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Improvement of training in maritime safety aspect by the implementation of S-VDR capabilities

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Abstract. Education and training are essential parts of institutional efforts to ensure a safer maritime environment. The contemporary well-indicated trend shows that improvement of maritime safety and security is efficient in a virtual environment using simulations in training process. Simulations should be as much realistic as it is possible in order to increase benefits of training fulfilling IMO regulations and rules of national maritime authorities. Shipborne Simplified Voyage Data Recorders (S-VDRs) need to follow strict requirements of IMO regulations. Maritime safety committee`s resolutions concern the adoption of revised performance standards that are applicable in the training process. Standardized specialized data related to the ship`s safety that are gathered and stored in regard to competent investigation authorities would be useful for improvement trainees` practical skills and knowledge in advance.

1. Introduction

It is a challenge to maritime education and training institutions to adapt its efforts to all demands declared by both all competent administrations and maritime industry stakeholders. Traditionally, their interests consist of claims for effective but affordable education and training in a realistic environment. It is a beneficial approach, because of all incoming requirements in safety and security aspect. These requirements are implemented by the International Maritime Organization (IMO) Conventions and Codes and it is covered by National Legislation. There is a steady trend in recent decades to put into practice new technologies. It is extremely noticeable in navigation, in the offshore industry, and during processes of monitoring and control of ship`s traffic. Protection of the environment and ecology are another milestone and essential part of wide spectrum activities at sea. Nowadays, the role of safety and security becomes higher and it is important precondition to increase economic benefits.

In fact, modern specialized simulators are widespread “training tool” among all maritime educational institutions. The technical characteristics of a given type of vessels are introduced in the simulation. Simulators are designed to provide a realistic reproduction of real-life environmental conditions together with resembled essential elements and characteristics of the modeled vessel. It gives an integrated comprehensive approach to implement theory at first hand during education. It is applicable during both base training and post-graduation qualification. At high extent, the efficiency of the executed drills and exercises depend on the level of correspondence between conditions of the real environment and conditions of a given virtual environment generated by the simulator. It is vital to analyze the discretion for updating the virtual environment factors according to all available requirements for maritime safety and security.

Results in presented research work are obtained by using a methodology based on system analysis. System approach makes possible to decompose the VDR system in order to identify and assess profitable elements related to the efficiency of simulation. Undoubtedly, Shipborne Simplified Voyage Data Recorders (S-VDRs) are useful for training purposes following strict requirements of IMO regulations. For instance, Maritime safety committee`s Resolution MSC.333 (90) concerns the adoption of revised performance standards that could be applicable in the training process. Standardized specialized data related to the ship`s safety that are gathered and stored in the interest of competent investigation authorities would be useful for improvement trainees` practical skills and knowledge in advance.

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2. Present-day safety demands in the Maritime domain

The Maritime Transportation System is a part of the global logistics system. It is international in nature and it becomes a subject to a complex array of policies and regulations often transcending national frameworks. Therefore, multiple states have intersections of common interests because of connected markets. It settles a prominent pillar for co-operation between interested parties.

Contemporary safety requirements for the Maritime transportation system consist of many national and multinational synchronized procedures and initiatives. By reviewing the current regulations in the field of safety, the leading and extensive role of the United Nation should be noted. Chronologically, a fundamental set of requirements is given by the Safety of Life at Sea (SOLAS) Convention of 1974/1988, the Standards of Training, Certification and Watch keeping Convention (STCW) of 1978, and the United Nations Convention on the Law of the Sea of 1982 (UNCLOS-82) identifying rights and responsibilities of flag states or coastal states.

Putting the elements of any analyzed complex system in a virtual environment is extremely efficient because of having significant potential to realize savings of financial and material resources. Creating a realistic model of the security and safety system makes it possible to simulate the interaction between different actors in Maritime safety environment. To achieve this goal, elements of the security and safety model should be selected precisely in accordance with a situation and changing environmental conditions. Decomposing the Maritime Transportation System into elements acknowledges that often safety has a mutual relationship with security. Governmental authorities and legitimate international organizations are involved in protection and security of sea lanes used for international trade as well as harbors and other crucial maritime infrastructure. Their responsibilities are applicable under the ISPS Code as an amendment to the SOLAS Convention (1974/1988). The Code is, in some way, cross point between a large number of specific issues concerning maritime safety and security. Stricter control concerning the evolution of crisis situations becomes compulsory in another aspect. Annex 10 of Chapter 5 sets basic requirements concerning carriage, download and playback equipment, periodical check and certification, IMO Guidelines on Voyage Data Recorders (VDR) Ownership and Recovery [1].

