Effect of Simulated Freefall Lifeboat Training on Launch Skill Acquisition

By

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Abstract

Freefall lifeboats (FFLB) are used worldwide as a means for evacuation and escape. Currently, FFLB launch training is normally restricted to benign weather conditions due to the inherent risk to personnel safety and asset integrity. Under such circumstances, the coxswain cannot develop the heuristic techniques necessary for launching under more likely dangerous and unpredictable evacuation and environmental conditions. Simulators can provide enhanced training opportunities for these conditions, so long as the simulation technologies and training paradigms address the contextual, mathematical and behavior demands of the physical training.

A high level of fidelity should invoke a level of participant presence suitable for performance-based learning and training objectives. The purpose of this research was to determine the effect of post-launch feedback on the rate of skill acquisition of novice participants performing simulated FFLB launches. Participants in two independent groups each went through 24 consecutive simulated launches under varying sea-states and visual conditions. One group was given pictorial feedback about the quality of each launch. The rate of skill acquisition and time to launch of this group was compared to a group that had no feedback.

Results show that: pictorial feedback did not affect launch success or time to launch of our FFLB launching trials, wave height had the greatest affect on launch success, visual clarity only had a significant affect on launch time in the no feedback group, and sense of presence was not affected by the inclusion of feedback or correlated to performance measures.

Key Words: Simulation, Presence, Free-Fall Lifeboat, Launch.

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

AI……………………………………….…………………Artificial Intelligence
ANOVA…………………………………..……………………Analysis of Variance
ARPA………………………………..……………Automatic Radar Plotting Aid
BST……………………………..……………………..Basic Survival Training
CAPP …………………………………Canadian Association of Petroleum Producers
CSA…………………………………...…………………….…Canadian Shipping Act
CIS……………………………………..…………………..Canadian Ice Services
CSV……………………………………..…………...….Comma Separated Value
DNV……………………………………..…………………Det Norske Veritas
EER…………………………………...………Escape, Evacuation, and Rescue
FFLB……………………………………..……………….…..Free-Fall Life Boat
HMD……………………………………..……..…………Head Mounted Display
HSE ……………………………………..…………..…Health and Safety Executive
HUET……………………………..……… Helicopter Underwater Escape Training
IMO………………………………..…………..International Maritime Organization
ISM………………………………..………..……International Safety Management
ISO……………………………………International Organization for Standardization
LCD………………………………..……………………...Liquid Crystal Display
LSA ……………………………………..…………………...Life Saving Appliance
MOUs…………………………………………….……………… Mobile Offshore Units
MPR…………………………………………...…..Marine Personnel Regulations
MSC ……………………………………………..…….Marine Safety Committee
OIM………………………………………………..…Offshore Installation Manager
PAR-Q………………………………....Physical Activity Readiness –Questionnaire
PBS…………………………………..………….……Performance Based Standards
PQ……………………………………..……………….……Presence Questionnaire
RNLI……………………………………..…..Royal National Lifeboat Institution
SA……………………………………..……………..Situational Awareness
SOLAS……………………………………..……………..Safety of Life at Sea
SMEs……………………………………..…………Subject Matter Experts
SSQ…………………………………………………Simulator Sickness Questionnaire
STCW…………………………....Standard Training, Certification, and Watchkeeping

SUS……………………………………………………………...……..Slater-Usoh-Steed

TARGETs…………………….....…Targeted Acceptable Responses to Generated Events

TEMPSC …………………………Totally Enclosed Motor Propelled Survival Craft

US……………………………………………………………………United States

UK…………………………………………………………………...United Kingdom

VE………………………………………………………………Virtual Environment

VMT………………………………………………Virtual Marine Technologies Inc

List of Appendices

Chapter 1 : Introduction

1.1: Background History

Launching lifeboats during an emergency abandonment scenario is a critical safety operation that generally will be undertaken in unfavorable conditions. The success of a marine evacuation is dependent on several factors, including the safety equipment itself, the people who have to use it, the nature of the hazard that initiates the emergency response, the prevailing environmental conditions, and the interaction of all these factors.

The importance of effective training in the overall safety management system has led to the assessment of methods for training lifeboat operators. Most lifeboat coxswains on ships and offshore installations learn how to operate survival craft through formal, live-boat training courses that comply with an accepted minimum standard, such as the International Maritime Organization's Convention on Standards of Training, Certification and Watchkeeping (STCW, IMO 1995). However, there are practical limits to what can be accomplished in such a training environment, particularly when the training itself can expose the trainees to risks of accident and injury. In the case of Free-Fall Lifeboats (FFLBs), it is not practical to use live-boat training for rough weather launches, as these operations are too dangerous to be undertaken for novice operators.

Sea trials are a poor method of investigating human performance issues for many reasons. Crisis situations cannot be safely replicated in live systems, and only a limited number of people can participate in a sea trial, making the observed results difficult to generalize to the entire marine community (Patterson, 2002). It is also impossible to control for external variables, such as swirling winds, changing weather and lighting conditions, and inconsistent swell heights which make it very difficult for investigators to identify cause-and-effect relationships relating performance and success. Having these factors controlled within a simulation environment allows us to identify which aspects of the launch have the greatest effect on human performance, and will allow trainers to effectively create training curriculum in these areas.

Researchers in the maritime safety field suggest that simulation training become a part of the training process for lifeboat coxswains, including traditional and other emerging methods (Barber, 1996). Patterson, McCarter, MacKinnon, Veitch, &

Simões Ré, (2011) highlight that lifesaving craft are used in scenarios that are generally characterized by rapidly escalating situations and adverse weather conditions. Simulation technology is being implemented to provide a safe means for offshore personnel to acquire experience launching survival craft in harsh weather conditions and under emerging hazard scenarios, such as low visibility and high sea states. Immersive full mission simulators, complemented by simpler multi-task and special-task simulation tools, have been developed to provide realistic, effective, and safe training for lifeboat coxswains. While the risk to the trainee is minimal in a simulation environment, the range of training experience can be increased beyond what could ever be safely done otherwise, thereby enabling trainees to improve situational awareness, develop skills, and practice procedures in order to elicit appropriate response in the real world.

It has been proposed that simulation must be presented to a trainee in a realistic manner in order to be accepted as an appropriate replacement for physical training (MacKinnon, Evely, & Antle, 2009). Tichon (2007) notes in her paper on training in virtual reality that “there is an important role for interactive simulators in replicating critical events and establishing them as a core component to cognitive skills training programs. Simulated environments provide safe, controllable environments in which necessary skills can be repeatedly practiced and the ability to demonstrate the effectiveness or otherwise of these applications rests on the development of *strong performance measures*.”(p. 288).

In studying the performance measures of the launching phase of a FFLB evacuation using a scale model, Simões Ré & Veitch (2007) found the setback due to the boat’s initial encounter with an oncoming wave, along with the progressive setback due to subsequent wave encounters were the most important factors in determining overall launch success. Setback occurs as the FFLB touches down into the water and the force of the oncoming waves push the FFLB back towards the installation that it is trying to escape. The amount of setback that is incurred by the lifeboat is determined mainly by two aspects of an oncoming wave; the phase of the wave in which the boat touches down, and the steepness of the wave. This research shows that when launching FFLB’s into heavy weather conditions, it is vitally important to hit proper wave phases to maximize the boat’s chances of successful sail away. As it would be too dangerous to practice this skill in live drills, offering a simulation alternative to trainees could be an effective way to achieve competency.

The existence of training transfer from virtual environments to the real world is not well documented. In early cases, those trained in the real world performed the task better than those trained in virtual reality (Kozak, Hancock, Arthur, & Chrysler, 1993). In more recent cases, participants executing a simple spatial task (Rose, Attree, Brooks, Parslow, Penn, & Ambihaipahan, 2000), performing aircraft maintenance (Barnett, Perrin, Curtin and Helbing, 1998), or practicing to use forestry machinery (Lapointe & Robert, 2000), there was no significant difference found between those trained using the real world equipment, and those trained in VR. This research indicates that VR may be as effective in training many tasks as real world training. This could in part be due to the improvements in simulation and VR technology as a result of computing technology advancements along with continued research into making reliable and valid VR systems. These innovations may be beneficial for training coxswains to launch into heavy sea states and low visibility as training in virtual reality takes the risks and dangers out of the learning process.

This experiment simulated the launch sequence of a free-fall lifeboat in various sea and visual clarity states using Virtual Marine Technology's (VMT) SurvivalQuest system and is particularly concerned with the performance measures defining where the boat makes first contact with the waves and the amount of time the participant takes to execute the launch the boat. The purpose of this research is to examine which aspects of the launch environment have the greatest effect on novice participant's performance, and to see if launch performance improves over the course of their training for extreme weather and high sea state launches. This will contribute to the growing body of knowledge regarding the need for increased specialized training for lifeboat coxswains.

1.2: Hypotheses

The Null Hypothesis for this experiment is that there will be no change in either the number of successful launches, or the time taken to launch between the no feedback and feedback groups. However, it is expected that the alternative hypothesis of a significant increase in successful launches, and a significant change in launch time by the feedback group as we predict they will be spend more time actively thinking about the outcomes of their launches. A significant change in launch time between the feedback and no feedback group may occur, as we predict that the feedback may either decrease launch times by giving participants additional confidence about their launches, or significantly increase launch times as they may begin to evaluate waves segments more hesitantly waiting for optimal sail away opportunities.

Chapter 2 : Review of Literature

2.1: Free-Fall Craft

In the early 1960s a departure from the conventional davit and fall launching system was first explored, and the development of free-fall launch began (Serco, 2007). The first free-fall launching apparatus was installed in 1961, although the system did not see widespread acceptance and use in the marine and offshore industries until the 1990s. The concept, which necessitated a complete rethink of the Temporary Enclosed Motor Propelled Safety Craft (TEMPSC) hull form and seating arrangements, abandoned davits, falls and hooks altogether in favour of releasing the craft and allowing it to ‘free-fall’ to the water.

Launching of free-fall craft is carried out in one of two ways; down an inclined plane away from the structure’s side to induce some forward motion before it falls free of the launching ramp, or being allowed to fall vertically, albeit with a bow down attitude. The free-fall TEMPSC differs considerably in hull form from the davit-launched craft because of the need to minimize hydrodynamic loads when it enters the water. To ensure the TEMPSC remains intact on entering the water from launch heights as great as 35 metres, as well as minimizing the decelerations on the occupants, the bow and forward canopy are designed to be submerged during launch and the hull’s deadrise is increased to facilitate water entry. Survivor seats are ergonomically shaped and orientated to minimize shock loadings on survivors. In many designs the seats face aft with high backs though in some craft they face forwards: this is in comparison to the benches around the sides and on the centerline of conventional craft (Serco, 2007).

Before entering the water, the craft may rotate slightly during the free-fall if the loading is not balanced, but should have sufficient stored forward momentum to clear the impact point and drift directly away from the vessel or installation. With the craft’s engine running and propeller engaged shortly before launch the craft can maneuver away seamlessly with reduced risk of backwash. However, depending on the direction and strength of wind and waves there is a possibility the TEMPSC may broach, set back, lie across the waves, or even capsize if conditions are severe enough. Although these are very real concerns it appears that little research has been undertaken into launch performance where the results are in the public domain. Even if scale or full-scale research is carried out interpreting the results is difficult; because the conditions existing at the moment of the craft's impact with the water, in what is an essentially a random seaway, are difficult to predict. Unfortunately this means there are no known criteria for the maximum sea state or wave directions where a good prospect of successful free-fall launch can be assumed (Serco, 2007).

2.2: Escape, Evacuation and Rescue (EER) Concerns

An examination of the various standards and regulations regarding lifesaving equipment and training processes recognizes the lack of training, testing and drills for adverse weather-related conditions. Totally Enclosed Motor Propelled Safety Craft (TEMPSC) has been designed as a temporary safe haven in the EER process. Research has shown that TEMPSC operations can be negatively affected by environmental conditions (Robson, 2007), yet these findings have not necessarily been considered when describing operational limits. In the majority of cases where performance data from research are available the operability limits tend to be expressed in terms of wind speed or the even broader measure of Beaufort force. Although there is a rough correlation between Beaufort force or wind speed and sea state there are a number of factors that affect both the significant wave height and, more importantly for boat launching, the wave steepness. The duration of a storm, the 'fetch' and water depth all play a part in creating wave heights and steepness that differ from place to place. Exposure to wind and wave conditions, along with launching and navigating away from the vessel or installation through ice or debris, is generally absent from international training standards.

Evacuation of offshore equipment can occur under a range of situations, from a routine training exercise, to a precautionary partial evacuation, or an emergency. The degree of stress and related human factors, and the degree of physical impairment of the installation and personnel will be related to the type of situation. An evacuation of healthy personnel carried out with well maintained equipment during a training exercise in good weather is likely to be more successful than an emergency evacuation of distressed and possibly injured personnel in foul weather with equipment that might be damaged by the event that caused the emergency.

The marine community has acknowledged the dangers related with practical drills for lifeboats that have resulted in injuries and casualties (Oil Companies International Marine Forum 1994, Marine Accident Investigations Branch Safety Study 1/2001). In light of this, regulations have been redefined for these drills through amendments to

SOLAS, and the requirement for launching full compliment lifeboats has been removed for participant and asset risk reasons (IMO, 2006b). Responsibility of performing lifeboat drills now lies with the Vessel Master or Offshore Installation Manager (OIM), depending on the environmental conditions (Patterson, 2007). This, along with the drastically decreased confidence of crews in the safety and practicability of lifeboat drills, has contributed to a culture of fear and unease surrounding them (Ross, 2006).

In some respects the historical approach to lifeboats/TEMPSC and other aspects of the evacuation sequence has been through the provision of effective and reliable EER equipment. This has been done at the expense of limited improvement, understanding and making meaningful estimates of what the limits of the equipment's operability would be. To some extent this is understandable as the number of incidents where installation evacuations are required is small and hence there is little real experience to consider. Even where data from such sources are available, it may be more subjective than that gathered by independent and verifiable means. Also, carrying out trials in adverse weather, and in doing so potentially exposing those involved to risk, may be morally difficult to justify. However, this leads to the training and skill evaluation of those involved in FFLB launching almost impossible to benchmark; even though it could have a profound impact on its success.

Training for TEMPSC operators is completed in harbours and sheltered ports under relatively nonthreatening conditions, because conditions more representative of extreme maritime environments (e.g. wind and waves) may pose unnecessary risk to trainers, students, and assets (Veitch, Billard, & Patterson, 2008b). Current regulations do not require operators, or duty holders, to demonstrate the capability of evacuation system performance as a function of weather conditions.

2.3: Simulation Training

The IMO's Marine Safety Committee (MSC) Circular. 1136 (2004) identifies the unacceptably high level of risk related with lifeboat drills, while still recognizing the importance of drills to gain experience in lifesaving system evacuation. In particular, this document distinguishes the benefit of simulation training in providing a realistic and safe environment for free-fall lifeboat training.

Simulated scale model experimentation allows for the investigation of evacuation performance and generate reliable data for empirical modelling that would otherwise be prohibitively dangerous to collect if done with full-scale manned equipment under controlled conditions (Simões Ré Veitch, & Spencer, 2010). The STCW Convention was revised in 1995, and changes were made to a number of regulations and recommendations, including possible inclusion of simulator-based training within the curriculum. Prior to 1995, little was published about the utility of maritime simulators for skill acquisition and trainee assessment. This changed when the United States and the United Kingdom brought position papers to the international level for the purpose of information sharing (Drown, 1996). Most recently, the IMO has introduced the 2012 Manila Amendments to the STCW Convention. These amendments contain improved guidelines on modern educational methods, such as distance and web-based learning.

