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New Learning Methods for Marine Oil Spill Response Training

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ABSTRACT: In Finland the Regional Fire and Rescue Services (RFRS) are responsible for near shore oil spill response and shoreline cleanup operations. In addition, they assist in other types of maritime incidents, such as search and rescue operations and fire-fighting on board. These statutory assignments require the RFRS to have capability to act both on land and at sea. As maritime incidents occur infrequently, little routine has been established. In order to improve their performance in maritime operations, the RFRS are participating in a new oil spill training programme to be launched by South-Eastern Finland University of Applied Sciences. This training programme aims to utilize new educational methods; e-learning and simulator based training. In addition to fully exploiting the existing navigational bridge simulator, radio communication simulator and crisis management simulator, an entirely new simulator is developed. This simulator is designed to model the oil recovery process; recovery method, rate and volume in various conditions with different oil types. New simulator enables creation of a comprehensive training programme covering training tasks from a distress call to the completion of an oil spill response operation. Structure of the training programme, as well as the training objectives, are based on the findings from competence and education surveys conducted in spring 2016. In these results, a need for vessel maneuvering and navigation exercises together with actual response measures training were emphasized. Also additional training for maritime radio communication, GMDSS-emergency protocols and collaboration with maritime authorities were seemed important. This paper describes new approach to the maritime operations training designed for rescue authorities, a way of learning by doing, without mobilising the vessels at sea.

1 INTRODUCTION

1.1 *Aim and scope*

The aim of this paper is to introduce new simulator training programme established for Finnish oil spill response authorities and the rationale behind the learning methods chosen. Responsibility in marine pollution response in Finland is divided between environmental and emergency authorities. The Finnish Environment Institute (SYKE) is the competent government pollution response authority. SYKE, accompanied with the Finnish Border Guard and The Finnish Defence Forces, conducts the oil spill response measures on the open sea. SYKE is also the nationally appointed authority that is empowered to request and give international assistance. The Regional Fire and Rescue Services (RFRS) are in charge of oil response operations in coastal areas. The Centres for Economic Development, Transport and the Environment assist the RFRSs in organising the oil spill response operation as well as approve the regional contingency plans of the RFRSs'. The number of agencies participating in an oil spill response operation is manifold. This paper concentrates on the field of operation of RFRSs. Furthermore, as the oil spill response involves various elements of both onshore and at-sea countermeasures, this paper focuses on the at-sea phase of an oil spill response operation and the maritime skills related. This focus was set on the basis of the competence survey conducted prior to the development of the training programme. The results of the survey indicated an apparent need for additional maritime training.

1.2 *Structure of the paper*

The paper presents the current situation of oil spill response education and the context in which the new marine oil spill response simulator training is developed. Research directing the development is described and the main findings highlighted. The designed training structure is presented and the learning methods are discussed in order to assess their applicability to meet arisen training needs. In conclusion, the training development processes is summarised and future application of the enhanced simulator environment is introduced.

2 SIGNIFICANCE OF OIL SPILL RESPONSE TRAINING

Even though the risk of oil spills is minimised by improved maritime safety and jointly adopted international or regional risk preventing measures, the capability to deal with the consequences of a marine oil spill is needed (Lampela & Jolma 2011). The uniqueness of the Baltic Sea, the shallow waters with slow exchange of water makes it highly sensitive to oil pollution. Also cold winters and long periods of ice cover slow the physical, chemical and biological decomposition of harmful substances. (SYKE 2017; HELCOM 2010; HELCOM 2016.) The sea-area is characterized by shallow waters, rocky shores and narrow fairways as well as a partial ice-coverage during the wintertime. Finnish fairways are mainly constructed according to the PIANC parameters and guidelines. In some navigational areas the parameters regarding the fairway geometry can not be fully complied with due to the scattered rocky formations, islands or the features of the sea bed (Larjo et al. 2010). These demanding navigational characteristics of Finnish waters combined with the increasing oil transportation pose a severe risk to the marine environment. The rapid response actions are needed also because of the vast sosio-economic impacts an oil spill might cause. (SYKE 2017; HELCOM 2016.)

