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POSSIBLE DANGERS OF AUTOMATION FAILURES ON BOARD AND MEASURES TO AVOID THE NEGATIVE EFFECTS OF THESE FAILURES

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Abstract

The first priority of the IMO (International Maritime Organization) is to ensure safety at sea. The ships are the critical elements of the shipping. The ships are the largest vehicles of the world and equipped with state of art management systems which are mostly furnished with highly automated systems. Any automated system failure may cause fatal accidents which hamper the human life, ship and environment as well as ports and terminals. Automated systems facilitate management of the ships and reduce manpower requirement. Unfortunately the seafarers assume these high technology products are very reliable and mostly neglects any possible failure on these systems. If we investigate seafarer's education and training systems, curricula do not cover sufficient knowledge on operation principles and limitations of automated systems. This insufficiency negatively affects their counter actions in case of an automation failure which endangers safety of sea. The application of automation systems on board speedily pervades following the rapid technologic developments on merchant ships as well as on naval ships. That means automation failure will become rather important in the future. This study investigates possible reasons for automation failures and proposals to prevent it and reduce the negative effects of such incidents. Finally, it is intended to define measures covering automation failure versus human element on board.
Key Words: Safety at Sea, Safe Management of Ships, Ship Automation, Automation Failures

1. Introduction

The modus operandi of maritime industry is changing following the rapid evolvement in the technology. Most important changes are condense use of automation, electronic data systems which provides numerous data and multipurpose on-line digital data transfer systems. These improvements also change operation styles on board.

The seafarers, in particular officers, are required to be able to extract and use data provided from different sources as well as having creative thinking ability. Excessive use of IT technologies on board also requires to equip officers with additional skills which enable them to understand capabilities and limitation of automated systems and professional use of IT systems.

In addition to practical information to manage vessels equipped with high technology, there is a need for officers with developed engineering skills. This will enforce us to review our existing education and training systems to meet new requirements.

The improved and realistic simulator scenarios covering autonomous system failures could help us to enable our cadets to prepare themselves to respond quickly even under pressure. Additionally, foundation courses to electronics and mechanical courses supported with experiential learning may provide cadets to fully understand operations of autonomous systems. Maybe, we can rearrange concept and content of sea training focused on dealing with the automation and digital systems.

The goals of safe, secure and efficient shipping on clean oceans can only be delivered by skilled, informed people that know what they are doing. We need to monitor and measure the performance of our crew so that we can keep track of their strengths and weaknesses, ensure compliance and look for development opportunities which ultimately enable us to optimise the efficiency of the fleet [1].

1.1. Importance of automation

Application of automated systems are facilitated ship management functions. They have reduced workload of the users and provided better control of the navigation and engine control activities as well as simplified record keeping and operation of alarm and control units. But not having a common sense which is only human being, still these highly improved systems are reliable. As a result of that, automation systems must always be under the supervision of human element to ensure safe and reliable operation of a ship. Automation system failures, in particular related to the ship manoeuvre, are utmost important for the ship operation navigating in restricted waters and condense traffic areas. Any failure on navigation and/or command control systems may cause serious accidents even the total loss of a ship as well as ships and port facilities in the vicinity.

These systems are products of high technology, but unfortunately seafarers are not equipped with the sufficient information on the working principles and specifications. These weakness will reduce their reaction capability to avoid any mishaps in case of failure in the autonomous system.

1.2. The realities of Digital Era

"Everything becomes connected, intelligent, observed efficient, optimized"**.** This is the resume of the digitalization and covers main aspects of digital era. New applications such as IoT (Internet of Things) connect humans and system. Evolution of IT provides on-line connection among all related organizations and systems. Both cost and operational effectiveness become important for all type of organizations. Optimization becomes a key element for planning and conducting any type of operation.

The famous futurist Gerd Leonhard (2015) assesses that "Humanity will change more in the next 20 years than in the previous 300 years [2]. This enforces us to create innovative approaches to adopt rapid developments in the technology into our education and training system.

One of the important issues that will come in the near future will be the training of seafaring officers to handle the Maritime Autonomous Surface Ships (MASS) as well as revision of the rules in the existing Collision Regulations (COLREG) to solve the problems raised due to deployment of MASS at sea.

