TRANSNAV
http://www.transnav.eu
the International Journal
on Marine Navigation
and Safety of Sea Transportation
Volume 13
Number 1
March 2019

DOI: 10.12716/1001.13.01.20

Efficiency of Maritime Simulator Training in Oil Spill Response Competence Development

J. Halonen & A. Lanki
South-Eastern Finland University of Applied Sciences Xamk, Kotka, Finland

ABSTRACT: Marine oil spill response operation requires extensive vessel manoeuvring and navigation skills. At-sea oil containment and recovery includes both single vessel and multi-vessel operations. Towing long oil containment booms, several hundreds of metres in length, is a challenge in itself. Boom deployment and towing in multi-vessel configurations is an added challenge that requires precise coordination and control of the vessels. Efficient communication, as a prerequisite for shared situational awareness, is needed in order to execute the response tasks effectively. In order to gain and maintain adequate maritime skills, practical training is needed. Field exercises are the most effective way of learning, but especially the related vessel operations are resource-intensive and costly. Field exercises may also be affected by environmental limitations such as high sea-state or other adverse weather conditions. In Finland, the seasonal ice-coverage also limits the training period to summer seasons as regards the vessel operations of the Fire and Rescue Services. In addition, the sensitiveness of the marine environment restricts the use of real oil or other target substances. This paper examines, whether maritime simulator training can offer a complementary method to overcome the training challenges related to the field exercises. The objective is to assess the efficiency and the learning impact of simulator training, and the specific skills that can be trained most effectively in simulators. This paper provides an overview of learning results from two oil spill response pilot courses, in which maritime navigational bridge simulators together with an oil recovery simulator were used. The courses were targeted at Fire and Rescue Services responsible for near shore oil spill response in Finland. The competence levels of the participants were surveyed before and after the course in order to measure potential shifts in competencies. In addition to the quantitative analysis, the efficiency of the simulator training was evaluated qualitatively through feedback from the participants. The results indicate that simulator training is a valid and effective method for developing marine oil spill response competencies that complements traditional exercise formats. Simulator training provides a safe environment for assessing various oil containment and recovery tactics. One of the main benefits of the simulator training was found to be the immediate feedback the spill modelling software provides on the oil spill behaviour as a reaction to the response measures.

1 INTRODUCTION

1.1 *Aim and scope*

The aim of this paper is to study the efficiency of oil spill response simulator training. The study is based on outcomes of two pilot courses conducted in late 2017 and early 2018. The pilot courses comprised of three days training in maritime simulator centre using three full-scale navigational bridge simulators and an oil spill recovery simulator. The participants consisted of regional oil spill response authorities, both management and operational personnel. This study compares the shifts in competencies estimated by the means of participant self-evaluation prior and after the courses. The aim is to examine whether the simulator training contributes specific oil response competencies and to find out which competencies display the most improvement.

1.2 *Structure of the paper*

This paper is divided into four main chapters. First, the concept of oil spill response simulator training and its development process are introduced. Second, a quantitative analysis of the learning results of two pilot courses are presented. Third, the effectiveness of the training is evaluated qualitatively based on the exercise debriefings and participant feedback. In the conclusions chapter, the outcomes are summarized and the efficiency of the maritime simulator training discussed.

2 DEVELOPMENT OF THE OIL SPILL RESPONSE SIMULATOR TRAINING

Oil spill response simulator training is a new training method developed in the South-Eastern Finland University of Applied Sciences (Xamk) in 2016–2018. The training differs from the comparable courses due to the comprehensive simulator training environment and the joint approach involving both operational and management level responders. For example, the simulator training used for the oil spill response exercising in the Netherlands provides simulation for the decisions-makers while the simulated vessels are manoeuvred by the training instructors themselves (Cross & Werner 2015). The main objective of the simulator training in Xamk is, by contrast, to use the bridge simulators to improve the maritime skills of the responders. The simulator training also utilizes an entirely new simulator specifically developed for this purpose; an oil recovery simulator modelling mechanical brush skimmer operated by excavator arm either onboard a response vessel or a barge or as a land-based unit from quayside. Simulators used were Transas NTPro 5000 version 5.35 navigational bridge simulator with Oil Spill Functionality module and Mevea Ltd custom built Oil Recovery Unit with Lamor Ltd controller. Transas bridge simulators were used as three (3) full-scale bridges and eight (8) workstations configuration. Integration of the oil recovery simulation into maritime simulators creates a unique learning environment, in which the elements of the oil spill response operation can be trained comprehensively (Halonen, Lanki & Rantavuo 2017).

