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Effect of Simulator Training on Novice Operators' Abilities to Navigate in Ice

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ABSTRACT

Shipping and offshore industries are migrating towards operations in ice-covered waters as gateways to operating in Arctic environments. With this move, there is an increased need for equipment, procedures, and training to operate in cold, harsh environments. Currently, no training exists for lifeboat coxswains charged with navigating lifeboats in ice-covered water during emergency evacuation situations. This research study sets out to examine simulator training in comparison with traditional Standard Training, Certification and Watchkeeping (STCW) training to observe performance differences in a simulated ice field. These findings will inform manufacturers, trainers and regulators regarding the demands associated with lifeboat navigation in ice-covered waters.

KEY WORDS: marine safety; lifeboats; ice navigation; simulator training

INTRODUCTION

As many facets of maritime industry such as shipping and offshore oil and gas move north, expectations for personnel to experience harsh environments, in particular, sea-covered ice is increasing. This shift in environment presents new and unique challenges to training, practice and performance factors that are part of the work environment (Arctic Marine Shipping Assessment, 2009).

Currently international training regulations and standards do not require coxswains of Totally Enclosed Motor Propelled Safety Crafts (TEMPSC) to undergo training for navigation in ice conditions. Training for these conditions can pose a safety risk to trainees.

Comprehensive plans for Evacuation, Escape and Rescue (EER) systems need to be developed to include training related to scenarios in ice-covered waters. As Veitch, Billard & Patterson (2008) report "it is not practicable to do drills with survival craft in even moderately rough weather because the drill itself poses an unacceptable risk to the health and safety of trainees". It has been determined that delivering training in a safe environment can be very challenging at the best of times and real-life training in harsh environments, like pack ice, is rather limited or non-existent.

Marine simulation has become an emerging area of research as technology has advanced. This has given opportunity for simulators to be developed for simulation of a variety of marine situations. Simulators can provide a safe and realistic alternative for personnel to acquire skills and experience without jeopardizing their personal health and safety.

Although simulation research and training in many domains have existed for many years, it has only recently become a part of maritime studies. Simulation training can potentially be used as a safe alternative to traditional training (Yuan *et al*., 2007, Veitch *et al.*, 2008, Edmonds, D., 1992). The benefits of simulation training have not yet been substantiated empirically, yet in studies in the field of medical research have reported that possible benefits include transfer of skills (Akinwuntan et al., 2005), improvement in psychomotor skills (Kewman *et. al*, 1985) and time to performance proficiency (Aggarwal *et.al*, 2006).

Success in EER depends on two elements, human and machine performance (Bercha *et al.,* 2003). This is extremely important to take into account when designing training for harsh environments. Performance based factors must be taken into account in standards, as this tests both human and machine performance. However, current standards for lifeboat training are based on prescriptive factors, which do not adequately address the reality of industry moving into northern and arctic environments.

This study will examine how simulated lifeboat navigation training may improve performance in pack and level-ice navigation situations compared to those trained under standard training regimes.

METHODOLOGY

Recruitment and Training

Recruitment

19 healthy individuals (7 females and 11 males) who were novice powerboat operators with no experience with lifeboats were recruited for this study. Memorial University's Human Investigations Committee, and the National Research Council's Research Ethics Board approved the study protocol. After participants gave informed consent, they were randomly assigned to three groups (defined in the Training section). Six were assigned to the control group (Group 1), seven to experimental group A (Group 2) and six to experimental group B (Group 3).