MASS is an important issue in the near future and needs to be considered in advance. The following issues should be clarified before deployment of autonomous ships at sea;

- The role of human factor on handling MASS,
- The arrangement of legal situation should be reconsidered, in particular responsibility and liability of the MASS ship handlers,
- Definition of MASS should be made clearly including the types of these ships based on the automation level.

1.3. New Technologies –New Professions

Technologists signal professionalism and deep expertise, and can accelerate career progression from satellite monitoring of oceans to fleet optimization, based on advanced data analytics, new technologies are being employed in the maritime sector as never before [3].

In order to adopt the new technologies in the maritime sector, new type of professions is required. These professions requires broader technical knowledge and having analytical problem solving techniques make innovative solutions for application of new technological into maritime life. They require more developed skills beyond classical engineering background and they are often engaged in the creative and innovative development of systems, processes and products in new and challenging environments when faced with a potential new opportunity, they can bring both theoretical understanding and practical experiences to bear in the analyses of the requirements in order to develop real-world solutions [3].

2. Research Method

This study aims to investigate possible reasons of automation failures and proposals to prevent it and reduce the negative effects of such incidents. Finally it is intended that to define measures covering automation failure versus human element on board.

The research covers three phases. The first phase is intended to understand the specifications and requirements of the automation era. The second phase is an investigation based on the existing studies on the accidents that happen due to failures of automated systems and new approaches to overcome automation related problems. The final phase will cover a study to formulate possible and probable solutions to overcome automation related problems, which directly affect the safe management of ships, as well as safety at sea..

3. Research and Discussion

3.1. IMO Approach on New Technology Application on Board Ships

IMO has published a MSC (Maritime Safety Committee) circular [4] on “Issues to be Considered when Introducing New Technology on Board Ship. In this circular, the following issues are worth discussing;

a. Issues to consider for the training of seafarers

- Standardization, although performance standards exist, many bridge systems, engineering consoles and cargo systems vary greatly in their user interface (layout of controls, displays and symbology) and functionality beyond what is required as a minimum (added features requiring extra controls, menu options or customised symbology).

- The result of non-standardized controls and displays is an increase in the amount of training needed to make a seafarer familiar with, and effective in, the use of the equipment.

- Increased training to facilitate the use of these systems; however, is not always achievable, such as when a pilot boards a ship or a seafarer joins a ship just prior to departure, or possible to provide, such as multiple systems in training centres. There are clear dangers for seafarers which find that the systems they are required to use at sea are very different from those on which they have received training ashore. One solution is to familiarise seafarers with equipment by training them using simulators (either desk top or full mission) prior to them joining their ships. This is made far more efficient where manufacturers provide assistance in developing the training tools.

- The solution is a common interface with standard symbology for common operations and where systems are capable of being customised into non-standard displays, the standard display should be able to be reverted to through a single and obvious control feature.

Finding: *The systems used on board the ships are hetero and not similar to the simulators in the training facilities. This requires additional training before joining the ships equipped with different type of equipment. The shipboard systems and simulator producers should be in close coordination to create optimum simulator types which reduce the adaptation time for different types of equipment on board. A standard symbology system should be established and standard symbology should be used on both equipment on board and simulators*

b. Challenges in training for technology

- There are many challenges encountered when assessing the training needs for seafarers in using technology-based systems on board, some are cultural and others are practical, but these issues need to be addressed if seafarers are to be able to utilize technology-based systems on board to make good decisions.

- In many cases, crews of new ships or ships retrofitted with new equipment may be trained ashore in accordance with a manufacturer‵s recommendation or model course criteria, but those initial crews may be required to train their reliefs, in situ, in the proper use of the equipment. This procedure is often known as cascade training. This leads to a situation where the initial crew might receive 3-5 days of specialist training for a system, but are required to pass this knowledge on to other watch keepers during a brief turn-round period in port. Additional aids, such as Computer Based Training (CBT) modules, used either aboard or prior to joining a ship, can improve the situation. Technical manuals can however be poor training tools.

- One issue of note for trainers is the realization that many young watch keepers have a culture of using information technology (home computers, Internet, video games etc.) and that during times of stress revert to electronic displays for their primary decision support systems. Inexperienced seafarers may seek more data and information in stressful situations, often confusing themselves further. Problems can also develop when novice navigators are trained on desktop simulators which do not have the advantage of a simulated —window "for visual observation. This may reinforce the habit of constant reliance on a digital display for situational awareness during actual operations.