There can be many reasons for advocating the use of simulation for training. Prof Peter Muirhead (2003) believed that the inexperienced mariner is likely to make errors of judgment early in any real ship training. The consequences of these errors could be both costly and catastrophic. In simulators, a mariner can make multiple errors, and receive extrinsic feedback to assist in improved performance onboard ships. Rapid repetition of difficult situations allows a review of tactics until a satisfactory conclusion is reached. Many situations cannot be experienced at sea. Emergency procedures, as well as maneuvering in difficult conditions or geographical locations are readily available only within simulator for safety reasons discussed previously. More importantly, the first-hand learning environment created by simulations is critical for enabling trainees to experience emotional arousal during performance episodes, develop an understanding of the relationships among the different components of the system, and integrate new information with their existing knowledge with a naturalistic environment (Keys and Wolfe 1990; Zantow, Knowlton and Sharp 2005; Cannon-Bowers and Bowers 2010).

An additional benefit of simulation training is the ability to provide refresher or recurrent training on board vessels and installations, making it possible for students to practice the skills they have gained (O’Hara, 1990). Simulator training is able to assist in the development of behavior patterns that students can draw upon during an emergency situation (Hytten, 1989) and expose them to important contextual characteristics relevant to the performance domain (Schiflett Elliott, Salas, and Coovert 2004). Muirhead (1996) defines “skill” in the simulator context as “the combining of mental and physical dexterity in the face of audio and visual cues to perform tasks to meet specific objectives" (p.259). The belief is that the skills and behaviors learned in a simulator will translate into real life situations and performance. The possibility of maintaining skill development and acquisition through at-sea training could give trainees an opportunity to have more frequent and recurrent training. Research suggests that continued skill development past the first successful demonstration of a skill set can lead to a better grasp of the desired tasks (Taber, 2010). Saus, Johnson, and Eid (2010) proposed that simulation training could be used as a means of improving maritime safety. Their research demonstrated that situational awareness (SA) could be improved through simulator training, especially in novice operators. Poor SA contributes to stress levels in both low and high workload situations, which in turn can cause more human errors. They advocate for the design of training to improve SA, since this could lead to greater prevention of human error. This supports their idea that simulation training can contribute to an enriched work environment.

Some experts in maritime education believe that simulation training could replace in-service training for seafarer certifications (Ali, 2007), with a month of sea service being replaced by one week of simulator time that would further enhance physical training (Drown, 1996). Yet, some experts (Muirhead, 1996) believe simulator training can never replace the real experience of physical training. He also reports that many watch keepers and senior maritime officers do not have the chance to acquire key skills, due to both safety and operational factors, and thinks that simulators may be able to aid in bridging this training gap.

Simulation training has emerged in a number of different areas as a potentially safe and effective alternative to traditional training methods. Simulation training can provide obvious training benefits, as such an environment can be used to assess learning aspects such as the capacity for developing and measuring situational awareness (Saus, Johnson & Eid, 2010), visual-spatial ability (Kewman, Seigerman, Kintner, Shu, Henson, & Reeder, 1985), and time-performance gains (Aggarwal, Black, Hance, Darzi & Cheshire,, 2006). However, the level of skill transfer to the real world is the critical component in examining the effectiveness of simulation training (Seymour, Gallagher, Roman, O'Brien, Bansal, Andersen, & Satava, 2002). Rose Attree, Brooks, Parslow, Penn, & Ambihaipathan (2000) examined learning and performance between virtual and real-time training; the results from this research demonstrated that those who completed virtual task training were less likely to be affected by unexpected interruptions than those who completed real task training. In a separate study, Barnett, Perrin, Curtin, and Helbing (1998) also concluded that training motor skills in VR and real-world environments yielded statistically similar results. The near-equality of VR and real world training for specific tasks presents a great advantage in training dangerous activities.

When properly used and supported by well trained and experienced instructors, simulator training should contribute to a reduction in accidents at sea and improve capability and efficiency of trainees, by providing them with the necessary experience and self confidence to carry out their onboard roles, functions and tasks.

2.3.1: Fidelity vs. Validity

Simulating emergency situations can contribute to confidence in performance and survival (Hytten, 1989). Although researchers differ on the level of fidelity required for a simulator to deliver expected skill acquisition outcomes (Dahlstrom Dekker, vanWinsen & Nyce, 2009), using a simulator to train for dangerous emergency situations has been shown to give trainees an increased confidence and competence towards future performance (Chopra, Gesink, DeJong, Bovill & Brand, 1994). Simulator training offers the benefit of delivering immediate performance feedback, and also allows for repetitive exposure to stimulus (Scalese, Obeso & Issenberg, 2007). Gallagher and colleagues (2005) further highlight the importance of error feedback in simulation training, as a participant will know the results of their actions immediately and experience realistic consequences associated with their choices without any real harm sustained.

Ali (2006) proposes there is a relationship between fidelity and validity in simulation training. Full mission simulators utilize the inclusion of the real world elements, such as authentic controls, spatial design and sight lines to closely replicate the real world environment. The inclusions of these elements also increase the simulation's training specificity, which has been researched and confirmed in many disciplines, and also contributes to validity of skill acquisition. He states, it is not appropriate to consider the 'amount of fidelity' as a substitute for validation of the system; However, there is generally more confidence in a high-fidelity system than a low-fidelity one (Ali, 2006). Fidelity can add to the validity of simulation; and although in the past it could affect the cost considerably, this relationship has changed with microprocessor development. However, it is necessary to study exactly what fidelity is adding to the effectiveness of simulation (Ali, 2006). If a virtual environment is accurately modeled after a real environment and possesses an increased number of specific contextual cues relative to the training task when compared to a desktop simulation of the same environment, the training conducted in such an immersive environment should yield better retention of task knowledge than a desktop simulation of the same environment (Jacquet, 2002). Some of the increased contextual cues in the virtual environment would include the spatial relationships in the task environment, such as the location of items in the work area with relation to each other and with oneself (Jacquet, 2002). Instead of looking at a flat picture of an environment, the individual immersed in a virtual environment can reach out and experience the spatial dimensions of the world, and sense the spatial relationships between objects. Because this environment contains more real world-like environmental cues, memories, and consequently learning, from this task environment may be more readily activated when the individual encounters the real world task environment in the future. Increased participant engagement should lead to less time for task acquisition, and improved retention of task knowledge (Jacquet, 2002).

Validation is an ongoing process and therefore when components of a system are changed they should be re-validated to ensure the fidelity level is consistent, if not lost. For example, new motions may be “poor” motion representations. The accuracy and fidelity of simulators can change dramatically from facility to facility. These variances can be caused by the differences in mathematical models used to develop the simulations, and facility operator modifications to models after installation. A number of facilities use in-house staff to develop their own models, which creates problems in reliably comparing data and results from one system to another.

To properly measure competency and proficiency in simulator training, as prescribed in the STCW Code A, the simulators in question should be appropriately validated for system performance, student performance (Muirhead, 1996), and instructor assessment (Barber, 1996; Drown, 1996; Ali, 2007). Muirhead (1996) suggests that outcomes must be based upon real world shipboard operations through criterion-based goals (p. 263). Having a trained instructor and assessor is very important to the delivery and validity of simulator instruction (Barber, 1996; Drown, 1996). Muirhead (1996) also proposes that those in charge of delivering simulation instruction should have formal simulator training certification. It is for this reason that institutions such as World Maritime University (Sweden), United States Coast Guard

(U.S.), and Transport Canada (Canada) continue the development of instructor courses for simulation training (Ali, 2007; Patterson, 2007).

Industry has been the driving force for regulation, specification, and classification of simulators in the last 10-15 years. Classification societies (such as Det Norske Veritas) have taken it upon themselves to publish standards for simulators (DNV, 2011) as one way to fulfill the requirements set out by the STCW code (Muirhead, 2006, DNV, 2011). Konsberg, a Norwegian company, has begun a project from a user-directed perspective that will examine simulation from a human factors point of view. As reported in Safety at Sea International, the company believes that aspects of human factors in simulation training are very important when examining and assessing the effectiveness of the training (Safety at Sea (45), 2011). The continued development of validation and certification processes for simulators and simulations should be endorsed. The extent to which accuracy of a simulation needs to be validated will depend on the proposed use of the simulation or the desired training outcomes.

2.3.2: Use Of Simulators in STCW training

There is a dedicated section of STCW Convention which highlights the *Use of Simulators*, as under;

Regulation-I/12-Use of Simulators.

Section A-I/12-Standards governing the Use of Simulators (Mandatory).

Section B-I/12-Guidance regarding Use of Simulators.

2.3.2.1:Regulation-I/12-Use of Simulators.

This regulation gives legal cover to the performance standards of marine simulators being used for the training and assessment of seafarers and their certification in compliance with STCW Convention.

2.3.2.2: Section A-I/12-Standards governing the Use of Simulators (Mandatory).

This section has two parts. The first part provides the performance standards of the simulators that can be used for the training and assessment of seafarers. STCW Convention desires physical and behavioural realism of the simulators appropriate to the training and assessment objectives. Capabilities and limitations of the original equipment along with possible errors should form part of the simulation. Simulators should be able to produce the emergency, hazardous and unusual conditions for the effective training value. The most important aspect of the performance standards in STCW Convention is the requirement of simulators to provide the simulator instructor with control and monitoring facilities along with recording equipment for effective debriefing to the trainees.

The second part provides the provisions for training and assessment procedures and discusses the simulator trainers and assessors standard conduct for simulator training. The STCW Convention foresees briefing, planning, familiarization, monitoring, and debriefing to be part of any simulator based exercise. It also highlights the importance of guidance and exercise stimuli by the instructor during simulation, and use of peer assessment techniques during the debriefing stage. Simulator exercises are required to be designed and tested by the simulator instructor to ensure their suitability for the specified training objectives.

2.3.2.3:Section B-I/12-Guidance regarding Use of Simulators.

STCW Convention has made only the RADAR / ARPA simulator training mandatory for the seafarers and in this section, it gives the detailed guidance how to use the RADAR / ARPA simulator for the training and assessment purposes.

2.4: Regulation and Training

The International Maritime Organization (IMO) is an international body that provides support, guidance, and defines international regulations and recommendations for member states on areas such as marine safety, security, and environmental preservation. The IMO is an United Nations Agency formed in 1948 to protect the lives of those who work at sea. Since then, IMO technical committees have been formed to address safety issues through conventions and committee reports. These committees are responsible for creating, updating and amending the standards, rules, and regulations used to prescribe training requirements. This international collaboration involves the participation of representatives from member states working toward developing an international culture of safety surrounding maritime industries around the globe.

The two primary Conventions established by the international community to ensure that seafarers are prepared to evacuate a vessel in the event of an emergency are the Seafarers' Training, Certification and Watchkeeping (STCW) and the Safety of Life at Sea (SOLAS) Conventions. STCW sets the requirements for initial and refresher training while SOLAS sets the requirements for on-board drills. Requirements for workers in the offshore oil and gas industry are contained in guidelines issued by the International Maritime Organization (IMO) in Assembly Resolution A.891(21) *Recommendations on Training of Personnel on Mobile Offshore Units (MOUs)*.

2.4.1: STCW and Training

Table A-VI/2-1 of the STCW Code outlines the minimum standard competence for seafarers in the operation of survival craft and rescue boats. The table lists five (5) core competencies that are further broken down into twenty (20) sub-elements. Given the nature of operating survival craft, the standard demands a practical demonstration of the competencies using real equipment.

Guidance for training providers is published by the IMO in the form of model courses. Model courses are developed by member countries and are the template courses for many countries when they approve their local training providers. The Government of India developed Model Course 1.23 *Proficiency in Survival Craft and Rescue Boats other than Fast Rescue Boats* and was published by the IMO in 2000.

While the IMO sets training standards, it is the duty of each individual country to set regulations and enforce the standards inside their jurisdiction. Within Canada, survival craft training is guided by the Canada Shipping Act, 2001 (CSA 2001), the Marine Personnel Regulations (MPR), and the technical publication *Marine Emergency Duties Training Courses* (TP 4957).

The CSA 2001 enables the Minister of Transport to make regulations regarding the training and certification of seafarers (CSA 2001 Part 3, Section 100) and requires Masters of Canadian ships to ensure that all crewmembers carry valid certificates (CSA 2001 Part 3, Section 82.(1)). The MPR identifies the minimum standard of training for officers and crews on board Canadian ships. MPR essentially enacts the STCW Code in Canada, as well as incorporates A.891(21) into Canadian legislation for the domestic offshore oil and gas industry. TP 4957 sets the detailed training requirements for course providers accredited to issue Canadian training certificates. TP 4957 incorporates much of Model Course 1.23, but also contains some elements unique to Canada and its operational environment.

2.4.2: SOLAS and Drills

While the STCW ensures that crewmembers have demonstrated their competence in the operation of survival craft, SOLAS ensures they develop and maintain proficiency in operating the craft on their particular vessel. Until recently, Regulation 19 under SOLAS Chapter III required that at least one lifeboat be lowered each month with its operating crew (Sect. 3.3.1.5.), and that each lifeboat be lowered, released and maneuvered by its crew at least once every three months (Sect. 3.3.3.). Provisions have been made for free-fall lifeboats that only require a full launch every six months or twelve months in the case where appropriate arrangements are made for a simulated launch every six months (Sect. 3.3.4.).

In Canada, the provisions for on-board drills are contained in the Boat and Fire Drill and Means of Exit Regulations. Section 18 of the regulations essentially repeats the SOLAS provisions by requiring each davit launched lifeboat to be launched and maneuvered in the water with its assigned crew at least once every three months (Section 18.(2).e.) and every free-fall lifeboat to be launched and maneuvered every six months (Section 18.(2).f.).

The need to periodically practice launching lifeboats with crew on board poses some significant safety hazards. A study published by the United Kingdom's Marine Accident Investigation Branch (MAIB), in 2001, noted that sixteen percent (16%) of the total lives lost over a ten (10) year period were due to practice launches and on-board inspections (Review of Lifeboat Launch Systems' Accidents). The MAIB report has triggered significant changes in the regulatory environment. The IMO has issued cautions about the risks involved with drills (See MSC.1/Circ.1206: Measures to Prevent Accidents with Lifeboats), and has implemented revisions to SOLAS Section 3.3.3 which no longer require that practice launches be conducted with crew onboard.

The ability to conduct drills using real equipment is constrained with the new SOLAS provisions. The decision to conduct a practice launch with crew onboard is left up to the Master who must also take into account the occupational health and safety implications of a crewed launch. Health and safety considerations, whether required through onboard International Safety Management (ISM) procedures or through national legislation (e.g.: Canada Labour Code), counter-balance the perceived operational or training benefits associated with having the crew onboard for a practice launch. In fact, mariner's view the new requirements effectively ban crewed launches during drills. While it *may* be feasible to conduct a practice in ideal conditions (after a thorough risk assessment is done and after a test lowering of the boat with no crew), it is unthinkable that a practice launch would occur in difficult conditions such as high seas or low visibility.

2.4.3: The Training Gap

The requirement under the STCW Code for a practical demonstration of the competence to operate survival craft immediately poses problems for those tasks that are too hazardous to perform in a training environment. In particular, students cannot demonstrate the "methods of launching survival craft into a rough sea". The prescribed training for rough weather launching is a lecture (See Model Course 1.23, Element 6.5 and TP 4957, Paragraph 11.6, Section 13.1).

