Combined Complex Maritime Simulation Scenarios for Reducing Maritime Accidents Caused by Human Error

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Abstract: 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 onboard 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. A team of researchers from our Constantza Maritime University had participated at a study, together with master students, which wants to release the dangerous situation on sea based on human factors. In this scope has been used a full mission ship handling simulator with three full bridges and liquid cargo handling simulators, developing applications in navigation and ship handling area, with different grades of difficulty and risk. These applications brings the future deck officers in usually situations on board, forced to use the present navigation technology and study their options and reactions in these cases, focus on situations with risk of errors, human errors, appearance. Students had to navigate and maneuver very large vessels, as tankers, LPG or LNG vessels. Scenarios used in the research were very complex, combining near coastal navigation with piloting and anchoring or mooring operations. All these actions were done in real time and in different weather conditions. Results of the study revealed the importance and benefits of a long term training of future deck officers, based on the use of modern and complex marine simulators, and the constant progress of the achievements of the trainees.

Key words: maritime education, navigation, maritime transport, human error, maritime accident, simulation

1 Introduction
With the financial crisis on a rampage throughout the globe, everyone from governments to the average citizen is looking to cut down on expenses. And this also includes ship owners and charters who are desperate to keep their business going and not to go in to bankruptcy. In their struggle they are looking into every opportunity to reduce the cost of their operations and to make a profit: minimum crew policies, crew wages, maintenance policies, insurance policies, and fees for transport. With an ever increasing number of ships crossing the seas and oceans at slow speeds, with half their cargo capacity met and their poorly paid crews (at least when comparing their wages with what they were paid only 5 years ago) under pressure to do more with less and less, one can but wonder when are the accidents going to start because this is a recipe for disaster [12].

Of course it can be argued that most of the ships that have survived the initial impact of the crisis and have not been scrapped are modern ones, which are fitted with up to date equipment that features an impressive number of automatic processes. Indeed in the last 10 years the maritime industry, which was not so long ago considered as one of the most conservative environments, has seen a lot of changes and this includes not only a ships cargo handling equipment and navigational electronics but also the way ships are designed, built and manned.

However, given the increasing prevalence of automated systems on board ships, it is important that the human element should be taken into account when considering their design [4], implementation process and operational use. It can be hardly be a good thing to have an exceptionally valuable and possibly important piece of equipment on board if there is no need for it, or if there is no one on board who knows how to use it in the first place. Nevertheless, even if such scenarios are not far from fiction, the modernisation of the maritime industry is not only a necessity, but also a reality. In other words, the change has already occurred, it is just a matter of keeping up with it.

Even a simple analysis can show that on board ships automatic processes can be beneficial to operators of
such complex systems because their workload is significantly reduced and important human resources are freed to perform other onboard duties, this being of course the very purpose of their design [3].

On the other hand, this increase in automated processes can also be potentially detrimental to system control because the risk of inadvertent human error when using them, leading to accidents or incident at sea is increased. A moment of bad judgement that is due to either moral fatigue, or lack off adequate sleep, or depression is all that is needed for an maritime officer to press the wrong button that launches an automatic accident.

The purpose of this paper is to convey the results of a study carried out by a team at Constanta Maritime University that clearly indicates how, despite the increased safety levels on board merchant vessels through automatization, human error can be main reasons for maritime accidents.

2 Base of the study
As stated above Constanta Maritime University (CMU) has been part of a project aimed at determining just how dangerous is the situation of having all these automatic processes on board ships while taking the human factor into account. For this purpose, during the study, the team has used a full mission ship handling TRANSAS 5000 bridge simulator with three full bridges, and liquid cargo handling simulators so as to have the ship in different cargo quantities on board situations, in order to make the simulation sessions as close to real life situations as possible [9]. The ships that were chosen for these exercises were very large vessels such as LPG s (Liqui

Figure 1 – Avoiding ship coming from starboard side

A very important part of the research project, if not the most important part, was to record and analyse each of the students reactions in these situations, the way their focus on certain sources of information while almost choosing to ignore others. Another important factor in this research was the way the students managed to solve situations of confusion were there was a certain risk of error, especially human errors. Most of the bad actions encountered during simulation are based on wrong decisions taken by the watch team. In figure 1 we can see a typical crossing encounter between two ships. Own
ship is a give way ship and the target vessel (container ship) is coming from our starboard side. Figure 1 shows the actions made by nine Own ships in this situation. From the nine teams, only four (Own ship 1, 2, 3, and 4) undertake the correct avoidance manoeuvre. Rest of the bridge teams ignored the danger and the COLREG provisions and passed ahead of the container ships at distances less than 5 cables. From the point of view of experienced seafarers, such a situation is the most common one and it is very easy to solve by altering Own Ship course to starboard. For the students in the beginning of their 3rd year of study, and without any sea experience, the things are not so easy to assess and as we saw from figure 1, only few of them do the right thing.

3 Results of research

Even from the beginning of the research programme, it was evident that the students had a problem of adaptation to the different equipment interfaces they had to use throughout their simulated exercises [13]. Although each of the students were by no means strangers to the navigational equipment that is to be found on board a ship, they had problems in locating the particular information that was necessary for them, particularly when the interface was changed. This in itself is not a new problem to a maritime deck officer, because, every time he boards a new ship he will require some time to accommodate with the ship’s particularities and with the ship’s electronical equipment [6]. However, if during this accommodation period a necessity arises that requires a quick decision-making, our research shows that the officer in charge of the watch will either rely on his personal experience or he will lose precious second while trying to locate exactly the piece of information he needs. Figure 2 shows a more difficult encountered between Own Ship and a target ship coming, this time, from port side. The target ship is a VLCC constrained by draught, consequently our ship is a give way ship. In figure 2 we can see the actions undertaken by ten Own Ships, and the correct decision was made only by Own Ships 1, 2, 3, 4, 5 and 10. Rest of the Own Ships generated very dangerous close quarter situations. The main reason for the incorrect actions was that the students assessed to late the real situation and realized that the VLCC has the right to pass due to his increased draught.