The development of the training courses commenced with a national study on the current oil spill response training possibilities and competence needs (See Halonen, Lanki & Rantavuo 2017). The objectives of the new training courses were based on the results of these education and competence surveys (n=144). Most of the respondents represented the regional rescue services (n=127) and the study encompassed 80% of the rescue services in Finland. Based on the survey results, the courses were built to focus on the maritime related skills, namely vessel manoeuvring and navigational skills as well as the skills related to the marine oil spill response operation (Halonen, Lanki & Rantavuo 2017). Main training topics were chosen to include the on-water oil spill response and recovery tactics and techniques, as well as conducting the response measures in challenging operating environments. The training topics were subjected to expert judgement within advisory committee meetings where they were accepted. Each exercise was designed to progressively improve the skills of the trainees by means of established sub-objectives. Sub-tasks within the exercises progressed, for example, from handling a single vessel into operating response vessels in formations, and from optical navigation into navigating in restricted visibility. The training topics are listed in Figure 1 as well as in Table 1.

In addition to the prior surveys, designing the training courses aimed to take into account the best practices that the previous training organizers have recognized when using traditional exercise formats. In general, the key elements of a successful oil spill response training are considered to include a well-planned establishment of exercise objectives, target-oriented facilitation as well as formal exercise debriefing and evaluation. The challenges recognized are related to costs, weather limitations, health and safety issues and narrow scope of the training content. (Leonard & Roberson 1999; Patrick & Barber 2001; IPIECA & IOGP 2014.) In order to maintain sufficient training frequency, the restricted resources of time and personnel are recognized to be the main limiting factor requiring effective, intensive and low-cost training solutions (Lonka 1998; Leonard & Roberson 1999; Halonen, Lanki & Rantavuo 2017; Halonen, Rantavuo & Altarriba 2017). The urge to reduce the training costs has boosted the use of discussion-based exercises. However, tabletops, when not facilitated properly, are found to provide unmeasurable results (Leonard & Roberson 1999) and blamed of going too far into exercise artificiality (Gleason 2014) and thus reducing the training efficiency. The mentioned challenges include the unrealism of the training scenarios and the inaccurate assumptions the discussions-based exercising may cause (Leonard & Roberson 1999; Patrick & Barber 2001; IPIECA & IOGP 2014). These challenges that the traditional exercise formats have demonstrated were taken into consideration when designing the new simulator training. In order to evaluate whether the simulator training can overcome the training challenges, two pilot courses were executed. The results of the pilot courses in improving the oil spill response competency are presented in the following chapter.

3 OUTCOMES OF THE PILOT COURSES

Pilot courses were conducted in November 2017 and January 2018 in Kotka Maritime Simulator Centre (KMC) in Finland. The first pilot course had a total of nine (9) participants, three (3) of which were management and six (6) operative personnel. The second pilot course had a total of ten (10) participants, four (4) of which were management and six (6) operative personnel. The participants represented six (6) separate rescue service regions around Finnish coastal and inland water areas, the geographical coverage encompassing the Finnish south-coast to Lapland.

The efficiency of the pilot courses was evaluated by means of quantitative and qualitative analysis. In the quantitative approach, the improvement of the competence levels of the participants were surveyed after the course in order to measure the potential impact of the training. In addition, the efficiency of the simulator training was evaluated qualitatively through the course debriefing discussions and written feedback from the participants. Both courses had same contents and the simulator trainings were executed in a similar way.

3.1 *Quantitative analysis of the learning results*

The participants of the pilot courses were asked to evaluate "How much did your competence increase in a given subject?" The questionnaire consisted of 25 subjects related to the oil spill response (Table 1, Figure 1). The subjects listed represented the course topics trained either by the means of the simulators, theory lessons, integrated tabletop exercises or e-learning materials for independent study. Respondents were asked to assess the increase of their competence in the scale ranging from one (1) to four (4), where value one (1) equals no shift, value two (2) equals slight shift, value three (3) equals considerable shift and value four (4) equals great shift in competence to an increasing direction. Zero value was reserved for subjects the respondents consider not dealt with within the training sessions.