Scalese, Obeso, & Issenberg, (2007) argue that within the domains of competence, we can assess learners at four different levels, according to the pyramid model conceptualized by Miller (1990). These levels are:

a) knows (knowledge)—recall of basic facts, principles, and theories.
b) knows how (applied knowledge)—ability to solve problems, make decisions, and describe procedures.
c) shows how (performance)—demonstration of skills in a controlled setting.
d) does (action)—behavior in real practice.

The inability to 'practice' or demonstrate skills in a controlled setting for difficult launch conditions during onboard drills reinforces the gap in training where difficult training launches are also avoided because they are too risky. As a result, the only time that a seafarer will be able to practically demonstrate their competence in rough weather launching is during an actual emergency.

The solution to the problem of safe but realistic training appears to lie within simulated environments. Simulators are already used in the marine industry to train ship's officers to work under unusual and fault conditions that would be too dangerous to practice using real equipment. This is another example of how simulation technology could fill a training gap for coxswains.

2.5:Launching and Set Back

Immediately after being launched into the sea, a lifeboat is prone to being pushed, or *set back*, by the advancing waves, particularly before it begins to make way. The distance that a lifeboat is set back due to its first wave encounter is an important performance measure. Previous tests have shown that set back distance increases with weather conditions (Simões Ré & Veitch, 2001). For a given weather condition, set back depends on the position on the wave that the boat is launched. The least set back occurs when the boat is launched on a wave crest or downslope; the most occurs when the launch occurs on the *upslope*, or face, of an advancing wave. In the latter case, maximum set back has been found to be approximately twice the wave height (Simões Ré & Veitch, 2001).

2.6: Simulation and Behaviour

Dr. Lochlan Magee, the head of simulation and modeling for the Canadian military, believes that at its most basic function a simulator acts as a human factors interface to a mathematical model. Dr. Magee’s description captures the two fundamental requirements for a marine simulator defined by STCW, in that it must possess sufficient physical and mathematical realism to provoke an appropriate behavioral response (Patterson, 2007).

A simulator’s ‘realism’ is normally sub-divided into two separate elements: mathematical realism and cueing realism (Veitch, Billard, & Patterson, 2008a). Mathematical realism relates to how the real world is represented mathematically in the simulator. Mathematical realism typically includes hydrodynamic properties of the vessel, environmental properties (waves for example), and navigation sensor properties. Key requirements for the mathematical models are that they must operate in real-time and be objectively measured. Cueing realism, on the other hand, relates to how the person using the simulator is cued to perceive the virtual world. Cueing realism relates to sights, sounds, motions, smells, etc. Cueing realism cannot be directly measured objectively and is evaluated subjectively, most often by questionnaires (Veitch, Billard, & Patterson, 2008a).

Appropriate behavioral responses convey to how the student reacts to the simulation. When the simulator cues a student, the student should react in the same way as if a similar cue happened in real-life. The simulator must provide sufficient cues for the student to recognize the situation and to take appropriate actions.

Simulators that trigger appropriate behavioral responses can be used by students to learn and demonstrate the competencies necessary to perform tasks, when real equipment is not a feasible training option.

Training simulators do not have to be an exact replica of the real world; however they have to be realistic enough so that skills acquired in a simulator can be used in the real world. Generally more complicated training requirements, require more sophisticated simulators. Implementing simulation into a training program requires matching realism to training objectives, and to strike a balance between mathematical and cueing realism. For marine training simulators a commonly used fidelity scale is: full mission (a high fidelity replica of the real-world intended for advanced training); multi-task (a medium fidelity replica of the real-world intended for operational training); limited-task (a partial replica of the real-world intended to develop basic skills); and, special-task or single-task (specialized simulator to teach particular skills) (Cross & Olofsson, 2000).

2.7: Implementing the Simulation Alternative

STCW envisions the use of simulators in a wide range of training applications as long as the program is approved by the local Administration (Transport Canada in the case of Canada). Individual Administrations determine if simulation is appropriate for a given training program, usually after considering if the simulator meets the functional requirements specified in Section A-I/12 of the STCW Code.

When the STCW deems simulation as a suitable method of demonstrating competence they add the phrase “approved simulator training, where appropriate” in column III, labeled “Methods of Demonstrating Competence” in the detailed competency tables. Recently, the table that includes lifeboat launching: Table A-VI/2-1 – was updated to include the simulation phrase so that simulators can be used to train seafarers to launch lifeboats as long as they are approved and appropriate. The Government of Canada had submitted the amendment for consideration at the 39th Session of IMO’s Sub-Committee on Standards of Training and Watchkeeping (STW) in March 2008.

Amending the STCW code to permit lifeboat simulation should trigger a review of the existing IMO Model Course 1.23 to make the necessary amendments to accommodate simulation-based training. In particular, practical demonstration of heavy weather launching using a simulator should be recommended rather than a lecture on launch technique. National training standards, such as TP 4957, should also be reviewed to shift rough weather launch training from lectures to demonstration in a simulator. Such revisions to the template training standards will bring the training regimes into alignment with Table A-VI/2-1 of the STCW Code that envisions practical demonstration for all aspects of lifeboat launching.

Once simulation is accepted as a training method for lifeboat crews, Administrations will need to approve individual simulation based training programs. Before approval, the Administration will need to be satisfied that the simulator meets the functional requirements defined in STCW, especially the two core requirements of physical and behavioral realism. Administrations can conduct their own assessment, or in some cases, accept a certification from Det Norske Veritias (DNV) that the simulator meets the requirements of guidance document 2.14 *Certification of Maritime Simulator Systems*. In either event, the accreditation criteria for lifeboat launch simulators do not currently exist and need to be developed. Memorial University of Newfoundland is presently conducting research to identify appropriate accreditation criteria.

SOLAS currently permits 'simulated' launches of free-fall lifeboats in lieu of actual launches with crews. In the case of free-fall lifeboats, the simulation envisioned is not a numerical simulation but rather a means to trap the boat and prevent it from launching from the ship. Regulation 19 of SOLAS should be amended so practice using a suitable numerical simulator would be accepted in lieu of crewed launches. The simulator could be brought on board or to the ship's side during port visits. The use of numerical simulators for practice drills would certainly outstrip current training scenarios; eliminate the critical safety issue of crewed launches; and, significantly raise the preparedness of the crew to react to an emergency.

2.8: Presence

In its most common usage in the Virtual Environment (VE) community, the term "presence" refers to a person's sense of physical location, that "of being" in a particular place. There is no standard recognized definition for presence; most of the literature, however, proposes something similar to the following: "Presence is the subjective experience of being in one place or environment, even when one is physically situated in another place or environment." Barfield *& Hendrix (1995)* define presence as “the participant’s sense of ’being there’ in the virtual environment”. This concept is confusing as its definition is relative to the understanding of the words ’sense’ and ’being’. Lombard & Ditton (1997) proposed to interpret presence as “a perceptual illusion of non-mediation”; presence is what happens when the participant ’forgets’ that his perceptions are mediated by technologies. This media-oriented approach allows one to analyze the causes of presence with objective variables: number and consistency of sensory outputs, visual display characteristics, aural presentation characteristics, interactivity, obtrusiveness of medium, and number of people involved. Witmer and Singer (1998), defined presence as the subjective experience of being in one place or environment, even when one is physically situated in another.

Defining presence has even become multidimensional in scope for some researchers, including a physical or perceptual dimension as well as a social dimension and co-presence. The physical dimension refers to the sense of being physically located in a mediated space (Lombard & Ditton, 1997). The social dimension is based on the perceived existence of others and the perceived possibility of interaction. Youngblut (2003) defines co-presence as “the subjective experience of being together with others in a computer-generated environment, even when participants are physically situated in different sites.” There are several things to note about this definition. First, like presence, co-presence is a subjective construct and the definition explicitly supports distributed VE applications. Also, in using the term “others,” we do not restrict ourselves to all the participants being human. Some may be computer-generated (artificial intelligence – AI) agents.

Social presence in the context of computer-mediated communications is an active area of research addressing issues in organizational communications, use of teleconferencing systems, and the role of Internet-based virtual communities. Social presence is a subjective phenomenon that depends on properties of the medium, the concept was developed to measure the ‘quality’ of a means of communication or, more specifically, to support comparisons between media for defined tasks. Most of the current measures of social presence for VEs are based on this early work, but some researchers have taken a different view. In this case, social presence goes a step further than co-presence to address social psychological ideas of personal interaction. Biocca (1997) believes “social presence occurs when users feel that a form, behavior, or sensory experience indicates the presence of another individual. The amount of social presence is the degree to which a user feels access to the intelligence, intentions, and sensory impressions of another.” This addresses more than a replication of face-to-face communication, reflecting awareness of another’s intelligence and intentions, and some sensory impression of the other.

2.8.1: Creating Presence

Research interest in presence is associated with the advance of technologies of communication, training, simulation, and entertainment. The aim of several research programs in this field is to optimize the user experience. The more real and the more engaging first-person experiences on virtual environments are, the greater the efficacy of training and education technologies. Generally, a strong sense of presence is a goal of most VE designers because of the assumption that with a greater sense of presence comes better performance of the task for which the device is being used. In short there is a pervasive belief that presence is causally related to performance. However, there is no clear evidence about the nature of this relation between presence and performance (Welch, 1999). Ma and Kaber (2006) did not find any relation between objective presence and performance. However, Witmer & Singer, (1998) found VE users frequently claim that they did better on a given task because of the strong sense of presence they experienced. Clearly more research is required to develop construct-valid measures of the presence concept.

2.8.2: Presence Questionnaires

Post-test questionnaires are the most frequently used measure of presence. These vary widely in scope and appearance, as the conceptualization of presence and context of its application has changed through differing studies. Some studies have only one general item addressing presence, while others have tried to develop questionnaires reflecting the multidimensional structure of presence.

There are several advantages of questionnaires. They generally have high face validity, meaning that they appear to measure the intended concept. They are relatively cheap, and easy to administer, analyze and interpret. Because they are administered afterwards, they do not interrupt the experience. Several questionnaires have been shown in studies to be sensitive to different levels of presence. The design and experimental usage of questionnaires has often gone hand in hand with theoretical development. By performing factor or cluster analyses, it is possible to identify underlying dimensions of the measured construct.

A main disadvantage of questionnaires is that they are retrospective and therefore rely on participant's memories, which are an incomplete reflection of the experience, and prone to several biases. For example, it seems likely that user's judgments will be more influenced by events near the end of the experience (recency effect). Questionnaires are also sensitive to demand characteristics, for example, the hints and cues in a research situation that may bias the participants' responses. For instance, Freeman, Avons, Pearson and IJsselsteijn (1999) have shown that simple post-test presence ratings are sensitive to the effect of unrelated prior training sessions.

Questionnaires have been shown to be sensitive enough to find differences in presence when used to examine: mode of locomotion (Usoh Arthur, Whitton, Bastos, Steed, Slater & Brooks, 1999), more sensory cues more presence (Dinh, Walker, Song, Kobayashi, & Hodges., 1999), and narrow versus wide field of view (Arthur, 1999). However a study that examined whether questionnaires could show differences in presence in participants that searched a real office as opposed to those who searched a virtual office raised inconclusive results (Usoh, Catena, Arman, & Slater, 2000). This brings into question the usefulness of questionnaires when comparing across different and/or no media, such as immersive virtual compared with real, and desktop compared to head-mounted display. However the ITC-SOPI questionnaire was designed to address this cross-media problem, though it is not yet widely used (Lessiter, Freeman, Keogh, & Davidoff, 2000).

2.8.3: Witmer & Singer Presence Questionnaire (PQ)

Witmer and Singer (1998) identified involvement and immersion as conditions for presence. Immersion is a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences. A VE that produces a greater sense of immersion will produce higher levels of presence. Witmer and Singer (1998) suggest that factors of immersion include isolation from the real world environment, perception of self-inclusion in the VE, the use of natural modes of interaction, and the perception of self-movement. Researchers including Slater and Wilbur (1997), Draper, Kaber, and Usher (1998) and Bystrom, Barfield, and Hendrix (1999) believe that immersion is based solely on the technological aspects of the system producing the environment. In other words, to be immersive, a system must possess a high-resolution display with a wide field of view. The system must also isolate the user from real world sensations such as light and sound to allow the user to become a participant in the VE, and not simply an observer of it.

Involvement is a psychological state experienced as a consequence of focusing one's attention on a coherent set of stimuli or meaningfully related activities and events. Involvement depends on the degree of significance or meaning that the individual attaches to the stimuli, activities, or events. In general, as users focus more attention to the VE stimuli, they become more involved in the VE experience, which leads to an increased sense of presence in the VE.

Witmer & Singer aimed to develop a measure of presence addressing factors that influence involvement and immersion. Main categories of such factors were derived from the work of Sheridan (1992) and Held & Durlach (1992):

- Control factors (degree, immediacy, anticipation, mode, and physical environment modifiability)
- Sensory factors (modality, environmental richness, multimodal presentation, consistency of multimodal information, the degree of movement perception, and active search)
- Distraction factors (isolation, selective attention, and interface awareness)
- Realism factors (scene realism, information consistent with the objective world, meaningfulness of the experience, separation, and anxiety/disorientation).

Thirty-two items were designed based on the above factors and tested for reliability. The final version of the PQ contained 19 items, rated on a seven point rating scale with a midpoint anchor (e.g., 1= not compelling, 4 = moderately compelling, 7 = very compelling).

The first version of the PQ was used in four experiments. In two experiments, participants performed psychomotor tasks in a simple VE. In the other two experiments participants learned complex routes through a virtual office.

Cluster analysis revealed three subscales: Involved/Control, Natural (in regards to human interaction with the simulator, how well the controls match their real world counterparts), and Interface Quality. PQ scores were then correlated with measures for constructs associated with presence. PQ scores were significantly correlated with the Simulator Sickness Questionnaire (SSQ) scores across experiments (Van Baren & IJsselsteijn, 2004). Significant correlations with performance of psychomotor tasks and spatial knowledge were found in some experiments, but not in others. No significant effect of natural interaction (head tracking) was found. A significant correlation was found with the Immersive Tendency Questionnaire (Van Baren & IJsselsteijn, 2004).

Usoh, Catena, Arman, and Slater (2000) have argued that presence questionnaires should be subject to a “reality test” where data obtained in a VE should be compared to data obtained in the real world. In such a study (n=20, between-subject design), they tested the PQ. It did not distinguish between real and virtual experiences.

Youngblut and Perrin (2002) gave an extensive overview of research that has been conducted with the PQ. The PQ gave consistent results (in two or more studies) for the factors: display field of view, head tracking, task-related experience, and gender. An experiment using the PQ and Slater-Usoh-Steed (SUS) questionnaire was conducted to investigate the relation between presence and task performance. Participants (n=40, between-subjects design) had to perform an aircraft maintenance procedure in a virtual world. The amount of practice was varied. An effect of practice was found only on the PQ Interface Quality subscale. The Involved/Control subscale correlated negatively with the number of errors. A significant correlation (r=.51) was found between the PQ and the SUS total scores, and also between all subscales. The authors concluded that their data supported the argument that the PQ and the SUS measured the same construct, but there was not enough evidence to draw conclusions about their validity.

2.8.4: Presence and Task Performance Measures

It has been proposed that task performance measures can be used as objective corroborative indicators of presence (Barfield & Weghorst, 1993). Though it is generally assumed that higher levels of presence are associated with better task performance, the exact relationship between presence and task performance remains unclear. To date, there is no firm evidence indicating a causal link between the two measures. Just as several characteristics of a VE can influence presence and task performance, characteristics of the user, such as ability and motivation, will influence task performance (Heeter, 2001). Task performance measures are only applicable in media environments where there is a clear task that should be performed.

