petrol storage has already caused a great deal of offshore arguments in some zones which have great amounts of storage of oil and gas. Some of them are solved in a peaceful way while the others are still a source of fights and conflicts and generate constant threatening over them. They are able to stop petroleum production and it, in the worst plot, may lead to intensive fight actions and attacks to mining installations in the contested offshore zones.

## ***10.3 Factors, heightening the threats in the sea***

### **■ Geography and enabling factors**

Inter-State Hostilities is a specific threat with some military characteristics, which isn't limited geographically. Although there are some preserving mechanisms, hostilities and wars happen and will happen in all parts of the world. There are a lot of possibilities for regional conflicts in the oil produced areas. Navy border arguments may be restricted to definite geographic zones such as South China Sea, Persian Gulf, Caspian Sea and the Atlantic Ocean.

Inter-State hostilities aren't limited to definite geographic regions and they may possibly happen everywhere in the world. In their attempt to achieve their own production of oil and gas the motivation of the countries may have some strategic or economic characteristics (dimensions) and the tactic may come in the form of interruption in the offshore operations in case of border arguments or intentionally destruction offshore installations during hostilities. Thus, according to the conditions this menace may be low or high. Violence and unfriendly behaviour of the countries are usually regulated by specific norms from the international law, including the rules for using a power. As the countries may be accused for actions which break the norms of the international law they are likely not to use force against offshore installations during peaceful time and they may prefer other alternative methods for solving the arguments with other countries. Therefore, there is a little possibility for such a threat to occur in a peaceful time, but it is higher during hostility or war.



### ■ Motivation and goals

In most of the cases the aims of the countries are political, strategic and economical. During a hostility or war, offshore petrol installations are seen as strategy military goals and it may evolve a motivation for them to be damaged or destroyed with the aim to make the opponent run out of energy supplies and fuel which is necessary to make wage war and it has an indirect affect on the economy of the country. In a case of disputable rights over the offshore petrol resources the motivation may be economical or political and what they want to achieve is to get access to oil deposits with a great importance for the national economy and the security of the energy supplies.

### ■ Capacities and tactics

It is obvious that the capacity of the armed forces in the different countries differ greatly. Even though, most countries have enough navy and air forces opportunities to cause great harm or full destruction of an offshore installation. Specific tactics used by the countries may include blocking the access to offshore fields in the aim of preventing offshore activities in disputed regions, as well as use of force including fleet attacks, air raids, use of explosives and take the control over the offshore installations. In case of hostility or war there is an opportunity for some countries to use some terrorist actions or terrorist groups for "asymmetric" attacks of the petrol offshore installations of their opponent.

### *10.4 Subjects of the threat.*

- organisations, structures - military, paramilitary, terrorist, separatist, extremist organisations;
- leaders - with very high military agent or other specific preparation;
- command or management - based on the newest technologies;
- armaments - in a wide rate of wide spread and easy for access items (mainly from the former soviet bloc) to the trendiest, which can be found on the black market costing a great amount of money;
- tactics and techniques - from the arsenal of the special force operations;
- capacities - for active undercover deep operations based on high preparation, motivation and good leadership.

## Discussion

### Actual situation of maritime security

#### Trends in modern piracy

Piracy on the world's seas has reached a five-year low, with 297 ships attacked in 2012, compared with 439 in 2011. Worldwide figures were brought down by a huge reduction in Somali piracy, though East and West Africa remain the worst hit areas, with 150 attacks in 2012.

Globally, 174 ships were boarded by pirates in 2012, while 28 were hijacked and 28 were fired upon. IMB's Piracy Reporting Centre also recorded 67 attempted attacks. The number of people taken hostage onboard fell to 585, while a further 26 were kidnapped for ransom in Nigeria. Six crewmembers were killed, and 32 were injured or assaulted.

IMB's piracy figures show a welcome reduction in hijacking and attacks to ships. But crews must remain vigilant, particularly in the highly dangerous waters off East and West Africa.

In Somalia and the Gulf of Aden, just 75 ships reported attacks in 2012 compared with 237 in 2011, accounting for 25% of incidents worldwide. The number of Somali hijackings was halved from 28 in 2011 to 14 in 2012.

IMB says navies deterring off Africa's East coast, with pre-emptive strikes and robust action against mother ships. So too are private armed security teams and crew's application of Best Management Practices. But the threat and capability of heavily armed Somali pirates remains strong. The continued presence of the navies is vital to ensuring that Somali piracy remains low. This progress could easily be reversed if naval forces were withdrawn from the area. In Somalia, and elsewhere, vessels most commonly attacked are container ships, bulk carriers and tankers loaded with oil, chemicals and other products. Fishing vessels and other smaller boats are also at risk.

#### Somali piracy case

What is the concept, methods and objectives of Somali piracy?

*Criminal piracy* could be carried out either by an organized or unorganized group. Criminal piracy is primarily driven by the desire for financial and material gains and has no ideological and political dimensions. The main objective is to secure personal financial benefit.

"*Terrorist piracy*" is practiced occasionally by a small number of terrorist or insurgent groups, prominent among them being the Tamil Tigers in Sri Lanka and the Abu Sayyaf group in the Philippines.

What is the evolution of Somali piracy?

- Initial phase: the illegal fishing activities and over-fishing by foreign vessels which has been taking place since the collapse of the state in 1999 left a power vacuum. In the beginning, Somali piracy activities, for the most part, were a simple act of protest which took the form of unorganized, spontaneous attacks carried out by a desperate group of Somali fishermen against foreign fishing boats operating around the Somali coast.
- Second phase: Somali people started to see the profit that lay in attacking foreign fishing boats, the act of robbery turned into organized or semi-organized piracy activities. Ships were hijacked, crews and passengers taken hostage and ransom demanded, thereby making piracy a lucrative business.

What are the factors facilitating Somali piracy?

- The political environment – the absence of an effective government following the collapse of the Somali state and economy coupled with the impact of a long civil war and outside military intervention;

- The geographical environment or the geographical location of the state and the nature of its terrain and coastline;
- The legal environment which was characterized by the lack of both an international legal framework and a response mechanism to counter piracy activities.

Attacks have dropped significantly in 2012. This drop is likely due to the increased / active military action on suspected skiffs, military land based anti piracy operations, preventive measures and increased use of armed guards on board ships as well as the monsoon season. Usual modus operandi of the Somali pirates is to attack ships in the northern, eastern and southern coast of Somalia.

### **The linkage between piracy, transnational organized crime and authority corruption**

The transfer of illegal, stolen, or unauthorized goods through the regular cargo transportation systems can proliferate, because many nations depend on large volumes of cargo shipments to sustain their economies. The movement of controlled goods, munitions, stolen property, drug proceeds, and other forms of trade fraud provide a number of risks for port security management that must be considered in developing mitigation and response strategies for security. Many non-drug-import crimes go undetected at seaports because only a very small fraction of cargo is physically inspected. This rate may vary at targeted ports and has actually increased significantly since the terrorist attacks of 2001. Challenges related to trade fraud and commercial conspiracies include the following:

- Diversion of imported or in-bond merchandise into the country's commerce
- Textile trans-shipments to avoid quotas
- Undervaluation, double invoicing, or false description of merchandise imported into the country
- Importation, transportation, and distribution of counterfeit goods subject to trade and copyright
- Importation, transportation, and transshipment of items that pose a threat to consumers or environment, such as tainted or prohibited foodstuffs, medicines and unapproved drugs

In the Somali case, a clear line can be drawn between criminal pirates and terrorist/militant groups. As piracy originates and is planned on land, pirates cannot operate without a strong link to a base on shore. A successful pirate attack has to be backed up by preparation and arrangements on land both to launch the attack and later to provide a safe place to anchor the seized vessel and facilitate negotiations. Militias, warlords, insurgent groups and tribal chiefs, who are in control of coastal cities, villages and ports, provide pirates with a safe haven offering them physical protection and the logistical support they need before and after seizing the ships.

Alliances with militant or insurgent groups could help to protect the pirates from political or legal pressures and shield them from punishment and retaliatory action by local and international authorities. These groups could also meet the pirates' arms and equipment needs. There are reports of pirates collaborating with insurgents and terrorists and helping them to smuggle weapons and supplies. Some pirate groups have reportedly received arms in exchange for a share of the ransom.

At the same time, insurgents and militants could use the pirates as a source of financial support by asking them to pay "taxes" or dues in return for protection. On their part, pirates could also offer assistance to other groups by marketing the seized goods and converting assets into cash via local, regional and international networks and black markets. Further, potential cooperation between the two groups could extend to exchange of intelligence and information related to ship movements.

Nevertheless, one has to be careful in presuming the existence of broad-based cooperation on an operational level between pirates and insurgents/militants or terrorist groups. The tactics of terrorist groups are based on seeking publicity, the mistreatment of hostages, and inflexibility in negotiations, and are, therefore, in contradiction with the preferred tactics of criminal groups, which are based on avoiding publicity and showing flexibility to secure financial gain. The nature of most criminal groups, including pirates, is to distance themselves from political or ideological causes. In this respect, there is little evidence to prove that Somali pirates have close or strong links with terrorist groups inside or outside Somalia.

## Seminar

### Contemporary problems of maritime security

**Aim of the seminar** – to control how students:

- can estimate main contemporary problems and its frameworks of maritime security;
- can understand influence of current maritime security threats and their nature on the maritime industry
- can make connection between the maritime security threats and maritime security conditions

**Issues for debate:**

#### **Contemporary situation in the maritime security.**

Historical aspect of the maritime security problem.

Geographical frameworks for maritime security.

Legal frameworks for maritime security.

Maritime security policies.

A need for partnership between governmental institutions and business organizations in managing maritime security.

#### **Current maritime security threats and their nature.**

Categories of maritime security threats.

Threats of the maritime security.

Analysing each threat of the maritime security – historical, geographical, legal frames.

General model of a Maritime Security Threat.

#### **Comparative analysis of the current piracy and terrorism at sea.**

##### **Terrorism and commercial maritime transportation**

*The legal definition of terrorism.*

*Historical, geographical and legal aspects of phenomenon terrorism.*

*Characteristics of contemporary maritime terrorism.*

*Subjects of the terrorist threat.*

*Typical examples.*

##### **Piracy and armed robbery**

*The legal definition of piracy and armed robbery.*

*Historical, geographical and legal aspects of piracy and armed robbery.*

*Characteristics of contemporary piracy and armed robbery.*

*Subjects of piracy and armed robbery:*

*Typical examples*

##### **Actual situation of modern piracy**

#### **The connection between the threats of the maritime security.**

Connection between threats of the maritime security – The „Four Circles“ Model.

Connection between threats for offshore petroleum security – The „Eight Circles“ Model

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# Game

## Defining the focus of the threats to maritime security in the Mediterranean-Black Sea region

### Game organization

The principal objectives of games are:

- a) To practice the command, control, coordination and communications arrangements;
- b) To exercise the responses to specific maritime security threats.
- c) To validate new processes and resources to be deployed.

Game should be developed and conducted by a team, which may be called the Game Planning and Control Team (GPCT). The GPCT will be headed by a Chief Controller who shall be responsible to a Game Director for the successful outcome of the game. The Game Director is in overall charge of the game, and has responsibility for the actions of the game controllers i.e. those who manage the game, as well as the game participants i.e. those who are being gamed.

The first task is to establish the aims and objectives of the game. It is useful to describe general and specific objectives so as to be very clear on what is to be achieved. Inputs for the objectives may be obtained from:

- a) The Port Facility Security Plan (PFSP) / The Ship Security Plan (SSP): Aspects of the PFSP which would not ordinarily be carried out in the normal course of business may be the subject of an game.
- b) New factors: Changes to the physical, organizational, operations, logistics, administrative or threat environment may impact on maritime security. The effect of such changes should be examined in detail, and the examination may be part of a game requirement or objective.
- c) Lessons learnt: The records from previous games should be re-examined for the lessons learnt. These will point to the measures implemented after the game, and possibly the need to assess the effectiveness of those measures in a new game.

### Game concept

Games may be conducted in phases, as follows:

1. The first phase usually involves planning for an operation or task given a general or specific threat and a set of planning parameters such as the aim of the task, the resources assigned for the conduct of the task, and the time frame it is to be conducted within. The planning results in the formulation of a plan which is published as a set of instructions to be conveyed to those who are to carry out the plan. A game may be designed to end at that point, in which case the product of the planning, having been approved by the management authority, is documented as a plan for the conduct of the operation or task.

2. The next phase is the conduct or execution of the task. For the conduct, the plan has to be issued as a set of instructions. The instructions are time, space and resource specific, and may be performed in a game as follows:

- Simulation - The conduct of the mission may be performed as a simulation, in which those responsible for the conduct of the task are directed by the planners to carry out the tasks in a role-playing game. Controllers may play the part of the entities to be prosecuted in the mission, and/or they may play the part of those who are directed to carry out the task. Their role is to provide the feedback on the outcome of the various activities associated with the task.

- Full scale or live - The conduct of the task may see the actual deployment of some of the resources specified in the instructions for the task.

## Scenario

The setting or scenario for an exercise may describe a maritime security situation that resonates with all participants i.e. they will be able to recognize, identify with; and relate to the situation, and craft responses to its demands as the exercise unfolds. The storyboard will set the scene and focus all participants on the events.

## Master Event List

The Master Events List is a list of events associated with the scenario that, when initiated in turn, may reasonably be expected to elicit a response from the participants that will generate a specific outcome or learning point. Thus, their formulation should be based on the exercise objectives, which may be to validate specific aspects or processes within a plan.

The Master Events List may be used to direct the exercise along a pre-determined trajectory, but should be subject to adjustments - additions/deletions as the exercise unfolds, particularly if these are needed in order to meet the objectives set. The events, or “injects” may be time-based or event-based, i.e. the next episode on the list will be initiated by a specific assigned time, or by the occurrence of a particular event e.g. the reaction of a participant. Controllers should evolve the scenario by exercising their imagination, creativity and discretion in formulating new events and injects as each is responded to by the participants.

Injects should not swamp participants’ ability to respond. This will be self-defeating, as it often results in disbelief and dissatisfaction, and invariably detracts from the usefulness of the exercise. A Master Events List is usually drawn up as a table incorporating columns for the time, event number, details of the event, the anticipated response from the participants, and any special notes

### EXAMPLE MASTER EVENT LIST

Serial №	Time	Event/Inject	Expected Response	Location / Remarks
0701	0900	Convening meeting and issue of the game scenario synopsis № 1 and start-state	All to familiarize themselves with the game scenario.	Conference room
0702	1300	An intelligence report of terrorist preparation to create unrest in the country has been received.	Scenario build-up – no specifying response expected	Operation control room
1808	1700	Game over	Dispersal of personnel and equipment as planned	

Various communications means will be required to plan and conduct the game. These range from written instructions to wireless communications. It is recommended that the responsibility for communications during the exercise be specifically assigned.

Game Instructions – Written instructions should be published to cover the intentions, objectives, schedule; and personnel, communications, and administrative arrangements for the game.

Means of Communications - The communications means and channels established under the existing Security Plans should be employed by the participants, unless a new communications arrangement is being tested during the game, or if special communications equipment and/or procedures are to be implemented at higher Security Levels. These communications channels must be set up for the flow of instructions, messages and reports that will be generated during the exercise. These communications

channels should replicate those that will be employed during an actual operation, and will include communications security considerations and equipment where necessary.

An independent body answerable directly to the game Director is required to oversee the safety aspects of a full scale or live game. The safety officer assigned for a full scale or live exercise should consider the scenario, the Master Events List and all vessels, vehicles, equipment and personnel safety to be used in his safety review.

### **Game Initiating Conditions**

The game scenario should paint the background events leading to the situation at the commencement of the game, providing the measures set in place by the national authorities, the adversary assessment as provided, and the conditions extant for the game purposes. The degree of specificity on the adversary will depend on the level of intelligence input it is desired to play. The first event from the Master Events List may also be used to commence the game. For example, this may be an incident that demands a response from security forces, and security measures to be enhanced, thus initiating the planning for the specific responses by the port facility.

Scenario synopses or narratives are provided by the game control to describe the situation at any stage in the game. They are usually used to provide the Game Initiating Conditions, and to advance the scenario to a next stage, e.g. from Security level 1 to 2, describing the events that led to the upgrade of the Security level; to provide the backdrop for significant learning benefit to be derived in progressing through the security plan.

In planning for the exercise, the EPCT will compose events or “injects” to test various aspects of the plans so that the game objectives may be realized. These are entered in a table called the Master Events List, and introduced during the game to develop the scenario, and to initiate situations that would lead to planning or action that would in turn yield insights or lessons on aspects of the operation plan and/or its components. If necessary, pre-planned injects and the scenario may be modified as the game progresses to ensure that the game objectives may be met. Responses to the injects by the participants constitute the game “play”, and these may take the form of decision-making planning sequences or actual deployments, or they may be simulated, in the case of tabletop simulation games.

Injects may be issued to participants in a variety of ways. They may be verbal (and recorded in a communications log), hand-written in a message form, or sent via email. Communications security is an important consideration whichever means is used.

### **Game Time**

The time frame played during a game is usually fictitious, reflecting the events in the scenario and/or Master Events List.

Narratives and Time-Jumps. Game activities in a tabletop simulation game may be performed in real-time, or when circumstances permit, at a specified rate, including the use of “time jumps”. Activities such as planning and meetings, etc. must be conducted in real-time, or “Rate 1”, which represents the passage of time multiplied by 1. Activities such as deployments of personnel, vehicles or vessels, during which no events or injects are scheduled may be performed at a higher specified rate e.g. “Rate 2” i.e. the passage of time multiplied by 2. This is usually practiced when the game is conducted using a simulator. Otherwise, it is more common to utilize “time jumps”, or narratives stating the situation at the end of a period representing, for example, the deployment of vessels to certain locations. Higher time rates and time jumps serve to nullify “dead time” in a tabletop simulation game where both participants and controllers would otherwise be waiting for routine activity to unfold. Such “rates” and time jumps obviously do not apply in the case of full scale or live games.

### **Termination**

Games are normally planned to end when the operations plan developed during the planning phase has been played out, either in simulation, or during the deployment phase. In addition, full scale or live



exercises may be halted or even terminated by the Game Director for a number of reasons, including situations such as:

Safety is compromised – Where the safety officer(s) or controller(s) observe that safety has become a concern, they should halt the game to address the concerns, and re-commence only when they are satisfied that the issues have been resolved satisfactorily.

Difficulties or unforeseen events faced by controllers and/or participants in the conduct of the game – Any number of concerns or challenges may arise during the conduct of the game to warrant its suspension or termination.

### **Debrief**

The primary purpose of debrief is to consolidate the lessons learnt and recommendations from the conduct of the game. Thus, debrief is an essential part of the game and must not be omitted. Prior to conduct of debrief, each operating group or force should conduct their internal hot washups (debriefs). Where a full scale or live game has been conducted, debriefs by the participants deployed should be conducted as soon as possible after their return. For efficiency, debriefs should not be a blow-by-blow review of the game. They should highlight issues of special concern for revision or future development. The following areas may be considered:

- a. Elements of the plan
- b. Challenges in execution
- c. Command and control
- d. Communications
- e. Human resource and logistics
- f. Administration

## Chapter XI

### Methods of assessment the risks of the security of a critical marine unit

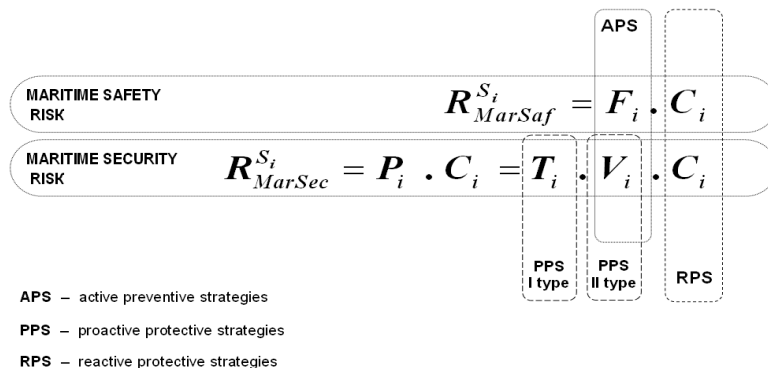
#### 11.1 Basics of analyzing the risks

The philosophy of Chapter XI-1, XI-2 of SOLAS-74 and ISPS Code and methodology for risk-based decision making requires , as a method of management in Marine Transport System (MTS) or important maritime object (IMO) , using Risk Analysis which includes:

- risk assessment of an item from MTS or IMO;
- risk-management;
- connectivity of the risks

#### 11.2 Methods used while calculating the risk

In maritime transport is used objective and subjective interpretation of probability. In practice, of great importance is the method of identifying risks which could be: engineering, model, expert statistical, sociological. These reflect the different aspects of risk and therefore should be used in combination.



#### Methods of defining maritime security and safety risk

The practical meaning of the differences between the methods, applied in maritime security and safety is shown above:

- Mechanisms, used in interest of safety, are focused on the consequences, which are result of unpredictable events;
- In interest of security it is influenced over threats and is provided active protection of vulnerabilities, thus the efforts of different institutions are combined and variety of tools, which form proactive defensive strategies, is used. In practice, the main resource shifts from 'elimination of consequences' to neutralizing threats and reducing vulnerability of maritime critical infrastructure.

#### 11.3 Assessment the risk based on two factors

There are two main factors in MTS which are used in risk assessment-probability or frequency of occurrence of accidents, related to maritime safety (AMS) or related to operational risk-management and the seriousness of the consequences, result from it.

$$R_{MarSaf}^{S_i} = P_i \cdot C_i \quad \text{or} \quad R_{MarSaf}^{S_i} = F_i \cdot C_i$$

- where  $P_i$  is the objective probability of occurrence of the i-AMS type in the total amount of observations;
- $F_i$  is the relative frequency of occurrence of the i-AMS type in the total amount of observations;
- $C_i$  is seriousness of the consequences (or extent of the damage, the cost of losses).

In risk analysis for AMS usually are used terms such as ‘intensity’, ‘frequency’ and ‘probability’, which are numerically identical, because of their relative rarity in time, but with different dimensions.

- Intensity of AMS (Scale 1/year) - density of the events (the type accidents) over time in direct proportion to the intensity of work with a coefficient of proportionality. Traditionally intensity is understood as frequency in time (a year);
- Probability of AMS is a dimensionless quantity and is also numerical characterization of the level of risk for a particular IMO (important maritime object).

Since the intensity of AMS depends on the period of examination there are substantial fluctuations arising from the rarity of the accidents in time and the limited average time for operation of a IMO (for MTS it is assumed to be about 50 years) , so it can’t be spoken of an accuracy of these quantities.

#### ***11.4 Assessment the risk based on three factors***

The three-factor assessment of risks meets more fully the European maritime security requirements and the more strict criteria, accepted in USA. The structure and the content of these factors is well presented in the model MSRAM of the United States Coast Guard.

In a study of MS, risk events are identified with deliberate and malicious acts mainly. In this case, frequency interpretation of risk is inapplicable because it is about unique or rare events with not enough statistical data. These events are considered as potentially possible within certain restrictions. The limits of the restrictions are determined by expert assessments, based on sufficient amount reliable data. Each scenario for AMS, which leads to undesirable consequences may be defined by the probability of its occurrence. In this case, the risk is assessed by three factors: threat, vulnerability and consequences. It can be represented by the formula:

$$R_{MarSec}^{S_i} = P_i \cdot C_i = ( T_i \cdot V_i ) \cdot C_i ,$$

#### ***11.5 Assessment the threats and vulnerability***

In maritime security for the assessment of threats and vulnerabilities are used different methods which stand on expert assessments, statistics and more. Nevertheless it is mandatory to be given account on all those factors that influence on their content and degree of occurrence.

The threat is generally seen as a set of conditions and factors that can cause a particular impact on the protected IMO. Each threat is associated with the realization of a scenario  $S_i^T$  for specific type of AMS (e.g. particular IMO attack, attacks on confidential information, violating the integrity of the object, etc.). In maritime security threats are based on reconnaissance information and on the assessment of the situation taking into account the fact that they are always designed on certain vulnerabilities. These are described by the level of maritime security and the selected measures for its maintenance.

The vulnerability is related to the probability that different security measures, taken against threats directed at IMO, may have no effect, e.g. the probability of success of particular type of terrorist attack. Vulnerability is most commonly assessed by examination of those factors that contribute to the

negative result on the particular IMO and are connected to real weaknesses in its defense. This leads to difficulties in accessing the IMO, its structural safety, endurance and physical integrity, strength, structural stability, safety of information etc.

### ***11.6 Assessment the gravity of the consequences***

The severity of the consequences or the cost of losses, result from AMS, is considered as a random variable of negative effects in case of successful realization of a scenario of an attack or other dangerous effects on IMO. This may refer to all or just some of the possible unfavorable effects when priorities are pre-defined. The potential impact of AMS on regional security, public health, economic security, ecological state of the sea, etc. It is important to be taken into account the possibility for the IMO to continue functioning, what are the rates of recovery of its normal operations and the extent to which this recovery may proceed, loss of reputation, economic impacts ,etc. These all can be represented as:

$$C = \sum_{i=1}^{c^I} C_i + \sum_{j=1}^{c^{II}} C_j ,$$

- where  $C_i$  - possible adverse effect of i-type
- $C_j$  - possible adverse effect of j-type
- $c^I$  - number of types of primary consequences
- $c^{II}$  -number of types of secondary effects

Each type of impact can be expressed in different units (number of victims, barrels of oil spilled, etc.) or with general equivalent (e.g. money).

## Chapter XII

### Ship security assessment

#### *12.1 Introduction to the SSA*

In case RSO is occupied with review and approval of the SSP or its amendment for a specific ship, RSO does not take part in preparing the SSA, SSP and the amendments, subjects of review.

CSO responds in the team that conducts the SSA, for a competent persons to be included, considering the valuation of the security of the ship according to paragraph 8, part A, taking into account paragraph 8, part B. People included in SSA must be experts considering the:

- Current Maritime Threats;
- Recognition and detection of weapons, dangerous substances and devices;
- Recognition of non-discriminatory basis of characteristics and behavioral pattern of people that may threaten the security;
- Knowledge of techniques used to circumvent security measures;
- Knowledge of methods used for causing incidents;
- The effects of explosives on ship's structures and equipment;
- Safety / security of the ship;
- Accepted options for implementation of the interaction ship-port;
- Contingency planning, preparation for emergencies and response;
- Physical protection / security;
- Radio and telecommunications systems, including computer systems and networks;
- Ship's machinery;
- Ship and port operations;

CSO must provide information necessary to conduct SSA, including:

- The general layout of the ship;
- Location of restricted areas - bridge, machinery spaces of category A and other control stations;
- Location and function of each actual or potential access point to the ship;
- Changes in tides, which can have an impact on the vulnerability or security of the ship;
- Cargo holds and organization of the displacement of the load;
- Places for storage ship's supplies and basic equipment for maintenance (servicing and repair);
- Places for storage of unaccompanied baggage;
- Available emergency and rescue equipment able to maintain basic services;
- The number of shipboard personnel, its obligations related to security and existing practices in the Company, related to training;
- Existing equipment related to safety and security, designed to protect the passengers and ship's personnel;
- Exit routes, evacuation, places of gathering that need to be maintained so as to provide an organized and safe departure of the ship;
- Existing agreements with private security companies providing services related to the safety of the ship or surrounding water surface;
- Already introduced security measures, including inspection and control procedures, identification systems, equipment for detection and surveillance, documents for identification of the personnel, communications, alarms, lighting, access control and other systems.

## ***12.2 Organizing the SSA***

Conducting SSA is related to the application of different heuristics for research and some methods for modeling. In all cases, the SSA team should be able to: prepare checklists, organize and conduct inquiries, discussions, limit conclusions in brief summaries, giving accurate estimates based on pre-defined descriptors, processing of datasets, to master various research techniques. More specifically this is described in the specific methodologies.

SSA is performed by RSO, approved by the Administration of the flag. This approach is beneficial for small and medium companies, for which is difficult to maintain a skilled team of SSA.

RSO, committed to the examination and approval of an SSP or its amendments for specific ship, should not have been involved in both preparation of the SSA, and the SSP, as well as the amendments which are expected to be examined.

SSA should inspect every possible access point, including open decks, and to assess the potential for its use from offenders. These include access points provided to persons with legitimate access but that could also be used by unauthorized individuals who are trying to entry.

SSA should:

- Assess the adequacy of the requirements, set by governing documents, to existing security measures, procedures and operations in routine conditions and emergencies and to define security guidelines;
- Consider the persons, activities, operations that need to be protected;
- Examine all possible threats, which include types of scenarios related to security;
- Take into account all possible vulnerabilities of the ship.

CSO and SSO should always pay attention to the impact that the connected with security measures may have on ship's crew who is on board for a long time. When developing security measures it should be paid particular attention to the crew who must maintain efficiency for long periods.

SSA must include the following phases:

- Information-analytical - determines: existing measures, procedures and operations; key operations on the board of the ship that are subject to protection, potential threats to the key operations of the ship and the possibility of their occurrence, in order to establish and prioritize security measures and weaknesses (including human factors, infrastructure, policies and procedures);
- Security inspection of the ship.

## ***12.3 Inspecting the security***

Security inspection on the ship is compulsory phase of SSA. Throughout its implementation must be studied and evaluated the existing security measures on board, procedures and operations for:

- Ensuring the implementation of all duties relevant to the ship's security;
- Monitoring of restricted areas, ensuring that only authorized personnel have access to them;
- Control of the access to the ship, including any identification systems;
- Monitoring of deck areas and other areas of the ship;
- Control of individuals coming onboard and their property (accompanied and unaccompanied baggage and personal property of the ship's personnel);
- Supervising the loading operations and delivery of ships' stores;
- Providing easy access to communication, information and equipment related to the ship's security.

This phase is carried out by specially defined person from the team which conducted the SSA. At special meeting the crew could be asked for their opinion. Without inspecting the safety of the ship there is no SSA.

### ***12.4 Documenting the SSA***

Every step is documented: restrictions/ assumptions made under SSA (region, trade area, systems, training of crew, etc.) and in the appropriate form (usually a table) are recorded current results. SSA is documented, reviewed, accepted and retained by the Company.

After the completion of the SSA should be written a report consisting of:

- A summary of how SSA was conducted;
- Description of each vulnerability found during the SSA;
- Description of countermeasures that could be used against such vulnerability.

If the SSA has not been done by the company, the report of the SSA should be reviewed and accepted by the CSO. SSA should be:

- Documented (electronic format is also accepted) by the one who carries it out;
- Considered – i.e. carefully examined by the Company;
- Adopted – i.e. after some form of defense- approved by the Company;
- And preserved by the Company (which may be in electronic format).

## Discussion:

### Discussing the methodology of the SSA of the Norwegian Shipowners' Association

**Aim of the discussion** – the students must acquire one of the most popular methods for the Ship Security Assessment (SSA) and its instruments.

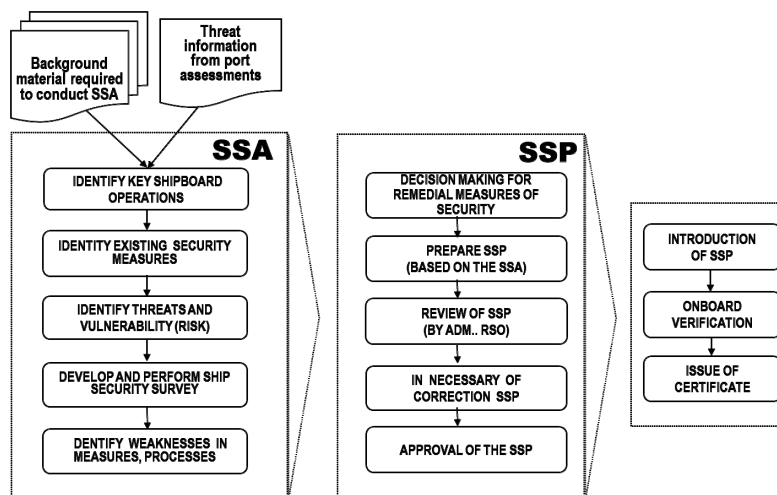
#### Discussing problems

##### Structure of the methodology

In Bulgaria, a more popular methodology of the SSA is Guideline for performing Ship Security Assessment (SSA) is that of the Norwegian Shipowners' Association. This SSA Guideline is made to assist owners and operators of ships to conduct security assessments in a rational, standardized and systematic approach. It is prepared in accordance with the requirements of Part A of the ISPS Code, and taking into account the guidance in Part B.

This SSA Guideline is prepared by also considering the requirements in the USCG NVIC 10-02 Security Guidelines for Vessels. Even though the ISPS Code and NVIC are two different, security regimes, NVIC 10-02 has been developed to assist vessel operators and owners to align with the security requirements under development in IMO at time of publication. We are therefore of the opinion that this Guideline meets the NVIC requirements to ship security assessment. (Further, it should be noted that the USCG expects foreign flag vessels to verify compliance with Part B of the ISPS Code, and not merely Part A, the USCG requires that “Verification of compliance could be established by flag administration documents or endorsements that indicate that the Ship Security Certificate was issued based upon full compliance with Part B”. This methodology fully meets the requirements of the European Union.

This Guideline is primarily designed as a self-assessment tool for CSOs and SSOs and other people responsible for security ashore or on board.



The SSA is an essential and integral part of the process of developing and updating the SSP. The relation between this SSA and the SSP can be illustrated by the upper figure.

#### The IMO Framework

- The Amendments to the SOLAS-74, Ch XI-1 and Ch XI-2. Against a background of



potential threat to maritime shipping and ports, IMO's Diplomatic Conference on Marine Security in December 2002 adopted new regulations to enhance maritime security through amendments to SOLAS Chapter XI. Chapter XI has been split into two chapters, where Chapter XI-1, "Special measures to enhance maritime safety" has been expanded to include additional requirements to Ship Identification Numbers and the carriage of a Continuous Synopsis Record. Chapter XI-2, "Special measures to enhance maritime security", addresses the mandatory requirements such as the provision of Ship Alert System and refers to the ISPS Code., Only the ISPS Code, and its application for ships (not ports), is dealt with in this document.

- **The ISPS Code.** Owners and operators of ships have the primary responsibility for ensuring the physical security – and safety, indeed – of their ships, and the new security measures are centred around a proposed ISPS Code. Part A of the ISPS Code will be mandatory, whereas Part B has been drafted as a guidance and is recommendatory. The regulations and the ISPS Code will apply to the following ships on international voyages:
  - All passenger ships including HSLC ships
  - All cargo ships and HSLC above 500 gt
  - MOU in transit.

In addition, the ISPS Code will apply to PFs serving such ships engaged on international voyages. An important part of the Code is the way risk is treated: because each ship and each port facility is different, the Contracting Government shall determine and set the appropriate security level:

- *Security Level 1: Normal; the level at which ships and port facilities normally operate.*
- *Security Level 2: Heightened; the level applying for as long as there is a heightened risk of security incident.*
- *Security Level 3: Exceptional; the level applying for the period of time when there is a probable or imminent risk of a security incident.*

The security levels create a link between the ship and the port facility since it triggers the implementation of appropriate security measures for the ship and the port facility. Further, it presents a methodology for performing security assessments so that plans and procedures to react to changing security levels can be established. This SSA Guideline provides such a methodology.

A SSP shall address the appropriate measures for the ship to move from security level 1 to 2 and from 2 to 3. Security level 1 is the level to which the SSA Guideline should be based, but the SSP must specify the additional protective measures to be implemented for the heightened security levels (2 and 3).

Further, prior to commencing the SSA, the CSO shall ensure that advantage is taken of information available on threat assessment for the voyage pattern and the ports at which the ship is calling. For ships trading between two (or more) fixed ports, these ports must be taken into account in the SSA. For ships on the spot market, however, ports of call may be difficult to envisage, and for such situations your company should select typical and representative voyage pattern and ports you want to use in the SSA (and the related SSP).

This Guideline deals with the part of the ISPS Code which is relevant to the SSA process only. Therefore, other requirements and guidance set forth in the Code are not further described here, and we refer to the Code for details about other ship security measures, port facilities and the responsibilities of the Contracting Governments.

- **IMO Requirements to the SSA.** The SSA is an essential part of the process of developing and updating the SSP, and the CSO shall ensure that the SSA gives answers to the questions:
  1. *Does a particular motive exist to attack my ship?*
  2. *Which key shipboard operations, systems, areas and personnel to protect?*
  3. *What existing security measures, procedures and operations are in place?*
  4. *How can anybody attack my ship?*
  5. *What are the likelihood and consequences?*

Part A of the ISPS Code provides that the SSA shall include an on-scene security survey where, at least, the following elements are included:

1. Identification of existing security measures, procedures and operations.
2. Identification and evaluation of key ship board operations that are important to protect.
3. Identification of possible threats to the key ship board operations and the likelihood of their occurrence, in order to establish and prioritise security measures.
4. Identification of weaknesses, including human factors in the infrastructure, policies and procedures.

Part B of the ISPS Code, gives further guidance as to how a SSA must be conducted. The CSO must also ensure that the SSA is carried out by competent persons with skills to evaluate the security of the ship. Importantly, the SSA shall be documented, reviewed, accepted, and retained by the Company.

### The Ship Security Assessment Process

The SSA Process according Guideline for performing Ship Security Assessment, Norwegian Shipowners' association including 4 stages and 8 steps

<i>STAGES</i>	<i>STEPS</i>
<i>Initial Screening</i>	<b>Step1:</b> Identification of Possible Motives <b>Step2:</b> Identification of Key Shipboard Operations <b>Step3:</b> Identification of Existing Security Measures, Procedures and Operations
<i>Threat Assessment</i>	<b>Step4:</b> Identification of Possible Threat Scenarios <b>Step5:</b> Threat and Vulnerability (Risk) Assessment
<i>Onboard Audit</i>	<b>Step6:</b> Development of Onboard Ship Security Survey Checklist <b>Step7:</b> Onboard Ship Security Survey
<i>Identification of Needs</i>	<b>Step8:</b> Identification of Weaknesses, Remedial Actions

After these 8 steps, the SSA is complete. The steps should be documented and is a basis for the development of a SSP. Remember also to document the limitations/assumptions of the SSA (trading area, onboard systems, etc.) The remainder of this SSA Guideline gives detailed descriptions for each step (1-8) including related checklists and other tools.

### Review of the methodology step by step

#### Step 1: Identification of Possible Motives

Identify any particular motives that may exist to threaten or harm your ship, persons, cargo, or operations. This step gives us the answer of the question: "Are there any particular motives for unlawful acts against my ship?"

*Objective:* To trigger a creative process to identify what types of motives for security incidents that do exist, and which motives that are particular for *my ship and business*.

*Outcome:* Prioritised list of relevant motives that may exist.

*Application:* The identified motives form a basis for the identification of possible threat scenarios (Step 4).

#### Step 2: Identification of Key Shipboard Operations

Identify critical operations, activities, and persons that are important to protect. This step gives us the answer of the question: "What operations, systems, areas, and personnel are important to protect to avoid a security incident?"

In the focus of the Step 2 must be the critical operations - people accessing the ship; ship navigation and operation; cargo handling; ship stores handling; security monitoring; emergency response,

*Objective:* To identify operations, systems, areas, and personnel critical to protect if subject to a security incident.

*Outcome:* A list of security-critical operations, systems, areas, and personnel onboard.

*Application:* To prioritise the most critical operations, systems, areas, and personnel to protect with respect to a security incidents.

### **Step 3: Identification of Existing Security Measures, Procedures and Operations**

Get an overview of security measures in place. This is an in-office screening and not a comprehensive review. Prioritize operations, areas, systems, and personnel for threat assessment, focus on those found most critical and with a low level of protective security measures. This step gives us the answer of the question: “What existing security measures, procedures and operations do I have in place?”

*Objective:* To identify and describe existing security measures, procedures and operations.

*Outcome:* List of existing security measures related to critical operations, areas, systems, and personnel.

*Application:* To get an overview of existing measures to be used :

- a. To identify critical operations that may have insufficient security
- b. Onboard during the ship security survey (Step 7).

### **Step 4: Identification of Possible Threat Scenarios**

Identify threat scenarios, or security incident scenarios, that reflect the motives and prioritized operations, areas, systems and personnel. If no particular motives are identified, and no prioritization can be made, use a standard list of possible threat scenarios. This step gives us the answer of the question: “How can anybody attack my ship?”

*Objective:* To identify the most relevant scenarios for security incidents that reflect critical operations, existing measures, particular motives, and the trade of the ship.

*Outcome:* List of relevant security incident scenarios, or threats.

*Application:* To assess relevant threats of the ship to prioritise the vital few for planning of security measures. The threat scenarios will further be evaluated with respect to vulnerability (Step 5).

### **Step 5: Threat and Vulnerability (Risk) Assessment**

Assess likelihood and potential consequences of the scenarios. Do it roughly and qualitatively. Likelihood may be classified as “unlikely” and “not unlikely”, and consequences as “moderate”, “high” and “extreme”. Prioritize scenarios found “not unlikely” in combination with consequence severity “high” or “extreme”. This step gives us the answer of the question: “Do some of the scenarios appear more likely than others and what could the consequences be?”

*Objective:* To assess ship vulnerability to threats – security incident scenarios – in terms of likelihood and potential consequences.

*Outcome:* List of the vital few scenarios implying the highest risk.

*Application:* To give guidance with respect to operations, areas, systems and personnel that should be evaluated and surveyed to identify whether additional security measures are required.

### **Step 6: Development of Onboard Ship Security Survey Checklist**

Develop a ship security survey checklist that reflects the prioritized scenarios, existing measures assumed to be in place, and critical operations. This step gives us the answer of the question: “What should I check onboard my ship and what is the status?”

*Objective:* Develop an onboard security survey checklist specific for your ship based on the information gathered through Steps 1-5 and relevant paragraphs of the ISPS Code, Part A and B.

*Outcome:* An onboard ship security survey checklist, to be used in Step 7.

*Application:* The checklist shall be used to perform, and document, an onboard ship security survey.

### **Step 7: Onboard Ship Security Survey**

Survey your ship with the checklist. Identify measures in place and comment on deficiencies, training

needs, safety conflicts, manning constraints, security equipment. This step gives us the answer of the question: “What security measures are lacking and what are the weaknesses of the existing?”

*Objective:* To perform, and document, an on-board ship security survey.

*Outcome:* Confirmation of security measures assumed to be in place, identification of non-existent/insufficient security measures.

*Application:* Security measures identified as non-existent/insufficient create the basis for the SSP. They also define the remedial actions to be taken. The SSP shall be written to include the duties and responsibilities of those on-board and ashore for implementing these security measures at varying security levels.

### **Step 8: Identification of Weaknesses, Remedial Actions**

Evaluate identified improvement needs through the ship security survey in terms of required security measures and weaknesses of existing measures.(and of possible remedial actions?). This step gives us the answer of the question: “What security improvements are needed to reduce vulnerability and weaknesses?”

*Objective:* To identify issues for which security improvements may be needed based on the onboard survey. Propose remedial actions.

*Outcome:* A list with identified needs for security improvements; outline of proposals for remedial action.

*Application:* The identified needs form the basis for the Ship Security Plan by having identified what to plan for.

### **Tools of the methodology**

The SSA Process according Guideline for performing Ship Security Assessment, Norwegian Shipowners’ association is a complex, tedious and a continuous process, which should put a lot of resources. It is close to a serious scientific study, which is often not enough information.

About it in the course of SAA have to use different tools as:

- b. **Worksheet for Identification of Motives (Appendix A)** is divided in motive categories: political; symbolic; economical; fear, and; other.

It is important that you think exclusively on motives, and that you are conscious about the category of the motive. In the end, make an overall assessment and evaluate which motives that should be considered. Keep the outcome from this evaluation of motives fresh in mind when you later on go through Step 4, “Identification of possible threat scenarios”. But first you should identify key shipboard operations (Step 2) and your existing security measures (Step 3).

- **Worksheet for Key Shipboard Operations (Appendix B)** may be used to:
  1. Identify critical shipboard operations, systems, physical areas and personnel that may be subject to security incident (left column, input from Step 2) - e.g., cargo operations, bunkering, repair work, change of crew/passengers, etc.. These should be evaluated in relation to your trading areas, the ship and operations characteristics, and so on. List systems, physical areas, and personnel that may be targeted and used in security incidents. which are important to protect?. The worksheet includes all elements that is recommended to be covered by the SSP.
  2. Existing security measures for the same operations, systems, areas (right column input from Step 3 - includes elements from Part B).
  3. Obtain and record the information required to conduct the ship security assessment, such as general layout of ship, stowage arrangement plans, etc (ref. Part B)
  4. Go through the list, discuss and identify the critical operations, systems, areas, and personnel that may be important to protect to prevent threats or security incidents.
- **List of Threat scenarios and Assessment (Appendix C)** use the list of threat scenarios developed (Step 4). Do not try to quantify consequences and likelihood, but indicate if they are “low” or “high”:

1. Assess whether some scenarios are more likely than others. Take into account motives, existing measures and critical operations when assessing the likelihood. Likelihood may be categorized in terms of “unlikely” and “not unlikely”.
2. Assess potential outcome of the scenarios. A consequence categorisation (“moderate”, “high” and “extreme”).
3. Prioritize the scenarios that are “not unlikely” in combination with consequence severity “high” and “extreme” (the two upper-right squares in the right-hand figure, below).

The SSA should consider all possible threats, which may include:

1. Damage to, or destruction of, the ship (bombing, arson, sabotage)
2. Hijacking or seizure of the ship/persons on-board
3. Tampering with cargo, ship equipment, systems ship stores
4. Unauthorised access or use, incl. stowaways
5. Smuggling of weapons or equipment, weapons of mass destruction
6. Use the ship to carry perpetrators and their personal equipment
7. Use of the ship as weapon or as means to cause damage, destruction

This list is not comprehensive but it provides you with a long range of scenario examples. Try to think “out of the box”, and find scenarios that are relevant for *your* vessel and *your* trade. Make comments and evaluate consequences and likelihood on an appropriate level.

Consequence categories to be used:

*Moderate*: Little or no loss of life or injuries, minimal economic impact, or some environmental damage.

*High*: Multiple losses of life or injuries, major regional economic impact, long-term damage to a portion of the eco-system

*Extreme*: Numerous loss of life or injuries, major national or long term economic impact, complete destruction of multiple aspects of the eco-system over a larger area.

- **Checklist for Ship Security Survey (Appendix D)** - the SSA should consider the continuing relevance of the existing security measures and guidance, procedures and operations, under both routine and emergency conditions and should determine security guidance. For practical purposes, and for the design of this checklist, we assume that a SSP is already in the making and/or onboard. If this is (still) not the case, please do not put too much emphasis on the questions in this checklist that directly refers to the SSP.

Perform an onboard assessment of the ship security by checklist developed in Step 6. Go through each item on the checklist and make remarks about the weaknesses, such as:

- a. Conflict between security and safety measures
- b. Conflicts between shipboard duties and security assignments
- c. Watch keeping and manning constraints with implications on crew fatigue, alertness, and performance
- d. Security training deficiencies
- e. Insufficient, poorly maintained, sub-standard security equipment/systems.

- **Summary of Security Measures (Appendix E)**

1. Go through the checklist from the ship security survey and evaluate the areas where remarks have been made.
2. Identify improvement needs per area.
3. Propose remedial actions for the same “security gaps”.

## Review of similar methodologies

- **Lloyd’s Register and IDS International ISPS Code – Practical Pack Document Version 0.1**

Step1: Reviewing the potential threats to a particular type of ship

Step2: Consequences Assessment

Step3: Vulnerability Assessment

Step4: Reducing the Impact

Step5: Execute

Step6: Audit, Review, Improve

- **Lloyd's Register Mariner - a risk-based software for operational safety and security on ships**
- **ABS Guide for Ship Security – American Bureau Shipping**
- **Bureau Veritas Ship Security Assessment** shall include the following steps, which should than be adapted to each type of ship:

Step1 Identification of key shipboard operations

Step2 Identification of existing security measures and procedures

Step3 Identification of potential threats (refers to threat scenarios)

Step4 Performance of an on-scene security survey

Step5 Identification of weakness in both the infrastructure and in the procedure

**Reference:**

1. DNV Guideline to International Ship Security Certification - Det Norske Veritas – July 2007
2. Guidance on the international ship and port facility (ISPS) code, International chamber of shipping, 2003
3. Guide for ship security, ABS March 2005, [www.eagle.org](http://www.eagle.org)
4. Guideline for performing ship security assessment Norwegian, Ship owner association, 2003
5. Guidelines Formal Safety Assessment (FSA) for Use in the IMO Rule-making process, [www.imo.org](http://www.imo.org)
6. International Ship and Port Facility Security Code (ISPS Code), IMO, 2003
7. Risk Based Decision Making Guidelines, [www.uscg.mil](http://www.uscg.mil)

## Chapter XIII

### Port facility (Port) security assessment

#### *13.1 Introduction to the PFSA (PSA)*

PFSA is focused on the following elements of the port (PF): physical security, structural wholeness, systems to protect staff, radio and communication systems, including computer systems and networks, relevant infrastructure, utilities and others, which if they are defeated, they can provoke death and injuries or to violate normal accomplishment of the operations in PF and to cause material losses. In the figure below is shown an option in the order of working in PFSA. In developed marine countries working in similar algorithm can be easily organized because in their laws are fixed basic quantitative parameters, on which the port PF can be categorized, to determine the form of assessment, etc., they have big experience in the management of emergency and crisis situations.

Different options are possible for an elaboration of an assessment of port security - separately for each PF; joint assessment for several bound PF (structural, functional or by the location) or general assessment for the entire port complex (major port). Contract government can allow certain assessment of port security to cover more than one PF, if the operator, the position, the activity, the equipment and the architecture of these harbor works are similar. Each contract government, which can allow such a measure, must present details about it to IMO.

Major ports, which consist of many elements, sometimes consider like one object and in other situations decompose in separate parts, this depends on concrete situation and on that how far the situation enters to the screen version for attack. For example, the whole port can be object in one screen version attack, but in other, different parts of the port can be considered like independent objects.

PFSA (PSA) is the basis of the risk analysis in all aspects of the port (PF), to define which parts of it are more susceptible in attack and/or there is bigger possibility - parts of the port to become attack objects. The risk in the security is function in threat of attack, combined with the vulnerability of the protected object and the consequences from the attack. In this way the possible threats for the port infrastructure can be “recognized” and the possibility of happening, which helps to define and order necessary secure measures.

PFSA must be considered and updated periodically, as we pay attention on changing threats and/or minor changes in PF, which are considered and updated always when serious changes occur in PF.

#### *13.2 Organizing the PFSA (PSA)*

PFSA (PSA) mandatory includes consultations with the corresponding organizations for national security to determine:

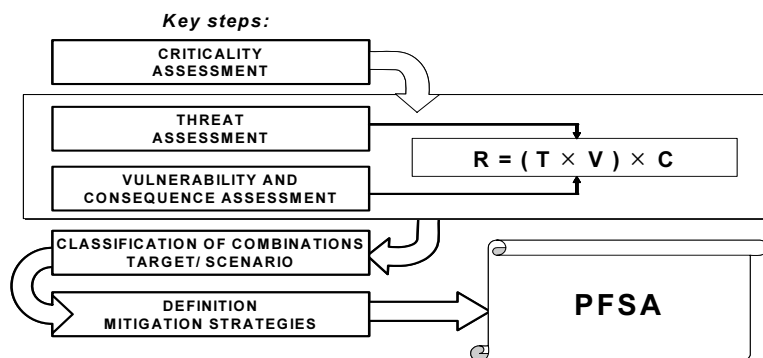
- all concrete aspects of PF, which includes the ship traffic using the installation, which can bring the possibility of it becoming a goal for attack.
- the possible consequences of losing a life, damaging to property, economical wrack, which includes destroying transport systems, at attack on or in Pf
- the ability and intentions of those, who might prepare such an attack
- the possible type or types of attack, with producing overall assessment of the level of the risk, against which is needed to develop security measures.

The process also includes consultations with the corresponding authorities, in the matter of the constructions, next to PF, which might inflict damage within the PF or can be used to inflict damage on the PF or for its illegal surveillance or for a distraction. Part B of the ISPS code gives the right to

the government to permit a single PFSA to overlay more than a single PF, if the operator, the location, the activity, the equipment and the architecture of those port installations similar. In this case the government needs to present the details for it to the IMO.

At the graphic beneath is shown the main idea for the Sample methodology for the port security (PF) assessment. It's an interpretation of „Guidance for Conducting a Facility Risk Assessment” from GUIDE FOR PORT SECURITY of the American company ABS Consulting. It's based on the scientific method "analysis of the risk" and the modern conception of the critical infrastructure. In witch are reported the more strict criteria of the coastguard in the USA, which insure the implementation of ISPS Code's requirements. It can adapt to specific ports and separate PF. It is more suitable for evaluating whole port or a group of functional connected PF, with which it comes closer to the European approach for port security, in Directive 2005/65/EC of the European Parliament and of the Council from 26.10.2005 for enhancing the security of the ports.

B1 Directive 2005/65/EC of the European Parliament and of the Council, 26 Oct 2005 on enhancing port security, Regulation (EC) No 725/2004 of the European Parliament and of the Council of 31 Mar 2004



*Sample methodology for port facility security assessment*

This methodology includes: assessment of the importance, assessment of the danger, assessment of the consequences, analysis of the vulnerability.

When PFSA is held from RSO, then the assessment must be considered and approved from the Contracting government, in which territory the PF is located.

The people, conducting PFSA, must possess the relevant skills for the purpose of evaluating the security of PF and to be able to offer expert help for:

- current threats for the security and possible variations of manifestation;
- recognition and detection of weapons, dangerous substances and devices;
- recognition of non-discriminatory basis of characteristics and behavioral patterns for people, who might represent threat for the security;
- the techniques, used to circumvent the security actions;
- the methods, used for causing an incident, related with the security;
- effects of explosives on PF's constructions and services;
- the security/the protection of PF;
- business practices of the port;
- planning unforeseen cases, preparation for and reactions at emergency situations;
- measures for physical security/protection of the PF;
- radio and telecommunication systems, including computer systems and networks;
- transportation, hydraulic and civil engineering;
- operations on the ship and at the port;

PFSA must include at least one of the following elements:



- determining and evaluating of important assets and infrastructure, which are important to be protected;
- determining possible dangers for the assets and infrastructure, and the possibility of their occurrence, to establish and prioritize the security measures;
- determining, selection and prioritization of countermeasures and procedure alteration, and their level of efficiency in reducing the vulnerability;
- determining weaknesses, including the human factor, in infrastructure, politics and procedures.

### ***13.3 Inspecting the security***

Inspecting the security on a spot is focused on:

1. Identification and assessment of important assets and infrastructure - process, during which to establish the importance of the constructions and installations for the functioning of the PF. This process gives the needed base to choose the appropriate mitigation strategies of possible influence of those assets and constructions, which is important to be protected from incidents with the security. Should be taken into account the potential loss of human life, economic importance of the port, symbolical value and the presence of government installations. The important assets and infrastructure which must be inspected exclusively carefully and pedantically are:

- access points, entrances, approaches and anchorages, maneuvering areas and berths on the quay;
- loading facilities, terminals, warehouses for storage and equipment for handling cargo;
- distribution systems, radio and telecommunication systems, computer systems and networks;
- ship traffic management systems at the port and navigation aids;
- power plants(electrical), pipelines for transfer of cargo and water;
- bridges, rail lines, roads;
- port service ships, including pilot boats, tugs, lighters, etc.;
- equipment and systems for security and observation;
- water areas adjacent to PF;

2. Identifying possible threats for the assets and infrastructure and the likelihood of their occurrence, to establish and prioritize security-related measures. Must be identifying the likely actions, which could endanger the security of the assets and infrastructure and methods for performing these actions, to determine the vulnerability of an asset or the location for security incident and to establish and prioritize security requirements, to allow planning and resource allocation. Identification and assessment of any potential action and it's method should be based on various factors, including assessment s of threats from government agencies. Through the identification and assessment of threats, those who carry out the assessment, shouldn't rely on scenarios for the worst case to guide planning and resource allocation. In consultation with the appropriate authorities for national security is defined:

- all the practical aspects of PF, including ship traffic, which can lead to a likelihood that it would become a target for attack;
- the possible consequences in terms of loss of a human's life, property damage, economic distress, including destruction of transport systems, attack on or PF;
- skills, intentions and motivations of the likely subjects of such an attack;
- the possible type or types of attacks;

3. Identification, selection and prioritization of countermeasures and procedural changes and their effectiveness in reducing vulnerability. For this purpose is necessary to conduct a thorough site survey, which includes:

- surveys, inspections, and security audits;

- consultation with the owners and operators of PF, and owners/operators of adjacent constructions;
- historical data on security incidents;
- operations on PF;

4. Identifying vulnerabilities (weaknesses) - focuses on the physical constructions, systems to protect personnel, processes, or other areas, that can lead to security incidents, to identify options to eliminate or alleviate them. On site are investigated:

- access from the sea / coast to PF and boats moored in it;
- structural integrity of the piers, facilities and adjacent structures;
- existing measures and security procedures, including systems for identification;
- existing measures and security procedures, of port and public services;
- measures protecting radio and telecommunication equipment, port and public services, including computer systems and networks;
- adjacent land/water areas, which might be used while or for attack;
- existing agreements with private security companies, ensuring security services from the sea/shore;
- any conflict between the safety and security measures and procedures;
- any conflict in security liabilities in PF;
- any limitation in activities and staff;
- any shortcomings, discovered during training and drills;
- shortcomings, discovered during the daily operations, following incidents or alerts, reporting of security alarms, implementing control measures, audits and etc.;

The vulnerability assessment might reveal weaknesses in port security (PF as its subsystem) or unprotected important infrastructure element (computer network, electricity, water supply, special construction, bridge or tunnel). For example, many terminals have a serious problem, resulting from the fact, that the distance from important parking areas for processing of loads or buildings, is so little, that the detonation of a car bomb could damage or destroy buildings and kill the people in them. To mitigate this threat, the distance between the parking areas and the buildings (the protected sites) must be increased.

### ***13.4 Documenting the PFSA***

In the source of PFSA are documented:

- evaluating the importance, the most important sites in the port, that becomes the focus of further assessment. For small ports or separate PF, assessment of the importance probably won't be made;
- threat assessment to identify the most likely scenarios. Defined potential threats are combined with plausible scenarios of attack;
- assessment of impacts and vulnerabilities for each combination of object-scenarios - they are described and attributed the degree of difference "high", "medium" and "low" through common for all experts descriptors, reported in tables: criteria for impact, to be used; criteria for vulnerability: to be accounted; criteria for vulnerability. The goal is to reach a common agreement between the result of the effects and a total score of vulnerabilities for each combination of object-scenarios;

After developing the PFSA a report is made on it, which contains:

- a summary of how the assessment was conducted;
- description of each vulnerability found during the assessment;
- description of the countermeasures, that could be used for each vulnerability;

The report must be protected against unauthorized access or disclosure.

## Discussion

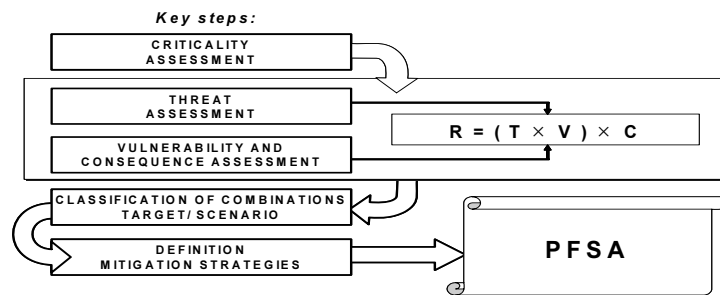
### Discussing the methodology of FPSA of ABS Corporation

**Purpose of discussion** – students should learn in depth one of the most popular methods GUIDE FOR PORT SECURITY of ABS Consulting and its instruments.

#### Questions to discuss

#### Structure of the methodology

Methodology is in Annex 1 GUIDE FOR PORT SECURITY, ABS Consulting. It is based on the scientific method -risk analysis, and takes into account the modern concept of critical infrastructure. Complies with the ISPS Code, but satisfies also the stricter criteria of the U.S. Coast Guard. It can be adapted to specific ports and to particular PFs. It is suitable for the assessment of entire port or a group of PFs, and fully complies with the European approach.



*Sample methodology for port facility security assessment*

Such assessments could identify vulnerabilities of port operations, security of the personnel, physical and technical security.

After the assessment of importance, threats, vulnerabilities and consequences, is completed, according to them, can be taken risk-based decision and to be taken grounded actions for better preparation against terrorist attack.

The main steps for PFSA are:

1. Evaluation of importance – in order to identify critical operations. It helps to identify the critical sites in the harbor, on which is focused the following assessment. It may not be made for small ports or particular PFs.
2. Threat assessment - for identification of the most likely scenarios. Defined potential threats are combined with probable scenarios of attack;
3. Assessment of impacts and vulnerabilities for each combination object-scenarios. The result is assessed as 'high', 'medium' or 'low' through common for all experts-descriptors written in tables: consequences criteria, categories of vulnerability, vulnerability criteria. The purpose is to reach a common agreement between the total result of the impact and the total result for vulnerabilities for each combination of object-scenarios;
4. Classification of the combinations object-scenario using table which helps to prioritize the scenarios according to their importance;
5. Determining mitigation strategies and methods of implementation - result from the previous step.

Each step involves consultation with the relevant authorities for sites connected with close to the PFs structures that could: cause damage, be used to cause damage illegal surveillance of PFs or distraction.

## **Review of the methodology step by step**

### **Step 1: Assessment of importance**

The aim is identification and assessment of objects which should be protected. This is a process by which is determined the importance of the protected object (PO) for the functioning of PFs. The important objects for port security are:

- Accesses, entrances, approaches, and anchorages, maneuvering and berthing areas;
- Cargo facilities, terminals, storage areas and cargo handling equipment;
- Systems such as electrical distribution systems, radio and telecommunication systems, computer systems and networks;
- Port vessel traffic management systems and aids to navigation;
- Power plants, cargo transfer piping and water supplies;
- Bridges, railways, roads;
- Port service vessels, including pilot boats, tugs, lighters, etc.;
- Security and surveillance equipment and systems;
- The waters adjacent to the port facility
- Others (list)..

So the defensive effort and related to it strategies focus on those sites that are with priority when comes to protection from Maritime Security Incident (MSI). It is taken into consideration the potential loss of life, the economic importance of PFs, the symbolic value and the availability of government installations. The main focus is to prevent / minimize deaths and injuries. It is also important to consider whether PFs (particular PO in it) may continue to operate without any element and the extent to which it is possible to be rapidly restored and get back to their normal way of functioning.

Identification of PO is important for the assessment of measures related to the security of PFs, prioritization of protective measures and taking appropriate decisions about allocation of resources for protection of the entire PF.

Important considerations:

1. Identification of the particular objects that support critical operations of PFs and their inclusion into the evaluation. Objects of them, which are considered, but not included, are documented for further assessment.
2. It is important to take into account the function of the object for the operations of the port. Five areas of missions are of general interest: public health, trade, national security / defense, transportation and communications.
3. The effect of the destruction of the object gives an account of the consequences of its loss.
4. Define possibilities of restoration of the object in case of demolition.
5. Finally, it is considered the number of the affected areas of missions, the extent of the effects and the possibility to recover and then it is made an overall assessment of the importance. Importance is graded as: critical, moderate, side.

### **Step 2: Threat assessment and choice of scenario**

Identification of possible threats to the security of particular protected object (PO) and ways of their implementation, are necessary for: assessment of its vulnerability or localization of MSI, define and prioritize security-related requirements for planning and allocation of resources. It is based on various factors, including threat assessments made by government agencies. When identifying and assessing threats, as well as when planning and allocating resources, the worst scenario should not be taken as a base. PFSA includes analysis based on consultation with the organizations of national security and defines:

- All specific aspects of PFs, including the ship traffic it serves, which make it a possible target of an attack;

- The probable consequences of an attack on PFs or on its elements concerning loss of life, property damage, economic ruin, incl. demolition of transport systems;
- The capabilities and intentions of those who could be plotting an attack;
- And possible type or types of attacks.

The result is an overall assessment of the risk level against which are developed the necessary security measures.

ISPS Code and some publications on maritime security provide a list of probable threats which must be combined with certain critical objects in order to develop scenarios that are needed for analyzes in PFSA:

- Damaging or destroying the PFs or the ship, e.g. with explosives, sabotage or vandalism;
- Abduction or detention of a ship or persons on board;
- Suspicious actions with cargo, important ship equipment, systems or ship's stores;
- Unauthorized access or use of anything, including presence of stowaways;
- Smuggling weapons or equipment, including WMD;
- Use of ships for transporting persons who intend to cause MSI or their equipment;
- Use of the ship itself as a weapon or to cause damage or destruction;
- Block port entrances, canal-locks, approaches, etc.;
- Nuclear, biological or chemical attack.

Attack scenarios (impact) on protected objects (PO) include possible realization of the potential threat to individual object under specific circumstances. It is important the developed scenarios to be possible and logically linked to any real persons with certain abilities and intentions, arising from past events and confirmed by intelligence.

### **Step 3: Assessment of vulnerabilities and consequences**

Identification of vulnerabilities in physical structures, systems for protection of personnel, processes, or other areas that may lead to MSI, is made to define options for their elimination or moderation. For example, the analysis could reveal vulnerabilities in the security systems of PFs or unprotected infrastructure that could be solved by taking physical measures, e.g. permanent barriers, alarms, signaling and security equipment (SSE) and more. During the identification of vulnerabilities the following points are taken into account:

- Access from the sea and from the coast to PFs and ships that are on its quays;
- Structural integrity of the piers, facilities and structures;
- Existing security measures and procedures, including identification systems;
- Existing security measures and procedures related to port services and public utilities;
- Measures for protection of radio and telecommunication equipment, port services and public utilities, including computer systems and networks;
- Neighboring areas that may be during an attack or for attack;
- Existing agreements with private security companies that could provide security from the sea and from the shore;
- Conflicts between safety and security-related measures and procedures;
- Any conflicts with assignments and duties related to PFs and security;
- Any forced actions and limitations of the staff;
- Any deficiencies identified during training;
- Any deficiencies identified during daily operation, after incidents or alerts, report of security-related matters, exercise control measures, audits, etc.;
- Training the personnel and its attitude on security issues.

In this step any combination of scenarios protected object/attack is seen in the light of potential consequences and the vulnerability of the object. In the assessment of the effects are included 5 components, listed in Table. In definition of vulnerabilities are included 4 elements also presented in Table.

The evaluation team discusses each element of vulnerability for a given scenario, but they need to summarize the results into a single score for each combination object / scenario as high, medium, low. The initial assessment of vulnerabilities is done without new mitigation strategies, even if there are already existing ones. In case of further evaluation, components that have been used are recorded. Assessing the vulnerability without strategies provides a more accurate baseline score for the overall risk, related to the scenario. After the initial evaluation, comparative evaluation could be made with consideration of new strategies. Categories and vulnerability criteria are given in Table.

#### **Step 4: Categorization of combinations object/scenario**

The evaluation team determines which scenarios should have mitigation strategies. This is done by defining where the combinations object/scenario falls in the table based on the results of assessments of the impacts and the vulnerabilities.

"Mitigation" means that mitigation strategies must be developed to reduce the risk for this combination object / scenario. PFSP should contain evaluated scenario, the results of the assessment and measures for mitigation.

"Discuss" means that the combination object /scenario is being discussed and mitigation strategies are developed, and each case is examined individually. PFSP should contain estimated scenario, results of the assessments and the reasons why mitigation measures were or were not taken.

“Documentation” means that the combination object /scenario currently does not require measures of mitigation and it is enough to be documented. PFSP should contain estimated scenario and results of the evaluation. This will be useful for further edition of the plan in order to be known if the basics have changed since the last edition of PFSA.

#### **Step 5: Defining mitigation strategies and methods of implementation**

Identification and prioritization of countermeasures provides the most effective security measures which will help reduce the vulnerability of a PFs or ship / port interface in cases of possible threats. Measures for improvements in security are selected on the base of factors that lead to reduction of the possibility of an attack and have to be evaluated using information that includes: reviews, inspections and audits, consultation with owners / operators of PFs, and those of neighboring structures, historical information about MSI, operations in PFs.

The significance of these estimates can be seen when they are applied for mitigation of the consequences and vulnerabilities. The aim is overall risk associated with the identified combinations object / scenario to be reduced. Often, when mitigation strategies are considered it is easier to reduce the vulnerabilities than to reduce the consequences of threats. The strategy is considered effective if it reduces the overall result of the consequences and the vulnerabilities. It is assumed to be partially effective if it reduces the overall result when applied with one or more than one other strategies. It is ineffective if it does not reduce any result.

The strategy is considered realizable if it can be applied without problems or without the accepted budget restraints. It is considered partially feasible if its implementation requires significant changes or additional funds. It is not feasible, if its accomplishment is a problem or its cost does not allow its implementation, except in cases of great danger.

It is important for the team for PFSA to remember that these strategies should be put in compatibility with different levels of threats for security, identified by the particular state agency. Ultimately, strategies must maintain an equivalent level of security, regardless of changes in the levels of threat. After the selection of mitigation strategies and methods of implementation the team for PFSA should check the results to ensure that critical operations are maintained. Some mitigation strategies may be associated with the termination of non-critical operations in cases of major threats.

### Tools of the methodology

Basic tools of the methodology are special tables that support the quantitative-qualitative analysis. These tables derive from the relevant legislation and ensure the development of PFSP by linking it to the process of crisis management. The methodology presents the following tables:

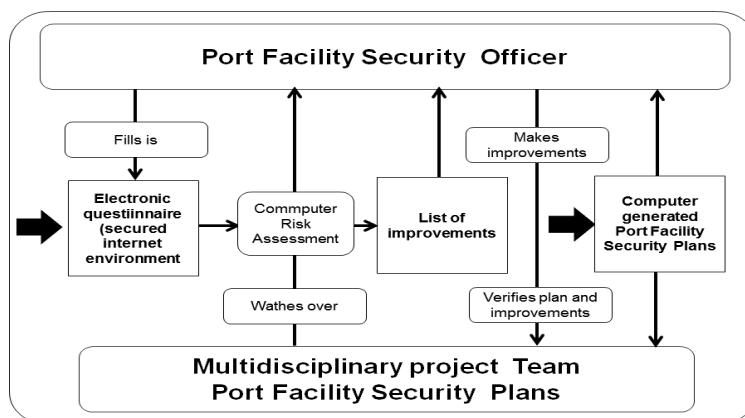
- №1 Assessment of importance
- № 2 Categories and descriptions of the impacts
- № 3 Criteria for evaluation of the impacts
- № 4 Categories of vulnerabilities
- № 5 Criteria for evaluation of vulnerabilities
- № 6 Matrix of vulnerabilities and impacts

This methodology and tables are used for software for support of the implementation of PFSP, development and maintenance of PFSP and administering the security of the port.

### 19.4 Review of similar methodologies

Most countries use specialized software that facilitates the process PFSA and the development, maintenance and updating of the PFSP. Examples of such software:

#### Self-Risk Assessment Tool - Rotterdam Municipal Port Management



- “СНПРТ 12” – ИСТА – Russian
- “Security LEADER” - ABS Consulting - USA;
- “ASSESS”- USA

#### Reference:

1. Directive 2005/65/EC of the European Parliament and of the Council, 26 Oct 2005 on enhancing port security
2. GUIDE FOR PORT SECURITY, ABS Consulting October 2003
3. Guidelines Formal Safety Assessment (FSA) for Use in the IMO Rule-making process, [www.imo.org](http://www.imo.org)
4. International Ship and Port Facility Security Code (ISPS Code), IMO, 2003
5. ISO 20858:2007 Ships and marine technology – Maritime port facility security assessment and security plan development [www.iso.org](http://www.iso.org)
6. Regulation (EC) No 725/2004 of the European Parliament and of the Council of 31 Mar 2004
7. Risk Based Decision Making Guidelines, [www.uscg.mil](http://www.uscg.mil)

## Chapter XIV

### Offshore facility security assessment

#### *14.1 Introduction to the OFSA*

There is no common understanding of "Offshore Facility" (OF) at this stage. It is suitable to use some definitions coming from Australia, which has a well-developed theory and adequate legislation in this area. OF is a facility located in an offshore zone used in the extraction of oil from the seabed or its subsoil with equipment- part of the facility. It includes:

- Any structure that is located in an offshore zone used in operations or activities associated with actions of this kind;
- Any vessel located in offshore areas that are used for operations or activities associated with actions of this kind.