- Care must be exercised to ensure that training on new technology centres on selection of the most appropriate technology and using it effectively to assist the decision-making process. Examples include officers who are very proficient in operating Integrated Navigation Systems who continue to use the system for decision support when other means are more appropriate, such as in close quarters situations, or where various pilotage techniques are more appropriate.

- The information supplied by navigation systems such as ECDIS and AIS can add value and improve operations when used by well-trained officers who understand how to manage and prioritise the information, however the same information provided to an officer without these skills can lead to information overload and poor decision-making.

Finding: *The training systems should stress on that highly improved technologic systems and are important for decision-making process, but could not be used for decision-making process solely. The decision making is a function of the human being and this cannot be delivered to the machines. Furthermore, the handicap of overreliance to these automated systems should be clearly understood by the learners.*

c. Taking the human element into account when introducing new technology

- Research has shown that automation has qualitative consequences for human work and safety and does not simply replace human work with machine work. Automation changes the task it was meant to support; it creates new error pathways, shifts the consequence of error further into the future and may delay opportunities for error detection and recovery. Automation creates new kinds of knowledge demands. Watch keepers must have a working knowledge of the functions of the automation in different situations, and know how to co-ordinate their activities with the automated system's activities. This manifests itself in situations whereby officers do not understand weaknesses or limitations of systems they rely on. Training in this respect will become more important as systems become more integrated and sophisticated.

It has been shown that operators will monitor less effectively when automation is installed, and even more so if the automation has been operating acceptably for a long period. There is also evidence that the more robust a system is in its design to prevent human intervention, the more difficult it is to know about and thus control what is going on inside its boundaries. Under these circumstances, the human operator has no means of checking the accuracy or fidelity of instrument read outs and thus may well ignore relevant information and revert to heuristic decision-making.

- It has been observed that sophisticated systems used by well-trained seafarers with a good level of underpinning knowledge use the systems to make better decisions. However, the same level of sophistication made available to seafarers with poorer understanding of the basic principles of navigation and collision avoidance often creates a more hazardous environment for decision-making.

Finding: *The sufficient knowledge should be delivered to the seafarers during education and training phase in the schools to enable them to understand use of technology including the weakness and limitation of these systems. So, the users should be well aware of opportunities for error detection and recovery. Furthermore, the handicap of overreliance to these automated systems should be clearly understood by the learners.*

Lim Ki-tack has announced a four pronged approach for his tenure as IMO Secretary General [5];

- Focus on implementation: Looking application and implementation of IMO regulations.
- Enhanced capacity building: Looking for closer cooperation between stakeholders such as those in funding (World Bank, UN Development Programme etc.) and the wider shipping industry.
- Less burden, enhanced services: Constant revisions to system and IMO functions so as to stay relevant.
- Global approach and awareness: Greater visibility, transparency and communication with industry and media and public.

Finding: *The IMO and related international organizations has created perfect systems to ensure Safety at Sea. But problems rises not lack of regulatory instruments but deficiencies during application and implications of these regulations. It is proposed that new mission of the IMO should be establishment instruments to control application and implementations of regulations in cooperation/coordination and collaboration with other respective inter-governmental organizations.*

3.2. The Main Reasons for Automation Failure Related Incidents

Many surveys, studies and research activities have been conducted by many respective authorities and institutions to investigate the main reasons for incidents due to automation failures in the maritime sector. The most enhanced and comprehensive study was published by the United Kingdom Maritime and Coast Guard Agency (MCA) in 2007 [6]). Many studies on these subjects have benefited from this study.

The resume of the main MCA findings are as follows:

a. The over-reliance on automation by crews

b. Ship crews are often overconfident in the data presented to them by automated control systems rather than the data provided by other manual methods, which is considered more time consuming.

c. There is often a lack of understanding by ships' crews of automated control systems and any inherent weaknesses they may have.

d. Automated ship-borne maritime systems do not always have optimal ergonomic design considerations.

e. Maintenance and calibration errors when setting up automatic control systems can lead to catastrophic consequences.

f. Man machine interface, in particular on some screen-based automatic control systems, the human-computer interface can be very confusing to the user.

g. Some current automated systems do not adequately support the system operators in developing and maintaining situation awareness which is highly important to handle a vessel.

h. The crew are overloaded with information provided by automated systems which is not easy to comprehend by human perception.

i. Any careless maintenance and calibration may create improper operation of the system which cause misconception.

