TP 13145E

MODERNIZATION OF THE PILOTAGE CERTIFICATION PROCESS IN THE LAURENTIAN PILOTAGE REGION

PREPARED FOR
TRANSPORTATION DEVELOPMENT CENTRE
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16. Abstract

This report details the research carried out to develop a modernized process for obtaining marine pilotage certificates in the Laurentian pilotage region.

The methodology included a review and assessment of the current training program and requirements for obtaining pilotage licences or certificates, interviews with key stakeholders, and an investigation of alternative and modern training applications used elsewhere. The existing pilotage certification process does not make adequate allowance for candidates' work environment, experience, and technology. Candidates currently lack a structured process to follow in preparing for the exam. The exam is based on a syllabus that consists of open-ended topics, with no objectives or standards defined.

The process should be modernized by creating a common body of knowledge, establishing a structured process for candidates' training, developing a program based on competencies rather than content, defining specific performance-oriented objectives and standards, and using a marine navigation simulator for training and validating. Upgrading the existing marine simulator at the *Institut maritime du Québec* and developing the programs and materials required could cost from $1.4 million to $2.4 million. Approximately eighteen months will be required to implement a modernized process following approval and funding.

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16. Résumé

Le présent rapport explique la recherche effectuée dans le but de moderniser le processus de délivrance des certificats de pilotage maritime dans la région de pilotage des Laurentides.

La méthode utilisée a compris l'examen et l'évaluation du programme actuel de formation et des exigences à satisfaire pour l'obtention de brevets ou de certificats de pilotage, des entrevues avec des intervenants-clés et l'analyse d'autres programmes de formation modernes utilisés ailleurs. Le processus actuel de délivrance des certificats de pilotage ne tient pas suffisamment compte du milieu de travail et de l'expérience des candidats ni de la technologie disponible. Dans l'état actuel des choses, les candidats ne disposent pas d'un cadre structuré qui leur permettrait de se préparer à l'examen. L'examen est fondé sur un programme comportant des sujets ouverts pour lequel aucune norme ou objectif n'a été défini.

Il faudrait moderniser ce processus. Pour ce faire, il faut constituer un bloc de connaissances communes, mettre en place un processus structuré de formation des candidats, élaborer un programme fondé sur les compétences plutôt que sur le contenu, établir des normes et des objectifs précis axés sur le rendement et utiliser un simulateur de navigation maritime pour la formation et la validation. La modernisation du simulateur en usage à l'Institut maritime du Québec et la conception des programmes et matériels didactiques nécessaires pourraient s'élever entre 1,4 million et 2,4 millions de dollars. Il faudra compter environ dix-huit mois pour mettre en oeuvre un processus actualisé, après obtention des autorisations et des crédits nécessaires.

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Executive Summary

Marine pilotage involves directing and controlling the movement of a vessel through near-shore and inshore waters. As stipulated in the Pilotage Act, these duties must be carried out by a licensed pilot within a compulsory pilotage area or by ship masters and other navigational officers who have obtained a pilotage certificate.

The process by which masters or other officers obtain a pilotage certificate has been subject to considerable debate in recent years and has been especially contentious for the compulsory pilotage waters of the Laurentian Pilotage Authority (LPA). The purpose of this study was to explore how the training and certification process can be modernized for the Laurentian region, in particular through the use of modern technology. The study results will also assist in responding to one of the requirements of the Canada Marine Act which was re-introduced to Parliament in October 1997. Licensing and certification standards for pilots, ship masters, and officers are to be reviewed and the findings reported back to Parliament within one year of the Act's passage into law.

The study was carried out according to the following major steps.

- **A review and assessment of the current training program and certification requirements**. Interviews with key stakeholders played a significant role in this process. Stakeholders included pilotage authorities (in particular, the LPA), the St. Lawrence River pilotage corporations, shipowners, and their respective associations (e.g., Canadian Shipowners Association, Association des armateurs du Saint-Laurent), and certificated ship masters piloting ships on the St. Lawrence River.

- **An investigation of alternative and modern training applications used elsewhere in the world**. Ten marine simulation and training centres were contacted or visited in Canada, the United States, and Europe. The simulator located at the *Institut maritime du Québec* (IMQ) in Quebec City was also visited. In addition, other organizations which employ simulators in their training programs (e.g., the Department of National Defence, Air Canada) were interviewed. Virtual reality technology was also investigated.

- **Development of a modernized pilotage certification process based on the findings of the previous steps**. This step included estimates of the time and costs required to implement the recommended certification process.

Based on our findings, we concluded the following.

- **Greater recognition is needed of candidates' work environment, experience, and technology.**

The work environment differs significantly between licensed pilots and pilotage certificate candidates. Licensed pilots are trained to be able to pilot any ship, including foreign-flag ships. Pilotage certificate candidates are concerned with their own ships. Certificate candidates are thus very familiar with the vessel they would pilot, including its handling behaviour, equipment, and crew.

Many potential certificate candidates have navigated safely for years in the restricted waters of the St. Lawrence above Montreal, and in the Great Lakes, without incident, and without a licensed pilot. By definition, potential certificate candidates also have extensive experience in LPA waters.

Many ships in the Canadian-flag fleet are well equipped with sophisticated technological aids for positioning and navigating (e.g., DGPS (Differential Global Positioning System) and electronic charts). CSA members' officers have undergone training in Bridge Resource Management, and several fleets are ISM-certified.

Within the context of the pilotage certification process, the existing process does not make adequate allowance for these factors.

- **The certification process needs to be revised.**

Pilotage certificate candidates lack a structured process to follow in preparing for the exam. No training program exists to guide them in their efforts.

Although laudable efforts have been made in recent years to bring a greater degree of fairness to the certificate exam (e.g., appointing a Transport Canada representative to the Board of Examiners), the exam process for certificate candidates is inappropriate. The exam is based on a syllabus that consists of open-ended topics with no defined objectives or standards. The exam places far too much emphasis on knowledge and not enough on performance. The aspect of the exam that attempts to test performance (i.e., certain elements of the oral exam) is unfortunately the most subjective part of the exam. These findings led us to conclude that the pilotage certification process needs to be modernized.

We thus recommend that the process be modernized by carrying out the following steps.

- Create a **common body of knowledge**, pooling the pilotage knowledge and techniques of all stakeholders, to develop a consistent source available to all.

- Establish a **structured process for certificate candidates** to follow for training, including access to materials.

- Create a training program using **a competency-based program development approach** (rather than content-based).

- Define **specific objectives for pilotage certificate candidates**: move away from an open-ended, knowledge-based syllabus to more concrete, performance-oriented objectives with associated standards to achieve.

- Introduce the **use of a marine navigation simulator for training candidates**.

- Introduce the **use of a marine navigation simulator as part of the certification process**.

Marine navigation simulators are used by many licensed pilot groups in North America, Europe, and elsewhere. Licensed pilots use simulators both for training and evaluating. The use of simulators for licensing or certifying is becoming more accepted by regulatory bodies, including the U.S. Coast Guard, the Department of National Defence, and the Port of Rotterdam.

We believe that marine simulation is a safe, useful, and important element in modernizing the pilotage certification process in the Laurentian region. The marine simulator at IMQ could be upgraded to meet the system requirements that we believe are necessary to achieve an adequate degree of realism and accuracy.

Costs to create a modernized process for pilotage certification include costs for designing a training program, preparing pedagogical materials, and acquiring or developing hardware and software. Total development costs would range from $1.4 million to $2.4 million. This does not include ongoing operating costs to deliver a modernized program.

The cost-effectiveness of installing and operating a full-mission bridge (FMB) simulator at IMQ must be weighed against the alternative of using an FMB-equipped marine simulation centre elsewhere for training and testing LPA pilotage certificate candidates. We do not believe that a FMB simulator would be cost-effective if it is only used for LPA pilotage certificate candidates. It may become cost-effective if also used for other purposes, such as Bridge Resource Management training, training licensed pilots, and training or certifying cadets and mariners upgrading their certificates of competency.

The time required to implement a modernized program for pilotage certification, including installing an FMB simulator at IMQ, will be at least 18 months from the time when approval and funding are in place. This assumes that IMQ staff create their own software, and that certain resources are dedicated on a full-time basis when required.

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I

Introduction

In this introductory chapter we describe the background leading up to this study and the objectives and scope of the study. A traditional definition of marine pilotage, as noted by Transport Canada, is as follows:

> "Marine Pilotage involves directing and controlling the movement of a vessel through near-shore and inshore waters unfamiliar to the ship's master or providing navigation advice to the master for this purpose. A pilot is traditionally a seasoned mariner with expert knowledge of local waters and special ship handling skills. The pilot is expected to integrate an in-depth knowledge of local geography, climate and traffic patterns with operational information to effect a safe passage. It should be noted that, by law, the master always remains in command and is ultimately responsible for the safe navigation of the vessel, including the actions of the pilot."[1]

Overlaying this traditional perspective of pilotage, ship's masters and other navigational officers have the opportunity to conduct their own pilotage in compulsory pilotage waters of the Laurentian Pilotage Authority (LPA), by qualifying for and obtaining a pilotage certificate. The process by which masters or other officers obtain a pilotage certificate from the LPA has been criticized by some stakeholders. The purpose of this study is to explore how the process can be modernized, in particular through the use of modern technology.

A. Background

Changes have been proposed to reform pilotage delivery in Canada; these changes will address long-standing issues and take advantage of modern technology.

1. The National Marine Policy and Canada Marine Act aim to reform marine pilotage

The National Marine Policy[2], unveiled in December 1995, was developed following a comprehensive review of Canada's marine sector by the House of Commons Standing Committee on Transport in early 1995.[3] Transport Canada also conducted its own consultations with shippers, carriers, other levels of government, trade associations, and others in the marine industry on the new policy prior to its announcement.

The policy identified four issues with respect to pilotage that must be addressed:

- The need to reduce costs;
- The validity of current compulsory pilotage areas and the mechanism for making such designations;
- The need to speed up the rate-setting process for new tariffs; and
- The criteria for qualifying as a pilot or holding a pilotage certificate, and he basis for granting vessel exemptions and waivers.

It is the fourth issue that is directly relevant to this study.

The Canada Marine Act, re-introduced to Parliament in October 1997, is intended to place the new marine policy within a legislative framework. The Act requires the Minister of Transport to review, *inter alia*, licensing and certification standards for pilots, ship masters and officers, and to report the findings to Parliament within one year of the Act's passage into law. The issue of modernizing the pilotage certification process is an important topic to many stakeholders.

Pilotage Authorities have submitted reviews of all designated compulsory pilotage areas to the Minister for the purpose of ascertaining if designation remains valid in every case. During the development process of the Canada Marine Act, a task force on marine pilotage was formed to deal with issues such as the licensing and certification standards for pilots, ship masters and officers, exemption criteria for vessels, and the feasibility of new training courses to prepare candidates for pilot licence and pilotage certificate examinations.

2. Several long-standing pilotage issues are relevant to this study

As is evident from the Minister's requirement for a review of the areas noted above, these issues have been long debated in the public arena, and are especially contentious in the Laurentian region. Among the pilotage issues that relate directly or indirectly to this study are the requirement for compulsory pilotage for domestic vessels; the training and certification process for pilotage certificates; the alleged monopolistic position of pilots; double pilotage; and the cost of pilotage.

The Great Lakes Pilotage Authority (GLPA) exempts domestic vessels from compulsory pilotage based on an attestation from the companies concerned that a ship's officer has made a required number of trips within the district in a specified period (i.e., ten one-way trips in the preceding three years). Unlike the GLPA district, compulsory pilotage is in effect for domestic vessels in the Laurentian region. (It should be noted that the GLPA has unsuccessfully tried to amend its regulations granting exemptions.)

For the first fifteen years since the LPA's inception in 1972, no Canadian officer applied for a pilotage certificate from the LPA. With the pilotage corporations' agreement, and in consultation with the CSA and the Association des armateurs du Saint-Laurent, the LPA implemented several changes to the examinations in 1992. These changes are considered by many to be important improvements to the process. The changes included replacing one of the Authority's representatives with a Transport Canada Examiner of Masters and Mates, appointing a CSA-nominated observer, the full transcription of oral exams, converting the oral exams on collision regulations to a written exam, and the participation of the Coast Guard representative in the preparation of both oral and written exam questions.

3. Pilotage issues are complicated, with different points of view

The above issues are complicated, with different parties holding different points of view. The need for safe navigation is universally acknowledged. Beyond this, however, the domestic marine industry is faced with issues of fleet productivity, flexibility, and pilotage costs with respect to pilotage in the Laurentian region.

Some parties defend the present approach through the belief that hands-on experience and local knowledge cannot be effectively duplicated electronically. The great strides in technological applications in other areas of transport such as aviation, now being applied in the marine sector, may counteract this argument.

B. Objectives and scope

The Pilotage Act stipulates that no person shall have the conduct of a ship within a compulsory pilotage area unless that person is a licensed pilot or a regular member of the ship's complement who is the holder of a pilotage certificate for that area.[4] Furthermore, no pilotage certificate shall be issued unless the Pilotage Authority is satisfied that the applicant has a degree of skill and knowledge equivalent to that required by a licensed pilot.[5]

The objective of this study is, respecting the guidelines of the present Act outlined above, to research, identify, and plan how new techniques and technology can be used to modernize pilot training and certification for the Laurentian region. Ultimately, it is felt that an independent certification program could be offered at a certified training facility, whereby the process would be approved and audited by the Pilotage Authority to ensure that safety is upheld. Within this framework, and as described in the Terms of Reference, *"it is now required to determine:*

- *the training required for certificate applicants;*
- *the methods by which this training can be offered; and*
- *the methods by which to verify successful completion of this training."*

The scope of the study, therefore, is on training and examining pilotage certificate candidates.

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[1] *Transport Canada internet site, accessed May 1997: www.tc.gc.ca/pilotage/english/ internet.htm*

[2] *Transport Canada, "National Marine Policy," Ottawa, December 1995.*

[3] *House of Commons Standing Committee on Transport, "A National Marine Strategy," Ottawa, May 1995.*

[4] *Pilotage Act, Section 25(1).*

[5] *Pilotage Act, Section 22(1)(b). Note that the wording in the French version of the Act substitutes "comparable" for "equivalent." Section 22(1)(b) of the Loi sur le pilotage reads as follows:*

"Il ne doit toutefois pas être délivré de certificat de pilotage à un demandeur à moins que l'Administration ne soit convaincue qu'il possède un niveau de compétence et de connaissance des eaux de la zone de pilotage obligatoire comparable à celui que l'on exige du demandeur qui présente une demande de brevet pour cette même zone."

II

Overview And Context Of Pilotage Certification

This chapter provides an overview of the LPA's responsibilities, powers and objectives, and some context within which the issue of pilotage certification should be viewed.

A. Overview of LPA

As a result of recommendations made by a Royal Commission on Pilotage in Canada[1], the Pilotage Act was assented to by Her Majesty and the Governor-in-Council and proclaimed in force February 1, 1972. The Pilotage Act created four pilotage regions with specific authorities, thereby replacing a large number of local pilotage districts. The four Pilotage Authorities (Atlantic, Laurentian, Great Lakes, and Pacific) are Crown Corporations, responsible to Parliament through the Minister of Transport. The LPA was established on June 30, 1971 and became effective on February 1, 1972, governed by the Pilotage Act and Regulations.

The objects of the Authority are to establish, operate, maintain and administer, in the interest of safety, an efficient pilotage service within the region.[2] The Chairman of the Authority is the Chief Executive Officer and has the direction and control of the business of the Authority. The board is composed of a maximum of seven members, appointed by the Governor-in-Council. The board includes representatives of the pilot corporations.

To carry out its responsibilities, the LPA has established general regulations[3] approved by the Governor-in-Council pursuant to the Pilotage Act, for:

- the establishment of compulsory pilotage areas;
- the prescription of the ships or classes of ships subject to compulsory pilotage;
- the prescription of the classes of pilots' licences and of pilotage certificates that may be issued; and
- the prescription of the tariffs of pilotage charges to be paid to the Authority for pilotage services.

In addition, the LPA is empowered, pursuant to the Pilotage Act:

- to employ such officers and employees, including licensed pilots and apprentice pilots, as are required for the efficient management of its operations;
- to contract with pilot corporations for the services of licensed pilots;
- to adopt bylaws concerning the management of its affairs;
- to purchase, lease or otherwise acquire land, buildings, pilot boats and other equipment and assets that they deem necessary and to sell any assets thus acquired; and
- to borrow, if necessary, in order to settle the Authority's expenses.

Finally, the Authority's corporate objectives are as follows.[4]

- to provide a complete, safe, efficient and economic pilotage service;
- to promote the efficient utilization of the installations, equipment and expertise of the Authority by the productive use of its resources in such activities and/or geographic areas as may be appropriate, in the interest of safe navigation;
- to provide the above-mentioned services within a commercially oriented framework, directed towards achieving and maintaining long term financial self sufficiency and viability; and
- to be responsive to the Government's economic, social and environmental policies.

B. Organization of pilotage within the LPA

The obligatory pilotage waters of the LPA are divided into several districts.[5]

- District I-1 encompasses the Harbour of Montreal, and licensed pilots serving this district are employees of the Authority. They are mainly involved in ship movages.
- District I covers the territory between Montreal and Quebec City. For operational purposes it is divided into two parts:
  - Montreal to Trois-Rivières;

– Trois-Rivières to Quebec City.

- Licensed pilots in this District are entrepreneur pilots. The pilots specialize in one part or the other of this district. For transits of the district, a change of pilots is required at Trois-Rivières.

- District II covers the waters between Quebec City and Les Escoumins, including the Saguenay River. Licensed pilots in this District are also entrepreneur pilots. For transits of the district, a single pilot is normally required, unless the time spent transiting the district exceeds a stipulated number of hours.

- District III is a non-compulsory pilotage zone, and covers the remainder of the navigable waters within the jurisdiction of the Authority, downstream of Les Escoumins.

Time spent by a ship in each district while transiting depends of course on the normal speed of the ship, plus other factors such as wind, tides, weather conditions, and marine traffic. As a point of reference, downbound Oceanex ships may typically take 16 hours between Montreal and Les Escoumins, while upbound transits may take 18-19 hours. Many other domestic ships would be slower than these times.

C. Classes of pilotage licences and certificates

The LPA has established four classes of licences or certificates. Class D licences are awarded to apprentice pilots, and allow them to carry out pilotage training on board vessels under the supervision of a licensed pilot. Thus a Class D licence exists only in the context of licensed pilots—there is no equivalent for certificated pilots.

The other three classes apply both to licensed or certificated pilots, and are based on ship sizes. Different types of measurements are used in different districts of the Authority. Exhibit II-1 displays the maximum vessel sizes corresponding to each class of licence or certificate, for each district.

Exhibit II-1
Classes of LPA licences and pilotage certificates—maximum vessel size

Class	Montreal Harbour District I-1	District I	District II	District III
A	No limit	No limit	No limit	No limit
B	≤ 12,000 NRT	≤ 12,000 NRT	≤ 50,000 DWT	≤ 10,000 NRT
C –in 1st year –in 2nd year	n.a.	≤ 5,000 NRT ≤ 7,000 NRT	≤ 20,000 DWT	≤ 5,000 NRT
D –apprentice pilot permit	No limit (Training in presence of licensed pilot)	No limit (Training in presence of licensed pilot)	No limit (Training in presence of licensed pilot)	No limit (Training in presence of licensed pilot)

D. Context

Pilotage certification is one issue among several pilotage concerns held by some stakeholders. It is important to have an overall appreciation of these concerns, since they form part of the context within which this study must be carried out, and help illustrate the importance of certification to domestic fleets.