Training

Participants took part in two training sections. The first was the Pleasure Craft Operator Course (PCOC), which all 19 participants undertook together. The PCOC is a course administered by the Canadian Power and Sail Association to familiarize people with the operations of small pleasure crafts. Participants were then randomly assigned to the three experimental groups. Group 1 training consisted of a portion of the Standard Training Certification and Watchkeeping (STCW) training focusing on lifeboat standard operating procedures and maneuvering in open water. Each participant spent thirty minutes maneuvering the lifeboat in calm, open water. Group 2 training was made up of the same initial STCW training and also included two hours of classroom theory-based training on maneuverings in ice. Group 3 was trained solely using simulation technologies. This group's training included the 2-hour ice curriculum, simulated STCW training criteria and simulation that engaged participants in scenarios that exposed them to increasingly worse ice and weather conditions. Each participant spent thirty minutes in the simulator. Members of the research team, who had vast experience in sea ice navigation, developed the ice curriculum for the classroom and the simulator scenarios. Group 3 simulator training took place in a davit launch lifeboat simulator designed by Virtual Marine Technology (St. John's, Canada). It is a full mission simulator class "S" approved by Det Norske Veritas (Norway). The simulator stands 1.98 m high, 1.92 m long and 1.56 m wide, representing a generic davit launch lifeboat. The steering wheel and throttle were located in similar positions to the real lifeboat used in the field trials. Visual and audio specifications included four 32″ LCD screens representing the port, starboard, bow and stern views with visual angles > 45 degrees. The sound system was comprised of five marine speakers with 5.1 Dolby surround sound.

Equipment

Lifeboat Description

The lifeboat (Figure 1) used in the field trials was a Totally Enclosed Motor Propelled Safety Craft (TEMPSC) manufactured in Beihai Shipyard, China. It is IMO-SOLAS rated for 20 occupants, but has been retrofitted as a research craft. The dimensions of the lifeboat are: length 5.28 m, breadth 2.20m and depth 1.10 m. During each trial run, there were two field trials staff members inside the lifeboat with the participant while they completed the test runs. The lifeboat was ballasted for full complement, which corresponds to a displacement of ≈3800 kg, made up of 3 occupants and 40 sand bags. The throttle was governed at an idling speed for all runs, but speed varied slightly over the duration of the test period due to changes in wind and current speed and direction.

Figure 1.Lifeboat in preparation for field trials

Test Field

The field trials were designed to take place in a medium depth body of water, reasonably sheltered from high winds and waves. The course through which participants would maneuver the lifeboat was designed to mimic approximately 10% ice coverage. Figures 2 & 3 demonstrate the proposed design of the ice field and the actual ice field located in Holyrood, NL, Canada. The simulated ice was created by a series of 40 small targets constructed from three 50 gallon plastic barrels held together against a yoke by straps and ballasted with water. There were 6 larger targets, which were comprised of aluminum frames on floating docks measuring 5x2.5m each.

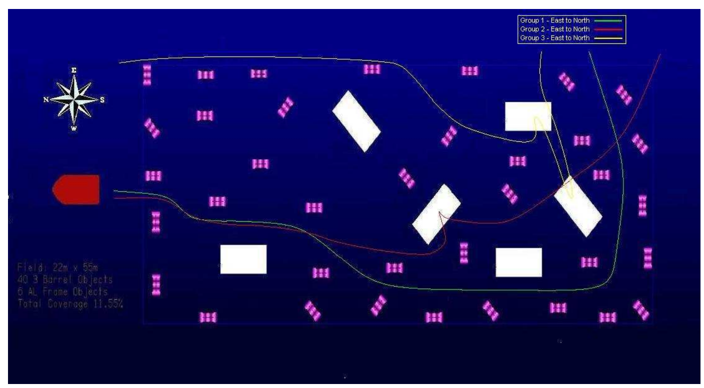

Figure 2. Design of simulated ice field for Field Trials


Figure 3. Actual Test Field

Instrumentation

Lifeboat

Measurements collected during this study included the following lifeboat parameters: accelerations (m/s^2), roll, pitch & yaw (^{o}), Differential Global Positioning System (DGPS), measured in latitude, longitude coordinates, video of the lifeboat from 6 different views, rudder executions, time through course (s), speed through course (m/s) and path length (m). Through conversion of the DGPS data into Northing and Easting measurements, researchers were able to determine the path for each run through the field. For observational analysis, eight cameras were secured inside and outside of the lifeboat to get a complete view of the lifeboat surroundings, the course and the impacts the lifeboat made in the field during each run (Figure 4).

Figure 4. View from bow camera during test run

Two of the cameras were placed internally, to view the impacts the lifeboat made from the position of the force plate located in a sea chest on the port side near the bow, and to view the participant driving the lifeboat (Figure 5).