In past research, task performance measures used when examining presence include completion time and error rate (Basdogan, Ho, Srinivasan, & Slater, 2000), number of actions (Slater, Linakis, Usoh, & Kooper, 1996), secondary task performance (Nichols, Haldane, & Wilson, 2000), and transfer to real world (Younblut & Perrin, 2002)

2.9: Feedback

Simulator based training has the ability of providing a breadth of knowledge which other wise could only be gained through years of real world experiences, or not experienced at all in safe real world training. Realization of this potential, however, depends upon the ability of simulator training program to take into account the special cognitive needs of the trainees and ability of the instructor to properly provide feedback to the trainees.

Feedback to the trainee regarding standard of performance is very important for maintaining interest and morale while improving performance (Stephen, 1985). With regards to effectiveness of the feedback provided to the trainees, Stephen said that two factors are important to be considered while providing feedback. First, timing of the feedback is very important. Some errors can change the subsequent run of the exercise and need to be corrected immediately. While other errors may take a series of trials to properly analyze their influence on performance. In these cases, it becomes more practical for the instructor to delay the feedback so it encompasses the full scope of the problem behaviour. Delayed feedback also helps the trainees with time to think and analyze their actions and consequences. The other factor influencing the performance feedbacks effectiveness is redundancy. Studies indicate that repetition of same feedback may reduce interest and motivation of the trainees.

While discussing the process of training on simulators, feedback provided to the trainees was divided by Stephen (1985) into three sub-categories;

1. **Intrinsic feedback** where trainee will come to know appropriateness of their actions through consequences achieved. This is the simplest form of the feedback and is always present in simulator-based training. It is duty of the

instructor to ensure trainee has the perception of high standards to compare his performance.

2. **Augmented feedback** can be provided to the trainees through providing the participant with an overview of their track followed and changes made. This bird's eye view will help them in understanding their successive inter-related actions with regards to consequences, and will even improve the intrinsic feedback's quality.
3. **Supplemental feedback** is highest form of feedback that can be provided to the trainee. When the participant is on task, their mind can become pre-occupied with the new information and they can come under stress and be unable to grasp new ideas or approaches. When the simulation is finished, providing them with a debrief of the exercise will be of great value as the trainee's mind will be free for self-criticism and true analysis of the actions taken during the simulator session.

Salas (2002) argues that performance in complex task simulations must be decomposed into its essential constituents and represented within the performance measurement. Doing this is critical for providing analytical feedback. For example, evaluation of a trainee in a simulation can be broken into functions of knowledge (i.e., did the trainee know what to do?), skill (i.e., did the trainee know how to apply knowledge of skills?), or motivation (i.e., did the trainee want to exhibit good skills?). These three options and any combination thereof are possible, and all require different feedback to correct the deficient competencies. It is very difficult to accomplish this without developing separate measures for each competency, and once these measures have been defined, it becomes important for the feedback to address them.

2.10: Assessment Problems and Issues

The Assessment process involves two concepts; *Performance Measures* identify how a trainee's performance is observed and recorded for evaluation by the instructor. *Performance Standard* is the level of performance that is established as acceptable and commensurate with the course objectives (Muirhead, 2003).

Both measures and standards can be subjective or objective. Objective measures and standards rely upon equipment that is able to give consistent and accurate measurement results. Subjective measures and standards rely primarily on the examiner's observation and interpretation of the performance.

Subjective evaluation and assessment of the trainee's performance is very delicate issue and needs special consideration. When using subjective measures and standards, it is very important to have subject matter experts (SMEs) as assessors to maintain validity and to use checklists and grading guidelines to maintain reliability.

A point to be noted here is that objective assessment was the traditional conceptual approach and always looks attractive and reliable. But with new requirements of competency based training and assessment, efforts to become more and more objective reduces the validity proportionately. This problem can be minimized by having qualified and experienced mariner as simulator instructor.

Muirhead (2006) describes the importance of monitoring and feedback to the assessment process. He mentions the work of Hooper, Witt & McDermott (2000), a pilot study utilizing hypertext and web tools to deliver exercise advice and feedback in electronic format with future trials looking at embedded online assessments. Muirhead also looks at Smith's (2000) investigation into the development of Instructorless Training, where a trainee can start, undertake and stop a simulator exercise, without any referral to an instructor. He concludes that although these are considered advances, Muirhead argues that such approaches place limitations on how the final judgment of the performance against set criteria is made. Understanding the varying levels of cognitive, affective and psychomotor skills that comprise the measure of performance becomes paramount, and visual perception by an experienced assessor must, or may, be mandatory. In most cases, determining competency to perform tasks or functions should not rely solely on technology as the yardstick of performance rather, it should be used as another supportive tool to the evaluation process.

2.11: Event-based measurement.

Salas (2009) defines an event-based measurement as a general approach to designing simulation scenarios and performance measurement tools that are systematically linked to competencies targeted for training. Targeted Acceptable Responses to Generated Events (TARGETs) (Fowlkes, Lane, Salas, Franz, & Oser. 1994) is an example of event-based performance measurement in simulation training. This is a structured observation methodology in which participants are exposed to scenarios consisting of contextually relevant exercises or tasks created by the researcher/trainer. These scenarios contain cues for the participant to exhibit behaviors that have been identified as important for that particular task. In addition to defining the tasks considered desirable to observe, the researcher/trainer must determine what an acceptable response to the scenario is *a priori* by means such as SME interview, task analysis, or investigation of standard operating procedures. Acceptable responses are determined in advance so that the observer can have a checklist at the time of the observation. This significantly adds to the reliability of the observational rating. Event-based measurement, such as the TARGETs methodology, provides the opportunity to observe behaviors that have a low frequency of occurrence in the real world and therefore are difficult to observe in a purely naturalistic setting (Fowlkes, Dwyer, Oser, & Salas, 1998).

Chapter 3 : Methodology

3.1: Participants

Fifty-four participants (46 male, 8 female) with a mean age of 23.0 ±2.9 years were recruited to participate in this study. Participants were recruited through the use of verbal scripts as presented to undergraduate classes at Memorial University, as well as written scripts that were e-mailed to possible participants by the research team (Appendix A). Participants were required to have no previous experience operating small marine crafts, and had to meet the following selection pre-requisites:

1. Not current holders of STCW (Standards of Training, Certification and Watchkeeping) lifeboat training certification
2. Little sensitivity to motion sickness
3. No health conditions that could be aggravated by increased anxiety
4. Lack of pre-existing heart or lung conditions that impair physical activity
5. Lack of pre-existing muscle or skeletal conditions that limit mobility
6. No fear of enclosed spaces

Those who met the above criteria were then screened and deemed able to participate by completing the Physical Activity Readiness Questionnaire (PAR-Q – Appendix B), All participants gave their written informed consent and were given the opportunity to discuss any concerns with the investigator(s) prior to participating in the study (Appendix C). Ethical approval for this study was granted by the Human Investigations Committee of Memorial University.

3.2: Equipment

Figure 3-1. Simulator and Instructor Station set up.

3.2.1:The Virtual Marine Technology (VMT) Survival Quest Simulator

The simulator represents the cockpit of a TEMPSC (totally enclosed motor propelled survival craft) freefall lifeboat with all the operating controls to launch and maneuver a lifeboat, including an ignition switch, battery switch, steering wheel, compass, and radio (see Figures 3.3 & 3.4). The simulator was mounted on a MOOG (Series 6DOF2000E Electric Motion Platform) actuator with six-degrees of freedom motion (see Figure 3.5) that replicated the boats rotation during freefall, as well as how the vessel would react to both hitting the water and the wave motions experienced while in the water.

The instructor's station gives the instructor the ability to apply a number of different variables to the training scenario including time of day, visibility, weather, seas state, and location (see Figure 3.6). The station also enables the instructor to monitor what the participant sees, as well as control the simulation scenario.

The visuals for the simulator were presented to the user through four 82 cm liquid crystal display (LCD) screens, consisting of four different views: two front windows, and windows on the port and starboard sides.

The instructor station of the simulator recorded data from each trial. A video camera and radio allowed for real time monitoring of the participant throughout the trials. Data were obtained by analyzing lifeboat simulator time and position co-ordinates during the simulation trials.

The dependent variables collected during this study include duration of each trial, vessel position at the beginning and end of each trial, and vessel rotation in the air.

Figure 3-2. Location of participant placement in the simulator.

Figure 3-3. Simulator navigation control panel complete with: steering wheel, inside and outside light switches, throttle, radio, and emergency stop button.

Figure 3-4. Simulator navigation control panel: the ignition switch and radio.

Figure 3-5. MOOG Series 6DOF2000E Electric Motion Platform Actuator

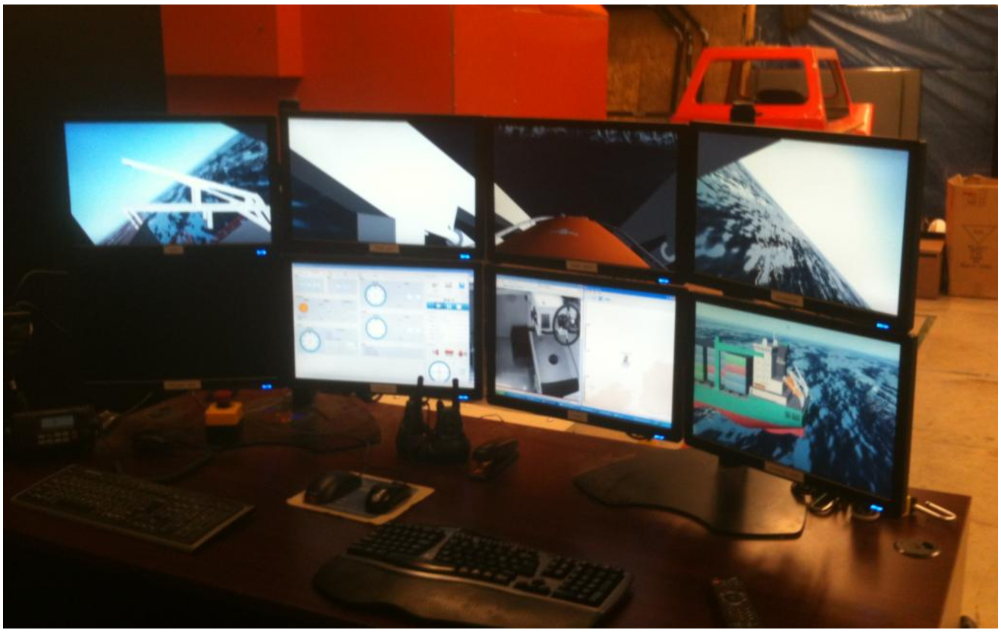

Figure 3-6. The Instructor’s Station.

3.3: Experimental Design

3.3.1: Lifeboat Launch Simulation

Participants arrived at the Virtual Environments Laboratory of Memorial University for one session lasting approximately 90-120 minutes. All participants were provided with the same pre-experiment training and experimental conditions. Participants received initial training, an overview of the simulator system, its operations and the objectives for the experiment. Participants were then briefed on the ideal launch orientation of the boat when it hits the waves, and potential real-life consequences of poor landing orientation. This was demonstrated using experimenter designed wave-quartile pictures (Figure 3.7) and viewing sample launch sequences of the simulation program from the instructor station and discussing the timing implication of proper launches.

The simulator launch trials for the practice and test phases were designed with consistent time of day and calendar date, as well as the lifeboat itself always launching in the north direction (0° compass bearing) to ensure that the only changes in visibility and light were caused by instructor manipulation. The trials were designed to provide the participant with various wave heights and directions, and various visual clarity states.

SurvivalQuest software makes it possible to manipulate many variables in a given trial. Wave heights can range from “0 – calm water” to “8 – moderately high waves of 5.5m - 7.5m”, wave direction can be expressed by any compass bearing (0° – 360°), precipitation of rain and snow can range from 0% to 100%, and visibility can range from 0 ft. to 100,000 ft.

Our study included two virtual wave heights as set by the SurvivalQuest software: “Size 5” waves (Moderate waves of 2-3m of swell) and “Size 8” waves (Moderately high waves of 5.5-7.5m of swell). It included 4 wave directions: South (180°), South-East (135°), South-West (225°) and North (0°). Finally, it contained three visibility states that were made up of different precipitation and visibility scores: “Clear” combined 0% precipitation with 100,000 ft. visibility, “Rain Storm” combined 100% precipitation with 10,000 ft. of visibility, and “Heavy Rain Storm” combined 100% precipitation with 500 ft. of visibility.

Participants were given a total of three practice launches into calm, moderate, and moderately big sea state conditions, and differing visual clarity states (Table 3.1). This mimics the STCW 1995 (Section A – VI/2, section 5.4 of the International Maritime Organization Model Course 1.23: students must complete a minimum of 3 practical launch/recovery exercises). All participants were given immediate feedback after each of the three launches by the instructor. After completing the practice launches, the participant began the experimental trials.

Table 3-1: Table of Practice Conditions

Practice Condition	Sea State	Wave Direction	Visual Clarity
1	0 - Calm	N/A	Sun
2	5 - Moderate	South	Rain Storm
3	8 - Moderately Heavy	South-East	Heavy Rain Storm

Participants were divided into two experimental groups, Group I and Group II. Both groups completed 24 experimental trial conditions (Table 3-2) in a randomized order. Group I was not provided any feedback regarding the success of the launch following each trial. Group II was provided with immediate feedback after each launch. Feedback was given in the form of a still image of the lifeboat on first contact with the wave. The picture was displayed on the starboard screen in the cabin of the lifeboat for fifteen seconds following the completion of the launch.

Table 3-2: Table of Experimental Conditions

Experimental Conditions			
Trial	Wave Height	Wave Direction	Visual Clarity
1	5	South	Sun
2	5	North	Sun
3	5	South-East	Sun
4	5	South-West	Sun
5	5	South	Rain Storm
6	5	North	Rain Storm
7	5	South-East	Rain Storm
8	5	South-West	Rain Storm
9	5	South	Heavy Rain Storm
10	5	North	Heavy Rain Storm
11	5	South-East	Heavy Rain Storm
12	5	South-West	Heavy Rain Storm
13	8	South	Sun
14	8	North	Sun
15	8	South-East	Sun
16	8	South-West	Sun
17	8	South	Rain Storm
18	8	North	Rain Storm
19	8	South-East	Rain Storm
20	8	South-West	Rain Storm
21	8	South	Heavy Rain Storm
22	8	North	Heavy Rain Storm
23	8	South-East	Heavy Rain Storm
24	8	South-West	Heavy Rain Storm

3.3.2: Landing Zones

Landing zones were defined by research results from Simões Ré, Pelley and Veitch (2003), specifically with regards to the performance measure of set back. When launching a TEMPSC, it is prone to being pushed, or set back by advancing waves before it begins to make way. The distance that a TEMPSC is set back due to its first wave encounter is an important performance measure with regards to successful sail away, which is illustrated in the top two panels of Figure 3.6. Set back depends on the position on the wave that the boat is launched; with the least set back occurring when the boat is launched on the peak or downslope of a wave, while the most set back occurs when the boat is launched on the upslope of a wave. If a lifeboat cannot begin to make way after initial set back (illustrated in panels 3 & 4 of Figure 3.6), then it should be deemed unseaworthy or incapable of being safely launched for those weather conditions (Atlantic Canada Offshore Petroleum Industry Escape, Evacuation and Rescue, 2010).

