Application of experimental results to evacuation system selection and arrangement

Simões Ré, A.; Veitch, B.

Publisher’s version / Version de l'éditeur:

8th Canadian Marine Hydromechanics and Structures Conference [Proceedings], 2007

Application of experimental results to evacuation system selection and arrangement

António Simões Ré, Institute for Ocean Technology, National Research Council, St. John's
Brian Veitch, Memorial University, Ocean Engineering Research Centre, St. John's

ABSTRACT

The capabilities of various marine evacuation systems have been investigated using systematic series of model experiments in a large test facility. Tests were done with a conventional davit-launched twin-falls lifeboat, a similar system with the addition of a flexible boom, and a free-fall lifeboat. The performance of each system was evaluated as a function of weather conditions, ranging from calm conditions to severe storms. The results of this experimental campaign can be used by designers, regulators and operators in their decisions concerning safety. In this paper, a simple application of some of the results is made in the context of a hypothetical case study to illustrate the utility of the experimental work.

INTRODUCTION

In the event of a marine evacuation of a ship or an offshore petroleum installation, all personnel on board must have access to an evacuation system, be able to embark and launch safely, clear the ship or installation, and survive until rescued. Further, personnel should have a reasonable expectation of avoiding harm arising from credible hazard scenarios, including those occurring in environmental conditions that can reasonably be expected to prevail during operations.

Fore knowledge of the performance capabilities of the selected means of evacuation must be incorporated into operational planning, including emergency response plans, recognizing the residual risks associated with operations that exceed any of the limits of the means of evacuation.

The performance capabilities of three evacuation systems have been evaluated in a large experimental campaign using model tests. Results of these tests have been presented elsewhere [1-3]. In this paper, some of the key results are presented and applied to a simple case study to illustrate their practical utility. The case study examines three alternative evacuation systems with regards to clearing an installation after launch in a range of possible weather conditions. While several measures of performance were used in the experiments and are potentially relevant to an exercise such as the one outlined in the case study, the approach taken here is illustrative and therefore focuses on only one measure of performance: setback.

APPROACH AND LIMITATIONS

The case study assessment is based primarily upon results of experimental work done with physical model versions of Totally Enclosed Motor Propelled Survival Craft (TEMPSC). Evacuation experiments were performed with a conventional twin-falls davit system, the same system modified by the addition of a flexible boom, and a ramp type free-fall system. These serial experiments were performed at the Institute for Ocean Technology over the past 6 years [1-3].

The model lifeboats were launched from a fixed platform that was meant to represent a generic jacket type structure. Figures 1 and 2 show the experimental set-up with the location of the evacuation station on the platform. Multiple launches were made in each of several weather conditions, which consisted of wind and waves. The weather conditions used in the experimental campaign are shown in Table 1. These represent Beaufort equivalent conditions in which the significant wave heights were used as the target regular wave height in the tests.

Neither mustering nor rescue nor human factors were included in the experimental work and are therefore excluded from the case study. Issues related to system reliability (for example, mechanical failures of the launch equipment, or power failure to the lifeboat's engine) are also outside the scope of the study.

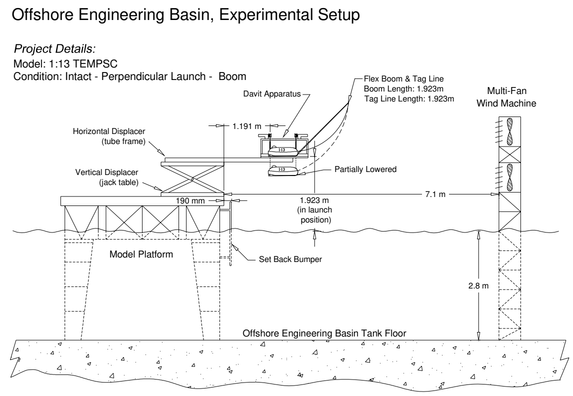

Figure 1. Test setup: Twin-fall davit-launched TEMPSC with and without flexible boom.