Figure 5. View from inside lifeboat focused on participant

Subjects

Subject-related measures included heart rate variability measured through an electrocardiogram (ECG) and subjective experience of testing and training, measured through questionnaires. Participants were asked to wear comfortable clothing for the testing period. They were instrumented with a three lead ECG recorder. ECG counts were collected using a Modular Signal Recorder (MSR) with a 3-lead placement (Figure 6). A baseline measurement was collected from participants, while they were setting and relaxing for five minutes, prior to entering the lifeboat. Once the baseline was established, participants wore the leads for the duration of the test period, collecting ECG data. Once the test period was completed, data was uploaded to a computer equipped with MSR software, which exported the data to ". CSV" for further analysis. The leads were attached after skin was exfoliated and sterilized. For the safety of the participants, they were required to wear full immersion suits.

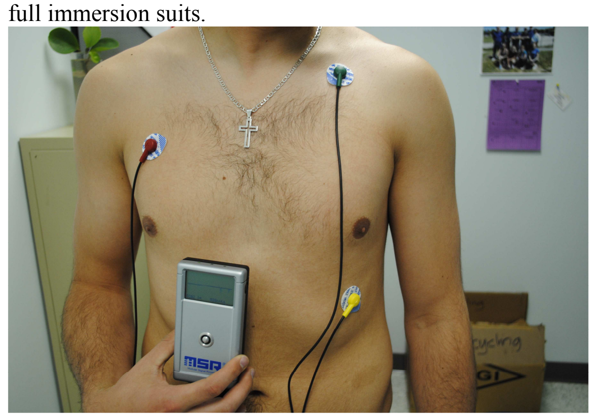

Figure 6. ECG 3-lead electrode placement

Questionnaires were created based on the NASA TLX (SOURCE), a scale used to measured subject experience of workload. Each participant completed a questionnaire after their training sessions and another after their testing. The questionnaires focused on the training they were given and their perceived confidence and proficiency at the skills they were taught, and post testing, focused on their experience from training and how that transferred to testing.

Experimental Protocol and Data Collection

The field trials period was one week long, and required approximately 90 minutes per participant, for lifeboat and subject preparation and instrumentation. After each base line ECG recording, the participant entered the lifeboat and drove out to the course. Each participant performed 6 runs through the simulated ice field, with entry into the field at 6 different points. These were completed in random order for each participant. Table 1 below describes the direction of the 6 runs.

Table 1. Description of Test Runs

Run	Direction
1	North to South
2	South to North
3	East to North
4	East to South
5	Southeast to Northwest
6	Northwest to Southeast

Performance data was collected for each run, and after each participant completed their test period, it was imported into a computer and it was saved in comma separated values ". CSV" form and imported into IGOR, a data analysis and organization program, to be calibrated and analyzed.

AN APPROACH TO DATA ANALYSES

At time of publication deadlines, preliminary performance data were limited. In order to examine whether experimental groups differed in performance, several metrics were considered. Human data were not yet in a form that allowed for analysis.

From the preliminary data examined, researchers have determined certain performance factors can indicate the validity of simulator training. Factors such as completed rudder executions and degrees of change between each execution can predict participant's abilities for navigation. Figure 7 displays rudder executions from one test run, for three participants.

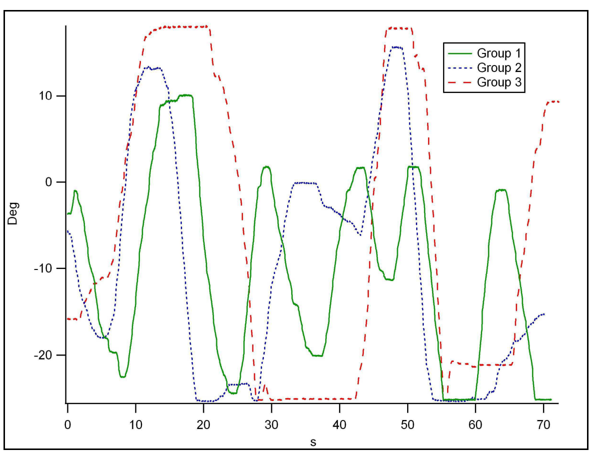

Figure 7. Rudder Executions from North to South test run

Upon closer examination, it is possible that counting the rudder executions and the magnitude of the change of rudder angle for each participant can also highlight differences between group training. Table 2 highlights the rudder executions and changes of rudder angle for the test run in Figure 7.