Another viewpoint is available in respect given by the IMO International Safety Management (ISM) Code adopted in 1993. The ISM Code is part of the broader framework that regulates a considerable portion of shipping operations. In fact, the Code obliges all steak-holders employing resources within the Maritime transportation system to initiate implementation of safety management systems. Contemporary safety challenges are emphasized by a number of accidents and fatalities in maritime areas. Every casualty or incident has particular distinctive sources of unfavorable impact. The logic of ISM Code points that identified sources of risk are covered by the prepared functional sections in the structure. It is founded on the basis of safety risk management having respect for human and organizational factors. The most serious challenges are related to the certification of plans and instructions for all activities, risk-management on board [2]. It concerns the company`s ability to be aware of when processes deviate from implemented standard procedures. By the same token, the safety of all Maritime transportation system`s elements, such as merchant vessels, supply and support vessels, etc., exists as a challenge of paramount importance.

Nevertheless, the analysis of empiric data of safety incidents at sea shows a well-expressed trend. For example, according to authors made research in maritime safety, risk factors could be distributed among the sections of the ISM Code. Thus, twelve groups of factors regarding safety are obtained. Total of 478 incidents is distributed between distinguished functional sections. Next, incidents are subdivided in order to be systematized in “very serious”, “serious” and “less serious” categories. The risk is considered as significant in the section “Master`s responsibility and authority” – in total 14.4% of cases, section “Resource and personnel” – 28.0% and “Development of plans for shipboard operations" – 13.6%. A major source of risk is defined as "unsafe supervision" that represent 30.8 % of causes. "Unsafe acts" constitute 28.0 % of all factors, corresponding directly competency of seafarers as an outcome of education and training system [2].

3. How S-VDRs could be beneficial in maritime education and training?

All kind navigational onboard sensors could be integrated into a sophisticated system related to the ship`s safety. Moreover, virtually there are not technical constraints that influence the conceptual realization of the new system`s configuration. It is necessary just to have a couple of new ideas, definitely acknowledged skills and adequate interface, converters and sensor adapters on the bridge. In general, it is necessary for the simulator to resemble a real-life working environment with workstations covering ergonomic criteria on board. Lessons learned at sea point that for safety purposes it is vital simulated data to be segregated from real ones [3]

As a complete system, designed to process, encode, final record and playback input signals, VDR has beneficial characteristics regarding maritime education and training process. Decomposition of VDR systems into subsystems in a functional aspect makes possible identification and assessment of useful elements related to further simulation. In accordance with IMO regulations stated in the Maritime safety committee`s Resolution MSC.333 (90), Shipborne Simplified Voyage Data Recorders (S-VDRs) should cover specific performance standards that are applicable in virtual simulations during a training process.

What makes VDR indispensable source of database applicable in scientific research works, education and training in virtual simulators? Actually, the implementation is possible because of trustworthy standardization in Maritime domain. Operational requirements for VDR clearly define that compulsory input into the system has to be exact time, ship`s position, heading and speed, bridge communications including voice records on the bridge. In addition to that, technical devices such as radar input, ECDIS and echo sounder are linked to VDR [4]. These requirements refer to collected and stored information by Data Collecting Unit. Next, output data are processed so that to become applicable to the analysis and assessment process. It gives sufficient capabilities to reproduce the evolution of potential destructive process on board or navigational accident.

VDR technology gives an informational output that complies with OODA-cognitive loop [5]. Risks have specific characteristics when originated in a maritime environment. Generally, the source of risk could be located among numerous interacting physical objects at sea. The aim of monitoring is to reveal on time any suspicious or potentially hazardous influences over the ship. During this phase, the trainee (or OOW at sea) has the opportunity to differentiate the physical source of risk or to identify preconditions for an emerging critical situation. Well-timed detection of threat is achievable by observation of environmental conditions and having awareness in the situation. It is reasonable to select some trustworthy indicators but some to be neglected in order to increase the efficiency of monitoring.

