

Development of a Behavioural Marker System for Rating Cadet's Non-Technical Skills

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ABSTRACT: Despite the adoption of crew resource management training for bridge teams over the last decades, the training is still heavily focussed on technical achievements. In an educational context, the situation is more problematical, since with requirement of developing the technical skills, there is a need to build and evaluate the non-technical skills of cadets with little experience in bridge team management. In parallel with the application of team leadership models, the Portuguese Naval Academy conducted a research to improve the development and assessment of non-technical skills in bridge simulators. This paper describes the method used to identify the key non-technical skills required for naval cadets and to develop a behavioural marker system for their measurement. A literature review of behavioural marker systems was supplemented with an analysis of interviews conducted with students and simulator instructors. Additionally, further analysis of Portuguese Navy accidents reports was made, applying the HFACS framework to identify the relevant non-technical skills involved in the accidents. The resulting rating system covers five skill categories (leadership, situational awareness, communication, team work and decision making), each one with three rating elements. The framework is currently under evaluation tests in bridge simulators sessions, within an educational context.

1 INTRODUCTION

Over the last decades, the maritime industry has witnessed some rewarding outcomes from the adoption of the Crew Resource Management framework and the use of simulators in the training of bridge officers. Still, there are doubts among maritime professionals about the effectiveness of such training in the improvement of maritime safety (Barnett, Gatfield, & Pekcan, 2006). In an educational context, the situation is more problematic since, among the requirements of developing technical skills, there is a need to build and evaluate the non-technical skills of cadets with little experience in bridge team management. For some time, the Portuguese Naval Academy have been using the ship's navigation simulator (NAVSIM) to conduct team leadership

model courses (Bué, Lopes, & Semedo, 2015). More recently, namely after the latest NAVSIM's upgrade in 2004, there was an overall perception among students and instructors that the complexity of the training needed a new approach for the development and assessment of non-technical skills. Thus, a study to further assess how the simulator is used and how to improve the evaluation and assessment of non-technical skills during navigation training was initiated. The adopted approach aimed to develop a framework supported by previous research results and contextualizing the needs of the Portuguese navy, not only through lecturer observations and assessment of the students, but also by analysing Navy accidents reports over the last two decades. This research is an important contribution to increase the effectiveness of NAVSIM training sessions, by

adding an objective framework for the assessment of non-technical skills to the present technical skill development program.

1.1 NAVSIM training and education

Regardless of the general consensus over the advantages of navigation simulators in education and training, namely in relation to increased safety (Cross, 2012; Magdy Ali Elashkar, 2016), their effectiveness has been questioned. McCallum and Smith (2000) evaluated simulators and provided a framework for their assessment. From another perspective, Cross (2003, 2007), Emad and Roth (2008) researched the development of competence-based training and assessment in simulators. Other researchers have shown that training programs display some weaknesses in the development of decision making skills, when addressing the management of complex situations (Chauvin, Clostermann, & Hoc, 2009). Other studies emphasize issues associated with the effectiveness of simulation training, such as the advantages of exhaustive training of unsafe situations balanced with the risk of imprinting risky behaviours (Forsman, Hill, Dobbins, Brand, & MacKinnon, 2012).

New insights on pedagogical strategies are calling for a more innovative role of the lecturer. Students need to learn by experiencing their working environment and performing tasks with experts. Thus, instructor shall gradually leave space for the students and coach them in their understanding of the undergoing processes (Emad, 2010; Magdy Ali Elashkar, 2016). A recent study, which was based on a survey to assess training in simulators at the Merchant Marine Academy of Athens, Tsoukalas *et al.* (2015) concluded that adjustments in the course programs and methodologies were necessary. They specifically suggested modification to methodologies used in the evaluation of trainees and the teaching-design for problem-solving.

1.2 Non-technical skills (NTS)

This term, commonly used in safety critical domains, has been defined by Flin, O'Connor & Crichton (2008) as the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance. Still, there are no straight guidelines to classify NTS, since their relevance and appearance are strongly coupled to the working context. Yet, NTS have two dissimilar effects, since good skills reduce the possibility of human errors and, on the other side, poor skill increases the chance of error occurrence or extend their consequences. Regardless of the research made to address the development of NTS in the maritime field (Barnett *et al.*, 2006; Devitt & Holford, 2010; Hetherington, Flin, & Mearns, 2006; Long, 2011; Magdy Ali Elashkar, 2016; Saeed, 2010), Hayward & Lowe (2010) identified significant shortfalls in maritime training, when compared to other domains.