Regarding both pilot courses, when distribution of all answers were combined, the competencies displaying the most improvement were found to be i) vessel manoeuvring, ii) navigation, iii) oil containment techniques such as booming, iv) use of radar and v) on-water oil recovery techniques (See Figure 1). Learning results, indicated by the shifts in competencies, related to these five topics are studied next in more detail. The results covering all 25 measured parameters are represented in Table 1.

After the first pilot course the highest positive values were detected in navigational competence with upper quintile value of four (4) and lower quintile value two (2) as seen in Figure 2. All of the top variables (i–v) had a median values between two (2/Slight improvement) and three (3/Considerable improvement).

After the second pilot course the highest positive values were detected in vessel manoeuvring competence, with upper quintile value of four (4) and lower quintile value one (1) as seen in Figure 3. All of the top variables (i–v) had a median values between two (2/Slight improvement) and three (3/Considerable improvement).

Table 1. Summary table of the results in quantitative analysis on the competency shifts in both pilot courses.

Topics/skills	Pilot Course 1 (n=9)				Pilot Course 2 (n=10)			
	Upper quantile	Median	Lower quantile	Mode	Upper quantile	Median	Lower quantile	Mode
Oil containment techniques	4	3	1	4	3	3	2,25	3
On-water oil recovery techniques	3	2	2	2	3	3	2,25	3
Response tactics in fast currents	2	2	2	2	3	2	2	2
Response tactics in winter conditions	1	1	1	1	2	1,5	1	0
Shoreline protection techniques	2	2	1,75	2	2,25	2	1	1,2
Onshore recovery and clean-up	2	1,5	1	0, 1	1,25	1	1	1
Sensitive environments	1	1	1	1	2	2	1	0
Sensitive species	1	1	1	1	2,25	2	1,75	0
Use of oil drift models and forecasts	1	1	1	1	2	2	1,75	2
Use of situational awareness systems	1,75	1	1	1	1	1	1	1
Response logistics	2	1	1	1	2	1	1	1
Oil waste logistics	1	1	1	1	1	1	1	0
Temporal storing of oily wastes	1,5	1	1	1	1	1	1	0
Managing long-lasting operations	2	1,5	1	0, 1, 2	2	1	1	0
Vessel manoeuvring	4	3	2	3, 4	3,75	3	2,25	3
Use of marine radar	4	3	2	3, 4	3	2	1	1
Navigational skills	4	3	2	2, 3, 4	3	2	2	2
Navigation in restricted visibility	3	2	1	1	2	1,5	1	1
Actions onboard vessel in distress	3	1	1	1	2	1,5	1	1, 2
Exercise design	2,25	1,5	1	1	2	2	1,75	0
Contingency planning	2	2	1,25	0, 2	1,5	1	1	0
Response organisations	2	1,5	1	0, 1	2	1	1	1
Internal communication	2	2	1	1	3	2	1	1
Marine radio communication	3	2	2	2	2	1	1	1
Radio English	2	1	1	1	1	1	1	0

* Shift in competence; neutral (1), slight (2), considerable (3) or great (4) improvement, N/A (0).