Transport Canada prepared a discussion paper on marine pilotage, which raised and discussed a number of issues.[6] The discussion paper set forth a number of criticisms, with each criticism followed by a commentary section. Relevant criticisms noted in the discussion paper included the following.

- *"The competence of Canadian pilots is recognized and is not an issue. However, it is felt by some that the mandatory nature of the service and the existing legislative/regulatory requirements are overly onerous for the domestic industry in some areas and that they could appropriately be relaxed without detriment to the safety of the system.*

- *Despite recent improvements, the eastern Pilotage Authorities have not consistently fulfilled their statutory requirements to be financially self-sufficient and their losses have had to be offset through government appropriations. This has resulted in calls for a strategy to return them to self-sufficiency or if need be, legislative change.*

- *Pilotage costs are viewed as being excessive by some, particularly the domestic shipping industry in eastern Canada that disagrees with the compulsory aspects of the service as it applies to its members, which has rationalized its own fleet and operations in light of the downturn in the economy, and maintains that pilotage costs constitute a critical component in its continuing competitiveness and survival.*

- *The domestic shipping industry contends that the examination process for its officers to obtain pilotage certificates in the LPA is unduly onerous and biased, that the composition of the Board of Examiners is weighted in favour of the pilot representatives and to the detriment of industry, and that the pilots concerned are, for their own self-interest and job security, not interested in a more flexible process or in making the system work. On the other hand, pilot groups and the Authority would argue that, despite amendments having been made to the process in response to these concerns, this segment of the industry will not be satisfied until it is granted a blanket exemption from compulsory pilotage, or exemptions under conditions that are similar to those which it currently enjoys in the GLPA and which are not provided for in the legislation.*

- *Some elements of the industry are dissatisfied with the regulatory requirement in certain Authorities to embark two (2) pilots at the same time, because of the nature/length of the voyage, and maintain that it is unnecessary and constitutes an additional cost that they can ill afford. These criticisms principally centre on the LPA, insofar as winter navigation, tankers and passenger ship requirements are concerned.*

- *It is contended in some quarters 'that recent technological advances such as satellite global positioning systems, coupled with computer based charting, allow for more precise and safer navigation and these would appear to be technologically superior alternatives to traditional pilotage' (Sub-Committee on the St. Lawrence Seaway of the Standing Committee on Transport, October 1994)."*

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[1] *"Report of the Royal Commission on Pilotage," Ottawa, March 1, 1968.*

[2] *Laurentian Pilotage Authority, "1996 Annual Report," page 1.*

[3] *Laurentian Pilotage Authority Regulations, C.R.C., c.1268.*

[4] *Laurentian Pilotage Authority "Corporate Plan 1998-2002."*

[5] *Laurentian Pilotage Authority Regulations, Schedule II.*

[6] *Transport Canada, "A Discussion Paper on Marine Pilotage in Canada," January 27, 1995.*

III

Current Process For Obtaining Pilotage Licences And Certificates

This chapter describes the current process for obtaining a pilotage licence or certificate within the compulsory pilotage waters of the LPA.

A. Process for obtaining a pilotage licence

The process for obtaining a pilotage licence is highly structured and well defined. The process begins by recruiting applicants into the system.

1. Apprentice applicants

The LPA and respective pilot corporation (District I or II) jointly agree on the number of apprentice pilots to recruit at any given time. Generally in the spring, the LPA publishes a notice to the effect that,

> *"The Laurentian Pilotage Authority will be recruiting for (April 1997) one or more apprentice pilots who, after a period of studies, training and examinations, will become marine pilots on the St. Lawrence River in (District No. I (area of Montreal-Quebec))."*[1]

Prerequisites exist for all applicants, including requirements of Canadian citizenship or permanent residency, bilingualism, medical fitness, a diploma awarded by IMQ or equivalent, for a four-year program of marine navigation, an ON-1 or equivalent certificate, and certain other requirements of the Pilotage Act.[2]

The Authority opens a file for each qualifying applicant, and ranks the candidates based on their qualifications, experience and knowledge. Selected candidates appear before the Board of Examiners for an oral evaluation. Successful applicants accepted into the licensed pilot apprentice program are then awarded a Class D licence.

2. Apprentice program

Apprentices begin with a one-week course, followed by a lengthy period of mentoring. Apprentices are required to complete a minimum two-year training program. During this time, their time is entirely devoted to the practice of pilotage within the St. Lawrence—in other words, they follow a full-time program of training and study for at least two years. While apprentices, they are paid by the LPA, rather than by the pilot corporation with which they are affiliated.

Their training program includes the regulatory requirement to effect numerous trips and movages under the supervision of a licensed pilot. During the two-year period, annual trip requirements are as follows:

- District I (Montreal to Trois-Rivières section):
  - 120 trips between Montreal and Trois-Rivières;
  - 18 trips between any place between Montreal and Trois-Rivières;
  - 6 trips between Montreal and Trois-Rivières in winter (January 1 to March 31).
- District I (Trois-Rivières to Quebec City section):
  - 130 trips between Trois-Rivières and Quebec City;
  - 8 trips between any place between Trois-Rivières and Quebec City;
  - 6 trips between Trois-Rivières and Quebec City in winter.
- District II:
  - 113 trips including 9 to Chicoutimi and 15 to Port Alfred;
  - 9 trips in winter.

Pilot apprentices strive to obtain a variety of experiences, by assisting on different sizes and types of ships. Some apprentices also spend a short period of time on board tugboats assisting in manoeuvres, to gain an appreciation of vessel manoeuvring from the perspective of a tug.

The regulations also prescribe the required number of dockings or undockings at certain harbours within each respective district, including Montreal, Trois-Rivières, Sorel, Contrecoeur, St. Lambert Lock, Quebec City, Chicoutimi (including Grande Anse) and Port Alfred.

Apprentices make several trips accompanied by administrators of the respective pilotage corporations. This allows senior representatives to observe first hand their progress and ensure quality control.

In addition to this extensive practical experience and coaching by licensed pilots, apprentices receive formal shore-based training by the pilot corporations, as sanctioned by the service contract between the corporation and the Authority. Each winter, apprentices attend a six-week course, aimed at reviewing, analysing, and learning from the practical experience obtained on board ships. At the end of the six-week course apprentices write an "internal" exam sanctioned by the pilot corporation. An apprentice is promoted to his second year only after successfully passing the exam during the first winter. If he fails, he starts his apprenticeship anew, including re-doing all of the trips accomplished in the preceding year.

Following the second winter course and successful completion of the second "internal" exam, an apprentice is recommended by the pilot corporation to attempt the exam provided by the LPA to obtain a Class C licence.

3. Examination process

Examination sessions are held twice a year in March and September, and are held at the same time and place for licences and certificates for all districts. The date, time and place of exams are announced in newspapers at least two months in advance. The syllabus for the exams, as published by the LPA, is included as Appendix A to this report. Prior to being admitted to a pilotage exam, a person must take a language test to demonstrate proficiency in French and English. Subject matters and expressions used in the test are marine related, and the test is administered by an officer of the LPA.

Exams are conducted by a Board of Examiners, chaired by the Authority's Director of Operations. The Authority also appoints one other member, who is a Transport Canada (Marine Safety Directorate) Examiner of Masters and Mates. The other three members of the Board are representatives of the pilot corporation. Typically, the Authority also appoints an observer to the oral part of the exam, who submits a report of his findings to the Chairman of the LPA.

The examination process has two basic parts, as summarized in Exhibit III-1. Part I of the exam consists of two written tests, one on "general knowledge" and the other on collision regulations. A candidate must be successful in Part I before being admitted to Part II. The second part consists of a written test on local knowledge, followed (if successful) by an oral exam in front of the Board of Examiners on local knowledge, regulations, and ship handling. The oral exam is recorded on tape, and in case of failure will be made available by the Authority to a candidate when requested.

Exhibit III-1
LPA exams session

Subject Matter	Type	Duration	Minimum requested
PART I			
General knowledge [1]	Written	3 hours	60% [a]
Collision regulations	Written	2 hours	60% [a]
PART II			
Local knowledge [2]	Written	3 hours	60%
Local knowledge, regulations and ship handling [3]	Oral		

As provided in the regulations:

[a] *The general average of the two exams of Part I shall be no less than 70%.*

[1] *Subject matters are listed in Sections 3, 4 and 5 of the Syllabus for Pilot's Licence and Pilotage Certificate between Les Escoumins and Montreal.*

[2] *Subject matters are listed in Sections 7 of the Syllabus.*

[3] *Subject matters are listed in Sections 4, 6 and 7 of the Syllabus. This examination may also include questions on subjects contained in Sections 3 and 5.*

A candidate can take Part II at the same session as Part I or at any of the next four biannual session. Failure to successfully pass one or both tests of Part II constitutes a failed attempt. In this case, both tests must be taken at a subsequent session. A person who has failed an examination three times is not eligible for further examination.

A licensed pilot can progress from a Class C licence to a Class B and eventually a Class A. In District I or II the pilot must serve as a Class C pilot for at least 24 months before making an application for a Class B licence, and in the most recent year have piloted at least two-thirds of the average number of pilotage assignments for the District.

To progress to a Class A licence in District I, the pilot must have served for at least 36 months while holding a Class B licence. In District II the time frame is at least 6 years as a Class B pilot. The same rule regarding at least two-thirds of the average number of assignments as described above also applies.

4. Retaining a licence or certificate

In order to retain a valid licence or certificate the LPA has established requirements for the minimum number of annual trips that a pilot must effect. A holder of a licence or pilotage certificate shall pilot each year at least eight one-way trips in District I or II during the period from April 1st to December 14th and, if applicable, two one-way trips during the period from December 15th to March 31st.

B. Process for obtaining a pilotage certificate

A pilotage certificate issued by the Authority permits the holder thereof to perform pilotage duties only on board the ship of which he is a regular member of the complement.

1. Requirements and restrictions for pilotage certificates

Candidates for pilotage certificates must have served on ships engaged in voyages in the appropriate District one year as master or three years as deck officer. During this required service period, the candidate must have effected on board a ship of a size that is subject to compulsory pilotage:

- 24 one-way trips per year between Montreal and Trois-Rivières; or
- 24 one-way trips per year between Trois-Rivières and Quebec City; or
- 12 one-way trips per year in District II (only six one-way trips per year are required for a restricted certificate in District II).

The regulations include various other requirements for movements in certain harbours. However, candidates can opt for a certificate for only part of a district, such as the case for a transit-only certificate. To date, certificate holders have opted to obtain certificates valid for transits only. Future candidates may seek less restricted certificates.

Candidates can also apply for a year-round certificate or one with a seasonal limitation. Some certificate holders have obtained year-round certificates, while others hold seasonal ones. For a year round certificate, candidates must have made six one-way trips per year during the period from December 1st in any year to April 8th in the year next following. Candidates will also face several questions related to navigating in ice.

Candidates must have a degree of proficiency in the French and English languages sufficient to effectively carry out their pilotage duties. They must also be declared medically fit to carry out pilotage duties.

As with pilotage licences, the LPA advertises in advance that it will hold examinations for pilotage certificates. These are held at the same time and place as the exams for pilotage licences, in March and September each year. The exams are identical for pilot licences or certificates.

Unlike the hierarchical progression for licensed pilots described above, a pilotage certificate candidate's first application may be for any Class of certificate (C, B, or A). Qualified candidates receive the LPA syllabus, and are notified of where to appear for their exam(s).

2. Local knowledge exam

A typical written local knowledge exam may have the following characteristics.

1. Limits of the District and general questions on visual marks (10 marks):
   - Geographical limits of the district (2 marks);
   - 5 questions on visual marks (1 mark each);
   - 3 questions on navigable channel widths (1 mark each).
2. Direction and speeds of currents (10 marks):
   - 5 questions (2 marks each).
3. Bearings, ranges and currents (10 marks):
   - 5 questions on bearings and distances of various buoys (1 mark each);
   - 5 questions on time of day and currents (1 mark each).
4. Isobathic and tidal questions (10 marks):
   - 5 questions on 10 m contours (1 mark each);
   - 5 questions on tides (1 mark each).
5. Questions on a particular section of the District (10 marks).
6. Drawing of charted features of a section of the District (50 marks):
   - Precision (15 marks);

– Buoys and ranges (10 marks);

– 10 m contours (25 marks).

Aside from the chart, the exam consists of a number of detailed questions, with each question worth only one or two marks. Some candidates expressed a preference for this approach rather than a handful of questions, each worth a significant amount.

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[1] *Standard notice provided by the LPA.*
[2] *Laurentian Pilotage Authority Regulations, section 20(4).*

IV

Comparison Of The Process For Licence Versus Certificate

In this chapter, we compare the process for obtaining a pilotage licence versus a pilotage certificate. The chapter begins with a review of the respective work environments for pilots and masters, followed by a look at candidates' preparation.

A. Work environment

1. Licensed pilots

The work environment for licensed pilots varies depending on the ship which they are piloting. The greatest variation occurs among foreign-flag vessels, where the experience may range from highly sophisticated vessels that trade regularly or frequently in the St. Lawrence, to older, less well equipped ships that trade very infrequently here. International ships may have crews of diverse nationality, with differing levels of experience and training. Domestic ships are more uniform and familiar to licensed pilots in terms of their crews, equipment, and handling.

A key point is that licensed pilots must be prepared to pilot <u>any</u> ship. Thus, their training is geared to give apprentices a wide range of experience in terms of vessel types and capabilities.

Licensed pilots typically undertake an average of 100-120 assignments each year, although this figure would include movages, dockings and undockings as well as trips.

2. Pilotage certificate candidates

Domestic Captains are assigned to the same ship, or very similar ships, for a period of several years or more. The Captain is thus very familiar with the handling properties of his ship.

The same typically goes for crewmembers, so that the Captain is also familiar with his crew. Domestic flag crewmembers are Canadian citizens. Most would have been trained in Canada, at one of a handful of local marine institutes.

The LPA regulations require as few as six one-way trips in the preceding year for a candidate seeking a restricted pilotage certificate in District II. In practice, successful candidates have completed more than six trips in the preceding year, and have benefited furthermore from several years or more of navigating in LPA waters as a Master or senior officer.

Most of a Captain's time on board is taken up either with navigational duties as a deck officer, or with administrative duties as the senior officer and company representative on board. Time aboard is definitely limited for preparing for a pilotage certificate, even for a highly dedicated individual.

Most relevant ships in the domestic fleet are equipped with a Differential Global Positioning System (DGPS), which many shipowners and the Coast Guard consider a highly accurate tool for instantaneously determining a ship's position. When DGPS is declared operational, it should allow a highly accurate course to be maintained automatically, by entering beforehand the coordinates of a passage into a DGPS receiver. Some 95% of ships in CSA members' fleets are also equipped with leading-edge electronic charts, according to a CSA representative. Some masters have noticed a change in the work environment for licensed pilots on ECDIS-equipped ships, whereby pilots are much more likely to proceed at night in the winter, and in poor conditions, than they were before the same ships were equipped with ECDIS.

Captains working for Great Lakes or Seaway-based fleets are very busy during the period in which the St. Lawrence Seaway is open, generally from late March or early April until the end of December. A large part of their time off occurs during the winter, from January through March. Working schedules are different for fleets whose activities are focussed on the St. Lawrence below Montreal, where sailing is done year round. In this case, a Captain may work for four or five weeks on board, followed by a rest period of equal length. Work schedules for the rest of the crew may be more like five weeks "on" and three weeks "off."

B. Preparation by candidates

At present there are six active LPA pilotage certificate holders, three of whom work for the same company (Oceanex). Companies employing these certificated pilots are members of the Canadian Shipowners Association and/or the Association des armateurs du St-Laurent.

Some of these certificate holders prepared study notes which they have made available to other candidates. Small details are added as the accumulated knowledge increases. The usefulness of these notes varied from one candidate to another, however. While candidates were all grateful for assistance, this method has its limitations, since:

- Captains are in the business of navigating their ships, and are not experts at preparing pedagogical materials;
- Even if they were expert teachers, Captains are busy navigating ships and don't have time to teach;
- Each candidate prepared in his own way, and some found the notes prepared by others to be of little or no use to them; and
- Shipping companies are in competition, and may hesitate to pass information to other companies.

The only other source of detailed information is proprietary to licensed pilots, and not available to certificate candidates. Thus, the burden of preparation is a heavy one, most especially for Part II (local knowledge).

Some candidates began their preparation while serving on board their vessel, spending approximately 20–24 hours per week studying. The proportion of total preparation time done aboard ship ranged from 0–30%. The remainder of time was spent in intensive studying.

One successful candidate mentioned that he prepared some 80 to 100 hours prior to writing Part I of the exam, during the preceding two-week period. Many devoted the better part of three months to their preparation for local knowledge, studying full time in this period. Several candidates estimated their total preparation time to have been upwards of 1,500 hours. Companies gave their masters paid time off for preparation.

C. Oral exam

The oral exam is before the Board of Examiners, chaired by the LPA. It consists mainly of a series of specific situations described for the candidate, who is then asked how he would pilot the particular ship under those particular conditions, and what factors would influence his decision. The Board is seeking an assessment of the candidate's piloting ability based on oral responses. The length of the oral exam can vary considerably, depending, it would appear, on the Board's degree of comfort with the candidate. A nervous, hesitating candidate giving some unsatisfactory answers can expect to be grilled by the Board for a longer period of time than a candidate who consistently impresses the

Board through his answers and demeanor. In the eyes of the LPA, this approach is valid, in that:

- candidates are not rushed to provide a response, and sometimes are prompted to re-think their response; and
- a sufficient amount of time is taken to allow the Board to fully assess the candidate's capabilities, and most especially to determine, in the opinion of the Board, whether the candidate will pose a hazard to safety.

On the other hand, this flexible approach has been viewed by some, including candidates, as an indication that the process is questionable or possibly biased.

Several observers reported the conduct of the exams as sufficiently measured, acceptable, and fair. These remarks were not necessarily intended by the latter Observers as support for the current examination process. They reported that, within the present process, they did not find any bias or unfairness towards candidates.

D. Comparison of the processes for licence versus certificate

The preceding description points out several important differences between obtaining a pilotage licence and certificate, summarized below.

- Both classes of pilots must be familiar with the LPA District(s), as evidenced by the requirements for a minimum number of trips in the District both as a prerequisite to applying for a licence (Class C) or a certificate, and as a requirement for maintaining a licence or certificate.
- The work environment differs fundamentally between licensed pilots and pilotage certificate holders. Licensed pilots are trained to pilot any ship; certificated pilots are concerned with just one ship, or one type of ship.
- Certificate candidates will therefore be very familiar with the vessel which they would pilot.
- Despite differences in work environment, both classes of candidates are faced with identical exams.
- Licensed pilots must also be familiar with secondary ports in a District. All pilotage certificate holders to date have certificates restricted to transiting the District.

- Licensed pilot apprentices are trained in a highly structured environment by representatives of the pilot corporations.

- Pilotage certificate candidates are essentially on their own for exam preparation. Much useful information to prepare for exams is held solely by licensed pilots, and is not in the public domain.

- It is difficult for masters to devote the time necessary to prepare themselves for the LPA's exams, both because of their duties and burden of responsibility while on board, and the physical and psychological importance of "recharging their batteries" while ashore.

Aside from the difficulty inherent in the present process, many question the fundamental relevance of applying the existing process to certificate applicants. This issue is examined in the following chapters.