Based on the existing findings, we may commonly agree with the following list of non-technical skills, frequently recognised when addressing safety issues:

- Situational awareness;

- Assertiveness, ability to criticize and to be criticized;
- Decision making;
- Problem Solving;
- Leadership, ability to use authority
- Managing stress;
- Workload management, Multi-tasking and selective attention;
- Team work, team building and cooperation;
- Communication, Inter-team communication;
- Coping with fatigue;
- Time management, planning and preparing
- Situation monitoring
- Anticipation of future states;
- Setting priorities;
- Crisis Management.

1.3 Behavioural markers systems

Following the first behavioural marking system made by the University of Texas (UT Behavioural Marker), created for pilots, others have been developed for several working domains, such as the:

- Pilots' non-technical skills (NOTECHS) in aviation;
- Non-Technical Skills for Surgeons (NOTSS);
- Anaesthetists' Non-Technical Skills (ANTS);
- Trauma Non-Technical Skills (T-NOTECHS);
- Well Operations Crew Resource Management (WOCRM) in offshore well control.

In the maritime industry, few developments are found with a firm employment of a marking scheme for the Bridge Resource Management (BRM) framework. After undertaking a study for the development of resource management and leadership behavioural markers for shipping, Devitt & Holford (2010) pointed out some factors that have to be considered when establishing behavioural markers, namely:

- Cultural implications;
- Shipboard and shore side contextual differences;
- Specific organisational needs and requirements;
- Training of Behavioural marker assessors.

Their behavioural markers were yet to be validated in simulated environments. In another research, Long (2011) developed a marking framework (Nontechnical Skills for Officers of the Deck - NTSOD) to be used for the evaluation of Officers of deck in the US Navy. It comprises four categories (leadership, decision-making, communications and situation awareness), with ten rating elements, on a scale of 1 to 4. This prototype was initially designed to be used on board, however, the author considered the need for further work, namely its implementation in simulation training for more tests and refinements of the rating system.

1.4 The HFACS Framework

Grounded in Reason's "Swiss cheese" model of accident causation, the Human Factor Analysis and Classification System (HFACS) was designed to provide a classification scheme and used for the systematic identification of accident causation factors (Shappell & Wiegmann, 2000). The HFACS comprises four hierarchical levels of failures, from Unsafe Acts at the front-end up to the Organizational Influence at

the back-end, passing by Preconditions for Unsafe Acts and Unsafe Supervision. After its initial application in military aviation accidents analysis, several derived models have been designed for other domains such as the rail, mining and medicine industry. Adaptation to the maritime industry, has also been undertaken by several authors (Celik & Cebi, 2009; Chauvin, Lardjane, Morel, Clostermann, & Langard, 2013; Chen et al., 2013; Rothblum et al., 2002). The HFACS-MA model designed by Chen et al (2013) includes an additional level (Other factors), set above the organizational level, to address the legislation and political factors. To perform the analysis of collisions at sea, Chauvin et al (2013) also made some adaptations to consider factors such as communication and BRM.

Additionally, it was found that, despite the positive results on inter- and intra-rater reliability tests of the HFACS framework, it still needs improvements in its implementation (Ergai et al., 2016).

2 METHODOLOGY

The proposed methodology aimed to develop an NTS behaviour marking system to be used in the NAVSIM of the Portuguese Naval Academy. Technical skills were not considered in this research, since there are already objectively evaluated thru the compliance of procedures and the effectiveness of the decisions and actions. Thus, we considered a four-step process to design a framework that should be coupled to the navy needs and context. The first step was a comprehensive literature review to create a list of NTS that have been effectively used in safety critical domain, which would be useful for the Officer of the Watch (OOW). This was followed by focus group questionnaires to NAVSIM instructors, aiming at a better categorization of the NTS. The third step aimed at the contextualization of the navy needs, thus we performed an analysis of accident reports involving navy vessels, complemented by a second set of questionnaires involving NAVSIM trainees. The last step consisted of the qualitative analysis of the collected data and design of the NTS behaviour marking system.