Findings:

- *The ship crew should have awareness of that the machineries' facilities our life on board but cannot replace the role of human being in particular for decision making.*

- *Unfortunately ergonomic design and man-machine interface could not be sufficiently considered on board the ships which harden to use the systems and may cause confusion.*

Additionally there are some other factors which have been reflected in the other studies: These are;

a. The existing education and training systems do not sufficiently cover the main principles, limitations and weaknesses of automation systems and the students are not capable of understanding this critical knowledge when they meet automated systems on board.

b. There are not a sufficient training courses and supporting tools to introduce trainees better understanding the emergency operation procedures and required actions in case of such failures [4].

c. The automation equipment is mostly based on electronic/electric systems and used by navigation and marine engineering officers and ratings. But the existing education programmes for deck and engine officers do not cover these subjects sufficiently to make them fully understand automated systems.

d. There is not an internationally recognized or recommended special training model course related to crew training on automation failures [7].

As far as accidents are concerned, human error takes the first place. It is commonly accepted that maritime accidents that are due to human error is in the range of 75% to 96% since 1999. In relation to this, studies have shown that human error has contributed to various types of accidents in the range of 84% to 88% of tanker accidents, 79% of towing vessel groundings, 89% to 96% of collisions and 75% of fires and explosions [8].

Although there is not a reliable study on accidents related directly to automation failures, we can discuss this by taking into account the reasons human errors based on a study made on 2016 [9].

a. Organizational Influences:

i. Resource Management—includes the corporate level in making decisions about maintenance,

ii. Organizational Climate—includes the surroundings of the organization such as culture, structure and policies.

iii. Organizational Process—includes the decisions and rule made at the corporate level that they have to comply in the organization. Examples are the methods and standard operating procedures for maintaining oversight of the work place.

b. Unsafe Supervision

i. Inadequate Supervision—the factors when the supervisor fails to identify hazard, risk, provide training or guidance which results in human error or an unsafe situation.

ii. Planned Inappropriate Operation—the factors when the supervision fails to access the hazards in an operation and resulted unnecessary risks.

iii. Failure to Correct Known Problem—the factors when the supervisor fails to correct known problems in the documentation, procedures, processes and fails to correct in unsafe actions of individuals which creates unsafe situation.

iv. Supervisory Violations—the factors when the supervision disregards the instructions, operating instructions and rules when managing organizational assets which create an unsafe situation.

c. Precondition for Unsafe Acts:

i. Software—includes the non-physical part such as the policies, manuals, charts, maps, computer programs, procedures and computer programs.

ii. Hardware—includes the physical parts such as the displays, controls, equipment and equipment and seats.

iii. Condition of Operators—the condition of the individual that could influence the performance of his/her job. Examples are mental, physiological status.

iv. Physical Environment—the factors of the environment which will affect the individuals in taking actions that results in human error.

V .Technological Environment—the factors that emphasize on the artificial environmental constructions such as the waterways, harbours and traffic control issues.

iv. Live ware—the systems human to human interactions, such as the supervision, communication, managements and crew interactions.

d. Unsafe Acts of Operators

i. Skill-Based errors—errors includes slips and lapse. Slips are unintentional action that involves attention and lapses are unintentional action that involves memory.

ii. Rule-Based mistakes—involves in appropriate matching of environmental signs to the situational component of well-tried troubleshooting rules.

iii. Knowledge-Based mistakes—happen when the individual has ran out of applicable problem solving routines and forced to work online, using slow and resource limited conscious processing.

iv. Routine violations—causal factors tend to be habitual by nature and often tolerated by governing authority. They occur every day as people regularly modify or do not strictly comply with work procedures, often because of poorly designed or defined work practices.

v. Exceptional violations—breach of work practice being ignored to carry out a task even though it was not to commit a malevolent act, but just to finish the job.

Findings:

- *There are not sufficient documentation, procedures, processes and fails to correct in unsafe actions of individuals related to the automated systems.*

- *Overreliance to automated systems may cause disregards the instructions, operating instructions and rules when managing organizational assets which create an unsafe situation.*

- *Design of the charts and maps for automated navigation systems are not similar to classical systems used manually and this may disrupt the user's attention. The computer programs (software) used in the automated systems cannot meet requirements to apply procedures fully.*

- *Physical parts such as the displays, controls, equipment and equipment and seats are generally not ergonomic and man-machine interface could not be achieved. Physical*

Environment in particular on the bridge and engine control room and this situation may results in human error.