V

User Needs And Requirements Of The Authority

This chapter identifies the requirements of the LPA and the needs of stakeholders regarding pilotage certification. It is based on extensive interviews that were conducted with representatives of the Authority, domestic shipowners, foreign-flag shipowners (through the Shipping Federation of Canada), certificated pilots, and licensed pilots. A list of individuals whom we interviewed is included as Appendix B.

This chapter presents the general position of each group of stakeholders regarding obtaining pilotage certificates. Comments that pertain specifically to the use of simulators and other technology are referred to the following chapter. Differences exist among the needs and positions of various groups, giving rise to several issues regarding certification. Some of these are touched on below. Major issues are dealt with more fully in a later chapter.

All parties interviewed emphasized the importance of safe piloting, and stressed that safety must be the primary consideration of any discussion of pilotage. Differences arise fairly quickly, however, on how safety is best ensured.

A. LPA

In order to help Canadian masters obtain pilotage certificates, the President of the Authority sees a fundamental need to create a more structured approach in the training process, by putting in place a structured training plan, and, if necessary, adjusting the examination process. There is a need to recognize the different work environment of licensed pilots versus Canadian masters, and to adjust accordingly the process for obtaining a pilotage certificate. The President sees a strong need to ensure that Bridge Resource Management (BRM) training becomes part of the pilotage certification process. This would enhance communication, coordination of tasks, and appropriate behaviour in the event of an impending incident, and strengthen the qualifications of certificated pilots.

The Authority's Director of Operations, who chairs the five-person Board of Examiners for pilotage exams, noted that significant changes have been made to both the syllabus and the exam process since 1993. Prior to that time the syllabus appeared to have been designed for people lacking basic navigational knowledge. The same process in examinations is used for licence and certificate candidates; oral proceedings are recorded, and observers are present. In essence, the current process is considered fair.

Authority representatives stressed the need to ensure that any candidate can safely and competently pilot through an entire district (or half a district, in the case of District I). It must be determined whether a candidate will know what to do under any potential scenario, anywhere in the district, and whether the candidate is capable of controlling his ship and himself.

Despite the lengthy syllabus, Authority representatives stated that the tests in Part I are geared towards "fairway pilotage," with questions on relevant topics such as tides, compass deviation, and emergency measures—basic, important concepts for piloting. Despite the "General Knowledge" title, the emphasis of Part I is on safety measures. Part II of the test determines the candidate's familiarity with the coastline and other local knowledge.

In the opinion of some Authority representatives, a number of candidates for pilotage certificates were not properly prepared. Many did not seem to realize what they would be tested on. Some appeared to have prepared superficially, but more importantly, they lacked appropriate direction and structure for their efforts.

B. Domestic shipowners

Shipowners are unsatisfied with the present regime for pilotage certification in the LPA, and point out the following.

- Exemptions for pilotage are granted within the Great Lakes Pilotage Authority (GLPA) after 10 one-way trips are completed within a three-year period.

- Exemptions are granted on the Fraser River for Canadian ships under 10,000 GRT that meet several conditions such as minimum number of transits; on the St. Lawrence, exemptions are only valid in the 1,500 to 2,000 GRT range.

- Pilotage certificates are common in the Atlantic Pilotage Authority. The type of pilotage differs fundamentally, of course, between harbour pilotage and "fairway" pilotage.

- Pilotage is not compulsory in the Arctic, despite potentially severe conditions.

- Ships operated by Her Majesty are exempt from compulsory pilotage.

- Shipowners perceive some measures within the LPA as economic irritants that do not enhance safety, including the requirement for docking pilots at Lower St. Lawrence River ports, and double pilotage requirement in winter.

- The LPA has not been financially self-sufficient in recent years, and has sought tariff increases to cover its losses.

- The economic "checks and balances" on pilotage that formed part of the Canada Marine Act have not yet become law.

The primary need of the shipping industry is for trained pilots who can conduct the passage of a vessel safely through the designated pilotage district. These pilots must be adequately trained and certified to meet the highest safety standards. It is in the industry's best interests that pilots are properly trained and certified. The safe conduct of the vessel is of utmost importance for industry, far ahead of direct costs associated with licensed pilotage. However, many in the domestic shipping industry believe that certificated pilots, who are both properly trained and examined with industry input, would offer superior pilotage services versus those offered by licensed pilots. This owes to greater handling experience with their particular ship, and experience in transiting the area many times on the same vessel.

In order to meet this need, the pilotage certification and examination process should be revamped. Specifically, the following should be undertaken in order to make the process meet the needs of stakeholders.

- The training requirements and program for obtaining a pilotage certificate should be established in conjunction with industry. The shipping industry should be involved in the development of a designated syllabus directed solely at developing competent pilots for the designated pilotage areas.

- The contents of the syllabus and the examination criteria must be made totally transparent and publicly available so that the candidates for certification are fully aware of their responsibilities and duties. This will enable them to be trained effectively. A third party such as Coast Guard or an independent organization would be responsible for maintaining the syllabus and for conducting fair and impartial exams.

- The training process must allow pilots to gain experience and to demonstrate proficiency in piloting a vessel in the required district. This proficiency must be demonstrated through actual practice and demonstrated experience in transiting the designated waters. No amount of training at shore-side facilities can compensate for actual time spent at the bridge. The use of shore-side facilities such as simulators should be made in conjunction with, not in place of, actual transit experience.

- The training process must stress the development and execution of passage plans, detailing the route or track to be taken within the pilotage district. This would make the pilotage of vessels conform with the principles of effective Bridge Resource Management (BRM).

- The examination process should be revamped, whereby the focus would be placed on candidates having to demonstrate their proficiency in pilotage skills. This could be accomplished by successfully completing a repeated number of trips under varying conditions through the designated pilotage district. Certificated industry representatives should sit on the Board of Examiners and be directly involved in the examination process.

The chief concern and requirement of the domestic shipping industry is to adjust the present system from one that is based on memorization to one that evaluates performance. The current syllabus is used to test knowledge, not performance, in the eyes of the domestic industry. Candidates for pilotage certificates need performance-based training and performance-based testing. Candidates should demonstrate their ability to prepare a passage plan and ability to follow it.

CSA representatives state that CSA members' fleets have spent over $5 million in the past two years on BRM training. By the beginning of the 1998 navigation season all masters and deck officers in CSA members' fleets will have been trained in BRM. Moreover, close to 50% of CSA members' fleets are ISM-certified, with the remainder intending to become so.

1. Importance of passage planning

Domestic shipowners highlight first the importance of preparing an adequate passage plan. Second is the requirement to communicate this plan to others on the bridge. Third is the need to properly execute this plan. In each of these areas, it was felt that ships' captains are doing an adequate job, especially when compared to licensed pilots. Some shipowners say that pilots do not prepare passage plans, do not communicate their intentions to captains, and are not as adept at sticking to a proper course as they might think.

2. Proficiency-based training and testing

Some shipowners believe that any system that places so much emphasis on memory is faulty. Knowledge-based systems tend to break down without a backup available, which may be called a decision support system. Furthermore, just knowing proper courses and turning points is not acceptable. Pilots or captains need to show that they can keep a ship on its track (which can be demonstrated on a simulator, for example).

Proficiency-based training should be based on information available to everyone, information that is written down and disseminated. The tightly-held "little black book" approach of licensed pilots is outdated, unfair to the domestic industry, and ignores the tools already available on the bridges of a number of ships. The process of piloting a ship should be instrument-driven using data available to all. In short, the industry should change its expectations of what it is trying to accomplish. The emphasis should not be on memorizing local minutiae through relentless repetition, but on creating a database of information available to all.

3. Recognition of the experience of domestic officers

Shipowners point out that many of their masters have sailed without incident for years in difficult waters without mishap, including sailing with a pilotage exemption in the Great Lakes and St. Lawrence above Montreal. The fact that this experience does not seem to be taken into consideration by the Authority or the pilot corporations, and especially that no distinction is made between domestic and foreign-flag ships, is aggravating to them.

Some shipowners wonder why the same process or requirements should be demanded of licensed versus certificated pilots. They point out that many or most domestic Captains interested in obtaining a pilotage certificate:

- would seek a certificate for just one vessel or type of vessel;
- are very familiar with that vessel and how it handles;
- have been trained at local training institutes;
- have years of local experience;
- operate with Canadian crews;
- have advanced navigational technology on board; and
- are seeking a certificate for transits only.

Shipowners care just as much about safe operations as any licensed pilot, they say. Shipowners point out that millions of dollars are at stake for every voyage, in terms of people, cargo and the vessel, so that safety is definitely their priority.

4. Examination process

The above comments make it clear that domestic pilotage users want the system for obtaining pilotage certificates changed, with the emphasis on performance assessment. The manner in which testing is done should also be changed, especially by taking advantage of modern means such as simulators to assess performance. There should be a logical progression and structure linking the syllabus, training, and exam, supported by technology. While continuing in future an exam of local knowledge was widely accepted, it was also widely felt that drawing a chart was not the way to test this. Lacking any performance component, this results in cramming details which are soon forgotten. In addition, other aspects of the current process should be revised.

A common concern was the make-up of the Board of Examiners, and the dominance of pilot corporation representatives on the Board. Opinion was varied regarding the future composition of the Board. Some felt that the examination process should be handled largely by instructors of the Institut maritime du Québec; others felt that Transport Canada should assume more responsibility; some felt the Authority should exercise more power; others felt those who had obtained pilotage certificates could play a role in future in examining candidates; and some felt that an external agency (e.g., a simulator centre) could assume responsibility.

Many felt that the maximum of three attempts to obtain a pilotage certificate is very onerous. Most Captains who fail twice would be loath to try a third time with so much pressure and so much riding on the outcome of an exam. To fail a third time is considered by many a serious career-limiting move, to say nothing of the “loss of face” among peers.

Several domestic industry representatives highly regard Bridge Resource Management training and see it as an important adjunct to the process for obtaining a pilotage certificate.

It was recognized that those Captains who had already obtained their pilotage certificates could act in useful ways to assist in the process for others. This could consist of acting as Observers at exams, acting as trainers, or passing along their knowledge.

C. International shipowners

The chief concern of foreign-flag shipping interests is that any revised process for issuing pilotage certificates to Canadian shipmasters must not have an adverse impact on either the safety or efficiency of foreign-flag ships using licensed pilots. Shipping Federation members represent the LPA's major client sector. The presence of competent pilots, certificated or licensed, on board ships using the St. Lawrence is crucial to the safety, continuity, and efficiency of the waterway.

D. Canadian-flag ships' masters

Canadian-flag masters who have obtained their pilotage certificates see the need to demonstrate their competency to safely conduct their ships through designated pilotage waters. However, they believe that insufficient credit is accorded them by the Authority in light of their demonstrated high level of skill at safely navigating vessels through demanding waters scores of times.

All masters were critical of the current examination process. They see a need for two important changes. First is a more structured approach to help them prepare, regardless of whether the process is the same as now or a revised approach. Second is a less demanding examination process. The sacrifice of time required and the difficulty are untenable. All certificate holders noted that a modernized process for obtaining certificates through the use of simulators must at the same time eliminate some or all of the existing process, otherwise future candidates will face an even tougher system.

A course of study prepared for pilotage certificate candidates is espoused by some officers who have gone through the qualifying more or less on their own. The advantages seen for a course are:

- It would save a lot of time for candidates since they wouldn't have to painstakingly prepare their own material.

- It would help to avoid a certain routine from setting in among those studying alone.

- Small groups of candidates could practice for the exam among themselves.

- Candidates would benefit from different points of view and different but legitimate approaches to piloting.

A course or program of study could be given in several staggered modules, touching on placement of buoys, depths, currents, etc. Allowing intervals in between modules would allow participants to absorb the material before preparing for and studying the next section.

At least some masters believe that it is important to retain some aspects of the present oral exam. They believe it is worthwhile to memorize and to demonstrate an understanding of some distances, aids to navigation, landmarks, anchorages, currents, tides, and other features—but not to anywhere near the present level of detail.

It is important for a certificated pilot to know the habitual courses taken by licensed pilots. In respecting the licensed pilots' local customs, all are assured that when meeting another ship, that ship's behaviour will be predictable. In addition, it is important to know not just the route of the normal course but also the distances to shore and the depths of the river while on that course.

Certificated pilots should have excellent knowledge of the currents and the effect of different tides on the currents. Since currents can reach 6-7 kn, this is significant for a vessel making only, say, 12 kn. One must be knowledgeable about local currents and not just reactive, otherwise one runs the risk of winding up in the path of an oncoming ship.

Pilotage certificate holders need a thorough familiarity with the local area in order to understand the verbal references made by licensed pilots. It is important to instantly recognize what landmarks are being referred to, without having to rely on a chart, for instance.

A certificate candidate needs a good understanding of emergency anchorages used by licensed pilots. Finally, a good understanding of French is important.

Quoting from the observations of a pilotage certificate holder,

> "In both oral examinations the absence of, or acceptability of, 'visual' marks contributed to the favourable or unfavourable assessment of the candidates. As this type of information is available to licensed apprentices during their on-board training periods, perhaps an official cataloguing of these marks would enable future candidates to better prepare."

E. Licensed pilots

The goal of pilot training, according to the president of the Mid St. Lawrence pilot corporation, is not only to teach a pilot how to get from point A to point B. The goal is also to teach pilots how to deal with unforeseen situations. Merely executing a successful transit does not prepare one for this requirement. Mid St. Lawrence pilots favour a more structured training program for pilotage certificate candidates.

Licensed pilots pointed out that pilotage in Canada was extensively reviewed for several years by the Bernier Commission (1962-70). Pilots point out that after such a lengthy review, the current system must be efficient. They also pointed out that several other reports arose from inquiries on the Pilotage Act and Regulations, such as the Marler Report (1973), the Desjardins Report (1974), the Blouin Report (1987), the Derôme Report (1988), the Dancosse Report (1994), and the Memorandum of Understanding between the LPA and CSA regarding the Board of Examiners (1992).

The Mid St. Lawrence pilot corporation noted that the Pilotage Act requires a pilotage certificate applicant to have a degree of skill and knowledge equivalent to that required by a licensed pilot. The spirit of the law is to avoid a system of parallel pilotage, according to the corporation.

The licensed pilots are not opposed to the concept of pilotage certification; furthermore, they respect the abilities of current holders of pilotage certificates. The pilot corporation representatives stress that all future certificated pilots must be equally qualified and safe. The conditions in the lower part of the River, with tides of up to 20 ft, and currents of 5 kn, with continually changing direction and strength, are difficult dynamics for Great Lakes/Seaway-based mariners to contend with. Currents found on the Great Lakes or in the Seaway are more stable and predictable.

Pilot corporation representatives note that the LPA’s syllabus has been revised and is now up-to-date. They stated that there have been no negative reports submitted by Observers. Seven certificates have been issued up to this point. These statements indicate that the current process is working. The pilots object to any change in jury composition or exam process since there is no solid justification for such action.

Lower St. Lawrence pilots contrast the regulatory requirements for the total number of trips required by apprentice pilots (a minimum of 226) versus certificate candidates (as few as 6). They find the difference in requirements “ridiculous.” They also question the quality control of the trips themselves, noting that apprentice pilots must spend their time on the bridge, which is not necessarily the case for a pilotage certificate candidate.

Lower St. Lawrence pilots are not interested in assisting in the training of certificate candidates. The pilots have participated in numerous meetings with a view towards “modernizing” and assisting with an understanding of the syllabus of study and examination for candidates for pilotage licences and certificates. A revised syllabus has been available since the winter of 1996-97 for future candidates.

The CSA, they believe, has the necessary expertise to train its own candidates; they have notes prepared and quality personnel are available. However, Lower St. Lawrence pilots question whether the demand for training exists among CSA masters and officers. The pilots state that to date most masters were obliged by their employers to obtain their pilotage certificates, and individual (as opposed to corporate) motivation is lacking. The pilot corporation estimates that 80% of otherwise potentially eligible certificate candidates are unilingual anglophones, whereas knowledge of the French language is a regulatory requirement.

Finally, Lower St. Lawrence pilots disagree with the notion of a Class A pilotage certificate (i.e., unlimited as to tonnage). They point out the increasing importance of environmental protection with increasing ship sizes, and note the old age of much of the domestic fleet. Lower St. Lawrence pilots favour one single class of pilotage certificate, limited to ships not greater than 32,000 deadweight tonnes (Seaway-sized), with an eligibility criterion for the candidate of twenty trips in the District in the preceding year.

VI

Views Regarding Simulators And Pilotage

We discussed in general terms with each stakeholder the value and potential for using simulators and other types of technology for obtaining pilotage certificates. In particular, we referred to Full Mission Bridge (FMB) simulators. It should be noted that a number of those interviewed had no direct experience with FMB simulators.

A. LPA

The Authority sees great potential for a simulator-based training program for certificate candidates. In addition, it was felt that simulators could be considered in the future, when such systems are approved, to largely replace the oral component of the exam, although some oral and written components must be retained. The President noted that the Department of National Defence's Maritime Command has replaced sea-time Phase IV requirements by the use of simulators for navigation purposes. Furthermore, virtual reality equipment could be used to help candidates prepare—to visualize the voyage, landmarks, ranges, etc.

Questions were raised regarding the appropriateness of a simulator for determining a candidate's competency throughout an entire district; how to judge a candidate's knowledge of the location of aids to navigation and the effects of currents and tides; and whether simulator-based exams might be more stressful than the current oral arrangement. However, the position of the Authority itself is one of strong support for the use of simulators in training, and the Authority wishes to explore the possibility of introducing simulator-based exams.

B. Domestic shipowners

A strong majority of the domestic shipowners whom we contacted believe that FMB simulators provide a means for a pilotage candidate to demonstrate whether he has sufficient skills to safely pilot his vessel in the St. Lawrence and thus satisfy the requirements for a pilotage certificate. Several members of the CSA fleet have used simulators extensively in training officers in Bridge Resource Management and for piloting waters in the Great Lakes jurisdiction. Some stakeholders believed that the entire exam process should be done by simulator. Others felt that it could replace much but not all of the existing process, while retaining an oral local knowledge component.

Shipowner representatives believe that simulators can verify the performance of a mariner in dealing with unforeseen circumstances. The current system does not demonstrate a candidate's performance.

Among those familiar with several simulator training centres, it was generally felt that some of the capabilities of the Centre for Marine Simulation (CMS) at St. John's exceeded the requirements for simulating St. Lawrence River transits. In particular, the hydraulically controlled movement of the simulator bridge is more suitable to Hibernia oil field manoeuvres than to the smoother waters of the River.

Shipowners are quick to point out that other regulatory examinations are carried out on simulators, including Simulated Electronic Navigation (SEN or SIM) courses and diesel simulators on which Engineers are tested. It should be noted that none of these courses use FMB simulators for evaluation, however.

Shipowners find the fact that St. Lawrence licensed pilots have trained at the CMS simulator a compelling argument in favour of simulators. It was certainly felt that licensed pilots could also benefit from training on simulators.

C. International shipowners

As stated in the 1996 Annual Report of The Shipping Federation of Canada when reporting on a project aimed at evaluating the use of simulator technology in the pilot certification process: "For its part, the Federation will oppose any measure which has the potential to jeopardize the safety or efficiency of the current pilotage system."

D. Canadian-flag ships' masters

Certain captains see simulators as an excellent tool for training and examination. Others who had not had the opportunity of training on a FMB simulator reserved judgment on the merits of simulators.

Some believed that an understanding of the effects of currents and a demonstration of knowledge of bearings and ranges could be tested and verified very well on a simulator. A simulator would allow candidates to correct their errors (at least during training), see what they had learned, and find themselves piloting in very difficult situations.