OF is a marine facility located in the offshore area and FSU any marine facility in the offshore area. The ship is not an offshore facility, and not part of an offshore facility, if it is:

- Tanker used for transportation of the extracted resources;
- Tugboat or Anchor Handling Tug Supply vessel;
- The ship is used to supply an offshore facility, or if it travels between sea-shore and shore facilities;
- Offshore installation does not include underwater pipelines;
- Mobile offshore drilling unit is not an offshore facility, and is not part of the offshore installation.

According to the legal concept, offshore area is part of the national seas, the exclusive economic zone (including external territories), the sea or the continental shelf.

There is no generally accepted methodology for conducting Offshore Facility Security Assessment (OFSA). The reasons vary and are result from the diversity of Offshore Facilities and their differences in construction, legal status, ownership, organization of usage, etc.

What are the possible approaches for conducting effective and efficient OFSA? Obviously they result from positioning, ways of exploitation and organization of their protection. Possible approaches are:

- For some of them that are related to the extraction of oil and gas, and as a construction and manner of use are vessels - the approach set out in the ISPS Code could be applied;
- For those that are close to the shore - to be treated as part of the critical infrastructure;
- For those that are out at sea, i.e. typical "Offshore", is appropriate to apply their assessment within the whole Offshore Area.

The methodology includes: evaluation of importance, threat assessment, impact assessment, vulnerability assessment.

Evaluation of importance is a process designed to identify and evaluate systematically critical resources (infrastructure, object) according to various factors such as function and importance. For example, they can be identified as "critical" to national security, public safety and the economy, according to their importance. PF can be critical for some time, but then not. For example, they are critically important as long as there are many people on them, a certain type of vessel (a particular ship) or dangerous goods. The evaluation of importance provides the basis for accurate focus on strategies for mitigation of the consequences and methods for contra-measures by identification of the valuable resource which is more important to be protected from attack. It takes under account the following factors:

- The importance of a resource to fulfill missions given by PF;
- An opportunity to restore its working capacity;
- Potential cost for its repair or replacement.

The assessments of importance should provide information about the impact on people's life/ health, economic security, symbolic value and national defense. They help for correct identification of



valuable resources and determine which objects are subject to further evaluation.

Threat assessment is used to assess the possibility of an attack on a valuable resource or area (region). It is a necessary tool for taking an adequate management decision, because it helps for the establishment and prioritization of requirements, for planning and allocation of resources to enforce and maintain security. on the base of various factors, including the ability and intention. Scenarios for the worst possible cases should not be taken into account, because they are associated with extreme consequences and usually lead to unjustified overruns and raise the cost of the security system.

Threat assessment, as an important tool for the decision-making, is highly dependent on the need of up-to-date intelligence information. Even if updated frequently it may be inadequate to the emerged threats. Regardless of how familiar are potential threats it should never be presumed that all threats are reliably identified or that there is complete information about the threats we are aware of. Threat assessments themselves are not sufficient to support key judgments and decisions that must be taken.

ISPS Code does not give an approach to threat assessment, but the assessment of the impact and vulnerability gives an idea of how attractive to attack an object is, which is a measure of threat.

The impact assessment gives an idea about the negative impact of a successful attack. It is a method that assesses the outcome of a scenario and the impact of the attack is defined by: death and injuries, economic impacts, impact on social security / national defense or on environment, symbolic effects.

Vulnerability assessment is a process by which:

- Are Identified actual or potential weaknesses in physical structures and systems for the protection of personnel, processes, or other areas, leading to breakthroughs in the <MC> ;
- Are offered opportunities to eliminate or mitigate these vulnerabilities.

Vulnerability assessment might reveal weaknesses in the security systems of OF (subsystem) or in unprotected important elements of infrastructure (computer network, electricity, water-supply, special equipment, bridge and pipeline). For example, some OFs have a serious problem caused by the fact that the distance of the major elements is so small that exploding their improvised explosive waterborne craft can be damage and destroyed facilities and initiating huge number of victims. To mitigate this threat the distance between the protected sites must be increased. Compliance with the safe distance, at which there might be potential carriers of explosive devices and putting cordons are two of the most effective preventive measures that are relatively easy and cheap to bring in.

Once the assessments of the importance, threats, vulnerabilities and consequences are made, it could be taken a decision based on specific risk and actions for better preparation against terrorist attack.

The main steps of the OFSA are:

- Assessment of the importance in order to identify key critical activities or operations. In that way are identified the most important elements of OF, on which is focused further evaluation;
- Threat assessment for identification of the most likely scenarios. Defined potential threats are combined with probable scenarios of attack;
- Assessment of impacts and vulnerabilities for each combination - object-scenarios. The result is assessed as 'high', 'medium' or 'low' through common for all experts descriptors written in tables: consequences criteria, categories of vulnerability, vulnerability criteria. The purpose is to reach a common agreement between the total result of the impact and the total result for vulnerabilities for each combination of object-scenarios;
- Classification of the combinations object-scenario using table which helps to prioritize the scenarios according to their importance. Three categories are accepted that determine the need for each case: development of mitigation strategies, separate examination, only documentation.

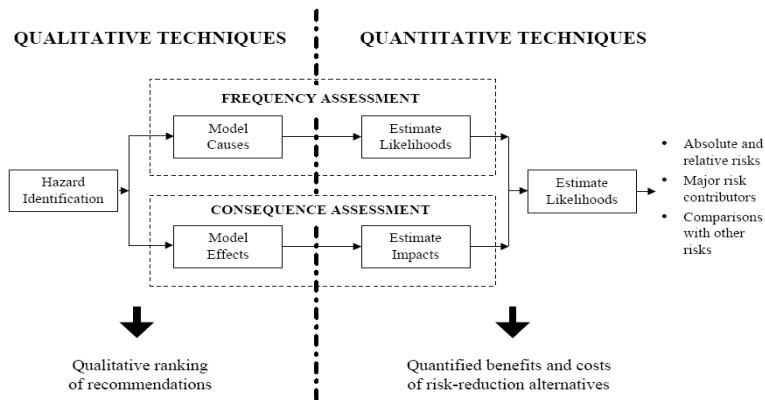
## ***14.2 American vision of OFSA***

American vision of OFSA is presented in Guidance Notes on Risk Assessment Applications for the Marine and Offshore Oil and Gas Industries (American Bureau of Shipping) and is versatile and systematic method for identifying levels of risk. It includes four main steps:

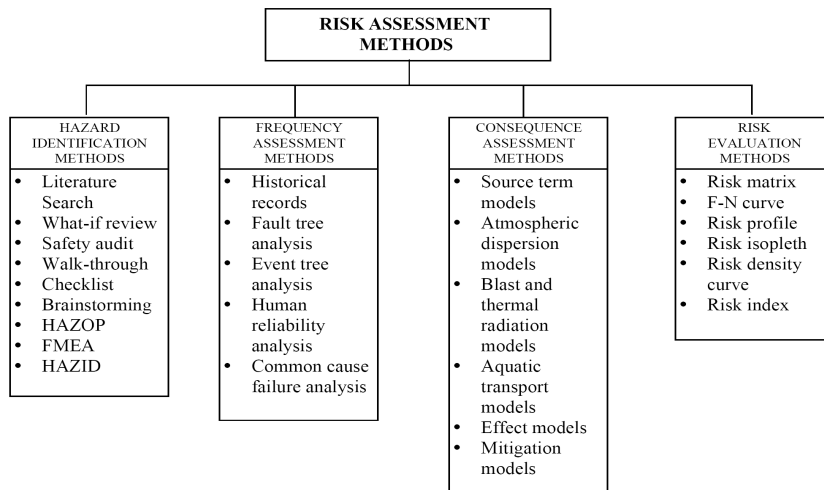
- Identification of dangers;
- Evaluation of frequency;
- Assessment of the consequences;
- Risk assessment.

In order to take valid risk-based solutions, information, which varies widely, is necessary. The process of risk assessment is shown in the figure below. After the identification of the dangers there are two possible alternatives for risk assessment:

- With qualitative methods is assessed the frequency of the dangers and on this basis are prioritized recommendations for risk management;
- A detailed quantitative analysis of the benefits and the costs of reducing the risk.



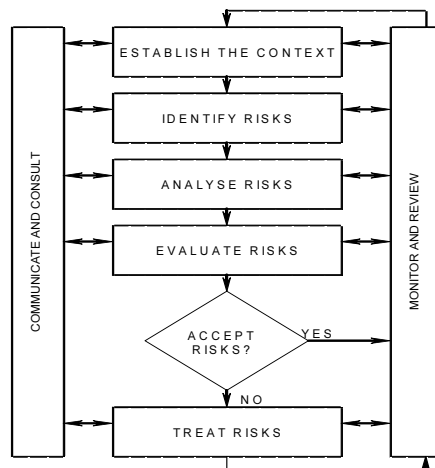
**SOURCE:** Guidance Notes on Risk Assessment Applications for the Marine and Offshore Oil and Gas Industries, JUNE 2000, American Bureau of Shipping, *The Risk Assessment Process*



**SOURCE:** Guidance Notes on Risk Assessment Applications for the Marine and Offshore Oil and Gas Industries, JUNE 2000, American Bureau of Shipping, *Overview of Risk Assessment Methods*

There are many different analytical techniques and models specifically designed to support the conduct of risk assessments. Some of them are summarized in the diagram below. The key to success of any risk analysis is in selecting the most appropriate method (or combination of methods) for the situation. This chapter provides a brief introduction for each step of the process of risk assessment and presents approaches for risk analysis in support of various types of decision-making within the marine and offshore industry. It should be noted that some of these methods (or their slight variations) can be used in the process of risk assessment for more than one step.

### 14.3 Australian vision of OFSA



*Steps in the 4360 Risk Assessment Process*

Australian vision of OFSA is consistent with DOTARS Maritime Risk Assessment Model and includes the following Steps in the 4360 Risk Assessment Process:

- Establish the context;
- Identify risks - what can happen and how can happen?
- Analyse risks - determine likelihood and consequences;
- Evaluate Risks - set risk priorities;
- Threat Risks.

This vision satisfies the requirements for evaluation of all types of objects at sea.

### 14.4 Benefits of Risk Assessment Applications

Techniques for risk assessment can be applied in almost all areas of oil and gas extraction and marine industries. We know that corporations, in order to be successful, must have a vision on the risks associated with them and how these risks affect people, part of their operations, financial results and corporate reputation. Increasingly, regulators are seeking to use risk-based approaches in the formulation of new regulations. The possibility of conducting meaningful risk assessments continues to rise by collecting more and better data and by the raising accessibility of computer applications.

There are four key areas in which risk assessment could be useful:

- Identification of dangers and protection from them;
- Improvement of activity;
- Efficient use of resources;
- Development in accordance with rules and regulations.

## Chapter XV

### Fundamentals of scenario approach in maritime security threats

#### 15.1 Characteristics and parameters of scenario approach

A *scenario* can be defined as a description of a possible set of events that might reasonably take place. The main purpose of developing scenarios is to *stimulate thinking* about possible occurrences, assumptions relating these occurrences, possible opportunities and risks, and courses of action.

*Building scenarios* means speculating about the uncertainty surrounding the future: basically it means envisaging a few different possible outcomes for the situation under scrutiny. In this understanding, scenario building is the necessary foundation for scenario planning, a management technology used by managers to articulate their mental models about the future and thereby make better decisions. Others link scenarios with planning. *Scenario planning* can be regarded as a tool for improving decisions making against a background of possible future environments.

The following main characteristics of scenarios are:

- Present alternative images instead of extrapolating trends from the present.
- Embrace qualitative perspectives as well as quantitative data.
- Allow for sharp discontinuities as well as quantitative data.
- Allow for sharp discontinuities to be evaluated.
- Require decision makers to question their basic assumptions.
- Create a learning organization possessing a common vocabulary and an effective basis for communicating complex - sometimes paradoxical – conditions/ options.

Further, scenarios should inform decision-makers and influence as well as enhance decision-making. The purpose of scenario building is to:

- anticipate future threats and opportunities,
- project multiple futures based on optimistic and pessimistic projections of past events,
- foster strategic thinking and learning,
- facilitate the art of strategic conversation,
- envision a future state,
- challenge or dispel assumptions about the “official” future,
- create a rallying point,
- provide leadership for new initiatives or direction,
- create options for decision making,
- create frameworks for a shared vision of the future to influence organizational and individual behavior,
- create an internal or external communication channel that transcends organizational boundaries, time and space.

A possible classification divides scenarios according to the classical PEST factors (politics, economics, society and technology). Commercial companies will be mainly interested in the analysis of the interrelations between economic factors and technological factors, whereas political and social factors will remain more or less in the background. The creative and communicative aspects are in use and different authors refer to the decision and action approach “mission scenarios”, “issues scenarios” and “action scenarios”. Under the aspect of action there are forward scenarios and backward scenarios. Scenarios can be exploratory or normative. Exploratory means starting from the past and present trends and leading to a realisable future. Anticipatory or normative means built up on the basis of different visions of the future; they may be either desired or, on the contrary, feared. The exploratory scenarios may, moreover, be trend-driven or contrasted, depending on whether they incorporate the most likely or unlikely changes.

Evaluating the effectiveness of any “future” activity, among them scenarios, is problematic. A conventional research approach towards measuring the effectiveness of a particular methodology is relatively straightforward. Possible criteria are the following ones:

- Was futures research (*the developed scenarios*) used in making the decision?
- Did the decision makers in each case take all relevant factors and implications into account?
- How confident or satisfied was each group with the decisions made?
- Did the decisions have their intended effect?
- Were all the consequences anticipated?

### ***15.2 Forms of presentation of scenario approach – strengths and weakness***

The use of scenario techniques has several strengths:

*Firstly*, it is important to note that “foresight” concepts differ from “forecasting”. In the past, attempts were often made to predict (forecast) the future as accurately as possible. However, different developments in related fields should leave open several possible developments. The strengths of scenarios is that they do not describe just one future, but that several realizable or desirable futures are placed side by side (multiple future)

*Secondly*, scenarios open up the mind to hitherto unimaginable possibilities and challenge long-held internal beliefs of an organization; moreover, the use of scenarios can change the corporate culture, compelling its managers to rethink radically the hypotheses on which have grounded their strategy.

*Thirdly*, scenarios are an appropriate way to recognize “weak signals”, technological discontinuities or disruptive events and include them into long-range planning; as a consequence, the organization is better prepared to handle new situations as they arise and to promote proactive leadership initiatives.

*Fourthly*, one function of scenarios beyond the planning aspect is improving communication: scenarios can lead to the creation of a common language for dealing with strategic issues by opening a strategic conversation within an organization.

*Fifthly*, another function beyond the planning aspect is the coordinating function: during the scenario process the aims, opportunities, risks, and strategies are shared between the participants which supports the coordination and implementation of actions. In fact, the organizational learning and the decision making process is improved.

*Sixthly*, the large number of different scenario techniques points out that the ways of building a scenario are very flexible and can be adjusted to the specific task / situation.

In contrast to these mentioned strengths, scenario techniques have several weaknesses:

- The practice of scenario is very time-consuming. Therefore, there could be a wish to condense scenario building to a half-day or one day activity. However, this may not give participants enough time.
- A more qualitative approach has to put a strong emphasis on the selection of suitable participants / experts, and in practice this could not be an easy task to fulfil.
- Further, it should not be overlooked that a deep understanding and knowledge of the field under investigation is absolutely necessary. Data and information from different sources have to be collected and interpreted which makes scenario building even more time-consuming.
- It could be difficult not to focus on black and white scenarios or the most likely scenario (wishful thinking) during the scenario-building process.

### ***15.3 Descriptive form of presentation***

Five key properties of descriptive form of presentation motivate their widespread use, as follow:

*First and foremost*, scenarios focus decision-making process on *maritime security threats*. What people can do with maritime security threats, and consequences for themselves and for their organizations, is described and analyzed prior to detailing the system functions and features that

enable for this process. Scenario descriptions of decision-making process provoke risk managers to reflect upon the concrete circumstances and experiences of seafarers throughout the decision-making process.

Scenarios *suspend commitment* but support *concrete progress*. They vividly document an analysis of task essentials, explaining why a course of action is needed by showing what it is used for. They also specify an analysis of alternative courses of action, by detailing how the concrete course of action is used. But scenarios are also rough: they are incomplete; they suggest alternative approaches and “what it?” lines of reasoning; the iteration between requirements, definition and scenario-based envisioning are rapid, easy, and cheap.

Scenarios provide a task-oriented course of action decomposition that can be used from *many perspectives*, including usability consequences and trade-offs, usability specifications and iterative development. They provide a framework of concrete seafarer tasks for developing course of action rationale and documentation, describing causal relationship implicit in a course of action and providing an analysis to which evaluation data can be subsequently adduced.

Scenarios *codify course of action knowledge* as a “middle-level” abstraction. This makes them somewhat less grand as science, but it allows the integration of course of action creation knowledge in a form more suitable for reuse.

Finally, scenarios are an ideal medium for *participatory course of action creation*. They allow creation process to be carried out in a common language. Seafarers may have difficulty describing their goals and visions in the language of features and functions, as traditional problem description languages and functional specifications are a language barrier to seafarers. But all stakeholders in a course of action creation process can “speak” the language of scenarios.

These properties of scenarios suggest an “ideal” scenario-centric process in which creation of courses of action of a system is influenced by scenarios from two directions. On the requirements side, observation scenarios, selected according to the orienting goals of the course of action creation, help identify issues and criteria, which can then be validated against further observation scenarios and against scenario abstractions reused from prior work. This sub-process drives the course of action creation through the definition of needs and opportunities. Once a prototype is available, *scenario-based evaluation* can complement and validate the requirements work. Observation scenarios allow the analysis of transformed situation and thereby the evaluation of the prototype. From such evaluations, further created abstraction can be induced, which collectively form a theory informs future requirements processes and this simplifies subsequent course of action creation.

#### ***15.4 Matrix form of presentation***

Mainly based on impact matrices, the prospective tool-box is a scenario-oriented combination of techniques. The prospective tool-box involves:

1. Asking the right questions and identifying the key variables: futures workshops and structural analysis with the so-called 'MICMAC' method.
2. Analyzing trends and actors strategies: retrospective studies and 'MACTOR' method.
3. Reducing uncertainties to realizable scenarios: morphological analysis, expert methods (Delphi, cross-impacts)
4. Identifying and assessing of strategic options: multi-criteria analysis and 'MULTIPOL' method.

The process comprises three major stages: construction of the basis, identification of major issues at stake and construction of scenarios.

#### ***15.5 Tree form of representation***

In some projects and assets, risk is not only discrete but is sequential. In other words, for the asset to have value, it has to pass through a series of tests, with failure at any point potentially translating into

complete loss of value. Decision trees allow us to not only consider the risk in stages but also to devise the right response to outcomes at each stage.

The first step in understanding decision trees is to distinguish between root nodes, decision nodes, event nodes and end nodes.

- The root node represents the start of the decision tree, where a decision maker be faced with a decision choice or an uncertain outcome. The objective of the exercise is to evaluate what a risky investment is worth at this node.
- Event nodes represent the possible outcomes on a risky gamble. We have to figure out the possible outcomes and the probabilities of the outcomes occurring, based upon the information we have available today.
- Decision nodes represent choices that can be made by the decision maker.
- End nodes usually represent the final outcomes of earlier risky outcomes and decisions made in response.

## Chapter XVI

### Application of scenario approach in maritime security threats

#### *16.1 Choice of priorities in scenario approach of maritime security threats.*

The choice of priorities is answer of the question what is needed criteria in scenario approach of maritime security threats.

The typology identifies three broad “macro” characteristics which are central aspects of scenarios and their development. The macro characteristics apply both to sets of scenarios and to individual scenarios. They address the “why?”, “how?” and “what?” of a scenario study: its goals, the design of the process, and the scenario contents. The goals influence the design influencing in turn contents. A rudimentary comparison of scenario analyses might confine itself to the use of the macro characteristics. A more in-depth comparison demands a greater appreciation of detail, which can be gained with the help of nine micro characteristics that are described in the following paragraphs. They are categorized according to the macro characteristic to which they are closest associated.

The *first group* of broad “macro” characteristics is the goals of scenario studies. There are *exploration* and *pre-policy research*. The first group divided into detailed “micro” characteristics:

- (1) The function of the scenario research involved *process* or *product*.
- (2) The role of values in the scenario process covered *descriptive* or *normative* modes.
- (3) The subject area covered *issue-*, *area-*, or *institutional based* scenarios
- (4) The nature of change addressed *evolutionary* or *discontinuity* (*abrupt* or *gradual discontinuity*).

The *second group* of broad “macro” characteristics is the design of the scenario process. There is *intuitive* and *analytical design*. The second group divided into detailed “micro” characteristics:

- (1) Inputs into the scenario process (*qualitative* and/or *quantitative* modes),
- (2) Methods employed in the scenario process (*participatory* or *model-based* methods),
- (3) Groups involved in the scenario process (*inclusive* and/or *exclusive* groups).

The third group of broad “macro” characteristics is the content of the scenarios. There is *complex* and *simple content*. The third group divided into detailed “micro” characteristics:

- (1) The role of time in the scenario (*chain* or *snapshot*),
- (2) Issues covered by the scenario (heterogeneous or homogeneous),
- (3) Level of integration (integration or fragmented).

The comparison of scenario analyses can confine itself to the broad macro features. In-depth comparison demands a greater appreciation of detail, for which further micro characteristics are described for each.

#### *16.2 Choice of applicable forms in scenario approach of maritime security threats*

The educational function of scenarios has gained in importance compared with its function as a planning tool. Scenarios began to be used more for exploratory ends than prediction, as illustrated by Royal Dutch Shell’s 1972 scenarios, which raised the possibility of a transformation in the supply chain for oil production. Some lead practitioners abandoned the planning aspect altogether, choosing instead to use scenarios primarily for learning and communication. Policy planning is still a feature of some approaches, which combines the exploratory with decision-oriented. Scenario planners in general do not start with a narrow focus, doing so increases the chances of missing key determinants of future conditions or events.

There are thus two poles of the spectrum in relation to goals – exploration and pre-policy research. *Exploration* covers learning, awareness-raising, the stimulation of creative thinking, and investigating the interaction of societal processes. In exploratory scenario exercises, the process may well be as important as the product. In *pre-policy research*, scenarios are used to examine paths to futures that vary according to their desirability. Decision support scenarios may be variously described as



desirable, optimistic, high-road, or utopic; conventional or middle-of-the-road; and undesirable, pessimistic, low-road, dystopic, or doom scenarios. Pre-policy research scenarios may propose concrete options for strategic decision-making. It is more common in pre-policy research scenario exercises to offer implicit policy recommendations.

In practice, studies are often hybrids straddling the two poles of exploration and pre-policy research. In the first phase, scenarios may be developed in exploration of a field which will often be too general to serve as the basis for decision-making. Therefore, new scenarios may then be developed using the exploration of the first phase to zoom in on aspects relevant to strategy development. For example, at Royal Dutch Shell, global scenarios are developed on a corporate level which are then used to help develop the second set of scenarios focused on the strategic issues most relevant to individual Shell operating companies.

### ***16.3 Methods of limiting uncertainty in scenario approach of maritime security threats***

In terms of methodological approach three forms of scenario planning are identified:

- **Intuitive Logics** is the best suited way to use every available information about the future; it generates new ideas and it can help in identifying the underlying patterns. On the other hand intuitive logic is strictly connected with the experts who work on the scenario, the techniques are assembled together in the most varied way and consequently it is difficult to check the validity of the particular approach adopted from a scientific point of view.
- **Trend Impact Analysis** is a combination of statistical extrapolations with probabilities. The methodology has the advantage of being formalised. At the same time it does not rule out creative thinking at all, as the choice of the factors influencing the development of a given trend is in its essence a creative procedure. But trend analysis has its shortcomings: it can be used only if long, detailed and reliable time series of data are available and if the researchers using it have a background in statistical and probability theory. For this reason, it is used by a minority of experts.
- **Cross-Impact Analysis** is probably the methodology most directly connected with the use of scenarios. The great advantage of cross-impact analysis is that it is a highly formalized method, which allows controlling the process. The disadvantage is that if it is not contained within certain limits it is the formalization itself to go out of control and to gain an excessive edge on the usefulness and reliability of the content. A number of experts is quite positive on the method, pointing out that it is often a good point of entry to begin with scenarios, that it arouses the interest of people of various backgrounds and that it is very good for stimulating new ideas, even if one does not bother to go as far as to extracting projections out of it.

The golden rule in deciding the number of scenarios is no less than two, and no more than four. There are five criteria for selecting scenarios:

- **Plausibility** – the selected scenarios have to be capable of happening.
- **Differentiation** – they should be structurally different and not simple variations on the same theme.
- **Consistency** – the combination of logics in a scenario has to ensure that there is no built-in internal inconsistency that would undermine its credibility.
- **Decision-Making Utility** – each scenario should contribute specific insights into the future that help make the decision identified in step one.
- **Challenge** – the scenarios should challenge the organization’s conventional wisdom about the future.

### ***16.4 Possibilities of this type scenario approach application***

*Process oriented* scenario development functions to promote: learning, communication, and improving observation skills. The learning/educative function is about informing people by deciphering the often

confusing overload of information, and integrating possible future events and developments into consistent pictures of the future. Making sense of the future in this way can challenge mental models and prevailing mind-sets, and can involve learning from the past and investigating fundamental uncertainties about the future. The educational aspects of scenario development may well serve to improve participants' intellectual and creative skills. Scenarios may have a communicative function. The process of scenario development provides a language to cross disciplinary boundaries. In organizations, it may provide a basis for "strategic conversations", to discuss perceptions on strategy, opportunities, and threats. Social interaction in a scenario process arguably helps an organization to improve its perceptive ability to anticipate both difficult times and upcoming opportunities.

*Product-oriented* scenario studies are more concerned with the nature and quality of the output than with how it was arrived at. Their functions are: the identification of driving forces and signs of emerging trends, policy development, and to test policy. Scenarios can be used to identify and prioritise the dangers and opportunities in emerging events and processes, signs of which are sometimes referred to as "weak signals", "early warnings", "seeds" or "traces". Scenarios may also be a tool for evaluating decisions and testing policy options by doing "practice runs" of possible future situations which indicate the possible effects of decisions.

Some might say that all scenarios are normative in that they reflect interpretations, values, and the interests of those involved in the scenario exercise. It is nevertheless useful to distinguish between *descriptive* scenarios and those which are explicitly *normative*.

Whether a scenario looks forward from the present situation to the future or back to the present from a particular future end point can have a bearing on whether it is normative or not. For instance, the backward-looking "back-casting" scenario is explicitly normative in its analysis of the measures and developments needed to reach a particular point in the future judged to be desirable. However, not all backward-looking scenarios are explicitly normative as the descriptions in the literature on anticipatory scenarios demonstrate.

The subject covered provides the focus to scenarios. The time scale adopted is one way in which focus is determined, though the perception of time is dependent on context. Yet, time scale is certainly relevant for establishing focus with regards to the *issue*, the geographical *area* and the *institution* the scenarios address.

*Issue-based scenarios* take societal questions. *Area-based scenarios* explore futures for a particular continental region, country, region or city. *Institution-based scenarios* address the spheres of interest of an organization, group of organizations, or sector. They can be broadly subdivided into macro or contextual scenarios, on the one hand, and focused or transactional scenarios, on the other. Related terms for macro scenarios are "global", "archetypal", "framework" and "external"; for meso scenarios, they are "decision" and "internal". The "contextual scenario" is about the institution's environment and the issues that they do not directly influence themselves. Contextual analyses can explore unfamiliar terrain. A "transactional scenario" refers to the institution's meso-environment and focuses on the interactions between variables and dynamics within a particular field. However, the distinction between the contextual and transactional environments may not always be clearcut. A study can combine scenarios based on issues, areas, and institutions to create systemic scenarios cutting across all these dimensions.

In the *nature of change* addressed in the scenarios, one can distinguish between evolutionary developments and discontinuities. Evolutionary scenarios are consistent with the notion of a gradual, incremental unfolding of a world pattern or system through time and space. This is the dominant scenario paradigm within which it is difficult, if not impossible, even to imagine discontinuity, let alone incorporate it into scenarios.

The sudden nature of change is the distinguishing feature of abrupt discontinuities. They give society a jolt, though possibly only a temporary and reversible one. Abrupt discontinuity manifests itself through events but these tend to be connected to underlying processes. Gradual discontinuity, on the other hand, is a self-reinforcing process of societal transformation where a diverse set of developments

– socio-cultural, technological, economic, environmental, and political – converges. The distinction between abrupt and gradual discontinuity is not always clear, however, as what constitutes a discontinuity depends on the time scale and the disciplinary perspective from which it is regarded.

The second broad macro dimension of the typology addresses the methodological aspects of scenario development. Numerous scenario communities have developed over the years, each with its own approaches. A basic distinction is between analytical and intuitive designs. On *analytical* approaches often uses computer simulations.

Model-based techniques as analytical approaches were among the earliest methods for scenario development, involving the quantification of identified uncertainties. The models used may be conceptual as well as arithmetic or computer-based. Computer simulations are more rigorous and less flexible than the intuitive approaches reviewed next. For instance, it is difficult to repeat certain steps taken in “prospectives”; relevant causal relationships often cannot be addressed in the model-based designs.

Another analytical approach to building scenarios is desk research, developing them through document analysis or archival research. This is less formalized and systematic than the model-based forms but may be just as rigorous. But desk research is not confined to any one method or scientific tradition, and covers the range from pursuit of hunches through research to the more structured procedures of data collection and analysis.

Compared with the analytical designs are the *intuitive* approaches. These importantly depend on qualitative knowledge and insights as sources from which scenarios are developed. Creative techniques such as the development of stories or storylines in workshops are good examples. The intuitive approach takes scenario development as an art form.

There are a number of basic steps in an intuitive scenario process: a) identification of subject or problem area; b) description of relevant factors; c) prioritisation and selection of relevant factors; d) the creation of scenarios. A subsequent step might be scenario evaluation as pre-policy research.

The above steps may be performed deductively or inductively. The deductive approach creates a framework early in the process with which to structure the rest of the scenario exercise. A two-dimensional matrix is a common method, which is created by identifying the two factors considered the most influential for the topic of concern. Other relevant factors can then be arranged around this framework.

- The *backbone approach* starts from a particular theory about relationships between the factors being addressed in the scenarios, as compared with the others below which rely on pragmatic choice to provide structure to scenario development.
- The *foundation approach*, as mentioned, reasons from two factors considered particularly important to the future of the issue in question, with which to structure the scenario development process and their interpretation.
- By contrast, in the *scaffolding approach* the structure is abandoned as the scenarios become more elaborated.
- The *shop window approach* imposes a structure at the end of a scenario development process in order to clearly present distinctions between the scenarios.

Inductive methods, however, do not use such frameworks to impose a structure on the scenario process. Instead, they rely on a freer process, with coherent stories generated from associations, inferred causal patterns, etc. When workshops use inductive approaches, the ideas generated are often represented in a series of post-it notes arranged sequentially to form storylines. The scenarios were developed in such a manner, although some use was made of what was called the “factor, actor, sector” framework, providing additional structure for thinking about the future.

Intuitive and analytical approaches may be used in combination. Desk research often forms part of more extensive intuitive scenario exercises, using workshops to generate creative ideas, backed up by research from the core scenario team elaborating the workshop ideas. There have also been attempts to combine the two in the opposite direction. However, combining intuitive approaches with model-based techniques is still experimental.

## Chapter XVII

### Application of scenario approach in maritime security vulnerabilities

#### *17.1 Choice of priorities in scenario approach of maritime security vulnerabilities.*

The choice of priorities is the answer to the question of what criteria is needed in the scenario approach of maritime security vulnerabilities. Discovering and taking actions, related to the limitation of the vulnerability influence, increases the possibilities for the non-controlled accumulation of the negative consequences by realization of the outside threat (for example, terrorist attacks). The opposite statement is valid. Not discovering of the vulnerability leads to the intensification of its impact on the realization the outside threat. Therefore, research of the vulnerability allows finding the possible inner threat for the critical maritime infrastructure. Discovering the vulnerability characteristic is a compound part of the process to find solutions.

In spite of differences in the original reasons and their realization, sometimes there are some essential similarities in the ultimate consequences for objects of the maritime critical infrastructure. For example, ten years ago, there was a great pollution with fuel of the system of portable water-supply of the city of Varna, which was caused by the systematic theft of oil products from the pipeline connecting “Lukoil” refinery in Bourgas with the fuel depository of the state reserve. Such consequences would be caused by terrorist actions. The threat of ecological catastrophe as a result of the stranding of the vessel “Moon Lake” was caused by the ambition of the ship-owner to receive the insurance. Such consequences may provoke the illegal actions of the tourist companies to compromise the sea resorts of Bulgaria.

Cause – effect and event consistency of the processes show similarity only in the vulnerability of the systems considered. Therefore, the main approach for developing the scenarios for the threat realization should be associated with the “characteristics of the vulnerability of threat objects”.

Stability of each system (organization) is the reflection of the biggest vulnerability. This principle is proved in practice. The principle has a contrary action – the compensation of the biggest vulnerability of the system increases the stability of the entire system. The principle does not have a linear dependence. In each system there is always the biggest vulnerability of the organizational system, continuous processes exist in the relations and statuses. Therefore, the place of the compensation of the vulnerability of the structural element or process, relation, status is taken by the followed vulnerability of the same or other structural element (process, relation, status).

Vulnerability shows weakness or insufficiency of object, compound elements connected systems, processes, personnel and other, which prevent and cancel different actions in normal conditions, prohibit passing in other statuses (associated with increasing the protection, its meaning performance and others) strengthen the negative consequences from threat realization and delay the restoration of the original status.

Vulnerabilities include:

- structural elements, including compound non-autonomous divisions as well as particular individual with typical motivation, selection, distribution, preparation;
- established relations, including inner and outer organizations, autonomy, subordination and others;
- passing processes, including compound phases, stages, episodes, inter-process influence by the consecution and/or contemporaneity passing, general space and time areas;
- transitional statuses, including original, interstitial and ultimate and so on.

In accordance with the organizational sources vulnerabilities can be:

- consequences of competition between institutions; corporations; institutions and corporations; service executors and users; employees and employers.

In accordance with the object of the critical maritime infrastructure, the following are estimated as the meaning in the international, regional and national maritime infrastructure: specialization; characteristic of inner-structural distribution/unit of object, in accordance with the main and supportive activities; characteristic of the transport incoming and outgoing communications; characteristic of the supportive infrastructure, electricity supply and electricity distribution, water supply and system of drains, fire-extinguishing system, transmissions, receiving and dissemination of messages and possibilities for the influence on an object protected; accessibility to a protecting object, its compound elements and preconditions for the infiltrations in its territory; characteristic of the neighboring areas and preconditions for influence without infiltration of a protecting object; personnel characteristic corruption sensitivity, qualifications, participation in protection of an object from terrorist attacks.

*Technological vulnerability.* The security and protection system is used to neutralize the discovered threats. The system has its own vulnerabilities, which should be compensated. They are based on characteristic. In accordance with its nature, vulnerability can be physical and informational.

Mathematical vulnerabilities are expressed by linear molding; non-linear molding of the fugitive processes and chaotic process molding.

Vulnerabilities have reciprocal independent character. Therefore it is impossible for the constructive vulnerability to be restricted partially or completely with other (organization, training preparation of the personnel, inter-institutional and other relation, connections) actions, unless the appropriate constructive solution was found. In other words, the indirect influence by means of compensation of other type of vulnerability is accepted in principle as an impossible one.

The purpose of institutional interests is connected with protecting specific society and state interests. These interests represent more “outside” threats for the corporative infrastructural object. Corporations assume that the neutralization of the “outside” threats is the obligations of the institutions within the framework of expenditure for the public needs as taxes and fees.

The purpose of the corporate activities is associated with decreasing of deliberate loss caused by wasteful practice, thefts, negligence and so on. Such activities are the “inner” threats for corporative infrastructural object, which decrease the benefit of the action performed and increase their non-competition. Anticipated level of the joint influence on “outside” and “inner” threats is considered the threat level of the objects of the critical maritime infrastructure.

Independent of existing differences in the organizational interests between institutions and corporations, there is the potential area of understanding the problems associated with security. The potential area of understanding of the problems associated with security is formed by the actions of the open market economy. All expenditures on the main activity of goods/services production and supportive activities find expression in forming the final consumer price. Specification of the activities, associated with their security and protection define a supportive function of the main activity on the purpose of the objects of the critical maritime infrastructure. Security and protection is adopted as the activities which increase the final consumer price.

Corporations consider the activities of compensating vulnerabilities with different influence in a different way. Such activities are associated with the support of the stability, continuity of the main process of goods and services production and are very important for the final results. Frequency of the event realization, associated with the “outside” (terrorist) and “inner” (coming from vulnerabilities) threat has very important meaning.

### ***17.2 Choice of applicable forms in scenario approach of maritime security vulnerabilities***

Assessment of the entire vulnerability is carried out by all physical and virtual objects of the appointed maritime critical infrastructure, executing processes in accordance with their function, support and existing mutual connection. The aim is to restrict the influence of the vulnerably upon critical objects.

There are six main actions for practical execution of the conception for vulnerability compensation by protection of the maritime critical infrastructure. These actions include the processes of:

1. Analyzing and assessment of the vulnerability sources and conditions for their realization. Stages of the vulnerability analysis are (1) preliminary assessment; (2) quality and quantity analysis and (3) adopted assessment for influence of vulnerability on passing conception for execution the operation for security and protection the maritime critical infrastructure objects.

2. Improvement of the system for vulnerability compensation.

The system for vulnerability compensation includes (1) determination of the consequences from the realization of derivative vulnerabilities; (2) expert assessment and offers for minimization of these consequences; (3) value-resource assessment to the realization of the recommendations for the minimization of the consequences; (4) scenario development for the realization of the recommendations and its impact on the ultimate results of the action performed; (5) scenarios playing, conclusions of their workability; (6) developing of standard presumption for the realization of the recommendations, including for preparation of the executive and management personnel.

3. Observation and recognition of the coming change after using the system for vulnerability compensation.

4. Compensation of the revealing processes. It represents possibilities for diversification of residual and newly originative vulnerabilities for minimizing their mutual influence. It includes restriction of the influence on the neighbor areas (outer infrastructural nets) for eliminating the transfer of their vulnerabilities on the object surroundings.

5. Preventing the possible negative consequences. It includes the limitation of the diffusion of the internal vulnerabilities of separate facilities, subdivisions, compound processes, and interstitial statuses on the ultimate results. It is carried out through the time and space fragmentation of the compound processes and conditions, which establish capabilities for eliminating the transfer of the stimulating vulnerabilities upon the following phases and stages of the action carried out and decisions about using the prognosticated forces, means, resources, time and space reserves for their extension.

6. Restoration of the system for compensation of the influence of the residual and newly originative vulnerabilities.

Analysis and assessment of the maritime critical infrastructure serves for the successful execution of the aims of national security through the vulnerability identification and variants of the force actions for their compensation.

### ***17.3 Methods of limiting uncertainty in scenario approach of maritime security vulnerabilities***

The successful execution of each mission depends on the process of risk assessment for each separate object and developing the appropriate versions of action for compensation of their influence.

The stages of the process of the risk assessment are changed when the necessity arises to carry out the requirements of the institutional needs in the field of national security. The entire activity of the process of risk assessment includes the following stages:

1. The process of risk assessment begins with the identification, which includes revealing the present requirements concerning the maritime critical infrastructure and/or the execution of some separate particular missions.

2. The next stage includes threats and hazards analysis. The aim of this analysis is to assist the mutual inter-institutional activity by revealing the threats and hazards for the objects of the critical maritime infrastructure. Conditions for the origin of further hazards are developed on the eight stages from the special vulnerabilities of the critical infrastructure objects. This assessment assists the defining of the current risk (stage nine), concerning to the revealed vulnerabilities.

3. The analysis of the protected critical maritime infrastructure is the following stage, which enables the national security sector to reveal the infrastructural functions, systems, objects, mutual commitment and processes, supporting the object activities.

4. The next stage in the process is analysis of supporting infrastructure networks, formally known as foundation infrastructure characterization and analysis. Supporting infrastructure networks are defined

as those infrastructures that are common for institutional and commercial infrastructural facilities and objects. The analysis of supporting infrastructural “grids” includes the research of the possible vulnerabilities typical to infrastructural work nets, in which protected critical objects take part. Continuous visualization of coming changes in providing infrastructural work nets in external and internal (inter-institutional, corporative and mixed) mutual dependences creates the product, which gives necessary useful information to the owner (concessioner, operator) of the critical object to provide its security.

5. Characterization of necessary security forces and means is carried out by adaptive planning. The critical element of the adaptive planning is the current information on the location, types, capabilities and readiness of the security components that execute missions, concerning security and protection of the infrastructural objects. Characterization of the necessary security capabilities shows necessary needs for satisfaction of the presented requirements.

6. The next stage after the characterization of the presented requirements is the stage, associated with the mission area analysis.

7. The next stage is concentrated on the analysis of the integrating of information covers the indicated processes and interdependences.

8. The next stage in the process of the risk assessment is the vulnerabilities assessment.

9. The final activity is the risk identification and related damages for duration of the execution of the protection from current threats and/or hazards.

#### ***17.4 Possibilities of this type scenario approach application***

Scenarios are models of the possible threats realization against the selected objects for protection. Scenarios are used to analyze, plan, improve, and develop the concept and practical use of the necessary capabilities for reflecting the threats of the objects of the critical maritime infrastructure. Scenarios include expert descriptions of the conflict situations with short explanation of the events consistency and their activities in accordance with the metric indications of the objects parameters of the maritime critical infrastructure. It is presented as the aggregate combination of the possible situations, when the threat degree requires the execution of the adequate contrary reaction from the system of the object protection of the maritime infrastructure. Scenarios are carried out in one or more phases. The scenario for the neutralization of the identified threat includes a phase of the control formation and support on the object of the maritime critical infrastructure, connected with current distribution of the available forces, means and resources; a phase of the factual counteraction of the realization threat and a phase of the restoration of the system stability.

In scenarios compounded by phases, playing patterns of a scenario are compounded by one or more playing phases. For each scenario pattern of a phase corresponds phase of playing. Playing patterns represent participants “contrary sides” in a work net of the developed scenarios, realizing current events, their consequences and using areas of mission carried out.

## Discussion

### Role and place of scenario approach in contemporary management of maritime security

#### Usage of scenario approach in contemporary management of maritime security

What are the main characteristics of scenario approach?

A *scenario* can be defined as a description of a possible set of events that might reasonably take place.

The following main characteristics of scenarios are:

- Present alternative images instead of extrapolating trends from the present.
- Embrace qualitative perspectives as well as quantitative data.
- Allow for sharp discontinuities as well as quantitative data.
- Allow for sharp discontinuities to be evaluated.
- Require decision makers to question their basic assumptions.
- Create a learning organisation possessing a common vocabulary and an effective basis for communicating complex - sometimes paradoxical – conditions/ options.

What is the application of scenario approach in contemporary management of maritime security?

The main purpose of developing scenarios is to *stimulate thinking* about possible occurrences, assumptions relating these occurrences, possible opportunities and risks, and courses of action. The purpose of scenario building is to:

- anticipate future threats and opportunities,
- project multiple futures based on optimistic and pessimistic projections of past events,
- foster strategic thinking and learning,
- facilitate the art of strategic conversation,
- envision a future state,
- challenge or dispel assumptions about the “official” future,
- create a rallying point,
- provide leadership for new initiatives or direction,
- create options for decision making,
- create frameworks for a shared vision of the future to influence organizational and individual behavior, create an internal or external communication channel that transcends organizational boundaries, time and space.

Possible criteria are the following ones:

- Was futures research (*the developed scenarios*) used in making the decision?
- Did the decision makers in each case take all relevant factors and implications into account?
- How confident or satisfied was each group with the decisions made?
- Did the decisions have their intended effect?
- Were all the consequences anticipated?

#### Scenarios approach and creation of risk mitigation strategies

What is the role and place of scenarios approach in creation of risk mitigation strategies?

Five key properties of descriptive form of presentation motivate their widespread use, as follow:

*First and foremost*, scenarios focus decision-making process on *maritime security threats*. What people can do with maritime security threats, and consequences for themselves and for their organizations, is described and analyzed prior to detailing the system functions and features that enable for this process. Scenario descriptions of decision-making process provoke risk managers to reflect upon the concrete circumstances and experiences of seafarers throughout the decision-making process.

Scenarios *suspend commitment* but support *concrete progress*. They vividly document an analysis of task essentials, explaining why a course of action is needed by showing what it is used for. They also



specify an analysis of alternative courses of action, by detailing how the concrete course of action is used. But scenarios are also rough: they are incomplete; they suggest alternative approaches and “what if?” lines of reasoning. Iteration between requirements definition and scenario-based envisioning rapid, easy, and cheap.

Scenarios provide a task-oriented course of action decomposition that can be used from *many perspectives*, including usability consequences and trade-offs, usability specifications and iterative development. They provide a framework of concrete seafarer tasks for developing course of action rationale and documentation, describing causal relationship implicit in a course of action and providing an analysis to which evaluation data can be subsequently adduced.

Scenarios *codify course of action knowledge* as a “middle-level” abstraction. This makes them somewhat less grand as science, but it allows the integration of course of action creation knowledge in a form more suitable for reuse.

Finally, scenarios are an ideal medium for *participatory course of action creation*. They allow creation process to be carried out in a common language. Seafarers may have difficulty describing their goals and visions in the language of features and functions, as traditional problem description languages and functional specifications are a language barrier to seafarers. But all stakeholders in a course of action creation process can “speak” the language of scenarios.

These properties of scenarios suggest an “ideal” scenario-centric process in which creation of courses of action of a system is influenced by scenarios from two directions. On the requirements side, observation scenarios, selected according to the orienting goals of the course of action creation, help identify issues and criteria, which can then be validated against further observation scenarios and against scenario abstractions reused from prior work. This sub-process drives the course of action creation through the definition of needs and opportunities. Once a prototype is available, *scenario-based evaluation* can complement and validate the requirements work. Observation scenarios allow the analysis of transformed situation and thereby the evaluation of the prototype. From such evaluations, further created abstraction can be induced, which collectively form a theory informs future requirements processes and this simplifies subsequent course of action creation.

What is the application of scenario approach in creation of maritime mitigation strategies?

The choice of priorities is an answer of the question what criteria is needed in scenario approach of maritime security vulnerabilities. Discovering and taking actions, related to the limitation of the vulnerability influence, increase the possibilities for the non-controlled accumulation of the negative consequences by realization of the outside threat (for example, terrorist attacks). The opposite statement is valid. Nondiscovering of the vulnerability leads to the intensification of its impact effect on the realization of the outside threat. Therefore, research of the vulnerability allows to find the possible inner threat for the objects of the critical maritime infrastructure. Discovering the vulnerability characteristic is a compound part of the process to find solutions for their overcoming.

Stability of each system (organization) is the reflection of the biggest vulnerability. This principle is proved in practice. The principle has a contrary action – the compensation of the biggest vulnerability of the system increases the stability of the entire system. The principle doesn’t have a linear dependence. In each system there is always the biggest vulnerability of the organizational system, continuous processes exist in the relations and statuses. Therefore, the place of the compensation of the vulnerability of the structural element or process, relation, status is taken by the vulnerability of the same or other structural element (process, relation, status).

## Seminar

### Risk assessment of maritime security

**Aim of the seminar** – to control how students assimilate:

- Main methods for assessing the risk of a different types critical marine;
- Basic idea for the scenario as an instrument in the risk assessment of maritime security;
- Characteristics of the maritime security assessment for different types of critical marine units.

**Issues for debate:**

#### **Methods for assessing the risk of a critical marine units**

Basics of analyzing the risks.

Methods used while calculating the risk.

Assessment the risk based on two factors.

Assessment the risk based on three factors.

Assessment the threats and vulnerability.

Assessment the gravity of the consequences.

#### **Computer-based methods for risk assessment of maritime security**

##### **The MSRAM methodology of the US Coast Guard**

*MSRAM - Maritime Security Risk Analysis Model*

##### **MSRAM Risk Model**

##### **Breadth of MSRAM Risk Information**

##### **Scenario Timeline**

*Analysis Process - Risk Analysis; Risk Management; Alternatives Evaluation*

#### **The scenario as an instrument in the risk assessment of maritime security**

Application of scenario approach in maritime security threats

Application of scenario approach in maritime security vulnerabilities

Role and place of scenario approach in contemporary management of maritime security

#### **Maritime security assessment**

Organizing the maritime security assessment

Inspecting the security of CMU.

Documenting maritime security assessment

#### **Characteristics of the maritime security assessment for different types of critical marine units**

Ship security assessment

Port security assessment

Port facility security assessment

Offshore facility security assessment

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## Game

### Formation and gaming of various forms of presentation of scenario approach

#### Formation of various forms presentation of scenarios

Ships at sea are at risk of becoming targets for a terrorist attack for several reasons: (a) Security countermeasures on board are usually limited to high-pressure water hoses or high-powered sirens to ward off potential attackers; (b) The number of crew available for defense is rather low; (c) The load onboard represents a flammable and environmentally hazardous product; (d) External security support is only available with considerable time delay, if at all. Therefore tankers are relatively easy targets for terrorist, as was demonstrated in October 2002 off the coast of Yemen. The supertanker *Limburg*, carrying 397,000 barrels of crude oil, was rammed by an explosive-laden dinghy on its starboard side. This attack resulted in one dead and twelve injured crew members. The Gulf of Aden suffered severe environmental damage due the uncontrolled spillage of 90,000 barrels of crude oil. The damage to the ship itself amounted to 30 million EURO.

Oil or gas exploration occurs usually in fields encompassing many individual exploration sites, stretching over large distances in remote areas. It is difficult to prevent intrusion from the outside, since attackers can use speed-boats (e.g., Nigeria), 4WD vehicles (e.g., Saudi Arabia), or unmanned aerial vehicles (UAV). Consequently terrorists can carry out coordinated attacks on individual oil and gas exploration sites within the field. The amount of explosives required for such an attack is relatively small (e.g., it has been shown that 5 kg of TNT for a single site is sufficient), enabling one individual to carry several such devices at once. The destruction of a pipeline resulting from the detonation of a shaped charge has a follow consequences - the pipeline is totally destroyed. Since shaped charges are commonly used in oil fields, they become readily available weapons for terrorists and are found in the vicinity of the target. A coordinated attack scenario on an exploration site could contain the following components: (a) Kidnapping of employees; (b) Suicide truck bomb/car bomb convoy against drilling installations; (c) Covert attack against auxiliary buildings; (d) Attack on the communication system.

The distribution of the products from the manufacturers to the end users is basically an open system in which the most vulnerable component, i.e., the truck or railcar, is clearly marked as carrying dangerous products. Every gasoline-truck or propane-loaded railcar is highly visible in the flow of traffic. Both modes of transport have periods where vehicles are stationary (during loading/unloading or parking), i.e., facilitating an attack as compared to a moving target. Also the endpoint, the location where the actual sale of the product occurs, is generally without any significant physical security. Frequently these sites are located in areas with high population density, thereby increasing the number of victims in view of any explosive potential of the dangerous goods. Concurrent environmental damage resulting from an uncontrolled release may be seen as an “added value” by terrorists.

## Gaming of various forms presentation of scenarios

### PORT SECURITY WAR GAME

Control actions	Timeline	Participants decisions
Threat revealed of an unknown number weapons and explosives (narcotics) entering the Republic Bulgaria via shipping containers. One such container discovered by accident at port of Bourgas and 3 men on GDBOP (General Directorate for Combating Organized Crime) Watch list arrested for suspicion of cargo theft at Port of Varna	day 1	Ports of Bourgas and Varna shut down. Carriers issue 24-hour stand-down, cargo is inspected and most carrier services are halted.
Public panic ensues in Bourgas despite reassurances from the Port authority, mayor and Governor	day 2	
One of the suspects arrested in Varna is linked to Hizballah Al'Qaeda); claims his mission was to pick up supplies in a container at the port and reveals that other teams may have similar missions at other Bulgaria's (Romania's) ports.	day 3	Carriers conduct voluntary self-inspection all trucks carrying containers in the Republic Bulgaria (Romania) .
Identical cargo to the first one found while unpacking a container at a distribution centre near Plovdiv (Galati) – container transported from Turkey to Port of Thessaloniki (Port of Constanta) and by truck (railway) to Plovdiv (Galati)	day 4	Customs closes all ports and border crossing indefinitely
Sofia (Bucharest) Bourse Index drops 500 points	day 5	Bulgaria's (Romania's) gendarmeries activated and set to be deployed.
Prices of hydrocarbons products skyrocket as port closures prevent ships from delivering energy resources	day 8	Supply chains report inventory shortage and plant closures,
	day 9	Port of Bourgas requests that backlogged ships not targeted for inspection be sent to Romania and Turkey
Romania (Turkey) opens ports to ships unable to reach Port of Bourgas	day 10	Industry-Government taskforce agree to container prioritization protocols for container inspection.
	day 12	All Bulgaria's (Romania's) ports open 24 hr, 7-day operations. Port of Bourgas requests that ships return to its port
	day 19	Ports return to normal operations (not 24 hr/ 7days)
Railcar carrying container of imported automotive details (entered Republic Bulgaria /Romania/ through port of Thessaloniki/ Constanta) explodes in downtown Plovdiv (Galati)	day 20	Carriers call for second 24-hour stand-down
	day 26	Port of Bourgas returns to normal schedule and inspection rate.
	day 52	All ports report vessel backlog cleared
	day 92	Container backlog stabilizes Total loses as of day 92: USD 2 million

### Analysis of outcomes of gaming scenarios

Corruption remains a serious problem in the police, customs, and judiciary. Despite reforms, the judiciary (which includes prosecutors and judges) consistently receives poor scores in public confidence and opinion polls. Complicated judicial procedures and legal loopholes result in excessive case delays which make it difficult to effectively prosecute high-profile organized crime and corruption cases. Often, officials discovered to be corrupt are reassigned or pressured to quit, rather than fired and prosecuted.

The GOB should continue efforts to strengthen its anti-corruption laws and should consider reintroducing legislation to implement some form of Non Criminal-Based confiscation. The GOB continues to make significant gains in counter narcotics enforcement against drug production and

trafficking. Bulgaria's law enforcement has actively contributed to international investigations resulting in considerable seizures and arrests in both Bulgaria and the region.

As a matter of governmental policy, Romania does not encourage or facilitate illicit production or distribution of narcotic or psychotropic drugs or other controlled substances (illegal trafficking small weapons and explosives). There is no evidence that senior Romanian officials engage in, encourage, or facilitate the illicit production or distribution of dangerous drugs or substances, or launder proceeds from illegal narcotics transactions (or illegal trafficking small weapons and explosives). Corruption and judicial inefficiency remain serious problems for the Romanian government. Convictions for many crimes, including drug-related crimes, were difficult to obtain, and as many as fifty percent of those convicted do not serve their full sentences. In addition, 49 Romanian border police and customs officers were brought to court in May 2011 to face charges of bribery. These officers are accused of receiving up to 2,700 Euros (proximally \$3600, per shift, from October 2010 to January 2011 from cigarette smugglers using the Serbia/Romania checkpoint. It is possible that members of the Border Police and Customs were also bribed by drug smugglers, but these officers were not prosecuted. In total, 234 police and customs officers have been indicted on corruption charges since February 2011. In 2011 Romania continued to benefit from U.S. financial assistance to the SECI Center for Combating Trans-border Crime (now SELEC). DEA personnel assigned to SELEC augment DEA Athens, which has responsibility for Romania. DEA personnel from Athens and SELEC coordinate narcotics information sharing, maintain liaison with participating law enforcement agencies, and coordinate with Romanian police on case-related issues. Concerns persist that the lack of funding due to the economic crisis will continue to negatively impact on the ability of the Romanian police to fight narcotics trafficking.

## Chapter XVIII

### Maritime forces and security of merchant shipping

#### *18.1 Naval coordination and Guidance for shipping*

For centuries, the navies and coast guards of the nations have been patrolling territorial and international waters to ensure freedom and protect the vital interests of their maritime borders. The Naval Coordination and Guidance for Shipping (NCAGS) organization operates under guidance of a NATO document titled Allied Tactical Publication 2 (ATP 2), which is easy-to-read manual that provides general plans, guidelines, and format for providing a service to both the merchant ships and the assigned naval commanders. ATP 2 provides plans for communications and procedural guidelines for ships at sea. For the mariner, it describes the processes for routing, passage, dispersal, emergency movements, and most importantly, for sending reports of position and intended movement (PIM). Similar to many international guidelines, this document is written in general policy terms to allow variations in scope, specific tasking, and operational procedures. It is highly recommended to be maintained as a shipboard reference.

Although there is an NCAGS functional presence in many navies and various exercise locations from time to time, the NATO Shipping Centre (NSC) is the permanent organization that serves as the focal point. The NSC is collocated with the NATO Maritime Component Command (MCC) Northwood, England, and is tasked with establishing and maintaining links with military, merchant shipping, National Shipping Authorities (NSA), and other international maritime agencies.

The aim of the NATO Shipping Centre (NSC) is to provide improved information exchange on merchant shipping, and facilitate increased voluntary co-operation between military commanders and commercial shipping operators. The NSC collect and process merchant shipping information, develop a surface picture of shipping in areas of interest, support military international requirements, and advise shipping on the evolving situation.

Normally, the NSC is the best conduit for merchant ship operators initiating communication between civil and military organizations for the purpose of increased cooperation and coordination. Unless otherwise informed through a national Notice to Mariners (NOTAMS) signal, which is part of the naval maritime domain operational process, NSC is the first point of contact that merchant ships can utilize. Serving as a collector and disseminator of issues related to maritime security, the NSC regularly receives “neighborhood watch” type of reports that it passes to the appropriate authorities for vetting and possible further action. In this sense, the NSC is similar to the IMB operations center for piracy, although its remit is not focused on piracy. If the situation warrants, there may be a broadcast message made, which inform mariners of a more appropriate point of contact.

If the maritime security situation warrants, NCAGS officers deploy to the responsible national navy and NATO MCCs, and possibly even to ports within affected shipping area. In brief, these NCAGS organizational cells will provide adequate information to the naval commander to determine merchant ship locations for maintaining a Recognized Maritime Picture (RMP). During peacetime, most navy commands maintain an RMP as provided by locator data within the SOLAS-mandated Automated Identification System (AIS) radio transmissions. Here, it is important to recognize that in a time of conflict or maritime security threat, it is likely that the merchant ships will switch off their AIS transmitters for their own individual security. Until security-dedicated ship-tracking systems, which provide secure encrypted signals, are in place (e.g. LRIT), and the appropriate information release agreements are made, it becomes a very difficult and manually based risk to maintain current plots of merchant ship traffic at sea for the maritime commanders. In such a scenario, there is need for more direct communication with merchant ships and the associated workload dramatically increases. In essence, it is this additional workload that is the lion share of the NCAGS operational function, and one which the merchant community can greatly assist.

Beyond the procedures described in the ATP 2 handbook, NCAGS officers also provide advice to NATO naval commands on specific aspects of commercial maritime operations. The NCAGS organization speaks the language of both of navies and merchant marine to provide a linkage for collaboration. For example, NCAGS is facilitating the bridge between the commercial maritime industry and NATO through the establishment of a NATO notification protocol for merchant ship security alert (ship security alert system - SSAS) and Global Maritime Distress Signals (GMDSS). Such inter-organizational protocols are necessary so that, under such circumstances, NATO assets can render assistance in a rapid but appropriate manner that is completely integrated and coordinated with port and flag state authorities. This should be no different from the present reaction by navies and coast guard to a distress call relayed from a Maritime Rescue Coordination Center (RCC). In the interest of safety and security, it is vital that a close relationship is maintained between like-minded maritime centers.

The NCAGS organization can provide a credible account to naval commands as new operational authorities are assumed in reaction to evolving maritime security threats, provided a degree of separation and impartiality is maintained. This could also include international disaster response and recovery operations. It is within NCAGS function to serve both the navies and the merchant marine. The NCAGS can help ensure that maritime information gathered for NATO naval commands remain focused on serving the safety and security of international maritime commerce and the environment. This is of course a common mission; however, a merchant navy-based influence can help remind naval commanders of specific details that may be overlooked in times of crisis.

For the seafarer, a security professional, or the government, the value of the NCAGS organization remains based on its evolving role in providing a recognized interface to both the navy and the merchant marine for increased security that shows tangible and measurable benefits to maritime commerce. Similar to many aspects of security, it may be another question that cannot be completely answered unless a given security situation deteriorates and the process can be completely tested.

As highlighted, ATP 2 is a publication, which provides ship owners, operators, masters, and watch-keeping officers with vital details regarding the interaction between naval forces and commercial shipping. In particular, the publication serves as a handbook for the worldwide application of NCAGS principles and procedures that exist to enhance the safety of shipping in times of peace and conflict.

## ***18.2 Operation Active Endeavour***

Operation Active Endeavour (OAE) is NATO's Article V Operation in the Mediterranean established in 2001 to fight terrorism at sea. The NATO Maritime Commander in Naples oversees this operation to deter terrorism and contribute to the peace, stability, and security of all nations in the region. The operation is based on international law, and directly supports the United Nations Security Council Resolution (UNSCR) against threats to international peace and security caused by terrorist acts. Specifically, Active Endeavour is now focused on the following four areas: It helps deter and disrupt any supporting terrorism at or from sea; controls "chokepoints" (i.e. the most important passages and harbors within the Mediterranean Sea) by deploying mine-hunters from one of the standing NATO Mine Counter-Measures Groups to carry out preparatory route surveys; provides escorts for designated vessels through the Strait of Gibraltar when necessary; and enhances the ongoing Mediterranean Dialogue program and other NATO programs intended to promote bilateral and multilateral relations.

At all times, NATO units dedicated to OAE are patrolling the Mediterranean basin, collecting information and assessing the situation in their vicinity. They provide the visible presence and potential reaction forces that may respond rapidly if required. The merchant marine community is encouraged to engage with these forces to collectively enhance maritime security.

As a recognized Regional Maritime Hub (RMH) in the Mediterranean, Allied Forces Maritime Component Command HQ Naples (CC-MAR Naples) controls the operation from its highly sophisticated Maritime Operations Center, working round-the-clock with many nonmilitary regional organizations. This operations center has close ties and exchanges information with national agencies



of many littoral countries. It can also act on any report fed to the NSC – a sister organization within the Allied Forces Maritime Component Command HQ Northwood (CC-MAR Northwood), which fulfills the same function for the Atlantic region.

Physical presence and interaction go a long way in maintaining security at sea. The Atlantic Ocean and Mediterranean Sea are patrolled by frigates and corvettes specifically dedicated to maritime security operations (MSO) by the NATO allies on a voluntary basis, and are supported by two maritime high readiness forces, if and when needed. In addition to these surface units, submarines provide complementary surveillance by providing discreet monitoring of specific areas to detect suspicious behavior, while Maritime Patrol Aircraft (MPA) provide wide-area coverage across the region using a variety of sensors to detect and classify vessels and other objects of interest.

### ***18.3 Other allied maritime security operations***

Active Endeavour is perhaps the best known allied MSO; however, there are several other operations providing vital security for commercial shipping in specific strategic sea areas. The most notable are the Operation Ocean Shield, Operation ATALANTA and operations of the Combined Task Forces 150, 152, and 158 (otherwise known as CTF 150, CTF 152, and CTF 158). It is important to note that although many NATO countries have participated in all operations of the Combined Task Forces, they are not NATO operations. Operations of the Combined Task Forces are comprised of naval forces from countries that are active participants in the U.S.-led war on terrorism. Essentially, the mission of all three CTFs is to conduct MSO in their respective areas of responsibility (or battle spaces). In this context, MSO is defined as follows:

*Maritime Security Operations (MSO) set the conditions for security and stability in the maritime environment and complement the counter-terrorism and security efforts of regional nations. MSO deny illegal use of the maritime environment as a venue for attack or to transport personnel, weapons, or other material.*

**Operation Ocean Shield** was launched by the North Atlantic Council on 17 August 2009. NATO is conducting counter-piracy activities as part of an internationally recognized and supported effort in a region of strategic interest to the Alliance. NATO's commitment is as a complementary player in coordination with the other international counter-piracy actors including the EU's Operation ATALANTA, CTF 151, and individual nations.

As a result and as part of comprehensive approach, the EU has launched European Naval Force Somalia – **Operation ATALANTA** (EU NAVFOR - ATALANTA) within the framework of the European Common Security and Defense Policy (CSDP) and in accordance with relevant UN Security Council Resolutions (UNSCR) and International Law.

After the launch of EU NAVFOR – Operation ATALANTA in December 2008, the operation continues to successfully perform its mission and contributes to improving maritime security off the coast of Somalia and in the Indian Ocean. The Council of the EU has decided to extend the operation until December 2014.

By UNSC mandate, EU NAVFOR – Operation ATALANTA conducts:

- the deterrence, prevention and repression of acts of piracy and armed robbery off the Somali coast;
- the protection of vessels of the World Food Programme (WFP) delivering food aid to displaced persons in Somalia. The protection of African Union Mission on Somalia (AMISOM) shipping;
- the protection of vulnerable shipping off the Somali coast on a case by case basis;
- in addition, EU NAVFOR – ATALANTA shall also contribute to the monitoring of fishing activities off the coast of Somalia

**Combined Task Force 150 (CTF 150)**, with logistic hub at Djibouti, conducts MSO in the Gulf of Aden, Gulf of Oman, Arabian Sea, Red Sea, and in the northern half of the Indian Ocean.

**Combined Task Force 152 (CTF 152)** was established in March 2004, conducts MSO in the south and central Arabian Gulf. Operating in the shipping lanes and littoral waters in the region, one of its main functions is to support the MSO of the navies of the Gulf Cooperation Council (GCC) nations<sup>3</sup> and complements their wider regional security efforts.

**Combined Task Force 158 (CTF 158)** was established as a result of Operation Iraqi Freedom, and consists principally of naval assets from the U. S. Navy, the Royal Australian Navy, and the Royal Navy. It also works in close conjunction with elements of the Iraqi Navy and the Iraqi Marines.

#### ***18.4 Information exchange in the Red Sea, Arabian Sea, and Arabian Gulf***

The interaction between the merchant navy crews and the naval forces at sea (whether they are part of NATO's OAE or from one several another MSOs) is not merely encouraged by the various military commands, it is essential to the very purpose and success of these MSOs. In addition to the interfaces for NATO, the United Kingdom and the United States have shore-based units dedicated to the exchange of information between merchant vessels and coalition forces in the regions encompassed by the MSOs. The Royal Navy's U.K. Maritime Trade Operations (MTO), which was established in Dubai in October 2001, functions as an interface between vessels in the aforementioned region through its Merchant Vessel Voluntary Reporting Scheme. Although the MTO's focus is ostensibly to support the U.K. flagged vessels and U.K. commercial shipping in the area, it also provides support across the entire maritime industry for vessels of all registries and countries of ownership.

Only on voluntary basis, ships of any flag or ownership are invited to report to MTO on passing the following geographical points:

- Port of Suez for vessels entering or leaving the region via the Red Sea
- 5° S for vessels entering or leaving the region via the Indian Ocean
- 78° E for ships entering or leaving the region via the Indian Ocean

Using [ukmtodubai@eim.ae](mailto:ukmtodubai@eim.ae), vessels are requested to pass on the following information:

- Ship's name
- IRCS
- Flag
- IMO number
- MMSI
- Inmarsat telephone number including satellite prefix
- Telex and fax number
- E-mail address
- Company having day-to-day management
- Type of ship
- Current position and speed
- Itinerary in the region with route way points and destination port(s).

MTP reciprocates by posting information for commercial mariners on its Web site. In the past, bulletins have included piracy and security warnings for the Horn of Africa, security sweep procedures for VLCCs loading at al-Basrah Oil Terminal, medical emergency assistance information, and details of some MSO activities that are of direct interest to merchant shipping in the region.

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<sup>3</sup> The GCC comprises of the kingdom of Bahrain and Saudi Arabia, the sultanate of Oman, and the emirates of Kuwait, Qatar, and United Arab Emirates.

## Chapter XIX

### Intelligence in maritime security

#### *19.1 Role of intelligence in maritime security*

The maritime intelligence is responsive to these objectives:

- Prevent terrorist attacks and criminal or hostile acts
- Protect maritime - related population centers and critical infrastructures
- Minimize damage and expedite recovery
- Safeguarding the maritime aquatories and its resources

The maritime intelligence is intended to be a flexible effort that will evolve with the change or improvement of capabilities, operational relationships, and changes in strategy or policy. A major aspect of the maritime intelligence, establishing improved access to maritime information, and data for all those requiring such access, will be difficult. The shared common awareness between the intelligence, law enforcement, and operational communities is complex and has many policy and legal implications that must be overcome in order to accomplish this necessary task. It will be the task of the leadership of the maritime intelligence enterprise to identify and seek to resolve these issues.

Intelligence information can be an extremely powerful tool. It is most useful when the consumer has a clear understanding of what intelligence can and cannot do. While laws, policies, capabilities, and standards are constantly changing, these general guidelines can help consumers make the most of this resource.

*Intelligence can* provide valuable services, such as:

- Warning of potential threats.
- Decision advantage, by improving the decision making of consumers and partners while hindering that of enemies.
- Insight into key current events.
- Descriptions of adversary modus operandi, including tactics, techniques, and procedures likely to be used in the future.
- Situational awareness.
- Long-term strategic assessments on issues of ongoing interest.
- Assistance in preparation for senior-level meetings that include national security-related subjects.
- Pre-travel security overview and support.
- Reports on specific topics, either as part of ongoing reporting or upon request for short-term needs.
- Enhanced knowledge on persons of interest.
- Pre and post-travel support.

Realistic expectations will help the consumer fill their intelligence needs. Some things that *intelligence cannot* do include:

- ***Predict the future*** - Intelligence can provide assessments of likely scenarios or developments, but there is no way to predict what will happen with certainty.
- ***Violate the National Constitution or National law*** - Intelligence activities and law enforcement operations must be conducted consistent with all applicable laws. All intelligence activities and law enforcement operations are subject to extensive and rigorous oversight both within the Executive Branch and by the Legislative Branch.

The strategic-level core intelligence element will:

- Establish and maintain, in coordination with the larger Maritime Community of Interest (MCOI) enterprise, a national-to-tactical common intelligence picture to feed the National

Maritime – Common Operating Picture (NM-COP), to include establishment of associated business rules and Tactics, Techniques and Procedures (TTPs).

- Manage the process for maritime specific domain information management of data and intelligence in the Intelligence’s shared information space in accordance with Intelligence standards.
- In support of the Maritime Operational Threat Response (MOTR) plan, maintain a 24-hour watch to ensure connectivity with other operational centers and intelligence entities.
- Conduct and disseminate strategic analysis and intelligence integration of maritime activity in support of Maritime Domain awareness and interagency operations at the national level.
- Maintain, in coordination with cognizant authorities and centers, a single-integrated lookout (SILO) list of all vessels of domestic and global intelligence interest.
- Maintain cognizance of operational activities that impact the global maritime intelligence picture.
- Provide a national center of excellence/coordination point for maritime intelligence integration and related issues.
- Provide a surge response capability for potential national emergencies in the Maritime Domain

The goals for coordination at the local level should be to:

- Provide an organizational architecture to maximize interagency all-source maritime intelligence sharing and close support to federal, state and local maritime enforcement elements in and around domestic seaports and along the coasts and maritime borders nationwide.
- Promote the maximum participation by federal, state and local agencies with the maritime enforcement responsibilities.
- Provide a secure Information Technology (IT) environment for participating agencies.
- Whenever possible, conduct collaborative and cooperative information and intelligence sharing.
- Whenever possible, conduct collaborative and cooperative analyses for wide dissemination to local intelligence and enforcement partners.
- Ensure that locally generated intelligence is routinely reported to the theater/area intelligence elements and the national core element.
- To the maximum extent possible, enlist the participation and cooperation of the civilian sector of the various aspects of the maritime industry.

