This is the published version of a paper presented at 18th International Navigation Simulator Lecturers’ Conference (INSLC 18), Sept, 12-15, 2014, Buzzards Bay, Massachusetts, USA.

Citation for the original published paper:

Boström, M. (2014)
Simulating Advanced Arctic Operations - Lessons Learned.
In: Sam Teel (ed.), 18th International Navigation Simulator Lecturers’ Conference Massachusetts Maritime Academy, USA

N.B. When citing this work, cite the original published paper.

Permanent link to this version:
http://urn.kb.se/resolve?urn=urn:nbn:se:lnu:diva-42213
**Simulating Advanced Arctic Operations – Lessons Learned**

Magnus Boström (Kalmar Maritime Academy, Linnaeus University, Sweden)  
magnus.bostrom@lnu.se

**Abstract:** The use of simulators is widely used for preparing someone, be it a person or organization, for an upcoming task. There are several reasons for this. Many endeavours are costly, and the gain from a real life experience might not justify its costs. Another reason might be that the task involves hazardous elements, with potential to harm people or the environment. There is also the possibility that the experience sought occurs so infrequently, that one is unlikely to experience it under real conditions. In all of these situations, a simulated training experience can be equally good, or even better, compared to real on-the-job training.

This paper gives an account of a course in advanced arctic operations, where the simulator was used in preparation for operations in ice. The preparations and execution of the training itself are explained, accompanied by the views of the course instructors about the lessons learned. The result indicates that one of the key components of successful training is to avoid having too detailed exercises, and rather to focus on the fundamental principles of the upcoming activity. In combination with the important debriefing where more specific aspects of the operation can be discussed, a broad training leaves the participant well equipped to handle real life challenges as they appear in the field.

1 **Introduction**

With the decline in sea ice coverage in the Arctic region, it is estimated that the shipping activity in that area will increase in the coming years. The global trend is that the average temperature is increasing, and in the Arctic this is done at a faster pace than in other areas [1]. However, an increased activity can already be observed on e.g. the Northern Sea Route (NSR); the number of transit voyages supervised by Rosatomflot has increased from four voyages in 2010 to 46 in 2012, and the amount of transported cargo has increased tenfold from 111 000 tonnes to 1 261 545 tonnes during the same period [2]. In addition to the increased number of transits on the NSR, the oil and gas activities are vibrant. With approximately 30% of the world’s undiscovered gas and 13% of the world’s undiscovered oil resources, and most of it under less than 500 meters of water, the Arctic region has great potential [3].

2 **Ice Navigation Training at Kalmar Maritime Academy**

The history of Kalmar Maritime Academy (KMA) dates back to the middle of the 19th century. Today, the academy offers an array of training programs within the maritime sector, as well as programs focusing on the land based energy and maintenance area. The Master Mariner program has, for more than 170 years, offered a theoretical knowledge base accompanied by practical training, altogether producing high-class nautical officers [4]. Naturally, the training has changed substantially over the years, to meet international regulations as well as the demands of the shipping cluster. Today, the Master Mariner program includes a number of lectures about navigation and ship handling in ice, in addition to ice simulator training. This includes most aspects of ice navigation, including e.g. physical properties of ice, voyage planning and ship handling in ice, the effects of low temperature on humans and machinery and working with icebreakers; consequently, all nautical officers trained at KMA will have at least a basic knowledge and understanding of ice navigation.
In addition to the Master Mariner training, KMA offers advanced ice navigation courses to active ship officers, as well as officers on board icebreakers. The generic course intended for ship officers on board merchant vessels is a four-day course, including 18 hours of simulator training, where the main objective is for the participants to get familiar with the special characterizations of ice navigation. That includes both operation of own ship when proceeding on one’s own through ice, and what to expect when being assisted by an icebreaker [5]. The course for icebreaker officers is offered in co-operation with the Swedish Maritime Administration and is compulsory for all watch going deck officers on board Swedish icebreakers. For more information about this course, see [6].

3 PREVIOUS STUDIES

Depending on whether a participant is a novice seaman or an experienced active ship officer, simulator training can be viewed differently, and can also be used in different ways. For a beginner student in ship navigation, the simulator might be the first time he or she is allowed to carry out an advanced operation, and mistakes are frequent. Moreover, the simulator is also a great tool for illustrating theoretical concepts, e.g. vessel interaction. Active ship officers, even with extensive experience, do make mistakes in the simulator as well, especially when manoeuvring vessels of different size and characteristics, with which they have no real experience [7]. Mohović et al. also reports that the novice students tend to view their work in the simulator as playing a video game, a problematic view that the instructor has to change. This can be mitigated by creating exercises as realistic as possible, which increases the students’ eagerness to act responsibly, as in a life like situation. The active ship officers have, contrary to the novice seaman, a very serious approach to training in a simulator.