Moreover, we have observed that most of the students did not use all the information available to them. They would often concentrate just on certain information sources, and they would look for other data only in exceptional situations. As a matter of fact, it has been long thought, by some theorists, that the information output on the bridge is almost at the limit of what a human being can process and that during the navigational watch an officer in not using all the information available to him. What was even more concerning was the fact that they would rather consult the display of a computer terminal instead of using the windows and trusting their senses.

Another problem that we have identified during these simulated exercises is one of information availability and equipment interface. The more an equipment producer desires to have a product where the user (i.e. the maritime officer) has all the information ready available the more the product will end having a display full of information. On the other hand if producer envisions an organized interface that made of many sub directories and sub routines, that will produce data only if required is also not advisable. This is especially true if the required data is four windows behind the main display [11].

During most of the exercises, we have also observed a tendency in our students to use only one source of information during the entire simulation [5]. While it could be considered perfectly normal that a person should prefer one information source and specialise in using that specific piece of navigational equipment, we have come to the conclusion that this is also a dangerous practice. During some exercises that featured the failure...
of some of the bridge equipment—such as the Electronic Chart Display and Information System (ECDIS), or the Global Positioning System (GPS)—we have observed that it was very difficult for students to revert to the use of the old paper chart. In addition, for them it was a daunting task to use different equipment in order to acquire the same information. During these exercises, there was much confusion in the watch team, and the possibility of an accident occurring because of an human error was very high. Figure 3 shows another specific situation: Own Ship must avoid a concentration of small fishing vessels (dots encircled). The area to be avoided is shadowed in figure 2, and we can also see seven Own Ship trajectories. Because Own Ship have to rich Pilot Station area, most of the students ignored the presence of the fishing vessels and tried to maintained the planned track of the Own Ship and go directly to the Pilot Station. In our example, from the seven Own Ships, only ship no. 6 undertook the correct manoeuvre and rounded the dangerous area. This kind of human error is almost typical for the cadets that have limited sea experience and who did not encountered yet in reality such a situation.

One other problem we have identified was that of the alarms. It is common knowledge that the modern maritime officer in an increasing number of fleets all over the globe is almost no longer required to determine the ship’s position using a sextant. He is nevertheless required to be able to distinguish between the many types of equipment alarms, to prioritise the emergencies should it be necessary, and to respond correctly according to safety protocols. However, we have discovered that repeated sound and visual alarms have a negative effect on the officer of the watch, because they induce sensorial and psychological stress and fatigue. After 2 to 3 hours into the exercise, we have found that some of the students were more preoccupied with cancelling the alarms rather than actually reading the information output of the navigational equipment. Some of the simulation participants had even had the sound alarms put on the mute and eventually failed to observe a dangerous situation developing until it was very close to actually occur.

Furthermore, we have observed that during this type of exercises some of the students were more preoccupied with solving one minor problem that they almost completely failed to observe another more important one, although it was visible in the adjacent display. When they were asked about their poor performance, they complained that the bridge was full of alarm sounds.

A minor relatively minor problem encountered by our team was the student’s overconfidence in their abilities to use navigational equipment, and by extent in the navigational equipment itself. As a result, they had a tendency not to compare the obtained data with other information from another source which developed into unwanted situations. In addition, these were the students who had the most serious problems with determining which of the navigational equipment had failed and what should be done in the equipment failure exercises we have mentioned earlier.

Perhaps the most surprising find of this research project was that during some of the simulations some potentially dangerous situations have developed from relatively a minor factor. During some complex exercises that required watch teams of up to 3 members, we have discovered that because each member of a team will usually assume that everyone has access to the same information as the rest of the team members he would not need to share his observations on a developing dangerous situation. As we can see in figure 4 without the aid of the ECDIS, piloting a ship on a very narrow channel can be a very difficult task for the students involved in such a scenario. From the six Own Ship trajectories depicted in figure 4, own ship 1 and Own Ship 4 run aground, at the south, respectively at the north of the fairway. The cause of the groundings was the incapacity of the bridge team to determine and to plot on paper chart the ship position quick enough in

Figure 3 – Avoiding fishing vessels

Figure 4 – Groundings
order to correct the wrong trajectory.

However, as the exercise progressed each of them ended following different parameters, and drawing different conclusions. The situations were eventually quickly resolved through good leadership and seamanship.

![Figure 4 – Piloting Own Ship along narrow channel](image)

### 4 Conclusions

Taking into account all that has been stated above, we feel confident in our assertion that even a fully automated ship, equipped with state of the art navigational equipment is not necessarily safe from being involved in accidents or incidents. Keeping in mind that all of the students were trained professionals highly regarded for their skill and seamanship we also feel that the observations made by the CMU research team during this project are invaluable for the development of new maritime navigational equipment [7].

Most of our researchers agree that equipment producers should spend more time and efforts designing equipment in such a way that the human element should be taken into account when considering their design, implementation process and operational use [10]. One possible way is that the end product should allow the maritime officer to customise the way the information is presented to him, or to give him the opportunity to select just how much information he requires at a specific time.

Furthermore, having identified the sound alarms as a stress factor, we believe that it would be beneficial for the watch-keeping team if they could select the pitch of the sound alarm while they are on the bridge.

The final conclusion of this training is that in most cases is the training of the maritime officer that has made the difference in most of the near miss incidence at sea, an that the long-term training of future deck officers, based on modern and complex maritime simulators, and on the constant progress of the achievements of the trainees is of greatest importance.

**References:**