2.1 Questionnaires

All questionnaires were completed over the first semester of 2016. The first questionnaire was given to lecturers and instructors who use or have recently used both NAVSIM from the Naval Academy and the Tactical Training Centre, in training and teaching sessions, making a total of 10 participants. The questionnaire was composed by three parts. The first one covered the demographic data including gender, age, years of experience and attended courses. The second part, aimed the evaluation of the educational program in relation to the use of the NAVSIM and the characterization of the simulated sessions (9 questions). The last part focused on the assessment of how the NTS are developed and which are considered the most relevant (24 questions).

The second questionnaire was directed towards student perceptions over the educational program around the use of the simulator. The questionnaire was presented to all students, except those from the 1st academic year, from all graduate degree program that use the NAVSIM, totalling 139 participants, representing 90% of the population (see Table 1). The navy graduate degree programme (63% of the cadets) has more courses with modules conducted in the NAVSIM. This questionnaire also comprises three parts. The demographic part collected age, gender, academic year and course program. The second part aimed the evaluation of the educational program in regards to their training as OOW (10 questions). The third part pointed the student perception over the development of their technical and non-technical skills in simulated training (22 questions).

Table 1. Student participants

Graduate prog.	Academic year				Total	
	1 st	2 nd	3 rd	4 th	5 th	N %
Naval administration	4	4	5	4	17	17 100%
Weapons, elect. Eng.	5	2	3	3	13	13 100%
Mechanical Eng.	7	6	3	5	21	21 100%
Marine	0	0	2	1	3	0 0%
Navy	28	28	24	18	98	88 90%
Total	44	40	37	33	154	139 90%
Participants (N)	42	33	35	29	139	95% 83% 95% 88% 90%

Both questionnaires involved mostly close-end questions of multiple-choice and ordering. Seven open-ended questions were included, three for the students and four for the instructors. Before the implementation, a pre-test was performed on 3 individuals, to validate the adequacy of the questionnaires. The analysis was performed with the SPSS v.20 software.

2.2 Accidents analysis

The analysis of the accidents was made with the HFACS- Coll framework proposed by Chauvin *et al* (2013), with minor changes to adapt it to the cases under analysis, namely to account the groundings. The accident reports used in this analysis were obtained from investigation reports set up by Portuguese Navy, on accidents involving navy vessels. All the navigation accidents cases were considered, totalling 20 cases. They involve 8 collisions, 5 groundings and 7 collision in mooring manoeuvres, from 1995 to 2016. The accident events occurred within the following context:

- Ocean navigation 2
- Coastal navigation 4
- Restricted water navigation 14
- Close manoeuvres 6
- Training programs 4

The coding process was separately carried out by two analysts, one of them an experienced mariner, using qualitative analysis software (NVIVO).

Two iteration were made and the inter-rater reliability was assessed by measuring percentage agreements and Kappa coefficients. As it is shown in Figure 1, the second iteration significantly increased

the degree of agreement. The adjustments of the HFACS framework were performed during the coding process, after discussions between the coders.

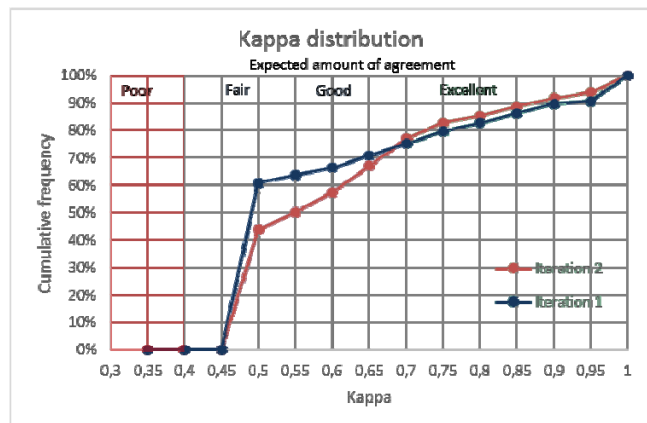


Figure 1. Kappa distribution diagram of the coding process

3 RESULTS

3.1 Non-technical skills

The NTS were mostly retrieved from existing behavioural marker systems, the UT Behavioural Marker (Klumpfer et al., 2001), NOTECHS (Flin et al., 2003), ANTS (Fletcher et al., 2004), NOTSS (Flin, Yule, Paterson-Brown, Rowley, & Maran, 2006), and NTSOD (Long, 2011), we also considered skills identified by Flin et al. (2008) and Devitt & Holford (2010). The literature review resulted in a list of 13 categories (see table 3), where a greater emphasis was found in skills like communication, leadership; situational awareness, decision-making and team work. The criteria used for choice and descriptions were guided by the necessity to: 1) cover all the critical behaviour; 2) avoid overlap between categories; 3) use terminology easily perceived within the organization; 4) be easily accessible and observable; and 5) be measurable in some dimensions, even qualitatively.