## ***19.2 The intelligence cycle***

An effective way to organize, develop, and manage intelligence activities is to use the intelligence cycle (also called the intelligence process) as a guide. It consists of the following six interrelated steps.

1. ***Planning and Direction*** - Planning and Direction is the leadership and management of the entire intelligence effort, from promulgating intelligence requirements to tasking collection to acquiring exploitation tools to prioritizing production requirements.

2. ***Collection and Reporting*** - Collection is the gathering of raw data from which finished intelligence is produced. It also includes reporting of the collected information. Because all naval personnel can be involved in obtaining information of potential intelligence value (thereby leading to the phrase “Every Seaman a Sensor”), a critical function of intelligence staffs is to sensitize personnel to collection requirements and intelligence needs.

3. ***Processing and Exploitation*** - Processing and Exploitation is the conversion of collected information into a form suitable for analysis. It includes translating, transcribing, preparing images, and transforming data stored in electronics and other media into text, tables, graphics, or charts.

4. ***Analysis and Production*** - Analysis and Production is the process of evaluating, interpreting, and integrating raw, processed, and exploited data and information into intelligence products for known or

anticipated purposes and applications. In the NAVY, intelligence staffs perform analysis and develop products for their supported commanders.

5. **Dissemination and Utilization** - Dissemination is the conveyance of intelligence to the consumer in a usable form. The NAVY has added “Utilization” to this step because intelligence that is disseminated but not utilized has little value.

6. **Evaluation and Feedback** - Evaluation and Feedback involve actions to improve the performance of intelligence operations and the overall functioning of the intelligence cycle.

**Intelligence modes** are well defined areas of intelligence collection, processing, exploitation, and reporting using a specific category of technical or human resources. The following are examples of intelligence modes:

**Open Source Intelligence (OSINT)** - Open Source Intelligence is intelligence derived from information publicly available from print or electronic forms, including radio, television, newspapers, journals, the Internet, commercial databases, videos, graphics, and drawings.

**Human Intelligence (HUMINT)** - Human Intelligence is intelligence derived from information collected and provided by human sources. It includes overt data collected by personnel in diplomatic and consular posts. It also includes information collected via clandestine sources of information, debriefings of foreign nationals and civil citizens who travel abroad, official contacts with foreign governments, and direct observation. As a military service, law enforcement and regulatory agency, and a member of the Intelligence Community, the Border Police has unique authorities, access, and abilities for conducting a wide variety of HUMINT activities. For example, Border Police HUMINT activities include domestic information gathering for situational awareness and against criminal adversaries. The vast majority of these activities involve overt observations and interactions made under Border Police law enforcement and regulatory authority, activities which align under a subset of HUMINT called Law Enforcement Intelligence Collection (LEIC). Interagency partners frequently associate the term HUMINT with collecting foreign intelligence, maintaining confidential sources, possessing specialized foreign intelligence HUMINT training, employing particular tradecraft, and operating under different authorities than the Border Police. Due to the Border Police’s law enforcement and regulatory authorities, Border Police law enforcement intelligence element personnel use the term LEIC rather than HUMINT when describing their collection activities.

**Signals Intelligence (SIGINT)** - Signals Intelligence is information gathered from data transmissions, including communications intelligence (COMINT), electronic intelligence (ELINT), and foreign instrumentation signals intelligence (FISINT). As a law enforcement agency, the Border Police also collects signals using law enforcement and regulatory authorities. Although functionally similar to SIGINT, this type of law enforcement function is more appropriately termed Law Enforcement Technical Collection.

**Geospatial Intelligence (GEOINT)** - Geospatial Intelligence is information describing, visually depicting, and accurately locating physical features and human activities on the Earth.

Examples of GEOINT products include imagery, analyses, maps, and navigation charts. Imagery intelligence (IMINT) is a subset of GEOINT.

**Measurement and Signature Intelligence (MASINT)** – Measurement and Signature Intelligence is information produced by quantitative and qualitative analysis of physical attributes of targets and events in order to characterize and identify them.

## Chapter XX

### Threat mitigation strategies (criminals)

#### 20.1 Types of behavior and activities to pose a security threat

**Mitigation** may be defined as the avoidance or favorable resolution of threat or incident through actions either of prevention, deterrence, denial, detection, containment, or response. The mitigation of security threats posed by criminals, terrorists, and stowaways to ports and commercial shipping is the foremost goal and challenge in maritime sector. It can be best served by a brief review of the behavior activities which may indicate targeting by criminal or piracy entities.

The scourge of piracy can be prevented, deterred, or denied through the implementation of mitigation procedures and the use of specialized security equipment in a layered approach. These security measures are designed to reduce the attractiveness of the ship as a target and its vulnerability to unauthorized boarding. A few of these measures are:

- *Employ Operational and Communication Security (OPSEC/COMSEC)*: Pirates (and terrorists) monitor ship-to-shore maritime communications traffic. For that reason, the tendency to discuss the type of cargo, routes, onboard security measures, and related information via the radio should be limited. In World War II, the British Navy had a poster warning the British people that “loose lips sink ships”. Today, the same threats exist from both pirates and terrorists. Communications and all forms of information (plans, documents, itineraries, manifests, ship locations, etc.) should be restricted for official ship business only.
- *Minimize the Lure*: The practice of carrying large sums of cash has always been a magnet for piracy and theft. Masters, CSOs, and owners should explore ways to eliminate the storage of large sums of cash in ship’s safe.
- *Deploy Security Personnel*: The smaller size of crews has also made ships more attractive targets for pirates and robbers. Smaller crews make the ships vulnerable to large groups of pirates and criminals because the crew is more thinly deployed and can be more easily overpowered. For this reason, the International Maritime Organization (IMO) recommend hiring additional personnel for security watch if the ship is at the anchor or in areas frequented by pirates. Over the years, the many attempts by pirates to board the vessels were successfully mitigated, in large part because of the visible presence of a uniformed, trained, and equipped security force. The IMO also recommends investment in maritime security closed surveillance systems to provide better observation of the ship’s perimeters and decks. Detection of the pirates prior to their coming alongside will significantly increase the likelihood of a successful outcome.
- *Use Specialized Security Equipment*: The increase in piracy over the past decade has led to the development and deployment of equipment whose goal is to prevent or deter these marauders from boarding. One such system is the “Secure-Ship” high-voltage fence produced by Secure-Marine. This electric fence is mounted off the outer edge of the main deck – protruding outward – and effectively deters unauthorized boarding while the vessel is underway and at anchor. The Magnetic Acoustic Device (MAD) is classified as nonlethal hailing device but has direct application as a means to deter and ward off pirates. The maritime-usage MADs range in size from large, mounted versions to portable systems, such as LP PMS-4, which projects an irritating sound of 140 db at 1600 watts for a distance of up to 1000 meters. A similar long-range acoustic device was used by the crew of the cruise ship SS Seaborne Spirit to ward off heavily armed pirates off the coast of Somalia in 2005.

The Maritime Safety Committee of the IMO in MSC Circ 623/Rev 3 provides a series of recommendations for deterring, responding to, and surviving pirate attacks, as well as offers “post-attack” recommendations. Many of these recommendations are further defined in BIMCO’s “The Ship

Master's Security Manual". For example, *ships travelling in areas frequented by pirates should do the following:*

- Identify suspicious crafts at the earliest possible moment and make their detection apparent by sounding the ship's alarm or illuminating the suspects using flares and floodlights.
- If possible, prevent the pirates from gaining access to the vessel.
- Lock all doors and lockers so that if pirates manage to come onboard they cannot gain access to valuable stores, equipment, or the ship's accommodations.
- Ensure the safety of ships and its passengers.
- Be aware of geographical areas in which problems of piracy are or have been reported. It may be necessary to reroute ships to avoid dangerous areas.
- Ships trading along coasts known for piracy are recommended to stay away from shore (at least 50 nautical miles).
- Keep as many lookouts posted as possible.
- Post double watches and have the radar and radio communications manned.
- Keep floodlights and signal projectors readily available to probe for suspect crafts.
- Keep water hoses under pressure and readily available for use.
- Keep the deck watch operations active at all times and spray water over the deck at positions where pirates might be likely to board. This will cause them to slip and fall.
- Practice good operational security! All information pertaining to sailing route schedules and the nature of cargo should be treated as confidential.
- When visiting a port frequented by pirates, try to time the ship's arrival to coincide with daylight. If the ship will not immediately berth, anchor off the coast in safe waters.

*Ships at berth in a port frequented by pirates should do the following:*

- Do not leave ropes or wires trailing over the side.
- Maintain the hawse pipe cover in place and secured.
- Control the number of people allowed access onboard and record the names of those who are admitted. Do not allow local traders onboard to sell their wares to crew members. Consider photographing everyone who comes onboard.
- Consider the use of CCTV to record movements in and around the main access to the ship.
- Do not rely solely on local gangway watchmen. Assign crew members to complement such posts to ensure that access to the ship is restricted to authorized persons.
- Arrange proper illumination of all decks and quayside areas during the night.
- Raise or close gangways, ladders, and ramps when not in use during the night.
- Patrol decks regularly, and at times of increased danger, have an additional security watch stand as a lookout. Deck watchmen should make their rounds at irregular intervals to avoid pirates timing a boarding in between rounds.
- Crewmen on watch should regularly contact the bridge (radio checks).
- Seal off all access to the accommodations, storage lockers. And hatches when possible.
- Keep cabinet doors and windows closed and locked.
- Keep water hoses under pressure and available for use as a weapon against the pirates.

*If pirates are detected approaching or attempting to board the ship, take the following actions:*

- Notify the bridge and activate the general alarm.
- Alert shore stations and other ships in the vicinity.
- Broadcast a piracy attack/armed robbery attack message, as described in IMO Circular 623.
- If the incident occurs at night, direct the vessel searchlight at pirates.
- If practical, use the fire hoses to direct a stream of water at suspicious approaching motorboats or pirates approaching on deck. The recommended pressure is 80 lbs. per square inch.
- Increase the vessel's speed and alter the course out to sea.
- If pirates are attempting to board using grappling hooks, cut the lines attached to the hooks.

*If the attackers are actually onboard the ship, do the following:*

- Activate alarm signals and advise the crew to seek refuge in previously designated secure areas, These areas should include ready access to the bridge, radio office, and engine room.
- Activate the *ship security alert system* (SSAS) and report the attack immediately to the nearby police and port authority.
- Transmit a piracy attack/armed robbery attack message, as described in IMO Circular 623.
- If practical, try to slow down the pirates' advance by spraying them with the fire hoses. However, if the pirates are equipped with firearms, safety is paramount.
- Crew captured by the pirates should comply with their demands.

*If the attackers have left the ship, do the following:*

- Crew should remain in designated secure areas until a prearranged all-clear signal has been given.
- If not already done, alert shore stations and other ships in the vicinity.
- Provide medical treatment to any injured persons.
- Collect all evidence of the attack. Crew members should make a written statement of the event including descriptions of the attackers.
- Make reports to the ship owners, administration, local law enforcement agencies, and relevant port authorities.

## **20.2 Types of behavior and activities of terrorists to pose a security threat**

Many people have been conditioned to think of certain type of person when hear the word **terrorist**. Unfortunately, they look at a person's appearance, language, and culture when evaluating suspicious actions. However, they cannot identify a person who may threaten security by how a person is dressed, what a person eats, where a person is from, or his or her accent. Conversely, observing a person's behavior or activity may well reveal indicators of potential criminal or terrorist targeting. Some of these potential indicators are:

- *Surveillance*: terrorists invest considerable time in selecting and planning attacks against their targets. Successful targeting requires long periods of surveillance and intelligence targeting. The terrorists' preparation for the 9.11.2001 attacks – 5 years of planning, skill acquirement, and practice – is an example of the dedication and patience of terrorists. In order to build “target folders”, terrorists take photos, make drawings, or shoot videos for use in planning an attack. For this reason, persons observed photographing, videotaping, or sketching diagrams of a port or facility should be challenged and questioned. Also, unusual requests for maps, blueprints, and related documents should be investigated. From the waterside, terrorists have launched boats near commercial and military ships to take photos. If these activities are not challenged, terrorist and criminals will have more confidence in their ability to successfully launch an operation against the port and/or ship.
- *Dry Runs*: Terrorists, drug smugglers, and other criminals have been known to conduct dry runs as a part of their planning. As an example, while conducting a vessel pre-departure search in the port of Buenaventura, Colombia, OSS Maritime Security Team officers deployed onboard a container ship discovered a hidden kilo-size package which had the outward appearance of being a narcotics shipment; however, upon opening it, they found the contents were cocoa beans. This act was an example of a dry run by narcotics smugglers to test the effectiveness of the search team. In some cases, the dry run may actually be a probing effort and intended to provide an indication of the vulnerabilities of the security systems protecting the ports and ships and the security response capabilities and procedures. For example, there have been cases of truck drivers (part of a container hijacking organization) arriving at the port claiming to have urgent verbal instructions or a hand-written drayage order to transport a container from the port to an off-port warehouse. However, the real purpose was to probe the reaction of security and gate personnel and see how far the drivers could get without proper documentation.



- *Suspicious Questions*: Terrorists and other criminals may openly ask port employees or vendors for information pertaining to security operations and activities. While the questions may be innocent and genuine, they also may be an attempt to solicit information concerning the security vulnerabilities, procedures, and personnel. Some criminals/terrorists might try to obtain information about the port by approaching port or vessel employees and their family members.
- *Questionable Workmen or Vendors*: Some criminals/terrorists might disguise themselves as workmen or repair personnel in order to gain access to the facilities and sensitive areas of the port. Fake vendors (or real ones with a second agenda) may arrive at the port attempting to gain entrance to the port under the pretext of marketing products and services to the port or port clients. The real purpose of the vendors' activities may be to gather intelligence for use in planning attacks or criminal operations at the port.

Again, behavior and activities are the keys to recognition. Watch for the following:

- ✓ Unknown persons approaching (in person or via telephone) employees or their family members inquiring about the facility.
- ✓ Unknown or suspicious workmen trying to gain access to the facility to repair, replace, service, or install equipment.
- ✓ Suspicious package drop-offs/attempted drop-offs.
- ✓ Unknown persons photographing or attempting to gain access to facilities to photograph port areas.
- ✓ Theft of "standard" operating procedures, ID badges, vehicle passes, employee uniforms, or facility vehicles.
- ✓ Unusual or prolonged interest by suspicious persons in the port security
- ✓ Unusual behavior by unknown persons, such as studiously watching personnel or vehicles entering or leaving designated facilities or parking areas.
- ✓ Unauthorized observation of security drills or exercises.
- ✓ Increase in anonymous telephone or e-mail threats to facilities or employees.
- ✓ Unknown persons conducting foot surveillance (involving two or three individuals working together).
- ✓ Unknown persons conducting mobile surveillance, using bicycles, scooters, motorcycles, cars, trucks, or boats.
- ✓ Suspicious general aviation aircraft operating in proximity to facilities.
- ✓ Prolonged static surveillance using operatives disguised as panhandlers, demonstrators, shoe skimmers, food or flower vendors, news agents, or street sweepers not previously seen in the port.
- ✓ Unknown persons noted to make discreet use of still cameras, video recorders, or note taking at non-tourist type locations.
- ✓ Use of multiple sets of clothing or identification by an unknown person.

## Chapter XXI

### Hostage survival and rescue

#### 21.1 Hostage survival techniques

After seizing the ship, in most cases, ships are berthed in ports or anchored at the shore next to the port. Once close to the shore, another group of pirates boards the hijacked ship to keep watch over the hostages. In most cases, hostages are held on the ship for weeks or even months for several reasons:

- Hostages on board a hijacked ship are less likely to attempt to escape as they cannot leave the ship and reach the land without outside support.
- Keeping hostages on board makes an attacks or a attempt more difficult; even if a rescue is attempted by an outside rescue team, the ship cannot be attacked or destroyed with hostages on board.
- Keeping the crew as hostages on board their own ship is seen as a form of assurance that they will released with ship and its cargo in one single deal.
- Hostages and pirates can use the food, water, and medicines stored on board.

There have been some cases, however, where hostages were moved to land. This sometimes happens when the hijacked ship is a yacht and has been sold even as the ransom negotiations are going on.

For securing the ship and hostages, it s necessary that the pirates agree, mostly in advance, with their collaborators on shore to provide protection and necessary facilities to safely anchor the ship and keep the hostages (both crew and passengers).

*In case of readiness to pay ransom, it would be necessary to:*

- Find the right contact for the negotiation of the ransom (usually information can be obtained from the captain and other members of the crew and/or from the ship's registration record and other documents on board).
- Open communication channels for negotiating directly, mostly using the ship's crew and utilizing the communication system on board the seized ship, or indirectly, by conducting negotiations through mediators based on the shore or, in a few cases, outside of piracy's country.

Secure the payout and determine method of ransom delivery. Ransom negotiations with pirates about a hijacked ship include three components:

- value of the ship
- value of the cargo, and
- value of the crew and/or passengers.

In their effort to decide on the amount of the ransom, the pirates will try to somehow relate the size of ransom they demand initially to:

- a certain percentage of what they perceive as the value of the three components, and
- what they expect the concerned party or parties (shipping company, insurance company, the state(s), the families) are willing to pay.

There are two strategies for conducting negotiations:

a) *Strategy 1:* A package deal (all in one) which seems to be the most common strategy wherein the pirates offer to take a single payment for releasing the three components (the ship, cargo, and crew/passengers). In general, pirates prefer to end the hijacking as quickly as possible, secure the ransom and re-shift capacity in order to hijack new ships and make more money. Therefore, they often prefer a package deal as it takes less time and they are not forced to tie down number of their "soldiers" in the control and protection of the hijacked ship for a long period.

b) *Strategy 2:* Striking separate deals by dividing the components wherein the pirates start negotiating the release of each component separately and demanding a price for cash one. Pirates declare their

intention to go for separate deals usually when negotiations break down or drag on indefinitely, or when they feel that dealing separately with the three components could bring in more money.

The process of negotiating ransom entails of steps which considerably the task of negotiations. In some cases, the pirates have to identify all or some concerned parties in the deal, like:

- the party (parties) that owns the ship
- the party that operates the ship
- the insurance company or companies responsible
- the state where the ship is registered (flag)
- the party (parties) that own the cargo
- the nationality of the crew and/or the passengers.

In most cases, pirates identify and contact with the owner of the ship. Then it has to be decided whether pirates and negotiators should try for a deal in which ransom is separately paid for the ship, crew or cargo, or whether they should try for package deal.

At the beginning of their operations, pirates demanded ransom amounting to hundreds of thousands of US dollars. Over the past eight years, ransom amounts have considerably increased. In 2008, they mostly ranged from \$500, 000 to \$15 million. Shipping firms are usually prepared to pay large amounts, as the sums are still low compared to the value of the ship and cargo. Realizing this, pirates have felt encouraged to demand more money.

Once the ransom amount is negotiated, pirates need to secure its delivery. According to one pirate leader, pirates have four ways to receive the ransom money:

1. The ransom could be delivered to a nearby ship (military or commercial), then a pirate boat would collect the cash, check the money, and issue order to release the hijacked ship.
2. The ransom could be delivered to the board of the hijacked ship by a plane (usually a helicopter) which could land or drop the cash bags on board.
3. The ransom could be transferred electronically from any city to informal indigenous “banks” – shop based in Somali, from where the pirates can collect the cash directly.
4. The ransom amount could be transferred electronically to an account in Kenya belonging to an associate who would then transfer is to the pirates on the basis of a previously agreed upon arrangements.

In the majority of cases, pirates receive ransom money in cash. Reports said that in a very few cases in the initial period of piracy attacks, ransom money was delivered electronically by *bawala* money transfer system. The person wanting to send money gives the broker the sum of money to be transferred plus a fee and the name and location of the person he wants the money delivered to. The report on the pirates’ use of *bawala* transfers has to be taken cautiously. After 2001, *bawala* systems came under the scrutiny of counter terrorism laws that perceived them as a means for terrorists to fund their operations and transfer money from one country to another. As a move to counter financing of terrorism, most governments have put a number restrictions on *bawala* transactions.

*Should the ransom not get paid, or if there is no agreement on the right amount of ransom, pirates have different options to convert the seized assets to cash:*

- Dispensing with the ship: Selling the ship in the black market with/or without forged registration documents, or dismantling the ship to be sold as scrap; sometimes pirates keep the ship for their own purposes.
- Dispensing with the goods (depending on the nature of the goods): Consumer goods could be used by pirates, distributed among the clan members, or sold in the local market. Non-consumer goods like machinery and industrial equipment could be sold in the regional or international black markets. Further, cargo and container ships usually carry large amounts of fuel and gas oil that could be taken by the pirates for their own use or for selling on the black market. In some cases, hijacked ships could be carrying products like rice and wheat as cargo. Pirates could keep such items for themselves or distribute them to friendly clans

and villages to achieve or ensure their sympathy and protection. It has been reported that, in some cases, to win the support and sympathy of the inhabitants of coastal villages.

- Releasing the hostages (crew and passengers) under certain arrangements, mostly with the help of international organizations.

## ***21.2 Properly reactions to possible rescue operations***

Most of the best researched information for hostage survival techniques has been extracted from publication of the United States military and from U.S. Department of State. A review of DoD Directive 1300.7 and U.S. Marine Corps Publication MCRP 3-02E 2001, “Individual’s Guide for Understanding and Surviving Terrorism,” offers valuable insight into hostage survival techniques. Some of the key points in Chapter 3 of this latter reference are:

- Realize that your chance of escape may be during the first few moments of the incident. (In several cases of commercial ships attacked by pirates at sea, crew members onboard avoided capture by jumping overboard).
- Observe and gather as much information as possible concerning the number of hostage-takers, their weapons, appearance, tattoos, accents, names, and locations.
- If you blindfolded, do not attempt to remove your blindfold. It may anger your hostage-takers and result in your death.
- Do not directly challenge or threaten your captors.
- Realize that you will go through a number of phases during your captivity. These phases are anger, denial, regression, and acceptance.
- Establish a rapport with the hostage-takers, but be leery of the Stockholm Syndrome (developing a sympathetic understanding and appreciation for the hostage-takers).
- Focus on survival. Practice good hygiene and, if possible, do exercises to maintain a level of physical fitness. This will help stress reduction during this challenging time.
- Psychologically prepare for the day of rescue and release.
- In the event rescue forces arrive at your location, keep your head down facing the deck and listen for the instructions of the rescue force.
- Realize that you will most likely suffer from post traumatic stress disorders after this incident. For this reason, you should obtain the services of professional counselor.

A hostage situation aboard a ship provides hostage-takers with a significant advantage over the military and law enforcement hostage rescue teams; however, a well-prepared ship security plan and proper reaction by crew members can play an important role in the successful mitigation of the incident. Accurate intelligence is essential for the rescue force to successfully plan for the liberation of crew and passengers onboard a tanker, cruise ship, or any other type of commercial vessel. The following information, most of which is available in a well-prepared ship security plan, is essential for the developing a successful rescue plan:

- Locations of the passageways.
- Locations of hatches.
- Locations of stairways.
- Construction of hull/bulkheads (steel, aluminum, or other material)
- How hatches and port holes open and may be secured.
- Access routes to different areas and alternate routes.
- Thickness of windows and port holes.
- Type of glass utilized.
- Height of deck above waterline (freeboard height).
- Type and location of lighting.
- Ropes, bumpers, or ladders on the side of the ship.
- Boarding ramps in place.

All of this information will be gathered, analyzed, and assembled into a set of intelligence reports used to create a hostage rescue plan of the ship. To appreciate the importance of proper reaction on the part of the crew during a rescue operation, let's review a typical rescue scenario, which is discussed in Leroy Thompson titled *Hostage Rescue Manual*.

According to Leroy Thompson, once a hostage rescue team has designed and rehearsed its rescue plan, the execution phase will be implemented. Insertion of a rescue team will usually be via fast rope from a helicopter or ascending from an inflatable fast boat. Fast rope insertion directly over the deck of the ship is the most practical insertion method. However, if there are armed hostage-takers onboard the ship, they likely will fire on the arriving rescue forces. For that reason, according to Thompson, it is essential that the rescue forces have a means of providing cover fire during the rescue action. The standard protocol is for a helicopter to approach from the rear, flying at wave top, and sneak in behind the fantail for fast insertion. On the other hand, if the vessel containing the hostage is small, rescue forces can board the ship via a Zodiac or other small boat. Rescue forces utilizing small boats usually insert from the rear. U.S. Navy SEAL Team 6 and the British SAS Special Boat Service are considered experts in this area. Combat swimmers and hostage rescue divers can also be used to gather intelligence or act as part of the rescue force. Some of these personnel might be equipped with assault ladders or telescopic ladders with padded hooks that allow them to be quickly placed on a railing or deck lip.

Thompson states that the rescue force will probably utilize inspection mirrors or tactical video cameras to clear stairwells and passageways aboard ship. It may be necessary to have one or two men crouching or crawling, while others cover them from behind the bulkheads. As the passageways are cleared, it is imperative that the hatches are secured along the route. The hostage rescue team members will usually identify themselves as they enter an area containing hostages. The hostage crew and passengers likely will hear the commands "Hit the deck!" and "Don't move!" It is important that the hostages literally hit the deck and not make any sudden moves.

Hostages must not attempt to take pictures of the rescue team members. It is quite possible that the hostages will be ordered by the hostage rescue force to place their hands on their head and crawl on knees to the hostage rescue force member. Hostages will likely be very briefly questioned by hostage rescue force members concerning the number and appearance of hostage-takers, their spoken language or accents, current locations, weapons, any deployed explosives or booby traps, and position/condition of remaining hostages. Hostages will be searched and their identity verified and may be handcuffed and moved to another area until the situation is secured. The reason for these actions is obvious. Hostage-takers often try to disguise themselves as hostages in order to escape.

If the hostage-takers have placed explosives in the ship, the clearing procedures will take considerably longer. In these cases, it is quite possible that a military *explosive ordinance disposal team* and *explosive detection K-9 teams* will be deployed to the ship. Depending on the scenario, securing the entire ship could take an entire day or longer. After the ship is secured, crew and any passengers taken hostage will be screened and treated by medical professionals and debriefed by government officials. The reaction of hostages and their observation play an important role in the successful mitigation of a hostage-taking incident.

## Chapter XXII

### Maritime security equipment

#### 22.1 General equipment used by maritime security

The constant monitoring of the location of ships in the World Ocean from coastal services and the operational announcement in case of physical threat is one of the most effective measures to ensure the security of ships and PFs. Technical means and systems used are:

- VTMS - Vessel Traffic Management System);
- AIS - Automatic Identification System;
- SSAS - Ship Security Alert System;
- LRIT – Long Range Identification Tracking.

The last three are mandatory for the ship.

**AIS** - aims to enhance the safety of life at sea, the safety of navigation and the protection of marine environment. This is achieved by exchange of information between AIS and vessels in the area and shore stations. With its help targets could be identified and exchange of information – simplified. Using AIS rises the quality of information and with the one from the radars helps to ease the situation and prevent conflicts. Tasks of AIS are:

- To transmit data continuously to the ships in the area and to shore stations;
- To receive data from nearby ships and shore stations;
- To transmit the received data to devices which are designed for displaying sea information (can automatically alert the danger of collision).

AIS data from ships are transferred automatically, but if the shore station requires more data, it could be additionally entered. It transmits three different types of data:

- Fixed statistical information which is entered in AIS while designing the ship. It is changed with the name or the type of the vessel;
- Dynamic information that is automatically transmitted in motion – it is used for navigation (coordinates, target velocity, ship course, circulation velocity);
- Information related to a specific voyage which is entered by hand.

Ships, fitted with AIS must keep it permanently connected, except in those cases where international agreements, rules or standards provide a shield of navigational information. Continuously working AIS can provide information not only to the authorities but also to terrorists equipped with necessary apparatuses. Amendments were adopted according to which the captain of a ship, carrying dangerous or valuable cargo may exclude AIS in hazardous areas.

**SSAS** - supports maritime security and cuts off acts of terrorism and piracy against shipping. The system is a joint project between Cospas-Sarsat and IMO. In case of attack, the radio beacon of SSAS activates and sends a signal to the appropriate law enforcement agencies or military forces. When SSAS is activated, rescue coordination centers (RCCs) or points of contact (SPOCs) for the country, the beacon transmits and discreetly notifies the national authorities in order to send adequate forces to deal with the terrorist or pirate threat. Using SSAS is governed by Rule 6 of Chapter XI-2 of SOLAS-74.

When SSAS is activated- a transmission of a security alarm signal is started to the appropriate authority, appointed by the administration; it does not send a signal to other ships; it does not raise alarm on the ship and it continues until it is stopped or brought into position.

SSAS should be able to be activated from the bridge and from at least one other location.

Points of activating SSAS must be selected carefully so that to prevent inadvertent operation. When Administration receives notice of a security alert from a ship, it shall immediately notify the Member in whose proximity operates the ship. When Contracting Government receives notification of a security alert from a ship that is not under its flag, that Contracting Government shall immediately notify the relevant Administration and, if appropriate, the State (s), near which the ship is operating.

**LRIT** - used for tracking and monitoring of ships engaged on international voyages. Ships integrated in this system are:

- Passenger ships, including high-speed passenger ships;
- Cargo ships with more than 300 gross tons;
- Maritime mobile drilling units.

Users of LRIT- Contracting Governments discharging their duties as Flag States, Port States, and coastal states as well as SAR-services. The Administration may waive the requirement that a vessel must be fitted with equipment for LRIT-broadcast information in case it is equipped with AIS, Class A, as defined in Rule 19.2.4 Chapter V of SOLAS, when operating exclusively in GMDSS area A1, where a coastal AIS monitoring system works. Key components of the LRIT-system:

- Ships;
- CSP – Communication Service Provider);
- ASP - Application Service Provider);
- DC (Data Centre)- including Vessels Monitoring Systems (VMS), national , regional, cooperative, international.Bulgarian Center is integrated with the European LRIT-Centre of the European Maritime Safety Agency (EMSA) It provides integration of ships flying the flag of any country in the LRIT-system, exchange of data from LRIT to centers of other Administrations and use of LRIT-information taken from these centers and EAMA (Executive Agency Maritime Administration);
- IDE - International LRIT Data Exchange;
- DDP - Data Distribution Plan;
- LRIT – coordinator.

Ships transmit LRIT-information and receive commands to transmit it in case of request from a particular center for LRIT-data. Each administration decides for its vessels to which LRIT-center to transmit LRIT-information. Automatically transmitted LRIT- information should include:

- Identification number of the ship;
- The location of the ship, determined by satellite positioning system;
- Information, generated by the LRIT-ship terminal, about date and time of the location ;

LRIT-information is used for:

- National security;
- To guarantee security of ports;
- Prevent marine pollution;
- Organization of SAR-operations in each region of the World Ocean.

LRIT-systems must have an option to be turned off or to stop the transmission of LRIT-information in the following cases:

- In cases where international agreements, rules or standards provide protection of navigational information;
- In exceptional situations for the shortest possible period of time if the captain considers that the LRIT-system puts the security of the ship at risk. In this case, the captain must inform immediately the Administration and write stating in the ship's log or another document meant for registering events related to navigation, the reasons for such decision and the period of time during which the system was excluded.

## ***22.2 Solutions for increasing the maritime security***

Technical means of protecting marine vessels: different locks and locking devices, lighting, portable radios, portable means of communication; GMDSS equipment; Closed-circuit television (CCTV). Automatic devices for detection and warning in case of intrusion, metal detectors, explosive detectors, and equipment for checking luggage, X-ray inspection systems for containers, general alarm, etc. Technical means of protecting marine vessels are integrated into security systems of: ships; PFs; important objects of maritime infrastructure and others.

The security system of PF must integrate security systems of several ships that are in this PF, and security systems of several PFs in the security of the port or in the regional system for maritime security. Solutions for increasing the maritime security are:

- additional - security and protection equipment;
- High tech;
- Combined;
- Object level or joined (inter-institutional).

However, they all make sense if they are united by common policies, common doctrine and **(TTP)** identical system for training people – i.e. setting up a special system.

### ***22.3 Systems and security equipment***

The mentioned above systems and technical tools are integrated into a system of maritime security (MSS).

Key features of MSS:

- Locating the offender, assessment of the situation;
- Detention or delay of the offender;
- Elimination of the offender.

The system of protection of PF, dealing with these tasks, can provide some of the functions of neutralization.

The tasks of physical protection of an object include:

1. Warning of unauthorized access;
2. Unauthorized access detection, classification and identification of the offender
3. Delay of the unauthorized access;
4. Neutralizing unauthorized access, blocking illegal objects or devices;
5. Arrest of the offender;
6. Collection and transmission of information about violations.

The physical protection of the object includes:

1. Organizational events
  - Complex events that are carried by the Administration of the vessel;
  - Regulations governing physical protection measures implemented by the administration of the vessel.
2. Physical protection includes:
  - Engineering resources - physical barriers, fences, checkpoints equipment and protective gear.
  - A set of technical tools – security alarm system, monitoring and access control system, CCTV, system for communication and system for securing power and lightning.

It should be taken into consideration that committing an attack is easier than theft. When committing a theft the offender firstly penetrates into the protected object, makes the theft and then leaves with the stolen property. Therefore, in most cases, the object management aim is to protect the object from theft and the better it is protected from thefts the better it is protected from other threats as well, including sabotage and terrorist attacks.

The security system of each object of MTS is being built in accordance with the following principles:

1. **Principle of adequacy of nature and possible consequences of threat realization within efficiency requirements of efficiency functioning the physical protection system.** - MTS should be built according to the importance of the object and it should be guaranteed that is impossible for intruders to penetrate in it.
2. **Principle of multilayered (zones) protection** – provides building an imposed zones (layers) for protection (protected zone inside, a particularly important area)
3. **Principle of equivalence** - requires the same characteristics of protection of objects on the different routes which might be chosen by the offender.



4. **Principle of continuous automated monitoring of functioning engineering tools and equipment for protection of objects** - suggests that all events are stored in computer memory and / or automatically analyzed by specific algorithm of the identification system. These include gates (points) of access, the deviation from the regime, disturbing situations, failures, errors of operator's actions and administrative system.
5. **Principle of ensuring a reliability** - guarantees reliable operation of all elements in the system under normal operating conditions.
6. **Principle of adaptability of engineering tools and instruments of physical protection** - implies that the system is capable to react in case of a change in the threat and the model of the violations, the configuration of the object and the boundaries of the protected areas, types and methods of protection and displacement of the technical means of physical protection.

#### ***22.4 Using the maritime security equipment***

Officials are not expected to have detailed knowledge of security operations and security equipment. However, they should be aware of the theoretical basis of the functioning of the technical means for protection of marine objects, their capabilities and requirements for proper positioning. Experience shows that different officials should be involved as consultants to the Company, PFs or IMO (Important Maritime Object) in the purchase and installation of such equipment.

The use of maritime security equipment should be in accordance with the relevant security plans and the duties of the officials. In all cases, each official must go through specialized training and be certified for operation, maintenance, testing, etc. this complex maritime security equipment. Unfortunately standard IMO courses do not provide one. Some companies provide training and certification of personnel along with the delivery and the maintenance of maritime security equipment. But proper use of maritime security equipment is a question of a new type of culture and education for managers and performers.

## Chapter XXIII

### Maritime security responsibilities and authorities

The basic concept of maritime security is focused on the so-called “triangle of responsibilities” – company – ship – port facility. It plays a major role in identification of threats to the maritime security and the elimination/minimization of accidents, related to security. The Contracting Governments, Administrations, Recognized Security Organizations have an important role in building and maintaining the security environment. The idea of IMO for a system of maritime security is based on different subjects, which are supposed to work together in order to form efficient and effective policy for maritime security.

#### 23.1 Governments’ responsibilities

Obligations of Contracting Governments concerning security rules are given in Chapter XI of 1,3,7-2 of SOLAS-74.

- Administrations must establish SL and observe the provision of information of SL for ships flying their flag. When changing SL, information about it should be updated as well according to the circumstances.
- Contracting governments establish SLs and should observe the provision of information for SLs about the ports in their territory and the ships which are prior to enter the port. In case of a change of SL information is changed according to the circumstances.
- In accordance to the regulations of Rules 3 and 7 Contracting Governments should establish SLs and give directions for protection of accidents related to security. Higher SLs will be an indicator of a greater possibility of an accident, related to security. Factors which are considered when determining the appropriate SL include:
  - Degree of reliability of the information about the threat
  - Degree of confirmation of the information
  - The extent to which information about a threat is typical or inevitable;
  - Potential consequences of maritime security in case of such incident
- Contracting Governments, when announcing SL3, distribute, if necessary, appropriate instructions and provide information, related to the security, to ships and PFs, which could be affected.
- Contracting Governments may delegate some of its duties to RSO, related to security, under Chapter XI-2 and part A of the ISPS Code, except:
  - Determining the applicable SL
  - Adoption of the assessment of the security of PF and following amendments on it
  - Determining the PFs, which will have to appoint PFSO;
  - Approving and accepting the PFSP, and subsequent amendments to such approved plan;
  - Implementation of measures, related to control, and compliance to regulation XI-2/9
  - Identifying requirements for preparation of Security Statement
- Contracting Governments will examine, to the extent they consider as appropriate, the effectiveness of SSPs or PFSPs, or effectiveness of the changes they made to these plans, or in this case with ships, the plans which were approved on their behalf.
- Contracting Governments set SLs and provide notifications on SL for ships operating in their territorial sea or ships that announced intention to enter the territorial sea.
- Contracting Governments must provide contact through which ships may seek advice or assistance and report any cases of security problems which may arise on other ships
- When there is a real danger of attack, the Contracting Government should advise the ship and administration:

- current SL;
- All security measures which should be taken by ships to defend themselves from attack, in accordance with Part A of the ISPS Code;
- Security measures which the State considers as appropriate to introduce.

### ***23.2 Responsibilities of Recognized Security Organizations***

Recognized Security Organization (RSO) is an organization with relevant expertise on security matters and with appropriate knowledge of ship and port operations, authorized to assess, control, approve or certificate in accordance with Chapter XI-2 of Rule 1.1.16 SOLAS-74 and Part A of the ISPS Code. RSO can:

- Conduct SSA;
- Develop SSP;
- Review and approve SSP;
- Issue International Ship Security Certificate –ISSC;
- Checks means of disclosure of threats, concerning security;
- Conducts PFSA

### ***23.3 Maritime security responsibilities of the company, the ship and the port facility***

Company under Chapter XI-2 of SOLAS-74 and ISPS Code has the following obligations:

- Providing to the captain the necessary documents, related to the ship's crew and his employment;
- Ensuring that SSP contains clear statement with emphasis on the captain's authority;
- Determining CSO and SSO and making sure that they receive the necessary support to fulfill their duties and responsibilities.

Port Facility according to Rule 1 Chapter XI-2 of SOLAS-74 is a place determined by the Contracting Government or the authorized institution where is performed the interaction between the ship and the port (included anchorages, and their subsequent approaches). PFs operate on the basis of security levels (SLs), set by the Administration on whose territory are they.

Obligations for Companies and ships under Rule 4 of Chapter XI-2 of SOLAS-74 are:

- Companies must comply with the requirements of this chapter and part A of the ISPS Code, taking into account the guidance given in Part B of the ISPS Code;
- Ships must comply with the requirements of this chapter and part A of the ISPS Code, taking into account the guidance given in Part B of the ISPS Code, the implementation can be verified and certified as specified in Part A of the ISPS Code ;
- Before entering the port or during a stay on the territory of the Contracting Government, the vessel must meet the requirements of SL, defined by a Contracting Government, if SL is higher than that set by the Administration;
- Ships must respond to any change to a higher SL;
- When the ship does not comply with the requirements of Part A of the ISPS Code or does not meet the requirements for SL, set by the Administration or other contracting government, it should be reported to the competent authorities before the interaction ship-port or before entering the port – whichever comes first.

Specific responsibilities of companies under Rule 5 of Chapter XI-2 of SOLAS-74.

The company must ensure that at all times the captain has access to information which will help the officers, authorized by a Contracting Government, to specify:

- Who is responsible for the recruitment of the crew or other people currently employed or engaged on board or who have any connection with the operation of the vessel;
- Who has taken the decision of hiring and usage of the vessel. In cases the vessel is hired under terms and conditions of a charter, which are the sides of the charter.

### **23.4 Responsibilities of the security officers of the ship, company and port facility**

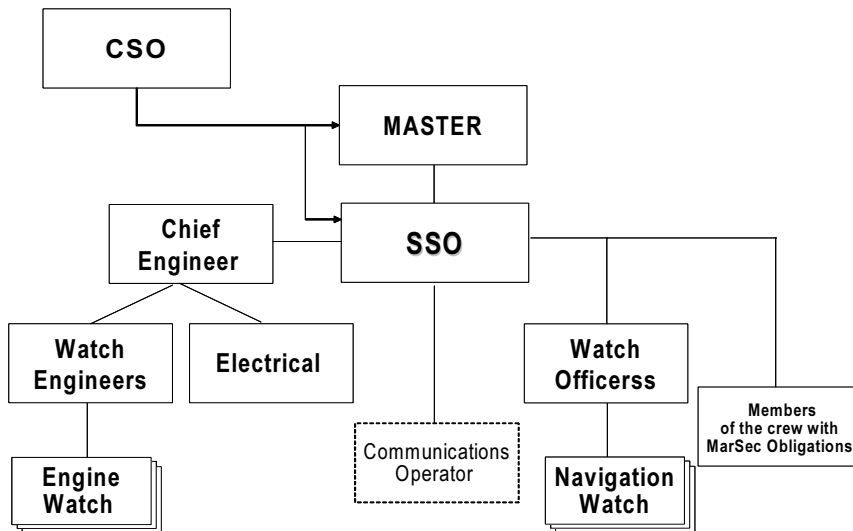
According to the requirements of ISPS Code, each company must appoint a CSO and SSO for every ship, under its jurisdiction. CSO must ensure that SSA is performed for each vessel and that SSPs are developed and submitted for approval by the Administration, and then left on board of every ship.

**SSO** is the person on the board, subjected to the captain, appointed by the Company as responsible for the security of the ship, for the maintenance of SSP and for keeping in contact with the CSO and PFSO. SSO has also responsibilities, related to:

- Regular security inspections of the ship to ensure that the appropriate measures to maintain security are taken;
- Maintaining and supervising the implementation of the SSP, including any amendments to the plan;
- Coordinating the security aspects when working with cargo and ship's holds with the personnel from the ship and relevant PFSOs;
- Proposing modifications to the SSP;
- Reporting to the CSO of any defects and discrepancies discovered during internal audits, periodic reviews, security inspections, compliance verifications and implementing any corrective actions.
- To increase awareness and vigilance, regarding security on the board;
- Ensuring that it is provided an adequate training for the ship's staff as necessary;
- Reporting all incidents related to security;
- Coordinating the implementation of SSP with the CSO and the relevant PFSO;
- Ensuring that security equipment is properly operated, tested, calibrated and maintained, if there is one.

**CSO** is a person, appointed by the Company, who guarantees that SSA has been done, has been submitted for approval and then is being applied and updated. Furthermore, he provides the link with PFSO and SSO. A company, according to the number and types of ships it operates, can recruit more CSOs, provided that the vessels for which each person is responsible are identified. Besides the above, CSO has the following duties and responsibilities:

- Providing information about the level of threats using security assessments and another relevant data;
- Ensuring that SSAs are made;
- Ensuring the development, submission for approval, the implementation and maintenance of the SSP;
- Ensuring that SSP is modified as necessary to correct the disadvantages and meet the security requirements of the individual ship;
- Settlement of internal audits and reviews of security matters;
- Organization of initial and subsequent verifications of the ship by the Administration or the RSO;
- Ensuring that defects and discrepancies, found during internal audits, periodic reviews, security inspections and compliance verifications, are properly identified and adjusted;
- Ensuring that there is an adequate training for the personnel responsible for the security of the ship;
- Ensuring the effective communication and cooperation between SSO and the PFSOs;
- Ensuring consistency between the requirements for security and those for safety;
- Ensuring that if security plans from similar ship or fleet are used, the SSP for each vessel will accurately provide the specific information which is related to that vessel;
- Ensuring that are implemented and maintained any alternative or equivalent measures and arrangements approved for a particular ship or group of ships.



*Version of the organization of ship's security*

All security officers in the maritime transport system must have extensive knowledge of various fields in order to fulfill their obligations. What knowledge and abilities they should have will be examined in a separate lecture. Necessary knowledge and skills for SSO are significantly larger. In some Companies are formed Shipping Groups (Committees) of security, which include: Master, SSO, Chief Officer; Passenger Vessel Officer; Chief Engineer; Maritime Electronic Officer. If a security team comes on the board its leader is subjected to the Master. All who are part of the security team and their leader must be certified according to STCW Convention as seafarers.

## Chapter XXIV

### Security's responsibilities of the merchant ship

#### 24.1 Perimeter security of the merchant ship

SSP defines the zones with limited access, which have to be set on the ship, it defines their rate, the time for practice, security measures, which have to be undertaken for exercising control over the access and those for control over the actions, which are performed inside of them. The aim of these zones is:

- To prevent unauthorized access
- To protect passengers, crew and staff from PFs of other agencies, authorized to be on the board of the ship
- To protect zones from the ship, sensitive to the security
- To protect from unauthorized access the load and ship reserves

SSP should provide the application of clearly defined politics and practices for exercising control over the access to all his limited areas.

Each SSP demands zones with limited access to be clearly marked, and to be pointed, that the access to a certain zone is limited and unauthorized presence in it, is a security breach.

Zones with limited access can include:

- bridge, engine rooms category A and control stations;
- areas, where are located systems and equipment, related to the security and observation, and also mechanisms for control of lighting system
- ventilation systems, air conditioning and others
- areas with access to tanks with drinking water, pumps or collectors
- areas, containing dangerous goods or risk substances
- areas for goods and places, containing stocks.
- spaces of crew accommodation
- any other zones on the ship, defined by CSO through SSA, to which the access must be limited, so the security can be kept.

In SL1, SSP must find the security measures, which have to be enforced to the zones with limited access, that can include:

- locking or fortification of the access points
- using an equipment for surveillance on the zones
- using guardians or patrols;
- using devices for automatic detection of violation for give alert signal to ship crew unauthorized access

In SL2, the frequency and intensity of surveillance and control over the access of zones with limited access must be increased, so they can ensure, that only authorized people will have access to them.

SSP must determine extra measures for security, which have to be enforced and they can include:

- establishment of zones with limited access next to the places of access
- equipment for continuous monitoring
- hiring extra staff for protecting and patrolling of the zones with limited access

With SL3, the ship should comply with the instructions, issued by those, who are in charge of security incidents or threats in this relation. SSP should provide detailed measures, related to the security, which can be undertaken by the ship, in close cooperation with those responding and PF, and they can include:

- establishment of extra zones with limited access on the ship, close to the incident, related to the security or possible place of the threat, to which the access is denied
- searching the zones with limited access as a part of searching the ship.

**Surveillance of the security of the ship.** The ship should control observe upon the ship, the zones with limited access and areas next to it. This happens through using:

- lighting
- guards and monitoring of the decks, including patrols
- devices for automatic find of violation and equipment for surveillance.

When used, the devices for automatic fins of violation should set sound and/or visual alarm on the place, which is constantly operated or observed.

#### ***24.2 Control of access to the merchant ship***

SSP includes related with the security measures, which cover all places of access on the ship: pilot or Jacob's ladders; gates, gangways; platforms, doors, side scuttles, windows, loading platforms; mooring lines and anchor chains; cargo cranes and gears. According to SLs appropriate restrictions for access or prohibition should be marked for each place.

For each SL, SSP defines the way of identification, the access to the ship for people, who have to stay on it, so they develop an appropriate system for identification of the crew and visitors on the ship. Every system for identification on the ship should be coordinated with this of PF. Passengers prove their identity by board cards, tickets, etc, but they are not allowed to enter in the zones with limited access, unless these zones are watched by the crew. SSP must ensure regular actualization of identification systems, and violation of the procedures is a subject of disciplinary measures.

Those who do not want or are not able to specify their identity and/or to confirm the aim of their visit, when their asked to do it, shouldn't be allowed to get on the ship and their try to get access should be reported to SSO, CSO, PFSO and local authorities of security.

SSP defines the frequency of administration of any kinds of control of access, especially if they are on unspecified or random principle.

SSP defines necessary for each SL procedures and equipment, also devices for insurance. The equipment for control must be in condition to work constantly, including eventual atmosphere influence or black-out.

With SL 1 measures of security, which are added, are combination of lightning, guars or using equipment for watch. In case of necessity barriers can be put or zones with limited access can be made. The deck and the access points to the ship should be illuminated during nighttime and while the visibility is low, while conducting ship / port activities or PF or anchorage. While on the move, where necessary, ships should use the maximum lighting available consistent with the rules for safe shipping COLREG. When choosing a location for the placement of lighting sources and their power the following should be taken into account:

- The crew should be able to detect actions beyond the ship, both from the shore and the sea;
- the illuminated surface should also include the surface around the ship;
- the access points should be sufficiently illuminated in order to provide identification of visitors and staff;
- Illumination can be provided through coordination with PF.

When using SL 2 additional security measures for strengthening the surveillance and monitoring capabilities are being carried out and can include:

- Increasing of the frequency and severity of security patrols;
- Increasing of the brightness and intensity of lighting or usage of security, monitoring and equipment;
- Hiring of additional staff- surveillance posts in interest of safety;
- Ensuring the coordination with boat patrols from sea and pedestrian or vehicle patrols on the shore side, where available.

It might be necessary additional lighting for protection against raised risk of security incidents. When necessary, the associated additional lighting requirements can be achieved by coordinating with PF in order the additional lighting from the coast to be provided.

When with SL 3, the ship should comply with the instructions issued by the authorities involved with security incidents or with the threat that can cause it. SSP specify security measures that could be taken from the ship in close cooperation with those responding and PF, which may be:

- the inclusion of all lighting and lighting of the area of the ship;
- the inclusion of all surveillance equipment on board, capable of recording the actions of or near the ship;
- the maximization of the time during which such surveillance equipment can continue to record activities;
- The preparation for underwater inspection of the hull;
- Measures, including Slow screw ship, if practicable, to deter underwater access to the hull.

### ***24.3 Basic security procedures considering of the merchant ship***

For the purposes of maritime security, all of the ship's crew should be familiar with their obligations under the SSP in the volume concerning them and implement them strictly. They are defined according to the security levels, which create a relationship ship - PFs, - security forces - an environment which determines the application of appropriate measures for the security of the ship and the PF. Through this connection the necessary synergic effect of their co proactive safety effort is being displayed.

- First Safety Level (SL 1) - continuously maintenance of the minimum appropriate protective security measures.

- Second Safety Level (SL 2) – for a period of time additional safety measures are being maintained as a result of an increased risk of incident security. For the ship SL 2 is announced from several hours to several days. According to USCG LS 2 PF can be maintained up to 60 days;

- Third Safety Level (SL3) –for a limited period of time additional safety measures for security are being maintained, when is possible or unavoidable to happen an accident, although it can be impossible the aim of the attack to be identified. Because of the stress, the crew is put under, the duration for the ship shouldn't exceed a few hours. According to USGGLS3 for PF, it can be limited to 30 days.

With SL 1 is fulfilled:

- Guarantee of accomplishing all duties, related to the security on the ship
- control of the access to the ship
- control of getting on board by people and their stuff.
- watching the zones with limited access, to guarantee an access to them only by authorized people
- watching the decks and zones, close to the ship

With SL 2 additional protective measures are being applied and are specified in SSP in terms of the above activities having in mind the guidelines that are set out in Part B of the ISPS Code.

With SL 3 additional protective measures are being applied and are specified in SSP including guidelines set out in Part B of the ISPS Code.

When the administration increases SL up to SL 2 or 3, the ship should acknowledge the receipt of instructions for changing the SL.

When the ship is put into harbor for which information was received that it operates at a higher SL, then the ship would also increase its SL and reported of PFSO.

If the Administration requires the ship to sail at high SL in a port of another Contracting Government, then it must notify the appropriate government.

When negotiating governments increase SL in their waters, they should announce the ships, sailing in them and to advice the to be vigilant and to report to their Administration of the negotiating government about an information, which attracted their attention and can affect MC in the area

When the negotiating government informs the ships about SL, tit should tell them about the measures of security, which they have to undertake if it's necessary, and also the measures of security, undertaken by the negotiating government



The real relation between the requirements of SSPs and their practical realization is possible because of procedures, like test of security, control under the access to the ship, monitoring of the parts on the deck and the zones near the ship, etc.

The safety measures and procedures in all three SL are necessary in order to:

- guarantee compliance with all of the duties for the security of the ship;
- controls the access to the ship;
- controls the uploading parties and its consequences;
- monitoring the restricted areas in order to ensure access only to authorized personnel;
- monitor the deck and areas surrounding the ship;
- coordinate the security of cargo handling and shipping facilities for stocks;
- ensuring that security communications are ready and able to use.

The performed security procedures cover the following shipping activities for each of the three SLs:

- Observation of the decks and the areas surrounding the ship;
- Monitoring of the restricted areas;
- Measures to control access to the ship;
- Measures to control the uploading of people and their belongings;
- Measures for controlling the cargo and ships' storages;
- Measures to ensure the specific port communication services security.

## Chapter XXV

### **Interaction between the merchant ship and the port facility in security's interest**

The relationship between ship and PF and the importance of the environment for its implementation is the point where usually arise maritime security incidents. This is why special attention is paid to the organization of the interaction between them.

All documents that regulate maritime security require those who are on board the ship to know and comply with the requirements concerning the safety of the ship and PF, while those in the PF to know and comply with security requirements of PF and ship. Because the ship and PF cannot provide separately their security, it is a function of the interaction between them.

#### ***25.1 Organization of the security of the port and its aquatory***

In NATO the Organization of the security of the port and its aquatory fits into an area defined by terms such as "naval control of shipping", "protection of merchant shipping", "protection of ports", "Critical Infrastructure Protection". According to the U.S. experience, it covers a wider area - Area Maritime Security, in which "layered defense" is built, that provides an opportunity to implement proactive strategies to protect and ensure maritime security. The Organization of the security of the port and its aquatory is carried out mainly by constant monitoring of the seas. In most cases it includes (except naval operations) also actions, related to: ensuring economic interests, preservation of the law, protection of sea borders, search and rescue at sea, fisheries control, fight against marine pollution, protection of the marine mining equipment, protection of the resources in the sea shelf, etc. Implemented by government agencies, nonprofit organizations, and private natural and legal persons who are working in changing international environment at high risk.

Since 2001 international community takes major steps to protect the MTS. New security practice is established based on modern technologies for advanced informational support for traditional naval technical parameters of merchant fleet. It combines extensive organizational, technical and engineering activities of military and police character as well as strengthening naval cooperation. The Organization of the security of the port and its aquatory is based on a "package security plans" of specially organized and conducted defense and law enforcement activities.

On 01.04.2004 the first phase of the introduction of a global security system was completed, with emphasis on the key elements of the MTS. The philosophy lies in chapters XI-1 and XI-2 of SOLAS-74 concerning special measures for increasing safety and security at sea and the consequent ISPS Code. This rule provides the basis for the formation of a complex system of protection of MTS and introduces preventive measures against terrorism, piracy, smuggling and illegal immigration. The basis of this system are: rule-based regulatory, coordinating bodies at different levels, maritime security units, forces and resources for security of ships and ports, standard procedures for monitoring cargo, crew, and others.

The European approach to maritime security is provided in Directive 2005/65/EC of the European Parliament and of the Council, in which there are some differences from those set in the ISPS Code. To improve port security, the EU Commission issued a proposal to include the measures from the ISPS Code and additional ones in a special European Act. The main goal is the introduction of measures for improvement of security at ports against terrorist threat: establishing common rules for port security measures, establishing a mechanism for their implementation, establishing a mechanism for monitoring. The European Commission considers that the adoption of the Directive will contribute to: achievement of a satisfactory level of port security and monitoring, as required by the EU, by complementing and ensuring the security measures, concerning the tangent point of the ship to the port; ensuring that all member states propose equal opportunities and conditions in order not to create different conditions for users of commercial port; ensuring the fastest possible implementation of the

necessary security measures for the entire port. It is important that the European approach to maritime security focuses on the entire port, and not only on its functional elements— terminal, port facility.

The concept of NATO for maritime security is based on two main principles:

- The focus of the defense is MTS and areas with intense maritime traffic, which provides enhanced naval presence;
- Maritime security is considered in the context of Euro-Atlantic security architecture.

The new NATO-concept for Naval Co-operation and Guidance for Shipping (NCAGS) is regionally oriented and significantly enhances the protection of MTS by: providing military assistance, guidance and leadership from NATO to increase the safety of merchant shipping in the World Ocean and support in cases of implementation of military operations aiming protection of shipping in peacetime, crises and conflicts. It provides different levels of support and guidance of the merchant ships of the Navy, by allowing compulsory military coordination, but only in certain situations during high-intensity conflicts.

Application of NCAGS is possible if there is agreement on: establishment of joint regional structures related to the problems of maritime security, mutual exchange of security information between the institutions of neighboring states, multinational interaction in cases of pursuit and destruction of vessels, engaged in terrorist or illegal activities at sea and more. An additional condition is highly professional naval training of seafarers in the Merchant Navy.

## ***26.2 Control and management of the access***

To a great extent qualitative implementation of security measures for cargo is a result of the interaction between the merchant ship and the PF. It helps prevent: unauthorized access to the goods, receiving and storage of cargo which is not meant to be transported.

Security measures, most of which are used in cooperation between the ship and the PF, must include effective procedures for control in access points. As for the allowance of large flows of people (passengers, workers, etc.) in PF and the ship, experience shows that it is appropriate to apply the practices of civil aviation.

Services of huge cargoes' flow with PFs without the analog in global logistical process. It is believed that in most PFs there is more that can be done in terms of security. The problem becomes even more complicated because of the increasing share of container traffic.

### **26.2.1. Control and management of the access in a PF**

PFSP determines places for search of persons, baggage and vehicles in accordance with the specified frequency. They should be covered in order to provide continuous search, regardless of weather conditions. After the search, persons, baggage and vehicles are directly routed to a restricted zone ready for loading, where is forbidden for those who are unchecked to come into contact with the ones who are checked.

PFSP provides regular updates for the systems of identification and prosecutes violations of established procedures. It defines the frequency of application of any kind of control on access, particularly if it is done arbitrarily or randomly. Depending on the input SL, the measures are:

- SL 1 – a checkpoint is established, restricted area is designed and a check-up is carried out on: the identity of all people who want to get into PF and in relation with a ship, including passengers, crew, visitors and those who confirm their grounds by crew list, tickets, boarding passes, work orders, etc.; vehicles used for entry into PF in connection with a ship; identity of staff and those who work within the PF and their vehicles. Moreover, the access to exclude persons who do not work for/in PF is restricted, if they are unable to confirm their identity; there is a search of persons, personal belongings, vehicles and their cargo. Access points which are not used regularly are closed and locked permanently. All who wish access to the PF are subject to search at a frequency specified in the PFSP. Members of

the ship's crew should not be required to search their colleagues or their personal belongings unless there are clear security grounds for doing so.

- SL 2 - PFSP introduces additional security measures, which include: additional guard at the points of access and patrols along the fence of the PF, limiting the number of access points to the PF and identifying those that need to be closed (locked) and also identifying appropriate means for their safety; increasing the frequency of searches of people, personal belongings and motor vehicles, denying access to visitors who are unable to demonstrate and explain their need for access to the PF; using patrol vessels to enhance security in the sea.
- The SL 3 measures comply with instructions issued by those responsible for the incident or threat associated with it. PFSP should specify the security measures that could be taken by the PF, in close cooperation with those who are responsible and with the ships at PF, which may include: suspension of access to the entire PF or parts of it; granting access only to those who work in connection with the security in relation with incidents or threats; termination of walking or movement of motor vehicles in the entire PF or parts of it; increasing security patrols in the PF; termination of port operations in the entire PF or parts of it; regulating the movements in ships in the PF; evacuation of the entire PF or parts of it.

### **26.2.2. Control and management of access in a ship**

For SL 1 SSP has to provide security measures for handling cargo, such as:

- Routine check of cargo, transportation TEUs and relevant services places before and during loading and unloading;
- Verification of compliance of the goods with their documentation;
- Ensuring efficient interaction with PF which guarantees that motor vehicles that have to be loaded on the board of car carriers, Ro-Ro and passenger ships are searched before being loaded, in accordance with the frequency required by SSP;
- Check of seals or other methods used to prevent unauthorized access.

An inspection of cargo can be carried out by the following means:

- Visual and physical examination;
- Usage of special equipment for scanning / detection, mechanical devices or dogs;
- Coordinating increased security measures with the shipper or another responsible person through agreements and procedures.

The security measures related to the delivery of ships' stores must: provide inspection of ships' stores and integrity / authenticity of their packaging; do not allow letting them in without inspection; prevent unauthorized access; not accept ships' stores without an order.

For SL 1 SSPs provide security measures which are applied at the delivery of ships' stores, such as: checking that stocks comply with the order before loading; immediate distribution in accordance with the best practices in maritime security.

For SL 2 SSPs provide additional security measures which are applied at the delivery of ships' stores through checking before the beginning of the delivery onboard and intensive inspections.

For SL 3 the ship must comply with the instructions issued by those who are responsible for responding to security incidents or threats to maritime security. In this case, SSPs specify security measures that could be taken by the ship in close cooperation with officials and PF, such as: more careful and comprehensive examination of ships' stores, limitation or termination of operations with ships' stores, refusal to accept ships' stores on the board.

*Works with unaccompanied baggage.* SSP has to provide security measures to ensure that unaccompanied baggage (i.e. any baggage, including personal items, which is not with a passenger or crew member at the point of inspection or search) is identified and subjected to appropriate scanning, including search, before it is accepted on board. Such luggage is not supposed to be checked from the ship and from the PF and in cases when both are equipped responsible for the checks is the PF. Close

cooperation with the PF is of particular importance and measures should be taken to ensure the safe handling of such baggage after check.

For SL 1, SSP should specify security measures that have to be applied when handling unaccompanied baggage to ensure the search, including in cases of X-ray inspection. For SL 2 SSP should provide additional security measures that have to be applied when handling unaccompanied baggage and X-ray screening of all unaccompanied baggage is needed.

For SL 3 the ship should comply with the instructions issued by those who are responsible for the security incident or threat in this regard. SSP must specify the security measures that could be taken from the ship in close cooperation with those who are responsible and PF. These measures can include: more detailed check of the luggage, e.g. by X-rays of at least two different angles, reduction or discontinuation of handling unaccompanied baggage; refusal to accept unaccompanied baggage on board.

## **26.3 Features of the interaction**

### **26.3.1 Declaration of Security**

A major part in organizing the interaction between the ship and PF is the compilation of the Declaration of Security. Its use is determined by Rule 1 of SOLAS Chapter XI-1. ISPS Code describes it, gives its functions, determine when to be completed, who can initiate it, and who should sign it. Contracting Governments shall determine when necessary Declaration of Security, through risk assessment, which is generated by the link PF-ship or ship-to-ship. A vessel may request the preparation of Declaration of Security when:

- Ship operates at a higher SL than PF or another ship it has to interact with;
- There is agreement on the Declaration of Security between Contracting Governments covering certain international voyages or specific ships on those voyages;
- There was a security threat or incident related to security, concerning the ship or PF;
- Ship is in PF, for which there is no requirement to have and implement an approved PFSP. These are: naval ports, some factory ports, marinas and ports of non-Contracting Governments;
- The ship implements activity with another ship for which there is no requirement to have and implement an approved PFSP. Such vessels are: military ships, yachts and harbor crafts with displacement up to 500 BRT.

Applications for the preparation of Declaration of Security are accepted by the respective PF or ship and are prepared by: the Captain or SSO in behalf of the ship, PFSO, authority responsible for maritime (coastal, port) security on behalf of PF.

Declaration of Security treats security requirements that could be shared between the PF and the ship (or between ships), as it defines the responsibilities of each side. Term storage of Declaration of Security is determined by the Contracting Governments for the PF and the Administration for ships.

When there is a threat to security for the interaction ship-PF or ship-to-ship, regarding people, property or environment, Contracting Governments may determine that it is necessary to have a Declaration of Security. A ship can request completion of a Declaration of Security, when:

- Ship is in operation at SL beyond that of PF or of another ship with which it is going to have interaction;
- There is an agreement between the Contracting Governments regarding the Declaration of Security, covering certain international voyages or specific ships on those voyages;
- There was a threat for security or incident, related to security that puts the ship or the PF at risk;
- The ship is at port for which was not required the implementation of suitable PFSP;
- The ship interacts with another ship that was not required to have and implement a security plan modified to the ship.

### 26.3.2 Pre-arrival list

The organization of interaction between the merchant ship and the port facility in security's interest begins 24 hours before the vessel is moored in PF at the earliest, with the agent who sends information to the ship about: name and address of PFSO; telephone, fax and telex of PFSO; SL, at which operates the PF.

The captain sends notice in which there is information about:

- Validity of the ISSC and the name of the authority that issued it;
- SL, at which the ship is currently operating;
- SL, at which the ship operated for the last 10 ports;
- Security incidents in the last 10 ports and any special or additional security measures taken in this regard;
- All records of the measures taken during stay in ports of Non-Contracting Governments;
- Information that appropriate ship security procedures were observed during the interaction with another vessel;
- In case that there are persons or goods on board rescued at sea, including their identity, if known, to determine the status of the saved regarding security;
- Information contained in the continuous synopsis record;
- Location of the ship when the report is made;
- Expected time of arrival of the ship;
- Crew list and expected changes of crew;
- A general description of the cargo on board;
- A list of the passengers.

In most cases, only the essential part of this information is sent, and the rest - at request of PFSO. Highlights of this Notice are included in mandatory form known as "Pre-arrival list". In this way before the ship moors in PF both sides have sufficient information for each other. When the ship docks in the port, however, SSO should make contact with PFSO and clarify and agree together with the following questions:

- SLs, at which the sides operate;
- Issues related to the implementation of the SSP;
- Security aspects of cargo handling and shipping supplies;
- Security measures in shaping the declaration of security;
- Actions in cases of breaching the security of the ship or PF;
- Admission of sailor and other trade unions and members of the families of the crew on board;
- Authorization of crew members to pass through the PF;
- Check of the communication concerning security with PF.

## Discussion

### Identification, recognition and reaction of threats for maritime security

**Aim of the discussion** – students must acquire knowledge about:

- Uncovering and recognizing weapons, dangerous substances and devices.
- Techniques used in detouring the security measures.
- Methods of searching and non-discriminate inspections - realization and coordination of searches.
- Psychological portraits of the types of violators of the maritime security.

#### Discussing problems:

##### **Uncovering and recognizing weapons, dangerous substances and devices**

The most dangerous situations for the Maritime Security are pointed to weapons, dangerous substances or devices. The weapons, dangerous substances and devices are exclusively difficult to discover and identify. This is the reason why people who work in the Marine Industry must be prepared for their recognition. This can be achieved during the Maritime Security Training, drills and exercise.

All critical marine units (CMU) must have Security Equipment: metal detectors and scanners, means of identification and others, for which exploitation there must be enough well prepared crew members.

How explosive devices is camouflaged?

How hand delivered and mail bombs is camouflaged?

How other than firearms weapons is camouflaged?

##### **Techniques used in detouring the security measures**

Discussion of some methods people disguised

Discussing the mainly used methods for falsification of documents

Discussing methods for how people are camouflaged in boats and floating crafts

Discussing methods for how people are camouflaged in vehicles

Discussing the mainly used methods for hidden penetration in protection CMU

- overland – separately and with vehicle;
- from the sky – separately and with vehicle;
- on water – separately and with vehicle;
- under water – separately and with vehicle.

Discussing the mainly used methods for hidden surveillance of protection CMU

Discussing occasions of attack of CMU with delusion.

##### **Methods of searching and unostentatious inspections - realization and coordination of searches**

###### ***Inspection of persons***

Inspection of persons is the strictest way of supervision of the crew and the visitors and must be conducted simultaneously in SL 2, and is necessary in SL 3. Inspection of persons is usually conducted with preventing importing illegal objects in CMU. The search is needed condition for entering CMU. Person, refusing to be searched does not get access to the ship and the PFSO is being informed.

- In SL 1 visual body search is enough.
- In SL 2 it is necessary for the luggage and vehicles to be searched randomly (25-50%)
- In SL 3 full search of each person and its luggage is being conducted.

###### **How body search is implemented?**

How not to derogate from human's reputation?

What are the methods for person searching methods are used?

How the check-point is being organized?

***Fulfillment and conducting searches.***

For fulfilling and coordinating the search there are two methods – responding method and preventive method.

**Discussing the conduction of the responding method in answer of a specific threat:**

- When it is conducted;
- Organization – pattern, check lists;
- Specific techniques, tactics and procedures.

**Discussing the conduction of preventive search is pointed against everyone who is potentially prepared to bring explosive device on the board of the:**

- When it is conducted;
- Organization – pattern, check lists;
- Specific techniques, tactics and procedures.

**Psychological portraits of the types of violators of the maritime security**

**Discussing the main characteristics of the Body Language. Signs for unusual behavior:**

- *glancing;*
- *putting hands in the pockets;*
- *sweating;*
- *stamp one's foot;*
- *unreasonable hurry for finishing the check;*
- *salient calm or haughty behavior, etc.*

**Discussing the main states of the face control.** – mimics, eyes, pupils, eyesight.

**How is the observation subject included in the general context of a situation** – clothing, accessories, luggage, giving/taking documents, how and with whom is he/she communicating.

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7. Guideline for performing ship security assessment Norwegian, Ship owner association, 2003
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## Seminar

### Maritime security plans

**Aim of the seminar** – to control how students assimilate:

The main ideas for development, approval and maintained of maritime security plans;

Key moments of different maritime security plans' content;

Procedures for maintenance and implementing changes in the maritime security plans

Content specifics and application forms of maritime security procedures.

**Issues for debate:**

#### **Purpose and contents of the maritime security plans**

Regulatory Basis

Responsibilities of security

Monitoring the security of the ship

#### **Purpose and contents of the port facility security plan**

Terminal/Port/Ship(s) security assets

Traffic regime of motor vehicles

Guard of perimeter on the land and on the water.

Contingency procedures

#### **Implementation of maritime security plans into practice**

Security audit

Monitoring the maritime security of the CMU

Verification

#### **Maintenance and change in the maritime security plans**

Records and documentation

Periodic Review Procedures

Security information

Training, drill and exercises

#### **Maritime security procedures**

Specific security actions to be implemented based on the SI for ship/PFS

- for SL 1
- for SL 2
- for SL 3

Security incident procedures

#### **Reference:**

28. BMP-4 - Best Management Practices for Protection against Somalia Based Piracy (Version 4 – August 2011)
29. International Ship and Port Facility Security Code (ISPS Code), IMO, 2003
30. Guidance on the international ship and port facility (ISPS) code, International chamber of shipping, 2003
31. Directive 2005/65/EC of the European Parliament and of the Council, 26 Oct 2005 on enhancing port security
32. MSC.1/Circ.1405/Rev.2 25 May 2012 Revised Interim Guidance to Ship owners, Ship Operators and Shipmasters on the Use Of Privately Contracted Armed Security Personnel on Board Ships In the High Risk Area
33. Sample Guideline for Developing a Port Facility Security Plan
34. SHIP SECURITY PLAN Version 1.0 August 2003 W. G. JACKSON Grand Valley State

## Chapter XXVII

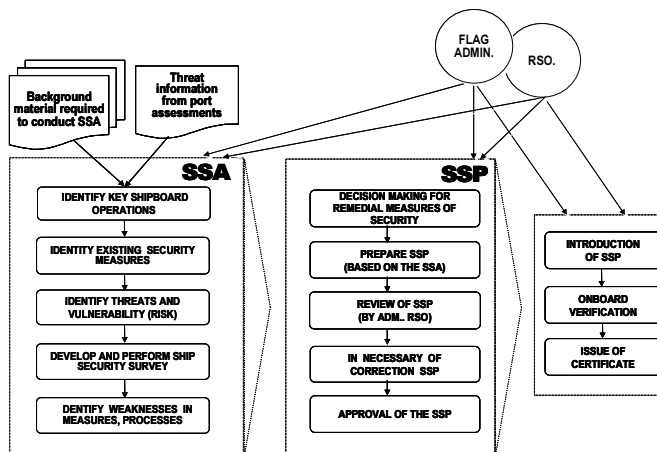
### Maritime security administration

#### 27.1 Levels of maritime security administration

- International – UN, IMO, MSC;
- European – EMSA;
- Regional – for Bulgaria and Romania the level of state of the maritime security administration must be the highest;
- National Operational Level – Maritime Administration, Port Authorities, Navy, Border police, etc.;
- Executive Operational level – company, harbor, ships and each one critical marine unit.