The idea is not a brand new in the field. There are good examples of realized integrated scalable simulators for both bridge officers and engineers that could be further upgraded [6]. Here, using VDR capabilities in a simulated environment could facilitate the training process. Further, the obtained information is delivered for assessment and analyses. There are some specifics in the monitoring of the environment at sea. Once collected, the information contains discrete environmental data over a period of time. Other restrictions are related to the limited number of available indicators, the values of which are monitored. Therefore, it is important the indication of the existence of a risk be disclosed in a priority sequence manner. Revealed risk triggers consecutive iteration process of monitoring and collecting information, analyses, synthesis, and implementation of lessons learned. The conclusion of each iteration loop allows other dormant risks to be discovered.

The assessment of the situation at sea is derived from Boyd`s orientation. It is composed of an analysis of obtained information, implementation of available experience and synthesis of a recognized picture. Thus, information is converted into useful information for subsequent risk management decision. Lessons learned contain accumulated shared practical experience of analogous risk incidents worldwide. Synthesis is a core element of the assessment stage. Actually, it is picture compilation and the decision maker becomes cognizant with the situation.

In order to mitigate the evolution of risk, the decision-making process could be supported by the set of planning scenarios. In relation to the results of the assessment stage, it is possible for the best scenario to be selected. It is essential that reaction time and inflicted damages here are suitable measurable criteria for evaluation [7].

In addition, using a system-scenario approach in a virtual simulator, it is achievable to change input, so that to develop scenario gradually and to achieve predetermined outputs. The situation could be growing by injects introducing the occurrence of events and their effects on safety environment. The discretion and the intensity of impact are determined by the specificity of observed changes in monitored indicators. The aim is to trigger trainee`s reactions which can be measured and evaluated qualitative and quantitative aspects. When the virtual environment is used for evaluation purposes, or for performing stress-test, it is an appropriate application of two hypothetical scenarios. Scenarios should be basic and aggravated depending on intensity, scope, and strength of injects. The input information should define initially triggered events. Essential “evolution” story-lines and critical intersection point in the development of destructive processes have to be “set in motion” in relation to trainees` decisions.

Further, the list of incidents and events forms arranged in advance scenario development lines. Trainees` decisions and selected options for the application of standard operating procedures are applied over the evolution of each destructive process as crisis management intervention. As it is mentioned above, critical points resemble decision-making opportunities timely to avoid lines of scenario toward aggravated end-state. Critical points have got dormant links with certain events and incidents that determine the development of the scenario. The decision, or the lack of decision, further determines the evolution of simulated processes. The basic scenario is founded on a long-term forecast of the state of a safe environment. It refers to the normal performance of routine activities for which safety requirements have been developed. The realization of the selected threats and dangers is simulated under simple conditions, i.e. under a scenario with events in regular succession and low intensity. The basic scenario is aimed to create preconditions for the assessment of standard procedures proficiency.

The aggravated scenario makes it possible to simulate the simultaneous occurrence of external and internal threats and dangers that have an effect directly on the security and safety of the vessel. It is necessary to develop at least two or three scenario lines that require different responses to which the level of correlation could be increased accordingly under certain stress-test conditions. The test is considered to be successfully performed when the values of prescribed indicators are effective evaluated. After that, recommendations are made on the basis of analysis and evaluation of recorded results. Evaluation criteria provide sufficient information to subsequent analysis and assessment – for instance, a final state of threat level, reaction accuracy, and disclosure of a breakdown process, accident detection, and pollution prevention. It is advantageous, results to be given separately for each activity and for each structural system`s element as well as aggregated for the whole process, taking into account the interaction between the elements of the system. Usage of performance reporting scale is necessary in order discrepancy of occurrence of events or injects according to the Main list of events and incidents to be optimized. In addition, it is possible the evaluator to change or specify the impact of a given incident on the environment so that a desired threshold of change to be reached. The Hazard level (HL) criterion is essential to determining the correctness of trainee`s actions.