3.2 Lecturer survey

The participants, were all navy officers, with an average of 6,5 years of experience in NAVSIM training, 90% male, two younger than 35 years and 4 older than 45, none with any documented simulator training education. The majority (80%) considered that the training in the NAVSIM could be improved. The participants use the NAVSIM for four different courses programs, as it can be seen in the table 2.

Table 3 presents the NTS that were considered as the most relevant, by asking the participant to select five of the 13 categories of NTS.

Two questions were directed for the perception of the best simulated session, one to know which type of session is usually used and a second to identify the recommended type for the development of non-technical skills. Looking at the results in Table 4, we may see that the recommended type of session is the one that flavour a greater integration of the lecturer within the team activity.

Table 2. Course programs conducted in the NAVSIM

Which course program do you manage?	Y	N
Tactical navigation / naval operations	6	2
Seamanship	3	5
Leadership / organizational behaviour	1	7
Navigation	7	1

Table 3. Identification of the most relevant NTS

NTS	N	Order
Decision making	9	1
Situational awareness	8	2
Leadership	6	3
Task planning and management	6	3
Monitoring, vigilance	6	3
Team work	5	4
Communication	5	4
Assertiveness	3	5
Managing stress	1	6
Perception, intuition	1	6
Coping with fatigue	1	6
Energy, mental alertness	0	12
Workload management	0	12

Table 5 presents the some results of the lecturers' survey. While the first set of questions attempts to characterize the context of the training session, the second tries to gives us some understanding over the participant perception in the development of non-technical skills.

3.3 Students survey

The participants of this survey were all students of the Naval Academy, being between 18 and 27 years old, 41.7% being between 21 and 22, 79% male. Bearing in mind that 97,1% have already performed tasks in a bridge team, 92.8% considered that simulation training could be improved and almost half of them considered long term sessions as a good way to increase their skills. Three different tests were performed with the collected data, Kolmogorov-Smirnov, Kruskal-Wallis and Mann-Whitney. Kolmogorov-Smirnov test shown that the data doesn't have a normal distribution, therefore we choose to proceed with non-parametric tests.

Table 4. Configuration types for the simulated sessions in the NAVSIM (Y=yes, N=no / scale 0 to 5, where 0 stands for no answer, 1 for disagree and 5 for totally agree)

Which type of session best suit the development of technical and NTS?	0	1	2	3	4	5	\bar{x}
Playing the scenario, with no interruption / instructor in the control room monitoring	6	1					1,1
Playing the scenario, with no interruption / active presence of the instructor in the bridge		1	2	1	3		3,9
Playing the scenario, with interruptions, for coaching and explanations of the instructor, in the bridge				3	4		4,6
Playing the scenario, with no interruption / active presence of the instructor in the control room			4	3			3,4

Table 5. Instructors perception on the use of the NAVSIM as an educational tool (scale 0 to 5, where 0 stands for no answer, 1 for disagree / never / very bad, and 5 for totally agree / always / very good)