Just like KMA offers ice navigation courses for active ship officers, so do many maritime academies around the world. A study investigating 14 of these courses shows that the length of the course varies from one to five days, the mode length being three days [8]. The topics covered in these courses vary; however, with the upcoming Polar Code which is expected to be made mandatory through SOLAS [9], it is likely that the courses will conform to that standard. Nevertheless, in situations where a generic ice navigation course will not suffice, special courses will still need to be arranged ad hoc, according to the customer’s special needs [8].

4 ICE MANAGEMENT TRAINING

The courses for active ship and icebreaker officers explained above in chapter 2 have been developed over the past decade and have been given on numerous occasions. Even though they change slightly over time, they could almost be described as off-the-shelf courses. However, in addition to these, KMA has repeatedly been approached by entities interested in performing custom made ice simulator training. These entities include both shipping companies, international oil companies, and the Swedish Maritime Administration, and during the past five years a number of courses have been performed with good result. The process of making and performing a custom-made simulator course generally includes the following steps: 1) An interested party contacts KMA, briefly explaining what they want to achieve, 2) KMA assesses whether or not the needs can be fulfilled based on the current technical capability of the simulator and experience of the instructors, 3) an initial training course is set up, 4) the course is tested in the simulator and evaluated.

1 International Convention for the Safety of Life at Sea.
2 The simulators are supplied by Kongsberg Maritime (KM). If current capability of simulator is unable to meet the demands of the customer, KM and KMA will try to find a solution by developing a new or modifying an existing function or model.
by KMA together with the customer and simulator manufacturer, and finally 5) adjusted until both parties are satisfied. This set-up, where the customer at an early stage is taking part in the development of simulator exercises, has proved successful. It ensures that the scenarios become realistic; even though the instructor responsible for ice navigation has first-hand experience from ice navigation and icebreaking, it is always extremely valuable to have early input and feedback from the persons or the entity that will perform the actual task, for which the training is intended.

Below, in chapter 4.1-4.4, some of the simulator exercises from a training program in advanced arctic operations are explained. The preparations for the training program, and execution of eight courses took place in Dec 2013 – May 2014. The exercises described below do not comprise the full training program, and are only intended to illustrate parts of the training. For each of the exercises, the scenario is first explained, followed by the intended objective. Finally, any special findings are presented; however, the findings are further discussed in the chapter 5.

4.1 SEARCH PATTERN

Scenario. A drill rig is positioned and anchored on location of a drill site. To be able to operate safely, the rig needs to be sure that there will be no ice obstacles interfering or interrupting its operation for a certain period of time. Even with weather and satellite data, there is a need of first-hand information about the presence of ice in the area. A number of icebreakers or search vessels are at the disposal of the rig, and are each assigned an area to patrol; for example in figure 1, vessel A patrols the sector from north to east at 10-15 nautical miles (NM). The presence of ice must be reported to the rig immediately, including the position, drift direction and speed, and an approximation of the size of the ice object. With this information, it can be determined whether or not an ice object poses a threat to the rig, and if so, how long time it will take the ice to reach the rig; consequently, it can be determined for how long the safe operation at the rig can continue, or at what time the operation has to be discontinued.

![Figure 1 Search pattern.](image)

Objective. The goal is, not surprisingly, that all ice objects will be located as quickly as possible, and reported to the rig without delay. To properly monitor the drift speed and course can also prove to be difficult; smaller ice objects can be very challenging to acquire on the radar, and the only solution might be to drift alongside it and monitor one’s own
speed. At the beginning of the exercise, all search vessels are already assigned a search area by the instructor. However, as time progresses and the weather changes, the overall situation has to be reevaluated with the possible result that vessels might need to be relocated to keep enough resources close to the path of the ice drift. In figure 1, it would probably be wise to relocate vessel B to cover the sector from west to north at 5-10 NM to protect the rig from the ice drifting from northwest. Furthermore, this exercise also proves useful to practice strict and unambiguous communication with closed-loop communication³, since numerous positions of ice objects have to be reported orally.