Flag State Administration have a variety of security responsibilities for ships registered under their authority. These responsibilities include:

- Providing guidance on the development of SSP;
- Providing guidance on measures for ships to implement at each security level;
- Providing guidance on the reporting for attacks of ships;
- Approving Ship Security Plans;
- Issuing International Ship Security Certificates (ISSC);
- Notifying ships of appropriate security levels;
- Notifying other governments of ship security alerts from ships within their jurisdiction;
- Specifying requirements for Declarations of Security;
- Agreeing to temporary measures to be implemented if security equipment fails;
- Deciding whether or not to delegate approval of SSP, verification of ship security systems and issuing ISSC to RSO and overseeing such delegations.



The scheme gives a more complete perception of the entire process of administering the security of a ship in the course of its certification:

Flag State Administration

- Guidance on security assessment;
- Approval of Ship Security Plan;
- Issue of Continuous Synopsis Record
- Nominating security agencies;

- Nominating RSO;
- Communicating information to IMO

Company Security Officer:

- Prepares SSP;
- Submits the SSP for approval
- Arranging for internal audits and review
- Advising the level of threats
- Consistency between Security requirements and Safety requirements

Port Facility Security Officer

- Provides maintenance 24 hour contact 24 hour contact
- Coordinating with security services
- Assisting SSO in confirming identity of those seeking to board the ship

### **Flow chart for management and implementation of ISPS CODE in Port Facilities**

The lowest executive operational level is the focus of more important activity, connected to the maritime security administration. Its appearance is given by:

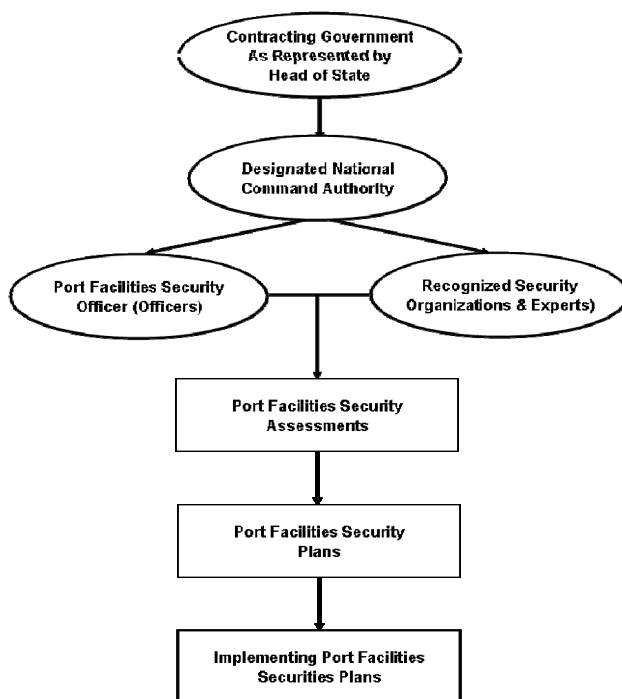
- Documentation and records
- Reporting security breaches
- Monitoring and control
- Security audits and inspections
- Reporting non-conformities

The documentation, that **always** has to be on the board of the ship and to be available for verification anytime are:

- International Ship Security Certificate;
- Ship Security Plan;
- Continuous Synopsis Record for a ship - reg.5 from Chapter XI-1 of SOLAS -74 defines the content, the way of its maintenance and storing.
- Ship Security Officer Certificate – for a “actual” SSO and for a “reserve” SSO;
- Documents, certifying the preparation of the security of members of the crew;
- Documents, connected with the technical condition and exploitation of AIS, SSAS and LRIT.

Ship Security Records cover all activities, viewed in SSP like:

- education, training and learning;
- Threats, considering the security and incidents;
- Security Breaches;



**Source:** A GUIDE TO UNDERSTANDING AND IMPLEMENTING THE INTERNATIONAL MARITIME ORGANIZATION INTERNATIONAL SHIP & PORT FACILITY SECURITY CODE (IMO ISPS)

- Messages related to the direct and specific Security Threats of the ship or PFs, where the ship is or has been;
- Internal audits and reviews of the Security Activities;
- Periodic Review of SSA;
- Periodic Review of SSP;
- Introducing changes in SSP;
- Maintenance, calibration and testing of any kind of Security Equipment, intended to be on board, including in testing the SSAS.

Records are kept on board, at least for a minimum period of time, defined by the Administrations. They are kept in the working language (languages) of the ship. If the used languages do not include English, French or Spanish, the translation in one of these languages is necessary. They can be saved in electronic format. In that case they have to be protected with procedures, aimed at preventing of unauthorized deleting, destroying or amendment. Records must be protected from unauthorized access or compromise.

In any harbor PFs, an element of the critical infrastructure or critical marine unit, are kept similar records.

### ***27.2 Making a report about accidents considering the security of the ship***

All incidents, related to security must be reported in accordance to specific demands and advanced stated scheme. Most Administrations have established special online forms, in which stated report requirements are stated in case of any incidents happen, connected to security.

The reporting line is on the Administrative Organization. The report obligations are as a result of the regulated for each post demands.

### ***27.3 Audits and inspections of the security of the ship***

The focus of the audits and inspections lays on the Security Plans. Their smooth operation requires the relevant Security Officer or Manager to revise these plans and to judge the effectiveness and relevance in a certain periods of time. For example ISPS Code determines that the ships for which are applied the demands of chapter XI-2 and part A of ISPS Code, must have SSP, approved from the Administration of the flag and they must function properly. CSO and SSO must practice monitoring under the constant relevancy and effectiveness of this SSP, including the launch of inner audits.

The changes in some of the elements of the approved SSP for which the Administration has determined that the approval is required, must be given for review and approval before their incorporated in the approved SSP and their fulfillment from the ship.

The audits and the Security Inspection of the ship are responsibility of the Captain and SSO, that must make a periodical examination of SSP. They are made in a way, similar to this described in ISM Code. Their goal is to evaluate the effectiveness of the SSP in each and every aspect. CSO and SSO are a vital part of the efforts to sustain SSP in optimal position.

### ***27.4 Verification and certification of the ship and port facility***

The attestation that a ship fits the requirements of ISPS Code of SOLAS-74 happens through the International Ship Security Certificate – ISSC. To be released for the first time (ISSC) it is necessary for the ship to pass the initial inspection, including a full review of the Ship Security System and either equipment associated with it. Through this inspection it is guaranteed that the Ship Security System and either equipment associated with it, fully responds to chapter XI-2 of SOLAS-74 and ISPS Code. It certifies that its condition is satisfying and that they are adaptive for the service, for which the ship is supposed. The certificate is issued for a period, determined from the Administration but it does not overtop 5 years. The ship must go through at least one intermediate check between the 2<sup>nd</sup> and the 3<sup>rd</sup> year to guarantee that the Security Systems and their equipment are in satisfied status for exploitation. An ISSC can lose its validity when:

- the required intermediate and renewal verifications have not taken place;
- It has not been endorsed following an intermediate verification;
- a new shipping company takes over the operation of the ship, or
- the ship changes its flag.

There is also an Interim International Ship Security Certificate (IISSC). Until the ISSC is issued, IISSC is valid for 6 months and it cannot be extended. Administration or RSOs may issue an Interim ISSC when:

- A ship is on delivery, or prior to its entry or re-entry into service;
- a SOLAS ship is changing its flag;
- a ship is being transferred from a non-SOLAS State, or;
- the shipping company operating a SOLAS ship changing its flag.

Publishing or confirming of ISSC:

- publishing only after verification;
- publishing or confirmation from Administration or RSO;
- deadline of maximum 5 years;
- copies from ISSC are compulsory stored on board and on company.

The Contracting Government within whose territory a port facility is located may issue the appropriate Statement of Compliance of a Port Facility (SoCPF). Each SoCPF shall be issued in the form specified in the ISPS Code. If the language used is not Spanish, French or English, the Contracting Government, if it considers it appropriate, may also include a translation into one of these languages.

### ***27.5 Voluntary ship and port facility security assessment***

The effective fulfillment of the Security Measures of the Companies, PFs and the ships is a constant obligation. A vital part of the Maritime Security Administration are the so called voluntary self-judgments of the Safety, for which there are the following:

- GUIDANCE ON VOLUNTARY SELF-ASSESSMENT BY SOLAS CONTRACTING GOVERNMENTS AND BY PORT FACILITIES;
- GUIDANCE ON VOLUNTARY SELF-ASSESSMENT BY COMPANIES AND COMPANY SECURITY OFFICERS FOR SHIP SECURITY.

Every guidance for voluntary self-judgement includes:

- Questionary;
- Instrument with instructions for it use.

The methods for their conduction are developed from MSC of IMO and are intended for use of the Contracting Governments, The Companies and PFs when conducting through internal voluntary self-judgements.

The self-judgements are performed periodically:

- In every 5 years for the Contracting governments;
- For PFs – every year;
- For the ships – in every 5 years.

## Discussion

### Maintenance of the security of critical marine units

**Aim of the discussion** – students must thoroughly examine:

- The main trends in the development of the concepts for protection of Critical Marine Units (CMU);
- Different means of security of CMU;
- The development of the Maritime Security Measures

**Discussing problems:**

#### Keeping the security of the ship

The new Maritime security situation and ISPS Code

Best Management Practices for Protection against Somalia Based Piracy (BMP-4)

Guidance to Ship Owners, Ship Operators and Shipmasters on the Use Of Privately Contracted Armed Security Personnel on Board Ships In the High Risk Area (MSC.1/Circ.1405/Rev.2)

Naval Co-Operation and Guidance for Shipping

Private military companies and maritime security

Maritime security and assurance

**Maritime Security Challenges** - Provide More Security for Critical Marine Units with Less People, Money and other resources:

- Protection measures for Critical Marine Units - Company risk assessment/pre-planning; Manoeuvring; Crew (Vigilance); Training; Physical measures put in place; Inherent (type/design/size/speed etc.); Vessel Protection Detachments, Private Security; Communications (Reports, Alerts), Weather;
- Ship Protection Measures – Hoses; Barb Wire/razor wire; Bulwark extension; Netting (Metal - chicken wire); Barrels; Smoke; Strobe Lighting; Sandbags; STEAM; Foam (Ox Blood); Dye markers (Red); Sound devices (Thunder flashes/flash bangs); Close inboard chaff; Citadel/Safezones; Electric wires.
- High-tech Protection Equipment – LRAD, laser,

#### Necessary actions considering the different levels of security

Discussing the maritime security procedures - ISPS Code;

- SL 1
- SL 2
- SL 3

Discussing the necessity of improvement of the Maritime Security Procedures

Discussing the conception of NATO for the Maritime Security

#### Maintenance of the interaction between the ship and the port

Organization of the security of the port and its aquatory - Area Maritime Security, where the „layered defense“is being structured, giving the possibility fore-closing proactive strategies for protecting the Maritime Security.

Using the declaration of security.

Using the Prearrival list.

Features of maintenance of the interaction between the ship and the US ports

**Reference:**

11. A Military Guide to Terrorism in the Twenty-First Century, Fort Leavenworth, Kansas 66027
12. ATP-2(B) Vol I, Naval Co-Operation and Guidance for Shipping Manual (NCAGS), December 2004, [www.shipping.nato.int](http://www.shipping.nato.int)
13. ATP-2(B) Vol II Naval Co-Operation and Guidance for Shipping, Manual (NCAGS) Guide to Owners, Operators, Masters, December 2006, [www.shipping.nato.int](http://www.shipping.nato.int)
14. BMP-4 - Best Management Practices for Protection against Somalia Based Piracy (Version 4 – August 2011)
15. International Ship and Port Facility Security Code (ISPS Code), IMO, 2003
16. Guidance on the international ship and port facility (ISPS) code, International chamber of shipping, 2003
17. Directive 2005/65/EC of the European Parliament and of the Council, 26 Oct 2005 on enhancing port security
18. MSC.1/Circ.1405/Rev.2 25 May 2012 Revised Interim Guidance to Ship-owners, Ship Operators and Shipmasters on the Use Of Privately Contracted Armed Security Personnel on Board Ships In the High Risk Area
19. Risk Based Decision Making Guidelines, [www.uscg.mil](http://www.uscg.mil)



## Seminar

### Ship and port security contingency planning

#### Contingency planning – a critical part of port and ship security management

A contingency plan, drawn up in advance, ensures a positive and rapid response to a changing situation. It often results from scenario planning and may form part of an organization's disaster management strategy. It is an action to be implemented only upon the occurrence of anticipated future events other than those in the accepted forwards plan. Contingency plans are sometimes called "crisis management plans". The Chinese symbols for crisis represent "danger" and "opportunity". Professor Ed Piper, who teaches contingency planning at John Hopkins University, points out that in other words, there is an opportunity to face danger in an organized and predictable fashion in order to save lives. Bob Roemer, an adjunct professor in crisis management at Northwestern University's Medill School of Journalism, in his latest book, *When the Balloon Goes Up*, mentions that an appropriate crisis response strategy could be as follows:

1. Protect people, assets, and the environment.
2. Correct the problem.
3. Connect with key stakeholders.

In Roemer's opinion, the primary focus is to organize people to respond effectively.

#### Getting the maritime community excited about contingency planning

The Rand Corporation, in a study on maritime terrorism, expanded the traditional scope of consequences of maritime terrorist attack to include the following:

1. Fatalities
2. Loss of salary
3. Loss of investments
4. Loss of public services
5. Destruction of ships, facilities, transportation infrastructure; loss of data, life, and injury
6. Disruption in the business cycle
7. Lag in delivery, loss of revenue business interruption
8. Increased transport costs
9. Long-term transportation efficiencies
10. Augmented security measures
11. Increased insurance rates
12. Loss of revenue for government
13. Changes in investment strategies
14. Reduced tolerance for risky investments
15. Loss of future revenue streams
16. Decreased foreign confidence and investment
17. Shift in stock market
18. Decrease in tourism and loss in revenue
19. Unknown political consequences/loss of faith in government

When you examine these losses or consequences in detail, you realize that the root cause can be attributed not only to terrorism but to all hazards. The all-hazard approach is based on the concept that a preparedness plan features the same principles and actions, regardless of the specific emergency. This means that the plan establishes a single, comprehensive framework. For the management of emergency events and applies standardized procedures and protocols. In the public sector, an all-hazards approach enables various parties to communicate and act as quickly and efficiently as possible

because they are operating under the same protocols. A comprehensive approach to emergency preparedness begins a plan into focus.

### **Sources and standards of contingency planning**

The essential features contingency planning, defined as follows:

1. *Common Terminology*: Using common terminology helps to define organizational functions, incident facilities, resource descriptions, and position titles.
2. *Modular Organization*: This type of management includes establishing overarching objectives; developing and issuing assignment, plans, procedures, and protocols; establishing specific, measurable objectives for various incident management functional activities; and directing efforts to attain the established objectives.
4. *Reliance on an Incident Action Plan*: Incident action plans (IAPs) provide a coherent means of communicating the overall incident objectives in the contexts of both operational and support activities.
5. *Chain of Command and Unity of Command*: Chain of command refers to the orderly line of authority within the ranks of the incident management organization. Unity of command means that every individual has a designated supervisor to whom he reports at the scene of the incident. These principles clarify reporting relationships and eliminate the confusion caused by multiple, conflicting directives.
6. *Unified Command*: In Incidents involving multiple jurisdictions, a single jurisdiction who multiagency involvement, or multiple jurisdictions with multiagency involvement, unified command allows agencies with different legal, geographic, and functional authorities and responsibilities to work together effectively without affecting individual agency authority, responsibility, or accountability.
7. *Manageable Span of Control*: Span of control is critical to effective and efficient incident management.
8. *Predesignated Incident Locations and Facilities*: Various types of operational locations and support facilities are established in the vicinity of an incident to accomplish a variety of purposes.
9. *Resource Management*: Resource management includes processes for categorizing, ordering, dispatching, tracking, and recovering resources. It also includes processes for reimbursement for resources, as appropriate.
10. *Information and Intelligence Management*: The incident management organization must establish a process of gathering, sharing, and managing incident-related information and intelligence.
11. *Integrated Communications*: incident communications are facilitated through the development and use of a common communications plan and interoperable communications processes and architectures.
12. *Transfer of Command*: The command function must be clearly established from the beginning of an incident.
13. *Accountability*: Effective accountability at all jurisdictional levels and within each organization includes the following - *Check-In; Incident Action Plan; Unity of Command; Span of Control; Resource Tracking; Deployment*;
14. *Incident Complexity*: “Incident complexity” is the combination of involved factors that affect the probability of control of an incident.

### **Focus of integration and cooperation**

When all interested parties to an organizational system can both understand and concur in the mission and strategy for accomplishment, there is less likelihood that conflicts will surface to obstruct progress. This is not to suggest that there will not be disagreements and suggestions for change. In fact, most leaders in organizations will welcome and invite discourse that surfaces to identify competing agendas

and reservations that, if hidden, work behind the scenes to the detriment of the organization. Another best practice for security planning is to focus on methods and tactics wherein all parties in the process perceive their input as valued and desired. Both individually and in groups, security managers should be assertively working to obtain users' concerns, answer their questions, and solicit their suggestions as plan are developed and refined to address specific and general security risks in the port.

# Game

## Cooperation enhancement between maritime institution at maritime security level 3

### Game organization

The principal objectives of games are:

- a) To practice the command, control, coordination and communications arrangements;
- b) To exercise the responses to specific maritime security threats.
- c) To validate new processes and resources to be deployed.

Game should be developed and conducted by a team, which may be called the Game Planning and Control Team (GPCT). The GPCT will be headed by a Chief Controller who shall be responsible to a Game Director for the successful outcome of the game. The Game Director is in overall charge of the game, and has responsibility for the actions of the game controllers i.e. those who manage the game, as well as the game participants i.e. those who are being gamed.

The first task is to establish the aims and objectives of the game. It is useful to describe general and specific objectives so as to be very clear on what is to be achieved. Inputs for the objectives may be obtained from:

- a) The Port Facility Security Plan (PFSP) / The Ship Security Plan (SSP): Aspects of the PFSP which would not ordinarily be carried out in the normal course of business may be the subject of an game.
- a) New factors: Changes to the physical, organizational, operations, logistics, administrative or threat environment may impact on maritime security. The effect of such changes should be examined in detail, and the examination may be part of a game requirement or objective.
- b) Lessons learnt: The records from previous games should be re-examined for the lessons learnt. These will point out to the measures implemented after the game, and possibly the need to assess the effectiveness of those measures in a new game.

### Game concept

Games may be conducted in phases, as follows:

1. The first phase usually involves planning for an operation or task given a general or specific threat and a set of planning parameters such as the aim of the task, the resources assigned for the conduct of the task, and the time frame it is to be conducted within. The planning results in the formulation of a plan which is published as a set of instructions to be conveyed to those who are to carry out the plan. A game may be designed to end at that point, in which case the product of the planning, having been approved by the management authority, is documented as a plan for the conduct of the operation or task.
2. The next phase is the conduct or execution of the task. For the conduct, the plan has to be issued as a set of instructions. The instructions are time, space and resource specific, and may be performed in a game as follows:
  - Simulation - The conduct of the mission may be performed as a simulation, in which those responsible for the conduct of the task are directed by the planners to carry out the tasks in a role-playing game. Controllers may play the part of the entities to be prosecuted in the mission, and/or they may play the part of those who are directed to carry out the task. Their role is to provide the feedback on the outcome of the various activities associated with the task.
  - Full scale or live - The conduct of the task may see the actual deployment of some of the resources specified in the instructions for the task.

## Scenario

The setting or scenario for an exercise may describe a maritime security situation that resonates with all participants i.e. they will be able to recognize, identify with; and relate to the situation, and craft responses to its demands as the exercise unfolds. The storyboard will set the scene and focus all participants on the events.

## Master Event List

The Master Events List is a list of events associated with the scenario that, when initiated in turn, may reasonably be expected to elicit a response from the participants that will generate a specific outcome or learning point. Thus, their formulation should be based on the exercise objectives, which may be to validate specific aspects or processes within a plan.

The Master Events List may be used to direct the exercise along a pre-determined trajectory, but should be subject to adjustments - additions/deletions as the exercise unfolds, particularly if these are needed in order to meet the objectives set. The events, or “injects” may be time-based or event-based, i.e. the next episode on the list will be initiated by a specific assigned time, or by the occurrence of a particular event e.g. the reaction of a participant. Controllers should evolve the scenario by exercising their imagination, creativity and discretion in formulating new events and injects as each is responded to by the participants.

Injects should not swamp participants’ ability to respond. This will be self-defeating, as it often results in disbelief and dissatisfaction, and invariably detracts from the usefulness of the exercise. A Master Events List is usually drawn up as a table incorporating columns for the time, event number, details of the event, the anticipated response from the participants, and any special notes

### EXAMPLE MASTER EVENT LIST

Serial №	Time	Event/Inject	Expected Response	Location / Remarks
0701	0900	Convening meeting and issue of the game scenario synopsis № 1 and start-state	All to familiarize themselves with the game scenario.	Conference room
0702	1300	An intelligence report of terrorist preparation to create unrest in the country has been received.	Scenario build-up – no specifying response expected	Operation control room
1808	1700	Game over	Dispersal of personnel and equipment as planned	

Various communications means will be required to plan and conduct the game. These range from written instructions to wireless communications. It is recommended that the responsibility for communications during the exercise be specifically assigned.

Game Instructions – Written instructions should be published to cover the intentions, objectives, schedule; and personnel, communications, and administrative arrangements for the game.

Means of Communications - The communications means and channels established under the existing Security Plans should be employed by the participants, unless a new communications arrangement is being tested during the game, or if special communications equipment and/or procedures are to be implemented at higher Security Levels. These communications channels must be set up for the flow of instructions, messages and reports that will be generated during the exercise. These communications channels should replicate those that will be employed during an actual operation, and will include communications security considerations and equipment where necessary.

An independent body answerable directly to the game Director is required to oversee the safety aspects of a full scale or live game. The safety officer assigned for a full scale or live exercise should consider the scenario, the Master Events List and all vessels, vehicles, equipment and personnel safety to be used in his safety review.

### **Game Initiating Conditions**

The game scenario should paint the background events leading to the situation at the commencement of the game, providing the measures set in place by the national authorities, the adversary assessment as provided, and the conditions extant for the game purposes. The degree of specificity on the adversary will depend on the level of intelligence input it is desired to play. The first event from the Master Events List may also be used to commence the game. For example, this may be an incident that demands a response from security forces, and security measures to be enhanced, thus initiating the planning for the specific responses by the port facility.

Scenario synopses or narratives are provided by the game control to describe the situation at any stage in the game. They are usually used to provide the Game Initiating Conditions, and to advance the scenario to a next stage, e.g. from Security level 1 to 2, describing the events that led to the upgrade of the Security level; to provide the backdrop for significant learning benefit to be derived in progressing through the security plan.

In planning for the exercise, the EPCT will compose events or “injects” to test various aspects of the plans so that the game objectives may be realized. These are entered in a table called the Master Events List, and introduced during the game to develop the scenario, and to initiate situations that would lead to planning or action that would in turn yield insights or lessons on aspects of the operation plan and/or its components. If necessary, pre-planned injects and the scenario may be modified as the game progresses to ensure that the game objectives may be met. Responses to the injects by the participants constitute the game “play”, and these may take the form of decision-making planning sequences or actual deployments, or they may be simulated, in the case of tabletop simulation games.

Injects may be issued to participants in a variety of ways. They may be verbal (and recorded in a communications log), hand-written in a message form, or sent via email. Communications security is an important consideration whichever means is used.

### **Game Time**

The time frame played during an game is usually fictitious, reflecting the events in the scenario and/or Master Events List.

Narratives and Time-Jumps. Game activities in a tabletop simulation game may be performed in real-time, or when circumstances permit, at a specified rate, including the use of “time jumps”. Activities such as planning and meetings, etc. must be conducted in real-time, or “Rate 1”, which represents the passage of time multiplied by 1. Activities such as deployments of personnel, vehicles or vessels, during which no events or injects are scheduled may be performed at a higher specified rate e.g. “Rate 2” i.e. the passage of time multiplied by 2. This is usually practiced when the game is conducted using a simulator. Otherwise, it is more common to utilize “time jumps”, or narratives stating the situation at the end of a period representing, for example, the deployment of vessels to certain locations. Higher time rates and time jumps serve to nullify “dead time” in a tabletop simulation game where both participants and controllers would otherwise be waiting for routine activity to unfold. Such “rates” and time jumps obviously do not apply in the case of full scale or live games.

### **Termination**

Games are normally planned to end when the operations plan developed during the planning phase has been played out, either in simulation, or during the deployment phase. In addition, full scale or live exercises may be halted or even terminated by the Game Director for a number of reasons, including situations such as:

Safety is compromised – Where the safety officer(s) or controller(s) observe that safety has become a concern, they should halt the game to address the concerns, and re-commence only when they are satisfied that the issues have been resolved satisfactorily.

Difficulties or unforeseen events faced by controllers and/or participants in the conduct of the game – Any number of concerns or challenges may arise during the conduct of the game to warrant its suspension or termination.

### **Debrief**

The primary purpose of debrief is to consolidate the lessons learnt and recommendations from the conduct of the game. Thus, debrief is an essential part of the game and must not be omitted. Prior to conduct of debrief, each operating group or force should conduct their internal hot washups (debriefs). Where a full scale or live game has been conducted, debriefs by the participants deployed should be conducted as soon as possible after their return. For efficiency, debriefs should not be a blow-by-blow review of the game. They should highlight issues of special concern for revision or future development. The following areas may be considered:

- a. Elements of the plan
- b. Challenges in execution
- c. Command and control
- d. Communications
- e. Human resource and logistics
- f. Administration

## Chapter XXVIII

### Fundamentals of training for opposition to threats for maritime security

#### *28.1 Basic security knowledge and skills for those who work in the maritime industry*

The requirements of ISPS Code training for security officers in the MTS suggest that they know very well the basics of crisis management and have the necessary military defense training. To obtain a certificate ISPS Code, the U.S. training organizations require providing evidence of completed courses in the Navy reserve. Most of the executive staff, personnel with security responsibilities, some of the young marine officers and some security officers RFs, they haven't simple military and military maritime training. The training of various categories of officials in maritime transport to achieve the requirements of the ISPS Code is found as a common flaw lack of training in basic management crisis. It is difficult to link the management of standard emergency situation on the ship, PFs, critical marine unit (fire fighting, flood water, etc.) with the broader issue of C2 in incidents related to security. Not take full account of the actual environment of security and the new security strategy in transport security, based on the assumption that the ship is not just an object of protection but also as a weapon. Manila amendments required by different categories of officials of critical marine unit significantly enhance the preparation to meet major challenges facing of maritime security.

Training requirements, training and exercises for the security are provided in the ISPS Code and STCW Convention and generally include:

- Specialized training based on the utilization of standard techniques, tactics and procedures;
- Technical training;
- Psychological;
- Practical.

Principles of Learning:

1. Preparation-realistic: determining the level of knowledge of students, linking the topic with their working environment. Preparation of materials suitable for the needs of students and the time available. Develop goals-clear, measurable, used "action verbs" e.g.: Demonstration, identification, description, enumeration, exposure....
2. Display – motivate student interest, explain, illustrate and demonstrate the material and present in an orderly, consistent manner.
3. Practical focus –providing activities, workshops, skills and practices.
4. Organization
5. Rating – carry information (oral or written). Provide feedback between learners and teachers, motivated.
6. Documentation- present, objectives, date and time of study or training.

#### **28.1.1. Basic security knowledge and skills for those who work in the maritime industry.**

Depending on job position on maritime security, generally people who work in the maritime industry can be divided into three categories:

- security officers;
- security obligations;
- all other staff/crew.

This job position determines their knowledge and skills in the field of maritime security.

CSO, the staff of the company, SSO, PFSOs might need to know and be prepared for the following:

- security administration;
- relevant international conventions, codes and recommendations;
- relevant Government legislation and regulations;
- responsibilities and functions of other security organizations;



- SSA or PFSA methodology;
- methods of ship security surveys and inspections;
- ship and port operations and conditions;
- ship and port facility security measures;
- emergency preparedness and response and contingency planning;
- instruction techniques for security training and education, including security measures and procedures;
- handling sensitive security related information and security related communications;
- knowledge of current security threats and patterns;
- recognition and detection of weapons, dangerous substances and devices;
- recognition, on a non discriminatory basis, of characteristics and behavioural patterns of persons who are likely to threaten security;
- techniques used to circumvent security measures;
- security equipment and systems and their operational limitations;
- methods of conducting audits, inspection, control and monitoring;
- methods of physical searches and non-intrusive inspections;
- security drills and exercises, including drills and exercises with other type critical marine unit;
- assessment of security drills and exercises.

In addition the SSO should have adequate knowledge of, and receive training, in some or all of the following, as appropriate:

- the layout of the ship;
- the ship security plan and related procedures (including scenario-based training on how to respond);
- crowd management and control techniques;
- operations of security equipment and systems;
- testing, calibration and whilst-at-sea maintenance of security equipment and systems.

2. Members of the staff /crew who have security responsibilities of the critical marine units have sufficient knowledge and ability to perform their duties as needed including:

- Knowledge of current security threats and their variants;
- recognition and detection of weapons, dangerous substances and devices;
- Recognition of characteristics and behavioral patterns of persons who are likely to threaten security;
- Knowledge of techniques used to circumvent security measures;
- Management of crowd control and techniques;
- Communications security;
- Knowledge of related emergency procedures and contingency plans
- Operations, security and maritime security equipment and systems
- Testing, calibration and maintenance of security equipment and systems, (while the ship is at sea);
- Techniques for inspection, control, and monitoring
- methods of physical searches of persons, personal effects, baggage, cargo, and ship's stores.

3. Other members of the staff /crew must have sufficient knowledge of security plan in volumes concerning them, including:

- The importance and the essential requirements of the different security levels;
- Knowledge related to emergency procedures and contingency plans;
- Recognition and detection of weapons, dangerous substances and devices;
- Identifying non-discriminatory basis, of characteristics and behavioral patterns of persons who are likely to threaten security
- Techniques, used to circumvent security measures.

## **28.2 Techniques for training**

Human Factor ultimately ensure the security of the ship, regardless of the conditions, but it is effective only if:

- Staff/crew has practical skills, discipline, experience and the right attitude to security;
- Leadership /command staff has high responsibility, knowledge, managerial culture on maritime security.

The "human factor" is extremely important the observation, precautionary and response that are acquired as a result of:

- Continuous education, combined with specific education, which provided the necessary motivation and personal qualities action in extreme conditions;
- Seriously focused training oriented to the most probable scenarios for a particular time and place

Limiting discussion with the crew or staff of PF with people from the Company regarding the specifics of the operations of the ship or PFs:

- Reporting of suspicious activity or behavior;
- Protection of ID cards and documents;
- Requirements for watch keeping or work.

## **28.3 Types of training – traditional and computer assisted**

The purpose of training and exercises are to ensure that the ship's personnel mastered all assigned duties related to the security of all security levels and the identification of any security flaws that require attention.

Different types of exercises which may include participation of the security officers of the Company, SSO, PFSO, relevant authorities of the Contracting Governments. These exercises should test communications, coordination, and resource availability of the reaction. They can be:

- Full scale or live
- Simulated on the table (card scheme, mock) or seminar
- Combined with other exercises as related to search and rescue or emergency response exercises.

Company participation in an exercise with another Contracting Governments could be recognized by the Administration. The teachings are very promising and other forms that are computer assisted. Because maritime security training is an extremely complex activity involving unique events that are difficult to replicate in a normal environment, computer assisted forms are the only alternative to overcome these contradictions. In essence, they played the same form, but are "based" on special simulators that fill them with higher realism.

## **28.4 Scenario as a tool of the security training**

Scenario oriented thinking, planning and preparation are the basis of modern maritime security training. The characteristics of the scenarios as a tool for maritime security training are:

1. The script is an integrated data model bound community events as defined by the application of a particular version of action for protection of critical marine units by offsetting their existing vulnerabilities and performance of normal activities.
2. The scenario describes:
  - Conflict situations
  - Existing threats and endangered
  - Available assets and resources, their distribution in the operational area;
  - Sequence of events leading to the incident in maritime security.
3. The script is used for:

- Maintenance Management System
- Development of skills;
- Testing of security plans at various critical marine units
- Providing practice management staff.

Threat scenarios are developed on two basic approaches "origin of the threat" and "vulnerability characteristics". The "origin of the threat" is far more difficult to bind with possible attacks by terrorist organizations. A more appropriate approach is "characteristic of vulnerability" as associated with possible measures to reduce the associated vulnerability. Pragmatism of this approach is confirmed by the fact that such effects can result from the effects of sources other than terrorist organizations.

Threats to critical marine units are classified into three main groups:

- Threats from natural disasters;
- Threats of flaws in the work of staff and technical failures;
- Threats from terrorist or other criminal activity.

Scripts must be adequate, the diversity of threats should be covered.

## Chapter XXIX Methodology for conducting maritime security training and drills

### ***29.1 Maritime security training and drills***

Basic requirements for maritime security training were more detailed in previous lecture. Their implementation ensures appropriate training for all personnel responsible for security of critical maritime units. Lifelong learning is one of the main factors for the development and improvement of professional and civic activities of all seafarers. Perhaps they were the first professional group, which reacted with the timing of the Memorandum of lifelong learning from the European Commission.

#### **29.1.1 Maritime security training**

The purpose of maritime security training can be:

- Familiarity with security policies;
- Learn basic concepts related to the use of the developed system for maritime security
- Ultimately forming a new culture of maritime security.

Maritime security training based on organizational and pedagogical principles:

- Define the methods and conducting studies
- Take into account the social and cultural characteristics (origin, history, atmosphere, environment, basic training, experience, skills) for students;
- Identify the environment and technology;
- Define interaction "student-teaching".

The most commonly used methods for training maritime security are: demonstrations, oral presentation of the material (lecture, story, lecture her academic type must be the exception) discussions, case studies, practical work (training, exercises), analysis of incidents, individual training. These methods are general and apply to the training of all categories of staff. Of course, depending on the specific duties and many other factors in practice it is necessary to use some special training methods. Some are borrowed from the Navy, Police, Special Operations forces.

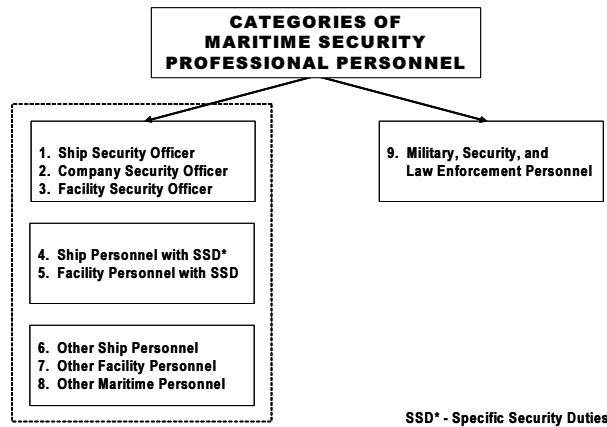
The board in the course of the work to be used in simple and mostly practical and applied methods such as- Initial Security Awareness Training; Refresher Security Briefing; Security Plan Training; Security Officers Training; Security Staff Training; Training with Bomb Detection Equipment. They provide the necessary supporting or refreshing training.

Amendments to the STCW Convention (known as Manila in practice) to improve basic maritime security training to all seafarers and similar recommendations to all officials in ports / PFs, with responsibilities for maritime security, which are not the seafarers purpose of that Convention, sets new more stringent and complex requirements to the level of preparation of the human element in the maritime sector.

By boarding (starting work on critical maritime unit) - receiving basic three-tier maritime security training to fill specific job position:

- security officer of the company, port, PF, offshore installation (critical maritime unit);
- Officials with special obligations in maritime security;
- and without obligation.

After boarding (starting work on critical maritime unit) organize training support- most experts believe that it should be held at least once a month. Based on US Experience in the figure below shows nine Categories of Maritime Security Professional Personnel. Each of these separate Categories of maritime security professionals have specific maritime security training and knowledge.



The main focus of maritime security training is the human factor - most dynamic components of the ability to ensure security critical maritime unit, irrespective of the conditions of operation. This training is effective only if:

- combines a deep understanding of the basics of the relevant security policies with the implementation of practical and applied knowledge and skills for action in an increased level of security or in response to an incident in terms of maritime security;
- Maintain the necessary motivation to work in a complex environment, based on a clear understanding of the importance of the global burden of maritime security.

In this preparation process behind the creation and development of new culture of thinking and quality maritime security training to all people from MTS. Special attention is paid to the collective maritime security training.

Changes in thinking and preparing will establish a new type of behavior. An important element of the new maritime security training is the use of modern information technology, modeling and simulation. Their application in the process of security training in MTS shall allow this process to the actual operating conditions of critical maritime units will enable students to make and implement management decisions or react in conditions close to real scenarios related to ensuring global maritime security.

### 29.1.2 Maritime security drills

The purpose of maritime security drills can be:

- To give real experience of the crew / ship personnel / critical maritime unit to carry out its obligations under corresponding security plan for all security levels;
- To acquire or upgrade skills to identify any shortcomings related to security, which must be overcome;
- To test individual elements of corresponding security plan for a certain level of security.

The focus of maritime security drills is the crew / staff or a significant thereof part

The most common theme of the training must be linked to:

- Access control;
- searches of residential premises under-deck spaces, administrative employees zones etc. charter bomb, charter stowaways, for Contraband Baggage;
- examination of the restricted areas and communications equipment;
- coverage of attacks;
- Transition from established maritime security level to another and so on, all that was envisaged in the plan.

Training is an extremely useful tool for testing the individual components of the plan are the security of the critical maritime unit. This creates a feedback on the usefulness of the developed plan and its

real effectiveness and how it could be improved. Ship and PF for the focus of this useful test may be important issues developed security system:

- How does it work for damage or destruction of the ship / PF, eg. by explosive devices, arson, sabotage or vandalism?;
- How you react to kidnap / seize ship / PF or people from the crew / staff?;
- How does the handling of goods, equipment, systems or resources?;
- What to do in unauthorized access or use, including presence of stowaways?;
- How did you react when smuggling weapons or equipment, including weapons of mass destruction?;
- What to do if you use a ship to carry those intending to pre-empt Diesel called security incident / equipment in the ship / PF?;
- How to respond if you use a ship as a weapon or as a means of inducing damage or destruction?;
- How to respond to attack the ship from the sea, while at berth or at anchor and in attack at sea?;
- How to respond to attack the PF or blockage of port entrances, locks, approaches?;
- How to respond to attack the PF with nuclear, biological and chemical weapons?;

In fact, it is not possible to enumerate all possible scenarios, which can be designed different and useful plans for training and exercises. It is good to be synchronized with scenarios that are drawn in the development of security assessments of the critical maritime units. It is allowed to combine training in topics related to practicing the other plans and drills and exercises, for example:

- the ship - the training on safety with these security;
- the port, PFs, offshore facilities - training in combat and disaster similar to those in the security.

To ensure effective implementation of the security plan a critical maritime unit (ship, port, PF, offshore facility) training should be conducted at least once every three months, unless the security plan or specific circumstances dictate otherwise. For example, in some companies, some of their ships, including container ships, their training SSP provides a search be conducted on a monthly basis, although such a search ships of this type are physically carried out more often.

When over 25% of the crew ship was replaced by people who have not previously participated in training on this ship in the past three months, they must be held within one week of the change.

## ***29.2 Planning, preparation and conducting maritime security training and drills***

Complex issues related to planning, preparation and conducting maritime security training and drills shall be resolved through strict implementation of special procedures to take in the plan; extraordinary content security of the critical maritime units. Unfortunately, experience shows that exactly this is not implemented in full. Another drawback that accompanies the maritime security training is inadequate methodological training officer / senior staff in the maritime industry in conducting effective preparation and implementation of modern methods in the process.

### **29.2.1 Planning maritime security training and drills**

Clear purpose - preparing to be realistic with clearly defined and specific purpose, taking into account the baseline knowledge of learners, linking the topic with their working environment. In the course its use materials suitable for the needs of students and the time available.

Tools:

- Programs and methodological guidance- for each type of critical maritime unit, company or public administration are different and meet minimum mandatory requirements of the relevant international conventions and codes- Most of them are public or proprietary information, others with some degree of PRIVACY and must be based on a solid basis, such

as crisis management concepts, management in critical situations, etc., are not yet widely accepted views;

- Useful tools- for example Security Drill Scenario Selector (SDSS) for SSO produced and distributed by Maritime Training Services. The task of the SSO to conduct successful training security is complex, more so must be considered and the need for interaction. SDSS was developed based on the ISPS Code to support SSO in developing mandatory training on the security of the ship. SSO can choose from 18 variables, structured into four main groups - level of security status of voyages; security threats; work the element of SSP. The result is more than 300 security training, each is unique and valuable opportunity for learning;
- PC-based or PC-assisted tools;
- e-training and e-learning;
- multimedia, audiovisual and other advanced training devices

### **29.2.2 How to conduct effective workout**

To be as realistic

- scenario should be the most realistic;
- train staff / crew has to be placed in a normal situation for the simulation stress;
- A trained person must be aware of the individual's responsibility for the security of the protected object;
- Today security a critical marine unit is an important part of any member of his staff / crew.

#### **Training should be spontaneous**

- is not providing binding participants in the training to know in advance that they will participate in it, but is obligatory always practice to be declared;
- is not providing binding workouts are always held at the same time (day or night, in bad hydro weather conditions - fog, heavy rain) or in the same place (on piers, anchoring, underway);

#### **Training should be primarily practical:**

- 90% practical work;
- Staff members / crew worked to practical use of security equipment, the actions in the implementation of security procedures, etc.;
- Primary care - this is as well night and day.

#### **Training must be progressive complexity:**

- build sustainable practical skills starting "from the simple to the complex," "Step by Step";
- skills must meet certain performance standards (eg, time), but never include running;
- increased complexity should be provided through the use of increasingly difficult scenarios for implementation;
- Scenarios can be more interesting and instructive must make typical real life "turns".

#### **Training must build capacity for teamwork as:**

- building effective teams, ensures adequate response to the impact of meeting versatile threats;
- teamwork significantly increases efficiency and prevents loss of life;
- Staff members / crew must be prepared for such substitution. by injury;
- teamwork is required in implementing security procedures;
- teamwork is required in implementing security procedures.

#### **Training should be positive:**

- not be used as punishment (of harassment, intimidation or difficult people and their work);
- have fun, build a sense of security and people feel confident with those who would rely on in an emergency.

### ***29.3 Evaluation of the maritime security training and drills***

Evaluation of training - at the end he:

- indicate to what extent it achieves its educational purposes;
- to determine whether it is achieving the desired exchange of knowledge and skills;
- providing feedback between trainers and trainees;
- given oral and written information by the established order;

At the end of each workout, making it official conducts its parsed to ensure that all identified deficiencies or errors will be corrected in the future will not be tolerated. All participants make their comments on its effectiveness. The results of the training are reported to the established order, for example:

- a training ship - the CSO, to ensure that ships' crews and shore based staff understand their responsibilities for maritime security;
- to train offshore facility - depending on the type, most often as the ship;
- Workout of PF - a security officer of the port;
- training for the port - the established government policy.

### ***29.4 Reporting for the maritime security training and drills***

Conduct analysis of each workout:

- considered a workout that ended only after she held debriefing;
- Each participant in it should have a say about what he learned during training and how it can be performed better.

Documentation - present, objectives, date and time of education / training.

The board and at least the minimum period specified by the Administration to be stored protocols for training, drills and exercises a security plan in accordance with the security of the ship, having regard to the provisions of Rule XI-2/9.2.3. Protocols:

- to prepare the working language or languages of the ship. If the language used is not English, French or Spanish, then it should include a translation into one of these languages.
- can be stored in electronic format. In this case they must be protected by procedures to prevent unauthorized deletion, destruction or amendment;
- be protected from unauthorized access or disclosure.

Example, obvious reason for the assumption that the vessel meets the requirements of the ISPS Code can be:

- Violation of order of reporting for the maritime security training and drills;
- Misleading or inability to conduct maritime security drills;
- No records of proceedings;
- The master or crew unaware important procedures for maritime security.



## Chapter XXX

### Methodology for conducting maritime security exercises

#### 30.1 Maritime security exercises

The general requirements for maritime security training, which were discussed in previous lectures, are applicable to the methodology for conducting maritime security exercises. In maritime industry there is a long tradition of conducting various maritime exercises, associated with SAR operations, eliminating the consequences of oil spills and other emergencies. The maritime security exercises are relatively new to the marine industry and it is characteristic of them that they are very close to the theory and practice of naval exercises. This military approach is understandable, since the leading organization in the maritime security is US Coast Guard – type of armed marine force, but against major global threats at sea (terrorism and piracy) is being led a war. This approach is useful for countries with security sector in a period of transformation, in which there is no effective school of crisis management, preparation, appropriate doctrine and TTP.

To ensure effective implementation of the security plan for a vessel, port, PF or offshore facility, collectively called - critical maritime unit (CMU), maritime security exercises must be conducted at least once every three months, unless the security plan or circumstances dictate otherwise. Maritime security exercises test the condition and the performance of key elements of the maritime security system, the currency of security plans and the degree of interaction between all institutions that maintain maritime security system. These include not only security officers from the interacting critical maritime units, but also relations are established with the relevant authorities of Contracting Governments and their law enforcement agencies operating in the sea. It should be noted that the participation of a company in an exercise with another contracting government must be acknowledged by the Administration.

The purpose of maritime security exercises could be:

- To give a chance of all categories of officials from the CMU staff to perform duties, related to security, according to the different levels of security;
- To improve their skills to identify deficiencies related to the security of CMU;
- To test the adequacy and the quality of security plans of CMU;
- To determine the actual readiness of the CMU to eliminate threats (localize the consequences);
- To work off the real interaction of forces from different agencies;
- To prepare all CMU officials for a proactive reaction to threats;
- To explore new concepts, organizational structures, etc. in conditions that are close to reality.

The main priority of these exercises is to test communications, coordination, ingenuity, resource availability, logistics, and maintenance of forces and the adequacy of reactions.

The goal is achieved through the implementation of the following tasks:

- increasing the capabilities of the system for maritime security, the readiness and the effectiveness of command and control (C2) of the maritime security forces;
- ensuring effective integration of naval forces of the State;
- strengthening civil-military cooperation;
- using available national / allied military and / or naval effectives wisely;

According to scale and manner of conduct they can be:

- full scale or live;
- tabletop simulation (armchair scientist, a model or a map) or seminar;
- combined with other exercises held such as emergency response, SAR operations or other port State control authority exercises

They can comprise part of the water area of a country as well as the global seas. Depending on their spatial scope (ability to interact) they are: local, regional, global.

These include security officers from the interacting critical maritime units (CMUs), establishing a connection with the relevant authorities of the Contracting Governments, CSOs, law enforcement agencies operating in the sea.

- For ships - such exercises should be held at least once a year with a maximum interval of 18 months between two consecutive exercises.
- For PFs - such exercises and related to them training aim to improve the quality of the PFSP and should be performed at least once a year, with a maximum interval of 18 months.

Categories maritime security exercises - depending on goals and way of organization, different aspects of the security plan of a CMU could be trained in order to understand the contents.

The following are the categories of maritime security exercise:

- Exercises to check the system of announcement;
- Headquarters exercises;
- Exercises on deployment of forces and equipment;
- Exercises on liquidation of consequences of a maritime security accident.

According to the U.S. experience the content of massive Area Maritime Security (AMS) exercises may have the following objectives: awareness; prevention; preparedness for response; crisis management and recovery.

### ***30.2 Planning, preparation and conducting maritime security exercises***

Basis for the successful planning, preparation and conducting of maritime security exercises is a good coordinated program of maritime security exercises, which includes different events with varying degrees of interaction and complexity. It takes under account the perspective of a longer period and should be included in other plans to receive the necessary funding.

#### **30.2.1 Guiding principles of planning, preparation and conducting of these exercises:**

- Provide full support from all levels of management for each stage of learning;
- Setting specific, clear, realistic and measurable goals for each exercise;
- The main purpose of the exercise - to achieve improvement in the general condition of the security, and not to attract any attention (for example - the media);
- Only the simplest and most commonly performed exercises can provide rapid improvement of the situation in maritime security;
- Not move on with complicated exercises unless there is a firm belief that the staff has the necessary knowledge, experience and competence;
- Unnecessary actions, dispositions and participants can complicate the exercise;
- Full analysis and timely reporting of the results of learning are as important as the successful conduct;
- Successful and safe completion of maritime security exercise is a key indicator of the quality of its planning, preparation and conducting.

A maritime security exercise can be combined with others with similar themes that include response measures for various situations and threat levels, such as:

- Responding to threats with deliberate malicious character - bomb threat, hostage negotiation / extortion, armed robbery, stowaways / refugees, demonstration / strike;
- Responding to threats (с техногенен или природен произход) - fire, explosion, chemical spill, oil spill, power failure, communication failure, mass casualties, cyclone, earthquake, tsunami or other natural disaster.

### 30.2.2. Every exercise includes the following stages:

1. *Concept and specification* - preparing the necessary input data, defining responsibilities, identifying key activities and main stages in the preparation of the guidelines of the planning authority and the specification of the exercise. Distribution of tasks, definition of framework and timetable.

2. *Planning and development of documents* - defining output data and responsibilities related to the organization of the exercise and preparation of all necessary documents for its implementation. It is necessary to take into account those aspects of the exercise, which would be essential to the public or the media.

3. *Implementation* - includes the organization, conduct and control of the exercise, under strict security measures. The focus is on modeling, simulation, conducting surveillance, data collection, monitoring and coordinating all activities to remain the exercise in terms of the planned design. It is particularly important actions of participants in the exercise to be objectively documented.

4. *Analysis and report of the exercise* – ensures the necessary data and defines the responsibilities, associated with the examination of the results, including assessment of the participants' achieved level of training and gaining the objectives of the exercise. The main focus is the collection and analysis of data, documentation of the conclusions and recommendations for improvement. In accordance with the upgrading of the tested security plans, the program for maritime security exercises is corrected considering the lessons, learned from previous exercises.

It should be noted that at all steps must be observed strict measures to prevent the disclosure of information regarding the current maritime security plans and other important documents, concerning the national security of the country in whose territorial sea is conducted the exercise.

### 30.2.3 Instrument:

- Annual plan for maritime security training for a calendar year;
- Programs and methodological guidelines:
  - Common methodologies for planning, preparation and conducting of maritime security exercise in CMUs;
  - Methodologies for planning, preparation and conduct of maritime security exercise of specific CMUs;
  - Maximum reducing the weight of work for different categories security officers by compiling standard plans for maritime security exercise;
- Hardware and software tools for alleviating the organization of maritime security exercise;
- Automated computer-supported systems for development and implementation of all forms of maritime security training, including preparation of current documentation and reporting;
- System for automated development of plans for maritime security drills and exercise for a specific CMU;
- Models and simulation;
- Scenario: *'The background story that describes the historical, political, military, economic, cultural, humanitarian and legal events and circumstances that have led to the specific current exercise crisis or conflict. The scenario is designed to support exercise and training objectives and, like the setting, can be real, fictionalised or synthetic as is appropriate. A scenario will be composed of specific modules, event and inject serials and technical data essential to the accomplishment of the exercise objectives or of the seminar/academic/experiment objectives.'*

### 30.3 Evaluation of the maritime security exercises

The evaluation of each security exercise is given after its final:

- Indicates the extent to which learning objectives have been achieved;
- Providing feedback between trainers and trainees;

- It is given oral and written information in the prescribed order.

At the end of each exercise, security officer of the critical maritime unit parses in order to correct the errors and the discovered defects so they could not be repeated in the future. All participants make comments on the effectiveness of the exercise by indicating their place and giving recommendations for effective protection. Results of the exercises are reported to senior instance.

### ***30.4 Reporting for the maritime security exercises***

Conducted maritime security exercises are documented in a special report according the ISPS Code, in which are written - attendees, learning objectives, date, time and venue as well as the achieved results. Under the ISPS Code, they must be kept on board for at least the minimum period of time required by the Administration and specified in SSPs. Besides these reports, for some CMUs are prepared other documents, according to the requirements of the relevant authorities.

*Analysis and reporting of results* (known in practice as parsing) is the final stage and the most important process of all exercises – aims to extract maximum benefit from the efforts and expenses, invested in its performance. In the parse should be emphasized on: lessons learned as a base for further corrective actions; issues, concerning counteractions to threats for maritime security; improving the quality of further exercises. The process of post-exercise analysis of an exercise includes:

- Planning - provides details of the actions which should be undertaken before any exercise;
- Observation and Recording - covers activities carried out by analysis team members and participants during an exercise;
- Reconstruction - covers the collection of exercise records and the processes needed to produce a reconstruction of the exercise activity;
- Analysis - includes a detailed examination of the data, which is needed to assess or evaluate the exercise in accordance with the objectives of the analysis;

## Seminar

### Problems of the training for opposition against the threats for the maritime security

#### Aim of the seminar – to control how students assimilate:

- The basics of methodical preparedness staff management about maritime security problems;
- The new ideas increasing qualitative of preparedness for maritime security interest;
- Personnel motivation approaches;
- Maintenance and change specifics in the maritime security plans;
- Content specifics and applicable forms of maritime security procedures

#### Issues for debate:

##### Methodical preparation of the managing staff in the maritime industry

Modern techniques for training

Basic security knowledge and skills for those who work in the maritime industry.

Training as tool for Integration and Cooperation in interest of maritime security.

##### Trained people's motivation

Fear as a motivation

Knowledge as a motivation

Confidence in own skills as a motivation

##### Planning, preparation and practicing the security of the crew of an important maritime units

Contingency planning – a critical part of ship and port security management.

Planning, preparation and conducting maritime security training and drills.

Evaluation of the maritime security training and drills.

Reporting for the maritime security training and drills.

##### Characteristics of the used computer programs in the training for opposition against the threats for the maritime security

Computer-assistance forms – advantages and disadvantages;

Correlation between on-live and computer-assistance forms

##### Opportunities for realizing a national/regional computer financing for the maritime security

Review of world experience

Review of national experience

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## Discussion

### Discussing the capabilities of the naval forces in taking part in the stabilization of the maritime security in the region

**Aim of the discussion** – thorough examination of the trends in the development of the abilities of the modern Naval Forces for strengthening the Maritime Security

#### **Discussing problems:**

##### **Legal basis for using the Naval Forces for stabilization of the Maritime Security**

Capabilities of the Naval Forces for stabilization of the Maritime Security

Law of the defence and armed forces of the Republic of Bulgaria

Law of maritime areas, internal sea routes and sea ports of the Republic of Bulgaria

##### **Doctrinal basics for stabilization of the maritime security**

Conceptions for using the Naval Forces for stabilization of the Maritime Security

Doctrine of maritime operations.

Approaches to increase contribution to the national Navies for stabilization of the maritime security

Modern Navies and the threat of terrorism

##### **International and regional partnership in interest of the maritime security**

NATO's initiatives

BLACSEAFOR

Naval exercises and their contribution for increasing the Maritime Security

##### **Using the naval coordination and guidance of shipping as a tool of maritime security**

Conceptual basis of **naval** control

Evolution of the conceptions for Naval control of shipping

Wartime conception for Naval control of shipping

Transitional conception for Naval coordination and protection of shipping

New conception for Naval coordination and guidance of shipping

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54. Guidance on the international ship and port facility (ISPS) code, International chamber of shipping, 2003

## Discussion

### **Discussing the capabilities of the national law enforcement structures in taking part in the stabilization of the maritime security in the region**

**Aim of the discussion** – thorough examination of the trends in the development of the abilities of the modern Marine Institutions for strengthening the Maritime Security and the methods for improving their interaction

#### **Legal basis for their use in the consolidation of the Maritime Security**

Law of maritime areas, internal sea routes and sea ports of the Republic of Bulgaria 2011

Law for Ministry of Internal Affairs, Ministry of Internal Affairs, 2012 Law of the defence and armed forces of the Republic of Bulgaria, 2012 Conceptions and Doctrines of Ministry of Transport and Ministry of Internal Affairs

Conceptions for using the Naval Forces for stabilization of the Maritime Security

#### **Capabilities of the Maritime Administration and Ministry Interior**

Capabilities of the General Directorate of Border Police - maritime unit

Capabilities of the Executive Agency „Maritime Administration“

Capabilities of the Maritime Rescue Coordination Centre

#### **Review of the past experience of the US Coast Guard in applying the interagency approach**

Common Responsibilities

Planning Cycle/Meetings/Briefings

Key Decisions/Objectives

Unified Command

Command Staff

Staff's sections

#### **International and regional partnership in interest of the Maritime Security**

Partnership of intelligence services

Police Cooperation

Partnership of rescue services - Ankara SAR Agreement

Science-Technical partnership

Partnership of non-government and civil organizations

#### **Reference:**

20. Law of maritime areas, internal sea routes and sea ports of the Republic of Bulgaria, 2011
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22. Mednikarov, B., Protection of Maritime Sovereignty, Naval Academy, Varna. 2008
23. BMP-4 - Best Management Practices for Protection against Somalia Based Piracy (Version 4 – August 2011)
24. Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation, 1988, additions 2005
25. Directive 2005/65/EC of the European Parliament and of the Council, 26 Oct 2005 on enhancing port security
26. Guidance on the international ship and port facility (ISPS) code, International chamber of shipping, 2003
27. Incident Command System/ Unified Command (ICS/UC) Technical Assistance Document
28. International Ship and Port Facility Security Code (ISPS Code), IMO, 2003

## Practical work

### Introduction to the possibilities of the main elements of the national system for maritime security

#### Familiarization to the mission, functions, tasks and the organization of the Maritime Rescue Coordination Centre

- Briefing the head of the Maritime Rescue Coordination Centre
- *Focus in function as National Maritime Security Coordination Center*
- Briefing the duty officer of the Maritime Rescue Coordination Centre
- Demonstration of the capabilities of Maritime Rescue Coordination Centre
- Discussion of future development of Maritime Rescue Coordination Centre and the national capabilities for SAR-operations

#### Familiarization to the opportunities of VTMIS, AIS, LRIT and discussing their use in the interest of the Maritime Security of the Republic of Bulgaria/Republic of Romania

- Briefing the Director of the Executive Agency „Maritime Administration“ direction Varna
- Demonstration of the capabilities of VTMIS, AIS, LRIT
- Discussion of future development of VTMIS

#### Familiarization to the plans for reaction in different levels of security in a Maritime Company

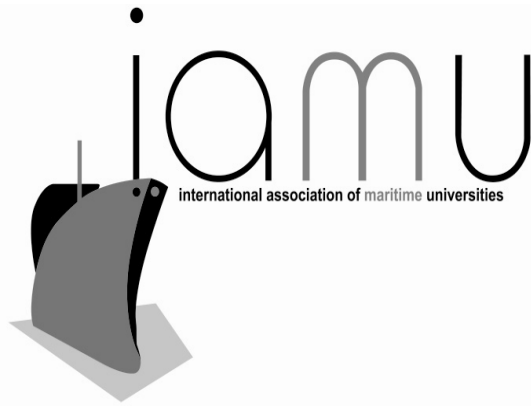
- Company Owner Briefing
- Company Security Officer Briefing for reaction in different levels of security in a Maritime Company
- Problems discussion about application of on-board armed security guards on ships of the company.

#### Discussing the interaction between the institutions with responsibilities in Maritime's Security interest of the Republic of Bulgaria/Republic of Romania

##### Participants:

- *officer of HQ of the Navy of Republic of Bulgaria/Republic of Romania*
- *officer of Maritime Border Police of Republic of Bulgaria/Republic of Romania*
- *officer of Maritime administration of Republic of Bulgaria/Republic of Romania*
- Discussing the interaction between the institutions
- Discussing of Joint training and exercises
- Discussing of chain of command in maritime security operations





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## *Safety based ship design*

*Teaching Syllabus*

*The materials and data in this publication have been obtained through the support of the International Association of Maritime Universities (IAMU) and The Nippon Foundation in Japan.*

## **Aims**

Safety based ship design aims at a systematic integration of safety risk analysis in the design process with prevention and reduction of risk to life, property and environment, embedded as a design objective, alongside standard design objective such as speed, cargo capacity, passenger capacity, and turnaround times. This implies the adoption of a methodology that links safety risk prevention/reduction measures to ship performance and cost by using relevant tools to address ship design and operation. This can be considered a radical shift from the current treatment of safety, as a design constraint imposed by rules and regulations. The present concept offers freedom to the designer to choose and identify optimal solutions to meet safety targets. For safety based ship design to be realized, safety must be treated as a life cycle issue, which in turn implies focus on risk-based operation and need for a safety-based regulatory framework.

Safety based ship design is expected to satisfy the international maritime industry need to deliver ever more innovative and competitive transport solutions to their customers as well as a wider societal need for increasingly safer transport. Is expected this concept to deliver the foundation for the maritime sector to sustain world-leadership on safety-critical and knowledge-intensive ships, maritime services, products, equipment and related software.

## **Objective**

Having successfully completed the course, the student will be able to demonstrate knowledge and understanding of:

- ✓ Tools and methodologies used in ship design process
- ✓ Statutory and regulatory requirements in ship design
- ✓ Needs to integrate safe design and operation within the ship design process
- ✓ Safety assessment methodology and risk acceptance criteria in ship design
- ✓ Concept of reliability based design in ship building
- ✓ Design principles and criteria
- ✓ High-level approval process for novel and risk and safety based design
- ✓ Operation of safety based designed ships
- ✓ Role of safety based ship design in collision and grounding
- ✓ Ship damage stability and survivability
- ✓ Safety based design for fire, explosion and evacuation in these situations

Having successfully completed the course, the student will be able to:

- ✓ Apply design tools and synthesise safety information
- ✓ Apply the methodology and tools used in the ship design process
- ✓ Interpret and apply statutory regulations and classification rules
- ✓ Estimate suitable dimensions according with the safety requirements, carry out checks on ship capacity, mass balance and compliance with statutory regulations, including assessment of ship economic viability
- ✓ Ensuring the arrangement meets the requirements for layout, capacities, choice of deck equipment and machinery, safety and statutory regulations

## **Training facilities and equipment**

For the training purpose are use an ordinary classroom with overhead projector and multimedia equipment for use of audiovisual material such as videos and slides.

## Bibliography (B)

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- R2 Interim Guidelines for evacuation analysis for new and existing passenger ships. MSC/Circ.1033, 2002
- R3 Guidelines for Formal Safety Assessment (FSA) for use in the IMO Rule-Making Process. MSC/Circ.1023, 2002
- R4 IMO Strategic Plan, C 89/12/1, 2002
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- R20 Goal-based new ship construction standards: Safety level approach—Safety level criteria. MSC 81/6/10, 2006
- R21 Goal-based new ship construction standards: Draft Guidelines on goal-based standards. MSC82/5/8, 2006
- R22 Report of the Maritime Safety Committee its eighty-second session. IMO MSC 82/24, 2006
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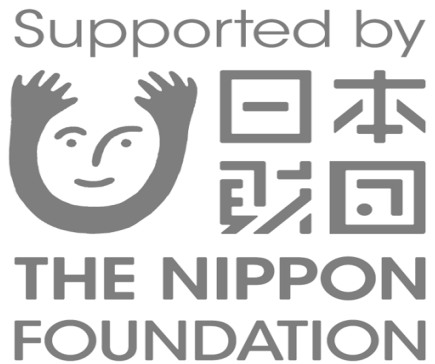
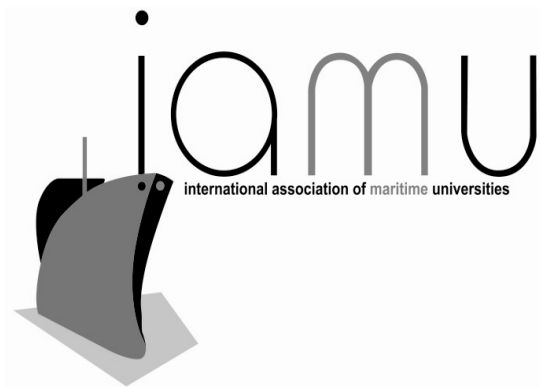
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## Course Outline

Knowledge, understanding and proficiency	Lectures, demonstrations and practical work (hours)
<b>1. INTRODUCTION TO SHIP DESIGN</b> 1.1. General 1.2. The ship design process	<b>4.0</b>
<b>2. SHIP DESIGN PRINCIPLES AND CRITERIA</b> 2.1. Design principles in ship economics 2.2. Design criteria for valuation of human life, health and safety 2.3. IMO Goal-Based Standards	<b>6.0</b>
<b>3. LEGAL REQUIREMENTS IN SHIP DESIGN</b> 3.1. Rules and regulations for ship design 3.2. Classification society's standard requirements	<b>6.0</b>
<b>4. INTEGRATION OF SAFE DESIGN AND OPERATION IN SHIP DESIGN PROCESS</b> 4.1. Marine technology and human factor 4.2. Integration of variable elements into ship design process 4.3. Ship complex systems management	<b>6.0</b>
<b>5. SAFETY ASSESSMENT METHODOLOGY</b> 5.1. Introduction in formal safety assessment 5.2. Applying of formal safety assessment in shipping industry	<b>6.0</b>
<b>6. RELIABILITY BASED DESIGN IN SHIP BUILDING</b> 6.1. Reliability-based design 6.2. Current practice in reliability-based design of ship structure 6.3. Emerging technology	<b>6.0</b>
<b>7. RISK MANAGEMENT IN SHIP DESIGN</b> 7.1. Risk evaluation criteria 7.2. Criteria for evaluation of high-risk level 7.3. Risk management for designing of systems and functions	<b>6.0</b>
<b>8. OPERATIONAL STANDARDS FOR SAFETY BASED DESIGNED SHIPS</b> 8.1. Safety standards for designing and building of ships 8.2. Safety standards in operation of special designed Ships	<b>6.0</b>
<b>9. ROLE OF SAFETY BASED SHIP DESIGN CONCEPTS IN COLLISION AND GROUNDING</b> 9.1. Novel design for prevention of collision and grounding 9.2. Tools for assessing the frequency of collision and grounding events 9.3. Structural damage assessment	<b>6.0</b>
<b>10. APPLYING OF SAFETY BASED DESIGN CONCEPT FOR SHIP DAMAGE STABILITY AND SURVIVABILITY</b> 10.1. State-of-the-art in assessing damage stability of ships 10.2. Damage stability and survivability design	<b>6.0</b>
<b>11. SAFETY-BASED DESIGN FOR OFFSHORE VESSELS</b> 11.1. Safety approach and formal safety assessment of	<b>6.0</b>

offshore ships 11.2. Innovative offshore vessels design	
<b>12. NEW DESIGNING CONCEPTS IN LIFE SAVING EQUIPMENTS</b> 12.1. Evacuation models 12.2. Alternative design and arrangements of life-saving appliances 12.3. Innovative life-saving equipments	<b>6.0</b>
<b>13. FUTURE CONCEPTS IN SHIP DESIGN</b> 13.1. Ships of the future	<b>6.0</b>
<b>14. ASSESSMENT OF ALTERNATIVE DESIGN SOLUTIONS</b> 14.1. Cost and revenue components 14.2. Economic evaluations 14.3. Techno-economical models	<b>6.0</b>
<b>15. ENVIRONMENTAL CONSIDERATIONS FOR NEW DESIGNED SHIPS</b> 15.1. Designing of technologies to reduce environmental impact from ships 15.2. Environmental impact of ship building and maintenance activities	<b>6.0</b>
<b>Review and Assessment</b>	<b>2.0</b>
<b>TOTAL</b>	<b>90.0</b>





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*Safety based ship design*

*Instructor Manual*

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# Chapter I

## Introduction to ship design

### *1.1 General*

Design methodology consists of a formal description of the design process, its premises, objectives and procedures. One of its essential foundations is the approach of systems analysis which became known and rapidly spread after the 1950's.

The prevailing design procedure was well captured in the image of the famous design spiral. This schema correctly depicts the iterative nature of design, but overemphasizes an apparently prescribed sequence of design steps. In practice the procedure varies from case to case and is much more flexible, given that provisional assumptions permit starting subtasks independently. At a later stage when concurrent engineering was pursued, the design team actually endeavored to perform several design subtasks simultaneously. Nevertheless the design spiral served well as guidance in coordinating design activities.

By about 1970 the methods of systems analysis had matured in many other applications and began to make a profound and lasting impact on ship design methodology. System analysis serves as a decision-making approach in the analysis, design and operation of large, complex systems. It can equally well be applied to ships, their subsystems and to the fleet or transport system of which the ship may be a part.

The approach of systems analysis made a deep impact on ship design methodology, not only because of its greater rigor, but also because it facilitated a coordinated division of labor in the design team. The introduction of computer aids in design enabled each designer to perform a greater share of subtasks in the design process and thus necessitated a reorganization of the division of labor in design. The subtasks of design attained greater scope and granularity, increasing the responsibilities of the individual team member. But systems analysis also provides criteria and methods for harmonizing the results of subsystem design in consonance with overall system performance.

Thus the system approach has been providing a common platform for many new developments and innovative design techniques for many decades. The degree of change in ship design methodology during several decades was significant and must be rated by the sum of many individual innovations in this general framework.

**Economic efficiency.** Economy remains with safety the most essential goals of commercial ship design. There is no doubt that significant improvements were made in the economic efficiency of ships. The economic assessment of alternatives has become a routine matter in early design stages. The computer made it even more feasible to get an immediate evaluation of economic performance for a proposed design. Design decisions thus have become more transparent and more rational. The sometimes superficially conflicting requirements of economy and safety can usually be reconciled by quantification. Several approaches exist for making these criteria more commensurable. The future trends are the design for lower lifecycle cost, i.e., shipbuilding and operating cost as well as the design for better product quality, i.e., improved functionality, performance and reliability of the ship. The reduction of the lead time for design and production to achieve shorter time to market is obviously also an important issue.

**Ship safety and risk assessment.** Ship safety requirements are as essential to shipping ventures as economic objectives. This concerns the safety of human lives, the risks of damage to or loss of ship and cargo, and the hazards to the environment. In fact it is the art of ship design to find solutions meeting both economic and safety requirements without compromising any safety principles. For many decades the management of safety in design has been a matter of improving regulatory requirements in response to experience with fatalities, damage or loss, by conventions issued by international agencies and institutions such as SOLAS and IMO. This is still necessary to set standards

and reach international agreement. Probabilistic methods for risk assessment have now gained full acceptance and are in practice replacing older deterministic, safety factor based regulations. Calculation methods for predicting ship performance in critical situations, in a seaway or in collisions and groundings, have been further developed. Quantification of risks in early design stages is becoming more and more feasible. Pursuing risk based design approach quantifying all hazards is the future trend. From a design perspective, Formal Safety Assessment is important for promoting goal based standards to support the design of new and innovative designs, as an alternative to prescriptive rules presupposing a specific technical solution. By explicitly defining the safety objective to be met, alternative design solutions meeting the same standard may be approved. This also opens up for risk based acceptance criteria, with classification societies using the formal safety assessment guidelines as basis for own rule development.