Several masters felt that a simulator could replace parts of the existing exam. The requirement to draw a chart to scale was one element that could be replaced very well by a simulator: for example, demonstrating capabilities on a simulator under very poor visibility would show whether a candidate knew the appropriate headings, channel limits, etc. It was also felt that a simulator would eliminate the potential for bias in posing questions to different candidates, since all could be objectively tested on the same simulator program.

E. Licensed pilots

The Mid St. Lawrence pilots see simulators as a potentially useful addition to training. Simulators are not a replacement for the current type of training program, however, and are not the basic tool for training.

Approximately 40 Mid St. Lawrence pilots trained on the FMB simulator in St. John’s, with the emphasis on docking and undocking moves. The pilots, according to the corporation’s president, were disappointed with the capabilities of the simulator, particularly in modelling the effects of currents and other factors at quays, when docking or undocking a ship.

One problem with simulators, according to the pilots, is that simulator users adapt to the needs of the simulator, which do not reflect accurately enough the requirements of actually manoeuvring a ship. Thus, a pilot becomes trained to accurately handle a simulator rather than being trained to safely and confidently manoeuvre a ship in a real situation.

The Lower St. Lawrence pilot corporation sends approximately a dozen licensed pilots each year for training on shiphandling in restricted waters. The training is performed on manned models at Port Revel, France. The pilots recommend and support this program, which experienced pilots consider worthwhile. Manned models are an excellent tool for learning and mastering certain skills. However, they are not a basic tool for training. Manned model simulators lack capacity in some tangible areas, such as adequately simulating currents and winter navigation. Manned models are not a substitute for the current training regime and are considered unsuitable for purposes of testing or evaluation.

Lower St. Lawrence pilots have some experience with computer-based simulation from the MSI facility at La Guardia Airport, New York. Based on this experience, they are unimpressed with computer-based simulators which they consider unsatisfactory. Computer-based simulators cannot be compared with manned models, which are completely different.

Lower St. Lawrence pilots stress that it would be a mistake to consider any type of simulator as a training element with a view to facilitating and relaxing the requirements and constraints currently in place for pilotage certification. The pilot corporation representatives oppose any move to bypass the current process.

VII

Issues Within The Current Process

Certain issues touched on previously are explored in more depth below.

A. Regulations and communication

The International Maritime Organization (IMO), in a recommendation adopted by Canada and included by Transport Canada in its *Recommended Code of Nautical Procedures and Practices*, describes a navigational watch with a pilot on board as follows:

> "Despite the duties and obligations of a pilot, his presence on board does not relieve the master or officer in charge of the watch from their duties and obligations for the safety of the ship. The master and the pilot shall exchange information regarding navigation procedures, local conditions and the ship's characteristics. The master and officer of the watch shall cooperate closely with the pilot and maintain an accurate check of the ship's position and movement."[1]

The level of communication between the licensed pilot and master or officer of the watch is critical for safe passage of the vessel. According to some companies, a current problem is the lack of communication between licensed pilots and the master. Licensed pilots do not appear to follow established procedures for formally making passage plans or for keeping an open line of communication with the master. This leads to the pilot taking charge of the vessel's navigation while the master is responsible for those actions. This is seen by some as a major source of conflict between pilots, masters and the shipping industry. It is a primary factor which has encouraged certain masters to obtain pilotage certificates.

The current setback to reforming pilotage legislation has resulted in some shipping companies holding back on encouraging their employees to obtain pilotage certificates. Companies have to spend significant time and resources to enable their employees to obtain their pilotage certificates; some estimate that it costs $35,000 for a Captain to obtain a pilotage certificate. Interviews indicated that companies would encourage certificate applicants once the legislative issues have been resolved and an effective training and examination process has been clearly established. This is predicated on the industry having direct input into the contents of the syllabus and training program, along with the examination process.

According to a recent report by the Transportation Safety Board,[2] "Many masters and bridge officers reported that pilots do not always provide information to the master or the officer of the watch (OOW) regarding the passage plan; most pilots claim that they do." The TSB also found that recent occurrences indicate continuing problems with respect to the adequacy of bridge teamwork, e.g., lack of a mutually agreed passage plan, lack of interaction, coordination and cooperation among the bridge team, lack of precise progress monitoring by the OOW, etc.

B. Language

LPA Regulations require that "every holder of a pilotage certificate shall have a degree of proficiency in the French and English languages sufficient to carry out effectively his pilotage duties."[3] This may serve to limit the number of LPA pilotage certificates that will be granted to masters of Great Lakes-based fleets, where the working language is English. While the level of French required for the certificate is not considered an insurmountable problem for most Great Lakes candidates, it is a barrier for some masters and mates with considerable navigation experience in the area.

C. Duplication of LPA syllabus and MOT certification

The certificated pilots followed the available syllabus to obtain their certificates. Overall the syllabus described the requirements for certification, but was considered very unclear and did not prepare the candidates for the examination process. It is acknowledged that it is not the LPA's responsibility to prepare candidates for exams. Rather, the difficulty is the lack of a structured system for training, preparation, and examination.

All masters interviewed believe that there was a significant level of overlap between the requirements for pilotage certification and the general requirements of obtaining their master's certificate. Specifically, there was overlap in the following areas:

- chart work and general principles of navigation;
- use of radar and other navigational instruments;
- general ship handling, including anchoring and berthing;
- meteorology, weather, currents and tides;
- general legislation, including knowledge of regulations and applicable publications.

The CSA requested the Ship Inspection Directorate of Transport Canada to compare the LPA syllabus with the Ministry of Transport certification syllabus for mariners' certificates of competency. A comparison was carried out in September 1995. Subsequently the LPA revised its syllabus in an attempt to remove duplicative elements.

The CSA again requested a comparison from the Ship Inspection Directorate based on the LPA's revised syllabus. That comparison was done and is reproduced in Appendix C. A review of Appendix C indicates, on paper at least, that a degree of duplication still exists between the LPA and MOT syllabi, according to the independent analysis.

The LPA maintains that in reality there is very little or no duplication between what candidates are tested on and what they have already been tested on for their certificates of competency. While the topics covered by the General Knowledge part of the syllabus are broad, the test questions are always focussed on safe operations and geared specifically towards knowledge important for piloting. They would also point out, in counter-argument, that MOT exams can duplicate any aspect covered in the syllabus of an inferior certificate.

It is recognized that there is variation in the instruction among different marine training institutes, and also variation in the difficulty of a particular certificate of competency exam, depending on where it is taken. Thus, even if some duplication of the LPA and MOT syllabi exists, at least everyone is on the same footing by going through the same process administered by the LPA.

According to masters, the only relevant section of the syllabus was that pertaining to local knowledge. It was acknowledged by all that most of their preparation time was spent on gaining experience in local knowledge, including chart work and visual sightings. All of the other sections were adequately covered during their preparation and examination for certificates of competency. The requirement of drawing a chart was introduced in an attempt to make the local knowledge exam more objective. Unfortunately, this requirement made the exam more difficult in the opinion of masters, due to the level of detailed memorization required, which they consider excessive, and which does not test performance.

D. Composition of Board of Examiners

The Board of Examiners comprises the LPA's Director of Operation (chair), a representative of Transport Canada, and three licensed pilots. While the shipping industry is currently represented by an observer during examinations, they do not form part of the examining committee. The Board is perceived by some as being biased against those attempting to obtain their certificates, since successful certificate candidates could affect the pilots' future livelihood.

Both certificate holders and shipping companies are unhappy with this structure and process. It appears to be overly subjective and biased against good potential candidates with plenty of experience, but who are unable to convince a Board of Examiners across a table in an exam room. The lack of certificated pilots on the Board is also a drawback. Shipowners believe that demonstrated ability to pilot a vessel should alone determine whether a candidate is competent or not.

Quoting from an Observer to an oral examination,

> "The validity of the examination process hinges to a large degree on the requirement of candidates for certificates to possess "comparable" (in the sense of being equal) knowledge as that required for candidates of licences. Variation in the interpretation of comparable may affect the success rates of attempts at certification, in as much as examining committees may in themselves differ."

This observation supports a more consistent approach to examination, which simulators may be able to provide.

E. District I pilotage certificates

In our interviews to date, there was very little interest expressed in obtaining pilotage certificates in the short term for District I. Several reasons account for this.

- According to those who successfully obtained certificates for District II, the current process has proven so onerous that they are not interested in going through a similarly demanding process for District I.

- The same individual could not act as pilot through both pilotage districts in the same transit, both because of regulations pertaining to the number of consecutive hours of work, and hours of rest and potential fatigue. This latter point is especially important for vessels that will also transit the St. Lawrence Seaway. In practical terms, if a master is doing his own piloting in the River above Montreal and is qualified or hopes to qualify to pilot in District II, then the time spent transiting District I must be dedicated to a rest period for the master.

- It is difficult under present circumstances for a Chief Officer to gain the experience required to attempt to obtain a pilotage certificate. The Chief Officer's duties emphasize ensuring proper stowage of cargo, vessel maintenance, and some administration. Shipowners are considering what crewing changes may be useful in order to obtain more pilotage certificates.

- District I is split in two parts. If an officer qualified to pilot in one of the two parts, his ship would still incur approximately half the present cost for pilotage in the District. The economic incentive to shipping lines is less evident than in District II.

- District I is widely regarded as more difficult than District II.

F. Progression for pilotage certificate holders

The LPA regulations did not foresee the possibility of a pilotage certificate holder wanting to upgrade his class of certificate. Thus the process for doing so is unclear. This became a practical concern in 1997. One Class B certificated pilot has been granted a Class A certificate after sailing a certain number of trips to meet requirements set by the Authority (but which are not currently supported by regulations). The entrepreneur pilots have objected to the LPA's action of granting the Class A certificate, without requiring an exam.

Masters and shipowners are also concerned about the process for upgrading a seasonal pilotage certificate to one that is valid year round. In such a case, the Authority has indicated that the candidate will be tested only on matters pertaining to winter navigation and manoeuvring in ice. The concern is that with the focus of the exam strictly on winter operations, this process will be more detailed and difficult than for other candidates whose original pilotage certificate is valid year round. In that case, winter operations were just one factor among several in the exam, rather than the sole focus.

The LPA is studying these issues internally through the revision of LPA regulations and will soon present to the Authority's Board of Directors a proposal to clarify these issues.

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[1] *IMO International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW), Regulation II/1, Paragraph 10.*
[2] *Transportation Safety Board of Canada, "A Safety Study of the Operational Relationship between Ship Masters/Watchkeeping Officers and Marine Pilots," Report Number SM9501, 1995.*
[3] *Laurentian Pilotage Authority Regulations, Section 22(1)(e).*

VIII

Marine Simulators And Virtual Reality

This chapter provides a review of marine simulation and virtual reality technology.

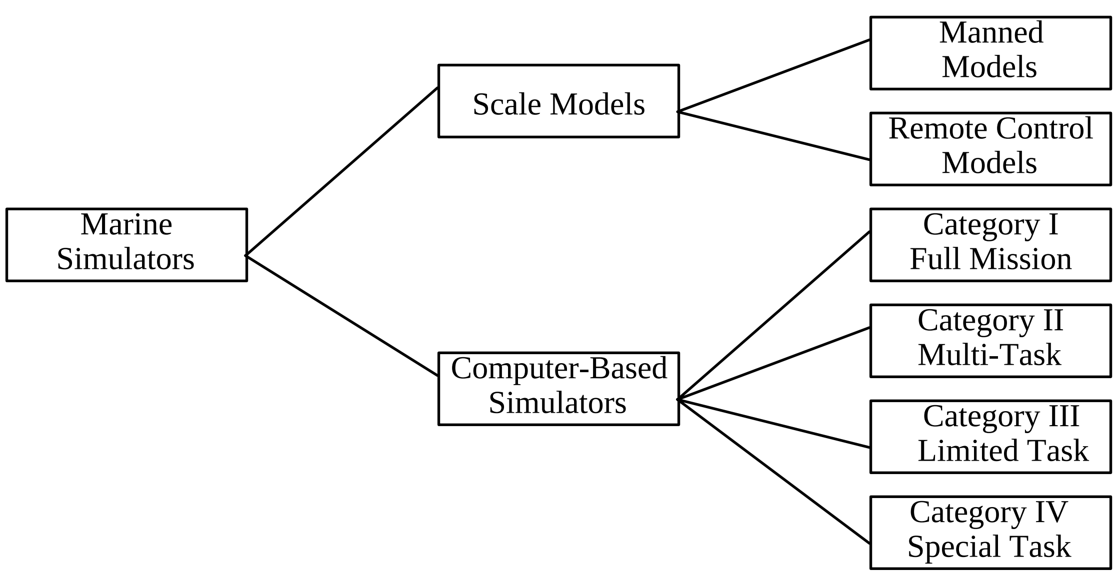
A. Marine simulators

Marine simulators are currently in use in various training centres throughout the world for training mariners, including pilots. This section provides details of the various types of simulators being used and highlights their major strengths and weaknesses.

1. Types

There are two primary types of marine simulators: those relying on scale models of vessels, and those using computer-based simulation. Exhibit VIII-1 indicates the major types of simulator currently in use.[1]

Exhibit VIII-1
Types of marine simulators



Simulators based on scale models or manned models were developed in France in 1966. Manned models, serving as scale replicas of real vessels, are primarily used for shiphandling courses. Centres in France, England, and Poland currently provide manned model training. Scale models are also used for channel design and developing manoeuvring strategies in new or unusual situations. Remote control models have been developed but are not used extensively.

Computer-based simulators fall into four major categories, as defined by a classification system proposed to the International Maritime Organization. Unlike the environment of commercial aircraft simulators, which has established design and operations standards, the marine industry is just now developing terminology for describing simulators. Industry-wide technical specifications are under development in the U.S. and Europe, however they are not available today.

- **Category I: Full Mission.** Capable of simulating full visual navigation bridge operations, including the capability for advanced manoeuvring and pilotage training in restricted waterways.

- **Category II: Multi-task.** Capable of simulating full visual navigation bridge operations, as in Category I, but excluding the capability for advanced restricted water manoeuvring.

- **Category III: Limited task**. Capable of simulating, for example, an environment for limited (instrument or blind) navigation and collision avoidance.

- **Category IV: Special task.** Capable of simulating particular bridge instruments, or limited navigation manoeuvring scenarios, but with the operator located outside the environment (e.g., a desktop simulator using computer graphics to simulate a bird's eye view of the operating area).

2. Validity

Simulators and the simulations themselves vary greatly among facilities. In order to consider the various types of simulators and their relevance to this project, it is important to understand the concepts of validation and validity. Validation is the process of evaluating specified characteristics of a simulator or simulation against predetermined criteria. Assessing the validity of a simulator or simulation includes the consideration of fidelity and accuracy. Fidelity describes the degree of *realism* or similarity between the simulated situation and real operation. Accuracy describes the degree of *correctness* of the simulation, focussing on ship trajectory and the location of aids to navigation.

For the purposes of this study, effective simulators and simulations will require a high level of both fidelity and accuracy. Fidelity is necessary to ensure that mariners will treat simulations as "the real thing," and maximize their instructional value. Accuracy is necessary due to the restricted channel and the precise location of navigational aids. A high degree of accuracy is required for ship models to accurately replicate how they will act and react to environmental conditions, especially in shallow water operations. Fidelity and accuracy are needed for geographic and bathymetric modelling. A high degree of visual accuracy is also needed, especially for shore-based land forms, buildings and other guides currently used by pilots and mariners for determining vessel routings.

3. Strengths and limitations

The use of simulators and simulations for training mariners enables the creation of dynamic, life-like situations in a controlled environment where mariners can:

- practice new techniques and skills;
- receive insight from criticism and comment by instructors and peers;
- transfer theory to real-world simulations in a risk free operating environment;
- deal with complex multiple problems concurrently rather than sequentially; and
- prioritize multiple tasks under high stress and changing conditions similar to those in actual shipboard operations.

The key to the effective use of simulators is to ensure that the simulator type meets the objectives of those being trained. The primary motivations for employing full-mission bridge simulators are as follows.

- **Safety**. Simulators allow mariners to repeat risky operations without the risk of potential damage to lives or equipment. It also removes the requirement for instructors to be available to intervene during all of the training sessions. It also allows students to benefit from having the opportunity to make mistakes without real consequences.
- **Lesson repetition**. Simulation training sessions can be repeated until the objective for the lesson has been met.
- **Recording and playback**. Simulators allow for the recording and playback of the completed training scenario for review, evaluation and debriefing purposes.

- **Flexibility.** Simulator-based training permits the systematic scheduling of instructional conditions for an effective training program.

- **Multiple tasks and prioritizing**. The use of simulation in training programs makes it possible to transfer classroom skills and practice and prioritize multiple task simultaneously. Simulation training enhances the development of these skills and provides the opportunity to exercise judgment in prioritizing tasks.

- **Training on new technology.** Simulators provide a safe environment for mariners to train on new navigational equipment (e.g., ECDIS).

- **Peer interaction**. Simulator-based training at a training centre provides a forum for peer interaction and evaluation which might not otherwise occur.

- **Cost effectiveness.** Simulators are generally less expensive to build and operate than the equipment being simulated. Training aboard commercial vessels can be difficult or impractical due to risks, operating practices and vessel schedules.

However, there are some potential limitations associated with the use of simulators. These include the following:

- **Heavy weather training**. Current simulators are not yet capable of recreating the motion experienced by ships in heavy weather, and cannot be adequately validated for complex interactions among steering, heavy seas, and wind. This does not pose a problem for simulating transits in the compulsory pilotage waters of the LPA.

- **Shallow water operation**. The ship model databases today cannot completely replicate the reactions of a vessel operating in shallow water. Conditions such as squat, suction, and close quarters operations are difficult to accurately recreate using mathematical modelling.

- **Reality gap**. Mariners who train on simulators do not necessarily act and react as they would naturally on a vessel. They tend to anticipate potential simulated situations and consequently react too quickly and perfectly. Also, the innate knowledge that they will not actually place lives at risk or damage a vessel in simulation, means that they do not train under the same types of stress that a mariner could experience in reality. On the other hand, simulators allow mariners to practice situations that are too dangerous to deliberately create in the real world except in emergency conditions.

B. Virtual reality

The recent advent of virtual reality has added the potential for simulation using a flexible portable system capable of training some mariners cheaply and effectively in certain limited situations. However, it has significant limitations which make it unsuitable for pilotage training.

The concept of virtual reality technology emerged in the 1970s. Today, developments in virtual reality technology are being used in a wide range of industries and applications, including the military and marine transportation industries.

Unlike existing bridge simulators, virtual environment systems use helmets with a video display and sound capabilities, and their sensor systems detect movements of a person's extremities. Such systems, although somewhat limited in capabilities, are progressing toward more complete simulations of visual environments and toward better developments of sound and sensation. A report by the U.S. National Research Council described such systems as follows.[2]

> "Virtual environment systems differ from traditional simulator systems in that they rely much less on physical mockups for simulating objects within reach of the operator and are much more flexible and re-configurable. Virtual environment systems differ from other previously developed computer centered systems in the extent to which real-time interaction is facilitated, the perceived visual space is three-dimensional rather than two-dimensional, the human-machine interface is multimodal, and the operator is immersed in the computer generated environment."

Virtual reality applications for marine navigation in Canada are currently being developed by the Department of National Defence at the Defence and Civil Institute of Environmental Medicine. Virtual reality technology is being used by the Naval Officer Training Centre in Victoria, British Columbia, primarily for training reserve personnel in shiphandling and manoeuvring. The technology being used, specifically the Officer of the Deck (OOD) Virtual Reality Training System (VRTS), is marketed by WTH Systems of Quebec.