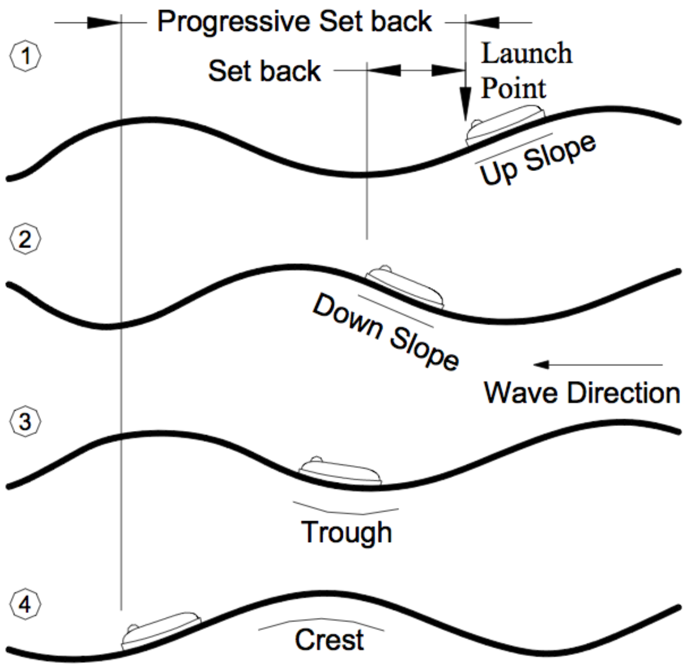

Figure 3-7. From Simões Ré, Pelley and Veitch (2003) - Setback and progressive setback

3.3.2.1:Landing Zone Scoring

Landing zone scoring was conducted by dividing waves into four equal parts, as illustrated in Figure 3.8.

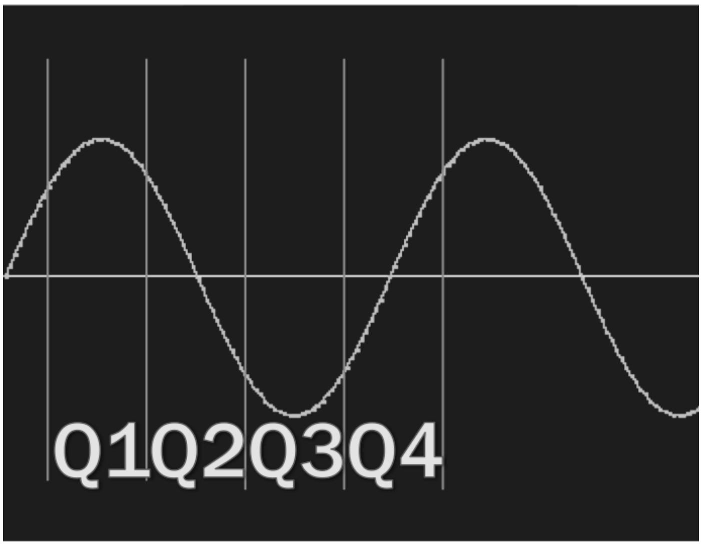

Figure 3-8. The four wave quartiles: Peak of a wave (Q1), the downslope running from peak to trough (Q2), the trough (Q3), and the upslope running from trough to peak (Q4).

Each launch was evaluated by the wave quartile in which the boat landed. Q2 was determined to be the most successful launch outcome (score of 4 points), followed by Q1 (score of 3 points), Q3 (2 points) and Q4 (1 point) respectively. Each participant completed 24 launches in the Survival Quest FFLB simulator. Waves were divided into four quartiles and participants were scored from 1-4 points according to the section of wave on which they landed (1 "upslope", 2 "trough", 3 "peak", 4 "downslope"). Therefore, performance scores for each participant could range from 24 (all upslope landings) to 96 (all downslope landings). As the FFLB contacted the water ten evenly spaced points along the long axis of the boat collected wave height information. A graphical analysis of these data was utilized to re-create the image of the landing position of the free fall lifeboat on the wave. Total Landing scores were calculated by summing each individual's launch scores from their 24 launches. Time to launch was recorded by the simulation program and was used to calculate mean times to launch.

3.3.3:Presence Questionnaire

After the participant's 24 experimental trials were completed each was instructed to complete a modified Witmer and Singer Presence Questionnaire (1998) that evaluated the quality of the simulated environment. Questions asked the participant to quantify the quality, responsiveness and involvement of different aspects of the simulator. Nine questions were graded on a scale from "0%" (not at all responsive / not at all involved / not at all easy to anticipate) to 100% (fully responsive / fully involved / very easy to anticipate), and three questions were open-ended short answer questions asking about the strengths and shortfalls of the simulated experience. Full questionnaire can be found in Appendix D.

3.3.4: Performance Measures

This experiment set out to examine if providing feedback will affect launch success of simulated free fall lifeboat launch operations across varying environmental conditions. Table 3.3 describes each metric of interest to this study.

Table 3-3: Performance Measures collected

Performance Measure	Derived Variables	Description
Position on Wave	Wave quartile analysis	Programmed recording of wave heights under boat as it hits the water, graphically plotted
Time	Total time to launch	Measured in seconds.
Presence Questionnaire	Subjective measure of simulator's ability to replicate real life	Scoring different elements fo the simulator with descriptive statistics.

3.4: Analyses of Performance Measures

The simulation program recorded wave position as the boat contacted the water and time to launch. Each file was transferred to Microsoft Excel and to be plotted and visually examined for the wave quartile and slope analysis. Analysis of variance (ANOVA) tests were then run to view the differences in mean scores between feedback/no feedback groups, wave height, wave direction, and visual clarity using SPSS v. 17.0. P values $< .05$ will be considered to identify statistical significance, while $p < .10$ will be considered approaching statistical significance as interpretations of these data are conducted.

Analysis of performance on specific trials was obtained by summing results of each participant's landing. As there were 27 participants in each group, theoretical scores can range from 27 (all upslope landings) to 108 (all downslope landings). Higher scores indicate a higher success rate of launches on that specific trial.

Analysis of skill improvement was obtained by comparing mean landing quartile scores, mean launch performance scores, and mean completion time of trials of each participants first six trials, trials 7-12, trials 13-18, and 19-24 respectively. It should be noted that because all participants completed their experimental trials in a random sequence that these groupings were always different.

Chapter 4 : Results

4.1: Performance Data

Analysis of variance between the feedback and no feedback groups showed there was no significant difference in mean landing scores (p = 0.137) or mean time to launch (p = 0.269) between the feedback and no feedback groups. These data suggest that the feedback was not sufficient in improving performance over the course of the trials (see Table 4.1).

Table 4-1: Performance measures by group assignment

Performance Measures		
	No Feedback	**Feedback**
Mean Score (St. D)	65.8 (6.8)	68.4 (5.8)
Mean Time to Launch (St. D)	20.4s (4.5s)	22.1s (6.1s)

Performance scores of specific trials are listed in Table 4.2 (see Table 4.2).

Table 4-2: Performance on each individual trial expressed by summed score and average time to complete.

Performance by Individual Trial									
				No Feedback		**Feedback**		**Combined Groups**	
Trial	Wave Height	Wave Direction	Visual Clarity	Mean Score	Mean Time	Mean Score	Mean Time	Mean Score	Mean Time
1	5	South	Sun	68	18	76	21	72	19.5
2	5	North	Sun	78	21	73	25	75.5	23
3	5	South-East	Sun	71	18	76	17	73.5	17.5
4	5	South-West	Sun	71	18	65	22	68	20
5	5	South	Rain Storm	71	19	76	22	73.5	20.5
6	5	North	Rain Storm	61	22	75	28	68	25
7	5	South-East	Rain Storm	58	20	61	21	59.5	20.5
8	5	South-West	Rain Storm	70	21	80	22	75	21.5
9	5	South	Heavy Rain Storm	77	22	74	28	75.5	25
10	5	North	Heavy Rain Storm	65	27	78	29	71.5	28
11	5	South-East	Heavy Rain Storm	67	19	70	21	68.5	20
12	5	South-West	Heavy Rain Storm	67	20	69	20	68	20
13	8	South	Sun	88	19	91	19	89.5	19
14	8	North	Sun	69	21	69	24	69	22.5
15	8	South-East	Sun	93	20	85	20	89	20
16	8	South-West	Sun	82	19	82	20	82	19.5
17	8	South	Rain Storm	74	21	94	23	84	22
18	8	North	Rain Storm	79	21	58	24	68.5	22.5
19	8	South-East	Rain Storm	72	20	77	18	74.5	19
20	8	South-West	Rain Storm	85	21	92	24	88.5	22.5
21	8	South	Heavy Rain Storm	80	20	94	21	87	20.5
22	8	North	Heavy Rain Storm	71	22	57	23	64	22.5
23	8	South-East	Heavy Rain Storm	84	20	89	20	86.5	20
24	8	South-West	Heavy Rain Storm	75	22	85	20	80	21

Analysis of variance showed significant improvements in performance scores and mean completion time as the trials progressed for the no feedback group (p = .036 & p = .018 respectively). Improvement in scores was caused by a significant decrease in upslope landings as trials progressed from a mean of 30.1% over the first six trials to a mean of 21.5% over the last six trials ($p = .017$). No significant changes in performance or scores were seen in the feedback group. See Table 4.3.

Table 4-3: Mean landing zone performance and completion times based on trial order of experience for the 'no feedback' and 'feedback' groups.

No Feedback						
	Upslope (1)	Trough (2)	Peak (3)	Downslope (4)	Mean Score	Time to Complete
1st 6 Trials	8	5	5	9	68	21.8 s
2nd 6 Trials	7	5	4	11	73	20.0 s
3rd 6 Trials	4	6	5	12	80	20.5 s
4th 6 Trials	6	5	7	10	75	19.8 s
Feedback						
	Upslope (1)	Trough (2)	Peak (3)	Downslope (4)	Mean Score	Time to Complete
1st 6 Trials	6	4	6	11	77	22.1 s
2nd 6 Trials	7	4	6	10	73	23.1 s
3rd 6 Trials	5	4	6	11	78	22.1 s
4th 6 Trials	6	5	5	10	74	20.8 s

Analysis on the effect of wave height, wave direction, and visual clarity were conducted. Results are presented as a percentage of total landings in each wave quartile for each condition (see Table 4.4).

Table 4-4: Landing zone performance based on wave height and visual clarity state expressed as a percentage.

No Feedback						
Sea State	Visual Clarity	Upslope (1)	Trough (2)	Peak (3)	Downslope (4)	Time to Complete
5	Sun	24.04%	20.19%	25.96%	33.65%	19s
5	Rain	34.62%	19.23%	23.08%	26.92%	21s
5	Heavy Rain	27.88%	19.23%	27.88%	28.85%	22s
8	Sun	16.35%	14.42%	18.27%	54.81%	20s
8	Rain	17.31%	25.96%	13.46%	47.12%	20s
8	Heavy Rain	17.31%	23.08%	19.23%	44.23%	21s

Feedback						
Sea State	Visual Clarity	Upslope (1)	Trough (2)	Peak (3)	Downslope (4)	Time to Complete
5	Sun	18.27%	22.12%	37.50%	25.96%	21s
5	Rain	18.27%	23.08%	33.65%	28.85%	23s
5	Heavy Rain	24.04%	17.31%	28.85%	33.65%	24s
8	Sun	24.04%	7.69%	13.46%	58.65%	20s
8	Rain	21.15%	13.46%	16.35%	52.88%	22s
8	Heavy Rain	17.31%	18.27%	14.42%	53.85%	21s

Analysis of affect of wave height was obtained by comparing mean landing quartile scores, mean launch performance scores, and mean completion time of trials 1-12 (size 5 waves) and 13-24 (size 8 waves) respectively. The no feedback group mean performance scores were 15% better in size 8 waves when compared to size 5 waves (p = 0.001). There was also a significant increase in the amount of downslopes hit between the two wave heights (48.72% for Size 8 waves as compared to 29.80% for Size 5 waves) (p = .001), and a significant decrease in upslope and peak landings (p = .001 and p = .047 respectively).

The feedback group performance scores approached significantly better scores – an 11% increase, when comparing size 8 results to size 5 waves (p = .056). There was also a significant increase in the amount of downslopes hit between size 8 waves and size 5 waves (55.13% for Size 8 waves as compared to 29.48% for Size 5 waves (p = .001), and a significant decrease in the number of trough (-7.7%) and peak landings (-18.9%) (p = .039 and p = .001 respectively) (see Table 4.5).

Table 4-5: Landing performance and completion time sorted by wave height.

Performance By Waveheight						
	No Feedback		Feedback		Combined Groups	
	Score Average	Time Average	Score Average	Time Average	Score Average	Time Average
Wave 5	68.67	20.42	72.75	23.00	70.71	21.71
Wave 8	79.33*	20.50	81.08**	21.33	80.21*	20.92

*Indicates significance at ($p < 0.05$)

**Indicates approaching significance ($p < 0.1$)

Analysis on the effect of visual clarity was obtained by comparing mean landing quartile scores, mean launch performance scores, and mean completion time of the sun, rainstorm and heavy rainstorm trials. The ANOVA indicated significant increase in mean completion time in the no feedback group caused by visual clarity (p = .048). However, visual clarity did not effect performance scores for either group, or mean completion time in the feedback group (p= .335, p= .996, & p= .440 respectively) (see Table 4.6).

Table 4-6: Landing performance and completion time according to visual clarity state.

Performance by Visual Clarity						
	No Feedback		Feedback		Combined Groups	
	Score Average	Time Average	Score Average	Time Average	Score Average	Time Average
Sun	77.50	19.25	77.13	21.00	77.31	20.13
Rain Storm	71.25	20.63*	76.63	22.75	73.94	21.69
Heavy Rain Storm	73.25	21.50*	77.00	22.75	75.13	22.13

*Indicates significance at ($p < 0.05$)

Analysis of the effect of wave direction was obtained by comparing mean landing quartile scores, mean launch performance scores, and mean completion time of trials grouped by wave direction. Mean completion times were significantly affected in both no feedback and feedback groups by wave direction ($p = .028$ & $p = .002$ respectively). North waves took the longest to complete with a mean time of 23.92s across all participants.

Wave direction also significantly affected the amount of upslope landings for the feedback group ($p = .010$), which had an approaching significance effect on the average scores of the feedback group ($p = .070$). See Table 4.7.

Table 4-7: Landing performance and completion time according to wave direction.

Performance by Wave Direction						
	No Feedback		Feedback		Combined Groups	
	Score Average	Time Average	Score Average	Time Average	Score Average	Time Average
South	76.3	19.8	84.2	22.3	80.3	21.1
South West	75.0	20.2	78.8	21.3	76.9	20.8
South East	74.2	19.5	76.3	19.5	75.3	19.5
North	70.5	22.3	68.3	25.5	69.4	23.9

4.2: Presence Questionnaire

The following questions were examined for the participant's responses on different aspects of the simulation experience. Analysis of variance determined there was no significant difference in mean response scores between the two experimental groups. Higher scores indicate a better presence experience by the participant, with the exception of question nine, which is inversely scored (see Table 4.8).

Table 4-8: Presence Questionnaire scale question results.

Presence Questionaire Results	No Feedback	Feedback
Scale Questions	**Mean (St. Dev.)**	**Mean (St. Dev.)**
1. How responsive was the simulated enviroment to actions you initiated (or performed)?	83.1 (8.2)	81.5 (9.5)
2. How natural did your interactions with the simulated environment seem?	76.3 (16.1)	75.8 (14.2)
3. How completely were *all* of your senses engaged?	74.3 (12.6)	71.9 (13.7)
4. How much did the visual aspects of the simulated environment involve you?	83.8 (12.6)	81.6 (8.4)
5. How much did the auditory aspects of the simulated environment involve you?	64.9 (21.7)	68.2 (20.3)
6. How much did the motion aspects of the simulated environment involve you?	83.7 (10.9)	87.3 (7.1)
7. Were you able to anticipate what would happen next, in the simulated environment, in response to the actions you performed?	73.3 (20.0)	72.8 (16.7)
8. How involved were you in the simulated environment experience?	81.3 (8.2)	80.7 (11.2)
9. How much delay did you experience between your actions and expected outcomes?	33.8 (23.7)	32.4 (23.4)

Further presence feedback was obtained through three open-ended questions about their simulation experience. Results are listed in Table 4.9.