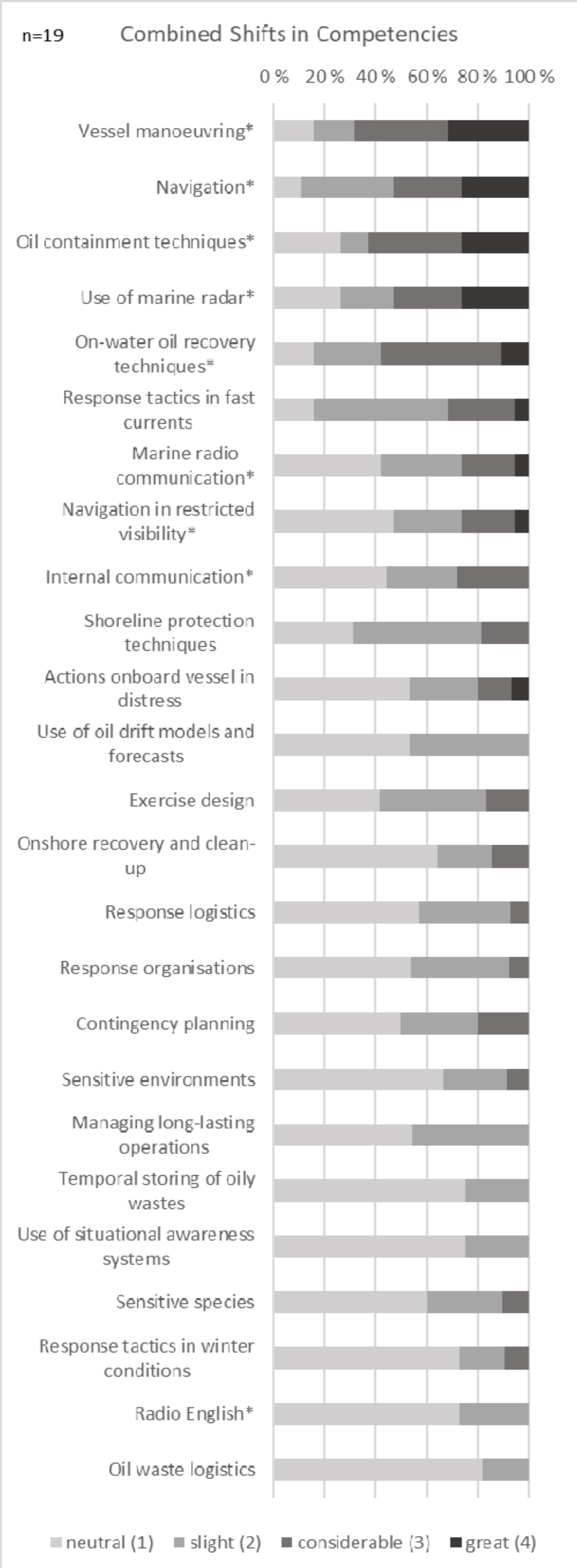

Figure 1. Competency improvements in both pilot courses. Marked topics (*) were the simulator specific objectives, the rest were trained by other educational means. Shift in competence; neutral (1), slight (2), considerable (3) or great (4) improvement. (n=19).

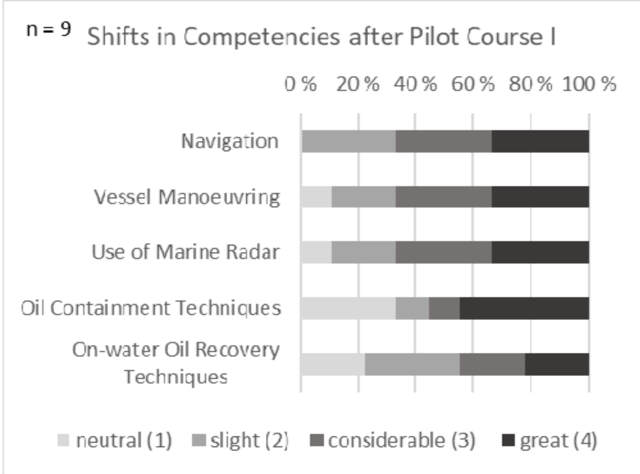

Figure 2. Quantile competency improvements in five simulator specific objectives due to the first pilot course. Shift in competence; neutral (1), slight (2), considerable (3) or great (4) improvement. (n=9).

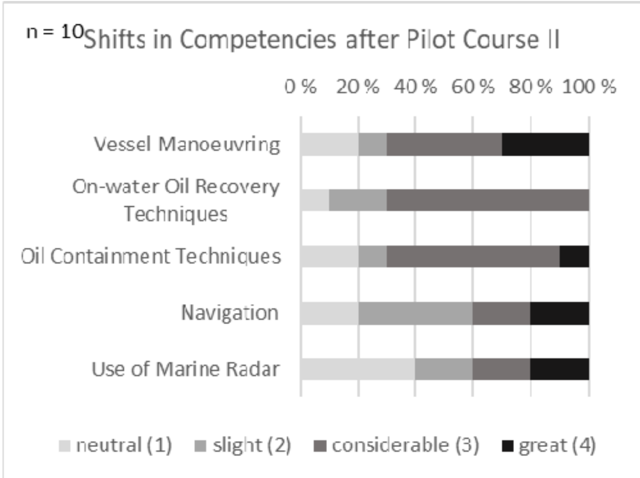

Figure 3. Quantile competency improvements in five simulator specific objectives due to the second pilot course. Shift in competence; neutral (1), slight (2), considerable (3) or great (4) improvement. (n=10).