The OOD VRTS consists of three principal functional components: the OOD interface, the bridge team, and instructional facilities.

1. OOD interface

The interface to the OOD trainee uses low-cost, commercial head-mounted display technologies and electromagnetic tracking. The system uses a display that provides the trainee with an instantaneous field-of-view 84^{o} wide and 65^{o} high. The view is directed by head motions for uninterrupted observation of the surrounding environment, including other ships in the formation. The design approach is generic, allowing any ship to be simulated. The hydrodynamics of a vessel and its physical appearance are both modelled. Four instruments: the peloris, rudder angle repeater, inertial compass, and clock that the OOD would see while on the bridge, are computer generated. Digital sound recordings are used for auditory signals such as foghorns and for the engine noise which is modulated with the throttle setting.

2. Bridge team

Voice recognition and production systems are used to interface the OOD with a surrogate bridge team. The voice recognition system captures the OOD's spoken orders and encodes them into a format that the simulator can use to adjust helm or engine speed. The system is also used to record verbal responses of the bridge team. The voice production system simulates unique voices for the yeoman, range man, helmsman and relative velocity man. For example, signals sent to the vessel are spoken aloud by the computer in their proper, decoded format just as they would be by the yeoman or other bridge team member. The voice recognition system is also used to record observations of the instructor conducting the training session. The benefit of this system is that it eliminates the need for additional personnel to perform the bridge functions, eliminates a source of uncertainty in the assessment of the trainee's performance, and provides an audit trail for later review and feedback.

3. OOD VRTS instructional facilities

The instructional facilities of the OOD VRTS address the needs of:

- lesson planning;
- monitoring and controlling the simulation during training; and
- reviewing and debriefing.

The instructor monitors and controls the training exercise using a workstation with computer windows and a menu-driven command structure. The functions of the windows are described as follows.

a) Lesson planning

Lesson plans may be created and edited in advance. They provide a script for the training exercise, listing the sequence of commands that will be issued by the instructor to the formation. During training, the lesson plan appears in one of four windows on the instructor's workstation. The instructor can schedule events as well as edit the lesson plan during its execution by selecting options from nested menus.

b) Monitoring and control

A second window provides a time-stamped record of actions taken by each OOD trainee so that the instructor can selectively monitor the performance of any individual. To aid this process, a third window on the instructor's screen provides a visual representation of the ships in formation. It can show either a chart (overhead) view that displays the ships as icons, or a virtual view that displays the ships in a three-dimensional format. In the chart view, the relative position of each ship is represented by an icon located within a set of concentric range rings centered upon the guide. Alphanumeric information displays the ship's type, call sign, speed, heading and rudder angle. In the three-dimensional view the ships and their environment appear as a virtual world that can be explored interactively. This view shows the visual relationships among the ships from any perspective, including any bridge.

An important feature common to each view is the trail left by the ships. Also common to each view is an option to display a textbook solution. When selected, this option generates trails based on standard solutions. The standard solutions are also used to automate the behavior of ships that are not controlled by students. This allows the instructor to conduct exercises that involve several ships without requiring a full complement of staff or students. A fourth window allows the instructor to take control of any ship. A graphical user interface provides the means for the instructor to start, pause and resume training and provides an event marker for flagging notable situations.

c) Review and debrief

The training exercise is recorded for reanimation. In this mode, the lesson plan, visual views and action logs are available. As well, there are utilities for controlling the review: stop, start, fast forward, rewind and skip-to-a-marked-event functions. These functions are also available for animating the performance of real ships at sea. This is done by replaying recordings of the ships' locations and orientations as they are obtained by differential global positioning systems and packet radio. The animation of real-world events can be made interactive, and incorporated with the simulation, so that a student may retry in the simulator a manoeuvre that was conducted poorly at sea.

4. Benefits of virtual reality

Currently the system is used for pre-training naval reservists on bridge operations and ship handling. To date, the major benefits of VRTS technology are identified by DND as follows:

- It allows for improved training transfer, enabling students to train effectively on a land based system. Overall, it increases the effectiveness of sea time.

- Significant operating cost savings are realized, through reduced use of training vessels and associated personnel and operating costs.

- The system is portable and relatively small, enabling it to be used on board vessels.

- The VRTS uses off-the-shelf hardware, and software upgrades are easily available.

- Being able to stop or pause during a simulation enables instructors to teach more effectively and impart more skills to students. It also allows students to practice difficult manoeuvres without the potential injury to vessel or personnel.

- It appears to increase the level of confidence for users, during the simulation process and at sea.

- The playback analysis feature, similar to that in conventional simulators, enables the review and interpretation of students' results.

- It has the potential to serve as a lower cost alternative to conventional marine simulator training.

Overall, virtual reality technology is used to supplement shipboard training, not as a replacement for sea time. It is a proven method for teaching and reinforcing ship handling skills. It is currently used for pre-training exercises, in order to make actual training on board ship more effective. While this type of training is currently being used by reservists, it could be used by regular officers and in commercial shipping.

There is some evidence that the Canadian Navy found that on certain at-sea shiphandling courses, students who had previously undergone VRTS training scored higher than those who had not. While these results are not necessarily fully conclusive, VRTS appears to serve as an effective complement to actual sea time for reservists and possibly for entry-level training of junior officers.

5. Limitations of virtual reality

The benefits of virtual reality are not universally recognized. A 1994 National Research Council report found that "despite the enthusiasm and the hype surrounding the synthetic environment (SE) field, there is a substantial gap between the technology available and the technology needed to realize the potential of SE systems envisioned."[3] Problems with current virtual reality technology include limited vessel and route data, the tendency for current headsets to disorient the user and induce nausea after extended use, and the inability of the technology to fully replicate all the sounds, actions, and sensations associated with bridge operations.

The potential for virtual reality must be balanced against the fact that the current manner and form of virtual reality simulations are substantially different from the ship-bridge operating environment and context in which mariners operate. In simple terms, the technology currently available does not present a realistic image. There does not appear to be any research available which determines whether or to what degree a realistic virtual environment simulation might be possible for commercial shipping. It is also unclear whether virtual reality simulation will offer an improvement over conventional simulation technology and whether it will be at all cost effective.

A key limitation of virtual reality is that it can only be used at present for open sea manoeuvring in generic waters. The system lacks any port specific data at present, let alone the capability to simulate long stretches of the St. Lawrence River.

Another limitation is that the system appears far from being able to simulate the effects of advanced manoeuvring and pilotage training in restricted waterways. In general, we do not believe that virtual reality is an effective training tool for fairway pilotage.

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[1] *National Research Council, "Simulated Voyages-Using Simulation Technology to Train and Licence Mariners," p. 41, Washington, D.C., 1996.*

[2] *National Research Council, "Virtual Reality: Scientific and Technological Challenges," Washington, D.C., 1994.*

[3] *Ibid.*

IX

Marine Simulation Centres And Other Simulator Training

In this chapter, we provide an overview of marine simulation centres, discuss certain relevant programs using simulators, and discuss the use of simulation technology for commercial aviation and in national defence.

A. Marine simulation centres

Marine simulation centres are located world-wide and have a wide range of uses and application in the marine industry. While marine simulators are primarily associated with the bridge-type used for training mariners in shiphandling, other types of marine simulators also exist (e.g., radar simulators, engine control room simulators). Marine simulators are used for the following applications:

- pilot training;
- fire fighting and emergency response training;
- oil rig towage and evacuation;
- vessel traffic services;
- cargo handling;
- collision avoidance/radar;
- tug handling and assistance;
- port and berth approach design;
- port safety analysis;
- military training, including handling submarines.

Ship-bridge simulators have more specific applications, and are used for training programs in the following areas:

- bridge team management and bridge resource management;
- shiphandling in open waters, channels and waterways;
- docking and undocking evolutions (especially if equipped with bridge wings or configured as a bridge-wing simulator);
- bridge watchkeeping, including terrestrial and electronic navigation;
- rules of the road; and
- emergency procedures.

The development of training centres is increasing, with new centres being commissioned worldwide. For example, recently Taiyo Electric Co. of Japan was awarded training simulator projects at three maritime academies: Kobe University of Mercantile Marine, Shimzu School of Seaman's Training, and Kiyako School for Seaman's Training. Other companies, such as Maritime Simulation Centre of The Netherlands (MSCN) are constructing new technologically advanced facilities primarily in Asia and South America. While a number of these facilities will be for in-house use, there is a growing number of centres offering courses to mariners and pilots from other countries. These centres compete against one another to train mariners and to develop geographical and ship modelling databases.

Most simulation centres offer programs in shiphandling, while only certain ones offer courses specifically designed for pilotage. Even fewer have been involved in training mariners to obtain pilotage certificates or exemptions. We contacted representatives of the following simulation centres:

- Centre for Marine Simulation (St. John's, Newfoundland);
- Danish Maritime Institute (Lyngby, Denmark);
- Marine Institute of Technology (Baltimore, Maryland);
- MarineSafety International (Newport, Rhode Island);
- MarineSafety International Rotterdam b.v. (Rotterdam, The Netherlands);
- Maritime Simulation Centre of The Netherlands (Wageningen, The Netherlands);

- Seamen's Church Institute (New York, New York);
- Simulation Training and Research (STAR) (Dania, Florida);
- Warsash Maritime Centre (Southampton, United Kingdom).

Of these simulation centres, we identified several that offer courses that are directly relevant to this study. Their facilities and programs are described below. We investigated marine simulation centres that currently are involved in pilotage exemption/certificate training, and/or that use simulators for testing approved by regulatory authorities. Other marine simulation centres also have high quality equipment and personnel, but are not currently delivering programs directly relevant to this study.

B. MarineSafety International Rotterdam

MarineSafety International Rotterdam b.v. is a private Dutch company co-owned by MarineSafety International (MSI), a subsidiary of Flight Safety International, and the municipality of Rotterdam. The company utilizes the port development and management experience from the Port of Rotterdam with simulator operations expertise of MSI. The facilities are located in Rotterdam, adjacent to the new cruise terminal currently under construction. There are currently 28 full-time employees at the centre, involved in simulator operations, research, and database development.

The MSI facility accommodates five ship bridge simulators, including one full-mission bridge, and one Vessel Traffic Services simulator. The full mission bridge simulator is equipped with DNV W1 compliant instruments, representing a real ship's bridge. The bridge can be re-configured to reflect the bridge design of any ship or design configuration.

The simulator wheel house is placed on a hydraulically moveable platform, allowing realistic ship's motions. The computer generated imagery system creates a visibility of 360^o horizontally and 35^o vertically.

The centre also has four other smaller full-mission bridge simulators, with 270^o visibility and based on non-moveable platforms. These can be operated in conjunction with the main simulator to effect, for instance, assistance by tugs. All of the simulators are of modular design and all five stations can be operated individually or interactively.

The centre also has a multi-station Vessel Traffic Service Simulator, capable of stand-alone training and research, but it can also be joined with the bridge simulators for interactive training and research. The simulation centre also has specialized facilities for debriefing trainees along with lecture rooms.

The centre prepares and uses its own databases for geographic and ship modelling. It does not contract out to other sources or suppliers. All databases are maintained at the centre and are updated by the centre's staff.

MSI Rotterdam provides a number of training courses for mariners, pilots, engine room personnel and VTS operators. The courses include the following:

- marine pilot training;
- ship handling;
- voyage management;
- accident analysis reconstruction;
- port optimization studies;
- bridge resource management;
- engine room resource management;
- bridge/engine room resource management;
- integrated marine decision support system;
- vessel traffic services communication;
- yacht captain.

Of particular relevance is a course they offer to officers on the North Sea ferries which call at Beneluxhaven in Europort daily. The masters of these ships are experienced professionals and have an excellent knowledge of local situations (environment, infrastructure, and vessel behaviour). They all currently hold pilotage exemption certificates. However, they are limited to operating in environmental conditions up to winds of Beaufort 7 and visibility of 700 m. In adverse conditions exceeding these parameters, the captain must take a pilot and use the assistance of tugboats. On the basis of an agreement between the Rotterdam Port Authority and North Sea Ferries, this limitation can be withdrawn if the masters attend and pass a three-day simulator course focussed on the handling of ferries assisted by tugboats under adverse conditions. The course objectives for this program are as follows:

- execute a safe and efficient handling of the ferry assisted by tugboats under adverse weather conditions;

- perform standardized communications procedures with tugboats and VTS operators.

Specifically, simulator-based training is used to:

- manoeuvre the vessel making adequate use of available propulsion and steering power;

- position the tugboats to make optimal use of the available towing power;

- communicate with the assisting tugboat captains;

- monitor safe passing distances to moored ships, dolphins and landmarks;

- monitor and encounter the effect of adverse weather on the ship;

- anticipate the influence of geographical features on the weather effect; and

- establish optimum information exchange with VTS.

Each course is planned for three North Sea Ferry captains and/or officers and two tugboat captains, and lasts three days. The first day of the course starts with a theoretical lecture about tugs and towing principles. Then familiarization runs are carried out. These are reasonably easy exercises to enable the course members to familiarize themselves with the simulator controls and the simulation. Each course member has the opportunity to make two familiarization runs out of four different scenarios. These familiarization runs are not recorded.

The course members rotate through the roles of Master, chief officer and helmsman, so that each captain or officer has a chance to function in each role for an equal amount of time. Each course member performs at least one run, but usually two runs for scenarios utilizing tugs.

Candidates are evaluated by a team consisting of:

- a representative of the "competent authority" (i.e., the Port of Rotterdam);

- MSI's project manager/head of the Nautical Department; and

- an MSI instructor (qualified as a Master Mariner and pilot educator).

On follow-up sessions, the local pilot organization will attend and assess the trainees as well. Relevant data such as performance track sheets are available to the evaluators.

Successful course participants obtain from the Port of Rotterdam a waiver which, together with the pilot exemption certificate, frees the captain of the obligation to take a pilot under adverse weather conditions. The waiver has a validity of two to three years, and can be extended with a refresher course. MSI reports that, "when trainees perform well on the simulator, with all its built-in limitations, they can be expected to perform even better in reality. North Sea Ferries deems the course a necessity"[1]

An important element of the sessions was the validation of the simulators and simulation. Two validation sessions were organized in 1995 attended by two North Sea Ferry captains, one North Sea Ferry superintendent and three Rotterdam Port Authority representatives. This validation team found the bridge layout to be acceptable, including complex rudder controls. The visuals, after some minor adjustments, were considered to be quite realistic and fully acceptable. The ship models were found to offer a realistic replication of the ferry and were validated by all parties. Overall, the course was fully validated by the representatives.

According to MSI, this course is the only one offered in Europe to masters attempting to obtain an exemption certificate for pilotage. All other relevant simulator courses are directed at training licensed pilots. Other training centres do not offer courses for pilotage exemption nor do they offer courses for fairway pilotage in narrow channels. Other pilotage courses focus on harbour and short channel operations, including those involving the assistance of tugs.

However, simulator-based training and assessment play a major role in these programs. They are offered to both experienced mariners and cadets. Our interviews indicate that simulator training at the centre was very useful for pilots and candidates for pilotage exemptions on the North Sea ferries.

C. MarineSafety International (MSI)—Newport, Rhode Island

MSI Newport is relevant to the present study in several respects: in the training that it currently provides to numerous pilots; in the simulator-based certification program approved by the U.S. Coast Guard (USCG); and in the pilotage training that it provides to CSA fleet officers. These points are addressed below.

1. Overview of the facility

U.S. Navy studies in the timeframe between 1976–1984 recommended shiphandling simulator training, but concluded that procurement was too costly. In 1985, the U.S. Navy issued a Request for Proposals for simulator training services at a contractor-owned, operated, and maintained facility. In 1986, MSI was awarded a five-year contract (subsequently renewed) for training to the Navy's Surface Warfare Officer School based in Newport, and for other training for fleet ships. Simulator training commenced in 1987. The U.S. Navy was by far the dominant user of the facility in its early days. Subsequently, MSI has attracted numerous clients from commercial shipping, as well as navies of other countries buying surplus U.S. ships.

Commercial programs are developed with shipping companies and pilot associations to provide the most useful exercises under the most challenging and realistic conditions possible. MSI offers U.S. Coast Guard (USCG)-approved courses for team training, radar observer certification, re-certification, ARPA training, and licence upgrades. MSI also is active in port and harbour research and evaluation for dredging, construction, and shiphandling safety studies. Finally, the facility conducts a mega-yacht training program.

MSI Newport has four simulators: a full mission bridge (FMB), a bridge wing simulator (BWS), and two visual shiphandling trainers (VST). Both the FMB and BWS contain adjacent learning feedback/debriefing centres. In addition, MSI's facility houses three classrooms, plus computer and administrative support spaces.

All simulators can use the same visual, ship response, and hydrographic databases. The BWS and FMB offer a visual perspective to develop a "seaman's eye" for alongside shiphandling, and provide engine and environmental sounds. An important feature at Newport is the ability to network as many as all four simulators to simultaneously interact in the same scenarios, to enhance formation or emergency shiphandling in different ships. Among other applications, this has been used to simulate the interaction of several tugs and a VLCC ship.

MSI Newport offers training in bridge resource management, shiphandling, collision avoidance and radar, special programs, and vessel traffic management. To give an idea of the scope of training available, we list below the specific courses offered in two relevant categories.

a) Bridge Resource Management

Bridge Resource Management for Ship Personnel (5 days)
Bridge Resource Management for Tug-Barge Personnel (5 days)
Bridge Resource Management Refresher (3 days)
Bridge Resource Management Seminar (2 days)
Bridge Resource Management for Marine Pilots (2 days)
Bridge Resource Management for Inland/River Towboat Operators (three to five days)

b) Shiphandling and boathandling

Shiphandling and Manoeuvring in Restricted Waters (3 to 5 days)
Shiphandling and Piloting (3 to 5 days)
Refresher Training for Working Pilots (3 days)
Apprentice Pilot Training (5 days)
Tug-Barge Boat Handling Refresher (3 to 5 days)
Advanced Tug-Barge Operations (3 to 5 days)
Ship Manoeuvring Proficiency (5 days)
Tug-Barge Handling Proficiency (5 days)
Manoeuvring Proficiency Check (2 to 3 days)
Shiphandling Accident Avoidance (4 days)
Tug-Barge Boathandling for Units on Inland Rivers (3 days)
Escort Tug Employment & Assist Tug Operations (3 days)
Shiphandling for Naval Officers (3 to 5 days)

c) Collision Avoidance & Radar/ARPA

d) Special Programs

e) Vessel Traffic Management

2. Simulator-based training of pilots at MSI Newport

Of interest is the extensive use of the simulators made by licensed marine pilots from Canada, the U.S., and elsewhere. The fact that these professional pilots voluntarily use the MSI Newport facility for their training attests to the usefulness and validity of simulators as a training and evaluation tool. Pilot groups who have trained recently at MSI Newport include the following.

- **Panama Canal pilots.** MSI "built" the entire canal, in eight separate databases with some overlap at each end. MSI provided a one-week course in emergency preparedness training to many Panama Canal pilots, focussing on the most difficult areas of the canal. MSI also re-created the control situations present in the canal, including normal voice communications, and the canal administration small craft that are prevalent. Senior training pilots from the Panama Canal assisted in the program development, and a retired Panama Canal pilot advised on the project. Ship exercises have been simulated from one end of the canal to the other, and some exercises involved integrating several simulators. Exercises typically lasted between 30–45 minutes.