	0	1	2	3	4	5	\bar{x}
Part II							
Are the number of instructors in NAVSIM session training enough?	2	1	2	4	1		3,3
What is the quality of the NAVSIM facilities?	2			1	6	1	4,0
Are the number of training sessions sufficient?	2			5	3	0	3,4
The total number of NAVSIM training hours for Navy graduate degree program is sufficient	4			5	1		3,2
The total number of NAVSIM training hours for Marine, Engineers and Administration graduate degree program is sufficient	6	3	1				2,3
Importance of long training sessions (> 12hours)	2	1	0	1	5	1	3,6
Part III							
Do you agree that training in NAVSIM is relevant for the development of both technical and NTS of the future OOW	2			4	4		4,5
How important is the development of NTS in the NAVSIM?				1	6	3	4,2
Do you perform briefings and debriefings?				2	4	4	4,2
Do you encourage OOW trainees to assign roles / tasks and clarify the responsibilities to the remaining members of their team?				1	4	5	4,4
Do you evaluate the trainees individually after each session?				2	6	2	4,0
Do you evaluate the trainees as a team after each session?				1	6	3	4,2
Do you encourage OOW trainees to monitor the tasks and sustain a common situation awareness within the team?				1	5	4	4,3
Do you encourage team work?	2			2	6		4,8
Do you encourage decision making in safety critical or uncomfortable situations?	2			7	1		4,1
Do you encourage the use of formal communication forms within the team?	2				8		5,0
Do you evaluate the radio communication procedures with other ships and shore stations?	2	1	0	3	4		4,3
Is the individual training session, preceded by planning work?	2		1	7			3,9
Is the group training session, preceded by planning work?	2	1	1	4	2		3,9
Just before the session, do you brief the students with the session goals, plan and evaluation methodology?	1		1	4	4		4,3
Just after the session, do you debrief the students with an analysis of the session, lessons learned and good practices?	1			3	6		4,7
Do you consider that NAVSIM training helps the development of leadership skills?	2			4	4		4,5
Do you encourage the OOW trainee to set priorities in accordance with the situations				3	7		4,7

The results of the Kruskal-Wallis test gave high degree of significance in 7 over 13 questions for the Academics Years, and 9 over 13 questions for the graduate degree programs. The Mann-Whitney tests (multiple comparisons) were made for the questions with high degree of significance.

The results express a clear trend from the 2nd to the 5th years, namely in regards to the increasing instructor's engagement to follow communication standards, providing team working instructions and decision-making in stressful situations. Differences were also found between the graduate programs, especially between the Navy graduates and graduates from the other programs. This could be connected to the fact that until the end of the 2nd year they all attend the same courses, later on they follow different curriculum, with the Navy graduates attending more courses and more demanding tasks in the SIMNAV sessions. This is also reflected in the instructor behaviour and, on the requirements, he/she sets for the trainees.

In general, more than half of the participants considered that they are motivated to manage tasks and to set responsibilities within the team.

Additionally, about 2/3 reported that they usually have briefings and debriefings of the sessions. 2/3 reports that the NAVSIM sessions helped them to develop their leadership skills. They considered that they are mostly evaluated as a team in the NAVSIM sessions rather than as individuals.

Table 6. Summary results of HFACS analysis (levels 1,2 and 3)

HFACS Factors	N	%
Unsafe acts	20	100
Errors	20	100
Skill-based errors	11	55
Decision errors	15	75
Perceptual errors	17	85
Violations	9	45
Routine violations	2	10
Exceptional violations	8	40
Preconditions for unsafe acts	20	100
Environmental factors	20	100
Physical environment	14	70
Hydro-METOC phenomena	10	50
Visibility or lighting	5	25
Technological environment	17	85
Ship building-bridge design	2	10
Radar, ECDIS, NAVAIDS failure	6	30
Non-use or misuse of instruments	17	85
Conditions of operators	12	60
Adverse mental state	12	60
Affected SA	3	15
Attention deficit-workload	12	60
Complacency	1	5
Personnel factors	19	95
SRM	19	95
Inter-ship communication	9	45
BRM	17	85
Ship-shore communications	2	10
Intra-ship communication	4	20
Unsafe leadership	19	95
Inadequate leadership	16	80
Planned inappropriate operations	15	75
Leadership violations	11	55
Failure to correct known problem	12	60

More than half mentioned that instructors encourage the monitoring tasks and support the development of situation awareness. While 60% felt that they are encouraged to work as a team, but only 1/3 referred that they are encouraged to take decisions.

In relation to the type of sessions, their opinions agreed with the instructors, preferring sessions with interruptions, for coaching and explanations of the instructor, with him in the bridge. This was highlighted in the open-end questions, where they reported that sessions were generally well planned but the instructors should be more time in the bridge, and they would like to have much more time in simulated training.

When asked about the evaluation process, they referred that it should be more frequent and objective. 80% of the participants considered that the proficiency of the instructor is good or very good.

3.4 HFCAS of Navy accidents

Table 6 present the results of the HFACS analysis, only showing the first 3 levels, that we considered to be more directly connected with the NTS. The causality factors with higher relevance are the decision and perceptual errors, non-use or misuse of instruments, BRM, inadequate leadership and inappropriate planning.