Table 4-9: Presence Questionnaire additional feedback responses.

Presence Questionaire Results	No Feedback	Feedback
Short Answer Questions		
1. The aim of each launch was to time the release of the boat so you entered the downslope of the oncoming wave. Do you feel that you improved upon your performance as the testing proceeded?	22/26 Yes 1/26 No 2/26 Maybe	23/28 Yes 3/28 no 3/28 Maybe
2. Of the complete simulation, which aspect (i.e. motion, visuals or auditory) did you find the MOST realistic?	20/31 Motion 10/31 Visual 1/31 Audio	22/36 Motion 10/36 Visual 4/36 Audio
3. Of the complete simulation, which aspect (i.e. motion, visuals or auditory) did you find the LEAST realistic?	15/23 Audio 6/23 Visuals 1/23 Motion	17/29 Audio 6/29 Visuals 2/29 Motion

4.3:Presence & Performance Score Relations

Correlations between performance measures and presence questionnaire responses were conducted to observe potential relations. Results are listed in Table 4-10.

Table 4-10: Correlations between Presence Questionnaire scores and Performance Measures.

Correlations													
	Measure		**Time**	**PQ1**	**PQ2**	**PQ3**	**PQ4**	**PQ5**	**PQ6**	**PQ7**	**PQ8**	**PQ9**	**Score**
Kendall's tau_b	**Time**	Correlation Coefficient	1	-0.101	-0.125	-0.046	-0.129	-0.058	-0.17	-0.16	-0.079	-0.066	0.048
		Sig. (2-tailed)	.	0.316	0.21	0.645	0.201	0.558	0.094	0.103	0.431	0.504	0.62
		N	54	54	54	54	54	54	54	54	54	54	54
	PQ1	Correlation Coefficient		1	.510**	.269**	.327**	.302**	.420**	.283**	.460**	-0.09	-0.106
		Sig. (2-tailed)		.	0	0.009	0.002	0.003	0	0.005	0	0.377	0.294
		N		54	54	54	54	54	54	54	54	54	54
	PQ2	Correlation Coefficient			1	.434**	.414**	.341**	.443**	.288**	.517**	-0.128	-0.098
		Sig. (2-tailed)			.	0	0	0.001	0	0.004	0	0.201	0.327
		N			54	54	54	54	54	54	54	54	54
	PQ3	Correlation Coefficient				1	.340**	.346**	.223*	.238*	.410**	-0.037	-0.034
		Sig. (2-tailed)				.	0.001	0.001	0.03	0.017	0	0.711	0.734
		N				54	54	54	54	54	54	54	54
	PQ4	Correlation Coefficient					1	.217*	.439**	.259*	.454**	-0.028	-0.19
		Sig. (2-tailed)					.	0.032	0	0.01	0	0.779	0.058
		N					54	54	54	54	54	54	54
	PQ5	Correlation Coefficient						1	.301**	.223*	.304**	-0.026	0.03
		Sig. (2-tailed)						.	0.003	0.024	0.002	0.792	0.758
		N						54	54	54	54	54	54
	PQ6	Correlation Coefficient							1	0.144	.526**	-0.023	0.001
		Sig. (2-tailed)							.	0.158	0	0.82	0.994
		N							54	54	54	54	54
	PQ7	Correlation Coefficient								1	.293**	-0.046	0.005
		Sig. (2-tailed)								.	0.004	0.641	0.958
		N								54	54	54	54
	PQ8	Correlation Coefficient									1	-0.131	0.043
		Sig. (2-tailed)									.	0.193	0.666
		N									54	54	54
	PQ9	Correlation Coefficient										1	-0.164
		Sig. (2-tailed)										.	0.095
		N										54	54

Correlations													
	Measure		**Time**	**PQ1**	**PQ2**	**PQ3**	**PQ4**	**PQ5**	**PQ6**	**PQ7**	**PQ8**	**PQ9**	**Score**
Spearman's rho	Time	Correlation Coefficient	1	-0.136	-0.167	-0.058	-0.169	-0.075	-0.23	-0.225	-0.092	-0.101	0.076
		Sig. (2-tailed)	.	0.327	0.226	0.679	0.222	0.592	0.095	0.102	0.507	0.466	0.586
		N	54	54	54	54	54	54	54	54	54	54	54
	PQ1	Correlation Coefficient		1	.634**	.346*	.429**	.391**	.521**	.355**	.566**	-0.125	-0.126
		Sig. (2-tailed)		.	0	0.01	0.001	0.003	0	0.008	0	0.367	0.364
		N		54	54	54	54	54	54	54	54	54	54
	PQ2	Correlation Coefficient			1	.556**	.539**	.420**	.542**	.381**	.658**	-0.177	-0.114
		Sig. (2-tailed)			.	0	0	0.002	0	0.005	0	0.2	0.41
		N			54	54	54	54	54	54	54	54	54
	PQ3	Correlation Coefficient				1	.443**	.442**	.307*	.312*	.517**	-0.051	-0.027
		Sig. (2-tailed)				.	0.001	0.001	0.024	0.022	0	0.714	0.846
		N				54	54	54	54	54	54	54	54
	PQ4	Correlation Coefficient					1	.275*	.527**	.339*	.558**	-0.048	-.270*
		Sig. (2-tailed)					.	0.044	0	0.012	0	0.731	0.048
		N					54	54	54	54	54	54	54
	PQ5	Correlation Coefficient						1	.385**	.283*	.371**	-0.03	0.049
		Sig. (2-tailed)						.	0.004	0.038	0.006	0.829	0.727
		N						54	54	54	54	54	54
	PQ6	Correlation Coefficient							1	0.196	.646**	-0.033	0.01
		Sig. (2-tailed)							.	0.155	0	0.812	0.94
		N							54	54	54	54	54
	PQ7	Correlation Coefficient								1	.388**	-0.046	0.009
		Sig. (2-tailed)								.	0.004	0.739	0.95
		N								54	54	54	54
	PQ8	Correlation Coefficient									1	-0.175	0.077
		Sig. (2-tailed)									.	0.205	0.582
		N									54	54	54
	PQ9	Correlation Coefficient										1	-0.219
		Sig. (2-tailed)										.	0.111
		N										54	54

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Chapter 5 : Discussion

5.1: Introduction

The results presented provide benchmarks of completion time and success rate of simulated FFLB launches into varying sea and weather states by novice operators. Our experiments are concerned only with the launching phase of the FFLB evacuation in an emergency response, which in real emergency procedures may also include an escape before evacuation and rescue after it.

The performance of the evacuation systems in the tests did not include mechanical issues, such as the reliability of the equipment, or launch failures due to design and operational faults, and the boat from which the FFLB was launched was a fixed object in the sea that was unaffected by wave swell.

This study set out to examine whether the addition of pictorial feedback post-launch and landing would lead to better subsequent launches performance by novice TEMPSC operators. It was hypothesized that those in the feedback group would perform more successful landings through out their trials, as well as having a significant change in launch time.

The most important findings from this study are:

- Wave height had the greatest effect on launch success.
- Pictorial feedback did not affect launch success or time to launch of our FFLB launching trials.
- Visual clarity only had a significant effect on launch time in the no feedback group.
- Sense of presence was not affected by the inclusion of feedback

5.2: Wave Height performance

Landing performance was significantly better for size eight waves than size five waves (Table 4-5). This increase in performance was, however, not accompanied by faster launch times. This may be due to increased visual cues presented with the larger wave 8 size, along with generally longer wave periods that meant bigger landing zones for the boat to touch down in than the smaller size 5 waves presented by the SurvivalQuest software.

This will become important for training protocols as it appears that as the operational limits of a FFLB (as determined by wave height) is reached, launching the boat may not be as big of a concern as properly maneuvering it after launching. The lower success rate in the size 5 wave launches indicate that when developing training protocol, some focus must be placed on the relatively smaller waves that have the potential to set back the FFLB into the installation it is trying to escape even though managing the rest of the evacuation may be simpler.

5.3: No difference in launch success as caused by visual clarity states or wave direction.

While there was a significant increase in launch time for the no feedback group caused by the different visual clarity states, there were no overall difference in launch success as a result of visual clarity states or wave direction (Tables 4-6 & 4-7). While the decreased visibility states may have a greater effect on the coxswains navigation of the FFLB to a designated safe area after launch, placing greater emphasis on the use of the compass for direction, it does not appear to significantly affect either launch time or success for launching into these wave types. Future testing should investigate whether the different visual clarity states have an effect on the boats navigation times and distances in the water. A study by Bradbury-Squires (2013), found no difference between participant’s navigation time and distance travelled through a multi-level oil platform virtual environment between a daytime scenario and nighttime scenario. Further testing should be done in this area to confirm if these results transfer to water navigation tasks.

5.4: No difference in launch success between groups

Analysis of the results shows that there was no difference between the feedback and no-feedback groups in launch success and launch time between the groups (Table 4-1). To further examine this finding we will look more closely at the data collection tools used and feedback quality.

5.5: Developments for Data Collection

The research team developed many data collection tools that will aid further research with this simulator. Many shortcomings can also be addressed in future software versions. Comma Separated Value (CSV) files were used to collect the time to launch and wave height data from each launch. Time was collected to the nearest tenth of a second, while wave height information was collected by pulling the mathematical wave information from directly underneath the FFLB at ten places equally spaced along the boats long axis as it hit the water. This technique's major shortfall was that it could not properly record successful launches into barreling waves as the parameters for success on those waves was different from all others tested. Developers began work to improve data collection by also collecting three points from the horizontal plane of the FFLB, but did not pass pilot testing while the data collection for this study was taking place. Another improvement made to the CSV file collection was pulling a second set of wave height data three-tenths of a second after the boat hit the water. This allowed a further verification of the wave phase for the boat's landing when choppy waves made assessment difficult.

Pooling of each participant's launching data were completed though the use of a Microsoft Excel template that would calculate slope information from the wave as well as graph it for experimenter evaluation of wave phase. This information could then be easily sorted to allow for further statistical analyses for both launch scores by situation, as well as launch scores improvements through trial progression.

5.6: Pictorial Feedback

Analysis of task performance in this study demonstrated that pictorial feedback had no effect on the success rate of a FFLB launching simulation into heavy sea states and various visual clarity conditions for novice operators. Hypotheses as to why this was the case for this study will be discussed further in sections 5.6.1 and 5.6.2.

5.6.1: Developing the Feedback

The pictorial feedback for the SurvivalQuest system was developed by having the software take a screenshot of an external view of the lifeboat perpendicular to the long axis of the waves as it touched down in the water. This way, the participant could best view the phase of the wave on which they landed, as their relation to the wave would be most evident. The image was displayed on the starboard window screen of the boat.

In the pilot stages, investigators and developers had hoped to use full video feedback after each trial, however, this proved impossible, as the software script to create waves, Vega Prime Marine by Presagis, could not be saved concurrently with the rest of the aspects of the launch trial. Thus, the launch time could be recorded for a given sequence, but the wave sequence that is randomly created at the start of each trial would be different (for both the original trial and the feedback recording), leaving the feedback unsatisfactory.

Text feedback was hoped to supplement the pictorial feedback with slope and wave quartile information. However this too failed pilot testing as angled and horizontal waves could not be read with enough reliability to produce accurate feedback to the participant’s landing position.

5.6.2: Shortfalls of the Feedback

Relying solely on pictorial feedback put much of the influence on the quality of the feedback on the visual aspects of the waves as they approached the FFLB. In the case of size 8 waves, feedback was generally informative as it was easy to discern the wave phase landed in and then reason what would be needed to fix subsequent launches.

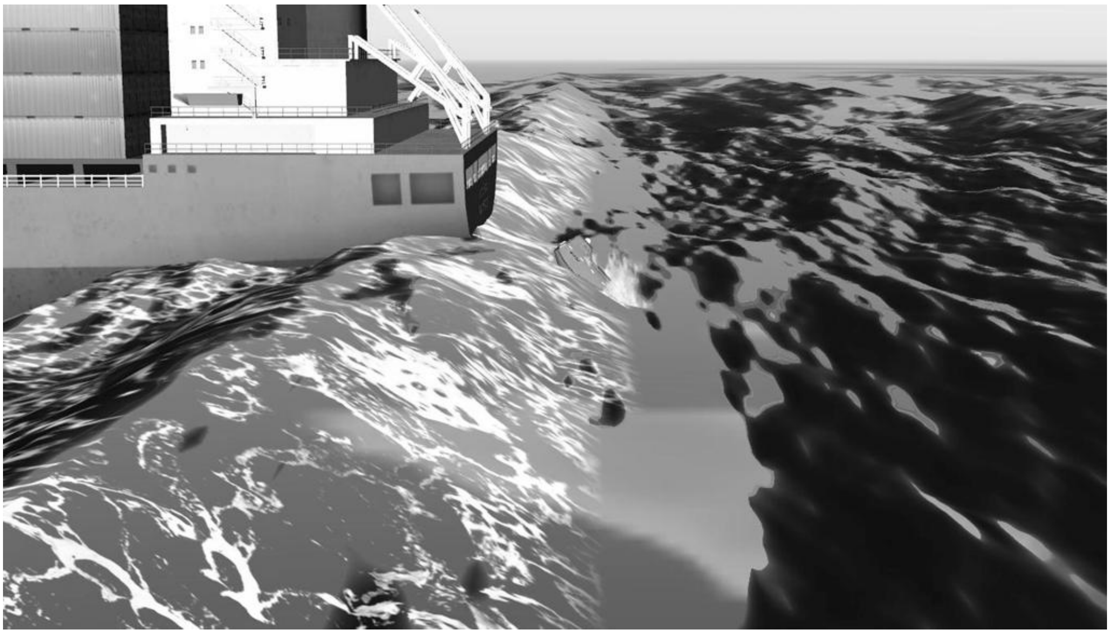

Figure 5-1: Feedback picture of a successful downslope landing of the FFLB into size 8 waves moving south.

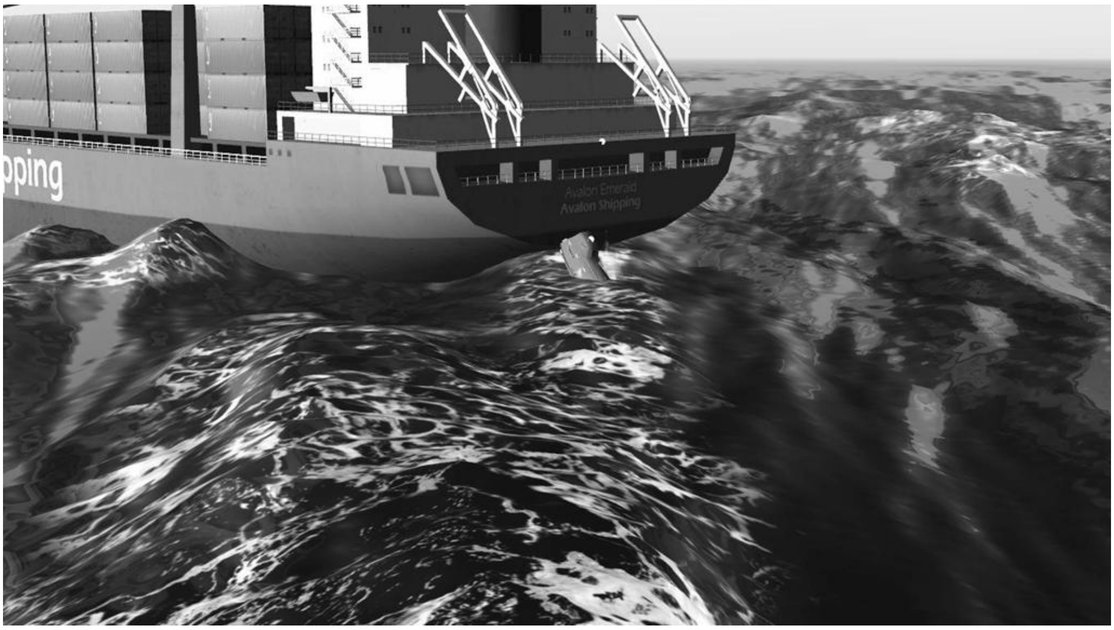

Figure 5-2: Feedback picture of a peak landing of the FFLB into size 8 waves moving southeast.