- Some bridges and engine control rooms cannot provide supervision, communication, managements and crew interactions as in the manual systems.

- Knowledge-based mistakes happen when the individual has run out of applicable problem solving routines and forced to work online, using slow and resource limited conscious processing.

3.3. Automation and Ships

Application of automation technology on board is a reality today and application of automated systems diffuse following the rapid change in technology. It is time to revise our operation methods and training systems to meet the new requirements introduced by automated systems.

These systems require the seafarers, in particular officers, to be donated with engineering skills to fully understand the automation philosophy, limitation of automated system and the role of the human being to supervise these systems. Actually, this requirement for further education is understood by the community and approximately all maritime schools are now organized as 4-year academic institutions instead of the 2-3 years vocational schools. An officer equipped with a strong engineering skills would be more suitable to handle the ships donated with state-of-art systems. But still it is needed to add some additional skills and revise our programmes to existing education and training system to fulfil their duties on board to meet the requirement of the technologic improvements.

The main regulating publications of IMO, SOLAS (Safety of life at Sea) and MARPOL and their associated guides are changing regularly in order to meet new requirements to ensure maritime safety. This also should lead the change of MET (Maritime Education and Training) system. The last major change to the primary document concerning MET, STCW (Standards Training Certification and Watchkeeping) Code in 2010. There is not a clear evidence to make a new modification to STCW, but it is strongly believed that the new arrangements should cover automation on board.

Findings:

- Some new courses should be created to enable seafarers be familiar with automated systems.

- The seafaring officers to be donated with engineering skills to fully understand the automation philosophy, limitation of automated system and the role of the human being to supervise these systems. These requires to make a significant change in officer training to cover further engineering skills to enable them to understand the operation of state of arts systems on board.

3.4. Automation Failure and Consequences

Our training system is based on teaching a system with its elements, operations, using as an operator. Normally, system failures and action to be taken in case of failure is not taught. Manufacturer manuals consist of trouble soothing in case of total collapse of the system and user generally use it when the system is totally out of order.

Automation system on board are generally used for critical systems such as steering gear, engine control, automated pilots etc. In case of an automation failure, the ship is under a vital danger, in particular in condense waters, and need to be corrected immediately for the sake of the ship. But unfortunately the respective crew are not well trained to take quick action in case of failure. It will be more appropriate to establish a training system covering actions to be taken in case of automation failure.

Especially in complex systems, consisting of several computer-based units and sub-systems, it is practically impossible to create such self-diagnostics that would be able to raise an alarm of every possible failure mode. Consequently, there is always a risk of such failure modes that cannot be identified by the self-diagnostics. When the system does not provide the user a proper alarm about a serious malfunction or a failure, a dangerous "automation surprise" takes place: The system suddenly behaves in a way that the user did not expect and the consequence can be an accident. Ahvenjarvi [10] created an event-tree of an accident resulting from poor monitoring and incomplete self-diagnostics of a safety-critical system is shown in Figure 1.