Table 2- Rudder Executions for test run North to South

	Change in Rudder Angle (Deg.)		
Rudder Executions	Group 1 Participant 12	Group 2 Participant 11	Group 3 Participant 10
1	2.71	12.197	4.05
2	17.09	31.395	29.18
3	4.45	38.676	5.7
4	32.61	1.835	37.46
5	34.53	2.051	1.88
6	26.25	25.250	1.78
7	21.79	2.414	42.91
8	21.73	3.350	3.1
9	24.14	21.731	1.58
10	24.23	40.823	38.21
11	-	9.872	4.49
12	-	-	24.86
13	-	-	5.35

Inspection of the rudder executions of participants for a North to South test run (Figure 7) highlights the differences between groups. Although it is not yet possible to determine if this trend is something that is characteristics of group training, this particular run highlights that the difference between Group 3 and the other two groups with more rudder executions and smaller magnitude of changes. It is possible that on a go-forward basis in the analyses of data, that this can be a better indicator of awareness of surroundings and object avoidance. Given that the simulator training program would immediately end the simulation if participants reached a certain speed upon impact with ice in the simulator, it is possible that this transferred into a Group 3 participant's navigation of the simulated ice field during field trails. Other pieces of data that can prove useful to determine the validity of this hypothesis are de-accelerations of the lifeboat during individual test runs, along with magnitude and frequency of impacts.

The paths taken through the course (Figures 8-10) highlight three different runs completed by participants from each group. On each figure, a perimeter run – performed by a member of the field trials team, collected DGPS data that established a path to compare the runs done by each participant, which were superimposed over the perimeter graph. Initial data indicates that the path taken by participants through the simulated ice field can also show how group training influenced the course each participant chose. This hypothesis will be tested further with the entirety of the subjects' data, to see if this emerging trend is a performance-indicating factor.