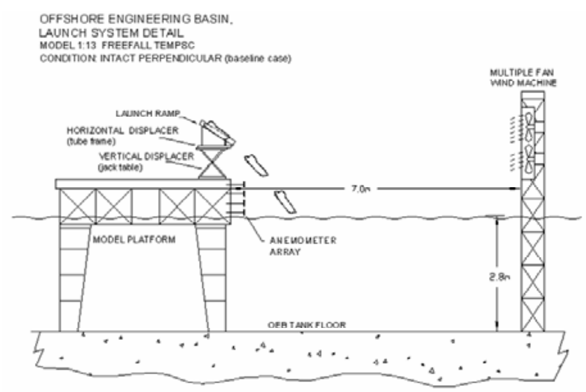

Figure 2. Test setup: Free-fall lifeboat system.

Table 1. Nominal environmental conditions.

(Beaufort) description		Mean wind speed	Average wave height	Significant wave height
		[m·s^{-1}]	[m]	[m]
(0) calm water	W1	0	0	0
(4) moderate breeze	W2	5.6–8.2	0.42-0.88	0.67-1.40
(5) fresh breeze	W3	8.7–10.8	1.16-1.52	1.86-2.44
(6) strong breeze	W4	11.3–13.9	1.95-2.93	3.04-4.57
(7) moderate gale	W5	14.4–17.0	3.35-4.88	5.49-7.92
(8) fresh gale	W6	17.5–20.6	5.79-8.53	9.14-13.72

Performance in our experiments was evaluated in terms of a variety of technical performance measures, such as the accuracy of the launch, the degree to which the lifeboat was setback due to its encounter with oncoming waves, the path taken by the lifeboat between launching and clearing to some distance away from the platform, and accelerations and motions relating to injury criteria and motion sickness, amongst others.

Setback due to the boat's initial encounter with an oncoming wave is illustrated in Figure 3, along with progressive setback. This was found to be a most important performance measure. The progression of passing waves is illustrated in the four wave profiles shown in the figure. At the top, a lifeboat is shown to have splashed down on the up-slope of the incoming wave. Despite its heading (to the right), the lifeboat is unable to make way and is pushed back by the passing wave, as shown in the second profile, until it crests the wave. The distance it is pushed back by the first wave encounter is the setback. After cresting the wave, the lifeboat begins to make way, as shown in the third profile. Progressive setback is illustrated in the fourth profile, which is additional setback due to subsequent wave encounters. Note that the dot shown on the consecutive profiles represents the original point on the wave where the boat was launched.

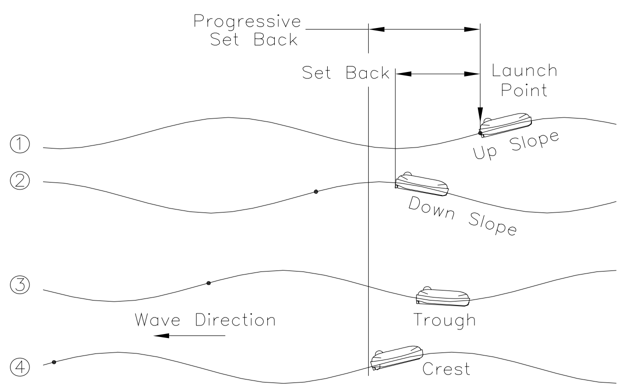

Figure 3. Setback and progressive setback.

The evacuation area can be divided into zones to help define the various performance measures; the zones are illustrated in Figure 4 for a davit-launched lifeboat and Figure 5 for a free-fall boat. With reference to Figure 4, an exclusion zone extends out from the installation far enough to accommodate launching in the range of weather conditions and damaged conditions for which evacuation is a planned contingency. The lifeboat should not enter this zone under any conditions as to do so would put it at risk of colliding with the ship or installation. In practice, the exclusion zone boundary should encompass all collision hazards, whether the hull of a ship or legs of a semi-submersible, and so will be particular to each installation.