- **B.C. Coast Pilots.** Both apprentice and licensed pilots train at MSI. Apprentices follow up a week of manned model training at Port Revel, France with a week of computer simulator training at Newport on their way back from Europe. Thus, apprentices shift immediately from training in an environment of 1:25 scale to training in an environment of 1:1 scale. MSI also provides training for experienced, licensed pilots. They concentrate on difficult manoeuvres such as large container ships in the inner harbour; restricted mooring areas of Nanaimo; manoeuvring at the Port Moody fuel dock; and casualty scenarios approaching the 2nd Narrows Bridge.

- **Puget Sound Pilots.** Both apprentice and licensed pilots practice at MSI, where they simulate piloting at the aluminum bauxite berth, fuel docks at Anacortes, and West Waterway of Seattle. In general, they practice in areas where manoeuvring space is limited due to shoal water.

- **San Francisco pilots.** MSI provides training to apprentice and licensed pilots focussing on containerships and tankers, and lightering of large ships, under typical weather conditions of fog and low visibility.

- **Gray's Harbor Pilots** from Washington State train at MSI.

- **U.S. Navy Pilots at San Francisco** train at MSI.

- **Southwest Alaska Pilots.** Training has focussed on Dutch Harbor, coordinating the work of pilots and masters of U.S. container ships calling for seafood to export to the Far East. MSI has helped to devise manoeuvring tactics for various weather conditions.

- **Barber's Point Pilots.** MSI has trained pilots working at this single point mooring site in Hawaii, where two pilots are normally used per operation. The mooring is just inshore from the ledge of an ocean shelf, and operations are often conducted in low visibility including nighttime and tropical downpours.

- **Brisbane Marine Pilots.** This pilot group concentrates on shiphandling, mainly shape up and docking, but also some fairly long fairway pilotage since Brisbane is approximately 50 miles upriver from the sea. MSI has also formally evaluated the skills of certain pilots at the request of the pilot association.

- **Port Phillip Pilots** from Melbourne, Australia, train at MSI.

- **Atlantic Pilotage Authority.** MSI trains a contingent of pilots from the APA on a regular basis, generally once or twice per year. Among other scenarios, MSI prepared a drydock exercise for APA pilots to simulate the drydocking task in Halifax Harbour.

- **Corpus Christi/Aransas/Galveston/Texas City Pilots**. MSI has provided shiphandling training to these Texas-based pilots.

- **Houston Ship Channel.** MSI has provided training for company pilots and captains of the Exxon tug-barge fleet.

3. Other pilot involvement at MSI Newport

In addition to direct training and/or evaluation, pilots also use the MSI facility as participants in harbour configuration simulations, as indicated below.

- **Rotterdam Pilots.** Before the MSI Rotterdam facility was built, MSI Newport assisted in the development of Europort. This harbour is adjacent to the North Sea and often has Force 4 to 5 seas. Pilots and masters were concerned with the Port Authority's plans to build berths close together, considering the operating conditions. MSI used its four simulators linked together to simulate a large bulk carrier or containership interacting with four tugboats.

- **Boston Harbor Pilots.** This group participated in a research project sponsored by the U.S. Army Corps of Engineers on dredging requirements at the Port of Boston. The harbor pilots subsequently attended a Bridge Resource Management seminar at MSI.

- **Los Angeles Pilots.** MSI used simulator technology to evaluate the proposed "L.A. 2020" terminal development project. L.A. pilots participated in the shiphandling scenarios testing the feasibility of the port expansion project.

- **Charleston Pilots.** MSI worked with pilots serving the Port of Charleston in evaluating the impact on ship traffic from three potential sites for a new container terminal.

- **Northeast Marine Pilots.** These pilots, together with ship captains, helped MSI evaluate the feasibility of safely manoeuvring CSL ships to deliver coal to a power plant in Fall River, Massachusetts. The passage required a 90^{o} turn with wind and currents frequently cutting across a channel just 250 ft wide. Several Northeast Marine Pilots also work as part-time instructors at MSI.

4. Pilotage training for CSA members' officers

MSI Newport offers several training programs for officers of CSA members' fleets. These include Bridge Resource Management, Piloting, Shiphandling, and

Emergency Shiphandling. Appendix E contains the outlines for several of these courses.

The five-day CSA pilotage course focusses on the St. Lawrence Seaway. It covers the following areas:

Between Clayton and Ironsides Island
Between Ironsides Island and McNair
Between Prescott and Cardinal/Iroquois
Between Snell Lock and Butternut
Transiting St. Louis Bridge

Participants transit each area several times in both directions. The FMB and VST simulators are both used. Conditions vary during the exercises, from good to poor visibility, with variable current, wind, traffic levels, etc.

The course emphasizes recognizing prominent navigation points, making course changes in particular areas, understanding the effects of river flow at different times of the year, techniques for handling traffic, areas to avoid meeting traffic, and setting up for lock approaches. Course participants are mostly 1st and 2nd mates of CSA members'ships.

Simulator training is intensive during the piloting course, averaging approximately five hours each day on the simulator. CSA representatives believe the pilotage training provides a highly practical and valuable training experience for their officers. The simulators are able to model with a high degree of accuracy the fairway piloting experience in difficult, restricted waters. CSA members' fleets now consider the course a prerequisite (in addition to the required number of actual trips) before considering an officer as qualified for a pilotage exemption in the St. Lawrence above Montreal.

5. Simulator-based certification (licence upgrade)

MSI Newport received authorization from the USCG as of April 1, 1997 to offer a licence upgrade course aimed at the "mid-level" licence community, replacing the USCG exam for upgrading to a Near Coastal Master's licence for 500GT or 1,600GT. The authorization expires April 1, 1999. As of July 1997, MSI has not yet offered the course. The six-day course will be offered to mariners wishing to upgrade their licences. The course will include several written examinations, and will culminate in a practical evaluation using a simulator. Appendix F contains a summary of the licence upgrade course.

MSI will act in the place of the official licensing body (the USCG). It is MSI's responsibility to decide whether or not a participant has successfully met the requirements to upgrade his licence. The candidate's performance on the simulator evaluation will be an important factor in this decision.

Although this course is not specific to piloting, the use of the simulator in the context of this certification process is instructive. Exhibit IX-1 indicates which elements of the course are graded in the simulator, which are graded in the classroom through written tests, and which are not tested at all.

Exhibit IX-1
Simulator-based and written elements of MSI's Near Coastal Master licence upgrade course

Graded in the simulator	Taught and tested in class	No test required
Piloting	Piloting	
- bearing problems	- charts and publications	
- distance off		
- fixes		
- dead reckoning		
Voyage planning		
		Situational awareness
Watchkeeping		
Meteorology and oceanography	Meteorology and oceanography	
- tides and currents	- weather and ocean systems	
Rules of the road	Rules of the road	
	Navigation (general)	
	- electronic navigation	
	- instruments and ACC	
	- aids to navigation	
	- compass (gyro/magnetic)	
	- NOTAMs	
	Power plants/ship's construction	
Communications	Communications	
- R/T	- R/T	
	- Storm signals	
	- H.O. 102	
	- SAR (MERSAR, AMVER)	
Shiphandling and manoeuvring I	Shiphandling and manoeuvring I	
	Emergency procedures	
Shiphandling II	Shiphandling II	
	Shiphandling III	
	Cargo handling	
	Stability and trim	
	Fire prevention and appliances	
	Medical and first aid	
	Maritime law	
	Ship management seminar	Ship management seminar
	- ship management and training	- USCG operations
	- ship's business	- legal and insurance
		- captain and owner liability
Simulator Pro-card final exercise		

Replacing the USCG exam with this course is an example of using a simulator for proficiency-based training and evaluation. MSI reports that while the same material is covered as before, integrating the simulator into the process has allowed MSI to shorten the written exams. The licence upgrade course makes extensive use of simulators over the six-day timeframe, as summarized below.

1. Familiarization Exercise. two students per simulator, 2-hour session.

2. Piloting Exercise. two students per simulator, 3-hour session.

3. Rules of the Road/Shiphandling I. two students per simulator, 2-hour session.

4. Shiphandling II. two students per simulator, 2-hour session.

5. Advanced Shiphandling Transit. two students per simulator, 2-hour session.

6. Pro-Card Exercise. Individual runs of approximately 1-hour session.

6. Simulator-based grading

Appendix G contains several simulator evaluation templates used in the past by MSI for various courses and customers. Evaluations are typically qualitative rather than quantitative. The style of evaluation responses is typically agreed to with the customer and may reflect the culture of the organization. In some cases, responses may be on a qualitative scale from Excellent–Very Good–Good–Fair–Poor. In other cases, evaluation during a training exercise may be based on a ranking of "Satisfactory Progress" or "Progress Required," while the formal evaluation concluding the course may be based on a ranking of "Proficient" or "Not Proficient." Remarks or comments by the instructor or evaluator are also generally included.

D. RTM Simulation Training And Research (STAR) Center—Toledo, Ohio

The STAR Center in Toledo is used primarily for shiphandling and fairway pilotage training. The center is particularly relevant to this study as it provides simulator-based training for mariners obtaining their pilotage endorsement for Great Lakes operations and it offers simulator-based courses for licensed pilots operating on the Great Lakes and in other districts. These points are addressed below.

1. Overview of the facility

The facility houses four bridge simulators—two visual bridge simulators (each with an operational electronic chart and positioning systems) and two Radar/Navigation (blind pilotage) simulators, as described below:

- Bridge One has a 233^{o} horizontal field of view.
- Bridge Two (tow-boat configuration capability) has a 178^{o} horizontal field of view.
- Bridges Three and Four are non-visual bridges equipped with radar, ARPA, and electronic navigation.

The two visual bridge simulators are used for both training and research tasks including vessel and bridge resource management, shiphandling, basic rules of the road, emergency response, tug operations, vessel and harbour familiarization and port design. The two non-visual bridges are used to support the visual bridges and are used for training in areas such as anti-collision, advanced navigation techniques, and VTS operations. The bridge simulators are augmented by a variety of mathematical ship models and harbour and waterway databases which reproduce diverse sailing environments. While some of the simulators are capable of interactive operation with each other, they may also be operated on a stand-alone basis.

The following is a listing of the equipment and instrumentation contained on the bridge simulators.

Overhead Instrument Panel	Gyrocompass Repeater
Steering Console	Fathometer
Propulsion Console	Bridge Clocks
Bridge Control Status	Decca Receiver
Watch Responsibility	Loran C Receiver
Joystick Steering Panel	Transit Satellite
Bow/Stern Thruster	GPS Navigator
Anchor Controls	MFDF
Doppler Log	Navigation Telex
Speed/Distance Log and Time Pane	Weather Facsimile Receiver
Communication Equipment	

Realistic simulation of the total man/ship/environment is an important requirement for both maritime training and in analysing the human operator in research applications. In addition to the navigation bridges, the STAR Center's facilities include the following.

- **Control Station**—A console from which the simulator operators or instructors can start, monitor, and terminate simulator exercises; control other vessel traffic; control and adjust environmental conditions; initiate ship system failures; specify and initiate exercise data to be plotted or recorded for post-exercise playback. Full communications capability is provided so that the operator or instructor can provide realistic input from sources external to the simulator's wheelhouse.

- **Visual Scene**—A large screen which may be either an arc segment or a completely surrounding circulator screen, on which a full-color computer generated image (CGI) presents a three-dimensional perspective representation of the external world, as seen from the ship's bridge. The CGI replicates land mass, buildings, aids to navigation and other ships.

- **Host Computer**—A PC-based digital computer which acts as the simulation controller. Signals are generated by the computer to simulate a variety of indicators, both digital and analog, on the ship's bridge to display parameters such as ship's heading and speed, propeller RPM, rudder angle, wind velocity, depth under the keel, etc., and to simulate the variety of alarms and simulated electronic navigation instruments with which each simulator wheelhouse is equipped.

A briefing/debriefing/monitoring subsystem enables trainees to learn from observing the performance of others and from reviewing their own performance through a variety of audio-visual and graphic presentations. Specifically, the subsystem includes a graphic feedback display system which presents a "bird's-eye" view of an exercise, track plot and data log, audio-video recording or bridge operations and visual scene monitors.

2. Simulator based training programs

The STAR center offers over thirty courses to mariners, including pilots. The following five courses are most relevant to those operating in the Great Lakes-St. Lawrence River system.

Introductory Shiphandling for First Class Pilots—This course is designed for the individual who is attempting to obtain a Mates certificate. It provides participants with a high level of knowledge and insight into the shiphandling task.

Advanced Shiphandling for First Class Pilots—This comprehensive course is designed to give mariners more challenging shiphandling experience through the use of particularly difficult simulation exercises that focus on advanced topics of interest to the shiphandler. It is primarily used by those attempting their Master's ticket.

Emergency Shiphandling for Great Lakes Masters and Mates—Attendees leave with the skills necessary to successfully cope with the most common emergency shiphandling scenarios.

ARPA, Bridge Resource Management and Emergency Shiphandling for Pilots—This five-day course is designed for full-time dedicated pilots, providing them with an overview of ARPA, APA-approved Bridge Resource Management and area specific emergency shiphandling designed to meet existing states' requirements.

This course has been attended by Great Lakes Pilots from Districts I, II and III, Los Angeles Bar Pilots, New York Bar Pilots, and Alaskan pilots. Full details of the course content are available in Appendix H.

First Class Pilotage for the Detroit, St. Clair, and St. Marys Rivers—This course is designed to assist mariners to obtain the U.S. Coast Guard pilotage endorsement (i.e., exemption).

This course provides 120 hours of instruction over a three-week period in all areas necessary to obtain an original endorsement as First Class Pilot on the Detroit, St. Clair, and St. Marys Rivers. The course uses a combination of shiphandling simulation and classroom exercises to insure attendees' proficiency in all knowledge and skill areas required for a pilotage exemption. During the course, each attendee participates in multiple simulated transits on each waterway. The rivers are run day and night, in both directions, on board a 767-foot pilot-house-forward lakes ore carrier. Several transits on a 1,000-foot pilot-house-aft ore carrier are made to illustrate differences between the vessels.

The course prerequisite is an unlimited tonnage inland or ocean licence as Master or Mate. It comprises eleven modules, focussing on shiphandling/traffic management skills, route knowledge, effect of wind, current, etc., on track keeping. Full details of the course are available in Appendix H.

While there is no final examination, performance standards for each module must be met in order to complete the course. Attendees who successfully complete the course are given a Course Completion Certificate. The U.S. Coast Guard accepts this course as equivalent to three of the twelve trips on the rivers, which are required for a pilotage exemption.

E. Maritime Simulation Centre of The Netherlands (MSCN)

MSCN does not currently have a training program for pilotage exemption certificates. However, it has developed a number of individual training schemes, including some for fairway navigation in narrow channels. The strengths of the company lie in its ability to develop tailored training schemes; produce accurate ship models, especially for shallow draft operation; and develop accurate geographical and hydrographic databases.

MSCN operates a simulator centre in Wageningen. The company specializes in the development and production of nautical simulators and in the provision of nautical training and consultancy services. An equal joint venture of two renowned maritime institutes, MARIN and Delft Hydraulics, the company has a staff of 25 persons. While the company was formed in 1992, it draws on over 25 years experience of its parent companies. It also works closely with Dutch universities in Rotterdam and Amsterdam.

MARIN, with a staff of 250 persons, is known in the marine industry for its calculations and model testing in the filed of ship hydrodynamics. Delft Hydraulics is an international engineering company, employing 500 persons and specializing in hydraulic and civil engineering. These two companies provide the required resources for developing accurate ship models and database development for construction and operation of nautical simulators. All research is carried out within the company, along with database development. The company assembles simulators using parts supplied by specialists throughout the world.

The centre operates two full-mission bridge simulators, four tug simulators, a vessel traffic services simulator, and a part-task simulator. The MSCN real-time simulators range from a primary bridge full-mission simulator with a 360^o outside view, to the secondary bridge simulator with 180^o outside view, to the tertiary bridge simulator with a bird's-eye view. All simulators can operate in the same environment, either alone or in combination with one another.

The MSCN simulators all work according to the concept of real-time simulation. This concept is highly modular and facilitates flexible adaptation to other configurations, e.g. joystick control, inland waterways push tows with flanking rudders, coupled bridges with human operated tugs, traffic simulation, etc. Switches from a single vessel situation into a multi-vessel system can be made in under one hour.

The centre offers simulator courses in the following areas:

- bridge simulation, including pilot training, shiphandling and Bridge Resource Management (BRM);
- engine room simulation;
- cargo handling;
- fully integrated simulations, involving the connection of all simulator types as if all simulators formed a ship.

MSCN is currently the main training centre for the Rotterdam harbour pilots, who use the centre for simulator-based training and assessment. MSCN provides the training facilities while the pilotage authority provides instructors. It developed its training program in conjunction with MSCN staff. The centre also trains pilots from around the world in shiphandling and emergency procedures. These programs tend to be custom designed for each client, and full details are not publicly available.

The centre is currently coordinating the Maritime Standardized Simulator Training Exercises Register (MASSTER) for the EC Waterborne Transport 4th Framework program. At present within the EU, there is no standard set of ship manoeuvres, operations and scenarios to be exercised in simulators for the harmonization of maritime training. The objective of MASSTER is to inventory existing simulator scenarios, and develop and document new scenarios, based on the assessment of gaps and shortcomings in the current scenarios. The resulting final catalogue of scenarios will then serve as a basis for the harmonization of maritime education and training for existing and future simulation facilities. Staff at the centre are experienced in developing and analysing specific training programs for a wide number of applications.

F. Commercial flight training

The training of pilots for flying commercial aircraft is based on requirements stipulated in the Air Regulations governed by Transport Canada. This section is based on an interview with the Manager of Flight Training for Air Canada.

1. Entry requirements

Entry level pilots selected by Air Canada to be trained to fly their aircraft must have the following minimal requirements:

- Holder of a commercial pilot's licence
- Have a multi-engine rating (i.e., ability to fly in the event of an engine failure)
- Have an instrument rating (i.e., can fly using only instruments—no visual)
- A minimum of 250 flying hours
- A graduate of an aviation college (this is not mandatory but is used by Air Canada to support the aviation colleges)

In many instances, Air Canada will require more than these minimums depending upon the need for and the availability of pilots.

2. Training programs

There are basically three types of training: 1) Initial training for new pilots which is the most extensive; 2) Transitional training for pilots, changing the type of aircraft flown; and 3) Recurrent training which is done once a year to update pilots on new equipment, regulations, etc. Training is done in-house by airline personnel. Approximately 60% of current Air Canada instructors remain active pilots with the airline.

a) Initial training

Initial training for new-entry pilots is the most extensive. It comprises the following components.

1. A 3-week orientation course which includes learning about company procedures, meteorology, etc.

2. A 2- to 4-week ground school which includes simulated devices training (e.g., instrumentation, communication) and procedures training. There is a written exam at the end of the ground school.

3. Simulator training which comprises a minimum of eight 4-hour sessions on a simulator for a particular aircraft (there are seven aircraft types and seven corresponding simulators at Air Canada). Generally, pilots train on a simulator until "they get it right." However, there is a limit until candidates are designated as a "failure to progress." There is a practical exam at the end of the simulator training.

New pilots must then get an "initial line check." Transport Canada stipulates at a minimum this involves 25 hours of flying time and 4 flight legs. Pilots then receive a "Pilot Proficiency Rating."

b) Transitional training

When switching to a new aircraft, pilots must undertake transitional training. Transitional training is similar in many aspects to initial training except for the orientation course. Pilots return to the ground school for 2-3 weeks and then proceed to take the simulator course (eight 4-hour sessions). Pilots then get a "Transitional Line Check" which involves a minimum of two flight legs in an aircraft.

c) Recurrent training

Recurrent training is carried out on an annual basis for all pilots. It involves eight hours of simulator training (two 4-hour sessions) and eight hours of class room training concerning new equipment, new regulations, etc.