The Finnish Environment Institute (Suomen ympäristökeskus, later SYKE) estimates that about 2,000 accidental oil spills occur each year in Finland, although in most of these incidents only small amounts of oil are released into the environment. There has been no large-scale oil spill since 1980's (SYKE 2017). Therefore it is crucial to maintain spill response ability with continuous training as real-life experience is not gained and routine can not been established. Although the probability of an oil incident is not very high in the light of realised incidents, the consequences of an oil spill emphasises the necessity of immediate preparedness attained by comprehensive oil spill training

3 MARITIME COMPETENCIES IN RESCUE SERVICES

Regional Fire and Rescue Services (RFRS) are responsible for the prevention of and response to marine oil spills within the coastal region. Despite their statutory role in the marine spill response, maritime studies are not included in the vocational education of fire and rescue personnel. Manoeuvring of vessels, navigation as well as maritime communication practices are today educated as an in-service training by the RFRSs themselves. Assigned officers have Certificates for Small Craft Operator issued by the Finnish Maritime Administration. However, maintaining the maritime skills has proven to be a challenge due to the restricted possibilities for onboard training. According to the competence survey, the maritime skills varied among the RFRSs and an apparent need for more comprehensive maritime education was recognised.

4 SURVEYS ON RESPONSE TRAINING NEEDS

To ensure the feasibility of the education proposed, response training needs were studied in detail by the means of online semi-structured survey with open questions together with fixed selection matrix. Survey consisted of two parts. First one studied the response training needs in a strategical level (later referred as an Education survey), and the other part the actual competencies in an operational level (later referred as a Competence survey).

Education survey was targeted at the rescue officers designated as oil spill response trainers in RFRS or other organisations assigned to oil spill response. This survey was aimed to provide background information on the current state of and the future requirements for the oil spill education, prospects for education arrangements, scale and scope of the education and other restrictions affecting the further implementation.

Competence survey was directed to the employee level of RFRS and other associated organisations. The aim was to define the key areas of expertise in the field of oil spill response, and to examine if any competency deficiencies exist. In addition subjective views on the level of importance of specified response competencies were studied.

Both parts of the survey were conducted nationwide. Respondents represented 39 organisations in total, and included the main response authorities, response agencies and voluntary response organisations in Finland. Main target group, RFRSs, composed 51,4 % of the survey participants. Majority (81,8 %) of the Finnish rescue services was represented as 18 of 22 Regional Rescue and Fire Services attended the survey. Other respondents included i.a. Finnish Environment Institute SYKE, Finnish Border Guard, the Finnish Defence Forces, Finnish Transport Safety Agency, Finnish

Meteorological Institute and WWF Finland. Also several response related enterprises gave their outlook to the subject. Survey participation rate was 67,2 % and the number of answers 189 in total. This was considered an adequate broad base of data for training priority analysis.

Main results of the Competence survey and the Education survey concerning the RFRSs are outlined in the following. As survey covered both operational and strategical (employee and employer) point of views, the equivalence between reported needs and goals could be compared. Subtle differences in training priorities were detected between the respondent groups. This lead to the customization and modularization of training programme to be discussed later in this paper.

4.1 *Competence survey*

Operational level survey examined competence deficiencies of the RFRS employees by 64 fixed and ten (10) open questions concerning areas of expertise related to the oil spill response. Respondent was asked to assess the level of personal competence in specified response task in numeral scale from 1 to 5, highest value (5) representing excellent level of competency. In addition, respondent was asked to assess the level of significance of the competency in question contributing to the overall success of the oil spill response operation.

Highest level of competencies (good to excellent competency) are currently displayed in skills to conduct reconnaissance of the oiled areas and the on-scene assessment of the situation. Second highest competencies (fair to good competency) are related to environmental and sosio-economic impacts of an oil spill, countermeasures to protect sensitive species and skills to maintain safe working procedures in terms of occupational safety. Respectively the current key strengths identified are related to the practical oil spill response and oil recovery skills such as response tactics and techniques in different operational environments and ambient conditions.