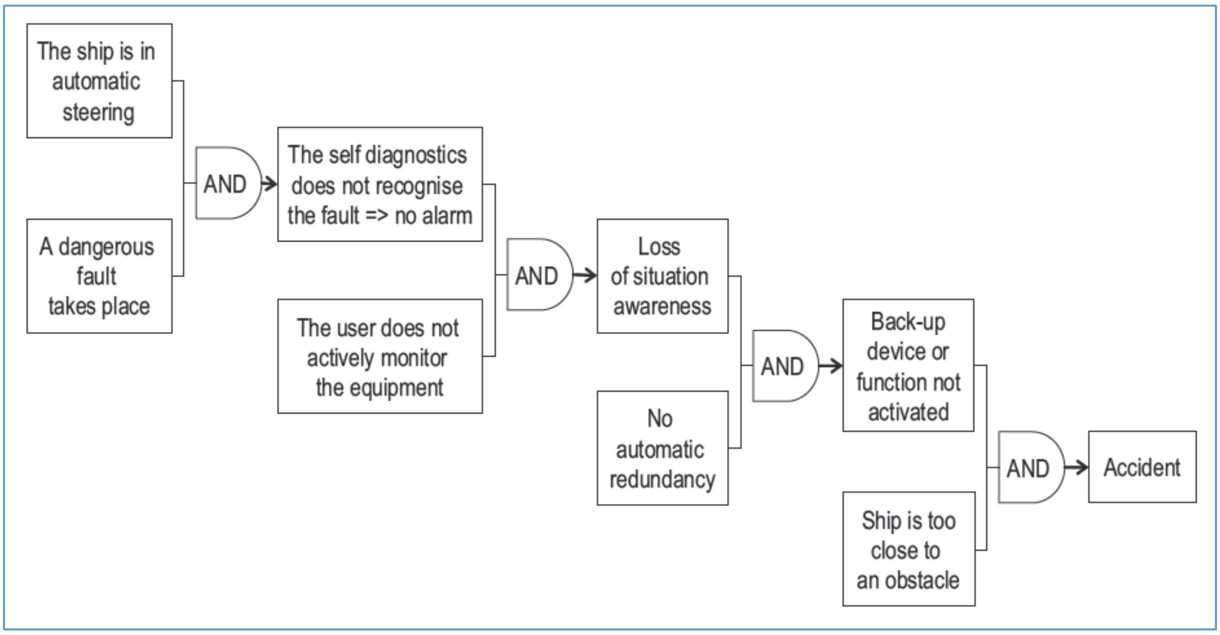

Figure 1. The event-tree presentation of a typical accident after a failure in a safety-critical automation system (Source: Ahvenjarvi, 2011 [10])

If we follow the diagram in the Figure 1, the followings are clearly understood;

- There is a strong need to have an alarm system for critical automated systems which may endanger ship movement.
- There should be a visual control system which shows any abnormality in the system and these controls should be in close distance which the user may easily follow.
- If the user loses situation awareness, he/she should apply "ambiguous rule" which means 'if there is an ambiguity, there is a danger' and user should take immediate action to get over the dangerous situation.
- The critical automated systems should be backed up (doubled) in order not to lose the control of the ship when a failure happens.

In the light of this actual situation, the significant points to lead technical, administrative and training requirements could be extracted.

- All critical automation systems should be equipped with alarm systems and control systems to follow the operational status of such systems should be placed in the vicinity of the user/operator like on board an airplane pilot.
- The user should start emergency procedures if he/she realizes existence of any suspicious situation in operation. The user should also have "emergency procedures" which will be used in this case. All users should be periodically trained on emergency procedures including simulator training.
- The critical automated systems should be backed up and operators should be well-trained to convert from original system to back up system just on time.

3.5. A European Union Project related to Automation (SURPASS Project)

The SURPASS Project has been initiated TUDEV (Turkish maritime Education Foundation) with support of SATAKUNTA University of Finland and C4FF with the participation of with several European institutions in 2009 and completed in 2011. The main aim of the SURPASS Project [11] is to fill this gap created as the result of emergence and application of the automated systems in the education and training of seafarers by provision of a training course enabling them to have a full understanding of automated systems, and these systems' weaknesses and limitations.

The research has shown that the older generations who received their education and training two or three decades ago are less familiar with the new technology than the younger generations who have become familiar with computer systems in their everyday life. But even for the younger generations, it is important to provide an education which introduces the subject of automation, operation and management of automated system used on board ships and, the use of safety-critical systems [12].

Finally, a special training of seafarers to update their knowledge on automation technology including system specifications, systems operation and limitations of the latest automation technology is improved. As a result of this project, a web based course material is produced and it is a unique example on Automation Failure Training.

Findings:

- The revision of existing training systems is required to include measures to be taken in case of automation failures which cover working principles, capabilities and limitations supported with CBT (Computer based training) and Accident based simulator training.

- The web based course material should be produced to support Automation Failure Training. SURPASS project is may be considered as an example to start such types of training.

3.6. MAIB Studies on Automation System Failures

A joint study conducted by UK MAIB (Marine Accidents Investigation Board) and SHK also covers an evaluation on "Mitigation of human error in automated systems" [13]. The significant points from this report are as follows;

Many modern vessels have become highly dependent on programmable electronic systems (PES), for example, for bridge equipment, propulsion machinery, and the automation of cargo handling systems. In many cases, the PES are integrated with each other. The risk of PES failure, and the need for such a risk to be managed has been identified, as has a need to change the way that such risks have been managed in the past. The difficulties experienced in podded propulsion systems, when different layers of software are required to work together, has been the subject of an academic paper [14]. This paper describes the need for rigorous testing in order to eradicate intermittent faults which may occur during operation, sometimes with serious safety consequences.