4 DISCUSSION AND CONCLUSIONS

4.1 Non-technical skills

From the results, we may see that five of the most common NTS were also addressed by the instructors in the survey. Those are also closely related with causality factor revealed from the analyses of the accidents reports. Subsequently, from the correlation analysis of the literature review, surveys and accidents analysis, five NTS categories were defined: Leadership, Situational Awareness, Communications, Team work and Decision making.

Some may argue that the methodology should have include a survey directed to the practitioners, this options was discussed and considering the extensive studies already made based on professional focused group, we proposed to follow that work and combining it with different perspectives, even though with some professional opinions – the lecturers.

Notwithstanding the adopted selection, we should notice the fact that several factors identified in the analysis of the accidents, have been already addressed by the Navy, mostly throughout the implementation of new procedures, instructions, changes in the training programs and qualification processes.

4.2 Developing non-technical skills in simulators

The existing trends found over the academic years, is understandable, since in the first two years the

education is heavily focused on the technical skills, which compels for a more individual training.

From the results, we may say that there is a strong engagement in strengthening the communication skills within the team, the lowest concern with radio communications procedures could be related to other courses, such as GMDSS and radio communications. However, the lecturers, when planning the scenarios and evaluating the sessions, should bear in mind that communication problems with other radio stations are also a contributing factor for accidents.

Both surveys show that simulated training demands more involvement from the instructors, or a different type of pedagogical approach. These students' and instructors' perceptions are in line with what Emad (2010) and Magdy (2016) claim over a more involving role of the lecturers in the team under training. Students undertaking tasks and working as a team in the simulator, seek for more cues and guidance than the ones provided by the warnings and alarms related with the effectiveness of their actions and decisions.

This involvement is quite like what happens on on-board training, since the trainee is deeply involved in the ship team. Thus, while ships have one or two trainees in the bridge team, simulators should have the instructor joining in the trainee team, so they may learn with him.

To increase student's autonomy, initiative was made to allow them to use the NAVSIM for self-training and preparation of their assignments. This decision required the establishment of a certification process to guarantee that the students had the minimum qualification to operate the NAVSIM control. A significant growth of the NAVSIM was noticed, from the 3rd year on, with high time use.

4.3 Behavioural markers systems in simulators

Next to the selection of the NTS, new iteration process was conducted to design the appropriate behavioural markers. We start to review the existent marking systems, but now focused on the identified skills. This analysis also considered the descriptions presented in the accident reports. Finally, we completed this process with observation of simulated sessions, to evaluate the effectiveness of the marking system and the practical challenges faced by the ratter. The actual version of marking system is shown in table 7.

It soon become obvious that prior to the implementation of any marking system it would be necessary to prepare the instructors on its usage. Furthermore, it would be necessary to collect their feedback. A hot debate emerged among the instructors and control staff, about the effectiveness and usability of the form, which finished to emphasised the necessity of new functions in the simulator that could support the evaluation of the behavioural marker. Recently, Olaiya (2016) pointed out the importance of establishing specification requirements for the simulators, driven from the maritime user needs.

Table 7. Behavioural marking model

Skill	Behavioural marker
Leadership	Takes the initiative Set intentions and goals Establish and control standards
Situational	Monitor and reports changes of situations
Awareness	Collects external information Identifies potential danger or problems
Communications	Shares information Keeps a continuous, clear and effective flow of information Promotes a constructive environment for communications
Team work	Considers all the elements of the team Coordinates the tasks of the team Assess the capabilities and corrects procedures
Decision making	Establishes alternative lines of action Assess and verifies the consequences of the decision and actions Considers and shares with the others, the risks of the different lines of action

The navy operates two NAVSIMs, one at the Naval Academy and the second at the Tactical Training Centre. While the first serves the cadet course program, the last is used to train the ship's navigation team. When, drawing a behavioural marking system for both facilities, we consider that it must account for the differences in the trainees and training goals. The Naval Academy is more focused in the understanding and initial development of the NTS and the students sailing experience is only based on the sea training voyages, whereas the Tactical Training Centre is oriented for more contextualized training to commissioned practitioners, that have been working as a team for some time. These teams, while training, are deeply focused on the fulfilment of the specific performance standards set by the Naval Fleet Command. These factors were already reflected by Devitt & Holford (2010), when they considered the influences of the contextual differences and the organizational requirements and needs.