Levels of competencies and levels of significance were compared in order to find potential competence deficiencies and thus top priority training needs to focus on. As a result, the most significant competence deficiencies seemed to fall upon two main categories, maritime related skills and marine oil spill response skills.

Regarding to the maritime related skills, the competence deficiency is greatest in vessel manoeuvring and navigation skills as illustrated in Figure 1. These skills are main factors contributing to the overall success of the response operation and are to be taken into account in designing the training programme accordingly. Based on the survey findings, new oil spill response education should include training modules in i) operating response vessels in formations, ii) use of radar and navigating in restricted visibility and iii) maritime radio communication including GMDSS-emergency protocol. Multi-agency collaboration is reasonable to include both in response planning tasks and in joint simulator exercises.

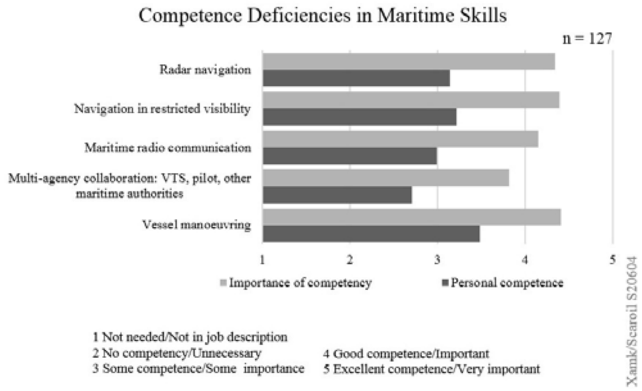

Figure 1. Maritime skills with greatest distinction in competency and significance of the skill.

Regarding to the oil spill response skills the greatest competence deficiencies reported were related to the various oil recovery and containment techniques as presented in Figure 2.

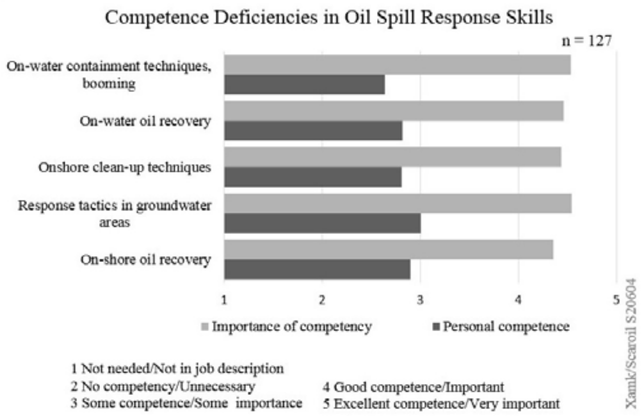

Figure 2. Marine oil spill response skills with greatest distinction in competency and significance of the skill.

In order to reinforce response skills and decrease the competence deficiencies in marine oil spill response, future training programme should include the following modules i) oil spill response tactics and techniques, ii) oil containment and booming and iii) on-water and onshore oil recovery techniques.

The results presented above are based on the answers of 127 fire and rescue personnel. The number of respondents in the competence survey was 144 in total representing 21 separate organisations. The competence levels of each respondent groups were studied alike. To verify improved skills, competence survey will be repeated after each training course and needed steps are taken to develop the training programme towards achieving the best correspondence.

4.2 *Education survey*

Education survey was aimed at the persons in charge of the response preparedness in a strategical level. Survey consisted of eight (8) open questions examining the current education situation and the future needs. The results indicated that demand for response education exists. Nearly half of the respondents (45,7 %) stated that the current state of the oil spill response education does not measure up with their requirements. Respondents partly satisfied with the current situation comprise 26,1 % and respondents fully satisfied with the current education situation comprise 19,6 % of the number of survey participants, 8,7 % representing respondents not able to express their opinion. The results of education survey is based on the answers from 45 respondents in total representing 37 separate organisations.