Tangent to the exclusion zone is a launch zone, shown nominally in Figures 4 and 5 as circular. The size of the launch zone depends on how much area is required to accommodate a safe launch, including setback, bring the lifeboat under control and initiate clearing towards the rescue zone. At its centre is the nominal launch target, which for the conventional davit-launched system illustrated in Figure 4 is on the sea surface directly below the aftermost part of the lifeboat. The decision on the size of the planned launch zone can be based on the weather conditions that are chosen by the operator to be the upper limit for a planned evacuation. Three alternative upper weather limits are illustrated in Figure 4.

A target level of safety in terms of successful launches can also be used as a second criterion for setting the launch zone boundary. This is based on using quantitative data, such as the experimental results referred to in this paper, to encompass a target proportion of launches in given environmental conditions. The higher the target level of safety is for a given weather condition, the bigger the size of the launch zone required to encompass the higher proportion of launches. Figure 5 shows this for three notional levels: relatively low, medium, and relatively high. For the circular launch zones used in the illustration, the size of the zone determines the position of the launch target, similar to the boundary set according to weather limits. These two criteria provide a straight forward and rational means of arranging an evacuation station using appropriate benchmark data.

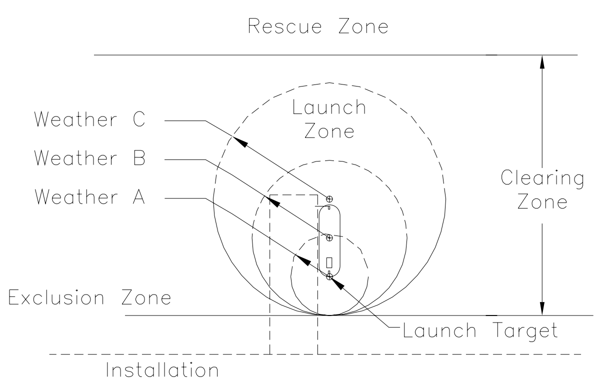

Figure 4. Evacuation area zones (and 3 design weather limits) for a conventional davit-launched lifeboat.

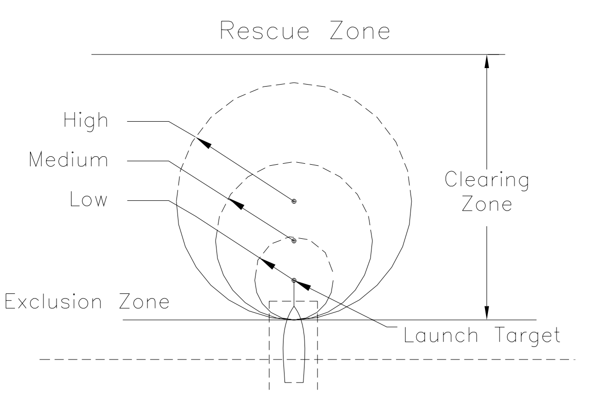

Figure 5. Evacuation area zones (and 3 target safety levels) for a free-fall lifeboat.

EXPERIMENTAL RESULTS USED IN THE CASE STUDY

Results of experiments performed with all three systems showed that the performance deteriorated as the weather worsened. The relationship between wave height and the setback and progressive setback measured in launches into head seas can be seen from the plots presented in Figure 6 for all three systems for a range of weather conditions. The results shown include tests done at wave steepness values of 1:15 and 1:20. For any given evacuation system, multiple tests were done in each weather condition.

The results show similar trends in the upper limit of setback, which increases approximately linearly with wave height for all three systems. One line is shown for the TEMPSC with the flexible boom, another for launches without the boom, and the third upper bound line in the plot is for the free-fall lifeboat. These results indicate, amongst other things, that the effect of the boom when used with a TEMPSC arranged perpendicular to the platform is to reduce the maximum setback. This is significant in terms of evacuation system design, for example in terms of ensuring suitable clearance between the platform and the launch target.