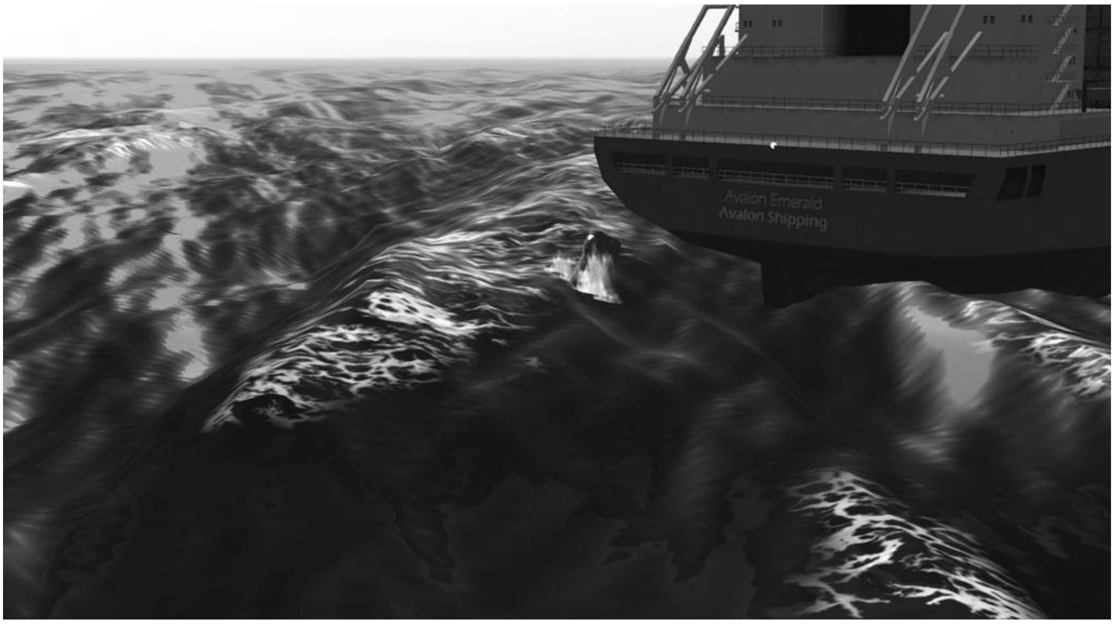

Figure 5-3: Feedback picture of an upslope landing of the FFLB into size 8 waves moving southwest.

Figures 5.1, 5.2, and 5.3 illustrate three examples of the feedback provided from the larger wave height. The white caps of the waves are easily viewed and launching decisions can be easily made according to their position. However, effective feedback for size 5 waves depended largely on spotting the wave crest break line as other aspects of the wave period were not often clear enough to present information to the participant. In some cases these lines were choppy or non-existent in the feedback picture making it hard to tell if launches were successful in real time.

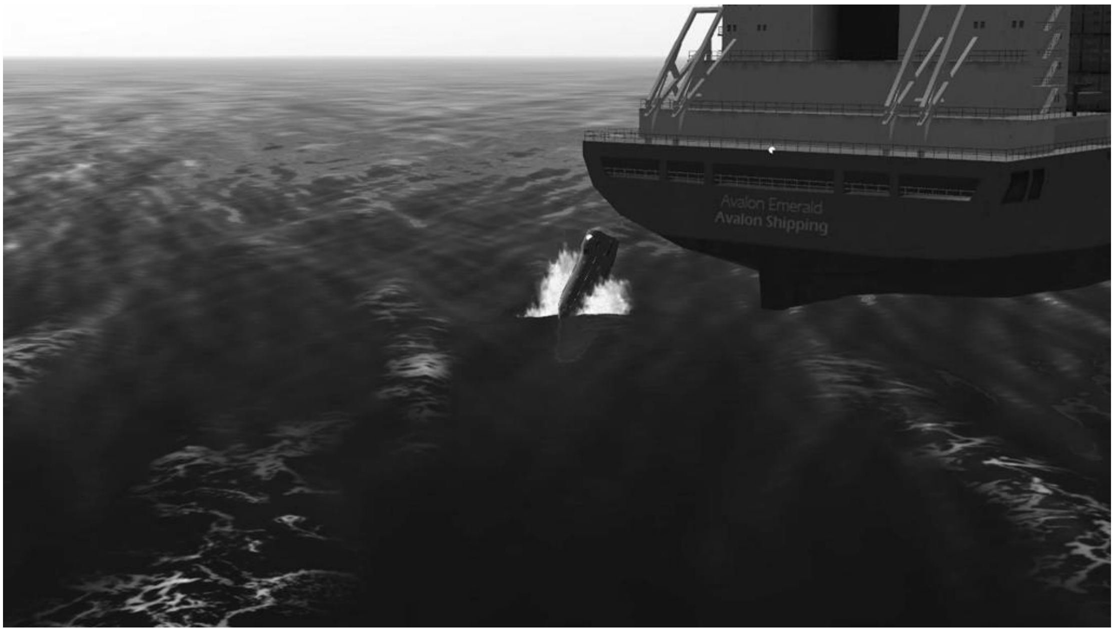

Figure 5-4: Feedback picture of a successful downslope landing of the FFLB into size 5 waves from the southwest.

When observing Figure 5.4, it could be argued that it looks as though the boat is touching down directly between two wave crests in a trough. However, analysis of the wave information provided by the CSV output revealed a downslope landing. While the wave information points would be from before reaching the deepest point of the trough (as that is where the nose is touching down), it would be hard for a novice FFLB launcher to correctly evaluate this feedback as a successful launch.

5.7: Time as a metric

Providing a trainee with feedback requires the trainer to be able to objectively assess performance through the use of metrics. The formulation of metrics requires breaking down a task into its essential components (task deconstruction) and then tightly defining what differentiates optimal from suboptimal performance. While the task of launching a FFLB has been deconstructed well by Simões Ré & Veitch (2007), the time aspect of launching needs more attention from the training and simulation industry. While many VR simulators use time as a metric, as an independent variable the use of time is at best a crude and at worst a dangerous metric. For example, being able to launch an FFLB quickly does not give a full indication of the quality of the launch. While evacuation is a time sensitive task, it is unknown how much increased (or decreased) launch time could affect overall launch and escape performance. The hypothesis that time to launch would significantly decrease due to feedback was linked with the hypothesis that performance for the feedback group would also be significantly different leading to a cause and effect conclusion. In this case, if time to launch had increased with feedback, we could infer the participants were more selective of the wave onto which they launched. Conversely, if launch time decreased with better performance scores, we could infer that feedback provided positive reinforcement and improved confidence over sequential launches. It will be important as research moves forward to track the trend between launch time and success to see what changes may occur between the two measures. Ideally, as a coxswain gains experience launching, it would be expected that the number of successful launches to trend upward while their time to launch would have a decreasing trend. Further studies wishing to quantify the effect of experience on launch time should include trial reoccurrence (as every launch situation was only experienced once in our testing), as well as follow up sessions to evaluate session-to-session changes.

5.8: Presence

Presence scores were generally high on their aspect scales and were not significantly different between the groups. This indicates that participants perceived presence during the trials was not affected by the inclusion of feedback.

Future studies can explore if these measures are consistent across other types of presence questionnaires, and investigate how different questionnaire answers correlate to physiological measures associated with presence throughout the simulation experience as participants complete the trials either in the full mission simulator or a desktop version of the SurvivalQuest system. These tests would further investigate how presence and immersion could influence learning and retention of FFLB launching skills.

In a study (Skalski et al, 2011) that compared realistic mapping controllers (e.g. steering wheel) to other non-realistic mapping controllers (joystick, keyboard), it was clear that a controller that replicated the real behaviors (steering wheel) in the virtual environment led to increased levels of presence and enjoyment. Tamborini and

Skalski (2006) argue that this effect is related to the participant’s ability to access mental models of the behavior more quickly and accurately using the realistic natural mapping controllers.

5.9: Moving Forward

Current STCW training requires that certain competencies be achieved in both classroom and practical settings. However, training opportunities in harsh maritime environments are limited due to the inherent risks to the student, instructor, and training assets. Currently, there is no regulatory standard in place for shipmasters to demonstrate their competence in all-weather navigation. Technology has, and can continue to facilitate advances in training, such as the development of TEMPSC simulator as means to prove one’s competence for launching into heavy sea states with limited visibility. These developments are promising for the field of maritime training, as simulator training becomes more widely accepted as a suitable program for skill acquisition, and as a means to achieve competency through skills developed beyond the classroom setting. Beyond specific skill building, simulation training can provide opportunities for building communication and teamwork, preparing for varied environmental conditions, and dealing with emergency situations in which lifeboat evacuation can occur.

5.10: Real World Application

Results from this study indicate that novice operators of FFLB launching procedures are more successful in the bigger wave height. As wave height decreases in simulation, visual characteristics of wave phases also decrease making it harder to determine the proper time to launch. The cause of this decrease may have been multifactorial. First, the motion bed was not activated in the pre-launch stages because the boat from which it was launching was a fixed object in the sea - so it was of no help in determining the given wave pattern. Also, the auditory cueing system did not include waves crashing into the boat as part of their track, so another sense was unable to assist in what was being depicted on the screen. Finally, there were limitations to what could be clearly distinguished by the graphics – especially in the rough weather conditions as white section of the wave crest was not always big enough or clear enough to truly know onto which wave phase you were launching.

While escaping the area after launch may be relatively easier in these smaller waves, the possibility of the FFLB being set back into the installation it is trying to escape is still a principal concern and was limited by factors of the simulation design.

Future research should further explore the relationship of launching success rate on different wave sizes. The scale model testing of Simões Ré, Pelley and Veitch (2003) can be expanded to see if novice operators can launch a scale FFLB onto proper wave phases for successful sail away. This may bring more insight as to how the visual characteristics of all waves (not just the simulation visuals) contribute to the success rate of launches. Research should also investigate if the inclusion of the hydrodynamic effects upon the installation from which the FFLB is launching helps the participants in timing the smaller wave launches, through kinesthetic or visual feedback.

5.11: Perceived Improvement

Eighty-three percent of participants believed that their performance improved as the testing proceeded as indicated by Short Answer Question #1 of the Presence Questionnaire. Only eight percent believed that their performance did not improve, while nine percent were not sure if they had improved or not.

However, the results indicate that there was no significant improvements in launch scores over the sets of trials from either group. An experimental design aspect of the study that could be confounding this data is the random order of trials for each participant. In an attempt to make the trials a random practice task, every participant experienced the test trials in a different order to see if progress could be found independent of trial order. However, because or the significant difference in launch success between size 5 and size 8 waves, the differing sequences may have had an effect on the apparent rate of learning as shown by launch success. Also, because each participant only experienced each specific trial once - we have no direct comparison for performance scores as practice time increased. Future studies will be needed to determine how to best evaluate and quantify improvements in launch success for training purposes.

5.12: Evaluating the Simulator

5.12.1:Realistic Aspects of Simulation

Presence Questionnaire Short Answer Question #2 responses indicated that participants believed the most realistic aspect of the simulation experience was the motion cues created by the MOOG Series 6DOF2000E Electric Motion Platform Actuator, as indicated by sixty-three percent of the total responses. Thirty percent of responses believed that the visual aspects of the simulation were the most realistic, while only seven percent believed the audio cues to be the most realistic.

While the long answer questions asked participants to: i) "state which aspect of the simulation they found most realistic?" and ii) "why?", the answers typically did not include their explanation. Typical explanations referred to participants previous experiences on boats or other floating crafts as being consistent with the motions experienced, as well as how motions experienced matched the wave forms depicted by the simulation on the cabin screens.

However, answers also identify the shortfalls both the visual and auditory aspects of the simulation experience, which are further addressed in section 5.12.2.

5.12.2: Unrealistic Aspects of Simulation

Presence Questionnaire Short Answer Question #3 responses indicated that participants believed that the least realistic aspect of the simulation experience was the auditory cues, as indicated by sixty-two percent of total responses. Twenty-three percent of responses believed that the visual aspects of the simulation were the least realistic, while only six percent thought the motion cues were the least realistic.

These answers confirm the quality of the motion cues from short answer question 2 (addressed in section 5.12.1)

Answers typically indicated they found the auditory cues to be the least realistic because they were repetitive, unvarying, and some believed inaccurate with regards to the environment. The audio cueing system had the track recordings of a platform alarm, people screaming, and vomiting/retching noises. Participants were presented with random combinations of these three tracks throughout their trials. Several participants noted the screaming audio didn't seem realistic because it sounded like there were children present, which did not seem believable on the freight ship that they were evacuating. Further, the syncronization of wind and wave noise happening on the boat with the visual aspects of the simulation may lead to improved scores in both domains - as that transfer of what was being depicted on the screen, and what was being experienced in the simulator was one of the main reason subjects scored the motion aspects of the simulation so high.

Feedback provided through SMEs further validated the need for improved audio cueing. They noted that generally aside from the platform alarm, people inside the FFLB before launching were very quiet to allow the coxswain to concentrate on their task. Then, after hitting the water people would begin to make noises due to impact injuries/strains and seasickness.

5.13: Future Directions

Simulation technology can fill the void left by impractical and unsafe real world training by controlling all aspects of the environment surrounding a launch, as well as recording all launching information in a controlled and safe environment. These trials have the ability to become more comprehensive as after the launching phase, the simulator system is also capable of tracking the time it takes to navigate to a safe rescue area. These trials would be impractical to train in real world situations but can be the source of invaluable experience for mariners faced with difficult environmental conditions during EER situations.

5.14: Performance Based Standards

Serco (2007) argues that the recent Canadian approach to performance-based standards (PBS) for evacuation, escape and rescue, follows the UK's general 'goal setting' regime. They argue it is imperative that consultations with all interested parties are broad in scope as well as detailed as to implement an ill-considered set of PBS could set back the process irrevocably.

However, in defining PBS difficulties still remain for those assessing the suitability and robustness of proposed EER measures in relation to the standards. This is because there is a general lack of empirical data on the escape process, particularly that part of the process dealing with TEMPSC launch and sail away, meaning that the assessment could become a somewhat subjective task. Greater levels of objectivity and transparency could be achieved with a larger body of validated data to draw upon and this data can be created through simulated trials (Serco, 2007). Perhaps this lack of information could be aided by considering within TEMPSC design specifications both a minimum speed for given sea-state and standards of maneuverability in waves. A limited amount data exists in respect of ‘set back’ although clearly there is a need for this to be expanded. Coupled with this is the need to better understand the hydrodynamic principles of the problem, possibly through the use of further, more robust mathematical modeling.