The availability of a marker system goes in line with the survey's results, were it was pointed out the necessity of more recurrent and objective assessments. Moreover, it opens new lines of research in the field of assessment in simulated training, since it is necessary to design computerised metrics to support the behavioural marking model. For instance, through the correlation of communications between individuals and interactions with the workstations, like RADAR or ECDIS. One would expect that, following the appearance of a new contact in the RADAR display, it would be reported by the RADAR operator and that report should trigger new interactions with the system, such as AIS or the lookout's digital Pelorus.

The results support the fact that the envisage changes in the instructor roles demands a larger number of personnel, as it is not conceivable to stay at the control room assessing several bridges teams.

The Quality Management System of the Naval Academy, includes a benchmarking process which collects the assessments of several internal and external stakeholders. One of the processes refers to

the self-assessment of competences and skills of the young officer (one year after graduation) along with the assessment of captains and senior officers. This information will be extremely valuable to support the refinement of this initial marking system.

Previous comprehensive studies on behavioural marking system are grounded in accident causal factors and analysis of the work domain, but we think that this model broads the existing work by attempting to by grasp the educational factors.

4.4 Conclusions

This paper presents the research undertaken to provide a behavioural marking scheme to support the evaluation of non-technical skill in NAVSIM. The methodology considered previous studies and other behavioural marking framework, but most importantly it was shaped to the context of its use: educational program, ship navigation simulators and Portuguese navy.

Very few results are found on the validation of behavioural markers in simulated environment, taking into consideration the distinctive needs and requirements of educational and training program. Current work sets for the preparation of workshops for assessors to get feedback about the markers. Follow up work will go on, as an iterative process to further develop this first marking system. Within three years we will have the first five-year program cycle complete, along with the feedback reports from the senior officers of the ships and the self-evaluations of the young officers.

REFERENCES

- Barnett, M., Gatfield, D., & Pekcan, C. (2006). Non-technical skills: the vital ingredient in world maritime technology? In *Proceedings of the International Conference on World Maritime Technology*. London: Institute of Marine engineering, Science and technology.
- Bué, I. M. G., Lopes, F. C., & Semedo, Á. (2015). The Use of the Portuguese Naval Academy Navigation Simulator in Developing Team Leadership Skills. *TransNav, International Journal on Marine Navigation and Safety of Sea Transportation*, (June), 83–88.
- Celik, M., & Cebi, S. (2009). Analytical HFACS for investigating human errors in shipping accidents. *Accident Analysis & Prevention*, 41(1), 66–75.
- Chauvin, C., Clostermann, J.-P., & Hoc, J.-M. (2009). Impact of training programs on decision-making and situation awareness of trainee watch officers. *Safety Science*, 47(9), 1222–1231.
- Chauvin, C., Lardjane, S., Morel, G., Clostermann, J.-P., & Langard, B. (2013). Human and organisational factors in maritime accidents: Analysis of collisions at sea using the HFACS. *Accident Analysis and Prevention*, 59, 26–37.
- Chen, S. T., Wall, A., Davies, P., Yang, Z., Wang, J., & Chou, Y. H. (2013). A Human and Organisational Factors (HOFs) analysis method for marine casualties using HFACS-Maritime Accidents (HFACS-MA). *Safety Science*, 60, 105–114.
- Cross, S. J. (2003). Enhancing Competence Based Training and Assessment for Marine Engineers through the Realism of Virtual Presentation. In *International Conference on Marine Simulation and Ship Maneuverability MARSIM '03* (pp. 1–7). Kanazawa, Japan.