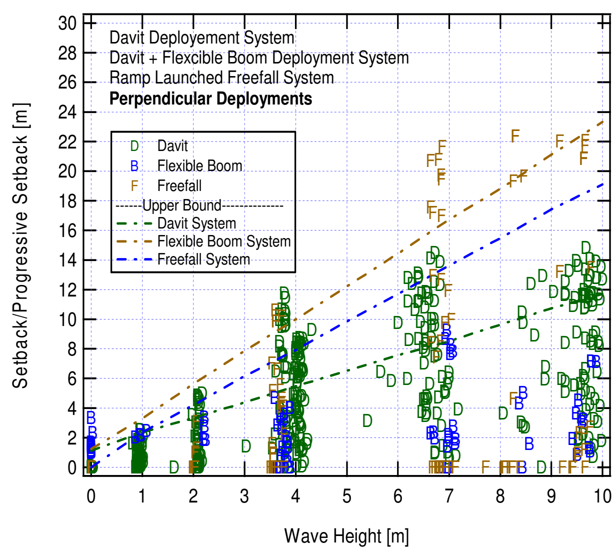

Figure 6. Setback and progressive setback versus weather conditions: three systems compared.

These results are incorporated in Figures 7, 8 and 9 where they help to establish launch envelopes for each of the three systems. The launch envelope for any given system and weather condition encompasses the positions of the lifeboat after launching during all tests made in that condition during the experimental program. These envelopes include movements of the lifeboats to port and starboard after launch, as well as setback and progressive setback.

For example, Figure 7 shows six envelopes corresponding to the weather conditions in Table 1. The lifeboat is shown in its position prior to launch, overlaid on the plot.

Similar results are shown in Figure 8 for the davit-launched lifeboat with a flexible boom. Compared to the envelopes in Figure 7, the ones in Figure 8 are offset toward the bow of the lifeboat, reflecting the effect of the flexible boom in pulling the lifeboat away from the platform during lowering. It is also clear from these two figures that the flexible boom improved the control of the lifeboat at launch and immediately afterward [4].

Results for the free-fall system are shown in Figure 9. The envelope boundaries for this case are offset out from the pre-launch position, reflecting in this case the trajectory of the lifeboat after it leaves the ramp and free falls. Note that the free-fall lifeboat launch system was not tested in moderate breeze conditions (W2).

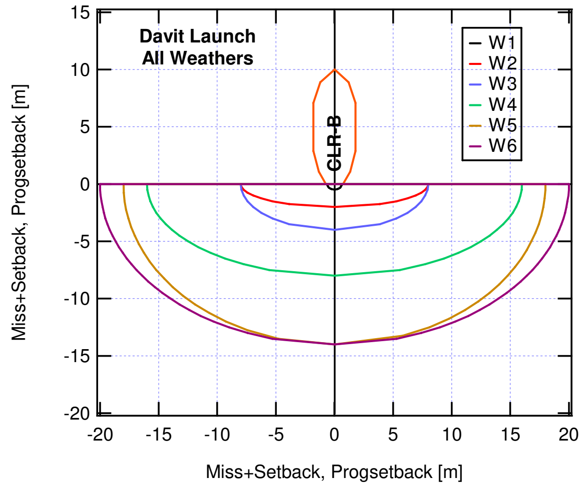

Figure 7. Conventional: Splashdown area boundaries.

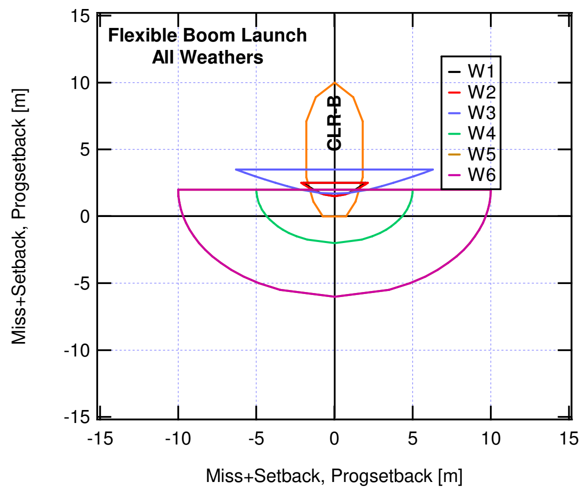

Figure 8. Flexible boom: Splashdown area boundaries.