Figure 3 shows the educational needs detected. The most urgent needs are related to the management of an oil spill response operation, the response techniques and tactics as well as the multi-agency collaboration. These aspects were also recognised in operational level. Proactive risk control measures and options to minimise the consequences of the spill seem also need more consideration. In addition to the current needs, the respondents were asked to assess the emerging educational needs as some revisions in response responsibilities are expected in the future.

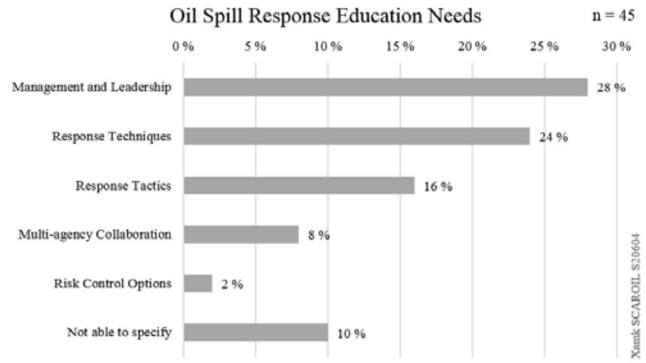

Figure 3. Most urgent oil spill response education needs.

Comparison of reported education needs to the existing education offering was conducted. The results were also compared to the findings of earlier studies (i.e. Lonka 1998; Kymenlaakso University of Applied Sciences 2011; Kujala 2012; Kull et al. 2012). Though the research data of these studies, the number of research subjects and respondents, was more limited, some similarities were found. The educational needs have remained same over two decades (Lonka 1998; Kujala 2012). Also the challenges in educating fire and rescue personnel seem repeatedly culminate in the restricted resources of time and personnel the RFRSs are able to release from daily operations to participate in trainings (Lonka 1998; Kymenlaakso University of Applied Sciences 2011; Kujala 2012). These restrictions directed the designing of new training programme and highlighted the importance of utilising space- and time-independent learning methods.

5 DESIGNING TRAINING PROGRAMME AND TRAINING METHODS

Training programme design was outlined by the target group's limitation to attend contact teaching lessons and the practical nature of the oil spill response as a study theme. Topics of the lessons were derived from the results of surveys described earlier in this text.

Applicability of existing teaching aids and arrangements in oil spill response training was evaluated. As a result, training provider's facilities seemed feasible. Operating the response vessels could be easily trained in the existing navigational bridge simulator yet the full adaptation required some scaling; new models for smaller vessels, work boats, barges and tugs, needed to be installed. As the bridge simulator mainly used for STCW-training of seafarers will be now utilised to train non-seafarers, each training task was assessed to find the most beneficial usage of the relevant functions of bridge controls and to determine the adequate scale and depth of exercising. Virtual training environment for the on-water operations was accomplished by upgrading the bridge simulator software with the oil spill functionality module. Maritime radio communication simulator and crisis management simulator can be utilised to stimulate decision-making, leadership and situational awareness. However, none of the available oil spill simulators modelled the oil recovery process in a satisfactory degree. Therefore, development of a new simulator commenced. Future simulator modelling oil recovery will consist of real-time simulator engine software, computation of oil behaviour, fate, and oil-water-recovery-rate and cabin type work station with authentic control levers. Integration of enhanced bridge simulator and new oil recovery simulator creates a unique learning environment in which the marine oil spill response operations can be trained realistically without a need for mobilisation of response troops or manning the vessels.

The simulator environment enables safe training in variable sea states and visibilities. Changing ambient conditions or introducing malfunctions of response equipment or engine failures of vessels will force the trainers to re-assess their response strategy and tactics. This kind of use of simulators enables contributing to the problem-based learning by developing students' reasoning skills (Savin-Baden 2000). Simulator training also enables learning to take place within a context relevant to the the students, and thus ensures that learning is attuned to world of work, which are the salient features of the problem-based learning (Savin-Baden 2000).