Only subtle differences in competency shifts were detected when comparing the results of two pilot courses. The first pilot course showed slightly greater impact on most of the simulator specific topics than the second pilot course. The first pilot course led to better learning results especially in skills related to the use of marine radar and navigation. Respectively, the second pilot course led to better learning results in oil recovery techniques.

Based on the competence shifts, the objectives subjected to the simulator training unparalleled the other means of education as seen in Figure 1. The top five learning results were all achieved by the means of the simulator training, while the sixth (6.) and 10.-12. highest learning results were detected in the topics of the theory lesson. The independent study materials led to the weakest improvements in competencies.

3.2 *Qualitative analysis of the learning results*

The simulator training structure included formal exercise debriefing and evaluation phases, during which the participants were asked to evaluate the performance and achieved objectives after each executed session. In addition to that, written feedback was gathered after the training days. The following analysis of the training efficiency is based on these participant inputs.

In the written feedback, the highest valued exercises were the bridge simulator exercises focusing on practical response measures; boom deployment, towing configurations as well as reconnaissance techniques. Second highest valued was the theory lesson concerning the use of different response tactics. (Halonen, Lanki & Punnonen 2018; Rantavuo et al. 2018a.) Comments received in the open question section were mostly related to the simulation and the overall objectives of the training. Most commonly mentioned issue was the training structure utilizing the opportunity to repeat training scenarios and to visualize actions taken by means of playbacks. Some of the exercise missions were repeated several times in order to allow the participants to test and assess different response options. This repetition was considered very useful and instructive, as the field exercises are usually limited to one experiment at a time. In addition, most of the field exercises take place in a fairly good weather, and therefore the possibility to demonstrate the feasibility of the response options in different weather conditions was found useful. Simulation was assumed to contribute identification of possible operational gaps, as testing the performance limits of the equipment in real-life is usually impractical for safety reasons.

Likewise, the respondents emphasized the significance of the immediate feedback the used simulation software and models provided. Realism of the simulator environment, authentic performance of the vessels and the modelled behaviour of the spilled oil enabled the understanding of possible impacts the selected response actions had, and are going to have in actual emergencies. The participants saw the exercises demonstrating the detectability of oil on water, the drifting of oil as well as oil behaviour at oil/boom -interface very valuable. They stated that, as the use of real oil is prohibited in field exercises, and the simulants (such as peat) do not react like oil, it is usually not possible to get a realistic response to one's actions. Besides the advantages of the oil modelling, the expertise of the instructors was also named to be a key factor in learning to understand causes and effects. According to the feedback, the significance of the instructors' input came most valuable in the debriefing situations, in which the completed exercise missions were analysed. Debriefings were also supported by the means of simulation replays and recorded aerial view of the scenario. That was assessed to facilitate also peer to peer communication and evaluation.

Several participants also mentioned that the selected target group of multi-level responders was beneficial. They considered that the simultaneous involvement of both management level and operative level fostered collaboration and contributed to the forming of a more comprehensive outlook. Especially the possibility for participants to change positions was considered valuable. (Halonen 2018; Halonen, Lanki & Punnonen 2018; Rantavuo et al. 2018a.) The exercise format allowed the executive level participants to see the immediate implementation of their response plans, whereas the operative level participants were able to see the reasoning behind the assignments. Both participant groups benefitted from the joint procedures and from achieving a mutual understanding on the used concepts as well as the position-related factors contributing to a shared situational awareness. (Halonen 2018.)