It should be pointed out that pilots always train together as a crew: Captain, First Officer, and for some particular aircraft, a Second Officer. Training usually commences on the smaller aircraft as a First (or possibly Second) Officer. Pilots usually work their way up to larger aircraft as a First Officer before starting back over again as a Captain on smaller aircraft. Captains must again go back on the simulator for the eight 4-hour sessions to take a "command course" even though the pilot has already been trained on a simulator for that particular aircraft as a First Officer. However, the pilot does not have to re-do the ground school training for that particular aircraft.

3. Role and types of simulators

As is evident, simulators play a key and indispensable role in air pilot training. All pilots who are to operate aircraft carrying greater than 50 passengers **must** be trained on a simulator. This is a Transport Canada regulation.

There are four categories of simulators: A, B, C, and D. For simulators A and B, simulator training is only part of the endorsement. Pilots must complete their training on board actual aircraft. For the more sophisticated simulators C and D, pilots can step right into the aircraft—no actual flying time is required.

There are two types of systems in a simulator: 1) visual which can involve the replication of actual airports and, 2) aircraft type. Both systems are an integral part of a simulator. Air Canada has seven aircraft-type simulators. In some instances, Air Canada pilots will train on other aircraft or airport-type simulators at other airlines for particular needs. Other airlines sometimes use the simulators of Air Canada.

Simulators are a necessity for pilot training. Simulators can replicate emergency situations and problems which cannot be carried out using actual aircraft due the high risk of accidents or loss of life.

4. Relevance to marine training

The reliance on visual flight simulators for training and certification in the commercial aviation sector is noteworthy. In fact, simulators *must* be used for commercial aviation training and certifying in Canada. Advances in aircraft simulation technology led to the development and acceptance of simulators as a training tool in the marine industry. One would expect that greater use could be made of marine simulators for certification purposes, based on their acceptance in the air sector. However, one must also recognize that certain fundamental differences exist between aviation and maritime simulation.

- Visual flight simulators for commercial air carriers are linked directly to development of specific airframes and are not modified to permit training in multiple airframes.
- Ship bridge simulators are developed independently of the vessels that they are intended to simulate.
- Moreover, ship-bridge simulators are intended to model multiple hull forms and sizes.
- No industry-wide standards presently exist for marine simulators, unlike commercial air carrier simulators. This is gradually evolving, through developments such as the Maritime Standardized Simulator Training Exercises Register being coordinated by MSCN.
- Some stakeholders assert that aircraft trajectories and behaviour can be mathematically modelled more accurately than ship behaviour, particularly at slow speeds and in shallow and restricted waters.

G. Department of National Defence

DND makes extensive use of multi-task, visual projection marine navigation simulators. Marine simulators are used for training Junior Officers, for advanced training and refresher training of Senior Officers. In addition to training, simulators are also used as part of the exam process at certain stages of the training program.

The following outlines the training program used by the Department of National Defence for the training of Navigation Officers. It is based on information obtained from the Officer-in-Charge of the Navigation Department of the Naval Operations School based in Halifax, Nova Scotia.

1. Training/advancement program

After basic recruitment training, Junior Officers can commence training to become Navigation officers with no or minimal sea experience. The program is described below.

a) Basic seamanship

Junior Officers commence navigation with an initial marine surface and subsurface course. This level of training is termed “MARS II” (i.e., maritime surface subsurface). MARS I relates to the basic training. The course length of MARS II is twelve weeks.

b) Basic navigation course

The Junior officers then follow a basic navigation course termed “MARS III” of 16 weeks in duration which includes three weeks of initiation at sea.

c) More advanced training

More advanced training termed “MARS IV” is covered over the next four-month period. This involves ship handling and watch manoeuvres and includes six weeks on a simulator. A typical week on the simulator is seven hours per day over five days. The Junior Officer acts as an Officer of the Watch for manoeuvres during the simulation training. The simulator is used both in training and as part of the Performance Check (i.e., the exam) at the end of this course.

d) Junior Officer in training

On-the-job training (e.g., fire fighting, how to stand watch at sea) aboard ship then follows for a six-month period. During this period, the Junior Officer acts as a Second Officer of the Watch.

e) Naval operations course

A land-based naval operations course then is conducted for a period of four months. It consists of people management and professional development (e.g., weapons use, materials/supply management). It also includes two weeks on the simulator to do “Advanced Relative Velocity.” This involves having the ability to proceed to a given point at a given time as well as diversion and scouting manoeuvres.

f) Bridge Watchkeeper Ticket

The Officer then returns to his ship. If the Captain is satisfied with the Officer’s capabilities, then he/she receives a Bridge Watchkeeper Ticket or a Certificate of Competency Level 1. The Officer stays aboard ship for a period of four months for more on-the-job training.

g) Certificate of Competency

At the end of the four months at sea, the Officer sits before the Professional Qualifying Board. If successful, the Officer receives a Certificate of Competency Level 2.

h) Director level training

The Officer then chooses a specialty such as navigation, above water warfare, underwater warfare, etc. If the navigation specialty is chosen, the course is five months in duration which includes one month on the simulator. The simulator training includes fleet manoeuvring, visual navigation, electronic aids, and blind navigation. The simulator is used both in training and as part of a Performance Check (i.e., the exam) and the end of this course, prior to a two-week session at sea.

i) Frigate Navigation Officer

The Officer then goes back to sea for two weeks of assessment. If all goes well, he/she becomes a Frigate Navigation Officer. This gives him/her the right to navigate certain larger ships in the Navy. It excludes ships such as auxiliary oiler replenishment vessels and amphibious assault ships.

In total, a Junior Officer can attain the status of Frigate Navigation Officer in about two and one-half years. There are exams or performance checks at the termination of all the program components listed above. Simulators are also used as part of the performance checks for MARS IV training and Director Level training to become a Frigate Navigation Officer. Failure to pass a particular exercise is dealt with as follows:

- one failure—a verbal warning
- two failures—a written warning
- three failures—go before the Training Review Board to explain reasons for failure. The Training Review Board can decide whether or not to give a fourth chance to the Officer
- four failures (if given a fourth chance)—the Officer fails the program

Training is done on an individual basis. Teamwork is learned on the job.

Class sizes are as follows:

- Junior officer — 12 students
- Navigation course — 8 students

2. Additional/advanced training

a) Advanced training

After a period of at least two years aboard ship, a Frigate Navigation Officer can apply to become a "Deep Draft Navigation Officer." It involves training of six weeks (the course used to be four months long but was recently revised) consisting of four weeks of classwork and two weeks at sea. Three of the four class weeks are in a simulator. At the end of this course, the Officer is qualified to navigate all vessel sizes. Class size is reduced to about four students for this training. The simulator is again used both in training and as part of the Performance Check (i.e., the exam) at the end of this course. The same rules apply in terms of failure to pass a particular exercise as outlined above.

b) Refresher training

It is mandatory that the ship teams undergo a refresher course twice a year in navigation training. The course is three days in length and is conducted on a team basis, not an individual basis. For navigation officers, all work is carried out on the simulator.

c) Commanding Officer training

After about fifteen years in the Navy, a Navigation Officer can be selected to become a Commanding Officer. There are thirteen qualifying professional exams to be written of which two involve navigation. In addition to navigation, the exams deal with all aspects necessary to command a ship including administration, human resource management, warfare, etc. There is no set time limit to complete all thirteen exams. Part of the exam includes the use of simulators before an Officer Board chaired by a Fleet Commander. This Board asks the prospective Commanding Officer to perform requested ship manoeuvres using a simulator.

3. Role and types of simulators

DND now use their own simulators. For advanced navigation, they had been using the MSI simulator in Rhode Island. However, a new simulator scheduled to be in operation by February 1998 at Esquimalt, B.C., will now be used. This simulator provides 360° of visual and a high degree of accuracy according to DND. There is also a simulator in Halifax which has been upgraded to 270° of visual. Thus, all training will now be in-house.

Eighteen to twenty ship types are programmed into the simulator. The Navy has the luxury of having a limited number of ship types to simulate and is content with the ability of the simulators to replicate those ship types.

Simulators are an important part of navigation officer training and have replaced the Training Squadron of ships that were formerly employed. Simulators are seen as a very cost effective tool but significant sea time is also a necessary and critical element of training. DND does not foresee simulators replacing more sea time than is now stipulated in the program.

DND also has four prototype Virtual Reality simulators which are still under development. They were developed by the Defense and Civil Institute of Environmental Medicine (DCIEM) in Toronto and the Naval Officer Training Centre at Victoria, B.C. They are now used at Naval Reserve Divisions as a proficiency maintenance tool for officers who do not have access to the main simulators. There are no plans at present to expand the use of Virtual Reality simulators in navigation training beyond their present use.

4. Relevance to pilotage certification process

Simulators play an integral role in the training of navigation officers, usually in combination with on-the-job sea-time training. There are many similarities between the skill and experience requirements of naval navigation and commercial navigation. This takes on added significance considering that DND is exempt from compulsory pilotage. DND representatives believe that simulator training is a safe and cost effective tool which, when combined with sea time training, improves the navigational skills of its officers.

DND have a significant number of vessel types (eighteen to twenty) that have to be programmed into the simulators. A similar number of vessel types could be more than adequate for the range of vessel types employed in commercial shipping on the St. Lawrence River that may be eligible for pilotage certification.

Based on the positive experience of DND, greater use of marine simulators for pilotage certification purposes (both for training and testing) is warranted.

H. Simulators presently used in North America for licensing

Numerous centres in North America have facilities for certifying mariners on simulators to obtain particular endorsements or certificates. Each of the centres has been accredited by the regulatory authority to provide simulator courses which are recognized by the licensing body.

1. Radar endorsements

In Canada and the U.S., numerous centres offer courses for training and validation on the use of radar using maritime simulators. These courses are aimed at mariners training for particular watchkeeping certificates. In Canada, the approval to conduct Simulated Electronic Navigation (SEN) courses is granted by the Board of Steamship Inspection. Initial approval is granted after the equipment is inspected and the course is monitored by a Transport Canada surveyor.

To successfully complete the SEN 1 Part "A", the candidate is required to demonstrate his ability to operate the instruments listed in the equipment checklist. This is conducted in the form of a practical test performed to the satisfaction of the instructor, who may supplement the test with oral questions. Verification beside each instrument on the check list attests to the candidate having successfully demonstrated his ability to operate the instrument.

2. MSI licence upgrade course

At its facility in Newport, Rhode Island, MSI offers a simulator-based certification program approved by the USCG for candidates wishing to upgrade their Near Coastal Master licences. In this case, course participants make substantial use of the simulator over a six-day period, both for training and for formal evaluation. MSI's simulator and instructors act as a partial replacement for the USCG written exam (candidates also write shorter versions of the former USCG exams).

3. SIMSHIP master's unlimited oceans licence

In 1994, the SIMSHIP Corporation proposed to the USCG that it offer training courses that combine training, written examination, and ship-bridge simulator assessment. This course would be equivalent to the written examination for the master's unlimited oceans licence and may be selected by the applicant as an alternative to the written examination. The USCG accepted and approved a combined training and testing course using a full-mission ship-bridge simulator to meet this objective. A significant difference from current USCG practice, in which USCG licence examiners conduct the testing, is that representatives of SIMSHIP would conduct both the training and the testing with USCG oversight.

The approved training and testing consists of a two week course with heavy emphasis placed on bridge resource management and manoeuvring vessels in restricted waterways. Training and testing is conducted separately. The first week is devoted to training, which addresses subjects to be examined on the simulator. The second week is devoted to testing for all elements of the licence examination. The testing includes practical demonstrations for communications, chart work, bridge resource management and situational awareness. Ship-bridge simulators are used only for those elements of the testing for which they are suited (e.g., bridge resource management, rules of the road, shiphandling). On successful completion of the course, licence candidates are issued a certificate that can be presented to the responsible USCG licensing official.

4. STAR Toledo First Class Pilotage endorsement

The Simulation Training And Research (STAR) Center in Toledo, Ohio offers a ten day training course for Masters and Mates seeking a first class pilotage endorsement (i.e., exemption) for the Detroit, St. Clair, and St. Marys Rivers. The course includes close to sixty hours on the FMB simulator, and includes periodic proficiency checks by STAR instructors. The USCG has authorized this course to count as the equivalent of three actual transits of these Rivers for successful course participants. Thus, the USCG accepts this simulator-based course as counting toward obtaining a pilotage endorsement.

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[1] *MarineSafety International Rotterdam b.v., "Proposal for Training to Obtain a Pilot Exemption Certificate," Rotterdam, 1995, Appendix H, page 5.*

X

Training And Validating Principles

This chapter provides a general discussion of experiential learning principles, of techniques to develop a course of study for pilotage certification, of general requirements of the validation process, and of using modern technology to address these requirements.

A. Continuing education

The following is an overview of the principles of ongoing skills development and training methodology relevant to training mariners via the use of simulators.

1. Continuing education and training

Developers of educational training programs generally believe that people learn:

- 20% of what they see;
- 40% of what they see and hear;
- 75% of what they see, hear, and do.

To that end, effective learning programs must reproduce job/performance content and skills requirements as closely as possible, and provide a forum both on and off the job where required knowledge, skills, and principles can be taught and reviewed.

2. Critical learning principles

According to experiential learning theory, a number of critical elements are essential for facilitating continuing education.

The most obvious principle is the need for training to be learner-focussed. Training must be sensitive and responsive to learner needs. It must respond to the questions: what is the real requirement?; what does the learner really need to learn to meet the requirement? As well, it must grant the learner the final role in evaluation.

A second key principle focusses on the fact that in order for training to be appropriate, it must be designed by qualified professionals with the active involvement of the learners as partners in the design process. As well, learners must be actively engaged in the total learning process. They must perceive the need to learn certain concepts and be able to relate those concepts to the environment in which they function. This interactivity is the dynamic exchange that takes place between the learner and the other components of the learning system (instructor/ facilitator, material/content, tools, technology, etc.). Questioning and active participation are viewed as essential components of the learning process. Each form of interactivity plays an important role in maximizing opportunities for learning.

A third axiom of continuing education is the need to provide immediate feedback to the learner. The constant need to know what is being learned and what is not, is a regular feature of continuing education. Immediate feedback serves to reinforce prior learning or signal the learner that more study and/or practice are necessary.

A fourth key element is the need to represent information in a variety of modes to facilitate learning. The importance of considering human factors is involved here. Not all individuals learn the same way. Learning must be concrete, authentic, and meaningful and must meet the learning needs of the individual. The ability to situate learning within an authentic and meaningful context has a significant impact on what is learned.

This also involves the need to value what the learners already know and build upon that knowledge and skills base. Using all chances to capitalize on a previous foundation of experience, knowledge, and existing skills will help to progress the learning at an appropriate pace for the learner.

3. Key elements of an effective learning program

Effective learning programs are based on the development of appropriate objectives. The overall objective of any program must be based on a clear understanding of the results to be achieved and measured during as well as at the completion of the program. Specific learning objectives form the milestones which learners must reach throughout the program. Learning objectives are developed from results required, learner profiles, and training scenarios. They show the learner what knowledge or skill he/she must demonstrate at the end of a particular module. To be effective, learning objectives should:

- Be observable and measurable.
- State the quality or level of proficiency deemed to be acceptable.
- State significant conditions for good performance.

Knowledge-based objectives and skills-based objectives should be distinguished. Both types should be incorporated into and measured by the training program. Knowledge-based objectives demand recall of facts, sequences, and key features that determine appropriate actions/procedures. Skills-based objectives demand performance of task sequences and procedures, and the verification of performance quality.

Once learning objectives have been set, the program should specify which learning elements are to be incorporated to reach each objective. An inventory of knowledge and skills listed in the correct learning sequence to attain the objective, is required.

Delivery of training, whether self-directed or instructor-led, individual or group-based, should be structured on mutually understood and agreed results with:

- Planned periods of learning (lesson plans) indicated.
- Expectations (learning objectives) clearly articulated.
- Information provided in an easily assimilated way.
- Accommodation to learner context (environmental constraints, challenges, opportunities).
- Identification of discrete elements of knowledge and skills to be learned.
- Adequate provision for learner practice in a similar/on-the-job situation to provide feedback on the gap between current and required performance.

To chart the results of learning sessions, knowledge and skills testing is required. Assessment of knowledge and skills is based on the agreed learning objectives and knowledge and skills inventories crafted previously. Test results provide valuable feedback that the gap between current and desired competence has narrowed.

Knowledge acquisition (retaining facts, processes, procedures, etc.) is measured by objective tests such as: written question/answer tests and/or oral testing.

Skills acquisition (performing a task, work sequence/procedure), on the other hand, is best evaluated through performance-based assessment. The performance test is based on the demonstration of learner ability to perform the activity learned. Performance tests should be constructed in the same experiential manner in which the learners have been taught and administered in carefully controlled conditions to ensure relevance and objectivity. Performance assessment should be designed to:

- Emphasize critical learning points: facts, principles, task sequences, procedural steps, etc.
- Show learners where they need more training or reinforcement.
- Hold learners accountable for their role in the learning process.

To ensure both knowledge and skills have been acquired at the appropriate level of competence, and well-rounded comprehensive learning has taken place, any evaluation process should incorporate both types of measurement practices.

B. Designing a training program

Two main approaches exist to design a training and validation program: content-based or competency-based. We believe that a competency-based approach is superior in this instance. (For the purposes of this report, we consider the terms "competence," "ability," "proficiency," and "skill" to be interchangeable.)

A content-based approach places too much emphasis on acquiring facts. However, facts can change over time (e.g., placement of buoys), rendering their memorization less relevant. Content-based programs are developed without reference to any associated goals, objectives, or skills. This ignores the principles of continuing education, namely that effective learning programs are based on the development of appropriate learning objectives, and that programs should include skills-based learning and validation. The LPA syllabus is content-based.

A competence-based approach stresses the definition and acquisition of the skills needed to perform a particular task or job. It incorporates knowledge learning, but emphasizes performance-based learning and testing. It can be particularly effective for situations like pilotage, where ultimately the safe performance of pilotage duties is the goal. Different approaches exist to designing a training program. Appendix I contains an approach suggested by the U.S. National Research Council in the context of mariner training. We summarize below the approach used by IMQ, and endorsed in appropriate circumstances by *le ministère de l'Éducation du Québec.*

1. Job-based situational analysis *(Analyse de la situation de travail)*

The process begins with an exercise aimed at describing the work situation: a portrait of the profession. This is accomplished by gathering a round table of experts in the field (e.g., 10-15) for a period of three days. The round table is led by an external facilitator. Considerable time is spent defining the activities that are done in the job or task under study. Information is gathered on the limits of carrying out the work analysed, the tasks and activities related to the profession, the work processes, technical and technological knowledge necessary, skills, habits, and attitudes required, working conditions and environment, responsibilities, particular requirements for entering the profession and practicing the profession, and suggestions related to training.

2. Definition of goals and competencies of the learning program

Building on the results of the job-based situational analysis, the next step describes the final results sought by the training, with a general description of the targeted profession and educational intent. In this phase of program development, activities include defining the goals of the training program starting from the final result sought, and the orientation of technical training, the characteristics of the group to train and the work situation involved. The competencies required or sought are defined, and linked to the information gathered from the job-based situational analysis. Estimates are established of the length of time required for training.

3. Validation of the training project

Experts from the profession, as well as other specialists in education and other interested parties, are gathered to review the training project suggested, including reviewing the validity of the overall goals and competencies for training. These may be revised based on feedback from the validation panel.