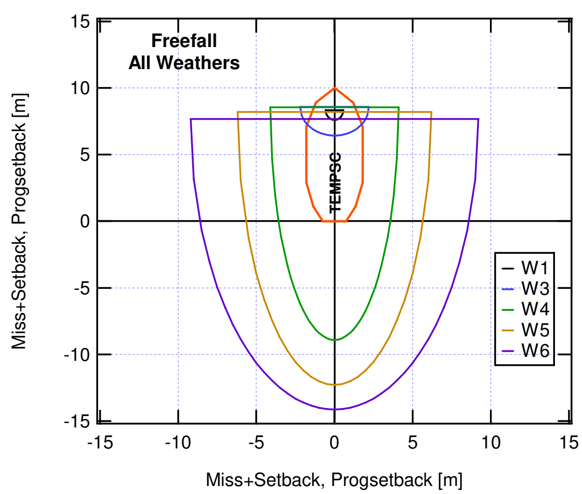

Figure 9. Free-fall: Splashdown area boundaries.

CASE STUDY: SELECTION OF EVACUATION SYSTEM FOR A HYPOTHETICAL OFFSHORE STRUCTURE

In the case study, we considered a hypothetical floating, column stabilized platform. In Figures 10, two of the platform's legs are shown at the waterline, with a lifeboat evacuation station arranged above as indicated. An exclusion zone boundary is shown surrounding the legs (giving a rather arbitrary buffer of about 2½m), and joining the narrowest point between the legs, which recognizes the risk associated with being underneath the platform.

We have only looked at a single case of a lifeboat launching into head seas, again with a view to illustrating the experimental results. In Figure 10 to 15, the results of the experimental campaign are super-imposed (using the envelopes presented in Figures 7 to 9) on the geometry of the offshore structure for each of the six discrete weather conditions. Overlaps between a given envelope and the exclusion zones indicate that the lifeboat is not suitably arranged for the corresponding weather, or that it must be moved farther outboard if it is to be suitable. Similarly, overlap between an envelope and the structure's boundary indicates a potential for collision and again, an unsuitable arrangement.

There are no overlapping boundaries for the first three weather conditions shown, indicating that any of the three systems would be acceptable if arranged with the clearance used in the case study, for launches into heads seas in weather conditions up to fresh breeze. For the strong breeze conditions shown in Figure 13, the davit-launched system is just about coincident with the exclusion zone, indicating that the weather limit for safe launches for this system in this particular arrangement has been reached.

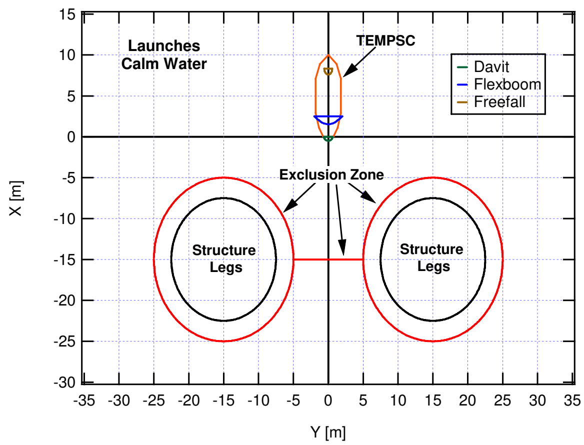

Figure 10. Splashdown boundary for calm water (W1)