Normally, the trainee's response is expected after each critical point of the scenario. Inspection of the hazard level should be done as a function of the learner's response to the impact of events $(\mathbf{A_1, A_2 \ldots A_m})$. If $\mathbf{HL_n}$ is a function of planned or stochastic event impact $\mathbf{A_m}$, measurable trainee`s reaction $\mathbf{R_n}$ and monitored parameter of an environment $\mathbf{E_n}$ the function $\mathbf{HL_n = f\ (A_m; E_n; R_n)}$ receives particular measurable values. The condition $\mathbf{HL_n < HL_{n-1}}$ is the criterion for the correctness of expected actions in response to given injected event or incident.

Examples of measurable indicator`s values are reaction time, a quantity of spilled hydrocarbons into the water, a degree of performance according to standard procedures (for example over 80% - satisfied; 60-80% - borderline results; under 60% - unsatisfied), etc.

4. A way toward improvement effectiveness of maritime education and training process

First of all, the implementation of S-VDR technology provides opportunities for gathering, processing, analyzing and assessing vital safety information. The useful segment of information should be systemized into a database. Actually, the database contains sensitive information that has not to be subject of sharing without control. This information is fruitful for creating a set of scenarios that cover a wide spectrum of risks. An essential factor for generating risk in the maritime environment is the presence of surface targets, navigational hazards, physical and geographical factors, hydro-meteorological factors, and last but not least, impacts of security factors. In general, navigational hazards, physical and geographical factors and hydro-meteorological factors are consolidated into so-called "environmental conditions". Environmental conditions could be represented to trainees by means of virtual simulation. If a realistic environment is once created, the most unpredictable and risky factor could be projected over the scenario. It is an inevitable complicated task to minimize inherent ambiguity of Human factor [8].

There are several important ways of dealing in reasonable extent with this kind of risk – adequate education that meets 'the next day' requirements and an appropriate training system. Competent maritime officers of the watch (OOW) that perform duties on the bridge or in engine room have to be experienced decision makers. OODA-loop cognitive process can give a sufficiently detailed description of reaction or particular proactive action on board ship so that to respond on an arisen situation. Possibility for simulation is derived from a set of scenarios starting with the basic one. The stress test is a key element in updating, maintaining and validating any maritime Safety Management Plan.

Moreover, there is another option for implementation of VDR in simulations. It is to support investigation authorities in order to figure out preconditions and to make inquiries about the given incident. Although the benefits of shared VDR-information are obvious the access to data is problematic. Investigator authorities have jurisdiction to dispose of the gathered VDR information for the purposes of the investigation. Whilst the memory is available to investigators without restrictions, a copy of the data should be stipulated to the ship-owner as soon as it is possible after accident take place. It is important to be mentioned that the access to VDR-memory is superintended by competent governmental institutions with respect of rights of the flag state. Guiding principles are determined in details in the IMO Code for the Investigation of Marine Casualties and Incidents [9].

Accordingly, the maritime transportation system should meet the demands of different legislations and jurisdictions. Maritime safety risks to shipping affect the predictability and efficiency of sea trade flows. Outcomes of maritime risk evolution have the potential to affect a wide spectrum of maritime transportation elements. For that reason, implementation of S-VDR has potential to influence education and training process worldwide, so it should be a matter of concern to international institutions in the field of maritime safety. There is growing necessity safety information to be accumulated by competent authorities and after assessment to be promulgated between educational institutions for training purposes. Such expanding importance gives cause for concern.

5. Conclusion

It is possible to be summarized that implementation of S-VDR`s capabilities for training purposes gives a broad spectrum of perspectives. Contemporary risks at sea give raising challenges upon both safety of Maritime transportation system and the focus of Maritime educational institutions. The effective control of Maritime safety environment requires all available to be assessed and accumulated as a statistical database. It provides multiple possibilities for using information in simulator conditions by produced scenarios. Modeling of realistic evolution of risk in real life environmental conditions is the best way to discipline decision making abilities and situational awareness when it is necessary at sea. So, three considerable development trends are outlined. The first one is the further application of S-VDRs information in maritime training process by improving simulation scenarios for bridge teams, engine teams, firefighters, etc. The second tendency is aimed at updating learning materials that would increase the quality and adequacy of education and training. The third one is quite pragmatic and is to develop maritime simulator capabilities so that to assist an activity of investigating authorities in incident inquiries.

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