**Rationality and probabilistic modeling.** Many influences on ship performance are uncertain at the design stage, in particular the hazards of loads and safety. The environment of the ship in an irregular seaway and the events involved in ship collisions and groundings are examples of random processes that need to be described in terms of probabilities. Fortunately some pioneering work has made these processes amenable to probabilistic modeling. Recent applications in design optimization are giving new significance to such models. Design for structural reliability belongs to the same category. Therefore in recent decades several computational methods have been introduced and have become routinely applied in ship design, where appropriate, to evaluate risks and contend with uncertainties.

**Optimization.** In the framework of the system approach optimization methods have become the favorite design solution tool. Many of the principal stages of the design process have been approached by optimization. The approach is invaluable for innovative design tasks and many confirm and thus reassure the solutions to more conventional design applications. The advantage of using optimization in design is not only the ease of finding the best possible solutions more or less automatically, but also having the assurance that improvements are no longer feasible by small changes in the design variables. It is an important result also to learn which constrains governing the solution, sometimes in order to soften certain constraints. The nonlinear optimization problem does not necessarily yield a unique solution, in multimodal cases several local optima exist. It is of value to know multiple optima if they exist. To enumerate several or all local optima necessitates a conscientious inspection of the whole feasible design space. Problem formulations with multiple goal criteria have become popular in ship design. This tends to occur when economic and safety indicators are both taken into account as equivalent goals. One possible approach to this dilemma consists of Multiple Criteria Optimization. These methods help to define the most suitable compromises.

**Integration.** It was one of the earliest dreams in CAD/CAM to have available an integrated, coherent software system that would support the entire design process. This meant that a set of design methods would share a certain database and build up the product model in successive design steps, not necessarily in any prescribed sequence. Thus the methods would be interfaced by sharing data sets in the database. The designer would be able to perform design steps in any desired and meaningful order without unnecessary responsibility for input and output.

**Open communication.** The communication between heterogeneous CAD/CAM systems and subsystems is now recognized as a key prerequisite for digital collaboration between suppliers and customers. The standardization shows an approach for neutralizing the interfaces. However open product model communication between distributed partners has not yet been fully achieved, especially if the systems differ in functionality.

**Versatility.** In ship design the lot size is usually one. Changes will always occur before and during production. Thus CAD/CAM systems must be extremely versatile to contend with ever changing design requirements. CAD systems during several decades have certainly become more comprehensive in scope and hence more versatile. Some system vendors claim to cover the complete CAD-CAM-CIM cycle. Exceptions from this trend still occur with new floating structures such as offshore wind mills and features as well as unconventional design objectives. Simulation and visualization have added to system versatility. The trend is in the right direction.

**Simulation and visualization.** Simulation and visualization together, known as “the virtual ship” , are also increasingly used in early stage design to display the product model of the ship in three-dimensional views together with its operating systems in order to review the geometry, subdivision and emergencies, the performance of lifesaving systems and many other operational scenarios.

## *1.2 The ship design process*

Today ship design can be viewed as an ad hoc process. It must be considered in the context of integration with other design development activities, such as production, costing, quality control, and others. In that context, it is possible for the designer to work on a difficult product, requiring high material or labor cost, and containing some design flaws that the production engineers have to correct or send back a new design before production. Any adjustment required after the design stage will result in a high penalty of extra time and cost. Deficiencies in the design of a ship will influence the succeeding stages of production. In addition to designing a ship that fulfils producing requirements, it is also desirable to design a ship that satisfies risk, performance, cost, and customer requirements criteria. More recently, environmental concerns, safety, passenger comfort, and life-cycle issues are becoming essential parts of the current shipbuilding industry.

With this paradigm, the selected design will be a producible, cost-effective, safe, clean, and functionally efficient design. This will enable shipyards to obtain great rewards, such as the reduction of construction time and costs, reduction of lead time, improving product quality, simplification of products, and gaining sustainable competitive advantages in the shipbuilding market.

Throughout the engineering disciplines, many design processes have been developed in order to correct the inadequacies of the designs during the ship design stages. This is the process of pro-actively designing products to optimize all the functions throughout the life of the product.

**Design for cost.** Design to cost is a management strategy and supporting methodologies to achieve an affordable product by treating target cost as an independent design parameter that needs to be achieved during the development of a product. Design to cost is an area which has attracted much attention recently. The objective with this strategy is to make the design converge to an acceptable cost, rather than to let the cost converge to design. Design to cost can produce massive savings on product cost before production begins. The basic concept is to estimate the manufacturing cost during the conceptual and early design stages in order to achieve the following objectives:

- To identify the model parts that might cause high manufacturing costs,
- To provide an environment to estimate alternative cost for comparative design models.

The general approach is to set a cost goal, then allocate the cost goal to all the elements of the product. Designers must then confine their approaches to set alternatives that satisfy the cost constraint. The control of costs to meet these objectives is achieved by practical trade-off involving mission capability, performance and other schedule objectives.

However, this is only possible once cost engineers have developed a tool set that designers can use to determine the impact of their decisions as they make them. In time have appeared different developments to help the designer analyze the impact of their decisions on the ship cycle.

**Design for maintenance.** Consideration of product maintainability and reliability tends to be an afterthought in the design of ships. The design of the support processes needs to be developed in parallel with the design of the ship and not after. Parallel design can lead to lower overall life cycle costs and a product design that is optimized to its maintenance processes. Maintenance characteristics of the design and particularly unplanned maintenance are very important mainly because they lead to a reduction in operability, and hence profit in the case of commercial vessels or the ability to complete the desire mission in the case of naval vessels.

Engineering techniques can be applied to systems design to minimize the time and effort required to perform periodic preventive maintenance as well as unscheduled maintenance. Some recommendations can be given to achieve higher quality, better reliability, lower operating cost, and better maintainability. For instance:

- Reduce the number of parts to minimize the possibility of a defective part or an assembly error;
- Reduce the complexity and time of the assembly/disassembly process;
- Improve the accessibility for testing or inspections of the components of the product;
- Use modular design for components with greater probability of replacement to facilitate assembly/disassembly;
- Utilize standard parts to minimize the amount of spare parts;
- Provide self test and self-diagnosis as more as possible;

**Design for environment.** This is a relatively new field, developed in parallel to pollution prevention. The aims are to minimize raw material consumption, energy and natural resource consumption, waste/pollution generation, health and safety risks, and ecological degradation over the entire life of the ship.

Design for environment integrates environmental considerations into the design of ships with a better environmental performance over the ship's entire life cycle. Decisions made about the types of materials and other resources, as well as manufacturing processes to be used during production, affect the environmental performance of the ship. Following the finished design, the ship's environmental attributes are generally fixed and cannot be changed. Therefore, a systematic integration of environmental considerations into the earlier stages of design is essential to achieve increased environmental performance. Incorporating design for environment attributes into ship design has some benefits, such as reduced energy and material use, reduction of emissions and waste, focus on material selection issues: design for recycling, design for disassembly, management of toxic materials, and evaluation of environmental attributes.

**Design for safety.** Rather than waiting for an accident to happen and then act in haste to set up new rules, all pertinent knowledge deriving from such accidents could be analyzed and stored to improve the safety as early as possible in the design process. It is widely accepted that rules provide minimum standards on average and in some areas there are not even rules to provide minimum standards of safety. Consequently, design for safety should systematically integrate risk analysis in the ship design process with prevention/reduction of risk embedded as a design evaluation attribute.

Design for safety is a real opportunity for ship owners to have ships customized to their needs while maintaining the same safety levels. However, design for safety is a very expensive and time consuming approach. Indeed, the resources required for additional safety during the design stage will inevitably have a cost. It is from this background that the marine design for safety emerged. The key drivers of the philosophy are to keep safety as an important functional characteristic of the design and to speed up the process of risk and cost analysis, so that the process itself becomes more usable. IMO, MSC, SOLAS, ISO, IACS and MARPOL are continuously improving and implementing the safety requirements in the shipbuilding industry. In particular, the IMO Maritime Safety Committee recently adopted a new philosophy and a working approach for developing safety standards for passenger ships. In this approach, modern safety expectations are expressed as a set of specific safety goals and objectives, addressing design, operation and decision making in emergency situations with special attention paid to flooding survival analysis and fire safety analysis.

**Design for retrofitting and refurbishment.** Retrofitting and refurbishment are significant cost factors in the life cycle of a ship. Retrofitting and refurbishment is being carried out mainly for the following reasons:

- To adopt ships to meet upcoming safety and environmental regulations, like, related to double hull structures for inland waterway ships or to meet new regulations in regard to gas emissions;
- To adopt the interior of passenger ships to varying passenger needs and comfort requirements;
- To adopt ships to new operational tasks, like conversion of tankers into FPSO.

For complex ships, the cost related to refurbishment can reach the order of magnitude of the original investment. Even if retrofitting is in many cases not driven by structural aspects, the structure of a ship is often affected by changes in the outfitting part.

**Design for robustness.** Robustness is defined as insensitivity, or stability, with respect to uncontrollable parameters and is becoming a standard concept, particularly for innovative designs. Many input parameters (e.g. loads, material data, thickness) held constant during the optimization process, are subject to uncertainties causing variations of the values in the criteria set and/or violation of constraints. They can also be costly to control. One way is to introduce safety margins on the constraints, but this leads to a reduction of the design space. Robust design has been developed with the expectation that the insensitive design can be obtained.

The robust design method greatly improves engineering productivity. Variation reduction is universally recognized as a key to reliability and productivity improvement. There are many approaches to reducing the variability, each one having its place in the product development cycle. The robustness strategy provides the crucial methodology for systematically arriving at solutions that make designs less sensitive to various causes of variation. It can be used for optimizing product design as well as for the manufacturing process design.

## Chapter II

### Ship design principles and criteria

#### *2.1 Design principles in ship economics*

Recent research advances in the economics of maritime transport discuss issues related to the value of ships, design methods to maximize this for stake holders, shipbuilding as a service, ship speed and others.

Observing the world trade figures can clearly state that without seaborne shipping, world trade would not be possible on the scale necessary for the modern world to functions. Around 90% of world trade is carried by the international shipping industry and this accounts for 4.5 trillion USD of exported goods. According to the same statistics, this figure brings 380 billion USD in freight rates, which is equivalent to about 5% of total world trade.

These figures indicate the efficiency of shipping. The ratio between the total freight rates and goods transported leads shows that on average less than 10% of the value of goods transported is required undertaken that transportation using the shipping of the world. Even if the annual investment in new building is add to this, in the order of 100 billion USD, the overall system is still very lean.

Modern shipbuilding demands a new approach that accounts for the opinions of multiple stakeholders. Traditionally, “ship designs were often developed by a stove pipe design organization without the direct, early participation of the future ship’s builder, ship owner, operators and maintainers”. In contrast, modern design teams employ concurrent engineering principles, which require the consideration of all the stakeholders’ preferences. It indicates that the ship valuation should be approached from the perspectives of different parties involved in the shipbuilding process.

The conventional ship value assessment adopts the Net Present Value approach, which only measures the tangible aspects of the ship, including ship’s features and functions, discounted through time. Net Present Value therefore fails to capture the importance of partnership and cooperation between the stakeholders of the shipbuilding industry.

Was studied the importance of the relationship between the shipyards as sellers, and the owners as buyers and turnkey suppliers, and was concluded that interdependency triggers stakeholders to continue the relationships, recognizing that they can to create more value together than independently.

On the other side, was found that currently there is insufficient understanding of the value of a ship by the ship owner and shipyard. A more complete understanding will enable designers to reduce the problems of over and under-engineering, prevent ship owners from making unrealistic requirements and avoid shipyards doing inappropriate things such as installing poorly performing equipment. Also, was concluded that for unique and sophisticated ships, like cruise ships, successful building was only possible if there was a strong relationship between the stakeholders that allowed flexibility to bridge all technical challenges. Less sophisticated ships, like bulk carriers or tankers, are built strictly according to specifications, and any demands for alterations are met with resistance. The dominant factor of value for these kinds of ships is price, while for sophisticated ships, the value is held in the passenger experience and the uniqueness that the ship has in the market.

This fact led many yards building cruise ships to extend their business activities to support the owner in the post delivery phase, offering to their clients not just a product, but a shipbuilding service. This service would include a maintenance service for the ship, but the primary objective was to engage in the refitting and enlargements of vessels in order to rejuvenate them after a certain period of time, perhaps 10 to 15 years.

Noticing the shipping industry’s trend toward the reduction of operating speed due to the rising oil prices and reduced economic activity in 2010 and onwards, an analysis was performed to identify optimal speeds dependence on freight rates. Following the premise of economic equilibrium, it was possible to draw a functional relationship between the optimal ship speed and the freight rates,



assuming constant transport capacity. Further to this, the relationship was also established with the cost of ship operations. Considering that the biggest cost in operation is the fuel, it is possible to estimate the optimal ship speed and the corresponding freight rate for a given price of fuel. Extending the result of this analysis into the present day situation of rising oil prices, or the addition of CO<sub>2</sub> taxes, we can expect that the ship speed will need to be further reduced if the economic equilibrium is to be maintained. Only a rise in the world economy could reverse this trend, but if the requirement to reduce the CO<sub>2</sub> emissions from shipping is accepted then maintaining the slow speed steaming and building more ships might in the long term build a more sustainable approach to “greener” shipping industry.

## ***2.2 Design criteria for valuation of human life, health and safety***

During engineering projects such as shipbuilding projects decisions have to be done how the performance of a system and namely its safety can be improved. This goes along with changes of costs of the project, may it be increased or decreased costs. As a consequence the engineer needs a support to determine the consequences of an option, as this may be a risk control option in the terminology of formal safety assessments, to improve the performance with regard to the costs. In this context, one of the most difficult issues in examining different risk control options for making engineering design decisions and policy formulation is the valuation of human life, health and safety in monetary terms which have meanings in pricing decisions. These decisions are usually made by politicians, taking into account the aversion towards human suffering in an intuitive way. An analysis of these decisions shows, however, that the implicit value of a human life is always finite.

The economic aspect of the problem is, that the scarce national means have to be divided over many investments, among which are a number of possible investments in health and safety. Any rational decision mechanism must therefore be able to weigh the probability of profit against the probability of saving lives and enhancing health. The growing application of risk based design methods makes it necessary to estimate the value of a human life, health and safety in addition to an assessment of the economic damage involved with failure of the system under design.

Generally, the most common approach is to conduct a cost and benefit analysis. One such analysis is to study the outcomes of political or societal decision processes, the investments made in a society to enlarge the probability of saving extra life. This value seems to be able to serve as a valuation of human life, as it indicates the willingness to pay for the saving of a life.

In their work, some researchers, contend that the characteristic value monism of cost-benefit analysis renders the practice inadequate for guiding environmental policy formation: not all choices are tradeoffs made on quantitative assessments of preference satisfactions, and some goods human life among them cannot and should not be measured in monetary terms. At a basic level, cost-benefit analysis can include within the scope of its reasoning diverse goods, including so called “human costs”, such as rights and duties, and environmental costs.

In its strategy, IMO has focused on the development of goal based new ship construction standards, where a more holistic approach towards the ship and its systems is applied. The second approach has a more risk-based and holistic attitude and is called the safety level approach, included the safety of seafarer, occupational health, passengers and safety of third parties. The intention with goal based standard, and in this respect, especially with regard to safety level approach, is that the standard is an overarching and holistic approach which covers all functions and systems onboard. The argument is that if there were a safety standard in place for all systems and workplaces on board, it would indirectly reflect positively on the health and safety of the crew. According to research studies, communication between ships’ design and ships’ ergonomics has been non-existent, and it is overdue for the working environment and the prevention of personnel accidents to be taken into consideration in the construction phase, where it is both cheaper and more efficient to create the solutions that efficiently prevents work-related accidents.

### 2.3 IMO Goal-based standards

The notion of “goal-based ship construction standards” was introduced in IMO at the 89th session of the Council in November 2002 through a proposal by two Member States, the Bahamas and Greece (C 89/12/1), suggesting that IMO should play a larger role in determining the standards to which new ships are built, traditionally the responsibility of classification societies and shipyards.

The submission argued that the Organization should develop initial ship construction standards that would permit innovative designs but at the same time ensure that ships are constructed in such a manner that, if properly maintained, they could remain safe for their economic life. The standards would also have to ensure that all parts of a ship could be easily accessed to facilitate proper inspection and ease of maintenance.

Over the next two years the matter was extensively discussed in the Maritime Safety Committee (MSC), the Council and finally the IMO Assembly which, at its twenty-third session in 2003, included the item “Goal-based new ship construction standards” in the strategic plan (A.944(23)) and the long-term work plan (A.943(23)) of the Organization.

After in-depth discussions in plenary and in the GBS working group during MSC 79 and MSC 80, MSC 80 in May 2005 agreed on in principle the basic principles of IMO goal-based standards as follows:

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

It is understood that these basic principles were developed to be applicable to all goal-based standards developed by IMO and not only to ship construction standards, in recognition that, in the future, IMO may develop goal-based standards for other safety areas, e.g. machinery, equipment, fire-protection, etc., as well as security and environment protection related areas, and that all goal-based standards developed by the Organization should follow the same basic principles. It was agreed to proceed with the development of GBS using a deterministic approach, while, at the same time, the use of risk-based methodologies was to be further explored over the next few sessions of the Committee.

Following deliberation on the subject, MSC 81 agreed to limit the scope of its consideration initially to bulk carriers and oil tankers and consider expansion to other ship types and areas of safety at a later time. For the GBS for oil tankers and bulk carriers, a five-tier system was agreed, consisting of the following:

- Tier I- Goals

High-level objectives to be met.

- Tier II - Functional requirements

Criteria to be satisfied in order to conform to the goals.

- Tier III - Verification of conformity

Procedures for verifying that the rules and regulations for ship design and construction conform to the goals and functional requirements.

- Tier IV – Rules and regulations for ship design and construction

Detailed requirements developed by IMO, national Administrations and/or recognized organizations and applied by national Administrations and/or recognized organizations acting on their behalf to the design and construction of a ship in order to conform to the goals and functional requirements.

- Tier V - Industry practices and standards

Industry standards, codes of practice and safety and quality systems for shipbuilding, ship operation, maintenance, training, manning, etc., which may be incorporated into, or referenced in, the rules and regulations for the design and construction of a ship.

The GBS Tiers I to III constitute the IMO GBS, which became mandatory on 1 January 2012 under the SOLAS Convention (new SOLAS regulation II-1/3-10), subsequent to the adoption of the following instruments at MSC 87 in May 2010:

- New SOLAS regulation II-1/3-10 “Goal-based ship construction standards for bulk carriers and oil tankers” (resolution MSC.290(87));
- International goal-based ship construction standards for bulk carriers and oil tankers (resolution MSC.287(87)) (the Standards); and
- Guidelines for the verification of conformity with goal-based ship construction standards for bulk carriers and oil tankers (resolution MSC.296(87)) (the Verification Guidelines).

SOLAS regulation II-1/3-10 makes the goal-based standards applicable to oil tankers and bulk carriers of 150 m in length and above, for which the building contract is placed on or after 1 July 2016; in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 July 2017; or the delivery of which is on or after 1 July 2020.

The new SOLAS regulation also requires that a Ship Construction File shall be provided upon delivery of a new ship and kept on board the ship and/or ashore. (see also Guidelines for the information to be included in a Ship Construction File (MSC.1/Circ.1343)).

MSC 89 in May 2011, with a view to providing the process for the development, verification, implementation and monitoring of goal-based standards (GBS) to support regulatory development within IMO, approved the Generic guidelines for developing IMO goal-based standards (MSC.1/Circ.1394).

The verification of conformity of ship construction rules of individual recognized organizations and/or national maritime administrations with the GBS will be carried out by international GBS Audit Teams established by IMO’s Secretary-General, in accordance with the verification Guidelines. These Guidelines foresee that recognized organizations and/or national maritime administrations submit requests for verification of their ship construction rules to the Secretary-General who will forward these requests to the Audit Teams to be established for a verification of the submitted information through an independent review. The final reports of the Teams with relevant recommendations will then be forwarded to the MSC for consideration and approval.

According to the implementation schedule (MSC 87/26/Add.1/Annex 13), the deadline for the receipt of initial verification requests at IMO is 31 December 2013. To facilitate audit preparation, IMO has sent Circ. Letter No.3097 in August 2010, inviting advanced notification of intent to submit a request for a GBS verification audit, and as of June 2012, eight notifications from classification societies have been received.

At the same time, a pool of auditors is being established. In response to Circ. Letter No.3076 of July 2010, inviting the nomination of GBS auditors, 33 nominations had been submitted by Member States and international organizations as of 12 July 2012.

The Assembly, at its 27<sup>th</sup> session, included in the Strategic Plan for the Organization (for the six-year period 2012-2017) (resolution A.1037(27)) a relevant strategic direction and in the High-level Action Plan (resolution A.1038(27)) a corresponding high-level action with two planned outputs:

- implementation of goal-based new ship construction standards for bulk carriers and oil tankers (by MSC);
- development of goal-based ship construction standards for all types of ships, including safety, security and protection of the marine environment (by MSC and MEPC).

For further study of risk-based methodologies, MSC 90 established a GBS correspondence group and instructed it to develop draft guidelines for the approval of equivalents and alternatives as provided for in various IMO instruments, which should be based on the Guidelines on approval of risk-based ship design annexed to document MSC 86/5/3.

## Chapter III

### Legal requirements in ship design

#### 3.1. Rules and regulations for ship design

Today, there are many new or updated regulations aim to reduce the risks to life or to minimize the environmental impact involved in shipping. Looking at the safety record over the last decades, the effect is largely positive. However, almost any new regulation requires new or additional documentation to be established and to be maintained.

The conventions and other mandatory instruments referred to above include, as a minimum:

- 1974 SOLAS Convention (chapters I, II-1, III, X, XI-1 and XII and other relevant chapters, as appropriate) and the 1988 Protocol relating thereto;
- MARPOL 73/78 (Annexes I and IV and other relevant annexes, as appropriate);
- International Life-Saving Appliance (LSA) Code;
- International Code of Safety for High-Speed Craft (HSC Code), 1994 and 2000;
- Guidelines on the enhanced programme of inspections during surveys of bulk carriers and oil tankers (resolution A.744(18));
- Condition Assessment Scheme (CAS).
- Code of Safety for Dynamically Supported Craft (DSC Code);
- Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU Code);
- Code of Safe Practice for the Carriage of Cargoes and Persons by Offshore Supply Vessels (OSV Code);

As example, for each ship type there are special requirements express through different regulations.

**International Maritime Solid Bulk Cargoes Code (IMSBC Code).** The International Maritime Solid Bulk Cargoes Code (IMSBC Code), and amendments to SOLAS chapter VI to make the Code mandatory, were adopted by the Maritime Safety Committee (MSC), 85th session, in 2008. The amendments are expected to enter into force on 1 January 2011. The IMSBC Code will replace the Code of Safe Practice for Solid Bulk Cargoes (BC Code), which was first adopted as a recommendatory code in 1965 and has been updated at regular intervals since then.

The aim of the mandatory IMSBC Code is to facilitate the safe stowage and shipment of solid bulk cargoes by providing information on the dangers associated with the shipment of certain types of cargo and instructions on the appropriate procedures to be adopted.

The international Code of Safe Practice for Solid Bulk Cargoes (BC Code) includes recommendations to Governments, ship operators and shipmasters. Its aim is to bring to the attention of those concerned an internationally-accepted method of dealing with the hazards to safety which may be encountered when carrying cargo in bulk.

The Code highlights the dangers associated with the shipment of certain types of bulk cargoes; gives guidance on various procedures which should be adopted; lists typical products which are shipped in bulk; gives advice on their properties and how they should be handled; and describes various test procedures which should be employed to determine the characteristic cargo properties. The Code contains a number of general precautions and says it is of fundamental importance that bulk cargoes be properly distributed throughout the ship so that the structure is not overstressed and the ship has an adequate standard of stability. A revised version of the Code was adopted in 2004 as Resolution MSC.193(79) Code of safe practice for solid bulk cargoes.

**SOLAS Chapter XII Additional Safety Measures for Bulk Carriers.** Following a spate of losses of bulk carriers in the early 1990s, IMO in November 1997 adopted new regulations in SOLAS containing specific safety requirements for bulk carriers, Chapter XII - *Additional Safety Measures for*

*Bulk Carriers.* In the same month, the 20th Assembly of IMO adopted the "BLU Code" - the Code of Practice for the safe loading and unloading of bulk carriers (resolution A.862(20)).

Following the 1998 publication of the report into the sinking of the bulk carrier **Derbyshire**, the Maritime Safety Committee (MSC) initiated a further review of bulk carrier safety, involving the use of Formal Safety Assessment (FSA) studies to help assess what further changes in regulations might be needed.

In December 2002, at its 76th session, the MSC adopted amendments to SOLAS chapter XII and the 1988 Load Lines Protocol and also agreed to a number of recommendations to further improve bulk carrier safety.

In December 2004, the MSC adopted a new text for SOLAS chapter XII, incorporating revisions to some regulations and new requirements relating to double-side skin bulk carriers. These amendments entered into force on 1 July 2006.

The new SOLAS chapter XII *Additional Safety Measures for Bulk Carriers* was adopted by Conference held in November 1997 and it entered into force on 1 July 1999.

The regulations state that all new bulk carriers 150 metres or more in length (built after 1 July 1999) carrying cargoes with a density of 1,000 kg/m<sup>3</sup> and above should have sufficient strength to withstand flooding of any one cargo hold, taking into account dynamic effects resulting from presence of water in the hold and taking into account the recommendations adopted by IMO.

For existing ships (built before 1 July 1999) carrying bulk cargoes with a density of 1,780 kg/m<sup>3</sup> and above, the transverse watertight bulkhead between the two foremost cargo holds and the double bottom of the foremost cargo hold should have sufficient strength to withstand flooding and the related dynamic effects in the foremost cargo hold.

Cargoes with a density of 1,780 kg/m<sup>3</sup> and above (heavy cargoes) include iron ore, pig iron, steel, bauxite and cement. Lighter cargoes, but with a density of more than 1,000 kg/m<sup>3</sup>, include grains such as wheat and rice, and timber.

The amendments take into account a study into bulk carrier survivability carried out by the International Association of Classification Societies (IACS) at the request of IMO. IACS found that if a ship is flooded in the forward hold, the bulkhead between the two foremost holds may not be able to withstand the pressure that results from the sloshing mixture of cargo and water, especially if the ship is loaded in alternate holds with high density cargoes (such as iron ore). If the bulkhead between one hold and the next collapses, progressive flooding could rapidly occur throughout the length of the ship and the vessel would sink in a matter of minutes.

IACS concluded that the most vulnerable areas are the bulkhead between numbers one and two holds at the forward end of the vessel and the double bottom of the ship at this location. During special surveys of ships, particular attention should be paid to these areas and, where necessary, reinforcements should be carried out.

The criteria and formulae used to assess whether a ship currently meets the new requirements, for example in terms of the thickness of the steel used for bulkhead structures, or whether reinforcement is necessary, are laid out in IMO standards adopted by the 1997 Conference.

Under Chapter XII, surveyors can take into account restrictions on the cargo carried in considering the need for, and the extent of, strengthening of the transverse watertight bulkhead or double bottom. When restrictions on cargoes are imposed, the bulk carrier should be permanently marked with a solid triangle on its side shell. The date of application of the new Chapter to existing bulk carriers depends on their age. Bulk carriers which are 20 years old and over on 1 July 1999 have to comply by the date of the first intermediate or periodic survey after that date, whichever is sooner. Bulk carriers aged 15-20 years must comply by the first periodical survey after 1 July 1999, but not later than 1 July 2002. Bulk carriers less than 15 years old must comply by the date of the first periodical survey after the ship reaches 15 years of age, but not later than the date on which the ship reaches 17 years of age.

The MSC at its 76th session in December 2002 adopted amendments to chapter XII (Additional Safety Measures for Bulk Carriers) of the International Convention for the Safety of Life at Sea (SOLAS),

1974, as amended to require the fitting of high level alarms and level monitoring systems on all bulk carriers, in order to detect water ingress.

The recommendation for the fitting of such alarms was first highlighted during the meeting of the Working Group on Bulk Carrier Safety held during the MSC's 74th session in December 2001, following on from recommendations of the United Kingdom Report of the re-opened formal investigation into the loss of the *Derbyshire*.

The new regulation XII/12 on Hold, ballast and dry space water level detectors will require the fitting of such alarms on all bulk carriers regardless of their date of construction. The requirement is expected to enter into force on 1 July 2004, under the tacit acceptance procedure.

In addition, a new regulation XII/13 on Availability of pumping systems would require the means for draining and pumping dry space bilges and ballast tanks any part of which is located forward of the collision bulkhead to be capable of being brought into operation from a readily accessible enclosed space.

A further regulation affecting bulk carriers was also adopted: Access to spaces in cargo areas of oil tankers and bulk carriers. The new regulation II-1/3-6 in SOLAS chapter II-1 (Construction - structure, subdivision and stability, machinery and electrical installations), Part B (Subdivision and stability), is intended to ensure that vessels can be properly inspected throughout their lifespan, by designing and building the ship to provide suitable means for access. Associated Technical provisions for means of access for inspections, also adopted, are mandatory under the new regulation.

The MSC at its 79th session in December 2004 adopted a new text for SOLAS chapter XII (Additional safety measures for bulk carriers), incorporating revisions to some regulations and new requirements relating to double-side skin bulk carriers. The amendments entered into force on 1 July 2006.

The amendments include the addition of a new regulation 14 on restrictions from sailing with any hold empty and requirements for double-side skin construction as an optional alternative to single-side skin construction. The option of double-side skin construction will apply to new bulk carriers of 150m in length and over, carrying solid bulk cargoes having a density of 1,000 kg/m<sup>3</sup> and above.

The MSC also adopted mandatory standards and criteria for side structures of bulk carriers of single-side skin construction and standards for owners' inspections and maintenance of bulk carrier hatch covers.

**Passenger ship regulation.** The Maritime Safety Committee (MSC) at its 82nd session in November-December 2006 adopted a package of amendments to SOLAS, the result of a comprehensive review of passenger ship safety initiated in 2000 with the aim of assessing whether the current regulations were adequate, in particular for the large passenger ships now being built.

The work in developing the new and amended regulations has based its guiding philosophy on the dual premise that the regulatory framework should place more emphasis on the prevention of a casualty from occurring in the first place and that future passenger ships should be designed for improved survivability so that, in the event of a casualty, persons can stay safely on board as the ship proceeds to port.

The amendments include new concepts such as the incorporation of criteria for the casualty threshold (the amount of damage a ship is able to withstand, according to the design basis, and still safely return to port) into SOLAS chapters II-1 and II-2. The amendments also provide regulatory flexibility so that ship designers can meet any safety challenges the future may bring. The amendments include:

- alternative designs and arrangements;
- safe areas and the essential systems to be maintained while a ship proceeds to port after a casualty, which will require redundancy of propulsion and other essential systems;
- on-board safety centres, from where safety systems can be controlled, operated and monitored;
- fixed fire detection and alarm systems, including requirements for fire detectors and manually operated call points to be capable of being remotely and individually identified;
- fire prevention, including amendments aimed at enhancing the fire safety of atriums, the means of escape in case of fire and ventilation systems; and

- time for orderly evacuation and abandonment, including requirements for the essential systems that must remain operational in case any one main vertical zone is unserviceable due to fire. The amendments are expected to enter into force on 1 July 2010.

The work on passenger ship safety has based its guiding philosophy on the premise that the regulatory framework should place more emphasis on the prevention of a casualty from occurring in the first place and that future passenger ships should be designed for improved survivability so that, in the event of a casualty, persons can stay safely on board as the ship proceeds to port.

With regard to the five pillars of the guiding philosophy for the Committee's passenger ship safety initiative, the following have been achieved since the work was initiated in 2000:

**Prevention:** Amendments to SOLAS and the STCW Conventions and supporting guidelines that focus on fire prevention, navigation safety, training and contingency planning.

**Improved survivability:** Amendments to SOLAS chapters II-1 and II-2 and supporting guidelines that focus on essential system redundancy, management of emergencies and casualty mitigation.

**Regulatory flexibility:** Amendments to SOLAS chapters II-1 and III and supporting guidelines that focus on promoting, through rigorous evaluation and approval procedures, the regulatory approval of new safety technologies and arrangements.

**Operations in areas remote from SAR facilities:** Action taken to develop amendments to SOLAS chapter III and supporting guidelines that will focus on reducing the time it takes to recover persons from survival craft and the water; supporting guidelines approved on external support from SAR Authorities, as well as guidance to assist seafarers taking part in SAR operations.

**Health safety and medical care:** Supporting guidelines that focus on establishing medical safety programmes and a revised Guide on Cold Water Survival.

The approved draft amendments to SOLAS chapters II-1, II-2 and III and the FSS Code relate to:

- alternative designs and arrangements;
- safe areas and the essential systems to be maintained while a ship proceeds to port after a casualty, which will require redundancy of propulsion and other essential systems;
- on-board safety centres, from where safety systems can be controlled, operated and monitored;
- fixed fire detection and alarm systems, including requirements for fire detectors and manually operated call points to be capable of being remotely and individually identified;
- fire prevention, including amendments aimed at enhancing the fire safety of atriums, the means of escape in case of fire and ventilation systems; and
- time for orderly evacuation and abandonment, including requirements for the essential systems that must remain operational in case any one main vertical zone is unserviceable due to fire.

The MSC agreed that the Sub-Committee on Ship Design and Equipment (DE) should develop performance standards for recovery systems for all types of ships, by 2008, with a view to preparing further draft amendments to SOLAS chapter III on recovery arrangements for the rescue of persons at sea. The Committee agreed that the new amendments and guidelines should be enforced by 2012. The MSC also agreed that the Sub-Committee on Standards of Training and Watchkeeping (STW) should develop relevant training standards after the performance standards have been finalized. The idea is that ships should be equipped to recover persons from the water and/or survival craft and rescue craft, and give functional requirements for achieving this.

The following circulars were approved:

- Guide to recovery techniques;
- Guidelines on the provision of external support as an aid to incident containment for SAR Authorities and others concerned;
- Enhanced contingency planning guidance for passenger ships operating in areas remote from SAR facilities, which includes Criteria for what constitutes an area remote from SAR facilities;
- Guidelines on training of SAR service personnel working in major incidents; and

- Guide for cold water survival.

A draft Assembly resolution on *Guidelines on voyage planning for passenger ships operating in remote areas* was agreed for submission to the next Assembly, scheduled for late 2007.

Further consequential work to be carried out includes the development of guidelines for the approval of novel life-saving appliances (DE); and guidelines on the lay-out and ergonomic design of safety centres on passenger ships (Sub-Committee on Safety of Navigation (NAV)).

The MSC also instructed the Sub-Committee on Stability, Load Lines and Fishing Vessel Safety (SLF) to consider draft amendments for water ingress detection and flooding level monitoring systems; and for a safe return to port capability for passenger ships in damaged condition. The STW Sub-Committee is instructed to review the guides for recovery techniques and cold water survival from the point of view of training.

### **3.2 Classification society's standard requirements**

#### ***“Traditional” ship structural design standards***

The origins of most current commercial and naval ship structural design approaches can be found in the work of a number of mid-19th century pioneers, including Rankine, Smith and Reed. They developed methods of estimating hull girder bending loads due to waves, and also developed response criteria for bending and shear. Early iron-framed ships tended to have wooden decks and hulls, meaning that buckling did not become an issue. Formal approaches to buckling date from the 1940s to 1960s, and material property issues (notch toughness, weldability) started to be addressed systematically within the same timeframe. One hundred and fifty years of research and development, cross-fertilized by efforts in other engineering disciplines have been incorporated in commercial and naval ship design standards in somewhat different ways.

Most commercial ships are constructed under the Rules of a Classification Society, such as the American Bureau of Shipping (ABS), Det Norske Veritas (DnV), Lloyds Register (LR), Bureau Veritas (BV), Germanischer Lloyd (GL), etc. These and other classification societies developed, starting in the 19th Century, in order to meet the growing needs of both governments and commercial interests to ensure that ships were adequately reliable and safe. Initially, they largely focused on national interests and fleets (or imperial, in the case of LR and BV); and most were whole or semi-government controlled. More recently, the market for ship classification services has become international in nature (in most cases) and so the classification societies have become more independent of national ties. However, most classification societies retain strong links with maritime administrations in their home countries.

In keeping with their origins, classification society rules developed in some level of isolation from each other for many years, meaning that (for example) ABS, DnV and LR requirements for different areas of design were presented in very different ways and could lead to significantly different outcomes in terms of scantlings. As technologies developed (new ship types, faster operating speeds, replacement of rivets by welding), rules governing their use were introduced into the various Rules, extending their scope.

Advances in analytical methodologies have also been incorporated as they have been developed. For example, Lloyd Register's rule scantlings were proportional only to displacement, which led to decreasing factors of safety for larger ships.

Subsequently, the rules were modified to incorporate a more systematic treatment of wave bending. Similarly, local strength and stability rule requirements were initially based on successful past practice and “rules of thumb”; and modified as the state-of-the-art expanded.

However, some of the historical features were retained, making the rule systems a mixed bag of analytical and prescriptive requirements.

The differences in Rules systems, and organizational issues that influenced their application, led to differences in outcomes in terms of safety and reliability. Accordingly, a group of the leading Classification Societies formed the International Association of Classification Societies (IACS) in



1968. Naval vessel structural design requirements have evolved along parallel paths to commercial rules, but with differences in approach. Considerable emphasis has been given by classification societies to making their rules simple to understand and to apply. Standardized cases and approaches have been used wherever possible. Naval ship designers have been more accustomed to application-specific methods for load cases in particular. Similar response formulations are incorporated in most naval and commercial standards, although there have been some naval specific load cases with unusual response modes (e.g., blast and shock).

In recent years, navy organizations in the US, Canada, and the UK have come under increasing resource constraints, making it more difficult for them to maintain their in-house structural (and other) design criteria. There has thus been a move to delegate responsibility for standards development to the classification societies, as discussed below.

### ***Recent Structural Standards Development***

As noted previously, some recent convergence in classification society rule systems has been generated by IACS. IACS can trace its origins back to the International Load Line Convention of 1930 and its recommendations. The Convention recommended collaboration between classification societies to secure "*as much uniformity as possible in the application of the standards of strength upon which freeboard is based...*". Milestones towards achieving this included the formation in 1948 of the International Maritime Consultative Organization (now IMO), by the United Nations, and major conferences of the leading classification societies in 1939, 1955, and 1968. The last of these led to the formation of IACS, which has since developed more than 200 Unified Requirements (URs) and many Unified Interpretations and Recommendations of rule requirements.

IACS was given consultative status with IMO, and works closely with IMO (though with frequent tensions) to address structural and other safety issues through the development of new URs and by other mechanisms. Two notable models can be cited. Under the High-Speed Craft Code, IMO has left structural requirements at a very broad and performance-based level. The responsibility for the development of appropriate rules was left to the classification societies, each of which has developed its own approach. Conversely, in the new Guidelines for Ships Operating in Arctic Waters (Polar Code) IMO has specifically referenced new IACS URs for structural and mechanical design. Representatives of the national administrations and of the classification societies have been involved in the development of both the Guidelines and the URs.

Other important developments within the last decade have included the move towards the use of numerical analysis (FEA) to optimize scantlings, and the development of automated systems (ABS Safehull, DnV Nauticus, etc.) to generate and check most structural components. To some extent, these have led to less standardization amongst class, although in principle all structures should still comply with the intent of the relevant URs. The 'black box' classification society packages simplify the work of the average ship structural designer but do not encourage insight into the structural issues involved. The use of FEA also carries risk for the unwary and for the occasional user, and classification society guidance notes are an imperfect substitute for training and experience.

In the same time, numerous navies have recently been abandoning their in-house structural design standards and turning towards classification society naval ship rules (NSR).

These new rules have generally been developed in concert with the national classification society, and the ways in which naval and commercial requirements have been combined vary considerably. For example, the LR and GL naval ship rules are essentially customized versions of the general steel (commercial) ship rules. Procedures for certain specialized types of analysis (e.g., shock) are defined, but DnV, dealing with a smaller domestic navy and more export orientation, has used its high speed craft rules as the basis for the naval rules. ABS meanwhile has incorporated much more USN practice directly into its NSR system.

In parallel with these 'organizational' changes to standards and to their implementation, the ship rule systems have continued to incorporate some of the developments in the technical state-of-the-art.

Another recent development is the increased involvement of national and international standards organizations (ASTM, CSA, ISO) in the development of structural standards for ships and offshore structures. To date, these have gained only limited acceptance in the shipping community, but they represent increased competition for traditional rule systems.

The two key aspects that are to be found in these developments can be taken as new treatments of the mechanics of structures (load and strength models) and the treatment of uncertainty (probability models, risk reduction strategies). All developments are aimed at inserting more rational understanding into the process of specifying structural requirements.

Taken as a whole, there has been a piecemeal approach to structural design standards. As technical developments occur (models of various structural behaviors, risk methodologies), they have been incorporated into structural standards. Individuals and rule committees have framed their own rules with an emphasis on certain load/strength/failure models, coupled with some risk avoidance strategy (explicit or implicit). It is hardly surprising that various standards are different, even quite different. More, rather than fewer, concepts are available to those who develop structural standards. In the absence of a binding philosophy of structural behavior, there will continue to be divergence along the way to improved standards.

It must be appreciated that all current standards “work”. Any of the current naval and commercial ship design approaches can be used to produce structural designs that function with adequate reliability over a 20+ year life expectancy, unless subjected to poor maintenance, human operational error, or deliberate damage. Changes to standards are, therefore, resisted by all those who have invested time and effort in them as developers and users. The rationale for change must be presented well, and its benefits have to outweigh its costs.

Experienced designers recognize that structural behavior can be very complex. Despite this, it is necessary to use simple, practical approaches in design standards, to avoid adding to the problem through overly-complex rules that are difficult to apply and more so to check and audit.

Stress is the primary load-effect that standards focus on, partly because it is so readily calculated. The main concerns are material yielding, buckling and fatigue. All of these are local behaviors, and all are used as surrogates for actual structural failure. A structure is a system, comprised of elements, which in turn are built from materials.

As an example, yielding can be considered. Yielding is a material level ‘failure’, very common, usually very localized, and usually producing no observable effect. It can be quite irrelevant.

The important issue is the behavior and failure of the structural system, even at the level of the structural components. Ship structures are especially redundant structures, quite unlike most civil structures and buildings. Ship structures are exposed to some of the harshest loading regimes, yet are usually capable of tolerating extensive material and component failure, prior to actual structural collapse. An essential deficiency of all traditional structural standards has been the failure to consider the structural redundancy (path to failure) and identify weaknesses in the system. Areas of weakness are normally defined as those parts that will first yield or fail.

However, far more important is the ability of the structure to withstand these and subsequent local/material failures and redistribute the load. The real weaknesses are a lack of secondary load paths. It is often assumed, wrongly, that initial strength is a valid indicator for ultimate strength, and far simpler to assess. There is a need to focus on ways of creating robust structures, much as we use subdivision to create adequate damage stability.

### ***Design standards review***

While the focus is on ship structures, the review covers a wide variety of structural standards. Ship and non-ship structures as well as naval and civilian standards are compared. There are a variety of features that rules may contain. Modern rules vary mainly in the degree to which they employ various features.

All structural rule systems are intended to assure safe and reliable structures. As a ‘standard’, the rules provide the user with the collected knowledge and experience of the organization(s) and specialists

that produced the requirements. The rapid evolution of our technical knowledge and available data has resulted in the rapid evolution of design standards, and even in competition to produce standards that can provide their developer with some form of competitive advantage. At present there are multiple overlapping standards, and designers are frequently faced with having to satisfy at least a few, if not several standards.

Figure 3.1 is a sketch of the steps that are normally found in most ship structural standards. The preliminary design phase determines what the overall structural design problem is. Structural design follows the preliminary design. The first step in the structural design is the determination of the structural arrangements. As the sketch indicates, there are a variety of factors that control the structural arrangement. These include designers' intentions, as well as requirements from multiple standards (e.g., IMO, Class, and National authorities). Arrangement rules are one of the types of rules that we will consider.

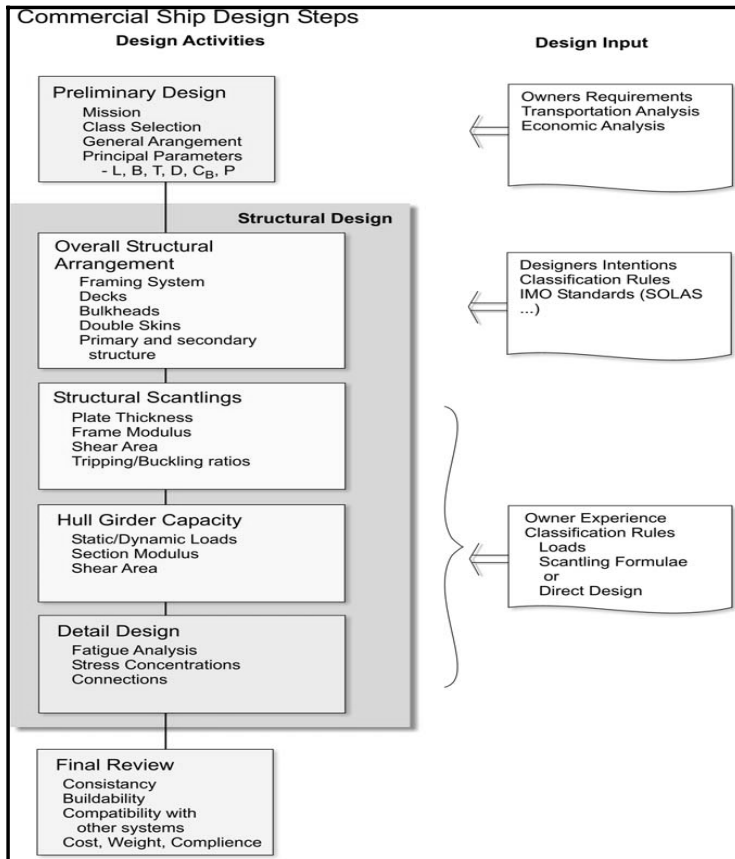
Following the structural arrangement, the usual next step is the determination of the scantlings. These are largely based on local strength requirements and primarily based (in most cases) on Class rules. The next step is to check and, if needed, to enhance the overall hull girder strength.

This is again mainly guided by Class rules. The final step is the design of details such as connections, openings and transitions. These details are guided by Class rules, general published guidance and by yard practices and experience. With this step completed, the structural drawings can be completed.

There is a final step that can affect the structural design. Structure must be reviewed for suitability in light of numerous other constraints. These include compatibility with other ship systems, maintainability, availability of materials and cost. Each step in the figure is part of a design spiral, and is repeated as necessary until a satisfactory result is achieved.

Figure is presented as a point of reference to facilitate discussion of various rule features. When thinking about structural rules, the focus is often on the numerical specifications for scantlings.

It is to these numerical specifications that safety factors and other risk measures can be formally applied. Yet there are many different types of components to be found in structural rules. There are suggestions and requirements for the structural arrangements (topology), type of analysis to be performed, and fixed limits on input or output values (minimum, maximum or both). It would seem that all such rule components are included for safety reasons, though some may simply be an expression of 'proper practice' for reasons of economy or other design goals. Regardless, these fixed and topological requirements certainly are as important to risk and performance as are the numerical quantities.



*Figure 3.1. Components of Rule-Based Ship Structural Design*

## Rule Features

Rule Feature	Description
1. Overall principles	The rule objectives and requirements are described in the broadest terms, as general aims for the designer.
2. Structural arrangement requirements	These requirements help to determine the structural layout and even the general arrangement. These requirements reflect concerns for stability (intact and damaged) and overall vessel safety. There are often overlapping requirements from Classification Society Rules and IMO conventions (SOLAS, MARPOL, and ILLC). (e.g. “in single hull ships the inner bottom is to be extended to ...”)
3. Structural scantling requirements	The scantling requirements are normally based on one or more of the following approaches: <ol style="list-style-type: none"> <li>1. specified requirements without explicit loads (<b>prescriptive rules</b>)</li> <li>2. mechanics-based requirements with reference to a design load, based on elastic stresses limits (<b>working stress rules</b>)</li> <li>3. mechanics-based requirements, usually based on elastic stresses, but with factors accounting for load and strength variability and target risk levels (<b>LRFD rules</b> – load and resistance factored design)</li> <li>4. specification of preferred theories, approaches and analytical methods to be used in a “first principals” structural strength assessment (<b>first principles rules</b>)</li> <li>5. newer approaches are being developed which often combine elements of the above with more refined risk and mechanics simulations. (<b>simulation based rules</b>)</li> </ol> Note: there is certainly overlap among these rule approaches. The general level of complexity of the rules steadily increases from 1 to 5.
4. Hull Girder requirements	The hull girder requirements may follow one of the five approaches described above, though not necessarily the same one as used for the local structure. The hull girder design is a special issue within all ship rules, due to the critical importance of the topic. Design may be based on either allowable stress or ultimate limit state design. In either case there may be a probabilistic approach for wave loads determination. Wave loads for commercial rules are normally based on IACS Unified Requirement.
5. Detail requirements	These requirements are used to avoid local stress concentrations and to prolong ship’s fatigue life.
6. Suggestions	Most rules contain suggestions and guidance notes based on experience and good shipbuilding practice, and are often worded as to allow flexibility (e.g., “the user may...” or “ shall preferably be...”)
7. Cautions	Cautions are strict requirements usually of a non-numerical feature. These are worded to limit the design options (e.g., “point loads acting on secondary stiffeners are to be considered when...”)

*Table 3.1. Rule features found in most structural standards*

## Chapter IV Integration of safe concept and operation in ship design process

### *4.1 Marine technology and human factor*

The Human Element has long been recognized as important to marine safety. This recognition has led to developments in the approach to ship design and the introduction of classification Rules for key aspects such as for Integrated Bridge Systems, Habitability and the application of ergonomic principles to machinery control station arrangements. There have been similar developments in the last few years affecting manning and ship operation, including introduction of the International Safety Management (ISM) and major changes to the Standards for Certification and Training of Watchkeepers (STCW).

The operational context is changing. The seafarer population is changing in terms of background, culture and skill set. Crew complements are reducing. Ship and equipment design is changing, with increased adoption of computer-intensive technology. It is not obvious that these independent developments are compatible.

Shipping, like other industrial activities, is in transition between an approach to specification and regulation based on detailed prescriptive statements and an 'open textured' approach based on goal-setting. The increasing adoption of system engineering approaches in a number of other sectors is in response to a similar trend. A related development on the commercial front in other sectors is the move away from hands-off procurement to supply chain management.

Apart from the changing skill patterns in ship operation mentioned above, there are changes in the operator community. Anecdotal evidence suggests that ship bridge crews are going through a similar change to that noted in aircraft cockpits. Older, but apparently more experienced, operators may not fully appreciate the capabilities and demands of the current technology but in an emergency would concentrate on the fundamentals of the situation. Conversely, younger, apparently less experienced operators would attempt to 'fix the computer' and not look out of the window.

There are, also, changes in other agencies that have a significant role in assuring maritime safety. The surveyor and auditor population is changing. The design community is now under greater time pressure than ever, also with much more automation, and anecdotal evidence suggests that more obvious mistakes are getting through the system and being delivered to the operators.

In a number of ways, shipping is responding to the issue of extensive automation later than other sectors. For example, the process industries responded to earlier incidents such as Flixborough and Three Mile Island. It may be possible, therefore to learn from experience in other sectors.

Adding automated monitoring, such as smart alarm systems, can be useful but brings other problems and ironies of automation. There is now a considerable literature and body of experience that addresses the problems of automated systems, notably the problems of 'clumsy automation' that is 'strong, silent and difficult to direct'.

The increasing commercial pressures on each part of the marine industry will make interfaces between them less compatible without external influence e.g. from regulation. The need for an integration role (other than by the user) is recognized, but it is unlikely to happen on its own.

Human variability and adaptability make detailed prescription particularly difficult for areas affected by the human element. For situations where there is any significant change in the manning, technology or type of operation, there are major difficulties with producing detailed prescriptive design specifications. Any solution of manning, documentation and procedures, user interface design and platform design can only be judged as correct against a context of use. The specification of fitness for purpose for the human element cannot be generic.

The principles to be followed in design, development and operation are known. The means to deliver a process and principles based solution that can take account of context of use exist. However, present approach to statutory regulation and within the Rules of classification societies, which form an essential part of the overall safety regulatory process, are prescriptive. In a prescriptive approach, the

owner and regulator need to understand requirements decomposition at all levels (e.g. from ship operation to equipment part numbers). The owner retains both business and technical risks. In return, he retains control over all aspects of the job. This can simplify the specification of implementations that are sub-optimal for the project in hand, but which enable a more optimized solution at the level of the client business. For example, the equipment may not be the best for this particular contract, but it is the equipment being used on other contracts and this choice simplifies support. The job of the supplier is relatively straightforward. Suppliers have evolved a skill base, culture and costing strategy based on straightforward compliance with specific requirements. For monitoring and acceptance in a contractual or regulatory setting, the prescriptive approach has the advantage that inspection is largely at the lowest implementation level, and comprises a series of simple checks. This may be a long series of checks.

The disadvantages arise because the specification is inevitably imperfect. Areas subject to rapid operational or technological change also suffer severely from this approach.

A goal-setting approach to procurement offers benefits to situations with an informed purchaser and an intelligent supplier. Similar benefits accrue to a situation with an informed regulator and an intelligent supplier or operator. The prospective owner specifies what he wants at the level of his business, in high-level ship operation terms. He retains the business risk. The supply chain translates this specification into something that is designed and delivered. The supplier retains the technical risks of implementation. Given an intelligent supply chain, this approach enables each level of supply to optimize the solution in its own area of expertise. The aim is that the client does no more work than is necessary, carries no more risk than is necessary and the suppliers are given maximum opportunity to innovate (gain market share) or to take profit. Appropriately supported, this approach minimizes the information exchanges as requirements and implementation evolve.

The disadvantages of this approach are:

- There is the risk that a non-intelligent supplier is selected for some part of the supply chain.
- There is the risk that the high-level requirement is misunderstood because of its abstract nature.
- In some markets, the number of intelligent suppliers may be very limited, restricting the client's ability to run a competition, with an inevitable increase in price.
- The ability of the client to monitor progress of the implementation may be limited.

There are mitigations for all of the above disadvantages, but they represent deterrents to adoption for much of the marine sector, posing an obstacle to broad adoption of Human System Integration.

Examples of goals and prescriptive requirements relating to the new SOLAS V Regulation 15 'Principles relating to bridge design, design and arrangement of navigational systems and equipment and bridge procedures' follow, in approximate order of abstraction: *Principle requiring an effective interface between the various agencies.*

The Regulation addresses designers, manufacturers and shipowners with respect to the bridge design and layout. However, the responsibility for ensuring correct bridge procedures are adopted lies with the Master. Facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions.

Minimizing the risk of human error and detecting such error if it occurs, through monitoring and alarm systems, in time for the bridge team and the pilot to take appropriate action. Enabling the bridge team and the pilot to have convenient and continuous access to essential information, which is presented in a clear and unambiguous manner, using standardized symbols and coding systems for controls and displays.

*Design principles (still requiring interpretation for the context of use).* Indicating the operational status of automated functions and integrated components, systems and/or sub-systems. It should be possible from this place to operate the ship safely, in particular when a fast sequence of actions is required.

*Design principles requiring limited interpretation of the context of use.* The height of the lower edge of the front windows should allow a forward view over the bow for a person in a sitting position at the

workstation for navigating and maneuvering and the workstation for monitoring. The console should be dimensioned and configured so that all relevant controls can be reached from a sitting position.

*Prescriptive design requirements that can be checked with no specific reference to the context of use.* There should be a field of vision around the vessel of 360° obtained by an observer moving within the confines of the wheelhouse.

Achieving the successful interfaces between the various agencies will represent a significant step forward. It will be necessary to find ways of demonstrating that the higher level principles are met. It will not be sufficient to assume that by meeting the various prescriptive design requirements, the higher level principles will be met.

#### ***4.2 Integration of variable elements into ship design process***

To understand the role that human factors engineering might and indeed should, play in preliminary ship design, it is necessary to set some boundaries on what is being addressed by the term preliminary ship design and what is intended by the application of human factors issues in the context of the preliminary design of physically large and complex entities such as naval combatants.

Ship design, has been stated to be a paradigm for the design of other large complex constructions; this is because of the characteristics of ships as physically large, multi-role, self-sufficient, inhabited (with high density) and mobile environments, together with the peculiar nature of their made-to-order and politicized design process. Design on such a grand scale with a high degree of inherent complexity, involves the assembly of a multitude of interacting and interdependent subsystems and the necessity to compromise between a wide variety of specific requirements, which are often conflicting therefore requiring tailored engineering solutions.

As an example of the complexity levels of the investigation in the research, some of the main characteristics typical of combatant ships are listed below:

- Technology dense,
- Equipment rich,
- Operationally intensive,
- Hazardous enclosures (e.g. fuel tanks and ammunition storage)
- Potential targets during war and terrorist attacks,
- Inhabited (with high population density),
- Mobile and self-sufficient,
- Physically large, but confined enclosures,
- Versatile and multi-role (changing scenarios and theatres of operation),
- Adaptable and usable in unforeseen roles,
- Used in extremely variable environmental conditions,
- Subject to rapid obsolescence (e.g. strategical and technological),
- Maintainable and upgradeable in time (systems, sub-systems and layout),
- Very expensive (e.g. design, manufacturing and through life costs).

In addressing the inherent complexity of ships, drawn attention the fact that the overall design process and, importantly, the initial design synthesis, is not a single invariant process common to all ships or other complex entities. This is true even when considering each of the intermediate steps and iterations constituting the design process. For example, even restricting the focus of the application of simulation techniques to the initial design of large scale products, it is difficult to recommend the use of a single simulation method with generic validity and applicability to a whole range of similarly large and complex entities.

The technical complexity of ships and their design process is comparable to the computational complexity of software packages used to perform simulations and to the procedural aspects of the use of such software. This is particularly true when considering software used to perform personnel movement simulation.



In general, computer-assisted simulation tools reproduce a system in a digital model, analyze its behavior over a certain domain (usually, time) and in a definite dimension (i.e. taking into account a limited number of factors) by understanding the interactions between the model's components. Simulation, in this context, gives the opportunity of understanding, forecasting and controlling, as well as undertaking trial-and-error studies on a model in a risk free environment. This represents a significant advantage for many disciplines as it provides the insight into the way a system will behave before it is actually built and without the need to produce a physical prototype. In several fields (e.g. industrial scale product design) simulation leads to significant benefits when compared to the use of prototypes (e.g. eliminating the cost of building and testing prototypes), in some other it may be indispensable in achieving the desired level of confidence in the design (e.g. consumer products). The benefits of using simulation are even more evident in the case of design on a grand scale and, for example, of the marine industry, where the construction of a full scale prototype is economically rarely justified.

There is also a need to consider how and when to undertake simulation in design which is a particularly relevant matter when considering this step in the context of human factor simulation and preliminary design. Aside from considerations of verification of compliance with standards and regulations, the decision to apply simulation tools to the design model, in general, could be seen as being governed by the minimum level of design definition appropriate for the application of the intended simulation technique or tool. Simulation techniques and the associated software tools are usually applied to a design once the design is largely defined and the process involves the concurrent input of many players from various disciplines rather than the few designers at the concept phase. Late in the design process simulation is used to quantify and/or assess the performance of the design against a set of specific design requirements. Should problems be revealed by a specific simulation, it is then likely to be far too late and extremely costly to rethink the design to resolve them. Instead, rather than considering the origins of the problems encountered (i.e. the root causes), it seems to be common practice to manually modify the system, for example, eliminating the non-compliances or, at least, diminishing their consequences. Thus, the modifications to the design are generally of a local nature (i.e. limited to the area of the design where the weakness is identified or, better, where the downstream consequences of a problem manifest themselves) and the resulting design certainly could be seen as a sub-optimal compromise since the root causes of the problems may well remain unaddressed. Inevitably, as a result of this concentration on mitigating the effects of a given set of problems rather than on resolving their original causes, compromise or remedial solutions are adopted.

The above consideration reinforces the contention that simulation should start in preliminary design not only to save on costs, but also to enable the early identification, addressing and resolving of the fundamental design problems. This would then reduce the risk compromising performance in later stages of the design process. With this perspective, the research has considered whether and to what level this early integration of simulation in preliminary ship design is possible in the case of simulating personnel movement evolutions.

To further clarify the complexity involved in the ship design process and to draw attention to the crucial importance of its preliminary stages, it is necessary to give a brief description of how the process of design progressively develops from its initiation. Usually, the ship design process is initiated by the owner's needs and, at the outset, the task takes the form of an exchange of ideas between the designer and the 'requirements owner'.

This discussion is informed by a range of suitable design options identified and assessed through design explorations, investigations and finally trade-off studies. Once the requirement is clarified and commitment to proceed obtained, then an increasingly more detailed working up of the design by a substantial and expanding multidisciplinary team can proceed to lead on the production of a design definition capable of being manufactured, constructed and assembled. Later phases of design require comprehensive design management procedures and are constrained by the early design decisions made on overall configuration and other important aspects which are best identified as associated with the term 'style'. The term "Style", in this context, refers to a wide range of issues not all of which are

amenable to numerical investigation, particularly in the early stages of design. Examples of stylistic choices include survivability standards, the overall architecture of propulsive machinery and margin policy. A broad range of issues can be incorporated in the definition of the “style” of the design, including: personnel movement, ease of outfitting, functional flexibility (adaptability) and location, layout and sizing of critical spaces such as the *Bridge*, *Ship Control Centre*, *Operations Room*, machinery spaces, accommodation and the main access routes linking them.

In large scale design the more detailed design phases are undertaken and managed by disaggregating the whole design into discrete subsets and assigning their refinement to different teams of specialist engineers and designers while the naval architectural team ensures the maintenance of the balanced ship design intent.

A balanced ship design refers to a naval architecturally balanced design where the design is balanced in the traditional aspects of primary ship performance, both in its technical and configuration features. Considering the pervasive use of computer aided design tools and the growing necessity of exchanging large volumes of information to improve concurrent engineering between teams from different disciplines, the use in the final design for production phase of computer based integrated product data environments and integrated product models is intensifying.

The downstream design work is characterized by numerous design decisions which have limited impact on the totality of the integrated model features and thus the overall design concept emerges as essentially determined in its main characteristics from preliminary design. This reinforces the importance of the decisions taken during the initial stages of design and emphasizes that they constrain the final solution. This also justifies the research presented here, specifically focusing on the integration of simulation techniques into initial design. However, this does mean that initial design needs to be more descriptive than traditionally has been the case.

The advantages of such an early integration are discussed as well as ways to effectively take into account those aspects, such as ship-scale ergonomics and operability, which previously have been difficult to address in the initial phase.

### **4.3 Ship complex systems management**

Shipping market volatility, energy prices, existing and upcoming environmental regulations, and anticipated climate change are all driving the maritime industry towards the adoption of more cost-effective and environmentally friendly operations and technologies. This has a significant impact on the entire machinery system of the ship, which is often pushed to the design limit, thereby imposing an increasing degree of sophistication and complexity.

Computer-aided methodologies can successfully address the increasing complexity of integrated marine systems. To maximise the benefit, however, a shift of focus is required: from components to systems. New approaches, methods and tools have to be adopted for marine systems’ configuration, design, operation and control that consider machinery and energy conversion from the integrated systems’ perspective.

Rising fuel costs, environmental concerns and upcoming emissions’ regulations impose a pressure on ships to operate in a more efficient, cost-effective and environmentally friendly way. In addition, anticipated climate change is high on the international agenda and means to reduce global CO<sub>2</sub> emissions in order to achieve stabilisation at 2 °C mean global temperature increase are discussed. For shipping, however, this can prove to be challenging as future seaborne CO<sub>2</sub> emissions are expected to rise.

The propulsion power and energy conversion on-board installation – i.e., the marine energy system – is the main contributor to the overall emission footprint, cost effectiveness and efficiency of a vessel. To meet these stringent and often contradictory requirements, the sophistication and, hence, complexity of modern marine energy systems increase, often operating close to the design limit. Emerging and future powering components, like fuel cells, batteries, or even renewable auxiliary sources, will result in even more complex configurations. At the same time, simultaneous assessment

of performance, safety, and reliability of marine systems, especially under real service conditions and transient operation modes, is becoming increasingly important for the shipping industry.

Traditional methods for improving efficiency focus on the optimization of individual components. With today's maturity of equipment technology, to achieve measurable efficiency improvements in existing and new marine energy systems, new approaches must be adopted for systems configuration, design, operation and control that consider machinery and energy conversion from a lifecycle, integrated systems' perspective.

Systems Engineering is a methodological approach to the design, implementation and operation of complex technical systems. These methodologies focus on the interactions of the constituents of the system, how they are interconnected, and what is their influence on the overall behaviour and/or performance of the system. In other words, this methodology is a way of looking at the "big picture" when making technical decisions.

Systems engineering is a multidisciplinary field lying at the intersection of several disciplines, including engineering, mathematics, physics, computer science and management. The need for systems engineering approaches arises from the fact that new technologies and modern engineering systems are becoming increasingly complex. They exhibit simultaneous growth in hardware and software complexity, operational sophistication with advanced control and automation, processing of larger amounts of data, all in an environment of entirely new market dynamics and innovative business models. A centreline in these approaches is the use of mathematical models and computer-based methods and tools that enable better comprehension and management of the embedded complexity in today's systems. This computer-aided approach is often termed as Model-Based Systems Engineering. Many industries have adopted model-based systems engineering approaches and have successfully incorporated them into their normal operational and/or business practices; for instance, aeronautics, defence, electronics, chemical/ processing, oil & gas, and space exploration. In addition, due to its successful track record and the intrinsic potential benefits, this approach is a quite active research field in both the academia and the industry, ranging from the nano- and micro-scale to enterprise-wide supply chain management.

In the shipping industry, modelling and simulation approaches have been rarely used in commercial shipping, being mainly focused on naval/defence applications.

On the other hand, computer-aided methods and tools are broadly applied in naval architecture and marine engineering. A common characteristic of these applications is that they mainly concentrate either on specific processes or components. At the individual component level, in particular, modelling technologies are mature, accurate, and robust.

Thus, the introduction of systems-level modelling, simulation and optimization approaches to the marine industry appears to be the next logical step towards managing the increasing complexity of marine systems, vessels, and structures. Recent/emerging approaches towards this direction include integrated methods on specific fields, such as: ship design, marine systems' control, and ship production/structural Finite Element Method analysis.

## Chapter V

### Safety assessment methodology

#### 5.1 Introduction in formal safety assessment

Formal Safety Assessment (FSA) is a structured and systematic methodology, aimed at enhancing maritime safety, including protection of life, health, the marine environment and property, by using risk analysis and cost benefit assessment.

Formal Safety Assessment can be used as a tool to help in the evaluation of new regulations for maritime safety and protection of the marine environment or in making a comparison between existing and possibly improved regulations, with a view to achieving a balance between the various technical and operational issues, including the human element, and between maritime safety or protection of the marine environment and costs.

Formal Safety Assessment should comprise the following steps:

- identification of hazards;
- risk analysis;
- risk control options;
- cost benefit assessment;
- recommendations for decision-making.

The process begins with the decision makers defining the problem to be assessed along with any relevant boundary conditions or constraints. These are presented to the group who will carry out the Formal Safety Assessment and provide results to the decision makers for use in their resolutions. In cases where decision makers require additional work to be conducted, they would revise the problem statement or boundary conditions or constraints, and resubmit this to the group and repeat the process as necessary. Within the Formal Safety Assessment methodology, step 5 interacts with each of the other steps in arriving at decision-making recommendations. The group carrying out the Formal Safety Assessment process should comprise suitably qualified and experienced people to reflect the range of influences and the nature of the event being addressed.

The depth or extent of application of the methodology should be commensurate with the nature and significance of the problem; however, experience indicates that very broad Formal Safety Assessment studies can be harder to manage. To enable the Formal Safety Assessment to focus on those areas that deserve more detailed analysis, a preliminary coarse qualitative analysis is suggested for the relevant ship type or hazard category, in order to include all aspects of the problem under consideration. Whenever there are uncertainties, e.g. in respect of data or expert judgement, the significance of these uncertainties should be assessed.

Characterization of hazards and risks should be both qualitative and quantitative, and both descriptive and mathematical, consistent with the available data, and should be broad enough to include a comprehensive range of options to reduce risks.

A hierarchical screening approach may be utilized. This would ensure that excessive analysis is not performed by utilizing relatively simple tools to perform initial analyses, the results of which can be used to either support decision-making (if the degree of support is adequate) or to scope/frame more detailed analyses (if not). The initial analyses would therefore be primarily qualitative in nature, with recognition that increasing degrees of detail and quantification will come in subsequent analyses as necessary.

A review of historical data may also be useful as a preparation for a detailed study. For this purpose a loss matrix may be useful.

The availability of suitable data necessary for each step of the Formal Safety Assessment process is very important.

When data are not available, expert judgment, physical models, simulations and analytical models may be used to achieve valuable results. Consideration should be given to those data which are already available at IMO (e.g. casualty and deficiency statistics) and to potential improvements in those data in anticipation of an Formal Safety Assessment implementation (e.g. a better specification for recording relevant data including the primary causes, underlying factors and latent factors associated with a casualty).

Data concerning incident reports, near misses and operational failures may be very important for the purpose of making more balanced, proactive and cost-effective legislation. Such data must be reviewed objectively and their reliability, uncertainty and validity assessed and reported. The assumptions and limitations of these data must also be reported.

However, one of the most beneficial qualities of Formal Safety Assessment is the proactive nature. The proactive approach is reached through the probabilistic modelling of failures and development of accident scenarios. Analytical modelling has to be used to evaluate rare events where there is inadequate historical data. A rare event is decomposed into more frequent events for which there is more experience available (e.g. evaluate system failure based on component failure data). Equally, consideration should also be given to cases where the introduction of recent changes may have affected the validity of historic data for assessing current risk.

The use of expert judgment is considered to be an important element within the FSA methodology. It not only contributes to the proactive nature of the methodology, but is also essential in cases where there is a lack of historical data. Further historical data may be evaluated by the use of expert judgment by which the quality of the historical data may be improved.

In applying expert judgment, different experts may be involved in a particular FSA study. It is unlikely that the experts' opinions will always be in agreement. It might even be the case that the experts have strong disagreements on specific issues. Preferably, a good level of agreement should be reached. It is highly recommended to report the level of agreement between the experts in the results of an Formal Safety Assessment study. It is important to know the level of agreement, and this may be established by the use of a concordance matrix or by any other methodology.

The purpose of problem definition is to carefully define the problem under analysis in relation to the regulations under review or to be developed. The definition of the problem should be consistent with operational experience and current requirements by taking into account all relevant aspects. Those which may be considered relevant when addressing ships (not necessarily in order of importance) are:

- ship category;
- ship systems or functions;
- ship operation;
- external influences on the ship.

## ***5.2 Applying of formal safety assessment in shipping industry***

### ***Identification of hazards***

The purpose of this step is to identify a list of hazards and associated scenarios prioritized by risk level specific to the problem under review. This purpose is achieved by the use of standard techniques to identify hazards which can contribute to accidents, and by screening these hazards using a combination of available data and judgement. The hazard identification exercise should be undertaken in the context of the functions and systems generic to the ship type or problem being considered.

The approach used for hazard identification generally comprises a combination of both creative and analytical techniques, the aim being to identify all relevant hazards. The creative element is to ensure that the process is proactive and not confined only to hazards that have materialized in the past. It typically consists of structured group reviews aiming at identifying the causes and effects of accidents and relevant hazards. Consideration of functional failure may assist in this process. The group carrying out such structured reviews should include experts in the various appropriate aspects, such as ship design, operations and management and specialists to assist in the hazard identification process and

incorporation of the human element. A structured group review session may last over a number of days. The analytical element ensures that previous experience is properly taken into account, and typically makes use of background information.

A coarse analysis of possible causes and outcomes of each accident category should be carried out by using established techniques, to be chosen according to the problem in question.