Another approach applied to the training programme design was promoting the case-based reasoning (CBR) in executing training tasks. CBR exploits the past cases in dealing with similar new cases with four step approach known as CBR-cycle i) retrieve, ii) reuse, iii) revise and iv) retain (Prentzas & Hatzilygeroudis 2011). Theory lectures providing an overview of earlier spill response cases support the students to apply what they learnt in a simplistic simulator exercise and when appropriate, increasing the level of difficulty by adding more variables, students revise their actions to demonstrate their understanding.

This approach complies with the established assessment of proficiency applied in the maritime field. The international Standards of Training, Certification and Watchkeeping for Seafarers (STCW Code) defines competence as a level of proficiency consisting of i) knowledge ii) understanding and iii) a demonstrated skill. This definition was used as basis for setting objectives and evaluating the simulation tasks. Each task has an objective that will require learned knowledge, increased understanding or acquired and demonstrated skill. (IMO 2011.)

Simulators are considered most applicable in training the practical skills, decision-making, teamwork, communication skills (Salakari 2010) and situational leadership (Edgley & Smith 2015). However, training sessions should not solely consist of simulator exercises. Excessive amount of simulator training in one session is proved to be exhausting and does not support students' learning abilities (Salakari 2010). It is also noted, that learning by doing does not displace other methods of learning but completes them (Kalalahti 2015; Salakari 2010). Balance between simulator training and theory lectures should be found (Salakari 2010).

Therefore oil spill simulator training was decided to follow 10-20-70-principle. This model includes a combination of structured learning sessions, social learning and simulation learning (Edgley & Smith 2015). The structured learning (10% of learning time) consists of theory lessons needed to provide the knowledge base of the subject. As Savin-Baden (2000) emphasises, the problem-based learning offers students opportunity to embrace, challenge or transcend the theories put before them, thus indicating the necessity of presenting the theory. Theory-based approach is completed by social learning (20% of course time) including workshops and group assignments. When appropriate, some of these sessions take place prior to actual course. Instead of traditional contact teaching lectures, new learning methods are used. An e-learning platform consisting of group and individual assignments, exams and video-blogs (vlogs) is created to support the students' self-directed learning. Simulator learning (70% of course time) provides opportunities to practice, test and demonstrate the required skills.

Degree of success of the training programme will be evaluated using a number of approaches. The competence levels of participants were surveyed before the course by the means on Competence survey and will repeated after the course. This allows measuring a shift in competencies in order to demonstrate the actual efficiency of the training, and to revise the training programme accordingly.

6 AN EXAMPLE OF TRAINING STRUCTURE

The structure of the RFRS pilot training programme will consist of four main modules. The modules are i) topical class lectures, ii) pre-assignments and workshops, iii) functional exercises in a navigational bridge simulator and iv) exercises with an oil recovery simulator. A single module will consist of three to seven tasks or topics as illustrated in Figure 4. The duration of the programme will be three to five working days.

Modules and their contents:

i) Lectures by topic	ii) Pre-assignments and workshops	iii) Bridge simulator excercises	iv) Oil recovery simulator
A. Lecture	a. Pre-assignment	1. Familiarization	I. Exercise
B. Lecture	b. Pre-assignment	2. Basic	II. Exercise
C. Lecture	c. Debriefing	3. Basic	III. Excercise
D. Lecture	d. Debriefing	4. Intermediate	
E. Lecture	e. Workshop	5. Intermediate	
F. Lecture		6. Advanced	
		7. Advanced	

Training Programme curriculum:

Day 1	Day 2	Day 3
ii) c. Debriefing (pre-assignment)	i) B. Lecture	ii) e. Workshop
i) A. Lecture		
iii) 1. Familiarization	iii) 3. Basic	i) D. Lecture
		iv) I. Oil recovery
iii) 2. Basic		iii) 4. Intermediate
	i) C. Lecture	

Figure 4. Example of a basic level training programme for response teams and programme structure demonstrating the learning modules, exercises (missions) and their relations.