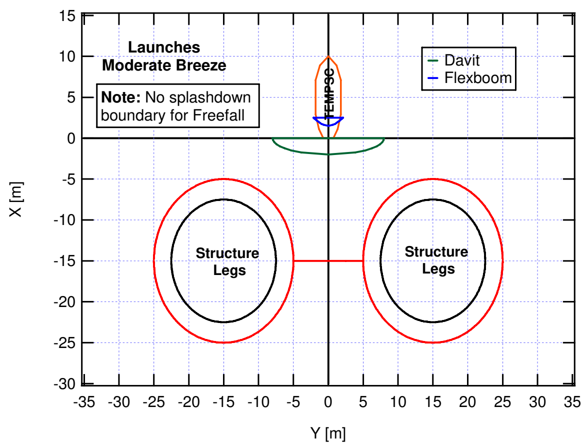

Figure 11. Splashdown boundary for moderate breeze (W2)

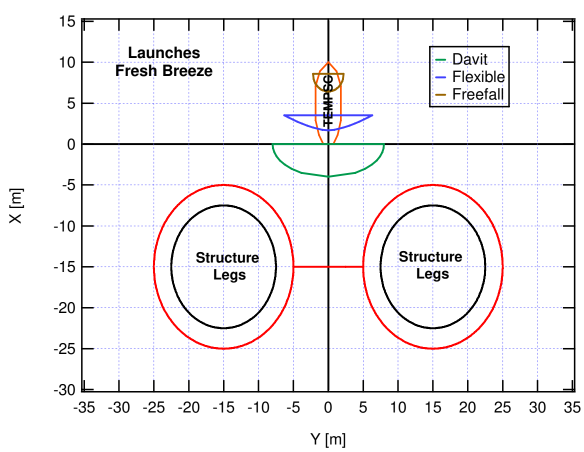

Figure 12. Splashdown boundary for fresh breeze (W3)

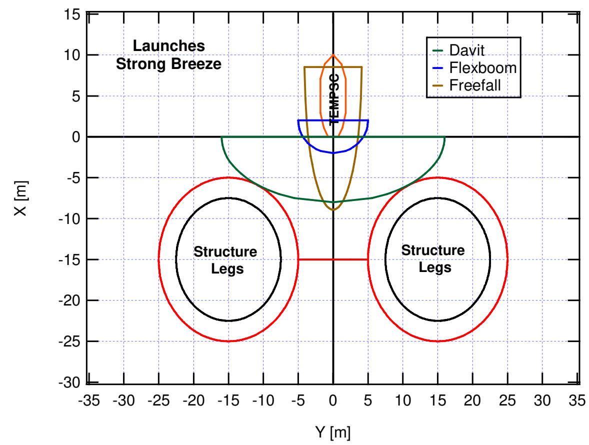

Figure 13. Splashdown boundary for strong breeze (W4)

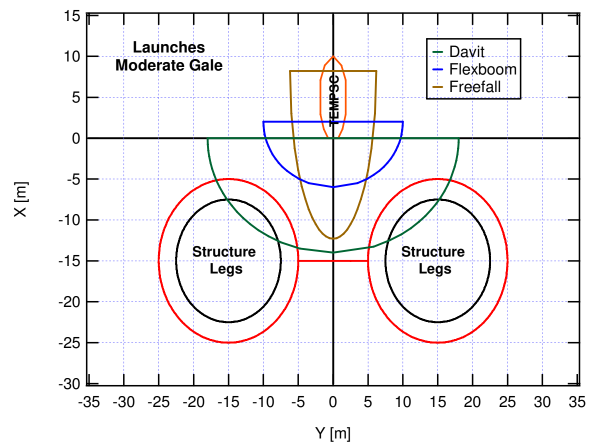

Figure 14. Splashdown boundary for moderate gale (W5)