Systems become much more complex when a person interacts with a computer, which then controls a machine. Of relevance to this accident, the MCA has published the findings of "Research Project 545: Development of Guidance for the Mitigation of Human Error in Automated Ship-borne Systems" [15]. This is summarised as follows:

Given the increasing prevalence of automated systems on board ships, it is important that the human element is considered throughout their design, implementation and operational use. Automation can be beneficial to operators of complex systems in terms of a reduction in workload or the release of resources to perform other on board duties. However, it can also potentially be detrimental to system control through increasing the risk of inadvertent human error leading to accidents and incidents at sea.

This research identified particular issues in design, selection, installation, use, maintenance, and updating or modification of automated systems which can present problems. A range of guidance points were produced for those involved in selecting or using automated systems, throughout the lifecycle of a vessel. In particular, these include the following: Shore-based company management, shipboard management, seafarers using automated systems, training providers.

Finding: *There is a strong need for rigorous testing in order to eradicate intermittent faults which may occur during operation, sometimes with serious safety consequences.* Automated systems *create much more complex situation when a person interacts with a computer, which then controls a machine.*

4. Conclusion

Accidents related to automation failures are real problems for shipping industry and these problems will become more serious while use of automation systems expands on board the ships. The results of these accidents cause huge economical losses even fatal results. To prevent these consequences, new measures should be considered and necessary action is taken.

The critical automated systems should be backed up (doubled) in order not to lose the control of the ship when a failure happens. All critical automation systems should be equipped with alarm systems and control systems to follow the operational status of such systems should be placed in the vicinity of the user/operator like on board an airplane pilot. The user should be capable to start emergency procedures if he/she realizes existence of any suspicious situation in operation. The user should also have "emergency procedures" which will be used in this case. All users should be periodically trained on emergency procedures including simulator training.

The ship crew should have awareness that the machineries facilitate our life on board but cannot replace the role of human being, in particular for decision making. Overreliance on automated systems is the main reason for the accidents as a consequence of an automated failure system.

At least, we should provide awareness of crew on limitations of automated systems. If the user loses situation awareness, he/she should apply “ambiguous rule” which means ‘if there is an ambiguity there is a danger’ and user should take immediate action to get over the dangerous situation.

The critical automated systems should be backed up (doubled) in order not to lose the control of the ship when a failure happens.

The revision of existing MET systems is required to include measures to be taken in case of automation failures which cover working principles, capabilities and limitations supported with CBT (Computer based training) and Accident-based simulator training.

Some new courses should be created to enable seafarers be familiar with automated systems. The seafaring officers should be donated with engineering skills to fully understand the automation philosophy, limitation of automated system and the role of the human being to supervise these systems. These requires to make a significant change in officer training to cover further engineering skills to enable them to understand the operation of state-of-art systems on board.

It is understood that there is a need to improve new contents, additionally new delivery and test methods to overcome accidents related to automation failure. All these aspects should be reflected to the IMO MET documents in support of officer and crew education and training programmes additionally continuous education content to adopt them to new automated system. Considering the working conditions of seafarers, different types of delivery methods for education, in particular distance learning, should be considered. The SURPASS project may be considered as an example to start such types of training.

Physical parts such as the displays, controls, equipment and equipment and seats are generally not ergonomic and man-machine interface could not be achieved. Physical Environment in particular on the bridge and engine control room and this situation may result in human error. Some bridges and engine control rooms cannot provide supervision, communication, management and crew interactions as in the manual systems. The cooperation between users and producers of automated systems will create synergy and platform for transfer of knowledge and innovations. This will also eliminate man-machine interface problems and feedback from end- users provides valuable information for the system designers.

The shipboard systems and simulator producers should be in close coordination to create optimum simulator types which reduce the adaptation time for different types of equipment on board. A standard symbology system should be established and standard symbology should be used on both equipment on board and simulators.

Because of the nature of operations at sea, not only merchant fleets but also navies experience the same problems. Most of the systems developed for merchant and war ships are very similar and they are usually produced by the same companies. Although it is not publicized, the studies made by navies may be shared. Safe seas is a necessity for both navies and merchant fleet. It is believed that a close cooperation on this issue could be achieved in support of the common manufacturers who produce system for both.

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