5.15: Presence Measures Did Not Correlate with Task Performance

This study investigated the relationship between presence and task performance full mission FFLB VE. Inconsistent with our hypothesis, presence measures did not correlate with task performance. The relationship between presence and task performance is unclear, as 51% of the literature included in a review by Youngblut (2003) did not find a correlation. Despite considerable face validity, a relationship between presence and task performance is unsupported by the present study. Further studies should investigate whether a full-mission simulator yields a similar relationship between presence and task performance as a desktop or HMD device. Another hypothesis is that presence and task performance are not related. Slater (1997) argued that no such relationship exists since presence is concerned with the similarities between behavior in a VE and a real-world environment and not with task performance in an environment. Although presence may not be related to task performance in a VE, Slater also states that it may be crucial for the transfer of skills learned in VE’s to real-world environments.

Chapter 6 Conclusions

Through the continuing advances in technology, simulation training is increasingly applicable to training coxswains the skills needed to operate in extreme environmental conditions, and can serve as a safe and reliable complement to current training regimes. This research demonstrates that simulation training can offer a host of performance and psychometric skill building parameters that may be refined and developed further with additional research.

It may be possible that this type of training can be translated into STCW training for lifeboat coxswains, during their time onshore, as well as during their time at sea, using either part-task or full mission simulators. This research provides preliminary evidence with which to lobby national and international bodies to formally include adverse weather launching in course requirements for lifeboat coxswains. Simulator training would also be useful in filling the gap that often occurs between standard training and drills, due to the high risk environment that survival craft are meant for use in.

Current practices surrounding STCW Coxswain training allow for participants to have between 30-72 minutes of hands-on physical training in the coxswain position in order to demonstrate operational competencies, including launching, maneuvering, recovering and transferring casualties, and steering by compass navigation (G. Small, personal communications, June 10, 2011). Other competencies include operational aptitude in a group setting including prelaunch checks, launch, towing, pacing, casualty approach and recovery, recovery of the lifeboat, and full abandonment. In this study, over a 90-minute period, participants were able to get acquainted with the simulator, fulfill the prelaunch and launch procedures, and complete a number of launch trials through varying wind and weather conditions. The simulator training placed participants in challenging scenarios that would not be experienced during typical training opportunities. According to Veitch, Billard, and Patterson (2008a), this training offers trainees the opportunity to improve SA in FFLB launching, while Taber (2010) believes that having the chance to practice a skill in a realistic situation will enable them to better recall that skill in real life.

More research is necessary in this area to determine benchmarks for performance standards at differing wave heights and visibility states. The findings in this study communicate to regulators that they should continue to examine the current

STCW coxswain training standards for inclusion of adverse weather launching. This evaluation is paramount for the safety of those onboard vessels and installations. Although the effect of simulation training on coxswain performance is not yet fully developed, this research allows parallels to be drawn with other the long established simulation training programs from both the medical and aviation fields. Many facets of medicine use simulation to educate students and to aid experts is maintaining and developing skills. Similarly, the maritime environment could potentially benefit from simulation training as a viable alternative or complement to current standard STCW training.

These preliminary findings provide an opportunity for those with an interest in bringing attention to the usefulness of simulators in training adverse weather launching. It establishes a basis on which future research can be expanded upon. Training through the use of simulators may allow regulators, institutions, and companies the prospect of enhancing and supplementing current lifeboat coxswain training standards.

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Appendix

Appendix A – Email recruitment

Hello

I am working as part of the Virtual Environments Project through the Major Research Partnerships at MUN. I am currently running a study titled "The Effect of Simulation Training Exposure on Skill Acquisition".. It would be great if you would be able to help me out and would like to participate in the study.

Participation in studies such as this are a great opportunity for students to learn more about the research that is taking place at MUN, the types of research taking place in the Health and Safety Industry, and represent a great opportunity for students to learn more about the research process.

Introduction/Background to the Study:

Simulation technology is the imitation of a real thing, environment or process usually generated by a computer system. It has application in many fields, including rehabilitation, medical training, and training operators of road vehicles, aircrafts, and marine vessels. This technology offers an effective medium for training that allows for a variety of environmental and operational conditions that are impractical, expensive or dangerous to train in real world.

The effectiveness of training in a simulator is influenced by the degree to which the user believes the virtual environment matches the real world environment, a perceptual situation referred to as 'presence'. The realism of the simulation, mediates the level of presence experienced by the operator.

The aim of this research is to determine if the addition of feedback to a lifeboat simulation environment will increase successful launch trials when launching into various sea, weather and visual clarity conditions.

Participants must:

- No lifeboat training certification
- Little sensitivity to motion sickness
- No health conditions that could be aggravated by increased anxiety
- Lack of pre-existing heart or lung conditions that impair physical activity
- Lack of pre-existing muscle or skeletal conditions that limit mobility
- No fear of enclosed spaces

All participants will receive initial training and overview of the simulator system, its operations and objectives for the experiment (i.e. successfully launch the boat). Participants will be briefed on the ideal launch orientation of the boat when it hits the waves and potential real-life consequences of failure.

During the session, you will take part in various trials, under different parameters and conditions, in which you will repeatedly launch a free-fall lifeboat simulator into varying ocean and surrounding conditions. Following each trail, some of you will receive feedback on the successfulness of your launch, in an attempt to improve subsequent trials.

If you choose to participate in this research study, you will be asked to attend one, 90-120 minute session in the Fluids Lab (EN 1035), Engineering Building, at MUN.

If you have any questions surrounding the research study, and/or participation in the study, or are interested in participating, please respond to this email and we can book your session time!

Thanks,

Alan Dalton & Andrew Caines

Appendix B: Physical Activity Readiness Questionnaire

PAR-Q & YOU

Physical Activity Readiness

Questionnaire - PAR-Q (revised 2002)

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES NO

___ ___ 1. Has your doctor ever said that you have a heart condition <u>and</u> that you should only dophysical activity recommended by a doctor?

___ ___ 2. Do you feel pain in your chest when you do physical activity?

___ ___ 3. In the past month, have you had chest pain when you were not doing physical

activity?

___ ___ 4. Do you lose your balance because of dizziness or do you ever lose consciousness?

___ ___ 5. Do you have a bone or joint problem (for example, back, knee or hip) that could be

made worse by a change in your physical activity?

___ ___ 6. Is your doctor currently prescribing drugs (for example, water pills) for your blood

pressure or heart condition?

___ ___ 7. Do you know of <u>any other reason</u> why you should not do physical activity?

If you answered YES to one or more of these questions:

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

• You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.

• Find out which community programs are safe and helpful for you.

If you answered NO

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

• start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.

• take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ____

SIGNATURE____

DATE____

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority)

____

WITNESS ____

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

HealthCanadaSantéCanada

Appendix C – Consent Form

Small Craft Simulation Project,

c/o Faculty of Engineering of Memorial University of Newfoundland,

St. John's, NL A1B 3X5

Consent to Take Part in Research

TITLE: The Effects of Motion Cues on Perception of Presence in a Lifeboat Simulation Scenario.

INVESTIGATOR(S): Dr. Scott MacKinnon, Mr. Steven Mallam, Mr. Alan Dalton, Dr. Brian Veitch, Ms. Jennifer Smith, Mr. Randy Billard, Cpt. Anthony Patterson

You have been invited to take part in a research study. It is up to you to decide whether to be in the study or not. Before you decide, you need to understand what the study is for, what risks you might take and what benefits you might receive. This consent form explains the study.

The researchers will:

- discuss the study with you
- answer your questions
- keep confidential any information which could identify you personally
- be available during the study to deal with problems and answer questions

If you decide not to take part or to leave the study this will not affect your student status [if applicable]

Introduction/Background:

Simulation technology is the imitation of a real thing, environment or process usually generated by a computer system. It has application in many fields, including rehabilitation, medical training, and training operators of road vehicles, aircrafts, and marine vessels. This technology offers an effective medium for training that allows for a variety of environmental and operational conditions that are impractical, expensive or dangerous to train in real world. In addition to the cost and safety factors, it has been suggested that new behaviors and operations can be trained in a more time efficient manner using a combination of virtual environment (VE) and real world training, rather than real world training alone.

The benefits of decreased expenses, risk, and time associated with training that can be gained by a simulator mean nothing if the simulator cannot provide an effective environment to properly train new behaviors and operations. The effectiveness of training in a simulator is influenced by the degree to which the user believes the virtual environment matches the real world environment, a perceptual situation referred to as 'presence'. The realism of the simulation, mediates the level of presence experienced by the operator.

It has been shown that increased number of cueing systems (ex. visuals, audio, force feedback, motion) present in a simulation environment can increase the perceived presence. Thus, a simulation environment with visual, audio and motion cues should be more realistic than a simulation environment with just visual cues. The aim of this research is to determine if the addition of motion cues to a lifeboat simulation environment will increase the perceived presence, which will ultimately increasing the effectiveness of training in the simulator.

2. Purpose of study:

The purpose of this study is to investigate if the addition of physical movement from a motion platform will increase the perceived presence in a lifeboat simulation environment, which will ultimately increase the effectiveness of training in the simulator.

3. Description of the study procedures and tests:

If you choose to take part in this experiment you will be asked to complete a PAR-Q (physical activity readiness questionnaire) form and a pregnancy/vestibular disorder questionnaire. You will be asked questions about any medical conditions you might have that may restrict you from participating in this study.

You will be asked to attend one 2 hour session in the Fluids Lab (EN 1035), Engineering Building, MUN. During their session you will be given an introduction into the operation procedure of the lifeboat simulator. Once you are comfortable with the operation procedure, you will be instructed to complete two trials, one with motion and one without motion. Random selection will be used to determine the order at which you will complete the trials. The motions will represent a moderate sea state.

Upon completion of each trial, you will be asked to complete the presence questionnaire. In addition to the questionnaires, you will be asked to wear a heart rate monitor with a chest strap and watch for the duration of the session. A five minute baseline measure of your heart rate will be recorded prior to each trial.

In addition, a video camera may be used to capture your actions and reactions during each trail and compared to determine if there were any differences between trials. The video will be viewed only by the investigators for analysis.

4. Length of time:

You will be expected to come to the Memorial University Engineering Building for one (1) session for approximately two (2) hours. Some testing might be performed over weekends.

5. Possible risks and discomforts:

Risks:

Potential for slips, trips or falls resulting in physical bruising or injury. However, since participants will be sitting and secured in a four point seatbelt at all times while the motion bed is engaged, the risk of the slips, trips or falls will be minimal.
The use of LCD televisions to view computer generated graphics contains minimal levels of risk, however participants may experience minimal eye strain.

The use of audio system may produce excessive sound levels that may cause temporary hearing impairment. National guidelines for noise exposure will be observed throughout the design and testing stages.

Discomforts:

- Possibility for motion-induced sickness (MIS), which includes symptoms such as nausea and dizziness.
- Wearing a four point seatbelt while on the motion bed might be somewhat restricting.
- (Potential for) physical fatigue during motion trials while attempting to maintain postural control. In other words, there is a possibility that you will become more tired because it is likely that you will use more muscles to maintain your position in a moving environment than you would use in a static environment.
- Being in a research-lab setting.
- Emotional distress and/or boredom may be experienced during the simulation scenario.

Inconveniences:
Interruption of normal daily schedules (i.e. early mornings, late evenings, weekends, etc.)

6. Benefits:

It is not known whether this study will benefit you.

7. Liability statement:

Signing this form gives us your consent to be in this study. It tells us that you understand the information about the research study. When you sign this form, you do not give up your legal rights. Researchers or agencies involved in this research study still have their legal and professional responsibilities.

8. What about my privacy and confidentiality?

Protecting your privacy is an important part of this study. Every effort to protect your privacy will be made. However it cannot be guaranteed. For example we may be required by law to allow access to research records.

When you sign this consent form you give us permission to

- Collect information from you
- Share information with the people conducting the study
- Share information with the people responsible for protecting your safety

Access to records

The members of the research team will see study records that identify you by name.

Other people may need to look at the study records that identify you by name. This might include the research ethics board. You may ask to see the list of these people. They can look at your records only when one of the research team is present.

Use of records

The research team will collect and use only the information they need for this research study.

Your name and contact information will be kept secure by the research team in Newfoundland and Labrador. It will not be shared with others without your permission. Your name will not appear in any report or article published as a result of this study.

Information collected for this study will be kept for 5 years.

If you decide to withdraw from the study, the information collected up to that time will continue to be used by the research team. It may not be removed. This information will only be used for the purposes of this study

Information collected and used by the research team will be stored by Dr. Scott MacKinnon and he is the person responsible for keeping it secure.

Your access to records

You may ask Dr. MacKinnon to see the information that has been collected about you.

9. Questions:

If you have any questions about taking part in this study, you can meet with the investigator who is in charge of the study at this institution. That person is: Dr. Scott MacKinnon

Or you can talk to someone who is not involved with the study at all, but can advise you on your rights as a participant in a research study. This person can be reached through:

Office of the Human Investigation Committee (HIC) at 709-777-6974 or
Email: **hic@mun.ca**

After signing this consent you will be given a copy.

Signature Page

Study title: The Effect of Motion Cues on the Perception of Presence in a Lifeboat Simulation Scenario.

Name of principal investigator: Dr. Scott N. MacKinnon

To be filled out and signed by the participant:

Please check as appropriate:

I have read the consent form	Yes { }	No { }
I have had the opportunity to ask questions/to discuss this study.	Yes { }	No { }
I have received satisfactory answers to all of my questions.	Yes { }	No { }
I have received enough information about the study.	Yes { }	No { }
I have spoken to Dr. MacKinnon, or member of the research team, and he/she has answered my questions	Yes { }	No { }
I understand that I am free to withdraw from the study at any time without having to give a reason without affecting my student status	Yes { }	No { }
I understand that it is my choice to be in the study and that I may not benefit.	Yes { }	No { }
I agree to be video taped during the data collection	Yes { }	No { }
I agree to take part in this study.	Yes { }	No { }

____________________________________ ____________________

Signature of participant Date

____________________________________ ____________________

Signature of witness (if applicable) Date

To be signed by the investigator or person obtaining consent

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

Signature of investigator/person obtaining consent Date

Telephone number: ___________________________

Appendix D – Presence Questionnaire

PRESENCE QUESTIONNAIRE

Name: ___________________ Date: ____________________

1. How responsive was the simulated environment to actions that you initiated (or performed)?

0% 50% 100%

Not at all responsive Fully responsive

2. How natural did your interactions with the simulated environment seem?

0% 50% 100%

Not at all natural Fully natural

3. How completely were *all* of your senses engaged?

0% 50% 100%

Not at all Completely

4. How much did the visual aspects of the simulated environment involve you?

0% 50% 100%

Not at all involved Fully involved

5. How much did the auditory aspects of the simulated environment involve you?

0% 50% 100%

Not at all involved Fully involved

6. How much did the motion aspects of the simulated environment involve you?

0% 50% 100%

Not at all involved Fully involved

7. Were you able to anticipate what would happen next, in the simulated environment, in response to the actions that you performed?

0% 50% 100%

Not at all easy to anticipate Very easy to anticipate

8. How involved were you in the simulated environment experience?

0% 50% 100%

Not at all Involved Fully involved

9. How much delay did you experience between your actions and expected outcomes?

0% 50% 100%

No delay A lot of delay

Additional Feedback

1. The aim of each launch was to time the release the boat so you entered the downslope of the oncoming wave. Do you feel that you improved upon your performance as the testing proceeded?

2. Of the complete simulation, which aspect (i.e. motion, visuals or auditory) did you find the MOST realistic?

3. Of the complete simulation, which aspect (i.e. motion, visuals or auditory) did you find the LEAST realistic?