**Findings.** One interesting, yet alarming, finding was that there seemed to be a lack of knowledge regarding the functionality of the ARPA⁴, and more specifically the necessity of steady state tracking⁵. On several occasions, participants were observed manually acquiring an ice object on the radar, and within seconds reporting the target’s course and speed to the rig. At the same time, the instructor could observe from the vessel’s radar display that the vector of the newly acquired target was fluctuating greatly, and that the ship officers were heard saying things like “Look at this strange iceberg, going from side to side”. This clearly showed that those participants were not familiar with the accuracy and limitations of the ARPA system.

### 4.2 TOWING OF ICEBERG

**Scenario.** A sighting of an ice object is reported in the vicinity of a rig. To get more detailed information about whether it poses a threat to the rig or not, an icebreaker with towing capability is sent to investigate. On scene, the icebreaker observes the drift speed and direction, and the rig determines the CPA to the rig to be too small. Therefore, the icebreaker is assigned to tow the ice object in another direction, with the intent to change its drift direction.

**Objective.** The main objective of this exercise is for the participants to practice a common manoeuvre. Upon approaching the ice object, the crew have to deploy a buoy and pay out the towing wire while slowly circling the ice. Once they reach the buoy again, the wire is connected to the towing winch and the ice object is gently being towed away from the rig (see figure 2). If the tow is pulled to harshly, there is a great risk that the ice object flips over and the tow is lost.

---

³ Closed-loop communication means that the full wording of a message is repeated by the recipient, as confirmation.
⁴ Automatic Radar Plotting Aid.
⁵ Steady state tracking means that neither the target nor the observing vessel has altered course or speed.
Findings. Depending on the previous experience of the participants, this exercise varied greatly with regards to time. Still, it proved to be important that every single participant got to practice this manoeuvre first-hand; it was not enough to stand next to someone performing it. As a consequence, for a large group this exercise could take some time to complete. To further increase the complexity, with the current software version of the navigation simulator at KMA, both the icebreaker and the iceberg need to be an own ship. Accordingly, with five available own ships only two bridges could practice this manoeuvre at a time, requiring even more time to complete this exercise. Some solutions to this problem are further discussed in chapter 5.3.

4.3 TOWING OF RIG IN ICY WATERS

Scenario. A drilling rig is being towed by two icebreakers, and transiting through waters with possible ice. Since any ice has to be avoided, in addition to the two icebreaker tugs, there are an additional three vessels escorting the rig, scouting for ice. Any ice has to be reported, and if necessary, measures need to be taken to avoid the ice, i.e. alter course.

Objective. This is an advanced exercise with numerous objectives, on different levels. First, the two icebreaker tugs towing the rig need to be perfectly synchronized, i.e. all course alterations need to be carried out in small intervals of just one or a few degrees at a time and the speed has to be adjusted carefully, and simultaneously at both vessels. Such a manoeuvre carried out unsuccessfully might result in the two tugs gradually slipping away from each other, eventually making the tow uncontrollable. In figure 3, the tugs towing the left rig are positioned correctly, whereas the tugs to the right are dangerously far apart. Furthermore, it is important that the one tug acting as leading tug steps up and strongly takes control of the operation. For the vessels searching for ice, it is important that they are positioned correctly, so they search the area for the planned track of the rig. The search area has to be derived with regards to wind and current.

Findings. As with many aspects of training, previous experience plays an important role in the outcome of an exercise. The towing of the rig failed miserably for those not having a clear communication and chain of command; those participants generally had little, or no, previous experience of this kind of operation. However, since experience was not a prerequisite, it was important that these failures were brought up and discussed, and if time permitted, that the exercise was repeated.
4.4 ADVANCED CASE

Scenario. The final task in the simulator during the course in advanced arctic operations can best be described as a simulation of the complete operation, with real time decision making. The rig is anchored on location, operating according to normal operating procedures, and has a number of vessels at its disposal. In addition to these, one group of participants take the role of a shore based operations centre, so in total, this exercise includes rig personnel, vessel crews and shore based personnel. The exercise runs for approximately eight hours (split into four sections, allowing for breaks and discussions in-between), and during the exercise, the weather conditions change. Weather forecasts and satellite images are distributed at regular intervals.