The criticism received was targeted at the technical features of the simulators. One of the negative aspects mentioned by the participants was the limitation of the visual view outwards the simulator bridge (Halonen, Lanki & Punnonen 2018; Rantavuo et al. 2018a). Bridges in real-life response vessels offer unhindered visibility in every direction, whereas in the simulator bridges the visual view covers only 120-degree sector at a time and needs to be changed manually. Especially the view astern of the vessel is important in order to properly see and control towing apparatus, and the lack of it was considered an inconvenience. The participants also noted that the visual determination of dimensions and distances was more challenging in the simulator environment (Halonen, Lanki & Punnonen 2018; Rantavuo et al. 2018a). As the bridge simulators utilized in the trainings are mainly used for STCW-training of seafarers (Halonen, Lanki & Rantavuo 2017), some differences compared to the rescue service vessels were to be expected. Since scale-difference was assumed to be a potential disadvantage, the participants were asked to assess the applicability of the full-scale bridges. The scale-difference, however, had no effect on the learning results. Although some specific dimensions, performance and manoeuvring responses of the vessels slightly differed, it did not hinder the learning or transfer of the skills, as the main functionalities, such as the navigation systems, were corresponding. (Rantavuo et al. 2018b; Halonen, Lanki & Punnonen 2018; Halonen 2018.)

4 CONCLUSIONS

This paper aimed to examine whether maritime simulator training can offer a complementary method to overcome the challenges related to the conventional oil spill response exercises. The objective was to assess the efficiency and the learning impact of the simulator training, and the specific skills that can be trained most effectively in maritime simulators.

Based on the two experiments, simulator training is an effective and valid method for developing marine oil spill response competencies. The results indicated that the simulator training was efficient especially in improving the vessel manoeuvring and navigation skills as well as skills related to oil containment and oil recovery techniques. Both separately executed pilot courses yielded similar results; no meaningful differences in the competency shifts were detected when comparing the course specific results. The combined mean values of improved competences also demonstrated the efficiency of the simulation as a training method. Simulator training provided better learning results than theory lessons and other conventional training methods (see Figure 1). The applicability of simulation is based on the ease of repeatability of the training scenarios in order to test different response options as well as assess procedures and operational limitations, and the flexibility in designing both scope and scale of the exercises. The re-playability of the exercise actions by visual means increases peer-evaluation and analytical discussions during the debriefing sessions. Exercise debriefings supported by the simulator software reports and the live-recordings of the actions also allow the evaluation of the exercise outcome to be based on tangible factors. This helps to overcome the challenges of the exercise artificiality and the unmeasurable results often associated with the traditional exercise methods. Thus, simulations can be said to complement traditional exercise formats in oil spill response training. This conclusion is also supported by the results of the qualitative evaluation. According to the course participants, the main benefit of the simulator training was the feedback the simulation provides on the oil spill behaviour as a reaction to the selected response measures. The level of realism of the simulation model was assessed to contribute to the true identification of areas of improvement and possible response gaps. The simulators offered added value in training of both technical and non-technical skills, and to concretizing the response related phenomena. It was also proved that simulator training provides a reliable and safe environment for assessing various oil containment and recovery tactics. As field exercises may be affected by environmental limitations, such as ice-coverage, high sea-state, poor visibility or other adverse weather conditions, simulator training is constantly available. With target-oriented simulator training, many of the benefits of field exercises are gained, while the safety of the responders and the time and costs-efficiency are improved.

The ease and flexibility of the simulator training is likely to increase the popularity of the method. It should be noted, however, that this type of training requires the instructor(s) to have adequate spill response expertise – otherwise there is a risk to train participants only to be excellent users of simulators. Setting the objectives and scenarios in a manner that enables the gaining of transferrable skills requires relevancy in the context of actual emergencies and response operations. Close collaboration with the target groups is also recommended as it enables increased efficiency in achieving specific learning results and supports customization of the training.

ACKNOWLEDGMENTS

The simulator pilot courses were conducted under SCAROIL project (Simulator Training for Cargo Handling and Oil Recovery, S20604) funded by the European Social Fund, South-Eastern University of Applied Sciences (Xamk), the Finnish Maritime Foundation, Palosuojelun Edistämissäätiö and William & Ester Otsakorpi Foundation. The software updates and development of new oil recovery simulator were funded by the European Regional Development Fund and Xamk in an investment project SCAROIL Simulators (A71714).

The project advisory committee comprised of the designated oil spill response specialists representing the Rescue Services of City of Helsinki, Eastern-Uusimaa, Kymenlaakso, Lapland, North Karelia, Northern Savonia, Oulu-Koillismaa, South Karelia, Southern Savonia, Southwest Finland and Western-Uusimaa, the Emergency Service College and the Centres for Economic Development, Transport and the Environment of Uusimaa and Southeast Finland. Special acknowledgment is made to the contribution of the participants from above mentioned response authorities and the Emergency Service College, and to our co-workers at Xamk attending the development of simulator courses: Mrs. Emmi Rantavuo and Mr. Perttu Juvonen.