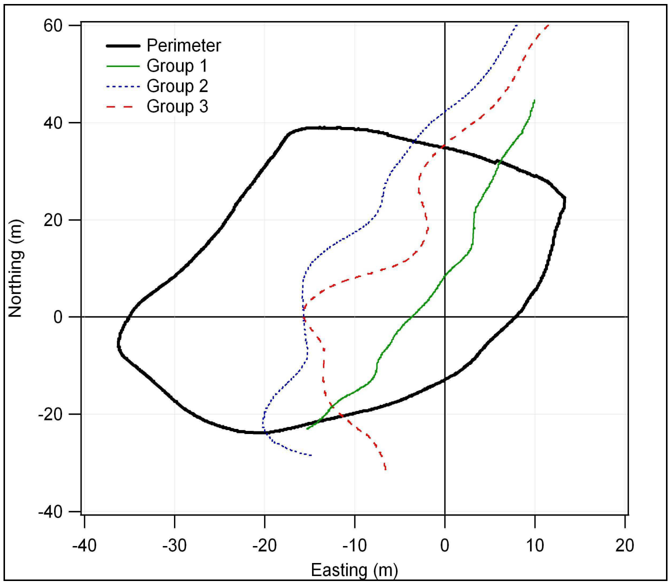

Figure 8. Test Run North to South: Northing vs. Easting

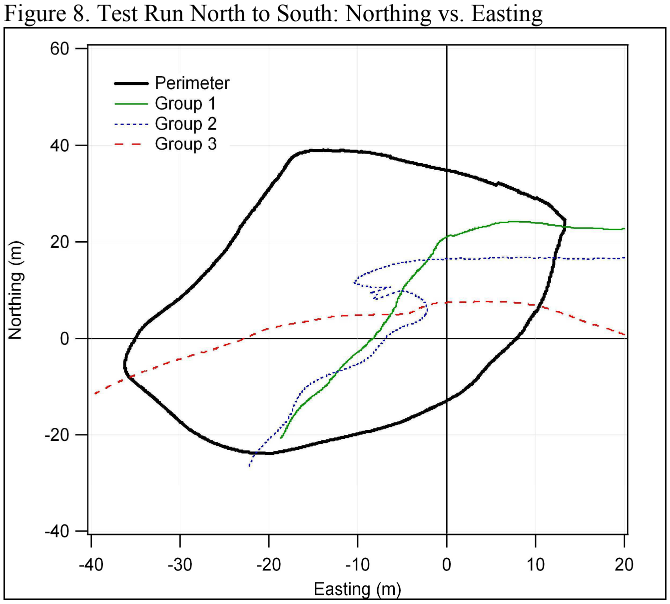

Figure 9. Test Run East to South: Northing vs. Easting

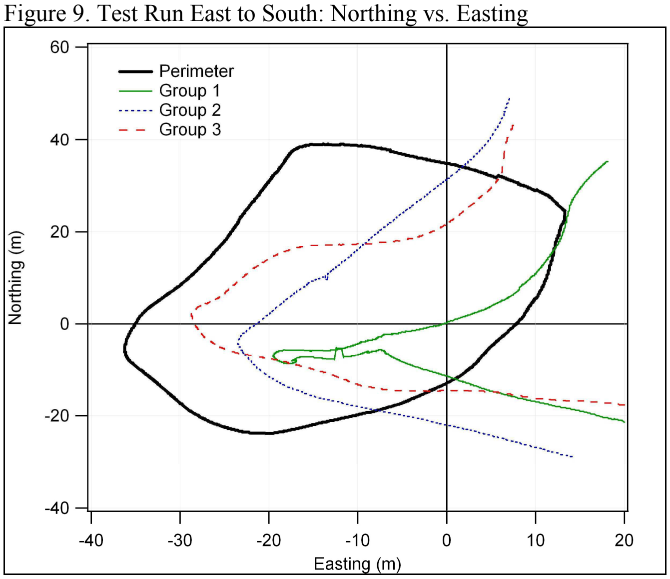

Figure 10. Test Run East to North: Northing vs. Easting

The path taken through the course is dependent on DGPS measurements. The size of the course shifted slightly each day during the test period because of varying weather conditions, although it is expected this will not heavily influence data. Weather conditions can influence the ability of participants to remain on course, especially if the wind velocity was high. Outside of these confounding factors, it is possible that the path taken through the course, as highlighted by Figure 8-10 can also determine if their training influenced the different choices made by participants. This will be considered during further analysis of the performance data.

Van Ravenswaaij-Arts *et al.* (1993) define heart rate variability (HRV) as “the amount of heart rate fluctuations around the mean heart rate.” Through spectral analysis of the two main peaks, low and high frequency regions, researchers can examine the response of the sympathetic and parasympathetic nervous systems, which are determining factors in stress response. It is hypothesized that participants from Groups 1 and 2 will exhibit higher levels of HRV due to their lack of experience maneuvering the lifeboat through the ice field, however, it is possible that Group 3 participants, who have never been inside a real lifeboat before may actually exhibit higher levels of stress. Data analysis is planned through wavelet analyses in IGOR.

Limitations

The test program was designed to minimize variability of the course participants drove through in the lifeboat. Due to a broad spectrum of weather conditions during the field trials, limitations in part can be attributed to the wind and weather conditions. Other limitations include malfunctioning of the ECG data acquisition system, small size of the simulated ice field, and finally, the fact that the course was made up of water barrels and rafts instead of ice, to maintain consistency in the course throughout the test program. This provides valuable information to the research team for future stages of this area of study.

CONCLUSIONS AND RECOMMENDATIONS

Preliminary examination of the data has shown that there can be possible correlations made between training and magnitude of impacts while navigating through the course. Other research completed at the Institute for Ocean Technology has shown that there is a threshold for damage cause by an impacts in ice with TEMPSC, depending on hull material and ice properties (Kennedy et. al. 2010). In future studies, it will be proposed that those who undergo simulation training are less likely to sustain damage to the lifeboat in ice-covered waters. This study has given proof of concept to the examination of simulation training for lifeboat coxswain training. Limitations will be addressed in Phase 2, set to be completed in Winter 2011, which will include creating a larger field, real ice targets for more realistic impacts and longer run trials, to induce more realistic stress response in participants. Also, expanding the training time would be recommended for Phase 2. It is expected that with longer training times for both control and simulator groups, participants will have more time to become acquainted with the lifeboat and more accustomed to the feel and behavior of the lifeboat. It is hoped that future research will further demonstrate that those who undergo simulator training attempt to navigate more diligently through ice fields.

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