Objective. All stations have to work together and practice all aspects of the operation, as they would in real life. When the weather deteriorates, the support vessels have to be utilized so that any ice objects that pose a threat are located, and if necessary, managed; this could be done by using the propeller wash to push the ice in another direction, using firefighting equipment to melt the ice, or by towing it away. If the ice cannot be managed successfully, it has to be decided whether the operation at the rig can proceed, or that the operation is to be discontinued and the rig moved to a safe location.

Findings. To complete this exercise successfully, a well-functioning teamwork was needed. This included a good chain of command with well-defined responsibilities for all bridges, and an unambiguous communication.

5 LESSONS LEARNED

In this chapter, some of the lessons learned are discussed. Some are general concerns that should be of interest to all simulator instructors, while other lessons learned are simulator type specific and might not be applicable to all navigation simulators.

5.1 TWO OR MORE SIMULATOR INSTRUCTORS

One important lesson learned is that simulating advanced operations requires a lot from the instructor. There might be a need to, simultaneously, monitor the exercise, change settings (e.g. weather), manoeuvre targets\(^6\), communicate with other vessels and solve any technical problems that might arise, and at the same time make sure that the exercise progresses according to plan. Therefore, one should not underestimate the value of having two or more instructors working together. During the courses in advanced arctic operations at KMA, there were always two instructors present; one focusing on the simulator and the other “directing” the exercise. This proved to be successful. The instructor responsible for directing the exercise had to adapt the directing to match the experience of the participants.

5.2 LESS IS MORE

Another general lesson learned is that the exercises do not need to be extremely detailed. Naturally, they need to involve the same elements as the real operation will, but it is extremely difficult to mimic every single detail, e.g. the exact distribution of ice. Also, the simulator bridges will most likely not have the same layout as the real vessels and the exact ship models might not be available from the simulator manufacturer, e.g. the generic model of the rig might have a different number of pods for steering, or the type of icebreaker used in the simulator might have different ice characteristics than the real one. It was not uncommon to hear participants make comments like “This would have worked on my vessel”, or “Why is the turning radius not smaller in this type of ice? It should be”. Altogether, this led the instructors

---

\(^6\) Targets are vessels operated by the instructor (or automatically by the simulator).
to the conclusion that it is more important to practice the general aspects of an operation, then to strive for perfection in every little detail. As a result, the exercises might seem a little “bare”; a towing exercise might only contain a few icebreakers and icebergs, but nothing else “to look at”. However, the pros of having practiced a complicated manoeuvre before the real operation, outweighs the cons of not having the throttle in the exact correct place or not having the exact model of a specific vessel.

5.3 SIMULATOR CAPABILITY – LIMITATION AND POSSIBILITY

The simulator used for ice navigation at KMA has the capability of handling five own ships (OS), and there are five bridges in the simulator. Presently, for an iceberg to be towable, it has to be an OS, thus occupying a bridge. Therefore, only two participants can practice iceberg towing at a time (leaving one bridge empty). Ideally, all participants should practice this manoeuvre on his or her own, and with a group size of approximately 12 participants, the exercise would have to be run six times, rendering a lot of idle time for the students. There are several ways to deal with this.

An organizational solution is to run this exercise in parallel with other exercises, so that one bridge (and one iceberg-OS) practices towing while three bridges practice something else. If the timing of the exercises works well, this might be a simple solution. However, a drawback is that not all five bridges can be used within the same exercise, which is often necessary for the more advanced exercises.

Another solution is to equip the simulator with additional “virtual” own ships which can be assigned to icebergs making them towable, without needing their own bridges. In that way, it would be possible to have several icebreakers towing icebergs at the same time. The issue with this solution is that every OS requires a license, which is associated with a licence fee. Nonetheless, after the next simulator upgrade at KMA in Dec 14, the new navigational simulator will have two additional virtual own ships. For any training centre that already has more than one simulator, another slightly more complicated solution would be to interconnect two (or more) simulators and handle all OS from one instructor control room. That way, the OS of one simulator could act as icebergs to the other one. This of course requires the possibility to interconnect the simulators, and that the second simulator is available. A more common use of this feature is probably to have combined navigational and engine room exercises.

5.4 COMMUNICATION

When co-operation between two or more parties is necessary, be it two persons on the bridge or sever vessels working together, it is essential that there is a safe way to communicate. When using oral communication, a common language has to be used. The courses in advanced arctic operations have had participants with diverse nationalities, including the Scandinavian and the Baltic countries, Russia, USA and Canada. The working language during the courses has been English. However, not all participants kept to the working language at all times. People with the same native language sometimes become complacent and used their own language, even though others were listening and thereby missing important information.