REFERENCES

Cross, S. & Werner, P. 2015. Oil spill response simulator revisited. In *Interspill Conference Proceedings 2015.* Amsterdam. p. 4.

Gleason, J. 2014. Getting Big Results by Going Small - The Importance of Tabletop Exercises. Article in *International Oil Spill Conference Proceedings 2014*. p. 120.

Halonen, J. 2018. Osaamiskartoituksesta tavoitteet öljyntorjuntakoulutukselle. Article in *Öljyntorjunnan simulaatiokoulutus, SCAROIL-hankkeen osaprojektin loppuraportti.* Halonen J. (Ed.), Xamk Kehittää 58. Kotka: Kaakkois-Suomen ammattikorkeakoulu. ISBN 978-952-344-121-7. p. 19.

Halonen, J. 2018. Öljyntorjuntaa simulaatioympäristössä. In *Liikkeellä: Toimintaa ja tuloksia Logistiikan ja merenkulun tutkimus- ja kehitystoiminnasta*. Halonen J., Potinkara P. (Eds.), Xamk kehittää 60. Kotka: Kaakkois-Suomen ammattikorkeakoulu. ISBN 978-952-344-126-2. p. 101, 103–105.

Halonen, J.; Lanki, A. & Punnonen, J. 2018. Ensimmäisen SCAROIL-pilottikoulutuksen palaute. Article in *Öljyntorjunnan simulaatiokoulutus, SCAROIL-hankkeen osaprojektin loppuraportti*. Halonen J. (Ed)., Xamk Kehittää 58. Kotka: Kaakkois-Suomen ammattikorkeakoulu. ISBN 978-952-344-121-7. p. 61.

Halonen, J.; Lanki, A. & Rantavuo, E. 2017. New Learning Methods for Marine Oil Spill Response Training. In *TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation*, Vol. 11, No. 2, p. 341, 342. Available at: http://dx.doi.org/10.12716/1001.11.02.18

Halonen J.; Rantavuo E. & Altarriba E. 2017. Öljyntorjuntakoulutuksen ja -osaamisen nykytila. SCAROIL-hankkeen selvitys öljyntorjunnan koulutustarpeista. Xamk Tutkii 4. Kotka: Kaakkois-Suomen ammattikorkeakoulu. ISBN 978-952-344-066-1. Available at: http://urn.fi/URN:ISBN:978-952-344-066-1. p. 15–17.

IPIECA & IOGP 2014. Oil spill exercises. Good practice guidelines for the development of an effective exercise programme. IOGP Report 515. p. 6, 19.

Leonard, J. J. & Roberson, M. 1999. Adding realism to tabletop exercises. Article in *International Oil Spill Conference Proceedings 1999*, p. 555, 556.

Lonka, H. 1998. Öljy- ja kemikaalivahinkojen torjuntavalmius Suomessa – ympäristövahinkojen torjunnan näkökulma. Suomen ympäristö 193. Suomen ympäristökeskus. Helsinki: Edita Prima Oy. p. 104–105.

Patrick, L. & Barber, C. 2001. Tabletop exercises - preparing through play. Article in *International Oil Spill Conference Proceedings*. p. 365.

Rantavuo, E.; Halonen, J.; Lanki, A. & Tuomainen, T. 2018a, Toisen SCAROIL-pilottikoulutuksen palaute. Article in *Öljyntorjunnan simulaatiokoulutus, SCAROIL-hankkeen osaprojektin loppuraportti*. Halonen J. (Ed)., Xamk Kehittää 58. Kotka: Kaakkois-Suomen ammattikorkeakoulu. ISBN 978-952-344-121-7. p. 74.

Rantavuo, E.; Malinen, H.; Halonen, J.; Lanki, A. & Punnonen, J. 2018b. Oil Spill Response Simulator Training – Realistic Enough To Improve Response Capability? Lessons Learnt From Pilot Courses. Short paper in *Interspill 2018 Conference Proceedings.*