The identified hazards and their associated scenarios relevant to the problem under consideration should be ranked to prioritize them and to discard scenarios judged to be of minor significance.

The frequency and consequence of the scenario outcome requires assessment. Ranking is undertaken using available data, supported by judgement, on the scenarios. The frequency and consequence categories used in the risk matrix have to be clearly defined. The combination of a frequency and a consequence category represents a risk level.

The output from this step comprises:

- a list of hazards and their associated scenarios prioritized by risk level;
- a description of causes and effects.

### ***Risk analysis***

The purpose of the risk analysis is a detailed investigation of the causes and consequences of the more important scenarios identified in step. This can be achieved by the use of suitable techniques that model the risk. This allows attention to be focused upon high risk areas and to identify and evaluate the factors which influence the level of risk.

Different types of risk should be addressed as appropriate to the problem under consideration.

The construction and quantification of fault trees and event trees are standard risk assessment techniques that can be used to build a risk model. An example of a conceptual risk model is the Risk Contribution Tree. Whilst the example makes use of fault and event tree techniques, other established methods (e.g. Bayesian network) could be used, if appropriate.

Quantification makes use of accident and failure data and other sources of information as appropriate to the level of analysis. Where data is unavailable, calculation, simulation or the use of recognized techniques for expert judgement may be used.

The output comprises the identification of the high risk areas which need to be addressed.

### ***Risk control options***

The purpose of this step is to propose effective and practical risk control options and comprises the following four principal stages:

- focusing on risk areas needing control;
- identifying potential risk control measures;
- evaluating the effectiveness of the risk control measures in reducing risk by re-evaluating previous step;
- grouping risk control measures into practical regulatory options.

Present step aims at creating risk control options that address both existing risks and risks introduced by new technology or new methods of operation and management. Both historical risks and newly identified risks should be considered, producing a wide range of risk control measures. Techniques designed to address both specific risks and underlying causes should be used.

The purpose of focusing risks is to screen the output of risk analysis so that the effort is focused on the areas most needing risk control. The main aspects to making this assessment are to review:

- risk levels, by considering frequency of occurrence together with the severity of
- outcomes. Accidents with an unacceptable risk level become the primary focus;
- probability, by identifying the areas of the risk model that have the highest probability of occurrence. These should be addressed irrespective of the severity of the outcome;
- severity, by identifying the areas of the risk model that contribute to highest severity outcomes. These should be addressed irrespective of their probability;

- confidence, by identifying areas where the risk model has considerable uncertainty either in risk, severity or probability. These uncertain areas should be addressed.

Structured review techniques are typically used to identify new risk control measures for risks that are not sufficiently controlled by existing measures. These techniques may encourage the development of appropriate measures and include risk attributes and causal chains. Risk attributes relate to how a measure might control a risk, and causal chains relate to where, in the “initiating event to fatality” sequence, risk control can be introduced.

The prime purpose of assigning attributes is to facilitate a structured thought process to understand how an risk control measure works, how it is applied and how it would operate. Attributes can also be considered to provide guidance on the different types of risk control that could be applied. Many risks will be the result of complex chains of events and a diversity of causes. For such risks the identification of risk control measures can be assisted by developing causal chains which might be expressed as follows:

*causal factors → failure → circumstance → accident → consequences*

Risk control measures should in general be aimed at one or more of the following:

- reducing the frequency of failures through better design, procedures, organizational polices, training, etc;
- mitigating the effect of failures, in order to prevent accidents;
- alleviating the circumstances in which failures may occur;
- mitigating the consequences of accidents.

The purpose of this stage is to group the risk control measures into a limited number of well thought out practical regulatory options. There is a range of possible approaches to grouping individual measures into options. The following two approaches, related to likelihood and escalation, can be considered:

- general approach. which provides risk control by controlling the likelihood of initiation of accidents and may be effective in preventing several different accident sequences;
- distributed approach. which provides control of escalation of accidents, together with the possibility of influencing the later stages of escalation of other, perhaps unrelated, accidents.

In generating the risk control options, the interested entities, who may be affected by the combinations of measures proposed, should be identified.

Before adopting a combination of risk control options for which a quantitative assessment of the combined effects was not performed, a qualitative evaluation of risk control options interdependencies should be performed.

The output from risk control option step comprises:

- a range of risk control options which are assessed for their effectiveness in reducing risk;
- a list of interested entities affected by the identified risk control options;
- a table stating the interdependencies between the identified risk control options.

### ***Cost benefits assessment***

The purpose of this step is to identify and compare benefits and costs associated with the implementation of each risk control option identified and defined in the previous step. A cost benefit assessment may consist of the following stages:

- consider the risks assessed in risk analysis, both in terms of frequency and consequence, in order to define the base case in terms of risk levels of the situation under consideration;
- arrange the risk control options, defined before, in a way to facilitate understanding of the costs and benefits resulting from the adoption of an risk control option;
- estimate the pertinent costs and benefits for all risk control options;

- estimate and compare the cost effectiveness of each option, in terms of the cost per unit risk reduction by dividing the net cost by the risk reduction achieved as a result of implementing the option; and
- rank the risk control options from a cost-benefit perspective in order to facilitate the decision-making recommendations in the next step (e.g. to screen those which are not cost effective or impractical).

Costs should be expressed in terms of life cycle costs and may include initial, operating, training, inspection, certification, decommission etc. Benefits may include reductions in fatalities, injuries, casualties, environmental damage and clean-up, indemnity of third party liabilities, etc. and an increase in the average life of ships.

The evaluation of the above costs and benefits can be carried out by using various methods and techniques. Such a process should be conducted for the overall situation and then for those interested entities which are the most influenced by the problem in question.

The output from this step comprises:

- costs and benefits for each risk control options identified in previous step from an overview perspective;
- costs and benefits for those interested entities which are the most influenced by the problem in question; and
- cost effectiveness expressed in terms of suitable indices.

### ***Recommendation for decision-making***

The purpose of present step is to define recommendations which should be presented to the relevant decision makers in an auditable and traceable manner. The recommendations would be based upon the comparison and ranking of all hazards and their underlying causes; the comparison and ranking of risk control options as a function of associated costs and benefits; and the identification of those risk control options which keep risks as low as reasonably practicable.

The basis on which these comparisons are made should take into account that, in ideal terms, all those entities that are significantly influenced in the area of concern should be equitably affected by the introduction of the proposed new regulation. However, taking into consideration the difficulties of this type of assessment, the approach should be, at least in the earliest stages, as simple and practical as possible.

The output comprises:

- an objective comparison of alternative options, based on the potential reduction of risks and cost effectiveness, in areas where legislation or rules should be reviewed or developed;
- feedback information to review the results generated in the previous steps.



## Chapter VI

### Reliability based design in ship building

#### 6.1 Reliability-based design

The development of reliability-based design criteria for ship structure needs to consider the following three components: loads, structural strength, and methods of reliability analysis. The methodology for reliability-based design of ship structures consists of the following two approaches: direct reliability-based design, and load and resistance factor design rules. According to this methodology, loads can be linearly or nonlinearly treated. Also in assessing structural strength, linear or nonlinear analysis can be used. The reliability assessment and reliability-based design can be performed at several levels of a structural system, such as at the hull-girder, grillage, panel, plate and detail levels. A rational treatment of uncertainty is suggested by considering all its types. Also, failure definitions can have significant effects on the assessed reliability, or resulting reliability-based designs. The method for defining and classifying failures at the system level considers the continuous nature of redundancy in ship structures. The direct reliability-based design approach can include both Level 2 and/or Level 3 reliability methods. Level 2 reliability methods are based on the moments (mean and variance) of random variables and sometimes with a linear approximation of nonlinear limit states, whereas, Level 3 reliability methods use the complete probabilistic characteristics of the random variables. In some cases, Level 3 reliability analysis is not possible because of lack of complete information on the full probabilistic characteristics of the random variables. Also, computational difficulty in Level 3 methods sometimes discourages their uses. The load and resistance factor design approach is called a Level 1 reliability method. Level 1 reliability methods utilize partial safety factors that are reliability based; but the methods do not require explicit use of the probabilistic description of the variables.

**Direct reliability-based design.** The direct reliability-based design method uses all available information about the basic variables, including correlation and does not simplify the limit state in any manner. It requires performing spectral analysis and extreme analysis of the loads. In addition, linear or nonlinear structural analysis can be used to develop a stress frequency distribution. Then, stochastic load combinations can be performed. Linear or nonlinear structural analysis can then be used to obtain deformation and stress values. Serviceability and strength failure modes need to be considered at different levels of the ship. The appropriate loads, strength variables, and failure definitions need to be selected for each failure mode. Using reliability assessment methods such the first-order reliability method (FORM), reliability indices for all modes at all levels need to be computed and compared with target reliability indices. In this condition, it is assumed all the random variables in the limit state equation to have normal probability distribution and the performance function is linear. However, in practice, it is common to deal with nonlinear performance functions with a relatively small level of linearity.

**Load and resistance factor design.** The second approach of reliability-based design consists of the requirement that a factored (reduced) strength of a structural component is larger than a linear combination of factored (magnified) load effects. In this approach, load effects are increased, and strength is reduced, by multiplying the corresponding characteristic values with factors, which are called strength and load factors, respectively, or partial safety factors. The characteristic value of some quantity is the value that is used in current design practice, and it is usually equal to a certain percentile of the probability distribution of that quantity. The load and strength factors are different for each type of load and strength. Generally, the higher the uncertainty associated with a load, the higher the corresponding load factor; and the higher the uncertainty associated with strength, the lower the corresponding strength factor. These factors are determined probabilistically so that they correspond to a prescribed level of reliability or safety. It is also common to consider two classes of performance function that correspond to strength and serviceability requirements.

The difference between the allowable stress design and the load and resistance factor design format is that the latter use different safety factors for each type of load and strength. This allows for taking into consideration uncertainties in load and strength, and to scale their characteristic values accordingly in the design equation. Allowable stress design, or called working stress, formats cannot do that because they use only one safety factor.

In the load and resistance factor design format, ship designers can use the load and resistance factors in limit-state equations to account for uncertainties that might not be considered properly by deterministic methods without explicitly performing probabilistic analysis. This format is concerned mainly with the structural design of ship hull girders under combinations of different load effects. The intention is to provide naval architects and ship designer with reliability-based methods for their use in both early and final design stages and for checking the adequacy of the scantlings of all structural members contributing to the longitudinal transverse strength of ships.

**Reliability checking.** The load and resistance factor design methods also provide formats for reliability, or safety, checking for various types of hull structural elements. In order to perform a reliability checking on these elements, the computed reliability safety index resulting from reliability assessment using methods like first-order reliability method, should not be less than the target safety index. Reliability checking for different classes of ship structural elements can also be performed using the general form of the load and resistance factor design format.

## ***6.2 Current practice in reliability-based design of ship structure***

Ships service life can vary from 30 to 50 years. Recent ship operability ranges from 25 to 30%. The ships service life is guaranteed by minimizing the likelihood of fatigue cracks. Extensive cracking could lead to early decommissioning of the ship. Minimizing the likelihood of fatigue cracks has the added benefit of reduction maintenance cost and reducing the likely hood of mission disruption. The likelihood of fatigue cracks is minimized by controlling hull girder seaway stress ranges based on the fatigue strength of the ship's structural details.

The emphasis of this practice is on reduced maintenance and manning. The trend is to design for production even though this usually means heavier structure. In terms of environment, ships are designed for world wide operations so extended periods in the open ocean and the arctic are all possibilities.

A fatigue allowable stress range must be tied to the ship's lifetime bending moments. The lifetime bending moments represent the magnitude and number of vertical bending moments expected during the ships service life. These bending moments included those due to changes in wave height and slam induced whipping. Ship speed and heading probabilities, wave height and whipping probabilities, ship characteristics, service life, operating time and area impact the lifetime bending moments. The fatigue allowable stress range is calculated using cumulative damage rule, the ship's lifetime bending moments, and the fatigue strength of the critical structural detail. This rule is a widely accepted method for calculating damage resulting from cyclic stress. The fatigue allowable stress range replaces the traditional design primary stress envelope.

The current design criteria utilize a standard wave for determining primary stresses. Developed over forty years ago, this approach was established at a time when high speed computers were not available and nor was our understanding of physical oceanography or applied statistics as advanced as they are today. Similarly, the methods available for predicting structural response were not available.

The standard wave approach determines the design bending moment by statically balancing the ship on a trochoidal wave whose length is equal to the ship length. The stresses derived from this bending moment are then compared with allowable values and adjusted on a trial-and-error basis, to reflect past experiences with ships already in operation. Although this approach has worked well, this standard wave approach does not specifically account for the effects of transient loads, fatigue or their effects on longitudinal distribution of bending moments other than by empirical "rules of thumb". In addition, torsion and associated effects are not addressed.

As a result of these uncertainties, the designer has been forced to apply a generous safety margin, particularly at stations forward of mid-ships, to account for effects of slamming. In addition, this design methodology applies only to ships that are within the historical database. We are now beginning to use new structural materials, develop unconventional ship designs and anticipate the need to improve ships' capability to operate at higher speeds and severe environments for longer durations. Furthermore, there is an ever present demand for lighter, more efficient structures. Although extrapolations of current design methods are possible, there exists a level of uncertainty when one takes an empirically based design procedure and applies it to different ship types, displacements or operational requirements.

With the advent of finite element methods the naval architect has the capability to assess these variations in design and/or materials. However, while these analytic techniques can help one evaluate the ability of specific structural members to resist a given load, the designer can be lulled into a false sense of security as the probability of failure cannot be determined. Therefore, structural safety needs to be based on an acceptable level of risk that can be defined as the product of the failure probability and of failure consequences. It is clear that alternate structural design criteria must be developed in order for the naval architect to have a quantitative basis from which appropriate safety levels can be determined.

As an interim solution to this problem, one-sided reliability methods have been developed. Philosophically, the two approaches are very analogous to each other. Both rely on the use of linear response amplitude operators for determining low frequency stress variations with slam induced whipping being handled in a somewhat empirical manner. Ultimately, the differences between the two methods result from what is considered to be governing to the design.

The procedure discussed outlines the Dynamic Load Approach developed by the American Bureau of shipping. This approach assumes a conventional short-term linear random model of response to waves, and a definition of the wave environment in terms of a scatter diagram. The method addresses the influence of nonlinear rolling upon some of the load components and the impact of pressures on the side shell at the mean waterline. A semi-empirical allowance is included to account for the effects of vibration.

There are several variations of probabilistic methods available for calculating the dynamic response of a ship in a seaway to obtain wave induced flexure, and bow impact whipping. One approach is to divide the total at sea time of the ship into several operational modes, or cells. An operational mode is bounded by a range in ship speed, range in heading relative to the waves and range in wave height. The structural response is determined for each operational mode up to the worst case situation. Several responses can be determined in this manner such as vertical bending, lateral bending and torsion. Lateral bending or ship rolling is considered in the design by assuming half of the stress at the neutral axis, on the shell only. Currently, only vertical and lateral bending moments are considered using the probabilistic method.

For a recent ship design, new procedures are used to access primary hull girder strength. The hull girder is checked for adequate section modulus to keep primary flexural stress ranges below the fatigue allowable.

Ship structure is composed of a complex arrangement of plating and scantlings designed to resist both environmental and operational induced loads. Assessing the strength of ship structure involves a breaking down of the complex arrangement into a framework of interconnecting beams, panels, and columns that can each be analyzed separately on a simpler basis. The adequacy of each structural member is based on specific calculation and various assumptions regarding end fixity at points of support and effectiveness of plating which acts in conjunction with a stiffening member, translation of externally applied loads into internal axial, shear, and bending forces, and translation of the internal forces into internal stresses. The modeling details reflect the importance of the piece of structure being assessed and strives to approximate how the structure will behave in service. The procedures used in performing the stress analysis, though computer based, generally employ formulae commonly found in engineering texts. In some instances, finite element models are made to determine service and failure

stresses from externally applied loads. Strength is assessed to prevent yielding in the case of tensile loadings and elastic modes of instability under compressive loadings. Fatigue strength is also considered in a strength assessment, but is discussed separately.

Once isolated into a single structural element, structural adequacy is assessed using loadings which generally consist of primary axial in-plane loads, arising from overall hull girder bending, and secondary bending loads, arising from hydrostatic or equipment loads. Strength is assessed in tension by combining the primary axial stress acting on the member with the secondary bending stresses and comparing the total stress to the yield strength of the material.

Ships have historically been designed implicitly against failure by fatigue and fracture. Design stresses for primary hull structure are also kept to sufficient low levels to avoid fatigue problems. The value of the primary design stress depends slightly on the material, increasing only slightly with yield strength. An additional stress margin is also incorporated for future growth of the ship. Care is also taken to produce welded connections during design and fabrication that do not contain imperfections and stress risers that would produce crack initiation sites.

Although many ship designs have addressed fatigue implicitly, the methodology has produced ships that generally tolerate the forces of the sea very well throughout their service life. The success of this procedure has perpetuated its use, but the empirical database has been limited to conventionally shaped mono-hulls.

Although a universal fatigue criteria has not yet been established, ships have been designed based on a factor of safety on service life with 50% probability of failure, actual service life with a much lower of probability of failure, or a combination of both.

### ***6.3 Emerging technology***

For marine systems, there are many influences that effect system safety. Sources of risk include equipment failure, external events, human errors, and institutional error. Equipment failure is the most recognized hazard on ships and can be divided into several sub-categories including independent failures and common cause failures. Risk from external events are caused by the hazardous such as collision by other ships, sea state, wind, ice, or weather factors. Human provide another source of risk to ships due to lack of skills, mistakes, fatigue, or sabotage. Institutional failure represents risks from poor management including training, management attitude, poor communications, and morale.

The relationship between risk and standards is not new and its definition is dependent on the point of view of observers. To better appreciate this dilemma we must take a look at risk and standards from a historical perspective. People have always sought to eliminate unwanted risk to health and safety, or at least control it. Great successes have been achieved in controlling risk, as evidenced by advances made in the development of building methods. Yet some of the familiar risks persist while others less familiar are found to escape our attention and new ones have appeared. Ironically, some of the risks that are most difficult to manage are those that provide us with increased standards of living.

Risk studies require the development of analytical methods at the system level that considers subsystems and components. In an environment of increasingly complex engineering systems, the concern about the operational and extreme-events safety of these systems continues to play a major role in both their design and operation. A systematic, quantitative approach for assessing the failure probabilities and consequences of engineering systems is needed. A systematic approach allows an engineer to expediently and easily evaluate complex engineering systems for safety and risk under different operational and extreme conditions with relative ease. The ability to quantitatively evaluate these systems helps cut the cost of unnecessary and often expensive re-engineering, repair, strengthening or replacement of the system.

The reliability analysis of ship structures requires knowing the probabilistic characteristics of the operational-sea profile of a ship, its structural system and strength, and failure modes and failure definitions. Also, tools of probabilistic and reliability analyses are needed. The reliability analysis of ship structures deals with several failure modes, and can be broken down into the following modules:

- operational-sea profile and loads
- nonlinear structural analysis
- extreme analysis and stochastic load combination
- failure modes, their load effects, load combinations, and structural strength
- library of probability distributions
- reliability assessment methods
- uncertainty modeling and analysis
- failure definitions
- system analysis

Each module can be independently investigated and developed. Although, some knowledge about the details of other modules is needed for the development of a module.

## Chapter VII

### Risk management in ship design

#### 7.1 Risk evaluation criteria

Hazard identification and risk assessment methodologies vary greatly across maritime industries, ranging from simple assessments to complex quantitative analyses with extensive documentation. Individual hazards can require that different methods be used, e.g. an assessment of long term exposure to asbestos can need a different method than that taken for equipment safety or for assessing an office workstation.

Each organization should choose approaches that are appropriate to its scope, nature and size, and which meet its needs in terms of detail, complexity, time, cost and availability of reliable data. In combination, the chosen approaches should result in an inclusive methodology for the ongoing evaluation of all the company's risks.

The management of change needs to be considered for changes in assessed risks, determination of controls, or the implementation of controls. Management review should be used to determine whether changes to the methodology are needed overall.

To be effective, the organization's procedures for hazard identification and risk assessment should take account of the following:

- hazards,
- risks,
- controls,
- management of change,
- documentation,
- ongoing review.

Risk assessment techniques can be applied in almost all areas of maritime industries. Ship owners know that to be successful they must have a good understanding of their risks and how risks impact the people associated with their operations, their financial performance and corporate reputation.

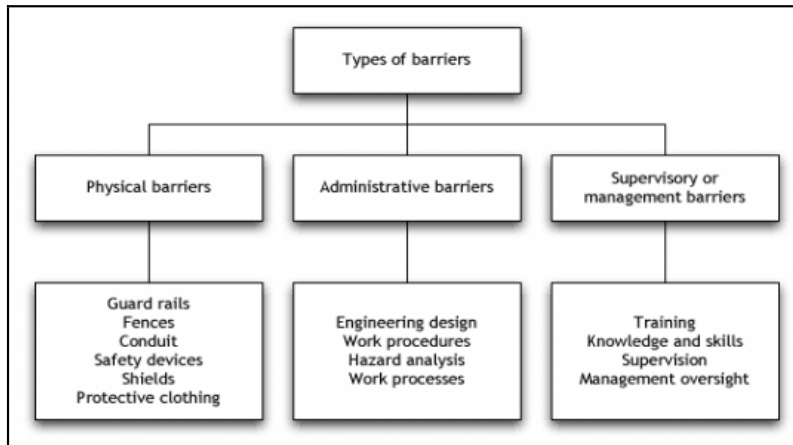
These objective values might be used in an optimization process to:

- achieve a reduced level of risk with a prescribed amount of money,
- reduce the costs that are required to achieve a target risk level.

Furthermore, compared with traditional root cause analysis approaches, risk analysis or risk assessment is proactive. Pro-active means that hazards are identified before the un-wanted event occurs. In that sense risk analysis helps to avoid fatalities, environmental pollution and economic losses.

One of the fundamentals of all safety systems is the understanding of the safety barrier principle. Whenever we design safety critical systems we provide them with a certain recovery potential. We do not want that safety critical systems fail because of single and simple mistakes. This is why we integrate certain safety barriers and controls in our systems. If a hazard occurs it might not affect the system because of pre-installed safety barriers.

These barriers do not have to be a physical protection, such as safety boots or gloves. They can also be of organizational nature etc. An overview is given below.



*Figure 7.1. Overview about measures to safeguard safety in shipping*

When barriers are designed and integrated in the systems one has to pay specific attention to the nature of the target of a hazard: the ship, the cargo, the crew or other humans involved, the environment. Different hazards and targets require different barriers.

Safety management is therefore a continuous process of assessment of safety barriers. The existing barriers are monitored constantly. In addition our safety critical system is monitored, too. The focus is here on missing barriers resulting from insufficient risk assessment or changes in the systems.

After accidents an analysis of the function of our pre-installed safety barriers is carried out. These barriers were not always installed based on previous experience. They can also be installed based on personal judgment etc.

It is therefore vital to analyze if the safety barriers in each system have the right dimensions. Accidents, unfortunately, are practical tests for our barriers. If they did not function, we have to improve them.

Before we install safety barriers we assess our systems. Risk management is a complex process. It consists of the following phases:

- Risk analysis and estimation
- Risk assessment
- Risk management and control

During the analysis the vital components of technical/operational systems and potential hazards endangering the functionality of these systems are identified.

The next step is concerned with the estimation of frequencies of the appearance of these hazards and the resulting consequences. During risk assessment suitable Risk Control Options (RCOs) are identified, evaluated, and the most appropriate Risk Control Measure (RCM) selected. The selected RCMs are the barriers that should prevent a hazard from hampering the vital components in our technical/operational systems.

In order to facilitate the approval of novel designs or novel systems, there is a need for different risk evaluation criteria, sometimes also referred to as risk acceptance criteria or risk tolerability criteria. The actual approval process may be considered independent from the risk evaluation criteria and the criteria may be derived from high-level goals independent of the actual design or system that seeks approval.

## **7.2 Criteria for evaluation of high-risk level**

High-level risk evaluation criteria may at least cover the risk to human life, including injuries and ill health, and the risk to the environment. Other types of risk could also be covered, as appropriate for

the design or system in question. Different criteria for each type of risk could also be employed and typically the following risk evaluation criteria are needed:

- criteria for individual and societal risk;
- criteria for risk to crew, passengers and people ashore, as appropriate;
- limits between negligible, ALARP area and intolerable levels of risk;
- cost-effectiveness criteria defining when risks are considered ALARP.

A thorough review of existing risk evaluation criteria included a review of different approaches to establish limits between the ALARP area and negligible and intolerable levels of risk to human life and cost-effectiveness criteria for risks to human life as well as a new approach to cost-effectiveness criteria for environmental protection against spills.

The revised IMO Guidelines on Formal Safety Assessment contain two appendices that discuss risk evaluation criteria and also propose GCAF and NCAF criteria for cost-effectiveness. Such criteria may have to be updated from time to time. However, the importance of having adequate risk evaluation criteria in place when performing safety-based approval of ship designs and systems is emphasized.

### ***7.3 Risk management for designing of systems and functions***

Risk-based design is an alternative to the present prescriptive rules, replacing the actual design regulation by goals and functional requirements. The risk-based ship system approval process requires suitable evaluation criteria. These criteria may be defined for the overall ship level, but also for specific ship functions. For the risk-based design of a specific ship system, evaluation criteria for this system may be provided. The relation between the overall risk and the risk contribution of a specific system is defined by the risk model and the risk analyses that have been performed as part of the risk-based design and approval process.

Based on the ALARP principle, a general procedure for how to derive risk evaluation criteria for ship functions may be described as follows:

- develop a risk model, including all scenarios that are affected by the function in question;
- use the decision criteria for cost-effectiveness for the function in question;
- derive the target reliability or availability by cost-effectiveness criteria;
- use the optimum reliability as a target for the function that is analyzed.

This procedure is a simplified FSA limited to the relevant function and it is implicitly assumed that the risk level is in the ALARP area, rendering cost-effectiveness criteria applicable.

It may be noted that risk evaluation criteria derived in this way may not be dimensioning for the function in question.



## Chapter VIII

### Operational standards for safety based designed ships

#### *8.1 Safety standards for designing and building of ships*

The strength and construction of hull, superstructures, deckhouses, machinery casings, companion ways and any other structure and equipment should be sufficient to withstand all foreseeable conditions of the intended service.

Ships should be fitted with a collision bulkhead and with watertight bulkheads bounding the machinery spaces. Such bulkheads should be extended up to the freeboard deck. In ships constructed of wood such bulkheads should also be fitted extending to the freeboard deck and should be watertight as far as practicable.

Propeller shafts and shaft logs or stern tubes should not be situated in any space other than machinery spaces containing main propulsion unless they are enclosed in watertight spaces or enclosures inside such spaces. May be exempted from these requirements, ships having constraint of space or engaged on sheltered voyages provided it is demonstrated that any progressive flooding of such space can be easily controlled and that the safety of the ship is not impaired. Stern glands should be located in spaces which can be easily accessible at all times for inspection and maintenance.

A collision bulkhead should be watertight up to the freeboard deck. This bulkhead should, as far as practicable, be located at a distance from the forward perpendicular of not less than 5% and not more than 7% of the length of the ship. Where it can be shown that it is impractical for the collision bulkhead to be located at a distance from the forward perpendicular of not more than 7% of the length of the ship, is possible to allow relaxation there from, subject to the condition that should the space forward of the bulkhead be flooded, the ship at full load condition will not be submerged to the margin line.

The collision bulkhead may have steps or recesses in it provided that they are within the prescribed limits. Pipes piercing the collision bulkhead should be kept to the minimum. Such pipes should be fitted with suitable valves operable from above the freeboard deck and the valve chest should be secured at the collision bulkhead inside the forepeak. Is possible to be permit the location of such valves on the after side of the collision bulkhead provided that they are readily accessible under all service conditions and the space in which they are located is not a cargo space. All such valves should be of acceptable material.

Where a long forward superstructure is fitted, the collision bulkhead should be extended watertight to the deck above the freeboard deck. The extension should be located within the prescribed limits. The part of the deck, if any, between the collision bulkhead and its extension should be weathertight.

In every ship provided with a bow door and a sloping loading ramp that forms part of the extension of the collision bulkhead above the freeboard deck, the part of the ramp which is more than 2.3m above the freeboard deck may extend forward of the specified limits. The ramp should be weathertight over its entire length.

The number of openings in the collision bulkhead above the freeboard deck should be reduced to the minimum compatible with the design and normal operation of the ship. All such openings should be capable of being closed weathertight.

No doors, manholes, ventilation ducts or access openings should be fitted in the collision bulkhead below the freeboard deck.

In every ship propelled by mechanical means where the chain locker is located abaft the collision bulkhead or extends into the forepeak tank, it should be watertight and provided with efficient means of drainage.

Each watertight subdivision bulkhead, whether transverse or longitudinal, should be constructed in such a manner that it should be capable of supporting, with a proper margin of resistance, the pressure

due to the maximum head of water which it might have to sustain in the event of damage to the ship but at least the pressure due to a head of water up to the margin line. The construction of these bulkheads should be to the satisfaction of recognised organisation.

Steps and recesses in bulkheads should be watertight and as strong as the bulkhead at the place where each occurs.

Where frames or beams pass through a watertight deck or bulkhead, such deck or bulkhead should be made structurally watertight.

The number of openings in watertight bulkheads should be reduced to the minimum compatible with the general arrangements and operational needs of the ship. Openings should be fitted with watertight closing appliances. Watertight doors should be of equivalent strength to the adjacent unpierced structure.

Watertight decks, trunks, tunnels, duct keels and ventilators should be of the same strength as watertight bulkheads at corresponding levels. The means used for making them watertight, and the arrangements adopted for closing openings in them. Watertight ventilators and trunks should be carried at least up to the freeboard deck.

Testing main compartments by filling them with water is not compulsory. When testing by filling with water is not carried out, a hose test is compulsory. In any case, a thorough inspection of watertight bulkheads should be carried out.

Tanks which are intended to hold liquids, and which form part of the subdivision of the ship, should be tested for tightness with water to a head corresponding to two-third of the depth from the top of keel to the margin line in way of the tanks provided that in no case should the test head be less than 0.9m above the top of the tank.

The tests are for the purpose of ensuring that the subdivision structural arrangements are watertight and are not to be regarded as a test of the fitness of any compartment for the storage of oil fuel or for other special purposes for which a test of a superior character may be required depending on the height to which the liquid has access in the tank or its connections.

**Accident prevention and crew accommodation.** Hinged covers of hatchways, manholes and other similar openings should be protected against accidental closing. In particular, heavy covers on escape hatches should be equipped with counterweights. Escape doors and covers of escape and access hatches should be so constructed as to be capable of being opened from either side of the door or cover. The dimensions of access hatches should be such that it will allow a person to have a quick and easy escape to a safe place in the event of an emergency. Where practicable, the dimensions of access hatches of cargo and machinery spaces should be such that they will facilitate expeditious rescue operation.

Handrails, grabrails and handholds of sufficient size and strength should be provided where necessary in the opinion of the Administration for persons to hold on when the ship is severely rolling or pitching.

Skylights of machinery spaces or other similar openings which are normally kept open at sea should be provided with adequately spaced protective bars or other arrangements to prevent a person from falling into the space accidentally. Where the size of such an opening is small, may waive this requirement where satisfied that due to the small size of the opening no protective arrangement is necessary.

Surfaces of all decks should be so prepared or treated as to minimize the possibility of persons slipping. In particular, decks and platforms in machinery spaces, floors of galleys, decks at winches and areas at the foot and head of ladders and in front of door and steps of ladders should be provided with anti-slip surfaces.

Every ship should comply with any other requirements which are deemed necessary to prevent accidents at sea and to maintain appropriate living and working conditions. Such requirements as set should be consistent with the ILO Code of Practice, "Accident Prevention on board ships at Sea and in Port" to the extent reasonable and practicable.

**Intact stability and subdivision requirements for cargo ships.** Stability information approved should be supplied to ships of 24 m in length and over to enable the master to assess with ease and certainty the stability of the ship under various operating conditions. Such information should include specific advice to the master warning him of those operating conditions which could adversely affect either stability or the trim of the ship. In particular, the information recommended in the relevant IMO Instruments should be included as appropriate. A copy of the stability information should be submitted to the recognized organization.

The approved stability information should be kept on board, readily accessible at all times and inspected at the periodical surveys of the ship to ensure that it has been approved.

Where alternations are made to a ship affecting its stability, revised stability calculations should be prepared and submitted to the recognized organization for approval. Where the recognized organization decides that the stability information must be revised, the new information should be supplied to the master and the superseded information removed from the ship.

**General requirements for mechanical and electrical machinery, equipment and installations.** All machinery and electrical installations, mechanical and electrical equipment and appliances, boilers and other pressure vessels, associated piping systems, fittings and electrical cables and wiring should be of a design and construction adequate for the service for which they are intended and should be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards. The design should have regard to materials used in construction, and to purposes for which the equipment is intended, the working conditions and the environmental conditions to which it will be subjected.

**Boilers.** All boilers and other pressure vessels, all parts of machinery, all systems, hydraulic, pneumatic and other systems and their associated fittings which are under internal pressure should be subjected to an approved pressure test before being put into service for the first time.

Adequate provisions should be made to facilitate cleaning, inspection and maintenance of machinery installations including boilers and other pressure vessels.

Where main or auxiliary machinery including pressure vessels or any parts of such machinery are subject to internal pressure and may be subject to dangerous overpressure, means should be provided where practicable to protect against such excessive pressure.

All gearing and every shaft and coupling used for transmission of power to machinery essential for the propulsion and safety of the ship or for the safety of persons on board should be so designed and constructed that they will withstand the maximum working stresses to which they may be subject in all service conditions, and due consideration should be given to the type of engines by which they are driven or of which they form part.

Machinery should be provided with automatic shut off arrangements or alarms in the case of failures such as lubricating oil supply failure which could lead rapidly to complete breakdown, damage or explosion.

**Controls.** Main internal combustion propulsion machinery and applicable auxiliary machinery should be provided with automatic shut off arrangement in the case of failures such as lubricating oil supply failure which could lead rapidly to complete breakdown, serious damage or explosion.

**Steam boilers and boilers feed systems.** Every steam boiler and every oil-fired steam generator should be provided with not less than two safety valves of adequate capacity. However, having regard to the output or any other features of any boiler or oil-fired steam generator, the recognized organization may permit only one safety valve to be fitted if it is satisfied that adequate protection against overpressure is thereby provided.

Every steam generating system which provides services essential for the safety of the ship, or which could be rendered dangerous by the failure of its feed water supply, should be provided with not less than two separate feed water systems from and including the feed pumps, noting that a single penetration of the steam drum is acceptable. Unless the pump is designed to prevent overpressure, means should be provided which will prevent overpressure in any part of the systems.

Boilers should be provided with means to supervise and control the quality of the feed water. Suitable arrangements should be provided to preclude, as far as practicable, the entry of oil or other contaminants which may adversely affect the boiler.

Every boiler essential for the safety of the ship and designed to contain water at a specified level should be provided with at least two means for indicating its water level, at least one of which should be direct reading gauge glass.

**Air pressure systems.** In every ship means should be provided to prevent overpressure in any part of compressed air systems and wherever water jackets or casings of air compressors and coolers might be subjected to dangerous overpressure due to leakage into them from air pressure parts. Suitable pressure relief arrangements should be provided for all systems.

The main starting air arrangement for main propulsion internal combustion engines should be adequately protected against the effects of backfiring and internal explosion in the starting air pipes.

All discharge pipes from starting air compressors should lead directly to the starting air receivers, and all starting air pipes from the air receivers to main or auxiliary engines should be entirely separate from the compressor discharge pipe system.

**Protection against noise.** Measures should be taken to reduce machinery noise in machinery spaces to acceptable levels. Where the noise cannot be sufficiently reduced, the source of excessive noise should be suitably insulated or isolated or a refuge from noise should be provided if the space is required to be manned. Where necessary, ear protectors should be provided for personnel required to enter such spaces.

**General electrical requirements.** Electrical installations should be such that:

- all electrical services necessary for maintaining the ship in normal operational and habitable conditions will be assured without recourse to the emergency source of electrical power;
- electrical services essential for safety will be assured under emergency conditions; and
- the safety of personnel and ship from electrical hazards will be assured.

Electrical installations should be such that uniformity in the implementation and application of the provisions of this part will be ensured.

All electrical apparatus should be so constructed and so installed as not to cause injury when handled or touched in the normal manner.

When a distribution system, whether primary or secondary, for power, heating or lighting, with no connexion to earth is used, a device capable of continuously monitoring the insulation level to earth and of giving an audible or visual indication of abnormally low insulation values should be provided.

In every ship other than ships propelled by mechanical means, cables and wiring external to equipment should be at least of a flame retardant type and should be so installed as not to impair their original flame retarding properties. Where necessary for particular applications, the Administration may permit the use of special types of cables such as radio frequency cables, which do not comply with the foregoing.

Cables and wiring serving essential or emergency power, lighting, internal communications or signals should so far as practicable be routed clear of galleys, laundries, machinery spaces of category A and their casings and other high fire risk areas. Cables connecting fire pumps to the emergency switchboard should be of fire resistant type where they pass through the high fire risk areas. Where practicable all such cables should be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkhead that may be caused by a fire in an adjacent space.

No electrical equipment should be installed in any space where flammable mixtures are liable to collect including those on board tankers or barges carrying liquid cargoes of flammable nature in bulk or in compartments assigned principally to accumulator batteries, in paint lockers, acetylene stores or similar spaces, unless the recognized organisation is satisfied that such equipment is -

- essential for operational purposes;
- of a type which will not ignite the mixture concerned;
- appropriate to the space concerned; and
- appropriately certified for safe usage in the dusts, vapours of gases likely to be encountered.

## 8.2 Safety standards in operational of special designed ships

In the last decades, passenger ship design moved from cruise liners to leisure cruise ships. Passenger ships are now basically designed as hotel accommodation fitted inside a ship, where public spaces and leisure areas demand larger space and where access to the sea, at least visual, is of utmost importance. Size and capacity of cruise ships have dramatically increased during the last years, creating new concerns with respect to fire safety and evacuation. Most of the passenger ferries also follow this evolution in order to offer so-called mini-cruises to the travelers.

Calculation tools and Rules notes have been developed to cope with new designs for large passenger ships and High Speed Crafts, such as the use of aluminum, extensive glass superstructures and large atrium.

One important issue has been the entry into force on 1st July 2010 of the SOLAS amendments requiring passenger ships of minimum 120m length or having three or more main fire zones to be able to return to port under their own power, and to provide passengers with sufficient safe areas onboard the vessel after a flooding or a fire incident. These new concepts have had, and will continue to have, considerable impact on the design of new concerned passenger vessels.

In addition to the general requirements applicable for all ships, passenger ships have to comply with specific provisions defined in Part D Ch. 11 of the Rules, and Ch. 12 for the Ro-ro passenger ships.

Due to their specific design (large rooms, stairs, lifts, large openings in decks and side shell, design point of view and safety consideration), the structure strength is to be particularly checked. An overall calculation using Finite Element Method (FEM) analysis is performed. The model includes all the different elements of the ship, such as all the decks, superstructure ...

Results show inter alia which part is taken by these elements in the longitudinal strength, and allow refinement of the steel structure by determining the highly stressed areas.

Another particular item which is necessary to verify is the longitudinal and transverse behavior of the structure (i.e. the strength of end parts of the ship in way of large openings in side shell and the racking study due to rolling acceleration).

**Equipment.** The main and auxiliary machinery systems, piping systems and electrical plant are checked and surveyed for compliance with appropriate parts of the rules. Special expertise has been developed regarding electrical propulsion and azimuth propulsion thrusters which have become very popular for these types of ships. The regulations specific to passenger ships generally cover the requirements of Load Line and SOLAS Conventions (e.g. bilge systems, emergency source of power).

**Construction - subdivision and stability, machinery and electrical installations.** The subdivision of passenger ships into watertight compartments must be such that after assumed damage to the ship's hull, the vessel will remain afloat in a stable position. Requirements for the watertight integrity and bilge pumping arrangements for passenger ships are also laid down. The degree of subdivision varies with the ship's length and the service in which it is engaged. The highest degree of subdivision applies to ships of the greatest length primarily engaged in the carriage of passengers. The requirements for machinery and electrical installations are designed to ensure that services which are essential for the safety of the ship, passengers and crew are maintained under various emergency conditions. SOLAS Chapter II-1 parts A and B have been totally revised starting with MSC 80 and MSC 82, including the new probabilistic damage stability requirements to be applied now for new passenger ships having their keel laying date on or after on 1st January 2009. The revision of SOLAS chapter II-1, part B, is intended to harmonize the provisions on subdivision and damage stability for passenger and cargo ships. The revised SOLAS chapter II-1, part B, encompasses now the following parts:

- Part B - Subdivision and Stability
- Regulation 4
- Part B-1- Stability
- Regulations 5 to 8
- Part B-2 - Subdivision, Watertightness and Weathertightness
- Regulations 9 to 17-1

- Part B-3 - Subdivision and Line Load Assignment for Passenger Ships
- Regulation 18
- Part B-4 - Stability Management
- Regulations 19 to 23-3

As per new SOLAS regulation Ch II-2/21.1, passenger ships constructed on or after 1 July 2010 having a length of 120m or more, or having 3 or more main vertical fire zones, shall comply with the provisions of regulation II-2/21. It is understood that all main vertical zones in the ship should be counted for the purpose of this regulation, irrespective of whether they contain accommodation spaces or not. Nevertheless, horizontal fire zone (special category and ro-ro spaces) should not be included in this count of main vertical zones. These new SOLAS amendments are introducing several new concepts which are detailed in the next paragraphs, such as: “Casualty Threshold”, “Essential Systems”, “Safe Area” and “Orderly Evacuation”.

**New SOLAS regulations II-1/8-1, II-2/21 and II-2/22.** Ch II-1 Reg 8-1 requires that “essential systems” listed in Ch II-2/21.4 remain operational after flooding of any single watertight compartment. It is important to note that both internal compartments and compartments having a boundary to the sea are concerned.

Ch II-2 Reg 21 provides design criteria for a “safe return to port” of the ship under its own propulsion after a fire casualty that does not exceed the “**casualty threshold**”. The fire casualty threshold is defined in §21.3 as being the loss of the space of origin up to the nearest A-class boundary if the space is protected by a fixed fire-fighting system, or the loss of the space of origin and adjacent spaces up to the nearest A-class boundaries which are not part of the space of origin.

As can be seen from the regulation text, the requirement was relatively vague and more detailed explanatory documents were needed by the industry for a proper and uniform implementation. Initial explanatory notes were developed by five leading classification societies (BV, DNV, GL, LR and RINA) with the assistance of major European Shipyards and some Operators, and were submitted by Italy and CLIA to the IMO Fire Protection subcommittee in October 2008. After review by a correspondence group and drafting of a proposal in April 2010 by IMO FP, the Maritime Safety Committee, at its eighty-seventh session in May 2010, approved the Interim Explanatory Notes for the assessment of passenger ship systems' capabilities after a fire or flooding casualty, to provide additional guidance for the uniform implementation of SOLAS regulations II-1/8-1, II-2/21 and II-2/22. These notes were published as interim explanatory notes in June 2010 as MSC.1/Circ.1369.

Regarding extend of casualty threshold in the case of the space of origin not being protected by a fixed fire-extinguishing system, the following interpretation was approved with the explanatory notes:

- Casualty threshold may include spaces one deck above (considering that fire is spreading upwards, the deck below has been excluded from such extension).
- Only spaces within the same Main Vertical Zone have to be considered.

§ 4 of Regulation 21 also lists all “essential systems” which are required to ensure propulsion and maneuverability after a casualty not exceeding the casualty threshold, and also to maintain safety in all parts of the ship not affected by the casualty, as well as to ensure services needed to be available in safe areas. These essential systems are:

- Propulsion systems with their necessary auxiliaries
- Electrical power plant with their auxiliaries
- Steering systems with their power and control systems
- Systems for filling, transfer and service of fuel oil. *Full redundancy for propulsion and electrical production will be required as well as for steering system. Propulsion engines and electrical generators will have to be distributed in two separate engine rooms, as well as main switchboards and all auxiliaries for propulsion and electrical production. Two steering gear rooms have to be arranged and fitted with a fixed extinguishing system if they are adjacent. Tunnel thruster is not to be considered for emergency steering. It has also to be taken care that necessary fuel for remaining main engine(s) and diesel generators is still available in sufficient quantity for the whole safe return to port operation. Operating*

- pattern of the vessel will have an important impact on this last issue as a worldwide cruise ship will have different need than a ferry certified for short international voyages.*
- Navigation systems. *In case of casualty affecting the bridge, an alternative place shall be arranged where essential equipment (fixed or portable) for navigation and detection of risk of collision shall be available for the duration of SRtP.*
  - Internal and external communication systems. *P.A system shall remain operational in all main vertical zones not affected by the fire. Portable communication system is acceptable for internal communication, provided repeater system remains operational and charging facilities are available in more than one main vertical zone.*
  - Fire main system. *It is accepted to have the fire main isolated in the main fire zone affected by the casualty. Affected main fire zone can then be served from hydrants of adjacent zones or watertight compartment. Fire hoses may be extended for fire fighting within the affected main fire zone using maximum two lengths of hoses from each hydrant. Manual local start of remaining fire pumps may be accepted after a casualty.*
  - Fixed fire extinguishing systems. *Lay-out of the sprinkler or equivalent system will have to be carefully reviewed and pumps will have to be duplicated and installed in separate compartments. Each section should not serve more than one deck in one main vertical zone. CO2 total flooding extinguishing system capacity to be sufficient to protect the largest and the second largest spaces.*
  - Fire and smoke detection system. *Architecture of smoke detection system will have to be modified in order to remain operational in spaces not directly affected by the fire casualty. It will be acceptable to loose detection in maximum one deck in one fire zone.*
  - Bilge and ballast systems. *Proper distribution of bilge and ballast pumps will be necessary, as well as careful routing of the piping. Extra manual controlled section valves will be necessary when crossing watertight compartment bulkheads to segregate any flooded compartment.*
  - Watertight and semi-watertight doors. *Position indication of the doors shall remain available for any fire casualty within the casualty threshold except for doors in the boundary of spaces directly affected by the casualty.*
  - Flooding detection system as per SOLAS II-1/22-1 requirement
  - Basic services to support “safe areas” as indicated in SOLAS II-2/21.5.1.2
  - Other systems deemed to be vital by the Administration for damage control efforts. “Safe area” is defined in II-2/21.5 as being generally any internal space(s) which is not flooded and outside the main vertical zone affected by the fire. It shall provide all occupants with the following basic services to ensure the health of all persons onboard (*text in italics refers to interpretations as per IMO.1/Circ 1369*):
  - Sanitation. *Minimum one toilet required for every 50 persons or fraction of.*
  - Water. *Minimum 3 liters per person per day drinking water, plus water for food preparation and hygiene.*
  - Food. *Food could be of any kind including dry food.*
  - Alternate space for medical care. *The alternate space for medical care to be in a different MVZ than the hospital, and to have lighting and power supply from the emergency source of power.*
  - Shelter from the weather. *Use of exterior spaces as safe areas might be evaluated taking into account possible current operation of the vessel in warm climates and short duration of SRtP operation.*
  - Means of preventing heat stress and hypothermia. *Temperature within safe areas should be maintained in the range of 10° to 30°C.*
  - Lighting. *Portable rechargeable battery operated lighting may be acceptable for use in spaces not covered by the ship’s emergency lighting system.*

- Ventilation. *Minimum ventilation volume available should be not less than 4,5m<sup>3</sup>/H per person.*

The above list will require a number of systems to be possibly evaluated as essential systems, in order to support these above listed basic services such as:

- Black & grey water system (although it is accepted that grey and black water could be disposed of into the sea during SRtP operation, as allowed by MARPOL Annex V, Reg 3).
- Potable water system
- Refrigerating system and galley system
- HVAC system (depending of the operation pattern of the vessel)
- Lighting distribution.

It is well understood that Safe Areas should preferably be arranged in accommodation spaces, and sizing could be based on the time needed for safe return to port operation. Interpretation 42 of Circ.1369 is asking for a minimum space of 2m<sup>2</sup> per person for a SRtP operation longer than 12 hours. An important issue related to the safe areas is the requirement asking for means of access to life-saving appliances which shall be ensured from each safe area taking into account that internal transit through the affected main vertical zone might not be possible. This requirement will be achieved easily on cruise ships having embarkation deck running the entire length of the vessel, but will have to be closely investigated for ferries or small and medium size cruise ships where each main vertical zone do not have direct access to external embarkation deck. For this purpose, it is accepted that external routes are considered to remain available also in the portion of the ship containing the main vertical zone affected by the casualty.

Ch II-2 Reg 22 provides design criteria for systems required to remain operational to support an “orderly evacuation” and abandonment of the ship if the casualty threshold is exceeded. The following systems will then be required to remain operational for at least 3 hours in all main vertical zones not affected by the casualty:

- Fire main
- Internal communication for passenger and crew notification and evacuation
- External communication
- Bilge system for removal of fire-fighting water
- Lighting along escape routes, at assembly stations and embarkation stations
- Guidance systems for evacuation (e.g. Low Location Lighting).

To achieve the above requirement, proper distribution of pumps for fire main and bilge systems will have to be taken care of, as well as careful routing and protection of concerned piping and cables.

It is important to remind that SOLAS Ch III Regulation 21.1.4 requirement stating that all survival crafts shall be capable of being launched with their full complement of persons within a period of 30 minutes from the time the abandon ship signal is given, remains fully applicable.



## Chapter IX

### Role of safety based ship design concepts in collision and grounding

#### *9.1 Novel design for prevention of collision and grounding*

Any ship that experiences flooding of one or more of its compartments is exposed to the risk of losing its stability and thus the risk of sinking. Collision and grounding are considered to be the most relevant accident scenarios that may cause flooding of ships, and will thus be the topic of this paper. Although accidents involving large ships are very rare, if a serious accident should occur, its consequences could be disastrous.

Even though a lot of effort is constantly being made to keep ships safe and measures are always taken to avoid serious accidents, one can never completely eliminate the probability of a serious accident to occur on board a ship. If an incident takes place, one can try to prevent it from evolving into a serious accident by for example intentionally beaching a ship that is taking in water and thus keep it from sinking. If such measures fail however, an evacuation provides a last opportunity to minimize the consequences of the accident by reducing the number of fatalities. In such situations, the evacuation performance will be very important and an orderly and timely evacuation can save the lives of many people on board.

Due to the conviction that an effective evacuation will be important in case of a maritime accident and realizing that modern passenger ships will normally carry a large number of people, new requirements from IMO states that an evacuation analysis shall be performed early in the design process for new Ro-Ro ships.

The evacuation analysis requirements do not state that advanced simulation software must be used for the analyses. There is an option to perform a simplified analysis using only pen and paper, considering evacuating crew and passenger as a flow of people through the escape routes in much the same way as water flowing through a pipe system. Performing a simplified evacuation analysis with no advanced tools is a very time consuming task however, and running advanced simulations can save several man-days of work for every evacuation analysis performed. It is thus expected that most evacuation analyses carried out in the future will utilize sophisticated tools such as the maritime Exodus to perform an advanced analysis. It should be noted, however, that regardless of whether the simplified or the advanced approach is taken, the objective is to assess the evacuation process through a set of well defined benchmark scenarios rather than to model the evacuation in a real emergency situation.

According to IMO guidelines, an evacuation analysis performed over a set of benchmark scenarios are required to demonstrate that possible emergency evacuations can be completed within 60 minutes for all new Ro-Ro passenger ships. The analysis should thus ensure that evacuation arrangements are appropriately adequate for swift evacuation of all passengers. This time limit corresponds to the requirements regarding confinement of fires within main fire zones of passenger ships. Passenger ships are required to be divided by thermal and structural boundaries into main vertical fire zones and horizontal zones, and these boundaries should be able to confine a fire for at least one hour within the fire zone where it originated. Historically, evacuations have primarily been considered in relation to fires and it has been assumed that evacuations would be successful if it is completed by the time the fire spreads from the zone of origin.

Depending on the extent of the impact, the ships involved in a collision may or may not sink. The striking ship will normally not be in any great danger of sinking, as it will receive the impact of the collision at the bow, and the bow in front of the collision bulkhead will normally receive all the collision energy. Damages restricted to this part of the ship will normally not affect the stability of the ship. The struck ship, however, if receiving a blow to its side, has a high risk of losing its stability and will thus be in danger of sinking. If the struck ship is a passenger ship with many people on board, effective and orderly evacuation of these people will be crucial to the outcome of the incident.

Another type of accident that may cause flooding of a ship and thus threaten the ship's stability is grounding. Grounding is thus a relevant scenario that might involve evacuation and abandonment of the ship, and the subsequent development of the scenario will determine the outcome, e.g. how much time will be available for evacuation. A grounding accident can cause flooding of the ship, and if the damage received by the ship is extensive, there is a possibility that the ship will sink. In order to describe grounding of passenger ships, the following model has been developed: 1) grounding, 2a) the damage received is too small for the ship to lose its stability 2b) the damage is sufficient to cause the ship to sink, 3a) the ship stays aground after the grounding, 3b) the ship is coming loose after the grounding, 4a) The ship is beached deliberately to prevent it from sinking, 4b) the ship is not beached and will thus sink. For ships that sink due to grounding it is furthermore distinguished between two different ways of sinking, i.e. sinking in an upright position and capsizing before sinking. A double bottom height of 2 meters is assumed for passenger ships in this general study. According to damage statistics, 88% of all damages due to grounding are penetrating less than two meters from the bottom shell. This corresponds to a possibility of the damage to extend through the double bottom.

## ***9.2 Tools for assessing the frequency of collision and grounding events***

Accidents do occur. In recent decades, significant effort has been put into understanding the response of ships, preventing and mitigating the consequences of ships subjected to collision and grounding. This is due to the continuous increasing public concern especially over several catastrophic accidents worldwide. The most famous and severe maritime disaster in human history may be the sinking of *Titanic*, a passenger liner, in 1912. The sinking resulted in 1,517 people perished. It was speculated that the collision with the iceberg initiated the hull to buckle and eventually collapsed. The grounding accident of *Exxon Valdez* in Alaska 1989 has been considered one of the most devastating man-made environmental disasters ever to occur at sea. The accident resulted in the pouring of approximately 40,000 tons of oil into a pristine wilderness area, which is now still suffering from adverse effects of the pollution. A single hull tanker, *Sea Empress*, driven by the current, ran aground at southwest *Wales* in 1996 with 73,000 tons of oil spill. About 200 kilometers of coastline was covered with crude oil which caused substantial environmental and aesthetic damage. In 2002, oil tanker "*Prestige*" split in two halves during a storm off *Galicia, Northwest Spain*. In total, about 20 million gallons of oil were estimated to be spilled into the sea. *Selendang Ayu*, a cargo ship, ran aground and broke into two off *Unalaska Island* in 2004. It created the worst *Alaskan* oil spill since *Exxon Valdez*.

It is noticed though the accident of "*Prestige*" is not connected to either collision or grounding, the consequence may have been significantly reduced if decisions such as grounding in a controlled manner was made instead of towing it to the open sea. According to the report from *IOPCF* (International Oil Pollution Compensation Fund), collision and grounding are responsible for about 50 percent of all major oil spills in its member states from 1970 to 2005.

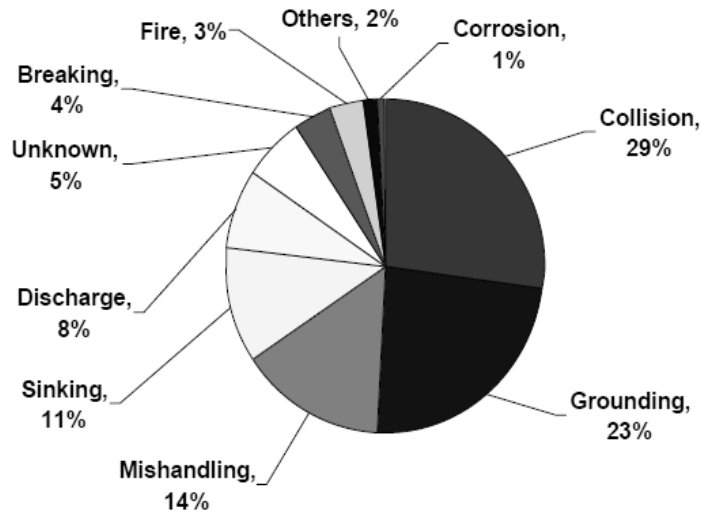


Figure 9.1. Cause of major oil spills from tankers

These disasters precipitated the discussions and research on measures to prevent accidental oil spills. Generally, the improvement of marine safety and enforcement of new regulations for marine structures were triggered by the disasters. The *Titanic* disaster led to the convening of the first *SOLAS* (International Convention for the Safety of Life at Sea) in 1914. In response to the grounding accident of *Exxon Valdez*, *OPA 90* (Oil Pollution Act, 1990) was commenced where a double hull is made mandatory for tankers shipping in *U.S.* waters after 2015. Similarly, *IMO* (International Maritime Organization) also requires double hull for tankers, but its interim guidelines accept alternative designs if it can be proved to have a level of safety equivalent to a standard double hull tanker. There is a clear indication from *IMO* that more rational safety regulations for individual ships are demanded instead of the generalized prescriptive regulations by use of formal safety assessment. Such formal safety assessment or rational design procedure aims at positively prevent or mitigate the disastrous consequence such as oil spill.

Indeed, design methods on a rational base have been pursued by naval architects at all times as it was stated in the book, *A Guide for the Analysis of Ship Structures*, - "It has been the dream of every ship designer to rise above the conventional empirical methods of structural design and create a ship structural design based on rational methods."

In 1995 has proposed a potential rational design procedure for collision and grounding, for design against grounding. Input parameters describing the accident scenarios should be properly and adequately specified. It is then essential to be able to check the structural performance during and after grounding. The consequence of ship accident, for example, in terms of oil spill, has been studied by, DNV and individual researchers. Sufficient residual hull girder strength is vital to avoid subsequent catastrophic consequences after the ship has been damaged.

As a last step, it is judged whether the acceptance criterion has been satisfied. The acceptance criterion could be in either deterministic or probabilistic manner. The design procedure for collision is constructed in a similar format.

If such a rational design procedure should be used, especially in the preliminary design stage, it is of paramount importance that the structural damage or strength of various designs can be checked and compared quickly for a large number of potential accidental scenarios. In this context, calculation tools with high efficiency and reasonable accuracy are required. Generally, experiments, finite element methods and simplified methods may be considered. Full- and large-scale physical experiments on

ship structures are usually too expensive and risky to be executed. Small-scale tests may be difficult to be interpreted to real scale events due to the intricate scaling laws involved. In the recent decades, large scale numerical analysis of ship collision and grounding, which has been considered as “numerical experiments”, has become practicable because of the rapid development of both the computational capacity and the finite element code itself.

### DESIGN PROCEDURE FOR SHIPS AGAINST GROUNDING

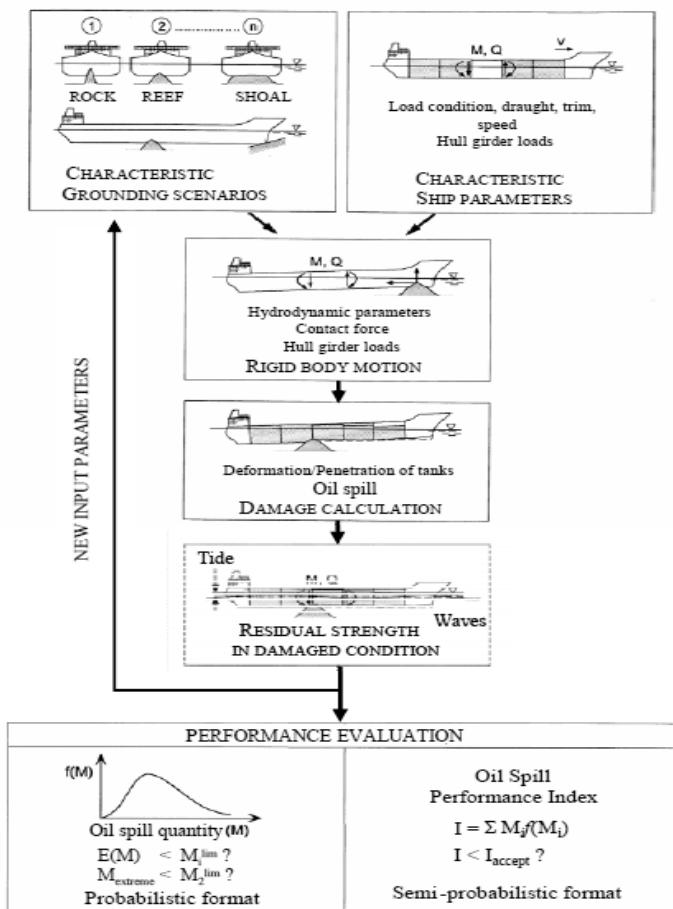
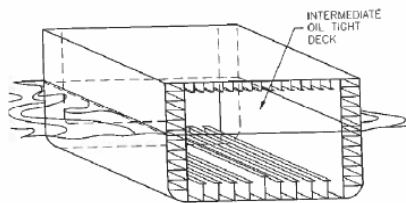


Figure 9.2. Design procedure for ships against grounding

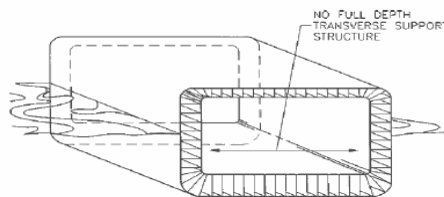
However, simplified methods, for assessment of high energy ship collisions, remain as advantageous tools regarding both time efficiency and relative prediction accuracy. Further, simplified analytical methods based on plastic mechanism analysis are considered advanced because they can provide significant insight into the deformation processes. The methods become mathematically tractable with reasonable accuracy as long as the mechanism can be constructed simply and as realistic as possible. Therefore, simplified analytical methods are considered the most appropriate means for evaluating the ship structural performance against collision and grounding. A number of researchers have contributed substantially to identification and development of fundamental theoretical models for ship structures subjected to accidental loads.

From the design point of view, the introduction of double hull to tanker vessels is believed to be effective in reducing oil spill in the event of collision and grounding. In early 1990s, the NRC (National Research Council) of U.S. has conducted a comprehensive study on design measures to

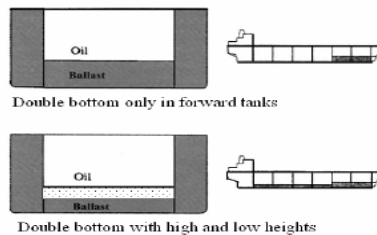
prevent and mitigate oil spill from tankers. The design alternatives have been grouped in three categories: adding barriers, oil outflow management and increasing penetration resistance. The advantages and disadvantages of these design concepts have been discussed in detail. In order to further improve the marine safety, continuous attempts are made to propose and apply novel design concepts which are capable of mitigating or preventing potential accidental consequences. Have proposed a double bottom with varying heights (see Figure 9.3. c). The forward cargo tank region, where there is highest damage risk, can be figured with largest height. Has been demonstrated the concept of mid-deck tanker as illustrated in Figure 9.3.a. *USDH* (unidirectional stiffened double hull), refer Figure 9.3. b, was proposed to provide potential increased resistance against accidental loading. Steel sandwich panels with X-core, Y-core, and other types of cores were proved to have larger energy absorption capabilities than the conventional double hull. In time, was extended the idea of applying a bulbous buffer bow, which deforms easily at the instant of impact. These studies showed that applying the bulbous buffer bow was an effective way to reduce hazardous consequences in collisions. In 2007 have been introduced the idea of arranging predetermined breaking points in the double hull so as to increase the penetration depth by separating the inner hull from web frame in collision. In 2008 have presents the concept of a deformable inner barrier, which considerably increases the intrusion depth in case of side collision. These conceptual designs have been more or less proved to be effective regarding collision safety. However, they seem to have a long way to go before being accepted by stakeholders such as shipowners, classification societies and maritime authorities. This in turn necessitates studies on ways to improve the structure resistance under the present design regime.



**(a) Mid-deck double side tanker**



**(b) Unidirectional stiffened double hull**



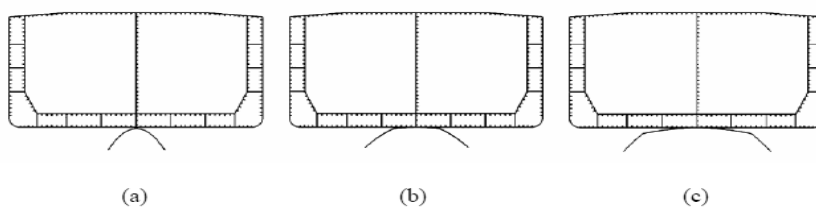
**(c) Tanker designs with varying double-bottom heights along ship length**

**Figure 9.3. Some design alternatives to prevent or mitigate tanker spills**

Up to date, based on simplified methods for external and internal mechanics, several tools or software packages have been made available for collision and grounding analysis, for example, *DAMAGE* (**DAM**Age **Assessment** of **Grounding** **Events**), *SIMCOL* (**Sim**plified **COL**lision **Model**), *GRACAT* (**Grounding** and **COL**lision **AN**alysis **TO**olbox), *MARCOL* (**Mar**itime **COL**lision **Model** of **MARIN**). They can be used in deterministic manner, for analyzing structural response, and, alternatively, in probabilistic manner, for risk analysis. Ultimately, such tools may play a significant role in a rational design framework.

However, taking into consideration the variety of the collision or grounding scenarios, the implementation of such methods is still far from being fully accomplished. For instance, in the case of “powered grounding”, the damage characteristics are highly dependent on the topology of the seabed obstacle, not to say the bottom structural arrangement. In a research paper from 2007 has defined three types of seabed indenter, namely “rock”, “reef” and “shoal”. In addition, grounding may also happen on relatively soft sea bottoms.

Generally, different topologies will lead to different deformation or failure modes. Nevertheless, a large body of the existing simplified methods for ship grounding is concerned with sharp seabed obstacles. To a large extent, this is due to the damage inspection in high profile grounding accident exemplified by *Exxon Valdez*. Simplified methods concerned with other types of seabed obstructions other than “rock”, for instance obstructions with large contact surface, are rarely seen, although they are considered common (Amdahl et al 1995, Wang et al 2000 and 2002). Theoretical models and calculation approaches are still lacking. A significant part of the present work is dedicated to this.



**Figure 9.4. Seabed topology with reference to bottom size: (a) rock; (b) reef; (c) shoal**

### **9.3 Structural damage assessment**

Damages to the hull occur in 53% of ships’ accidents. On average, each ship of the world fleet suffers hull damage once in 10 years with two ships out of one hundred damaged ships being lost. A great variety of incidents exist, such as collisions, grounding, explosions and fires, severe storms, etc. Therefore, a great variety of hull structure damages exist as well.

Besides holes, there are many damages of the hull that can be identified, such as rupture of elements (infringement of integrity of a hull structure element due to exhaustion of its plastic deformation limit), cracks (infringement of integrity of a hull structure element due to fatigue) or one-time overload in area of indents or bulges resulting from buckling, as well as different kinds of deformations that are observed after accident.

The following types of residual deformations can be defined: indentions (local plate permanent deflection in some areas between stiffeners); corrugation (permanent deflections of several adjacent areas of plate between stiffeners); dents (local permanent deflection of a panel, which includes the plate and supporting stiffeners); bulge (permanent deflection of the stiffener’s web plate or the stiffener’s attached plate).

The assessment of the effect of incidents on the hull structure strength and ship survivability is based on the damage dimensions, i.e, length, height, depth. The assessment of the effect of changed external loads on the hull structure is based on data for the wind and wave conditions during the incident and the distance to a place of refuge, which determines the greatest possible wave load. Therefore,

statistical data for damages resulting from incidents is necessary both in the design stage and in the process of developing operative methods to save the ship.

Until now, the Classification Societies' requirements for damaged vessel survival regulate their trim and stability (bulk carriers, tankers, chemical tankers, gas carriers, passenger vessels, and also dry-cargo vessels with length greater than 80 m; for other types only if the damage dimensions are significant). For damage stability calculations of sea-going ships at design stage, the length of the hole is taken as a function of the ship's length. For ships with a length smaller than 100 m, the design lengths of the holes and the available statistical data are very close. For oil tankers, chemical tankers and gas carriers the design and statistical data are close for lengths up to 200 m. For vessels of greater length, the SOLAS and MARPOL requirement are lagging behind the average statistical data.

It is necessary to take into account that the holes are not the only damage of the hull as a result of grounding, collisions or explosions.

The available statistics of hull damages confirms these conclusions. In reality the hole occupies a rather small space in comparison with the zone of damage - cracks, ruptures and deformations of plates and framing. It is necessary to note that the functioning of longitudinals in this zone changes substantially. These changes are caused by the loss of their cross-sectional area, reduction of the attached plates, tripping of stiffeners and large permanent deformations, change of the support of the main supporting members, and buckling. There is also the so-called "shadow" effect of the damaged area, i.e. as a result of the damage, a zone exists of physically intact longitudinals, which do not participate or only partly participate in hull girder bending in cases of large permanent deformations, destruction of the side structure reinforced transverses, transverse bulkheads leading to reduction of the hull girder strength.

Thus, in general, according to the statistical data, the holes dimensions used in the standard calculations are close enough to their mean values, which allow for the recommendation of these dimensions for strength calculations of damaged ships at design stage.

Based on the statistics for actual damage dimensions and the increase of still water loads resulting from the intake sea water, it is possible to unequivocally assert that it is necessary to consider essential reduction of the overall hull girder strength resulting from ship's incidents:

1. Increase of the still water loads can occur in collisions with vessels and other objects; grounding, explosion; during salvage operations – anti heeling, unloading before removal from ground or during fire extinguishing.
2. Increase of the still water loads can occur not only in collisions or other reasons, but also during removal from a grounding incident by unloading (10 % - 15 % from the initial displacement).
3. Change of loading can occur by virtue of properties of the cargo in the flooded compartment – oil spill, dissolution of raw sugar, etc.

**Damages due to ship collisions.** The determination of the damage of a ship involved in a specific collision comprises the definition of the "loading" during the collision incident and the application of an acceptable method to calculate the structural response. In such a case the "loading" should be described by a set of input parameters rather than solely from the force, which is applied on the impacted structure and depends, among other factors, on the relative stiffness of the structures that collide. In particular, the description of the loading on a ship involved in a ship-ship collision includes the speed of the colliding ships, collision geometry. i.e. striking location, impact angle, relative orientation between striking and struck vessels, loading conditions - full load and ballast conditions are usually considered - draft, trim, bow shape, ship hull and striking bow structural arrangement, sea conditions, wind and current, and ship maintenance level.

Human response may also affect the consequences, in particular the possibility of occurrence and the details of the scenario itself.

The values of these parameters, which define the collision scenario, may be taken as those that would have the most unfavourable consequences, or those that have a predefined level of occurrence. A more delicate approach could consider the probability density function of each parameter and finally

calculate the risk of the colliding ship. In any case the hypothetical scenarios should represent situations that are as close as possible to those encountered in reality. Investigating ship to ship collision scenarios that are included in existing rules and regulations or have been applied in the design process of a ship, and present data concerning the distributions of the kinetic energies of ships traveling worldwide and examples of use of these distributions for the prediction of the energies that are available to cause structural damage in particular collision cases. Some times, quantitative examples of the “loading” according to rules and regulations or derived from the energy distributions is included, which is to be used in the design process of a ship.

Design against collision has been an issue since the design of nuclear powered vessel “Savannah”. At that time it was decided to design her collision protection, in a way to withstand a collision with a T2 tanker at full load, i.e. a ship having a displacement of 23000 tons, and a full design speed of 15 knots. The decision took into account a survey of the world’s merchant fleet and the distribution of the maximum kinetic energy based on full load displacement and the design sea speed.