- Cross, S. J. (2007). Competence Based Learning and Evaluation: Developments and Non-Developments in MET. In *IFSM 33rd Annual General Assembly*. Antwerp, Belgium.
- Cross, S. J. (2012). Aspects of simulations in MET - improving shipping safety and economy. In *International Maritime Lecturers Association 20th Conference*.
- Devitt, K. R., & Holford, S. D. (2010). The development of resource management and leadership behavioural markers for the Merchant Navy. In *Proceedings of the Maritime Human Resource Solutions Conference*. St John's Newfoundland, Canada. Retrieved from <http://ssudl.solent.ac.uk/1426/>
- Emad, G. R. (2010). Rethinking Vocational Education and training: Hauling in from Maritime Education. In R. V. Nata (Ed.), *Progress in Education* (Vol. 22, pp. 125–140). Nova Science Publishers.
- Emad, G. R., & Roth, W.-M. M. (2008). Contradictions in the practices of training for and assessment of competency: A case study from the maritime domain. *Education and Training*, 50(3), 260–272.
- Ergai, A., Cohen, T., Sharp, J., Wiegmann, D., Gramopadhye, A., & Shappell, S. (2016). Assessment of the Human Factors Analysis and Classification System (HFACS): Intra-rater and inter-rater reliability. *Safety Science*, 82(May), 393–398.
- Fletcher, G., Flin, R., McGeorge, P., Glavin, R., Maran, N., & Patey, R. (2004). Rating non-technical skills: developing a behavioural marker system for use in anaesthesia. *Cognition, Technology & Work*, 6(3), 165–171.
- Flin, R., Martin, L., Goeters, K.-M., Hörmann, H.-J., Amalberti, R., Valot, C., & Nijhuis, H. (2003). Development of the NOTECHS (non-technical skills) system for assessing pilots' CRM skills. *Human Factors and Aerospace Safety*, 3(2), 95–117.
- Flin, R., O'Connor, P., & Crichton, M. (2008). *Safety at the sharp end: a guide to non-technical skills*. Aldershot England: Ashgate.
- Flin, R., Yule, S., Paterson-Brown, S., Rowley, D. I., & Maran, N. (2006). *The Non-Technical Skills for Surgeons (NOTSS) System Handbook v1.2: Structuring observation, rating and feedback of surgeons' behaviours in the operating theatre*. University of Aberdeen. Retrieved from <http://www.abdn.ac.uk/iprc/notss>
- Forsman, F., Hill, J., Dobbins, T., Brand, T., & MacKinnon, S. N. (2012). Exploiting Simulation to Enhance Operational Effectiveness and Interoperability in Littoral Maritime Operations. In *STO Modelling and Simulation Group Conference*.
- Hayward, B. J., & Lowe, A. R. (2010). Chapter 12 – The Migration of Crew Resource Management Training. In *Crew Resource Management* (pp. 317–342).
- Hetherington, C., Flin, R., & Mearns, K. (2006). *Safety in shipping: The human element*. *Journal of Safety Research* (Vol. 37). London.
- Klampfer, B., Flin, R., Helmreich, R. L., Hausler, R., Sexton, B., Fletcher, G., ... Dieckmann, P. (2001). Enhancing Performance in High Risk Environments, Recommendations for the Use of Behavioural Markers. In *Behavioural Markers Workshop, GIHRE*. Zürich, Switzerland.: Gottlieb Daimler and Karl Benz Foundation.
- Long, W. M. (2011). The development of a prototype behavioral marker system for US Navy officers of the deck. *Safety Science*, 49(10), 1381–1387.
- Magdy Ali Elashkar. (2016). the Use of Simulation Techniques in the Development of Non-Technical Skills for Marine Officers. *International Journal of General Engineering and Technology (IJGET)*, 5(5), 19–26.
- McCallum, M. C., & Smith, M. W. (2000). Evaluating Simulators for use in assessment of mariner proficiencies. In *Proceedings of MARSIM 2000* (pp. 1–8). Orlando, Florida.
- Olaiya, J. Oi. (2016). Marine Simulators: Technical And Performance Specifications - A Paradoxical Parallelism ? In *IAMU*.
- Rothblum, A., Wheal, D., Withington, S., Shappel, S. A., Wiegmann, D. A., Boehm, W., & Chaderjian, M. (2002). Improving incident investigation through inclusion of human factors. *United States Department of Transportation – Publications & Papers*, (32). Retrieved from <http://digitalcommons.unl.edu/usdot/32/>
- Saeed, F. (2010). The Importance of Non-Technical Skills in the Maritime Education. In *International Association of Maritime Universities AGA11* (pp. 103–114). Busan, South Korea.
- Shappell, S., & Wiegmann, D. (2000). *The Human Factors Analysis and Classification System – HFACS*. Federal Aviation Administration Technical Report DOT/FAA/AM-00/7. Springfield, Virginia: National Technical Information Service.
- Tsoukalas, V. D., Papachristos, D. A., Stefanakou, A. A., Tsoumas, N. K., & Nikitakos, N. (2015). Questionnaire assessment of training in a marine simulator. *WMU Journal of Maritime Affairs*, 14(2), 293–312..