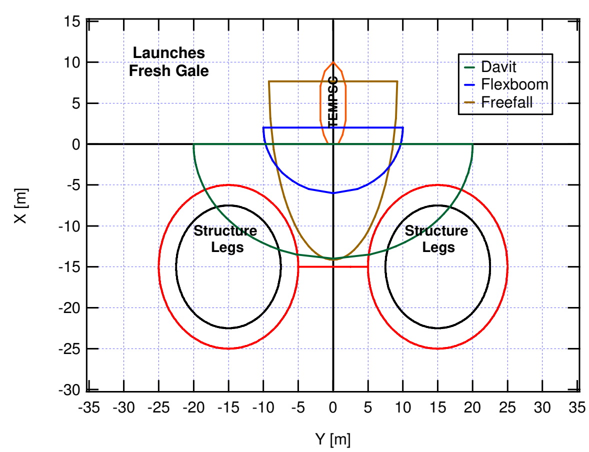

Figure 15. Splashdown boundary for fresh gale (W6)

The case is worse for the moderate gale conditions in Figure 14, where the figure indicates that collisions with the platform's legs may occur with the conventional davit-launched system. The free-fall envelope does not overlap with the platform's boundaries for these conditions, but one might conjecture that launches into oblique seas rather than heads seas might be prone to collisions in these conditions. The davit-launched lifeboat with the flexible boom appears to be fine in these conditions.

Similar results are indicated in Figure 15 for fresh gale conditions, where the same qualitative comments apply as for the moderate gale: the conventional lifeboat shows heavy overlap with the platform, the free-fall system is without overlap, but would likely be found unsuitable in these conditions if tested against launches into oblique seas, and the flexible boom system is satisfactory.

The results could be used to modify the evacuation station arrangement used in the case study. For example, with reference to Figure 15, moving the lifeboat station outboard by about 6m would avoid the overlapping boundaries between the conventional lifeboat and the platform in fresh gale conditions. Alternatively, one might choose to accept some probability of collision between the lifeboat and platform, rather than move the station so far outboard. In any event this is a simple illustration of how the results from the physical model experiments can be used to establish evacuation station arrangements for a given weather limit or level of safety.

It is important to note at this stage that there are differences between the physical model scenarios and the offshore installation used in the case study (and any other installation to which the results may be applied). To begin, the test platform used in the physical model experiments was largely transparent to the waves in all the weather conditions. The platform used in the case study is quite different. It is a floating platform with 4 columns that would likely affect the wave conditions in the lifeboat's splash down area. Further, the physical model experiments were conducted at different launch heights. This parameter was found to have relatively small influence on the overall performance of the lifeboats. The case study launch height was within the range of the launch heights tested at model scale. As well, the experimental evacuation station was tested in different launch orientations, from perpendicular to parallel. The case study considered only perpendicular launch orientation. The majority of the experiments were conducted in waves of steepness of 1:20 to 1:15, with a small number conducted in waves of 1:10 steepness. The experimental study showed that wave steepness affects the lifeboats' performance, so application of the results should account for steepness effects, including shallow water waves.

ACKNOWLEDGMENTS

The authors acknowledge with gratitude the financial support provided by the following organizations: Transport Canada, Natural Resources Canada, Canadian Association of Petroleum Producers, National Research Council, Petroleum Research Atlantic Canada, Natural Sciences and Engineering Research Council, National Search and Rescue Secretariat, and the Terra Nova Project partners led by Petro-Canada. We also acknowledge the role of peers who have offered constructive criticism of this work, colleagues at the Canada-Newfoundland & Labrador Offshore Petroleum Board who have provided advice over a period of years, and the technical staff who have executed a lot of model tests.

REFERENCES

[1] Simões Ré, A. and Veitch, B. 2001. Experimental evaluation of lifeboat evacuation performance. *Trans. SNAME*, Vol.109, 18 p.

[2] Simões Ré, A., Veitch, B. and Pelley, D. 2002. Systematic investigation of lifeboat evacuation performance. *Trans. SNAME*, Vol. 110, 20 p.

[3] Simões Ré, A. and Veitch, B. 2007. A comparison of three types of evacuation system. To appear *Trans. SNAME*, 20 p.

[4] Simões Ré, A. and Veitch, B. 2004. Evacuation performance of davit launched lifeboats. *Proc. OMAE2004-51528,* Vancouver, 8 p.