The survey revealed that at that time the number of ships having a kinetic energy greater than  $2.6 \times 10^6$  tons-knots<sup>2</sup> (approximately 671MJ), which corresponds to the energy of the selected striking ship, falls off rapidly. The calculation of the damage of the target ship as well as the bow of the striking ship was performed using the formula of Minorsky. In order to use the pioneering formula, it was necessary to use as input parameter the entrance angle of the striking bow, which was taken equal to 57.2 deg., and the vertical relevant position of the two ships. The latter was selected so as to result in the most unfavourable situation. The analysis showed that the nuclear vessel could withstand the collision with the T2 tanker travelling with 15 knots without damage of the reactor compartment. The volume of the damaged material outside the this space was calculated equal to 2,89 m<sup>2</sup>·cm for the target and 2,46 m<sup>2</sup>·cm for the A design approach similar to that followed in the case of Savannah, has been adopted for the collision protection of the First Nuclear Ship of Japan (FNSJ). An investigation to assess her performance in case she is involved in a ship-ship collision aimed in the calculation of the critical speeds of 15 striking vessels versus her navigation speeds. The 15 ships had displacements varying from 6,360 tons to 239,000 tons and navigation speeds varying from 15 knots to 20.8 knots. The analysis showed that in some cases the navigation speed of the striking ship was higher than the critical speed, but it was claimed that the most probable percentage of the world fleet capable of penetrating the reactor compartment of the FNSJ was 0.7%. It was further noted that as low speeds are used in harbours, a collision resulting to rupture in a harbour area is practically impossible.

Later have been designed the collision protection barrier of Otto Hahn on the basis of a series of large scale collision tests. The striking bows selected for the tests were the models of bows of existing ships and the impact speed corresponded to their service speed.

The above mentioned procedures that have been followed for the design of nuclear powered vessels, took into consideration the world merchant fleet at the time of design of the vessels, and the collision scenarios that were considered were those that could potentially release relative large amount of energies. However, the absolute amounts of energy are not large, in comparison to the energies that may be released today in case of a ship-ship collision, because both the size of the vessels and their speed has been increased considerably.

**Damage due to grounding.** The probability of grounding occurrence and in general accident occurrence may be computed from statistics based on historical data, expert opinions and predictive calculations. Historical data provide realistic figures, which nevertheless should be used for future predictions with caution, because a) they are relevant to structures, which may differ from those in use today, and b) operation methods are usually improved with time, in order to offer higher safety standards.

Using the data from LR of Shipping’s World Casualty Statistics, have reported that the total losses of all ships during the years 1995–1998 are 674 in number and 3.26 million in gross tonnage. Grounding accounts for total losses amounting to 17% in number of ships and 24% in GT. The grounding incident rate for Ro-Ro and merchant navy ship types with lengths greater than 100 m, for incidents in the period 1990–1999 inclusive, is approximately 0.02 per ship year, which is about half the incident rate



for ship collision. This figure implies that if it is assumed that the life of a ship is 25 years, every second ship is expected to experience grounding in her life.

In order to quantify the probability of grounding occurrence and to investigate the effect of various factors on the likelihood and consequences of grounding, in 2007 have been developed a database of accidents and populated it with data of accidents on Greek ships over 100 GT. The data were retrieved from the records of the Directorate of the Safety of Navigation of the Hellenic Ministry of Mercantile Marine (HMMM), which should cover all accidents of ships sailing under the Greek flag with size over 100GT, from 1992 to 2005. The investigations of accidents of ships over 100 GT, with Greek flag, from 1992 to 2005 revealed that groundings were the most frequent accidents: 47% of the total number of the reported accidents were groundings or caused grounding of a ship. However, only a few of those had catastrophic consequences. Further investigation of the accidents also revealed that:

- The decrease with time of the total number of accidents is proven to be statistically significant whereas the trend for groundings cannot be given as statistically significant;
- The dry cargo vessels suffer the most from groundings, 58% of the groundings involved dry cargo vessels, even though the ship-years of cargo vessels in the Greek fleet is 33%.
- Aged ships, i.e. ships in the between 21-30 years old and 30+ years old, suffer the most from groundings even though the ship-years of the ships in these age categories is relatively low.
- The ratio of groundings over the total number of accidents is higher for large rather than for smaller ships. From the investigation of the data it was found in every ten accidents for ships between 100 GT and 1000 GT there were 4,2 accidents with grounding and 5,8 accidents with other types of accidents, while for every 10 marine accidents for ships larger than 30000 GT, there were 6,7 accidents with grounding and 3,3 accidents with other type of accidents, and this differentiation was found to be statistically significant.
- There is a statistical difference between the mean values of the size (in GT) of the tankers that after grounding produced pollution and of those that did not lead to oil spillage; whereby larger ships tend to pollute more rather than smaller.

The process of ship grounding involves large contact forces, crushing of the hull structure and rupture of shell plating, while interacting with global motions and overall hull strength. It may cause serious consequences. The property of the sea bed, the bottom topology and the grounding scenarios are the governing factors for the damage process. Adequate information on sea floor topology is, however, very limited. Most of the analysis models for ship grounding in the past published works assumed that a rock opened a large part of the ships bottom structures. The damages of hull structures after grounding were classified into five fundamental damage modes, which are: (a) the stretching mode of shell plating and local large deformation, (b) plate perforating model for ruptured plating, (c) plate denting mode for main supporting members and (d) axial crushing mode for intersection of main supporting members and (e) plate tearing mode for plate in plane compressed by sharp body.

The simplified formulae for approximation of energy dissipation and impact resistance of four fundamental damage modes were derived. The overall energy dissipation and impact resistance of struck structures can be estimated by assembly of these fundamental failure mechanisms.

In 2002, a group of researchers have investigated the behaviour of various double bottom configurations in stranding damage scenarios. The ship bottom is loaded with a conical indenter with a rounded tip, which is forced laterally into the structures in different positions. The resistance forces, energy absorption and penetration with fracture for four different structures were compared, which were:

- type I, a conventional double bottom,
- type II, a structure with hat-profiles stiffened bottom plating,
- type III, a structure with steel sandwich panel in outer bottom and
- type IV, a structure with hat-profiles in both inner and bottom.

The results showed that the penetration where the tank top fractures is almost the same inner bottom was quite high for structures II and IV, whereas the weights of those structures are not much higher

than for the conventional structure. Structure IV, for example, is 4% heavier than the conventional structure (structure I) but the average energy absorption at the point of tank top fracture is 33% larger than for the conventional structure. Sandwich panels are locally weak due to the small thickness, when a sharp local contact takes place. On the contrary, for a wider shape of contact the double bottom construction will be stronger than conventional stiffened plate bottom.

The effect of different indenter size has been investigated, and was done through a series of scaled down double bottom grounding experiments. The study clearly shows that small indenters puncture the hull skin with relative ease, while larger indenters damage the internal web configuration before the shell plating ruptures.

## Chapter X

### Applying of safety based design concept for ship damage stability and survivability

#### 10.1 State-of-the-art in assessing damage stability of ships

From a ship stability viewpoint, the most fundamental goal to be achieved is for a ship to remain *afloat* and *upright*, especially so after an accident involving water ingress and flooding. Regulations to address the former are targeting subdivision and the latter damage stability. More recent instruments in the regulatory process tend to cater for both issues whilst contemporary developments have adopted a more holistic approach to safety that encompasses considerations of all principal hazards over the life-cycle of the vessel.

Notably, the first Merchant Shipping Act of 1854 is the first known legal requirement addressing safety at sea concerning watertight bulkheads, leading eventually and after heavy loss of life to the adoption of the first internationally agreed system of subdivision in SOLAS 1929. The first damage stability requirements, on the other hand, were introduced following the 1948 SOLAS Convention and the first specific criterion on residual stability standards at the 1960 SOLAS Convention with the requirement for a minimum residual GM of 0.05m. This represented an attempt to introduce a margin to compensate for the upsetting environmental forces. "Additionally, in cases where the Administration considered the range of stability in the damaged condition to be doubtful, it could request further investigation to their satisfaction". Although this was a very vague statement, it is representative of the first attempts to legislate on the range of stability in the damaged condition. It is interesting to mention that a new regulation on "Watertight Integrity above the Margin Line" was also introduced reflecting the general desire to do all that was reasonably practical to ensure survival after severe collision damage by taking all necessary measures to limit the entry and spread of water above the bulkhead deck.

Subsequently and at about the same time as the 1974 SOLAS Convention was introduced, the International Maritime Organisation (IMO), published Resolution A.265 (VIII).

The next major step in the development of stability standards came in 1992 with the introduction of SOLAS part B-1 (Chapter II-1), containing a probabilistic standard for cargo vessels, using the same principles embodied in the 1974 regulations. The same principle was used in launching at IMO the regulatory development of "Harmonisation of Damage Stability Provisions in SOLAS, based on the Probabilistic Concept of Survival" in the belief that this represented a more rational approach to addressing damage stability safety.

Evidence, however, of "common sense" driving rule making is very scarce; with accidents providing the main motivation for rule making, emphasis has primarily been placed on reducing consequences, i.e., on cure rather than prevention. Against this background, it is widely believed that the prevailing situation could be drastically improved through understanding of the underlying mechanisms leading to vessel loss and to identification of governing design and operation parameters to target risk reduction cost-effectively. This in turn necessitates the development of appropriate methods, tools and techniques capable of meaningfully addressing the physical phenomena involved. Having said this, it was not until the early 90s when **dynamic** stability pertaining to ships in a **damage** condition, was addressed by simplified numerical models, such as the numerical model of damaged Ro-Ro vessel dynamic stability and survivability.

The subject of dynamic ship stability in waves with the hull breached received much attention following the tragic accident of Estonia, to the extent that lead to a step change in the way damage stability is being addressed, namely by assessing the performance of a vessel in a given environment and loading condition on the basis of first principles. In parallel, motivated by the compelling need to understand the impact of the then imminent introduction of probabilistic damage stability regulations on the design of cargo and passenger ships and the growing appreciation of deeply embedded

problems in both the rules and the harmonisation process itself, an in depth evaluation and re-engineering of the whole probabilistic framework.

Deriving from developments at fundamental and applied levels in project HARDER as well as other EU projects such as NEREUS, ROROPROB and SAFEVSHIP and other international collaborative efforts (e.g., work at ITTC), a clearer understanding of damage stability started to emerge together with a confidence in the available knowledge and tools to address the subject effectively. All these efforts provided the inspiration and the foundation for SAFEDOR (2004 – Design / Operation / Regulation for Safety), which provided the opportunity for consolidating contemporary developments on damage survivability, thus rendering implementation possible even at design concept level. The knowledge gained can now be used to address critically all available regulatory instruments and to foster new and better methodologies to safeguard against known design deficiencies in the first instance, until safer designs evolve to reflect this knowledge. At this point in time, it is known for example that damaged ships in waves may capsize in one of the following modes (the first three after the final equilibrium condition is reached post-damage):

**High freeboard ships:** *Provided there is some minimal positive righting lever and range of stability the ship will not capsize in moderate waves. Wave impacts on the side of the ship will induce some rolling in marginally stable cases, which could result in capsize at the larger sea states. Often ships are more vulnerable with the damage to leeward, since the GZ levers are typically less in the damaged direction and the induced dynamic roll is typically somewhat greater leeward.*

**Low freeboard Ro-Ro ships:** *This is the typical mechanism of capsize for Ro-Ro ships. The wave action gradually pumps water up onto the vehicle deck. The height of the water gradually increases until either a reasonably stable equilibrium level is reached where inflow is approximately equal to outflow for ships with sufficient reserve stability, or if stability is inadequate, the heeling moment of the water will cause a capsize to windward. In some rare cases Ro-Ro vessels may heel to leeward after the first few wave encounters with an insufficient freeboard on the weather side to prevent further water accumulation and the ship will continue to take water on the vehicle deck until a capsize results.*

**Low freeboard conventional ships:** *This is the typical mechanism of capsize for non-Ro-Ro ships. The highest waves will form boarding seas and will pile-up on the windward side of the deck, inducing roll and capsize, usually to windward. The weather deck tends to drain quickly if there is no capsize, and there is no build-up or accumulation of water as seem with enclosed Ro-Ro decks. One or two high waves in close succession are often sufficient to cause capsize.*

**Multi-Free-Surface Effect:** *This mechanism of capsize is relevant to ships with complex watertight subdivision such as cruise ships. As the hull is breached, water rushes through various compartments at different levels, substantially reducing stability even when the floodwater amount is relatively small. As a result the ship can heel to large angles, even for small damage openings, letting water into the upper decks that spreads rapidly through these spaces and may lead to rapid capsize at any stage of the flooding.*

The aforementioned mechanisms of vessel capsize help to judging how relevant or effective available regulatory instruments are, in being able to prevent or mitigate disasters, as indicated in the following for the instruments currently in use or due to be enforced:

- SOLAS 74: 1 - compartment standard (prevent • ship from sinking if one compartment is breached; resistance to capsize in waves unknown)
- SOLAS 90: 2 - compartment standard (prevent • ship from sinking if any two compartments are breached; resist capsize of 2-compartment worst damage in sea states with  $H_s$  approximately 3m – Ro-Ro vessels)
- Stockholm Agreement (as above but with a pre-defined level of water on deck depending on freeboard and in operational sea states of up to 4m  $H_s$ ),
- Harmonised SOLAS Chapter II-1(SOLAS 2009 – equivalent to SOLAS 90).

Concerning the latter, a stage has now been reached where the draft text of the major revision to the subdivision and damage stability sections of SOLAS Chapter II-1 based on a probabilistic approach

has been completed following final amendments in January 2005 to Regulation 7-1 involving calculation of the “p” factor. The revised regulations were adopted in May 2005 at the IMO MSC and entered into force for new vessels with keels laid on or after 1st January 2009. The new regulations represent a step change away from the current deterministic methods of assessing subdivision and damage stability. Old concepts such as floodable length, criterion numeral, margin line, 1 and 2 compartment standards and the B/5 line will be disappearing.

With this in mind there appears to be a gap in that, whilst development of the probabilistic regulations included extensive calculations on existing ships which had been designed to meet the current SOLAS regulations, little or no effort has been expended into designing new ships from scratch using the proposed regulations.

## ***10.2 Damage stability and survivability design***

Contemporary regulatory developments are already a step ahead, necessitating concerted effort at global level to ensure safe transition from deterministic to goal-based safety. More specifically, in May 2000, the IMO Secretary- General called for a critical review of the safety of large passenger ships noting that “what merits due consideration is whether SOLAS requirements, several of which were drafted before some of these large ships were built, duly address all the safety aspects of their operation – in particular, in emergency situations”. This visionary prompt led IMO Maritime Safety Committee (MSC) to adopt a new “philosophy” and a working approach for developing safety standards for passenger ships. In this approach (SLF 47/48), modern safety expectations are expressed as a set of specific safety goals and objectives, addressing design (prevention), operation (mitigation) and decision making in emergency situations with an overarching safety goal, commensurate with no loss of human life due to ship related accidents. The term “Safe Return to Port” has been widely adopted in discussing this framework, which addresses all the basic elements pre-requisite to quantifying the safety level (life-cycle risk) of a ship at sea.

More specifically the following elements are explicitly addressed:

1. **Prevention/Protection:** Emphasis must be placed on preventing the casualty from happening in the first place as well as on safeguards (in-built safety) to limit consequences.
2. **Timeline Development:** The focus is clearly on the timeline development of different events. For the first time in the history of rule-making, it is not only important to know whether a vessel will survive a given casualty in a given loading condition and operating environment but also the time the vessel will remain habitable, the time it takes for safe and orderly abandonment and for recovery of the people onboard.
3. **Casualty Threshold:** This advocates the fact that the ship should be designed for improved survivability so that, in the event of a casualty, persons can stay safely on board as the ship proceeds to port. In this respect and for design purposes (only), a casualty threshold needs to be defined whereby a ship suffering a casualty below the defined threshold is expected to stay upright and afloat and be habitable for as long as necessary 5 days recommended in order to return to port under its own power or wait for assistance.
4. **Emergency Systems Availability / Evacuation and Rescue:** Should a casualty threshold be exceeded the ship must remain stable and afloat for sufficiently long time to allow safe (3 hours recommended) and orderly evacuation (assembly, disembarkation and abandoning) of passengers and crew. Emergency systems availability to perform all requisite functions in any of the scenarios considered is, therefore, implicit in the framework. In addition, the ship should be crewed, equipped and have arrangements in place to ensure the health, safety, medical care and security of persons onboard in the area of operation, taking into account climatic conditions and the availability of SAR functions and until more specialised assistance is available.

Considering the above, it is worth emphasising that none of the questions arising (survival time?; functional availability post-casualty?; time needed for abandonment?) can be addressed in terms of

rule compliance. Nonetheless, achievement of these goals in the proposed holistic, goal-based and proactive approach would ensure safety of human life commensurate with the safety expectations of today, by implicitly addressing all key elements of risk, for total risk (Safety Level) estimation and for direct use in Risk-Based Design.

Flooding survivability analysis normally entails the following, the first three of which are addressed here at various levels of detail.

- Statutory Assessment:
  - Compliance with SOLAS 2009 (probabilistic rules)
  - Optimisation of watertight subdivision
    - Transient-, cross- and progressive-flooding assessment
  - Static vs. dynamic stability
  - Time to flood
    - Time to Capsize
  - Probabilistic approach for selection of damage (collision and grounding) cases
  - Vulnerability approach for survivability assessment
    - Systems availability for each flooding scenario
  - Geometrical and topological evaluation of main ship systems
    - Evacuability assessment
  - Assembly and evacuation performance
  - Assessment of time to capsize against total evacuation time
    - Evaluation of casualty threshold / return to port capability
  - Probabilistic approach; link to system availability post-casualty

Acknowledging that emphasis on preventing a casualty from occurring in the first instance must take priority, focus on risk reduction by passive means (in-built safety) must come next and this must start at the beginning. To this end, the dilemma of prescriptive SOLAS-minded designers, in the simplest of levels, must be overcome. It is obvious that internal subdivision arrangement is a key issue affecting ship performance, functionality and safety, all of which have to date been catered for through the provision of rules and regulations that reflect, in essence, codification of best practice. Throwing this away and leaving on the table a blank sheet, makes ship subdivision a very difficult problem indeed.

Building on the understanding of Index A, affords a straightforward way of determining the relative (collision damage) risk profile of a vessel at an early design stage and hence devise an effective means of risk reduction by focusing primarily on the high risk scenarios.

The fully automated optimization process typically produces several hundred design alternatives depending on the complexity of the ship's layout and the number of variables. Typical variables of the optimization problem include: type of subdivision, number, location and height of watertight bulkheads, deck heights, tank arrangement, casings, double hull, and position of staircases, lifts and escapes.

In order to make the process effective, participation by all decision makers (designer, owner and yard) is essential to properly define the optimization variables, objectives and constraints as early as possible in the design stage. Using this approach, known as platform optimization, high survivability internal ship layouts can be developed, without deviating much from the current SOLAS practice, this making it easier for ship designers to relate to the proposed procedure. In order to make the process effective, the participation of all decision-makers (the designer, the owner, the yard) is essential to properly define the optimisation variables, objectives and constraints. Using this approach, high survivability internal ship layouts have been developed, without deviating much from the current SOLAS practice, this making it easy for ship designers to relate to the proposed practice.

## Chapter XI

### Safety-based design for offshore vessels

#### *11.1 Safety approach and formal safety assessment of offshore ships*

Following the public inquiry into the Piper Alpha accident, the responsibilities for offshore safety regulations were transferred from the Department of Energy to the Health and Safety Commission (HSC) through the Health and Safety Executive (HSE) as the single regulatory body for offshore safety. In response to the accepted findings of the Piper Alpha inquiry, the HSE Offshore Safety Division launched a review of all offshore safety legislation and implemented changes. The changes sought to replace legislation that was seen as prescriptive with a more “goal setting” regime. The mainstay of the regulations is the Health and Safety at Work Act. Under that act, a draft of the offshore installation (safety case) regulations was produced. It was then modified, taking into account comments arising from public consultation. The regulations came into force in two phases:

- (a) at the end of May 1993 for new installations and
- (b) on November 1993 for existing installations.

The regulations require operational safety cases to be prepared for all offshore installations. Both fixed and mobile installations are included. Additionally, all new fixed installations require a design safety case. For mobile installations, the duty holder is the owner.

The HSE framework for decisions on the tolerability of risk has three regions: (a) intolerable, (b) as low as is reasonably practicable (ALARP), and (c) broadly acceptable. Offshore operators must submit operational safety cases for all existing and new offshore installations to the HSE Offshore Safety Division for acceptance. An installation cannot legally operate without an accepted operational safety case. To be acceptable, a safety case must show that hazards with the potential to produce a serious accident have been identified and that associated risks are below a tolerability limit and have been reduced ALARP. For example, the occurrence likelihood of events causing a loss of integrity of the safety refuge should be less than  $10^{-3}$  per platform year and associated risks should be reduced to an ALARP level.

It should be noted that the application of numerical risk criteria may not always be appropriate because of uncertainties in inputs. Accordingly, acceptance of a safety case is unlikely to be based solely on a numerical assessment of risk.

Fires and explosions may be the most significant hazards with potential to cause disastrous consequences in offshore installations. Prevention of fire and explosion and emergency response regulations (PFEER) were developed in order to manage fire and explosion hazards and the corresponding emergency responses that protect persons from their effects. A risk-based approach is used to deal with problems involving fire and explosion and emergency response. PFEER supports the general requirements by specifying goals for preventive and protective measures to manage fire and explosive hazards, to secure effective emergency response, and to ensure compliance with regulations by the duty holder. Management and administration regulations (MAR) were introduced to cover areas such as notification to the HSE of changes of owner or operator, functions, and powers of offshore installation managers. MAR is applied to both fixed and mobile offshore installations (excluding sub-sea offshore installations).

The importance of safety of offshore pipelines has also been recognized. As a result, pipeline safety regulations (PSR) were introduced to embody a single integrated, goal-setting, risk-based approach to regulations covering both onshore and offshore pipelines.

After several years of experience, the safety case regulations were amended in 1996 to include verification of safety-critical elements, and the offshore installations and wells (design, construction, etc.) regulations (DCR) were introduced to deal with various stages of the life cycle of the installation. From the earliest stages of the life cycle of the installation, the duty holder must ensure that all safety-critical elements be assessed.

Safety-critical elements are parts of an installation and of its plant (including computer programs) or any part whose failure could cause or contribute substantially to or whose purpose of which is to

prevent or limit the effect of a major accident. In DCR, (a) a verification scheme is introduced to ensure that a record is made of the safety-critical elements; (b) comment on the record by an independent and competent person is invited; (c) a verification scheme is drawn up by or in consultation with such person; (d) a note is made of any reservation expressed by such person; and (e) such scheme is put into effect. DCR allows offshore operators to have more flexibility to tackle their own offshore safety problems. Offshore duty holders may use various safety assessment approaches and safety-based decision making tools to study all safety-critical elements of offshore installations and wells to optimize safety. This may encourage offshore safety analysts to develop and employ novel safety assessment and decision-making approaches and to make more efforts to deal with offshore safety problems.

Compliance with current offshore safety regulations is achieved by applying an integrated risk-based approach, starting from feasibility studies and extending through the life cycle of the installation. Design for safety is considered to be the most important. This is achieved through stages of hazard identification (HAZID) for the life cycle of installation from concept design to decommissioning and the use of state-of-the-art risk assessment methods. In a risk-based approach, early considerations are given to those hazards that are not foreseeable to design out by progressively providing adequate measures for prevention, detection, control, and mitigation and further integration of emergency response.

Recently, the industrial guidelines on a framework for risk-related decision support were produced. In general, the framework could be usefully applied to a wide range of situations. Its aim is to support major decisions made during the design, operation, and abandonment of offshore installations. In particular, it provides a sound basis for evaluating the various options that need to be considered at the feasibility and concept selection stages of a project, especially with respect to “major accidents hazards” such as fire, explosion, impact, and loss of stability. It can also be combined with other formal decision-making aids such as Multi-Attribute Utility Analysis (MAUA),

Analytical Hierarchy Process (AHP), or decision trees if a more detailed or quantitative analysis of the various decision alternatives is desired. It should be noted that there can be significant uncertainties in the information and factors that are used in the decision-making process. These may include uncertainties in estimates of the costs, time scales, risks, safety benefits, the assessment of stakeholder views and perceptions, and so forth. There is a need to apply common sense and ensure any uncertainties are recognized and addressed.

**Current status of formal ship safety assessment.** Due to serious concerns over the safety of ships all over the world, the International Maritime Organization (IMO) continuously deals with safety problems in the context of operation, management, survey, ship registration, and the role of the administration. Improving safety at sea is highly stressed. The international safety-related marine regulations are guided by lessons learned from serious marine accidents that have happened. These lessons were first observed from the accidents. Then, the regulations and rules were produced to prevent similar accidents from occurring. For example, the capsizing of the *Herald of Free Enterprise* in 1987 greatly affected the rule-developing activities of the IMO. The accident certainly raised serious questions on operation requirements and the role of management, which stimulated discussions in those areas at the IMO. This finally resulted in the adoption of the International Management System (ISM) Code. The Exxon Valdez accident in 1989, which was a large-scale oil spill, seriously damaged the environment. It facilitated the implementation of the international convention on Oil Pollution Preparedness, Response and Cooperation (OPRC) in 1990.

Double hull or mid-deck structural requirements for new and existing oil tankers were subsequently applied. The Scandinavian Star disaster in 1990 resulted in the loss of 158 lives. Furthermore, the catastrophic disaster of the *Estonia*, which capsized in the Baltic Sea in September 1994, caused more than 900 people to lose their lives. Those accidents highlighted the role of human error in marine casualties, and as a result, the new Standards for Training, Certificates and Watchkeeping (STCW) for seafarers were subsequently introduced.



After Lord Carver's report on the investigation of the capsizing of the Herald of Free Enterprise was published, the UK Maritime and Coastguard Agency [previously named Marine Safety Agency (MSA)] quickly responded and in 1993 proposed to the IMO that formal safety assessment should be applied to ships to ensure a strategic oversight of safety and pollution prevention. The UK MCA also proposed that the IMO should explore the concept of formal safety assessment and introduce formal safety assessment in relation to ship design and operation. The IMO reacted favorably to the UK's formal safety assessment submission. Since then, substantial work (including demonstrating its practicality by a trial application to high-speed catamaran ferries and bulk carriers) has been done by the UK MCA. In general, for the last several years, the application of formal safety assessment has significantly progressed. This is demonstrated by the successful case studies of a high-speed craft and a bulk carrier and by the IMO approval of the application of a formal safety assessment for supporting rule-making process.

Safety assessment in ship design and operation offers great potential incentives. Application of it may:

1. Improve the performance of the current fleet and make it possible to measure the performance change and ensure that new ships are good designs;
2. Ensure that experience from the field is used in the current fleet and that any lessons learned are incorporated into new ships; and
3. Provide a mechanism for predicting and controlling the most likely scenarios that could result in incidents.

Possible benefits have already been realized by many shipping companies. For example, P&O Cruises in the UK reviewed the implementation of risk assurance methods as a strategic project and proposed short/medium- and long-term objectives. Its short/medium-term objectives are (a) to provide a reference point for all future risk assurance work, (b) to develop a structure chart that completely describes vessel operation, (c) to complete a meaningful HAZID as the foundation of the data set, (d) to enable identification of realistic options for vessel improvement, (e) to be a justified record of modifications adopted or rejected, and (f) to be capable of incorporating and recording field experience to ensure that the knowledge is not lost.

Its long-term objectives are (a) to provide a mechanism for understanding the effect of modifications on total vessel performance, (b) to be capable of future development, (c) to provide a basis for total valuation of identified improvements using cost benefit analysis (CBA), (d) to generate a meaningful risk profile for vessel operation, and (e) to provide a monitor for evaluation of modification effectiveness.

The idea of formal safety assessment may well be fitted to the above objectives in order to improve the company's performance.

**Offshore safety assessment.** The format of safety case regulations was advocated by Lord Robens in 1972 when he emphasized the need for self-regulation and pointed out the drawbacks of a rule book approach to safety. The concept of the safety case was derived and developed from the application of the principles of system engineering for dealing with the safety of systems or installations for which little or no previous operational experience exists. The five key elements of the safety case concepts are:

1. HAZID. This step is to identify all hazards with the potential to cause a major accident.
2. Risk estimation. Once the hazards have been identified, the next step is to determine the associated risks. Hazards can generally be grouped into three risk regions known as the intolerable, tolerable, and negligible risk regions.
3. Risk reduction. Following risk assessment, it is required to reduce the risks associated with significant hazards that deserve attention.
4. Emergency preparedness. The goal of emergency preparedness is to be prepared to take the most appropriate action in the event that a hazard becomes a reality so as to minimize its effects and, if necessary, to transfer personnel from a location with a higher risk level to one with a lower risk level.

5. Safety management system (SMS). The purpose of a safety management system is to ensure that the organization is achieving the goals safely, efficiently, and without damaging the environment. One of the most important factors of the safety case is an explanation of how the operator's management system will be adapted to ensure that safety objectives are actually achieved.

A safety case is a written submission prepared by the operation of an offshore installation. It is a stand-alone document that can be evaluated on its own but has cross-references to other supporting studies and calculations. The amount of detail contained in the document is a matter of agreement between the operator and the regulating authority. In general, the following elements of an offshore installation are common for many safety cases:

1. A comprehensive description of the installation.
2. Details of hazards arising from the operation installation.
3. Demonstrations that risks from these hazards have been properly addressed and reduced to an ALARP level.
4. Description of the safety management system, including plans and procedures in place for normal and emergency operations.
5. Appropriate supporting references.

The following activities characterize the development of a safety case:

1. Establish acceptance criteria for safety, including environment and asset loss, if possible. These may be both risk based and deterministic.
2. Consider both internal and external hazards using formal and rigorous HAZID techniques.
3. Estimate the frequency or probability of occurrence of each hazard.
4. Analyze the consequences of occurrence of each hazard.
5. Estimate the risk and compare with criteria.
6. Demonstrate ALARP.
7. Identify remedial measures for design, modification, or procedure to avoid the hazard altogether, reduce the frequency of occurrence, or mitigate the consequences.
8. Prepare the detailed description of the installation including information on protective systems and measures in place to control and manage risk.
9. Prepare a description of the safety management system and ensure that the appropriate hazard procedures are identified.

In offshore safety analysis, safety-based design/operation decisions are expected to be made at the earliest stages in order to reduce unexpected costs and time delays. A risk reduction measure that is cost effective at the early design stage may not be ALARP at the late stage. HSE regulations aim to have risk reduction measures identified and in place as early as possible when the cost of making any necessary changes is low. Traditionally, when making safety based design/operation decisions for offshore systems, the cost of a risk reduction measure is compared with the benefit resulting from reduced risks. If the benefit is larger than the cost, then it is cost effective, otherwise it is not. This kind of CBA based on simple comparisons has been widely used in offshore safety analysis.

Conventional safety assessment methods and CBA approaches can be used to prepare a safety case. As the safety culture in the offshore industry changes, more flexible and convenient risk assessment methods and decision-making approaches can be employed to facilitate the preparation of a safety case. The framework for risk-related decision support can provide an umbrella under which various risk assessment and decision-making tools are employed.

The guidelines in the framework set out what is generally regarded in the offshore industry as good practice. These guidelines are a living document. Experience changes the working practices (both the business and social environment), and new technology may cause them to be reviewed and updated to ensure that they continue good practice. It should be noted that the framework produced is only applicable to risks falling within the ALARP region.

The life cycle approach manages the hazards that affect offshore installations (offshore safety study has to deal with the boundaries of other industries such as marine operations and aviation). In offshore

safety study, it is best to obtain the optimum risk reduction solution for the total life cycle of the operation or installation, irrespective of the regulatory boundaries. The basic idea is to minimize/eliminate the source of hazard rather than place extremely high reliance on control and mitigatory measures. To reduce risks to an ALARP level, the following hierarchical structure of risk control measures (RCMs) should be followed:

- Elimination and minimization of hazards by “inherently safer” design
- Prevention
- Detection
- Control
- Mitigation of consequences

Decisions evolve around the need to make choices, either to do something or not to do something, or to select one option from a range of options. These can either take the form of rigid criteria that must be achieved or of goals or targets that should be aimed for but which may not be met. The offshore oil and gas industry operates in an environment where safety and environmental performances are key aspects of successful business. The harsh marine environment and the remoteness of many of the installations also provide many technical, logistic, and operational challenges. Decision-making can be particularly challenging during the early stages of design and sanction of new installations where the level of uncertainty is usually high. In many situations, there may be several options that satisfy the requirements.

It may also be difficult to choose a particular option that is obviously the best. If this is the case, there is a need to consider what is or may be “reasonably practicable” from a variety of perspectives and to identify and assess more than just the basic costs and benefits. The decision-making process can be set up to:

- Define the issue,
- Examine the options,
- Make the decision, and
- Implement, communicate, and review the decision.
- Making risk-based decisions can be very difficult because it can be difficult to:
  - Ensure that the choices have been properly selected and defined;
  - Find ways to set out criteria and objectives;
  - Identify risk issues and perceptions;
  - Assess the performance of options against aspects that may not be quantifiable or that may involve judgments and perceptions that vary or are open to interpretation;
  - Establish the relative importance of often widely different types of objectives and factors;
  - Deal with uncertainties in estimates, data, and analyses;
  - Deal with conflicting objectives and aspects of performance;
  - Deal with differences in resolution of estimates, data, and analyses (these may not provide a fair reflection of the actual differences between the options being considered); and
  - Deal with or avoid hidden assumptions or biases.

A narrow view in the decision-making process may result in decisions creating problems in other areas at a later time. For example, in a life cycle view of the project or installation, decisions made during design to decrease engineering and installation costs may lead to higher operating costs, reducing the overall profitability of the venue.

Safety and risk factors in the decision-making process include risk transfer, risk quantification, CBA, risk levels and gross disproportion, risk aversion, perception, risk communication, stakeholders, and uncertainties. As decision-making moves from the prescriptive nature to the descriptive nature, technology-based decision-making begins to include values. The hierarchical structure of the decision context is as follows:

- Prescription
- Well-established solution
- Well-understood risks

- Very novel
- Significant trade-offs or uncertainties
- Strong views and perceptions

The factors that affect offshore safety-based decision-making include degree of novelty versus well-understood situation or practice, degree of risk trade-offs and uncertainties, strength of stakeholder views and risk perceptions, and degree of business and economic implications. Decision calibration changes with design context. As the design context moves from prescription to strong views and perceptions, means of calibration change from codes and standards to external stakeholder consultation through verification, peer review, benchmarking, and internal stakeholder consultation.

The framework proposed is also capable of reflecting the differences between the design of safety approaches for fixed offshore installations operating in the continental shelf versus mobile offshore installation operating in an international market. Fixed offshore installations in the continental shelf are usually uniquely designed and specified for the particular duty and environment, and their design basis can be set against very specific hazards and specific processing and operation requirements. Many of the more complex design decisions therefore often fall into the Type B context in the detailed framework. Mobile offshore installations have to operate in very different environments and tackle a wide range of operational activities and reservoir conditions. Specific codes and rules need to be applied. Therefore, many mobile offshore installation design decisions fall into the Type B context. Where neither codes and rules cannot be effectively applied nor traditional analysis cannot be carried with confidence, such installation may be categorized as Type C.

## *11.2 Innovative offshore vessels design*

Over the past several years, innovative vessel concepts have been built by major operators. We discuss the merits of these designs and under what conditions they provide advantages over existing vessels.

**Large deadweight PSVs.** In many deepwater scenarios, mud supply is currently a bottleneck. This is only expected to get worse with water depth. A mud change occurs at the request of the drillers when they need a change in mud composition or density. An industry rule of thumb for a typical deepwater mud change volume is around 950 cubic meters. As such vessels have been designed and built around this standard. PSVs in the current fleet built before 2005 have an average deadweight of 1,000 tons, while PSV's built between 2005 and 2010 have an average deadweight of 2,500 tons. Pushing the boundary of this trend toward increasing deadweight have been vessels explicitly designed to serve more than one drilling platform. These vessels incorporate mud capacities that are multiples of the standard 950 cubic meters mud change volume. Vessels with extremely large mud capacities may become attractive for either supply scenarios that include multiple deepwater drilling rigs or rigs in extremely deepwater where the mud requirements to fill the riser are very high.

**Faster and larger FSIVs.** In 2008 has been launched by Seacor Marine a twin-hulled catamaran FSIV capable of speeds up to 40 knots. At such speeds, the intent of the vessel is to compete with helicopters for crew transfer. Despite being significantly faster than other OSVs, this ship and her sister ship have not succeeded in displacing helicopter crew transport. According to industry interviews, most platform operators prefer to send crew out to platforms on helicopters, and will likely not change their mind in the near future. The main advantage of an extremely fast crew boat is reduced crew transport cost when compared to a helicopter, while the disadvantages include paying crew for an extended crew-boat ride and long crew-boat ride recovery periods for platform personnel. In addition, highly-trained technical crew are often required on short notice. Even as a contingency vessel, a faster FSIV does not offer significant advantages over a traditional PSV, let alone a standard CSV. As the contingencies a crew-boat can handle probably do not occur more than once every couple weeks, it is unlikely that faster FSIVs will provide any significant advantage over traditional CSVs. The only possible niche for fast crew-boats is in the delivery of extremely low-cost personnel to highly-manned and tightly-clustered production and drilling platforms very far from shore. These conditions presently only exist in very few deepwater fields, mainly off the coast of Brazil. Even these CSV opportunities

are extremely limited by vessel motions, which are severe at high speeds and can be very uncomfortable for crew. As such, we expect only innovative hull shapes, such as Small Waterplane Area Twin Hull Craft (SWATHs), that significantly reduce ship motions to offer feasible crew transport solutions.

**Redundancy.** In the recent past, major oil companies have focused increasingly on reliability and incident avoidance. In the wake of the BP Macondo spill, accident avoidance will be intensified. Even before the Macondo spill, most newbuild OSVs were expected to be DP II for almost all service types. In the future, almost all OSVs will be expected to not only be built, but also operated, according to DP II standards, and some oil companies are already requesting DP III vessels or DP II vessels that are easily upgradeable to DP III. The demand for redundancy is so great that even crewboats are being outfitted with DP II systems.

**Automation.** Aside from specialized large vessels, OSVs are typically built to minimum manning standards by staying below 6,000 GRT. As even standard PSVs are getting significantly more complex, outfitted with DP systems, advanced liquid cargo handling systems, and often Diesel Electric propulsion, while the number of crewmembers stays constant, automation is playing an increasingly important role in vessel design. In fact, a large portion of the price increase for a standard PSV can be attributed to the increase in vessel automation. Modern vessels often have integrated fuel-tracking, onboard maintenance-tracking systems and DP systems.

**Safety.** All major operators are committed to safety as a priority company mission. OSV designs are adapting to reflect that commitment. The recent Rolls-Royce design in their UT-700 AHTS class exemplifies safety-minded design. The vessel features small cargo deck cranes that move on rails mounted on the port and starboard gunwales. These cranes eliminate a large portion of manual handling on deck of ropes, wires, chains, shackles, and deck cargo and are part of a larger system designed to minimize the amount of manual work on deck. The vessel also features a 360 degree bridge view, made possible by a wet exhaust system that eliminates the need for a smokestack. A vessel safety and an alert crew go hand in hand, a number of improvements in crew comfort directly support the demands of oil companies in the area of safety.

**Crew comfort.** A side effect of increasing OSV complexity is the difficulty in hiring and training crew. Modern OSV operators must be significantly more specialized and technical than their counterparts 30 years ago, and the need for additional training is expected to continue to increase with advances in automation. In addition, the increasing demands on crew require levels of performance that are difficult to achieve in the relatively uncomfortable environment of the traditional OSV. In order to attract good crew and keep their level of performance and safety high, OSV operators are expecting vessel designs that are more comfortable and appealing to mariners. Newbuilds are increasingly conforming to class society comfort notations, and designers have made a number of conscious design decisions to increase habitability. Such improvements include increased engine room insulation, more spacious cabins, and moving accommodations higher to avoid bow thrusters noise and vibrations. Comfort improvements not only attract quality crew, but also reduce crew exhaustion and thereby increase vessel safety.

**Environmental performance.** Increased environmental performance on vessels has two main components: reducing emissions from fuel consumption, and reducing emissions helps operating costs when it means reduced fuel consumption, but hurts operating costs when it means burning more expensive fuels. Operators and oil majors are already pushing for increased efficiency of both propulsion system and hull forms, which will both aid environmental performances. Design choices enhancing fuel efficiency and environmental performance will be made inasmuch as they pay for themselves with reduced operating expenses or are required by regulations. Emissions Control Areas are being set up in a number of areas that OSVs operate in. These will precipitate the burning of more expensive fuels, and thereby provide even greater incentives for increasing efficiency. As stringent emissions regulations are being put into place rapidly, we expect significant moves toward more efficient hullforms, more efficient propulsion systems, and changes in fuels.

## Chapter XII

### New designing concepts in life saving equipments

#### *12.1 Evacuation models*

The International Maritime Organization (IMO) MSC Circ 1238 on the ‘Guidelines for Evacuation Analysis for New and Existing Passenger Ships’ require the passenger ship evacuation to be assessed by computational means during the design phase. The objective of the analysis is to check that the evacuation of the ship complies with the rules in terms of the overall duration and flows along the evacuation route. In particular it can identify congestion points and critical areas, providing an opportunity of optimizing routes to muster stations and lifeboats. For instance the width of doors or corridors can be modified to control the flow going through certain areas.

The guidelines allow for this analysis to be undertaken by either a simplified or a more advanced passenger ship evacuation method. The simplified method used to calculate the time taken to evacuate passengers treated people like particles moving in a liquid flowing through a pipe. They moved at constant flow rates heading for the nearest exit. In reality passenger behaviour is fair more complex and sometimes even irrational. The guidelines recognize that the inherent assumptions in the simplified method have their limitations particularly as passenger ships get more complex. With this approach the overall ship evacuation duration can be assessed but the local analysis of the flow is difficult. There are fundamental the differences in the physics of a crowd and a fluid, such as the possible overtaking or creation of gaps in a crowd, which cannot be represented by a fluid. However, the simplified method is relatively easy to use at the early stage of the ship design process and it can provide an approximation of expected evacuation performance.

On hearing an alarm many passengers may initially do absolutely nothing. It is only when they see other passengers reacting or seen some direct evidence of fire or smoke do they start to react. Whilst fleeing afire people will often try to retrace their steps and leave the area by the way they came in, rather than heading for the nearest exist even if it is much closer. Some may search for other members of their group or family before heading towards an exit. The more advanced method uses modern computer simulation techniques to try and model the movement of individual people, building on technology using in the gaming and film industries. Each one of these computerized people (agents) is programmed with specific instructions giving a destination and a range of actions to choose from and leaves them to determine their own route, partly based on data gathered from observing real crowds.

By their very nature these multi-agent methods can take account the interactions between the different agents, environmental conditions, and offer the possibility of more evolved behaviour models. Walking speeds and directions, reactions to external events can be modeled to take account of changes in situation and terrain.

There has been much research on the evacuation of occupants from inhabited enclosures such as building and aircraft. While buildings and ships (and trains and aircraft) may be very difference types of structures they have a surprising number of features which they share in common.

Therefore, ship evacuation simulation models can benefit from the significant work carried out for buildings and aircraft. Large passenger ships comprise cabins (rooms), passageways, public spaces, stairs, and have doors and elevators similar to a building. Small passenger craft such as high speed ferries and tour boats may comprise high density aircraft style seating.

However, there are a number of additional aspects that are particular for passenger ship evacuation modeling:

- Ratio of number of crew to number of passengers
- Lifejacket retrieval process.
- Ship motion
- Ship floating position

- The evacuation system (lifeboats, liferafts, slides, etc)

The collection of human performance data in full-scale ship trials is vital for the calibration and validation of ship based evacuation models. One of the main issues is the limited amount of data currently available and the fact that the exact conditions of the trails are often only partially know (initial conditions, degree of awareness of the participants, degree of involvement, gender and age distributions of participants, etc.). Currently, the guidelines in MSC Circ.1238 do not for instance take account of family group behaviour or the effect of ship motion, heel and trim. Nor does it consider the impact of smoke or heat on the passenger/crew performance. The guidelines acknowledge the need for more information and data on full-scale tests on human behaviour during ship evacuations, particularly for any future upgrading of the present guidelines.

## ***12.2 Alternative design and arrangements of life-saving appliances***

Before a novel Life Saving System (LSS) can be approved onboard a vessel, it should be tested and evaluated to the satisfaction of the Flag State Administration.

For the stakeholders taking part into projects bringing in novel life-saving systems like LSA manufacturers and shipyards for instance, it is important to follow a comprehensive approval process supporting the development of innovative products and complying with the international regulations. The approval scheme complies with the various requirements of the regulatory framework shown on Figure 12.1. below.

The scheme describes the suggested approval process. It is basically based on requirements from the SOLAS regulation III/4 §3, SOLAS regulation III/38, IMO circular MSC.1/1212 and its structure is inspired from classical approval processes. The scheme can be seen as a dialogue between stakeholders and the Flag State Administration: for a successful approval of the life-saving system, all along the process, the Administration reviews each step of the evaluation and testing activities carried out by the stakeholders who then take the appropriate action/decision in order to comply with the Administration's expectations expressed during the review.

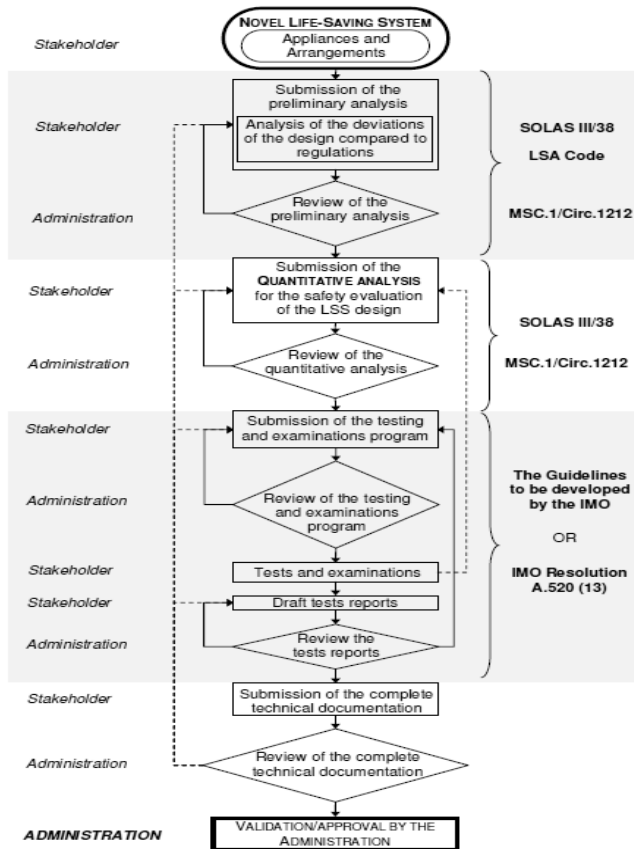


Figure 12.1. Alternative LSA design and arrangements approval scheme

Novel life-saving appliances and arrangements have to be demonstrated equivalent to prescriptive appliances and arrangements in terms of safety in order to be approved by the Maritime Administrations. In this purpose, an engineering analysis complying with the alternative design principles is required by regulation SOLAS III/38 that is carried out along the approval process.

Moreover, in order to demonstrate equivalency, the engineering analysis should be based on an assessment method allowing the performance evaluation (in terms of safety) of novel concepts of LSS as well as conventional prescriptive LSS as described in MSC Circular 1212.

Before starting the evaluation and testing of the novel life-saving system dealt with, it is very important to identify all the stakeholders of the project: the interested parties and the Design Team.

The approval scheme in the IMO guidelines on alternative design and arrangements for SOLAS chapters II-1 and III is relevant to a ship design project for which alternative LSA design or arrangement is sought.

In this context, according to MSC.1/Circ.1212, §1.4, “all interested parties [...] should be in continuous communication from the onset of a specific proposal to utilize these guidelines”.

This should include:

- (1) The Administration or its designated representative,
- (2) Owners,
- (3) Operators,
- (4) Designers, and
- (5) Classification societies.



The Design Team is in charge of performing and reporting the evaluation of trial alternative designs to the Administration (or its designated representative).

In the IMO guidelines, the Design Team is established by the owner and should include:

- A representative of the owner (or building or designer).
- Expert(s) having the required competencies and experience in safety, design and/or operation regarding the evaluation case.
- Other members including marine surveyors, ship operators, safety engineers, equipment manufacturers, human factors experts, naval architects and marine engineers.

More precisely, it would be recommended that the DT includes:

- A representative of the owner
- A representative of the LSA manufacturer(s) involved in the system development.
- A representative of the Classification society competent in risk-based approval (or an external consultant if the Classification society is acting on behalf of the Administration to assess the conformity of statutory rules).
- A specialist in human factors with a sound background in biomechanics.

**The preliminary analysis.** The preliminary analysis stands in the first step of the approval process. It will allow the qualitative assessment of the novel life-saving system being studied. From this analysis, both stakeholders and the Administration will have a first idea of the advantages and drawbacks of such a novel concept as well as an estimation of the resources required for carrying out the quantitative analysis and the tests for demonstrating the safety equivalency. The preliminary analysis is composed of the following steps: It is important to begin the preliminary analysis with the definition of the technical, operational, environmental and regulatory main characteristics and limits of the study. The system definition aims to provide the DT participants with the necessary information regarding the LSS (prescriptive and alternative), its components and the operational procedures:

- Plans and drawings of the ship, LSA, stowing arrangement, launching devices, and general arrangement;
- Ship operating characteristics and conditions of operation;
- Operating and maintenance procedures of LSA in drill and casualty situations;
- Personnel assigned to the operation of LSA and evacuation process;
- Accidental and failure data of lifeboat and system associated.

The evacuation and rescue process: including abandonment (of the mother ship), survival at sea (in survival craft), and retrieval (by a rescue vessel) should also be defined clearly.

In this context not only individual LSAs but also the whole evacuation and rescue system or Life-Saving System (LSS) should be studied. Since two or more different types of LSA can be fitted on a ship. The capacity of each LSA unit, the location onboard, and the means of transfer from the survival craft to a rescue ship are critical to characterize the Life Saving System (LSS).



*Figure 12.2. Example of a Life-Saving System (LSS)*

The performance assessment method detailed in the following sections is based on the physical capacities of people evacuating. As the approval scheme is specific to a ship design project, the proposed method takes into account the physical capabilities of the population expected to be onboard the ship: the age distribution of the population onboard is a parameter of the system definition. Special

attention should be given to the increased vulnerability of elderly people or people with reduced mobility.

The regulatory analysis aims to identify the prescriptive requirements not complied with by the proposed alternative design. SOLAS chapter III and the LSA Code should be screened and any deviation reported together with a comprehensive description of the deviation. The technical documentation should be analyzed in detail in order to identify deviations.

Depending on the extent of the deviations, two situations are possible:

- Only a few provisions are affected and/or the regulations affected provide explicitly the related safety objectives (measurable). In that case, the alternative design is directly comparable to an existing conventional design and the analysis may be limited to assess the safety performance of the alternative design against these safety objectives.
- The proposed alternative design is so innovative that it deviates from the majority of the prescriptive provisions. The safety objectives are either not explicitly stated or the provisions are simply irrelevant. In that case, the implicit safety objectives will be made explicit and the safety performance can be assessed against them.

After having defined the scope of the engineering analysis, the Design Team needs to identify the significant hazards to be taken into account for assessing the life-saving systems (prescriptive and novel concept). The design casualty scenarios are then derived from these hazards.

Design casualty scenario means a set of conditions that defines the development and severity of a casualty within and through ship space(s) or systems and describes specific factors relevant to a casualty of concern.

Hazid (hazard identification) should be used (brainstorming exercise aiming to select and specify design casualty scenarios) for both the hardware component of the system (mechanical failure, structural failure, etc.) and the human vulnerability towards hazards faced during the process (impacts, accelerations, hypothermia, seasickness, etc.).

This process aims to name and specify the hazards that may affect the correct functioning of the LSS system. Recognized Hazid techniques shall be used within the working group to carry out the hazard identification (FMEA, SWIFT...).

Hazards identified are assessed qualitatively in terms of probability and consequence, so that they can be ranked in a risk matrix.

As referred to in the IMO guidelines, hazards shall be grouped into incident severity classes: localized, major or catastrophic. In the case of a cruise ship, only localized and/or major incidents need to be considered.

To help formalizing the process of building casualty scenarios, the concepts of Escape & Rescue Route and Obstacles are introduced:

- Escape and rescue route: The sequence of operations to be performed with the LSS in order to evacuate safely the entire population onboard (from the muster station to the rescue vessel). It involves the passengers, the crew and the hardware components of the LSS. Each LSS is associated with a specific escape & rescue route. Conventional existing systems have similar escape & rescue routes but novel concepts can differ radically in this respect. The escape & rescue route elements (deployment, boarding, lowering, clearing, etc) that are identified for each LSS type can be grouped together within the three generic phases: (1) Abandonment; (2) Surviving at sea; (3) Retrieval.
- Obstacles. As the hardware systems and the humans proceed along the escape & rescue route, they may face hazards and subsequent damages.

Thus, the escape & rescue route can also be considered as the series of obstacles that the hardware and humans must overcome for the evacuation & rescue to be completed. An obstacle is characterized by the hazard generated when the system meets with it. Some hazards directly affect the human body (like seasickness), whereas some primarily affect the hardware system (like mechanical failure), as shown in Table 12.1.:

Phases	Elements	Obstacles	Type
Leaving the vessel	Deployment	Malfunction	Hardware
		Fail to start engine	Hardware
	Boarding	Mobility failure	Human factor
	Lowering	Premature release	Hardware
		Failure /impact hull	Hardware
		Injuries / impact hull	Human factor
	Release	Fail to release	Hardware
Injuries / Slamming		Human factor	
Survival at sea	Clear ship	Fail manoeuvring	Hardware
	At sea	Capsizing	Hardware
		Seasickness	Human factor
		Tossed around	Human factor
Rescue	Recovery	Climbing pilot ladder	Human factor

**Table 12.1. Example of escape & rescue route relevant for a davit-launched lifeboat**

Assessment scenarios: A set of scenarios for which the performance along the escape & rescue route will be assessed is defined. This approach follows the IMO guidelines that refer to the definition of Design Casualty Scenarios against which prescriptive and trial alternative designs must be assessed.

**“Design Casualty Scenarios” ↔ “Obstacles” x “Assessment Scenarios”**

These scenarios should characterize the ship and environmental conditions during the evacuation & rescue process. Possible scenario parameters may include at least the following:

- Sea and wind conditions
- Period of survival at sea
- Sea/air temperature
- Mother ship heading angle in waves (including dead ship condition)
- Mother ship list and trim conditions (representing damaged ship conditions)

By varying and selecting the most appropriate values for the scenario parameters, a limited number of assessment scenarios should be derived, as shown in Table 12.2.

Scenario	Sea state (Beaufort scale)	Period of survival at sea (h)	Abandoned ship		
			Heading angle	List (°)	Trim (°)
Sc 1	0-1	24	./.	0	0
Sc 2	3	24	Beam	0	0
Sc 3	5	24	Head	10	5
Sc 4	5	24	Beam	20	10
Sc 5	6	24	Beam	20	10

**Table 12.2. Example of assessment scenarios and related sea and wind conditions**

It should be emphasized that the assessment scenarios should be selected in the view of assessing both the prescriptive design and the alternative LSS design. This means that they should allow the assessment of these systems’ performance against hazards identified for 1) the prescriptive LSS design and 2) the alternative LSS design.

Design casualty scenarios: They represent the set of obstacles to be considered in the assessment scenarios. Since each escape and rescue route is *a priori* specific to one type of lifesaving appliance and/or arrangement, design casualty scenarios are intrinsically specific to one LSA as well. Thus, the systems' performance should be assessed regarding, on the one hand the obstacles of the E&R route, and on the other hand the assessment scenarios.

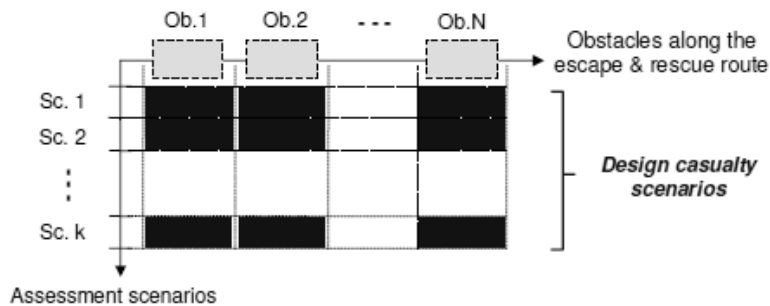


Figure 12.3. Design casualty scenarios for a given LSA

It should be noted that the hazard identification and the specification of the design casualty scenarios are critical phases for the assessment of the lifesaving systems. They may seem time-consuming, however experience shows that success of the whole assessment strongly relies on these phases.

**Quantification of uncertainties.** During the performance assessment of the Life-Saving Systems, some uncertainties have been introduced. The methodology adopted requires much input data as well as different types of models describing the effects of hardware and human factors obstacles on the health status of passengers.

Some of them are systematic uncertainties (only depending on the model used) while others are dependent upon the type of obstacle analyzed and consequently the escape route and the type of LSA studied.

Thus, it is crucial when comparing Performance indexes of prescriptive designs with Performance indexes of alternative designs to quantify data and model uncertainties on these Performance indexes. Otherwise, the comparison and therefore the whole engineering analysis cannot be reasonably validated.

Obstacles are represented by local degradation matrices. Due to data and model uncertainties, the coefficients of the associated local degradation matrices are likely to be different from the nominal values used. Depending on the type of uncertainties introduced, coefficients can take different values above and below the nominal so that the obstacle is more or less favorable for the assessment of the LSAs' performance.

The uncertainties associated with the global degradation matrices representing the entire escape & rescue routes are derived from the combination of the uncertainties on the local degradation matrices. The uncertainties on the Performance indexes are derived from the uncertainties on the global degradation matrices.

**Testing.** In the approval scheme suggested by Bureau Veritas, the novel life-saving system should be tested and examined according to the requirements of the "Code of Practice for the evaluation, testing and acceptance of prototype novel life-saving appliances and arrangements (annex to resolution A.520 (13))" as far as practicable (some novel concepts may not fit in some of them due to their intrinsic innovative character) or the IMO Guidelines (not yet developed when this guidance note was published).

During the tests, particular attention should be paid to the issues raised by the operation of the novel life-saving system. Indeed, these systems are likely to require new skills from seafarers. These skills

should be taught in accordance with the requirements from the International Safety Management (ISM) Code.

In the engineering analysis, even if human error may be considered as an obstacle on the escape and rescue route, it is assumed that the seafarers in charge of guiding passengers and launching life-saving appliances are efficiently trained. The testing and examination program should be submitted to the Flag State Administration for review and validation before carrying out the test.

After having carried out the test, the draft test reports should be submitted to the Flag State Administration (FSA) for review and validation. The FSA may ask the stakeholder to modify and re-submit a test and examination program if necessary.

### ***12.3 Innovative life-saving equipments***

In recent years the focus on the capabilities and features of free-fall lifeboats offshore has drawn high attention. The Torpedo lifeboat is representing a new and innovative alternative to ordinary free-fall lifeboats.

Tests performed demonstrate that the design of the Torpedo Lifeboat has clear advantages compared to any known design today; especially when it comes to reduced impact to onboard personnel, and in regards to forward distance and directional stability from drop point.



***Figure 12.4. The Torpedo boat***

Features:

- Design and hull strength withstand the impact loads generated from drop heights and extreme weather/wave conditions
- The combination of design and weight increases the braking time and distance and therefore reduces the loads on the human body and increases the forward speed and distance
- It covers a considerable distance from the drop site due to hydrodynamic design and ballast weight
- Its directional stability is superior
- External conditions, such as wind and waves, have less effect on performance (distance, speed, direction and loads) compared to competing designs.

The Torpedo Lifeboat will be designed and produced according to SOLAS.

The Torpedo Lifeboat is designed to be installed on fixed installations, FPSO's, drill ships, jack ups or floating units as well as ships. The building techniques, standards and outfitting represent a new level of quality in the SOLAS free fall lifeboat segment.

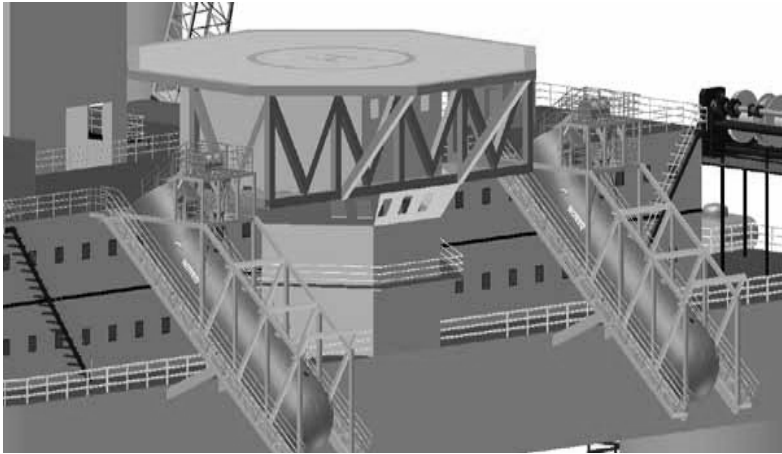
It is designed and developed in Norway where rough conditions and harsh environment are the rule rather than the exception and the Torpedo Lifeboat is made to meet these conditions. It is designed to maintain its unique properties even from shorter drop heights.

The Torpedo Lifeboat is designed to meet the demands of tomorrow, fitted with:

- Bigger interior space than any other SOLAS free fall lifeboat
- Larger seating area
- Custom made seat-belts
- Crew capacity for up to 70 persons

A new system for release, retrieval and secondary launching has been developed.

This will increase the level of safety as well as easing the operation. Two optional launching systems will be available. One for mounting outside offshore rigs and one a frame solution for deck mounting on vessels.



*Figure 12.5. The Torpedo boat launch system*

## Chapter XIII

### Future concepts in ship design

#### 13.1 Ships of the future

**A new Handysize bulk carrier concept design.** The Green Dolphin, created by the Shanghai Merchant Ship Design & Research Institute (SDARI) and development partners DNV and Wärtsilä - uses existing technologies to meet owners' needs for fuel efficiency and operational flexibility while also being ready for future environmental regulations.



*Figure 13.1. Green Dolphin*

The Green Dolphin concept design is a five-cargo-hold CSR double-hull bulk carrier that meets current and future expected air and water emissions regulations. The design aims to be fuel-efficient and maintenance-friendly, with high operational flexibility.

Green Dolphin's main dimensions also suit the majority of the world's ports which receive Handysize bulk carriers.

The hull design has been a combined effort by SDARI and DNV. The hull is designed to provide improved overall performance at different loading conditions, speeds and sea states. The propulsion efficiency is increased through the fitting of a wake equalising duct in front of a large-diameter, slow-rotating propeller. A rudder transition bulb and rudder fins reduce the hub vortex and recover rotational losses.

The Wärtsilä two-stroke low-speed RT-flex50 main engine is Tier II compliant and can easily be retrofitted to dual-fuel engine in the near future. Multiple fuel tanks allow for strategic purchasing of heavy fuel oil, low sulphur fuel and distillates. "Design variants are available for fuel switching systems, installation of selective catalytic reduction and exhaust gas scrubbing systems and, in the near future, the use of LNG as fuel" says Giulio Tirelli, Business Development Director of Wärtsilä – Ship Power. "The concept design also includes shaft torque and exhaust gas monitoring equipment to maximise the fuel consumption optimisation possibilities while constantly monitoring emissions," he adds.

A heavy ballast condition is achieved without using a cargo hold for ballast water and the cargo holds are equipped with compressed air, power and wash water supply. Wash water holding tanks are also included. Wide hatch openings and fully electrical deck equipment improve the loading, discharge and cleaning efficiency so port turnaround time can be minimised. A ballast water treatment system is included as well as holding tanks and treatment systems for sewage and bilge water.

**First specialized vessel for the carriage of Nickel Ore.** The vessel, the Jules Garnier II, was built by Naikai Zosen Corporation and delivered to Japanese shipping major JX Shipping Co. Ltd on 19 September 2012, and is the first vessel in the world to be recognized as a Specially Constructed Cargo Ship for the carriage of Nickel Ore in accordance with the IMO's IMSBC Code. The announcement followed a monthly meeting of the Society's Classification Committee, which reviewed and officially certified the vessel's registration on 22 October 2012.



*Figure 13.2. Jules Garnier II*

Nickel Ore cargoes can liquefy during transport, drastically impairing the ship's stability and safety, and these cargoes have been cited as the cause of four vessel casualties and the loss of 66 seafarers in 2010-11. INTERCARGO has since named Nickel Ore "the world's most dangerous cargo" and efforts are underway at the IMO to strengthen the International Maritime Solid Bulk Code (IMSBC), which regulates the loading and transport of bulk cargoes such as Nickel Ore.

The ISMBC code currently requires that the moisture content (MC) of cargoes that may liquefy be tested prior to their loading onboard ships, and forbids non-specialized vessels from loading cargoes with an MC greater than the specified Transportable Moisture Limit (TML). However, questions have been raised about the testing procedures and validity of moisture content test results for Nickel Ore, and there is growing concern about whether nickel ore can safely be carried by standard vessels. While the ISMBC code allows for these dangerous cargoes to be carried by "Specially Constructed Cargo Ships", no definition or requirements for such vessels are included in the code itself.

In order to address this issue and ensure the safety of the world's bulk carrier fleet, ClassNK began carrying out independent research on the physical characteristics of Nickel Ore in 2009. Based on this research, ClassNK developed the world's first hull structure and stability requirements for building such "Specially Constructed Cargo Vessels" in 2011, and released them for use by the maritime industry as part of its Guidelines for the Safe Carriage of Nickel Ore in March 2012. These requirements have since been approved by the government of Panama and Japan for use in vessels flagged with their administrations. They have further earned the recognition of INTERCARGO as well as the wider maritime industry, and ClassNK was presented with the "Safety Award" at the Lloyd's List Global Awards in September 2012 for its contribution to the safe transportation of Nickel Ore.

The 27,200 dwt Jules Garnier II is the first vessel in the world to apply ClassNK's new requirements in its construction and makes use longitudinal bulkheads in its cargo holds to ensure stability and structural strength even when liquefied nickel ore cargoes are loaded. The ship's design earned the approval of the Panamanian government in September 2012, and with its completion in September 2012, is the first and currently only vessel to be certified as safe to carry liquefied Nickel Ore cargoes in line with the IMSBC code. The vessel is also the first to earn ClassNK's new SCCS notation for safe carriage of nickel ore in recognition of its special construction.



**New Aframax Tanker Concept Design.** Wärtsilä Ship Design announced that they have come up with a new Aframax tanker design concept that they believe will provide higher fuel efficiency, lower operating costs, and an environmental performance profile to meet all current and forthcoming emissions legislation.

This new tanker has a CFD-optimized double hull, and is powered by a Wärtsilä X62 engine. Wärtsilä also notes that time in and out of port will be quicker as this ship allows for high loading and discharge rates.



*Figure 13.3. New Aframax Tanker Concept Design*

The X62 engine is an electronically controlled, common-rail engine with an extra long stroke and low rpm. It also has a minimized physical width to allow a slimmer aft hull form design, further benefitting the propulsion efficiency. It comes in 4 to 8 cylinder configurations and has a cylinder bore of 620 mm and its power output is in the 8,000 to 21,280 kW range.

Compared to currently available main engine options, Wärtsilä claims the X62 engine can achieve fuel savings of seven percent on the specific vessel design. Furthermore, the same vessel speed can be reached using one less cylinder, i.e. six instead of seven cylinders. The seven cylinder version provides even greater efficiencies due to the lower rpm and higher de-rating.

For emissions compliance, an integrated Wärtsilä exhaust gas scrubber (epurator) has been placed on the funnel. Main engine, auxiliary engines and auxiliary boilers are all connected to the integrated scrubber. The scrubber effectively reduces sulphur oxide (SO<sub>x</sub>) emissions, and meets the 0.1 percent sulphur limit even with Heavy Fuel Oil (HFO) having a sulphur content of 3.5 percent. A Wärtsilä SCR (Selective Catalytic Reduction) system has been placed before the turbocharger turbine for the main engine. The SCR is a post combustion nitrogen oxides (NO<sub>x</sub>) abatement system that permits optimized combustion, in terms of efficiency, while reducing NO<sub>x</sub> emissions by more than 90 percent. The abatement equipment is tuned with the main and auxiliary engines for effective operations across the complete load range and IMO Tier III requirements can be fulfilled.

The Aframax tanker design approach used the most advanced optimization environment by integrating software tools to predict required propulsion power, stability, oil outflow index, cargo capacity and hull structural scantlings according to IACS Common Structural Rules.

This was achieved by linking the FRIENDSHIP-Framework with SHIPFLOW, NAPA and POSEIDON, and by using parametric models for the hull form, layout and structure. Related design parameters were systematically varied and approximately 2,500 design variants were generated and assessed.

Compared to the reference design, an existing pre-CSR tanker, a 7% improvement in cost of transport was realized due to the better hull form for the best design variant. Determining the “best” variant for the final design depends on the weighting of the different optimization targets. Depending upon the

choice of the designer, a design optimized for oil outflow, EEDI, or for cost-of-transport might be selected.

The optimization of the hull form results in a speed of 15.6 knots at design draft with a 95% confidence interval. The speed at ballast draft of 7.4m is 16.8 knots. This represents a favourable speed increase when compared with recently built vessels of the same size. Cargo capacity was also improved to “best in class” levels. With a standard main engine for Aframax oil tankers, a MAN 6S60MC-C, the fuel consumption of this vessel is comparable to similar vessels.

This combination of high speed and large cargo capacity means that the vessel easily meets future expected EEDI requirements. The attained EEDI value is 84% of the latest reference value for ships of this size, most likely putting the design in compliance even with the IMO’s first set of reductions to the EEDI reference line.

To reduce the environmental impact of accidents, the double hull side width was set to 2.65m, reducing oil outflow. The inner bottom of the cargo oil tank 1 was raised from 2.10m to 2.75m to further reduce cargo tank penetration in grounding events. To ensure structural continuity, an inclined inner bottom is proposed between two frames. The global strength of the hull structure in the cargo hold area was evaluated with finite element analysis according to IACS CSR.

**Triality VLCC concept.** The introduction of a new crude oil tanker concept that is fuelled by liquefied natural gas, has a hull shape that removes the need for ballast water and will almost eliminate local air pollution. This concept vessel also recovers hundreds of tons of cargo vapours on each voyage and represents a major step towards the new environmental era for the tanker shipping industry. The new crude oil concept vessel, named Triality, has been developed through a DNV innovation project. As its name indicates, it fulfils three main goals: it is environmentally superior to a conventional crude oil tanker, its new solutions are feasible and based on well known technology, and it is financially attractive compared to conventional crude oil tankers operating on heavy fuel oil.

The Triality concept VLCC has been compared to a conventional VLCC. Both ships have the same operational range and can operate in the ordinary spot market. Compared to the traditional VLCC, the Triality VLCC will emit:

- 34% less CO<sub>2</sub>
- 82% less NO<sub>x</sub>
- 94% less SO<sub>x</sub>
- 94% less particular matters
- Eliminates VOC releases (Volatile Organic Compounds)
- Eliminates ballast water, and
- Uses 25% less energy than a conventional VLCC

Given that a supertanker with Triality design operates for one year, the following reductions would be achieved:

- CO<sub>2</sub> 25900 tonnes
- NO<sub>x</sub> 1785 tonnes
- SO<sub>x</sub> 1500 tonnes

Today 504 supertankers are in operation worldwide. Given that all of these vessels had the Triality design and operated for a year, the following reductions would be achieved:

- CO<sub>2</sub> 13 million tonnes
- NO<sub>x</sub> 900 000 tonnes
- SO<sub>x</sub>

Triality’s environmental performance is markedly better than a conventional tanker; Madsen said that local emissions are ‘virtually eliminated’. Moreover, it solves two other problems of VLCCs: the escape of volatile organic compounds (VOCs) from the cargo; and the need for ballast water to ensure that the ship rides at the correct level in the water when emptied of cargo. Taking on ballast water in the port where the oil is unloaded, then travelling to an oil terminal in another continent and discharging the ballast there, leads to the introduction of marine organisms into alien environments

that can seriously endanger native species, Madsen said, and international regulators are becoming increasingly concerned about this.