Bridge simulator exercises-module is constructed from a set of missions. Bridge simulator exercises (missions) may include simultaneous vessel formations, manoeuvring and radio communication. Students will be able to manage oil booms, barges and other response objects in various configurations and operating environments including shallow waters and different lighting conditions. These exercises represent controlled, objective-driven activities in a prior scripted oil spill incident scenario. An individual exercise focuses on one or two main problems at the time. Duration of such a mission is one to three hours. Exercises are progressive and the scenario increases in complexity as the simulator environment becomes more familiar and the skills of the trainees improve.

The bridge simulator module used in a single training programme will consist of four to six progressively complex individual missions. An example of an easier basic level simulator mission would be aligning two or three vessels in open sea and in calm daytime conditions. The focus would lie in coordination, vessel handling and radio communication with other trainees.

An example of a more advanced mission would consist of three or more vessels performing a coordinated towing of oil boom(s) and/ or storage barges in Finnish archipelago with other vessel traffic while the prevailing ambient conditions are nighttime and rain. The focus would lie in advanced coordination, vessel handling and communication between other vessels and the Vessel Traffic Centre.

A module consisting of mainly basic level missions would be targeted for on-scene response teams whereas a module with advanced and more challenging missions would be targeted for the officers or trainees that have participated in the programme before. This approach will keep the programme relevant for several years and allows for refreshment training on the individual level.

Described example module utilizes the navigational simulator system with an oil spill response functionality. Typically, bridge simulators are used for single ship navigational training with relatively large merchant vessel models. In this programme the emphasis is in constructing training tasks for non-seafarers such as RFRS personnel. Trainees will be able to perform simulated, realistic coordinated and simultaneous tasks and missions with smaller vessel models. At the time of preparing this paper, a study assessing the possibility of constructing an exact digital model of an RFRS vessel type is under progress.

Complete programme will be constructed by combining the modules in a way, which reflects the level of knowledge and skills of the trainee group. The 10-20-70-ratio can be adjusted to shift emphasis toward the missions in the navigational simulator instead of structured learning. Modular structure allows flexibility and possibility for customization, such as tailor made programmes for a student group from a specific region or group consisting of trainees of various positions and/or spill response duties.

7 CONCLUSIONS

This paper described the process of developing a new marine oil spill response training for Finnish response authorities, mainly targeted at the Regional Fire and Rescue Services. The contents of the training programme is based on the research on competence strengths and educational needs. The key training topics identified include the response tactics and techniques along with the maritime skills, such as vessel manoeuvring and booming configurations. Navigational bridge simulator was considered the most applicable learning environment for training these practical skills. The applicability of simulator training was endorsed as it also contributes learning of communication skills, situational leadership, teamwork and decision making.

The training programme applies the method of problem-based learning; the training sessions are built on the scenario-based settings accompanied with the theory-based lessons. Creating learning missions permitting students to manage, conclude and review operations develops the students' problem-based learning abilities. The modular structure and a mix of exercises enables the customization of training programme for diverse target groups. The blended-learning approach with new e-learning methods gives flexibility to the implementation of the course.

Even complex oil spill scenarios can be trained in a simulator environment. The new oil recovery simulator currently under development will substantially complete the training aids. In addition to the training, this unique simulator environment can be used as a risk analysis tool for oil spill response contingency planning.

FUNDING AND GUIDANCE FOR DEVELOPMENT WORK

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The project steering committee constituted to guide the development of simulator training is comprised of the designated spill response specialists representing the Rescue Services of Eastern-Uusimaa, Helsinki, Kymenlaakso, Lapland, Northern Carelia, Northern Savonia, Oulu-Koillismaa, Southern Carelia, Southern Savonia, Soutwest Finland and Western-Uusimaa, the Emergency Service College and the Centres for Economic Development, Transport and the Environment of Uusimaa and Southeast Finland.

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