All participants had different levels of general English, the type of English one use for everyday conversation and small talk. However, quite quickly it became evident that it was not the person with the best general English skills that managed to communicate successfully during the exercises; it was the one who had a good command of maritime English.

---

Interconnecting two, or even three, navigation simulators is possible at KMA, which could provide 15 OS; however, the combined workload of the computers increases the risk of technical interruptions.
Features of maritime English, or SMCP\textsuperscript{8}, which proved to be effective included message markers\textsuperscript{9}, clear turn-taking\textsuperscript{10} and the use of simple standard phrases found in the SMCP.

5.5 DE-BRIEFING

When participants fail to meet the objectives of an exercise, this has to be dealt with in some way. If there is additional time available, the best solution is likely to let the participants try again (maybe some part can be skipped to save time). Giving the students a new opportunity to succeed has two advantages. Firstly, practice makes perfect, and if they did not succeed the first time, chances are they will the second time. Secondly, failing an exercise might leave the participants with a negative feeling of both the course itself and the upcoming operation, which can affect it negatively.

No matter if the exercise is repeated or not, one should not neglect the important de-briefing afterwards. It is important to let the participants discuss the outcome of the exercise, preferably with a playback\textsuperscript{11}. If the objectives for the exercise were known to the students beforehand, it can be a good idea to display them again and discuss whether or not all goals were met. If, for example, a manoeuvre failed it should be discussed why this happened, and what could have been done instead. The instructor must remember that the de-briefing is a learning opportunity, just like the exercise itself.

6 CONCLUSIONS

Even though this paper has focused on how advanced arctic operations can be simulated, many areas of what has been discussed are relevant to all activities taking place in the navigation simulator, for example the just mentioned de-briefing, which should not be overlooked no matter what the exercise is. To let the students express in their own words how the exercise was carried out, and why any mishaps occurred, can be just what is needed to avoid the same mishap in real life, an accident that would have much worse consequences than the one in the simulator. If time is limited, see if there is a way to re-structure the exercise to gain 10 minutes at the end. Another general area where improvements easily can be done is within communication. Just reminding the students about why a common language is needed might not be enough; the instructor must always take the lead and set a good example. If English is the working language, this should always be used in the simulator, and this has to be stressed even more when working with groups of same language non-English students, who easily tend to fall back to their native language.

After conducting eight courses in advanced arctic operations within only a few months, many valuable lessons have been learned. One example is the extra virtual own ships, which will be delivered with the next upgrade of the simulator, partly because of the outcome of these courses. However, the one most valuable conclusion after these courses is that to simulate something real, you need to involve highly qualified personnel from the start, namely the persons who are going to perform the real task. For Kalmar Maritime Academy, that means working in close co-operation with the shipping cluster. Even though most simulator instructors are experienced officers, specialized courses need special competency and experience. By combining the cutting-edge knowledge of a subject-matter specialist, with the technical know-how and pedagogical view of a simulator instructor, one get a great team that will be able to provide the course participants with the best basis to meet the challenges posed by their particular field of work.

---

\textsuperscript{8} Standard Marine Communication Phrases.

\textsuperscript{9} A word that indicates the nature of the following message: instruction, advice, warning, information, question, answer, request and intention.

\textsuperscript{10} Clearly indicating when you have finished your message and it is the other person’s turn to talk.

\textsuperscript{11} A playback is a video recording with a bird’s-eye view of the area.
7 REFERENCES


8 AUTHOR BIOGRAPHY

Magnus Boström is a Master Mariner with experience from both the merchant fleet and the role of deck officer, as well as from being a master and instructor in the Amphibious Corps of the Royal Swedish Navy. Since 2009 he is a lecturer at Kalmar Maritime Academy at the Linnaeus University, Sweden, with a personal interest in Maritime English. Apart from teaching at the Master Mariner’s Program, he also plans and holds courses in icebreaking and ice management. As of 2013, Boström is also enrolled in PhD-studies in maritime science, within the area of icebreaker operations.

9 AUTHOR INFORMATION

Captain Magnus Boström
Kalmar Maritime Academy
Linnaeus University, Kalmar, Sweden
Tel: +46(0)480 49 76 56 (Direct)  
+46(0)772 28 80 00 (Switchboard)
Email: magnus.bostrom@lnu.se