The air-quality improvements in *Triality* stem from a single change in the way the ship operates: it is fuelled with liquefied natural gas (LNG) rather than heavy fuel oil or marine diesel. 'Directly, without the need for any kind of treatment plant, this reduces SOx and particulates by 95 per cent, while it also reduces NOx and CO2 emissions,' said project leader Torill Grimstag Osberg. Conventional VLCCs need to install scrubber systems for SOx and catalytic converters for NOx; these add complexity and cost, and also have a fuel penalty because they consume energy in operation.

LNG is a new marine fuel, but it is beginning to make its first footholds in the market and DNV believes that it will become increasingly important in the coming decades. There are already about 20 ships around the world that are fuelled by LNG, who has previously specialised in safety systems for gas-fuelled ships. They're mostly smaller vessels such as ferries, but one of the goals of this project was to see whether a large vessel could be designed to be gas fuelled. And as VLCCs are the biggest thing on the water, if you can do it with them, you can do it with anything.

The new concept tanker has two high pressure dual fuel slow speed main engines fuelled by LNG, with marine gas oil as pilot fuel. The next phase of the *Triality* concept development will review the use of dual fuel medium speed engines and pure gas engines. The generators are dual fuel (LNG and marine gas oil) while the auxiliary boilers producing steam for the cargo oil pumps operate on recovered cargo vapours (VOCs).

When you're running a ship on LNG, the biggest problem you have is where to put the fuel tanks, because it takes up quite a lot more space than other fuels, but with VLCCs, that actually isn't much of a problem: there's lots of space on the cargo deck.

The *Triality* concept includes two LNG pressure vessels, each capable of storing 6,750m<sup>3</sup> of LNG at -160°C and five-bar pressure; enough for 25,000 nautical miles of operation- are located on the deck in front of the superstructure.. This capacity was important, because ports that carry enough LNG to refuel a VLCC are rare. This is enough to go all the way around the world, so a ship that bunkers LNG in the Middle East will have enough fuel to go to the US and back without rebunkering. The tanks also have to be able to cope with the increase in pressure caused by evaporation of the LNG during storage. Standard marine engines can cope with LNG fuelling, so the *Triality* is equipped with two large dual-fuel two-stroke main engines, which burn natural gas at 300 bar. These engines need to be started using low-sulphur marine gas oil, which is also used as a back-up fuel, particularly when the engines need to operate below 25 per cent loads while manoeuvring at low speed. One advantage of switching to gas is it removes the need for the equipment to treat heavy fuel oil, a substance that has to be preheated and treated to flow into engines. This reduces the engineering complexity of the ship and therefore cuts costs.

The low temperature of the LNG provides another opportunity. It has to be evaporated and heated to 45°C before it enters the engine, but this means there is potential for cooling on board, something that can come in rather handy. It means that the evaporation of volatile organic compounds (VOCs) from the tanker's cargo can be recovered.

A VLCC can lose up to 500 tonnes of cargo through evaporation on a typical voyage. The cargo tanks are not designed to handle pressure and as the vapour accumulates, it has to be vented; generally, just to the atmosphere. There are air-quality implications from this, such as VOCs plus NOx and sunlight-produced ozone, which is toxic. There are also commercial implications, of course, especially as the compounds that escape tend to be the more valuable light fractions from the crude oil.'

The *Triality* concept includes a system to collect VOCs from the cargo tanks and condense them in a heat exchanger. They can be burned as fuel on the voyage, especially during cargo operations, when they can fuel the boilers to produce steam to operate the pumps. Alternatively, they could be stored for sale at the port. I suspect that would be a commercial decision, based on the prices of the substances in the VOCs and of LNG, but either would be an option.

The cold LNG is also used to cool the air needed for combustion, in the engines, this increases the air you can get into the engine, which enhances efficiency by two to three per cent.

A traditional tanker in unloaded transit needs ballast water to obtain full propeller immersion and sufficient forward draft to avoid bottom slamming. The new V-shaped hull form and cargo tank arrangements completely eliminate the need for ballast water in the VLCC version. There will also be much less need for ballast water on other kinds of crude oil tankers, such as Suezmax, Aframax and smaller ships. The new hull shape results in a reduced wetted surface on a round trip and has a lower block coefficient and thus a more energy efficient hull.

The elimination of the need for ballast was achieved by changing the shape of the hull. 'Conventional tankers were mostly designed when the cost of fuel wasn't a problem and the main concern was getting the maximum amount of cargo on board, so they're flat bottomed

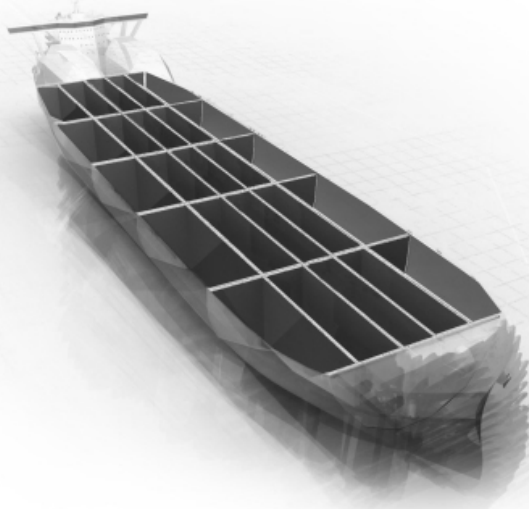
V-shaped hull that sits lower in the water at all times, so the propellers are always under water and the bow is down – that's what ballast does in a conventional ship.'

A VLCC in unloaded transit will normally carry between 80 000 and 100 000 tons of sea water containing organisms that can cause damage when released into foreign ecosystems. In addition, a lot of fuel is needed just to transport this extra water. And finally, the initial coating and later maintenance of ballast tanks during operations are among a shipowner's main concerns.

The concern over marine organisms in ballast is leading ship owners to look at installing water-treatment systems on board to clean the water before it is discharged, but this, like the gas treatment systems, increases complexity and adds cost. Ships can carry up to 100,000 tonnes of seawater – that's a huge volume to have to handle and treat.

In 'light mode', the draught at Triality's bow – the amount of the ship that is under water – is two metres less than the stern, but that is still enough for safe operation, because of the shape, the ship is bigger – 361m long and 70m wide – but the cargo volume is the same. The cost of manufacturing the hull should not be much different from a conventional shape.'

The other reason for using ballast on a tanker is to keep it balanced while loading; conventionally, ballast water is pumped out while the oil is pumped in, which prevents the changing load from twisting the ship. In Triality, this is achieved by a new configuration of cargo tanks. The ship is divided into five sections along its length, with each divided by bulkheads across the ship.



*Figure 13.3. Triality VLCC concept*

Each longitudinal section is filled along its entire length, from the central section outwards, with the pairs of sections on either side of the centre filling simultaneously.

Running without ballast also reduces the fuel usage considerably. When there's no water, the wetted surface of the hull is reduced by about 16 per cent, because the ship is so much lighter. That equates to a fuel reduction of about 11 per cent per year.

The Triality VLCC can collect and liquefy more than 500 tons of cargo vapours during one single round trip. These liquefied petroleum gases will then be stored in deck tanks and up to half will be used as fuel for the boilers during cargo discharge, while the rest can be returned to the cargo tanks or delivered to shore during oil cargo discharge.

**Enisys ship concept.** The Enisys ship-concept represents state-of-the art high speed and slim body ship design with low fuel consumption and efficient cargo handling equipment. The concept has excellent sea-keeping and manoeuvring capabilities due to "azimuth" technology and bow thrusters. The ship handles containers, trailers, swap bodies, cassettes, with automatic lashing. The vessel enables high reliability and flexibility and is environmental friendly due to low emissions.



*Figure 13.4. The Enisys vessel*

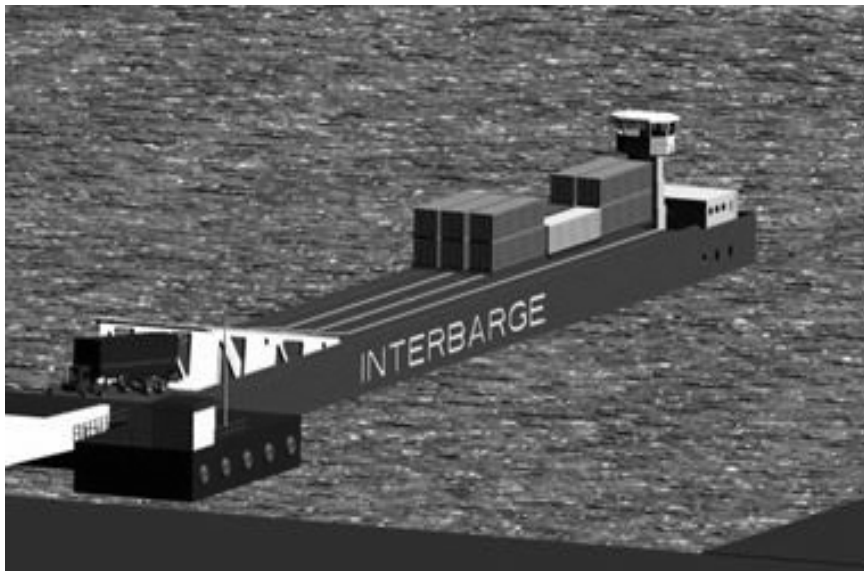
Excellent sea-keeping and manoeuvring capabilities enable the vessel to operate in areas out of reach for conventional ships of same size. An example is in the Halden fairway in Norway, where the current legislation limits the vessel size to 140meter length and 20 meter width, but bigger vessels have been accepted by the sea-pilots at specific terms such as daylight, good weather and no stream in the fairway.

A feasibility project which has been done by Marintek together with Norske Skog (a major global paper producing company) with involvement from local Sea-pilots, Halden Port Authority and the Coastal Department has verified that with a vessel with the Enisys performance and maneuvering abilities it will be possible to increase these limits to 180 – 190 meters and less than 26 meter width. In addition to strict requirements to the vessel the project has highlighted that new seamarks and, more lightning should be installed in the fairway, which will of course be an advantage for all vessels going through this fairway.

The principle for this system will be that the vessels either through autopilot control or through computer guidelines and detailed sailing procedures follows the exact same track through the fairway on every trip.

The Enisys vessels represent a new generation Ro-Ro vessels to be used in Short Sea Shipping and between countries such as the Scandinavian countries and the European continent. The construction goal behind the vessel design has been to combine the advantages of modern hydrodynamics and aerodynamic design with efficient cargo handling and carrying abilities.

**Interbarge concept.** The Interbarge concept represents state-of-the-art barge design with efficient Ro-Ro technology. The barge construction has reduced steel weight through the use of curved steel plates enabling better cargo carrying capacity and economy for transporters compared to conventional barges of same size. The Interbarge new construction concept enables building ship hulls and especially barge hulls easier and faster with less use of steel, fewer and easier operations during production, and thinner shell plating due to the concepts increased ability to resist water pressure.



*Figure 13.5. The Interbarge*

FEM-Engineering in Trondheim, Norway, had an idea for a new structural concept for barge design. By combining the structural concept with the principles of IPSI, the Interbarge alternative was established. The basic idea of the structural concept is to take advantage the imminent strength capacity of a plate after the bending resistance limit is exceeded. A plate clamped at the ends is many times stronger when the acting forces are absorbed in the plate as membrane tensions instead of stresses as in bending.

By giving the plate a curvature, this state will be obtained and the stress level in the plate decreases compared to a flat panel. This again will allow the plate thickness to be reduced without a reduction of the strength of the plate.

The second benefit that comes from using this concept is that the number of strengthening members in the construction can be greatly reduced. In contrast a flat panel, has to be supported by closely spaced supports due to the low bending resistance of the plate. A curved plate in tension will need no support between the clamping.

## Chapter XIV

### Assessment of alternative design solutions

#### 14.1 Cost and revenue components

Optimization means finding the best solution from a limited or unlimited number of choices. Even if the number of choices is finite, it is often so large that it is impossible to evaluate each possible solution and then determine the best choice. There are, in principle, two methods of approaching optimization problems:

1. **Direct search approach.** Solutions are generated by varying parameters either systematically in certain steps or randomly. The best of these solutions is then taken as the estimated optimum. Systematic variation soon becomes prohibitively time consuming as the number of varied variables increases. Random searches are then employed, but these are still inefficient for problems with many design variables.
2. **Steepestness approach.** The solutions are generated using some information on the local steepness (in various directions) of the function to be optimized. When the steepness in all directions is (nearly) zero, the estimate for the optimum is found.

This approach is more efficient in many cases. However, if several local optima exist, the method will 'get stuck' at the nearest local optimum instead of finding the global optimum, i.e. the best of *all* possible solutions. Discontinuities (steps) are problematic; even functions that vary steeply in one direction, but very little in another direction make this approach slow and often unreliable.

Most optimization methods in ship design are based on steepness approaches because they are so efficient for smooth functions. Repeating the optimization with various starting points may circumvent the problem of 'getting stuck' at local optima. One option is to combine both approaches with a quick direct search using a few points to determine the starting point of the steepness approach. Also repeatedly alternating both methods - with the direct approach using a smaller grid scale and range of variation each time - has been proposed.

A pragmatic approach to treating discontinuities (steps) assumes first a continuous function, then repeats the optimization with lower and upper next values as fixed constraints and taking the better of the two optima thus obtained.

Although, in theory, cases can be constructed where such a procedure will not give the overall optimum, in practice this procedure apparently works well. The target of optimization is the objective function or criterion of the optimization. It is subject to boundary conditions or constraints. Constraints may be formulated as equations or inequalities. All technical and economical relationships to be considered in the optimization model must be known and expressed as functions.

Procedures must be sufficiently precise, yet may not consume too much time or require highly detailed inputs. Ideally all variants should be evaluated with the same procedures. If a change of procedure is necessary, for example, because the area of validity is exceeded, the results of the two procedures must be correlated or blended if the approximated quantity is continuous in reality.

A problem often encountered in optimization is having to use unknown or uncertain values, e.g. future prices. Here plausible assumptions must be made. Where these assumptions are highly uncertain, it is common to optimize for several assumptions ('sensitivity study'). If a variation in certain input values only slightly affects the result, these may be assumed rather arbitrarily.

The main difficulty in most optimization problems does not lie in the mathematics or methods involved, i.e. whether a certain algorithm is more efficient or robust than others. The main difficulty lies in formulating the objective and all the constraints. If the human is not clear about his objective, the computer cannot perform the optimization. The designer has to decide first what he really wants. This is not easy for complex problems.

Often the designer will list many objectives which a design shall achieve. This is then referred to in the literature as ‘multi-criteria optimization’. The expression is nonsense if taken literally. Optimization is only possible for one criterion, e.g. it is nonsense to ask for the best and cheapest solution. The best solution will not come cheaply, the cheapest solution will not be so good. There are two principle ways to handle ‘multi-criteria’ problems, both leading to one-criterion optimization:

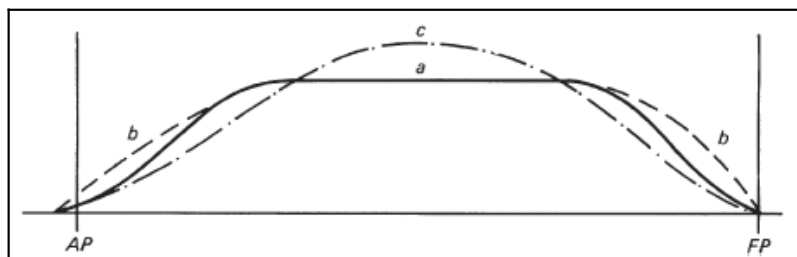
1. One criterion is selected and the other criteria are formulated as constraints.
2. A weighted sum of all criteria forms the optimization objective. This abstract criterion can be interpreted as an ‘optimum compromise’.

However, the rather arbitrary choice of weight factors makes the optimization model obscure and we prefer the first option.

Throughout optimization, design requirements (constraints), e.g. cargo weight, deadweight, speed and hold capacity, must be satisfied. The starting point is called the ‘basis design’ or ‘zero variant’. The optimization process generates alternatives or variants differing, for example, in main dimensions, form parameters, displacement, main propulsion power, tonnage, fuel consumption and initial costs. The constraints influence, usually, the result of the optimization. Optimized main dimensions often differ from the values found in built ships.

There are several reasons for these discrepancies:

1. *Some built ships are suboptimal.* The usual design process relies on statistics and comparisons with existing ships, rather than analytical approaches and formal optimization. Designs found this way satisfy the owner’s requirements, but better solutions, both for the shipyard and the owner, may exist. Technological advances, changes in legislation and in economical factors (e.g. the price of fuel) are reflected immediately in an appropriate optimization model, but not when relying on partially outdated experience. Modern design approaches increasingly incorporate analyses in the design and compare more variants generated with the help of the computer. This should decrease the differences between optimization and built ships.



*Figure 14.1. Changes produced in sectional area curve by various optimization constraints:*

*a) is the basis form;*

*b) is a fuller form with more displacement; optimization of carrying capacity with maximum main dimensions and variable displacement;*

*c) is a finer form with the displacement of the basis form a, with variable main dimensions*



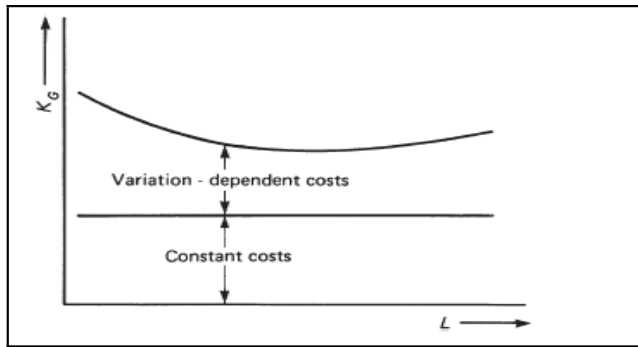


Figure 14.2. Division of costs into length-dependent and length-independent

2. *The optimization model is insufficient.* The optimization model may have neglected factors that are important in practice, but difficult to quantify in an optimization procedure, e.g. seakeeping behaviour, manoeuvrability, vibrational characteristics, easy cargo-handling. Even for directly incorporated quantities, often important relationships are overlooked, leading to wrong optima, e.g.:
  - (a) A faster ship usually attracts more cargo, or can charge higher freight rates, but often income is assumed as speed independent.
  - (b) A larger ship will generally have lower quay-to-quay transport costs per cargo unit, but time for cargo-handling in port may increase. Often, the time in port is assumed to be size independent.
  - (c) In reefers the design of the refrigerated hold with regard to insulation and temperature requirements affects the optimum main dimensions. The additional investment and annual costs have to be included in the model to obtain realistic results.
  - (d) The performance of a ship will often deteriorate over time. Operating costs will correspondingly increase, but are usually assumed time independent.

The economic model may use an inappropriate objective function. Often there is confusion over the treatment of depreciation. This is not an item of expenditure, i.e. cash flow, but a book-keeping and tax calculation device. The optimization model may also be based on too simplified technical relationships. Most of the practical difficulties boil down to obtaining realistic data to include in the analysis, rather than the mechanics of making the analysis. For example, the procedures for weight estimation, power prediction and building costs are quite inaccurate, which becomes obvious when the results of different published formulae are compared. The optimization process may now just maximize the error in the formulae rather than minimize the objective.

The result of the optimization model should be compared against built ships. Consistent differences may help to identify important factors so far neglected in the model. A sensitivity analysis concerning the underlying estimation formulae will give a bandwidth of 'optimal' solutions and any design within this bandwidth must be considered as equivalent. If the bandwidth is too large, the optimization is insignificant.

A critical view on the results of optimization is recommended. But properly used optimization may guide us to better designs than merely reciprocating traditional designs. The ship main dimensions should be appropriately selected by a naval architect who understands the relationships of various variables and the pitfalls of optimization. An automatic optimization does not absolve the designer of his responsibility. It only supports him in his decisions.

Formal optimization of the lines including the bulbous bow even for fixed main dimensions is beyond our current computational capabilities. Although such formal optimization has been attempted using CFD methods, the results were not convincing despite high computational effort. A typical application would be the optimization of the main dimensions.

However, optimization may be applied to a wide variety of ship design problems ranging from fleet optimization to details of structural design.

In fleet optimization, the objective is often to find the optimum number of ships, ship speed and capacity without going into further details of main dimensions, etc. A ship's economic efficiency is usually improved by increasing its size, as specific cost (cost per unit load, e.g. per TEU or per ton of cargo) for initial cost, fuel, crew, etc., decrease. However, dimensional limitations restrict size. The draught (and thus indirectly the depth) is limited by channels and harbours. However, for draught restrictions one should keep in mind that a ship is not always fully loaded and harbours may be dredged to greater draughts during the ship's life. The width of tankers is limited by building and repair docks. The width of containerships is limited by the span of container bridges. Locks restrict all the dimensions of inland vessels. In addition, there are less obvious aspects limiting the optimum ship size:

1. The limited availability of cargo coupled to certain expectations concerning frequency of departure limits the size on certain routes.
2. Port time increases with size, reducing the number of voyages per year and thus the income.
3. The shipping company loses flexibility. Several small ships can service more frequently various routes/harbours and will thus usually attract more cargo. It is also easier to respond to seasonal fluctuations.
4. Port duties increase with tonnage. A large ship calling on many harbours may have to pay more port dues than several smaller ships servicing the same harbours in various routes, thus calling each in fewer harbours.
5. In container line shipping, the shipping companies offer door-to-door transport.

The costs for feeder and hinterland traffic increase if large ships only service a few 'hub' harbours and distribute the cargo from there to the individual customer. Costs for cargo-handling and land transport then often exceed savings in shipping costs. These considerations largely concern shipping companies in optimizing the ship size. Factors favouring larger ship size are:

- Increased annual flow of cargo.
- Faster cargo-handling.
- Cargo available one way only.
- Long-term availability of cargo.
- Longer voyage distance.
- Reduced cargo-handling and stock-piling costs.
- Anticipated port improvements.
- Reduced unit costs of building ships.
- Reduced frequency of service.

After the optimum size, speed, and number of ships has been determined along with some other specifications, the design engineer at the shipyard is usually tasked to perform an optimization of the main dimensions as a start of the design. Further stages of the design will involve local hull shape, e.g. design of the bulbous bow lines, structural design, etc. Optimization of structural details often involves only a few variables and rather exact functions.

To establish such complicated design models, it is recommended to start with a few relations and design variables, and then to improve the model step by step, always comparing the results with the designer's experience and understanding the changes relative to the previous, simpler model. This is necessary in a complicated design model to avoid errors or inaccuracies which cannot be clarified or which may even remain unnoticed without applying this stepwise procedure. Design variables which involve step functions (number of propeller blades, power of installed engines, number of containers over the width of a ship, etc.) may then be determined at an early stage and can be kept constant in a more sophisticated model, thus reducing the complexity and computational effort. Weakly variation-dependent variables or variables of secondary importance (e.g. displacement, underdeck volume, stability) should only be introduced at a late stage of the development procedure. The most economic solution often lies at the border of the search space defined by constraints, e.g. the maximum permissible draught or Panamax width for large ships. If this is realized in the early cycles, the relevant variables should be set constant in the optimization model in further cycles.

Simplifications can be retained if the associated error is sufficiently small. They can also be given subsequent consideration.

**Annual income and expenditure.** The income of cargo ships depends on the amount of cargo and the freight rates. Both should be a function of speed in a free market. At least the interest of the tied-up capital cost of the cargo should be included as a lower estimate for this speed dependence.

Expenditure over the lifetime of a ship includes:

1. *Risk costs.* Risk costs relating to the ship consist mainly of the following insurance premiums:
  - Insurance on hull and associated equipment.
  - Insurance against loss or damage by the sea.
  - Third-party (indemnity) insurance.

Annual risk costs are typically 0.5% of the production costs.

2. *Repair and maintenance costs.* The repair and maintenance costs can be determined using operating cost statistics from suitable basis ships, usually available in shipping companies.
3. *Fuel and lubricating costs.* These costs depend on engine output and operating time.
4. *Crew costs.* Crew costs include wages and salaries including overtime, catering costs, and social contributions (health insurance, accident and pension insurance, company pensions). Crewing requirements depend on the engine power, but remain unchanged for a wide range of outputs for the same system. Thus crew costs are usually variation-independent. If the optimization result shows a different crewing requirement from the basis ship, crew cost differences can be included in the model and the calculation repeated.
5. *Overhead costs*
  - Port duties, lock duties, pilot charges, towage costs, haulage fees.
  - Overheads for shipping company and broker.
  - Hazard costs for cargo (e.g. insurance, typically 0.2–0.4% of cargo value).

Port duties, lock duties, pilot charges and towage costs depend on the tonnage. The proportion of overheads and broker fees depend on turnover and state of employment. All overheads listed here are variation independent for constant ship size.

6. *Costs of working stock and extra equipment.* These costs depend on ship size, size of engine plant, number of crew, etc. The variation-dependence is difficult to calculate, but the costs are small in relation to other cost types mentioned. For this reason, differences in working-stock costs may be neglected.
7. *Cargo-handling costs.* Cargo-handling costs are affected by ship type and the cargo-handling equipment both on board and on land. They are largely variation independent for constant ship size.

Taxes, interest on loans covering the initial building costs and inflation have only negligible effects on the optimization of main dimensions and can be ignored.

## 14.2 Economic evaluations

For purposes of optimization, all payments are discounted, i.e. converted by taking account of the interest, to the time when the vessel is commissioned.

The rate of interest used in discounting is usually the market rate for long-term loans. Discounting decreases the value of future payments and increases the value of past payments. Individual payments thus discounted are, for example, instalments for the new building costs and the re-sale price or scrap value of the ship. The present value (discounted value)  $K_{pv}$  of an individual payment  $K$  paid  $l$  years later - e.g. scrap or re-sale value - is:

$$K_{pv} = K \cdot \frac{1}{(1+i)^l} = K \cdot \text{PWF}$$

where  $i$  is the interest rate. PWF is the present worth factor. For an interest rate of 8%, the PWF is 0.2145 for an investment life of 20 years, and 0.9259 for 1 year. If the scrap value of a ship after 20 years is 5% of the initial cost, the discounted value is about 1%. Thus the error in neglecting it for simplification is relatively small.

A series of constant payments  $k$  is similarly discounted to present value  $K_{pv}$  by:

$$K_{pv} = k \cdot \frac{(1+i)^j \cdot i}{(1+i)^j - 1} = k \cdot \text{CRF}$$

CRF is the capital recovery factor. The shorter the investment life, the greater is the CRF at the same rate of interest. For an interest rate of 8%, the CRF is 0.1018 for 20 years and 1.08 for 1 year of investment life.

The above formulae assume payment of interest at the end of each year. This is the norm in economic calculations. However, other payment cycles can easily be converted to this norm. For example, for quarterly payments divide  $i$  by 4 and multiply  $l$  by 4 in the above formulae.

For costs incurred at greater intervals than years, or on a highly irregular basis, e.g. large-scale repair work, an annual average is used. Where changes in costs are anticipated, future costs should be entered at the average annual level as expected. Evaluation of individual costs is based on present values which may be corrected if recognizable longer-term trends exist. Problems are:

1. The useful life of the ship can only be estimated.
2. During the useful life, costs can change with the result that cost components may change in absolute terms and in relation to each other.

All expenditure and income in a ship's life can thus be discounted to a total 'net present value' (NPV). Only the cash flow (expenditure and income) should be considered, not costs which are used only for accounting purposes.

Yield is the interest rate  $i$  that gives zero NPV for a given cash flow. Yield is also called Discounted Cash Flow Rate of Return, or Internal Rate of Return. It allows comparisons between widely different alternatives differing also in capital invested. In principle, yield should be used as the economic criterion to evaluate various ship alternatives, just as it is used predominantly in business administration as the benchmark for investments of all kinds. The operating life should be identical for various investments then.

Unfortunately, yield depends on uncertain quantities like future freight rates, future operating costs, and operating life of a ship. It also requires the highest computational effort as building costs, operating costs and income must all be estimated.

Other economic criteria which consider the time value of money include NPV, NPV/investment, or Required Freight Rate (D the freight rate that gives zero NPV). The literature is full of long and rather academic discussions on what is the best criterion.

But the choice of the economic criterion is actually of secondary importance in view of the possible errors in the optimization model (such as overlooking important factors or using inaccurate relationships).

Discounting decreases the influence of future payments. The initial costs are not discounted, represent the single most important payment and are the least afflicted by uncertainty. (Strictly speaking, the individual instalments of the initial costs should be discounted, but these are due over the short building period of the ship.) The criterion 'initial costs' simplifies the optimization model, as several variation-independent quantities can be omitted. Initial costs have often been recommended as the best criterion for shipyard as this maximizes the shipyard's profit. This is only true if the price for various alternatives is constant. However, in modern business practice the shipyard has to convince the shipowner of its design. Then price will be coupled to expected cash flow.

In summary, the criterion for optimization should usually be yield. For a simpler approach, which may often suffice or serve in developing the optimization model, initial costs may be minimized.

**Initial costs (building costs).** Building costs can be roughly classified into:

- Direct labour costs.
- Direct material costs (including services bought).
- Overhead costs.

Overhead costs are related to individual ships by some appropriate key, for example equally among all ships built at the accounting period, proportional to direct costs, etc.

For optimization, the production costs are divided into:

1. *Variation-dependent costs.* Costs which depend on the ship's form:
  - (a) Cost of hull.
  - (b) Cost of propulsion unit (main engine).
  - (c) Other variation-dependent costs, e.g. hatchways, pipes, etc.
2. *Variation-independent costs.* Costs which are the same for every variant, e.g. navigation equipment, living quarters, etc.

Building costs are covered by own capital and loans. The source of the capital may be disregarded. Then also interest on loans need not be considered in the cash flow. The yield on the capital should then be larger than alternative forms of investment, especially the interest rate of long-term loans. This approach is too simple for an investment decision, but suffices for optimizing the main dimensions. Typically 15–45% of the initial costs are attributable to the shipyard, the rest to outside suppliers. The tendency is towards increased outsourcing. Of the wages paid by the shipyard, typically 20% are allotted to design and 80% to production for one-of-a-kind cargo ships, while warships feature typically a 50:50 proportion.

*Determining the variation-dependent costs.* Superstructure and deckhouses are usually assumed to be variation-independent when considering variations of main dimensions. The variation-dependent costs are:

1. The hull steel costs.
2. The variation-dependent propulsion unit costs.
3. Those components of equipment and outfit which change with main dimensions.

*The steel costs.* The yards usually determine the costs of the processed steel in two separate groups:

1. The cost of the unprocessed rolled steel. The costs of plates and rolled sections are determined separately using prices per ton. The overall weight is determined by the steel weight calculation. The cost of wastage must be added to this.
2. Other costs. These comprise mainly wages. This cost group depends on the number of man-hours spent working on the ship within the yard.

The numbers differ widely, depending on the production methods and complexity of construction. As a rough estimate, 25–35 man-hours/t for containerships are cited in older literature. There are around 30–40% more man-hours/t needed for constructing the superstructure and deckhouses than for the hull, and likewise for building the ship's ends as compared with the parallel middle body. The amount of work related to steel weight is greater on smaller ships. For example, a ship with 70.000m<sup>3</sup> under-deck volume needs 15% less manufacturing time per ton than a ship with 20.000m<sup>3</sup>.

For optimization, it is more practical to form 'unit costs per ton of steel installed', and then multiply these unit costs by the steel weight. These unit costs can be estimated as the calculated production costs of the steel hull divided by the net steel weight.

*Propulsion unit costs.* For optimization of main dimensions, the costs of the propulsion plant may be assumed to vary continuously with propulsion power. They can then be obtained by multiplying propulsion power by unit costs per unit of power. A further possibility is to use the catalogue prices for engines, gears and other large plant components in the calculation and to take account of other parts of the machinery by multiplying by an empirical factor. Only those parts which are functions of the propulsion power should be considered. The electrical plant, counted as part of the engine plant in design—including the generators, ballast water pipes, valves and pumps—is largely variation-independent.

*The costs of the weight group 'equipment and outfit'.* Whether certain parts are so variation-dependent as to justify their being considered depends on the ship type. For optimization of initial costs, the equipment can be divided into three groups:

1. Totally variation-independent equipment, e.g. electronic units on board.
2. Marginally variation-dependent equipment, e.g. anchors, chains and hawsers which can change if in the variation the classification numeral changes. If variation-dependence is not pronounced, the equipment in question can be omitted.
3. Strongly variation-dependent equipment, e.g. the cost of hatchways rises roughly in proportion to the hatch length and the 1.6th power of the hatch width, i.e. broad hatchways are more expensive than long, narrow ones.

*Relationship of unit costs.* Unit costs relating to steel weight and machinery may change with time. However, if their ratio remains constant, the result of the calculation will remain unchanged. If, for example, a design calculation for future application assumes the same rates of increase compared with the present for all the costs entered in the calculation, the result will give the same main dimensions as a calculation using only current data.

### **14.3 Techno-economical models**

The basic design process of ships and its machinery is a highly intensive task. Frequently, during this design process, different design configurations have to be calculated before “optimal” one is found. Prompted by higher demands on effective use of resources in general, it is thus very convenient to have access to an optimization program that allows a quick, simple as well as reliable calculation in designing ships main dimensions and power requirements, and at the same time generate a consistent approach to select machinery for the ships.

The problem in designing optimum ship and marine machinery and its selection, however, appears due to the great number of the considerations that must be taken into account. This problem becomes even heavier with the development of the machinery systems on board, in terms of the complexity and number of components. This condition clearly increases the capital cost and the complexity of the design option. Consequently, the decision on a ship’s design and its selected machinery must guarantee that the ship and its machinery will operate with low level of failure, safely and efficiently, with high level of availability and at the end of the time will deliver an optimum rate of return on the capital being employed. In more general terms, precision in designing ship’s main dimensions and its marine machinery would, therefore, be one of the most critical points in achieving reliable ship operation.

The techno-economic evaluations are often used to assess the suitability of alternative technical solutions of marine machinery for ships. They utilized a comprehensive method in selecting the machinery arrangement for a Panamax size bulk carrier of 70,000 DWT. Main distinguished differences with this study is that our study takes the design problem at the basic design process, which allows the optimization process to determine the optimum ship’s main dimensions and its related machinery characteristic within the given constraints, and our proposed method can make possible the subjective judgment to get involve within the selection process.

Following will be considered an alternative process in optimizing marine design, particularly on the determination of ship’s main dimensions and its power requirements at the basic design stage and use those results as the parameter in machinery selection. This procedure, hereafter, is called the Qualitative-Quantitative Joint Analysis Method (QQJA). The QQJA process is basically intended to facilitate integration of qualitative and quantitative analysis into one selection process. Figure 14.3 shows the basic structure of the QQJA method. There are two main stages for selection process. The first stage is the optimization of the main dimension of the ship and its power requirement. This must be done prior to selection process because machinery onboard is generally a function of ship dimension and propeller-hull interaction.

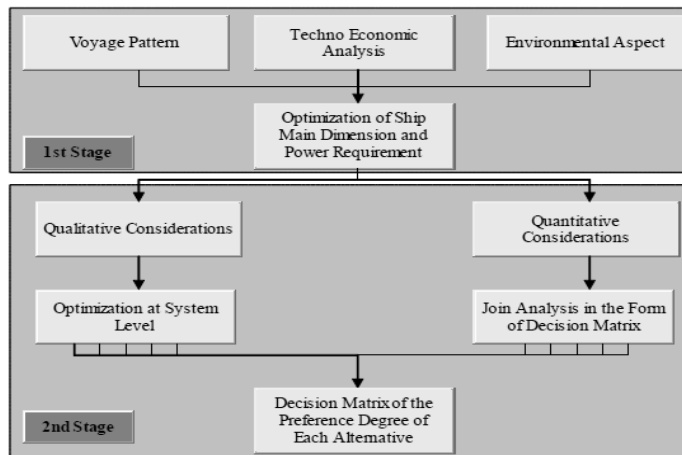


Figure 14.3. The QQJA process

Spreadsheet modeling will be adopted at this stage, because this method needs no painful and exhaustive effort to produce programming codes, especially when the problem and optimization model have been well defined. Non-linear programming (NLP) can express the problem, and Generalized Reduced Gradient (GRG) method can be effectively used to work with the NLP problems. The second stage is the process in which qualitative consideration takes place in selection process. The qualitative consideration is expressed in a form of subjective judgment.

Before selecting and ranking the components, all designer's preferences are assembled in a form of a decision matrix. The quantitative considerations can directly be arranged into a decision matrix format by obtaining their preference degree. The qualitative consideration, on the other hand, needs further quantification process before being able to join the selection process.

At the basic design stage, it is required to design a number of series ships (tanker), which have optimum main dimension and optimum specified power. The ships are used to serve a crude oil delivering contract of a certain throughput. Economic Cost of Transport (hereafter ECT) is utilized as the objective of the optimization problem. In other words, the minimum ECT must be obtained to guarantee that the optimum design is achieved. The tanker is picked up to serve a certain route with distance of xxxx (optional) nautical miles. Port characteristics require such constraints, as the ship must not exceed yyy-m in length and zz-m in draught. Some economic data are employed during the optimization process and mainly obtained from.

In favor of making the optimization problem easier, the *input folder* and the *equation folder* are grouped into several directories. The *input folder* of the model consists of several given parameters and grouped into different directories. The Ship Data directory takes the cargo density of aaa kg/m<sup>3</sup>. Appendages factor, which influences the resistance calculation, is assumed to have value of b.bb. This directory also allocates the need to use a reduction gear for engine speed reduction. The Machinery Data directory allows the alternative of using either single main engine or multiple main engines. The model also provides the flexibility of employing the number of generator sets. In terms of the machinery, this specific tanker design model is only focused on the determination of the main engine and the generator set.

The cost of failure replacement and cost of preventive replacement are also assumed before the optimization process can be executed. Bearing in mind that the ships are still in design process, then total knowledge of the reliability aspects of the main engine is not yet available. For that reason, some tangible aspects in the determination of the maintenance and replacement policy, such as MTBF, MTTR, failure rate, reliability parameters, etc., can be only estimated from failure data concerning machines working in other ships under more or less similar operating condition. In this particular paper, such data are obtained from reference. The Voyage Data directory is one of the vital directories

in the optimization model. Optional trip distance and number of intermediate ports make the model flexible. The assumed outbound and inbound load factors allow the model to be more realistic. Moreover, to determine the number of voyages per year, we must assume the duration required for annual docking days and unscheduled maintenance in advance. The Economic Data directory and their related values are gathered from many different sources and play a very important role within the optimization model. The annual adjustment factor provides a more realistic calculation of the operating cost. This allows the annual increase of the operating cost component to be taken into account. The loading and unloading data are mainly used during the determination of port time and cargo pump capacity.

The *equation folder* consists of several directories such as the ship coefficient, machinery, reliability, loading and unloading, fuel, operating cost and the economic considerations. The Coefficient and Ship directory collects all equations for determining the main dimensions of the ship. Since the related equations usually stand as empirical formula, then the interpolation process takes part in play when the required ship lies beyond the original range.

Determination of ship resistance and power prediction calculations are carried out using Harvald's power prediction method. The estimation of the propeller data and its cavitation prediction are based on the Wageningen B-series propellers. The Vessel Cost directory allows us to perform a basic hull cost, outfit cost, machinery cost and estimated overhead cost. These calculations employ many constants taken from many related sources.

The SFOC-Speed-Power directory estimates the optimum percentage of rated BHP to be used during the service condition. This estimation is only based on the objective to minimize the SFOC and appropriate operation condition (speed) of the propeller. The Reliability directory of the equation element determines the failure rate and unreliability of the main engine based on given Weibull parameters. This directory also estimates the expected length of operating hours before failure cycle. The number of voyages per year, which strongly influences the Economic Cost of Transport, takes part in the Trip per Year directory. However, in order to find an integer number of operated ships, the calculation might generate a non-integer number of voyages per year. A decision must be made whether accepting the optimization results by rounding up or down the number of voyages per year, or simply altering other parameters to find a more realistic value of the annual number of voyages. The Fuel and Lubricating Oil directory estimates the annual fuel and lubricating oil requirement per year. Since the model does not refer to any particular engine, the calculation is then made empirically. The Operating Cost directory determines the annual operating cost for all required ships. To deal with this estimation, some parameters such as unit of insurance cost, unit of port cost, unit of crew cost and others must be assigned in advance. In this case, the perplexity happens because the determination of precise operating cost constituents that play a major position in the determination of the ECT is quite difficult. The investment scheme also affects the value of optimized ECT. Therefore, the Loan Repayment directory and the Time Value of Money directory are allocated to give the flexibility in determining the preferred investment scenario.

The *constraint folder* comprises of the expected replacement cost, reliability index, unloading pump capacity, specific fuel oil consumption (hereafter SFOC) for Main Engine (ME) and Auxiliary Engine (GE), cargo handling rate, percentage of the required brake horse power (hereafter BHP), required freight rate, L/B ratio, and the maximum allowable ship length in port.

The *output folder* yields the optimum preventive maintenance interval, block coefficient, optimum design draught, optimum Specified BHP, service speed, propeller rpm, number of shore connection unit, B/T ratio, and the number of ships. These values are sought with the main objective to minimize the ECT of the ship. ECT, the *objective* for this particular optimization problem is composed by several variables, namely the required freight rate (hereafter RFR), the inventory cost of cargo and the annual tons of cargo carried (ATC). The optimum value of RFR itself depends on the annual capital recovery of the vessel cost, the annual operating cost, and the annual throughput.



## Chapter XV

### Environmental considerations for new designed ships

#### 15.1 Designing of technologies to reduce environmental impact from ships

A review of the environmental impact of ships is presented, focusing on aspects concerned with ship building (including hull design and use of new materials), maintenance and dismantling. The main environmental issues are discussed, together with previous and on-going R&D in these areas and recommendations for future work.

Improved hull design can reduce operational emissions (through reduced fuel consumption) and accidental pollution (through improved hull strength). Design for corrosion prevention/control is a key issue. Other areas of hull design involving environmental impact are wake wash and noise. In shipbuilding the main alternative materials to commonly used steels are extra high strength steels, aluminium alloys, plastics and fibre reinforced composites. The main environmental consequences concern reduction of ship weight (giving reduced impact in the ship operation phase), requirements for protection (corrosion, fire) and maintenance, and disposal/recycling of the materials at end of life. Selection of alternative materials needs to be studied in a life cycle context.

The main environmental issues regarding building processes are release to water of grinding and blasting substances, coatings, etc., release to air of noise, dust, particles and gases, and production and disposal of waste. The building phase involves local environmental aspects at the shipyard. These are often subject to regulations and can largely be addressed by introducing clean production principles as in other industries. In a life cycle perspective the main factors are those that influence the operational phase, such as anti-fouling coatings and their effects on fuel economy.

The most important ship maintenance processes concern the ship hull surface and the machinery and auxiliary systems. A major issue is the planned banning of TBT anti-fouling coatings and the consequences of using substitute products. Inspection and maintenance to control corrosion are of major importance. The introduction of condition based maintenance for machinery systems has considerable potential for reducing environmental impact.

Regarding ship dismantling, R&D is required to improve technologies for recovery, disposal and recycling of materials and substances and to establish the total environmental impact of these technologies. Methods are needed for establishing inventories of materials on board a ship.

Environmental impact can be reduced by improved ship hull design that achieves reductions of:

- *operational emissions* through improved hull form resulting in reduced fuel consumption;
- *accidental pollution* through improved hull strength and/or subdivision resulting in reduced spillage of oil or of dangerous goods in case of an accident.

Other emerging areas linked to environmental impact are:

- The phenomenon of *wake wash*, i.e. the waves generated by passing ships and the disturbance they produce. Wash is of particular relevance for ships designed for high speed operation (though in practice it is often a problem when these ships travel at lower speeds in estuary and harbour areas).
- *Noise pollution and vibrations* which affect the quality of the environment both inside the ship (i.e. working conditions for the crew and passengers) and outside.

It has further been suggested that an improvement in quality of design and fabrication, with an increase in scantlings, would increase the lifetime of ships and thereby reduce the number of ships to be scrapped, leading to both environmental and economic benefits. However, research is needed to test this assertion.

Loss of structural integrity due to collision and grounding are the most important contributors to accidental pollution at sea.

Consideration during hull design is to be given to (1) improving the hull strength and energy absorption and (2) ensuring sufficient residual strength after damage to allow for salvage operations. Hitherto the main focus has been on preventing pollution from tankers. However, there is now increasing concern about the potential consequences of damage to bunker tanks of other ship types, some of which may carry several thousand tonnes of fuel oil.

Concerning *improvement of hull strength and energy absorption*, present R&D is focusing on the development of simplified calculation methods to be used for assessing the ability of different structural assemblies to withstand collision and grounding forces. When complete numerical simulations by the finite element method are considered, comparisons with experimental results have shown the importance of including the vertical motion of the ship for grounding simulations as well as the motion of the striking ship or struck object in the case of collision simulations. Significant research has been devoted to the assessment of existing and proposed design solutions for improved collision and grounding strength.

Relatively simple *post accident strength assessment* can be performed using 2-D methods for the prediction of the collapse strength of a hull girder. When these methods are used, the ability of the damaged ship to survive is assessed by comparing the calculated strength with the environmental loads, the latter normally calculated without considering the effect of the damage on the motions and loads acting on the ship. Research is therefore on-going with the aim of improving ship response calculation models to account for the effects of damage for both ships and mobile offshore units (e.g. in the current DEXTREMEL EU project).

The following are considered to be the main R&D needs in these areas:

- Concepts for ship subdivision to minimize the consequences of impacts on the hull, and concepts for hull structure design to increase the resistance to impact and the residual strength after damage.
- In particular, further development of energy absorbing double bottom and side shell designs and their assessment through model and full scale tests and comprehensive numerical models.
- Development of ways of protecting bunker tanks from collision and grounding for new ship designs.
- Integration of numerical models for external dynamics (ship motions) and internal mechanics.
- Development of simplified calculation methods for prediction of energy absorption capability of specific structural solutions.
- Collection and analysis of collision and grounding casualty data with the aim of developing reference design scenarios and environmental impact indexes able to account for the energy absorption of different structural configurations.
- Development of design criteria for prevention of pollution due to grounding and collision.

Apart from collision and grounding, other causes of hull integrity loss are excessive loading, fatigue/fracture problems and effects of corrosion. The first two topics are comprehensively covered by other thematic networks and are not considered here in detail.

Corrosion is dealt with by providing additional plate thickness at the design stage and including corrosion protection systems, many of them based on coatings that require maintenance through the life of the ship. Corrosion problems can also be reduced by *good detail design* of the structure. An aspect that offers potential but has received little attention is *design for maintenance* e.g. by ensuring appropriate access for inspection of local structures and for application of coatings.

The main R&D needs in this area are thus concerned with

- design of ship hulls for corrosion prevention/reduction and for ease of inspection and maintenance. Refer also to the later section on ship maintenance.

**Methods for reducing fuel consumption through hull form optimization.** Hull form optimization is to a large extent based on model tests, and towing tank tests play an important role in the procedure. Besides tank testing, hull form optimization is now also based on use of CFD (computational fluid

dynamics) calculations. Practical application of CFD in hull design is, for the time being, partially limited by the need for considerable expertise and judgment. An increased automation of the process would result in more frequent and uniform application, in particular in the field of viscous flow calculations.

The main R&D needs in this area are thus:

- improvement of CFD models for both steady and viscous flows, and
- increased automation of CFD modeling to enable easier use in design offices.

**Methods of reducing wave/wash generation.** Wake wash recently came to the attention of designers due to limitations now being set for wave generation by ships, in particular for high-speed craft. Reducing wash is basically the same operation as reducing wave resistance, and free surface potential flow codes are the primary tools used. For *predicting* wash however, extensions may be required because prediction of wash far from the ship generally requires too much computational effort and is often replaced by empirical formulations. Furthermore, application taking account of variation in water depth is not usually possible.

The main R&D needs are as for hull form optimization and in addition, full-scale and model testing of wash effects, including study of the environmental consequences.

**Methods of reducing noise and vibration.** Reduction of noise from gas turbine propulsion systems is an issue for high-speed ferries. However, the main cause of noise and vibrations in ships is cavitation on the propeller. Cavitation occurs mainly due to the non-uniform wake field in which the propeller operates. There are two ways to reduce noise and vibrations:

1. Appropriate design of hull-propeller interaction. Make the inflow more uniform i.e. improve the wakefield, e.g. by using bulbous sterns or by moving the propeller out of the wake.
2. Improve the cavitation behaviour of the propeller in a given wakefield by designing new blade sections to reduce vibration excitation (not really a *hull design* problem).

In order to study and refine hull design with improved wakefield, CFD tools will be needed, in combination with refined model test techniques using flow visualization and boundary layer tripping techniques. While use of 3D finite element models of the whole ship are quite well established to predict vibration levels at the design stage, *noise prediction* is far less advanced and in most instances is still based on semi-empirical formulations whose use needs considerable judgement and experience. The introduction of techniques used in other industrial sectors, such as the SEA (statistical energy acoustic) method, is considered to have significant potential for improving noise prediction capabilities for ships. A parallel field of research is the use of finite element models for noise prediction.

The main R&D needs in this area are the following:

- Development and assessment by model tests and numerical calculations of hull shapes leading to improved wakefield.
- Further development of POD propulsion and of propellers with improved cavitation behaviour.
- Developments of noise prediction methods based on SEA and FEM.

**Hull design: R&D priorities.** Of the many R&D needs related to hull design, the following are believed to have highest priority:

- Protection of bunker tanks, and energy-absorbing structures for ships in general.
- CFD for optimization of hull forms (for reduced resistance and wash).
- Design for corrosion prevention and ease of inspection/maintenance.

In addition, the use of safety-related technologies for environmental aspects for different ship types to reduce the risk of pollution is believed to offer scope for study.

### Use of new materials

Life Cycle Assessment for ships shows that the fuel consumption from the use phase is the dominant contributor to overall environmental effects. Reducing weight in the structure and components generally leads to a reduction in fuel consumption for a given payload and distance travelled. The use

of new materials, as alternatives to normal ship-building grades of steel, offers considerable potential for weight saving. The main environmental impact of using new materials thus appears in the operational phase. However, different materials have different environmental impact characteristics. Thus, to assess these materials, a life cycle perspective has to be introduced.

**High strength steels.** The use of high and extra high strength steels, e.g. quenched and tempered or TMCP (thermo-mechanically controlled processed) steels, can lead to lower plating thicknesses in the ship structure as compared to conventional ship building steel grades. Thus the total weight of steel that is required is reduced. However, this reduction may be limited by fatigue considerations, and will be to some extent offset by increased complexity in the construction process (e.g. greater need for stiffening of plates, with consequent increase in the amount of welding). Further, the higher strength combined with lower ductility may influence collision and grounding performance. With lower plate thicknesses, the requirements for corrosion protection may be more severe.

**Aluminium.** In ships aluminium is mainly used in:

- high speed vessels up to 125 m length (both catamarans and mono-hull vessels);
- superstructures in ferries and cruise ships;
- fishing boats, yachts and small vessels.
- components such as funnels, balconies, fairings, mezzanine decks, safety barriers in ferries, railings and interior components.

Aluminium is about half the weight of steel for equal strength. This gives appreciable potential for reducing fuel consumption and thus emissions during operation.

Primary aluminium production is energy-intensive. However, process improvements have reduced the amount of energy required for production, with a decrease of over 30% from the 1950's to 1997. More than 55% of the world's primary aluminium is produced using hydro-electric power, which is considered to be clean, renewable and highly efficient.

Secondary aluminium production from recovered scrap consumes only 5% of the energy required for production of primary aluminium. This makes recycling of aluminium attractive.

Aluminium and its alloys can be easily shaped by rolling, extrusion, forging and casting. However, the electrical conductivity of aluminium is greater than that for steel, and it therefore requires higher capacity power sources for resistance welding. Currents for welding aluminium are higher than those for steel, so additional protection from the more intense arc radiation is necessary. The high voltage results in increased ozone formation. The thermal conductivity is also greater than for steel, so more heat input is required during the welding process. The recently developed friction stir welding process for aluminium<sup>6</sup> does not require welding gas and results in reduced noise, elimination of ozone formation, and lower energy consumption.

Although aluminium is a very reactive metal with high affinity for oxygen, it is highly resistant to most environments and to a great variety of chemical agents. Aluminium-magnesium(-silicon) alloys are the main alloys for marine structures. A variety of protection methods are applied to aluminium and its alloys in order to enhance their corrosion resistance.

Amongst the most common methods is anodising. Other protection methods include chemical conversion coatings and various paint finishes.

Aluminium is easily recycled. New scrap (from metal production) has a recycling rate of 100%, whilst the recycling rate for old scrap is 63%. In 1994, around 30% of the aluminium supplied to the European market originated from recycled metal. The quality of recycled aluminium is equal to that of the primary metal. Recycling of aluminium is economically attractive, and a reduction of aluminium waste is thus expected in the future.

**Plastics and fibre reinforced composites.** The use of fibre reinforced composites in *hulls* is mainly confined to pleasure craft, yachts, high performance racing craft, rescue and patrol vessels (customs, coastguard, etc.), fishing vessels, passenger and cargo vessels (mainly up to about 40 m), and naval craft. Other applications for fibre composites within ship-building are found in superstructures and secondary structures.

The main materials used in applications requiring structural strength and stiffness are fibre-reinforced thermosets, principally glass-reinforced polyesters, vinylesters and epoxies, commonly known as “GRP”. More limited quantities of aramid and carbon reinforcements are in use, with an increasing amount of carbon fibre in the last 2-3 years as the price of such fibres has dropped sharply. The weight-to-strength ratio for GRP is roughly 2-3 times that of steel. For more advanced composites with carbon fibres, the ratio can be significantly higher.

An important aspect of production of fibre-reinforced composites is the emission of gases, both during raw material production and in the building phase. In particular, tighter controls are being introduced to reduce styrene emissions, in terms of both emissions to the atmosphere and concentrations in the workshop. While reduction of the styrene content of the resins themselves helps to meet these requirements, there is also a trend towards more *closed production processes* at the site where construction takes place.

Corrosion is generally not a problem with fibre-reinforced composites, though for hull shells some protection against sea water (by gel-coats) is often considered necessary, depending on the resin used. Special paints are sometimes applied to enhance fire performance or to provide electrical conductivity (and thereby electromagnetic shielding). Otherwise paints are normally only applied for the sake of appearance.

Fire performance is one of the major concerns when using plastics and fibre composites in ships. The IMO Code of Safety for High Speed Craft specifies strict requirements. Although the requirements for *fire reaction* properties (flammability, flame spread, smoke, toxicity) present challenges, adequate *structural performance* can be readily achieved using either conventional insulation systems or newer, lightweight protection systems. Furthermore, the good thermal insulation properties of fibre composites help to contain a fire once started.

Some limited studies have been carried out on *recycling* of plastics and composite materials. Thermoplastics can (in principle) be readily reclaimed and remoulded. However, most structural applications use thermoset resins: for fibre composites based on these resins the only way of recycling that seems to have been investigated to any extent is grinding the material up and using it as a resin filler in applications where there is a need for volume and demands on strength are less critical. Otherwise the main *disposal* method is combustion. There is a need for further R&D in the area of disposal/recycling of these materials

**Combining dissimilar materials.** There is an increasing trend towards combining dissimilar materials in a single ship structure, particularly for high-speed vessels where weight reduction is critical. Examples include vessels built with steel hulls and aluminium superstructures, and vessels having aluminium hulls and superstructures, but with parts such as masts, control surfaces and even bilge keels constructed in fibre composites. As direct welding of dissimilar materials cannot normally be applied, the main joining methods available are explosive welding (aluminium to steel), mechanical fasteners such as bolts and rivets, adhesive bonding and combinations of these methods.

Such use of dissimilar materials presents special challenges in terms of recycling and disposal, as the different materials must be separated before further treatment. As far as the authors are aware, this topic has not been specifically addressed up to now.

### Ship building processes

The discussion of this section is limited to building (and conversion) processes for *steel* ships. The most usual environmental aspects regarding these processes are:

- Related to water: Grinding substances, blasting substances, anti-fouling, coatings.
- Related to air : Noise, dust, particles, gases (e.g. from welding), smell, aerosols.
- Waste: Metal pieces, oil contaminated waste, paint, cables, etc.

Traditional environmental impacts related to building processes are considered to be emissions of noise and dust during sandblasting and painting. In addition, the efficiency of the usage of steel plates has been of some concern.

Important processes are *cutting, forming, joining, grinding, sandblasting, painting and outfitting*. The most important environmental aspects concerning those processes are mainly local aspects with relation to air and water as described above. The impact on the environment depends however on which technologies are being used. For example, newly developed techniques like underwater plasma welding, electron beam welding, friction stir welding and laser cutting and welding can lead to reduced environmental impact as compared to more traditional methods. They all reduce gaseous emissions as well as requiring less energy than conventional methods such as flame cutting and arc welding. Adhesive bonding (unless requiring a high-temperature cure) avoids heat input during the joining process, but some adhesives and surface treatments emit harmful fumes.

The outfitting resource consumption can be reduced mainly by performing “early outfitting”, i.e. outfitting on ship hull panels and on hull sections before final assembly. Erection and outfitting require steel materials, electrodes, gases, transportation resources etc. Environmental aspects are emissions to air of welding gasses, and resource utilisation in general. In addition the transportation of plates, profiles, sections etc. may be an environmental aspect.

The roughness of the external hull surface after coating is of importance with respect to resistance and fuel economy.

Local environmental problems caused by outdoor sandblasting and painting present a special challenge. There are existing technologies to protect against such pollution, but their introduction is hindered by cost considerations.

The environmental impacts from the building processes are mostly local and their contribution to the total environmental performance of a ship in a total life cycle view may be ignored compared with the impact from the emissions from the operational phase. However, the impact of building processes is significant in a local perspective, and should not be disregarded. Furthermore, environmental effects that are initially of a local nature may have long-term impacts and, if they occur at several neighbouring locations, they may lead in time to more global consequences such as reduced biodiversity.

Several studies have been performed on the identification of environmental issues at a shipyard and on how to minimize the environmental impacts. Most of the identified studies were carried out in Norway or in the Netherlands and identify material usage of certain sub-processes as important. However, they cover only a few aspects related to environmental impact from ship building.

To reduce the environmental impact of ship building all contributors (ship yards and sub-suppliers) need to improve their knowledge about the environmental impact related to their responsibilities, be made aware of the potential savings in resource consumption, and, if possible, apply production equipment and production methods aiming at cleaner production.

R&D in this area must focus on how to implement the findings in the shipbuilding (and ship dismantling) industry. Specific R&D actions that should be considered are to develop a European handbook for cleaner production in shipyards, and to perform benchmarking for environmentally optimised building.

### **Ship maintenance processes**

During the operational phase a ship is maintained periodically, e.g. bottom hull treatment and recoating every 2-4 years, and rebuilding or conversion once or twice in a period of 20-30 years. Machinery maintenance takes place periodically when the ship is in operation and when it is docked for other reasons. The maintenance intervals depend partly on the type of antifouling system and the fuel system.

Due to hull surface cleaning, paint removal, changes of zinc anodes, and paint application important environmental aspects are:

- Discharges to water: heavy metals, paint effluent, flush down water and sand blasting substances.
- Noise and dust emissions (from sandblasting, grinding etc.), emission of solvents.
- Waste treatment.

**Coating systems - fouling, TBT and alternatives.** On ocean-going vessels fouling leads to a significant increase in fuel consumption and loss of speed and manoeuvrability.

TBT self-polishing copolymer (SPC) antifouling coatings so far offer the highest degree of reliable and consistent fouling protection. An interval of five years between dry-dockings is normally possible. Since their introduction more than 40 years ago, TBT-based paints have continually improved and today pose reduced risk to the environment. In recent years, there has been a move to develop tin-free alternatives to TBT paints. Although advances in technology have narrowed the gap in performance between tin-based and tin-free antifouling systems for smaller vessels, no adequate tin-free antifouling systems are currently available for large ocean-going vessels.

Tin-free systems for deep-sea vessels are still in the early stages of testing, only allowing up to three years between drydocking, and may require regular cleaning to remove fouling. It is estimated that increased dry docking, hull blasting and repainting will result annually in 0.8 billion litres of contaminated wastewater, 2.3 million tonnes of contaminated grit and 1.8 million waste paint cans requiring disposal. Very few countries currently have regulations concerning the disposal of waste from the cleaning of ship hulls.

Additionally, as a result of frequent repainting of ships, two to three times more solvents will be released into the atmosphere. Solvents contain volatile organic compounds (VOCs) and hazardous air pollutants (HAPs). VOCs and HAPs contribute to ozone depletion and photo oxidant formation.

The IMO has proposals pending to regulate the use of TBT-based antifouling paints. In anticipation of new regulations, the marine paint industry has developed alternatives to tributyltin self-polishing copolymers (TBT-SPCs). One alternative is to use copper compounds as toxins, but presently they are not as effective and do not last as long as TBT-SPCs. From an environmental perspective the most desirable approach to fouling control is a system which does not rely on release of biocides to achieve its effect. It is difficult to evaluate the full environmental impact of these products without more comprehensive scientific research and evaluation. To date, none of the tin-free alternative antifouling paints has been shown to be safe to the environment<sup>11</sup>. In fact, none of the new SPC alternatives to TBT paints meets the air quality requirements for volatile organic compounds (VOC) of the US Environmental Protection Agency.

The following areas offer development potential but require further R&D effort:

- *Drag reduction systems and application techniques*, i.e. efforts to smoothen the hull surface. In order to find a sound scientific explanation as to how a surface coated with foul-release reduces drag, the characteristics of the turbulent boundary layer near such a surface need to be analyzed. There is a need for studies on foul-release paint systems, application techniques and their implication on resistance and fuel consumption.
- *Cost reduction efforts*. In general, foul-release coatings are currently 5 times more expensive than TBT-SPCs, and 2.5 times more expensive than tin-free SPCs. There is a need to develop methods that will help ship owners to perform cost/benefit evaluations of marine coatings taking into account life cycle costs and environmental aspects.
- *Risks to marine environment*. Because TBT-free paints do not effectively control fouling, they increase the risk of ships introducing invasive, non-native species that can cause economic and environmental ecosystem damage, including the collapse of a region's fisheries. In addition, little data exists on the potential chronic or long-term risks to the marine environment of tin-free products. Biocides may pose a risk to the environment; only a little data on this is available. Studies are needed in these areas.
- *Alternative paint stripping media and equipment*. Dust from grit-blasting and noise emissions are regarded as local environmental problems. Today some alternatives are vacuum blasting, water/abrasive systems, and hydroblasting. Hydroblasting has been tested extensively. However, although giving outstanding improvements, this technique still lacks the feasibility and quality expected. Other cleaning media include plastic, sponge, wheat starch and carbon dioxide. Most of these can be used several times. However, capital costs are high. There is a need for development and testing of new technologies such as these.

**Corrosion control and the problem of inspection.** Corrosion is a major problem for hull design and maintenance, in that it can have a major weakening effect on the hull leading to polluting accidents. Corrosion avoidance relies very much on inspection planning and maintenance because there are many factors affecting corrosion that cannot yet be dealt with fully at the design stage. Since local failure of coating systems is enough to initiate the corrosion process, the question of durability and lifetime of corrosion protection systems is still an area of current research interest. Related measures to control the corrosion process are the inspection procedures. The efficiency and cost of inspection and maintenance policies is an area of current research interest and one in which technology could be transferred from the offshore industry.

A number of possible causes of accelerated corrosion warrant further study to determine their relative importance. The Oil Industries International Marine Forum suggests that the effects of some of the following factors may need to be addressed separately or in combination:

- Additional monitoring and review of existing records should be carried out to establish the temperature profile of a cargo tank throughout the loaded and ballast voyages and its effect on corrosion rate. As this profile will vary considerably by trading area, the inter-relationship of steel temperature, trading area and incidence of accelerated corrosion should be examined.
- The corrosion characteristics of TMCP steel should be studied to determine whether or not they differ from steels manufactured by other methods.
- The influence of the cyclical loading and deflection of steel structures on corrosion rates should be examined. The degree of deflection of newer, high tensile structures vs. older mild steel structures should be quantified to determine whether the deflection contributes to the separation of scale.
- The effect of crude oil washing on corrosion should be evaluated including the influence of a film of oil on steel, the effectiveness of different types of crude oil washing machines, and the impact of crude oil washing on rust scale separation from steel surfaces.
- The effectiveness of coal tar and pure epoxy coatings should be evaluated in an environment that includes microbial influenced corrosion.
- The composition and moisture content of inert gas should be examined to determine its influence on the corrosion rate and methods for decreasing the corrosive constituents of the gas should be considered.
- Methods for decreasing the humidity level in cargo tanks should be examined, including de-humidification of the inert gas.
- An effort should be made to determine if some crudes are more liable to create accelerated corrosion than others.

**Maintenance of machinery and auxiliary systems.** The major environmental aspects related to maintaining machinery and auxiliary systems are oil (additives), coolants, gases, electrical/electronic waste, seals, insulation, and scrap-metals. A sound maintenance management system is a vital part of a safety management system (SMS) and is a part of the requirement for obtaining and maintaining ISM certification.

The maintenance system shall provide continuous improvement of existing procedures and routines. Improvements in maintenance are mainly motivated by cost reduction and increased operational reliability and safety considerations, but often have positive environmental consequence in addition.

Maintenance may be divided into 2 main groups: unplanned maintenance and planned (preventive) maintenance (hereunder periodical maintenance and condition based maintenance). Unplanned maintenance includes all maintenance that has to be carried out due to an unexpected occurrence and where the planned maintenance system procedures have failed to prevent the incident. Preventive maintenance can be divided into periodical maintenance and condition based maintenance.

Preventive maintenance procedures should be established at least for the following: hull and superstructure steelwork; safety, fire-fighting and anti-pollution equipment; navigational equipment; steering gear; anchoring and mooring equipment; main engine and auxiliary machinery; pipelines and



valves; cargo loading/discharging equipment; inert systems; fire, gas and heat detection systems; bilge and ballast pumping and separator systems; waste disposal and sewage systems; communications equipment.

The maintenance costs of a merchant ship represent 15-20% of the operating costs. Adopting new, condition-based maintenance methods has the potential to cut these costs significantly and increase the availability of the vessel. These methods require computer aids and accurate sensors. A study in the USA, presented the following benefits from a computerized maintenance and spare part planning system:

- Initial reductions of 20% or more in maintenance, repair, and operations inventory.
- A 15% improvement, according to vendors, in the availability of production equipment.
- Cost savings between 20% and 30% from efficiently executing both planned maintenance and corrective maintenance tasks.
- Availability of historical data for fine-tuning planned maintenance procedures and schedules.

Other aspects to focus on are:

- Reduction of harmful substances during maintenance
- Better waste management (e.g. guidelines on tracking the recycling of waste material like oil, spent solvents, batteries, oil filters, liquid waste)
- Training of employees on proper waste control and disposal procedures, maintenance instruction and better work conditions.

## ***15.2 Environmental impact of ship building and maintenance activities***

Shipyards, because of their physical location, wide variety of process equipment and materials, and the outdoor nature of the work conducted at such a large scale, are especially prone to polluting the surrounding air, water and land. Shipyards have a broad range of opportunities to reduce toxic and hazardous exposures and releases to air, land and water, and to save money and improve public image. A description of the potential health and environmental effects of several key operations and processes in the shipyard industry make a case for investigating and implementing opportunities and best management practices:

**Abrasive Blasting.** This process generates particulate matter, spent slag and abrasives, and heavy metals such as lead, nickel, zinc and copper, from the breakdown of the removed pigmented coatings and substrate. Particulate matter and/or fine dust, causes respiratory and other human health problems if inhaled. The dust can also degrade air and water quality. Fugitive emissions from blasting operations can travel beyond the blasting area, carried by air or by water. They can migrate to other production areas causing worker exposure, and potential contamination of painting or other operations, contamination to storm drains, other drainage pathways, sediment, and water. Air can carry fugitive blasting emissions outside the shipyard and impact the general public and environment.

**Marine Coatings.** Conventional primers and paints contain solvents and pigments with heavy metals. Many solvents contain volatile organic compounds (VOC) and/or Hazardous Air Pollutants (HAPs). Over 180 HAPs are regulated under the Clean Air Act. All HAPs and some VOCs are shown to cause cancer, so exposure to workers is a critical issue. Some HAPs and VOCs also contribute to the formation of ground level ozone (smog). Coating application processes produce overspray, that may become airborne because of the outdoor work and the huge pieces or ship hulls that are coated. Overspray can contain heavy metals, particulate, and volatiles.

**Antifoulants.** The colonization of barnacles, algae, and other fouling marine organisms onto hulls greatly reduces vessel fuel efficiency and speed. The bottoms of vessels that have prolonged contact with seawater are commonly coated with "antifouling" paints containing biocides that inhibit the attachment of fouling organisms to hulls. The active biocides have typically been tributyltin (TBT), or cuprous (copper) compounds, such as cuprous oxide, cuprous thiocyanate and metallic copper powder. These coatings introduce contaminants to the water column and bottom sediments through sloughing of paint during use, through discharge of paint chips, and during paint removal and vessel maintenance

activities. These contaminants tend to accumulate more so in water areas with much ship traffic and docking, such as harbours and ports.

TBT causes adverse reproductive and immune effects on shellfish at low levels. If copper accumulates in the aquatic environment, it can have a detrimental effect on marine life. Significant copper accumulation is unlikely to occur in fast flushing open coastal areas, but can accumulate in the sediments of low flushing waters including streams, rivers and bays.

Currently, however, there are few viable alternatives to TBT and copper as the biocide ingredient for marine coatings. (Alternative antifoulant product research is underway).

**Vessel Maintenance.** Ship maintenance activities generate waste engine fluids - such as oil, hydraulic fluids, lubricants, and anti-freeze. Fueling activities generate waste liquids and vapor releases to air. Spills and leaks of hydrocarbons, glycols and other pollutants in these liquids can harm aquatic life. Additional waste streams are bilge and ballast waters that contain oil, solvents, and other hazardous constituents.

**General Facility and Yard Operations.** Solid waste generation, and electricity and water consumption are costly and have their own set of environmental impacts. Unrecoverable solid waste fills landfills and generates leachate. Energy generated via fossil fuels results in greenhouse gas emissions and smog. Excess water consumption reduces water for natural habitat, drinking water, and other important uses. Storm water must be controlled to prevent contamination of groundwater and surrounding surface waters.

### **Cost Savings and Avoidance**

Often, businesses only account for waste disposal costs rather than considering all of the associated costs of using toxic raw materials and polluting, energy or water-consuming processes, and inefficient technologies. Total cost accounting ensures that certain management, engineering, and overhead costs are tagged to cost considerations for environmental operations. Consider all potential cost and savings opportunities associated with improving environmental performance:

#### **Raw Materials Reduction in Quantity or Toxicity**

- Storage and inventory
- Spill prevention
- Secondary containment
- Container labels
- **Water Use Reduction**
- Water use
- Sewer and discharge fees
- Wastewater treatment
- Sludge handling and disposal

#### **Solid and Hazardous Waste Reduction**

- Waste collection and containers
- Labelling
- Onsite management
- Recycling and reuse opportunities (and avoided purchase of new or virgin materials)
- Disposal and transport

#### **Air Pollution Reduction**

- Inspection and monitoring
- Ventilation
- Pollution control equipment
- Permit and discharge fees

#### **Management and Overhead Costs to Consider**

- Permit preparation and maintenance
- Regulatory impact analysis
- Hazard analysis and communication

- Product/vendor research
- Emergency planning, spill response procedures and equipment
- Right-to-know, emergency, and other safety and health training for staff
- Inspections and audits
- Information and tracking systems
- Regulatory reporting
- Legal fees

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