4. Preparation of objectives and standards

Objectives and standards for the program are prepared. Objectives define the competence, skill or knowledge to acquire or perfect. Each objective is aimed at acquiring a particular competence. Objectives are formulated in clear terms that explain observable aspects of the competency, but they do not present the learning activities necessary to acquire or perfect the competence. Objectives are framed as an *action* or *activity* to accomplish or achieve.

Standards represent the level of performance considered as the threshold to recognizing that an objective has been attained. Standards are thus defined so as to permit the measurement of whether the objective has been attained. Standards include the context for their achievement (e.g, with which tools, under what working conditions). Standards do not themselves imply a particular measurement technique or process, only the level to attain.

A competency (objective) may be defined as having several elements, and each element has specific performance criteria (standards) attached.

5. Advantages of a competency-based approach

The great advantage of a competency-based approach is that it defines what competencies are to be learned, why it is important to learn them, what level of attainment will be required, and how that will be measured. None of this is clear from a content-based approach (or from the LPA's syllabus).

Using a concrete example, the LPA's syllabus states at one point simply:

> *"6.06 Collision Regulations—Chapter 1416."*

Lacking any further direction, the candidate has no understanding of which collision regulations, in what detail, and how he will be evaluated on this aspect.

By way of contrast, IMQ has defined one particular competency as "Preventing collisions." Elements of this competency include the following:

- Interpret lights, markings, and visual and audible signals;
- Navigate under all visibility conditions;
- Navigate in different traffic systems;
- Organize work flow on the bridge;
- Carry out radar checks.

The first element (interpreting lights, etc.) has the following performance criteria:

- Correct recognition of the direction and status of vessels;
- Correct determination of the right of way;
- Exact interpretation of lights, markings, and visual and audible signals;
- Exact application of regulations.

Other elements also have several associated performance criteria clearly defined. In this way, the student/candidate has a much clearer understanding of learning requirements and the evaluation process.

C. Requirements of a certification process

Certain initiatives were undertaken over the past few years to improve the pilotage certification process of the LPA. Notable improvements include the inclusion of a Transport Canada representative on the Board of Examiners; the appointment of a CSA observer; efforts to revise the syllabus; recording on tape the oral portion of the exam; and efforts to augment the objectiveness of the process.

However, many stakeholders still perceive difficulties with the current process for certification. Difficulties are perceived, to varying degrees, by domestic shipowners, ship masters, Transport Canada, and the Authority itself. The present study is a direct result of those perceived problems. Its objective is to study the means by which the present process can be modernized through the use of new technologies. We see the following as necessary for a modernized process for pilotage certification.

1. **Reliable.** Above all, the process must be reliable, whereby pilotage certificate candidates who can prove their ability, and who do not represent a risk to safety, are successful; and candidates who lack sufficient experience or skill, and who do pose a risk to safety, are not successful.

2. **Objective.** The process should maximize objectivity and minimize subjective assessments that are open to criticism and second-guessing.

3. **Independent.** The process should continue under the auspices of the LPA, and continue to be independent. While controlled by the Authority, the process also needs the expert input of licensed pilots.

4. **Credible.** All stakeholders need to accept and have faith in the process and its results.

5. **Efficient.** The process should be efficient, both to administer and to prepare, without compromising safety.

6. **Performance-based.** The process should put greater emphasis on demonstrating and measuring adequate performance of the candidate to act under any circumstances.

D. Using simulators to address these requirements

Simulators can address positively the above-noted requirements.

Simulators promote ***objectivity*** in several ways. Candidates can be put through the same or similar scenarios, to ensure equal treatment. Their performances can be compared against others, against a preferred track line, and especially against pre-determined evaluation criteria covering a number of aspects, such as:

Traffic management
Communications
Radar usage
Trackline control
Rules of the road
Emergency response
Situational awareness
Voyage planning and monitoring
Judgement

Simulators can be included in an *independent* process that is managed by the LPA, is not controlled or dominated by any particular party, and relies on the independence of third party simulator instructors and evaluators.

The *credibility* of simulators continues to grow as their capabilities are enhanced, and as their use increases. Simulators have been accepted for licensing by the USCG for Masters certificates. Simulators are also widely used by pilot groups, not only for training but also for formal evaluations. We envisage simulators as an important element, but not the only element, of a revised process that would retain a written and oral aspect.

Simulators promote *efficiency* in several ways. Small groups can be trained at the same time on simulators. Simulator-based evaluations reveal much about a candidate's performance in a relatively short time (e.g., 1–2 hours). Using simulators for evaluation, one can replace a large part of the written and oral exams.

Simulators are *performance-based*. The flip side to the axiom that we learn best by "doing" is that we are also evaluated best by "doing." The only way to be more performance-based is for the Board of Examiners to accompany a candidate on an actual ship. Simulators in fact offer advantages over that approach, because in a simulator one can control the environment, manipulate the evaluation scenario, and train (and evaluate) candidates under difficult and dangerous situations that one may encounter in real life.

On the other hand, it is important to recognize the existing shortcomings or limitations of using simulators for LPA pilotage certification. Before simulators are introduced for training or certification, one must:

- ensure the validity of vessel, geographic, bathymetric, and visual data;

- determine the overall cost-effectiveness of a simulator-based certification scheme, especially considering the length of the LPA's compulsory pilotage zones, and language considerations;

- recognize the importance of the people involved, not just the hardware, software and facility, and the need for experienced, credible, independent simulator operators, instructors, and evaluators; and

- address the concerns for the need to ensure competency over the entire LPA district, not just in a few trouble spots.

XI

A Modern Training And Validation Program

The objects of the Authority are to establish, operate, maintain, and administer in the interests of safety an efficient pilotage service.[1] The Authority may prescribe the qualifications that a holder of a pilotage licence or certificate shall meet, including the degree of local knowledge, skill, and experience.[2] The Authority may also prescribe the manner for determining whether a person who applies for a pilotage licence or certificate meets the qualifications required.[3] Thus, the mandate of the LPA empowers the Authority to develop an efficient and effective process for examining pilotage certificate candidates.

Equally as important as revising the exam process, we believe that "modernization" should include the establishment of a framework to assist certificate candidates to prepare. This involves a training program to promote both proficiency and an appropriate degree of knowledge. A discussion of training elements and structures must be based on a clear understanding of the reason for training. In this case, we would define the purpose of training as follows:

> *to develop, promote, and ensure safe fairway pilotage knowledge, skills and abilities appropriate for pilotage certificate candidates for Laurentian Pilotage Districts I or II.*

In this chapter we identify several ways to help candidates prepare, and to modernize the system. The discussion below represents KPMG's position, after considerable research and reflection, on an appropriate approach to modernize the pilotage certification process.

A. Establish a Common Body of Knowledge

A key early step in modernizing the process is to create a Common Body of Knowledge combining existing reference material with mariners' knowledge, techniques, and advice related to pilotage within the LPA. This tool will pool the experiences, knowledge, and techniques of pilotage certificate holders and other experienced mariners. The aims are to create a global repository that exceeds the knowledge of any one individual, and to benefit future candidates who can refer to a consistent base of material. This Common Body of Knowledge would undergo revisions or updates as new sources of information become available.

The Common Body of Knowledge will require the cooperation of various shipowners, to create something that will benefit the industry as a whole. The Authority should also be involved as a resource when preparing the guide. The process should be facilitated, and the document should be produced by an expert in the preparation of pedagogical material.

To date, candidates have had to prepare their own study materials. Although some have passed on their notes to others, these notes were not prepared by "teaching" experts, and they were only of very limited use (despite good intentions). We found only marginal synergies among active pilotage certificate holders, in terms of their preparation.

The Common Body of Knowledge could address both general competencies (e.g., winter navigation) and competencies specific to piloting in LPA waters. The greater benefit would come from addressing specific competencies. Most candidates are already reasonably well prepared for more general skills.

B. Create a training program

Another method of modernizing the process is to develop a training program based on competencies. This would follow the methodology outlined in the preceding chapter, which has already been established as an effective approach for teaching mariners, and is recognized by *le ministère de l'Éducation*. This will involve defining goals, objectives, and standards related to pilotage, including specific competency elements and performance criteria.

The result will be a program of competencies that would replace the current LPA syllabus. We recognize that the syllabus has undergone revisions in recent years. What we propose, however, is a markedly different way of presenting the syllabus. Rather than simply stating a topic, or the vague "Knowledge of….", it will contain specific competencies related to those topics, with associated standards to achieve.

The LPA's syllabus presently covers the following major areas (the complete syllabus appears in Appendix A):

Chartwork, tides, and practical use of radar and other aids.
Vessel performance in confined and restricted channels, shiphandling, anchoring.
Meteorology and winter navigation.
Legislation, regulations, and publications.
Local knowledge.

We see merit in evaluating candidates' competencies in these areas, for several reasons.

- Candidates' knowledge and experience may vary depending on their career path.

- The Authority will continue to require some evidence that candidates are expert shiphandlers, familiar with the rules of the road, etc.

- Simulators could permit a more practical demonstration of ability in areas directly relevant to fairway pilotage than the current lengthy written exams.

Our vision, however, is to create a more transparent process whereby candidates have a much better understanding of what competencies they need to attain, and to what measurable standard. This is a key point to grasp. We do not see this training/validating process as a continuation of the existing process, with other elements such as a simulator possibly tacked on. By redefining requirements in terms of competencies, and creating measurable standards, the entire process undergoes a revision towards an open, transparent, and modern learning process.

By relying on the syllabus as it is now presented, the certification process will always remain flawed. It will be open to continuing criticism and debate between various stakeholders. Some will consider the process to be subjective; others will consider the content to be at fault. Rather than using the syllabus as the starting point, the "real operation" of piloting should be the starting point for developing a program of competencies that must be acquired.

Certificate candidates must possess both knowledge and ability. A pilot needs knowledge of the coastline, of channel depths, of the location and bearing of aids to navigation, of the behaviour of currents and tides. However, an appropriate recognition of competency is missing from the current process. The present system overemphasizes knowledge, and underemphasizes skill and ability. The process overemphasizes knowledge because:

- candidates are required to memorize facts well beyond the level of detail that:

  - they can retain for any period of time;

  - they actually rely on for piloting purposes; and

  - appears to be necessary in light of available electronic aids to mariners

- a significant amount of knowledge is not in the public domain or available to certificate candidates—it is proprietary to licensed pilots.

The current process underemphasizes skill and ability, considering that:

- knowledge does not necessarily translate into ability;

- learning based on doing is recognized as a more effective way of learning than efforts based on watching or memorizing; and

- simulators allow an assessment of performance and ability, but these tools are not currently used.

C. Establish the infrastructure required for program delivery

Pilotage certificate candidates need a structured training program. The type of training program referred to above should be developed as a cooperative effort between the Authority, shipping companies, educators, and Transport Canada. Ideally, the pilot corporations would also be involved because of their specialized knowledge.

We do not advocate training that is geared towards passing an exam. That approach does not promote safety or develop abilities to deal with unforeseen circumstances. On the other hand, a structured training process will ensure that the training and the candidates' efforts are appropriately focussed.

The "population" for this training consists of already skilled and experienced mariners. They have proven that they already possess a knowledge of navigation techniques, in obtaining their senior level certificates of competency (i.e., ON-1 or MM). Candidates should undergo some general training, as opposed to training to develop Local Knowledge. That training needs a sharp focus on training specifically geared to fairway pilotage.

Based on experiential learning theory and the variety of competencies to perfect, we believe that the most beneficial training program for certificate candidates will be one that combines different styles of training and instruction. This may include self-directed study, group instruction, and simulator-based training.

The training program must recognize that candidates are employed full time as mariners and have limited time available for study and training. Most training should be delivered in winter, when the majority of candidates have greater time available for preparation.

We propose that training be delivered in several modules. The modules should be fairly compact in terms of time, but can be sufficiently detailed since each would address a portion, rather than all of the required competencies of candidates. Modules could be developed as follows.

Collision regulations—This would address only those situations relevant to fairway pilotage. The module could identify particular regulations, define competencies, and describe relevant scenarios to consider and practice.

Navigation and shiphandling—As noted earlier, candidates for pilotage certificates are already skilled mariners, but their proficiency in these areas should still be addressed.

Local knowledge/pilotage training—The Common Body of Knowledge would help candidates prepare for specific aspects of this module. This may be reviewed through a self-study format to address topics such as location of aids to navigation, behaviour of currents, etc. Group sessions in a classroom session may be particularly appropriate for this phase, allowing trainees to benefit not only from an instructor/facilitator, but also from each others' experience.

We also believe that a simulator would be especially beneficial to develop the competencies required for pilotage. Candidates could make extensive use of a simulator to enhance their knowledge and familiarity with the district, and to practice and gain experience in piloting under a variety of conditions.

D. Use a simulator in training

The existence of sophisticated simulators and instructors can and should promote a fundamental shift in the approach to both training and examination for LPA pilotage certificates. The focus of training and exams should be different, emphasizing ability rather than memorization.

Simulators can be used for training in a number of areas, as highlighted below. All of these elements can be practiced under varying conditions of visibility, wind, currents, and tides. They can be tailored to enhancing candidates' local knowledge, by using data appropriate to LPA waters for modelling ships, bathymetry, and the visual scene.

- **Passage planning.** Properly executing a passage plan developed by the candidate before a simulator run.

- **Rules of the road.** Demonstrating an understanding and correct application of collision regulations.

- **Meeting or overtaking traffic.** Demonstrating safe, appropriate performance in handling other traffic, especially in restricted areas.

- **Familiarity with the environment.** Identifying and enhancing familiarity with aids to navigation, uncharted aids, the coastline, etc.

- **Anchoring.** Locating safe anchorages and demonstrating appropriate anchoring techniques.

- **Emergencies.** Handling a disabled vessel or otherwise responding to emergency or difficult situations.

- **Communications.** Communicating appropriately with VTS, with licensed pilots, and with other mariners including small craft, and demonstrating a familiarity with local place names and expressions.

- **Shiphandling.** Demonstrating skill in shiphandling appropriate to the local environment, including identifying appropriate turning points and correctly changing course, recognizing the effect of, and dealing with, currents and tides, etc.

- **Navigation.** Appropriately using navigation techniques including parallel indexing.

- **Equipment problems.** Recognizing and correctly adapting to compass, radar, or other equipment problems; recognizing bearing problems, distance off, etc.

E. Revise the validation process

After identifying and developing competencies, objectives and standards, the most appropriate methods of validation can be determined. We believe that a simulator can be used within the exam process. There is also merit in validating local knowledge and competencies through a written and oral process. In that case, however, the usefulness of the simulator must be recognized, and the written and oral portions must be significantly reduced in scope and length.

It is important to note that, while the examination could continue to have written and oral aspects, the validation process itself will be substantially different—objective, transparent, and measurable. This in itself is a substantial improvement.

1. Pre-requisites

We propose to maintain the same prerequisites as exist for pilotage certificate candidates, in terms of minimum number of trips, years of experience, certificate of competency, language ability, etc. We also see considerable merit in adding as a prerequisite the successful completion of a simulator-based training program in Bridge Resource Management at a recognized training centre. This would promote safety in pilotage on the St. Lawrence River. The Transportation Safety Board noted the following.[4]

> "As a result of the problems identified in this study relating to the absence of hand-over briefings, the ineffective monitoring of the vessel's position and in view of the frequency of occurrences involving demonstrated breaches of sound teamwork principles, the Board recommends that:

The Department of Transport require that the initial training syllabus for all ship officers be modified to include demonstration of skills in BRM; that

The Department of Transport require that all ship officers demonstrate skills in BRM before being issued Continued Proficiency Certificates; and that

The Department of Transport require that all pilots demonstrate skills in BRM before the issuance and/or renewal of a pilotage licence."

2. Board of Examiners

The composition of the Board of Examiners would cease to be a contentious issue, as the process becomes more measurable and less open to criticisms of bias or subjectivity. We believe that successful certificated pilots could sit on future Boards of Examiners for certificate candidates.

3. Simulator-based validation

Simulators can and should be used as part of the validation. Any of the competencies noted above regarding simulator-based training can also be evaluated by simulators. A simulator-based exam could consist of a transit of a portion of the district, in simulated "real time," and include a realistic portrayal of wind, wave, current, tide, visibility conditions, other traffic, and communications.

We note the following requirements for validating candidates' proficiency through the use of simulators.

- Validation of skills for the purpose of formal certification should occur some time after the training period (i.e., several weeks after). This will allow the knowledge and skills learned to be fully absorbed by the candidate, and present a more realistic portrait of his ongoing skill level.

- The evaluator should be someone other than the candidate's instructor(s). Otherwise, the candidate will not benefit fully from the training program, by avoiding asking questions or practicing difficult scenarios where he may "fail," in front of his future evaluator.

- In addition to simulator staff, evaluators could also include any or all members of the present Board of Examiners, and a certificated pilot.

- The framework for simulator-based evaluation must be understood and agreed to ahead of time by all evaluators and key stakeholders. This would include establishing ahead of time:

- the criteria to be evaluated;
- the ranking scale(s) to be used;
- the level of performance associated with each rank or score; and
- the required level of proficiency to warrant a passing mark.

- Scenarios used for validation need to be developed through close consultation among the LPA, simulator operators, shipowners, and ideally licensed pilots. All must agree with and participate in the development of scenarios that constitute a fair and reasonable test of a candidate's abilities.

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[1] *Pilotage Act, Section 18.*
[2] *Pilotage Act, Section 20(f).*
[3] *Pilotage Act, Section 20(g).*
[4] *Transportation Safety Board of Canada, "A Safety Study of the Operational Relationship between Ship Masters/Watchkeeping Officers and Marine Pilots," Report Number SM9501, 1995, page 35.*

XII

System Requirements And Costs

In this chapter, we describe the system requirements needed to modernize the pilotage certification process, and the resulting costs.

A. Program development

Requirements for program development include creating the Common Body of Knowledge, creating a training program, and establishing the infrastructure required for program delivery.

1. Create Common Body of Knowledge

Proficiency-based training should be based on information available to all. The notion and benefits of a Common Body of Knowledge were described in the preceding chapter. The Common Body of Knowledge would build on existing data books of the waters of the LPA. It would go beyond existing resources in several ways:

- by being prepared as a training tool by a professional educator;
- by incorporating up-to-date input from mariners;
- by incorporating qualitative aspects also (e.g., shiphandling techniques for specific areas or circumstances);
- by using a multi-media approach.

a) Development of written material

Several stakeholders should be involved in adding input to the Common Body of Knowledge:

- certificated pilots (masters);
- the LPA (i.e., Director of Operations);

- Coast Guard;
- masters who have not yet obtained their pilotage certificate;
- shipowners (i.e., operations managers);
- licensed pilots.

The individual appointed to prepare the Common Body of Knowledge should combine an understanding of marine navigation with formal experience in developing pedagogical materials. This person should consult individually with the parties listed above. Next, topics of knowledge should be discussed with small groups of stakeholders, to identify areas of common agreement or areas of differences.

A draft of the Common Body of Knowledge should be prepared and circulated to stakeholders for their feedback. The document would then be finalized based on their input. A provision should be made for periodic updating of the Common Body of Knowledge as circumstances change (e.g., following the permanent removal of a significant number of existing aids to navigation).

b) Multi-media approach

We believe that the Common Body of Knowledge would benefit from a multi-media approach: for example, printed material supported by a CD-ROM. A CD-ROM could provide moving images for visual demonstrations; could incorporate electronic chart data; and could make use of audio clues as well (e.g., local place name references commonly heard via radio).

The degree of sophistication, and hence cost, of creating a CD-ROM depends on factors such as:

- extent of multi-media employed (use of audio features; quality of visual images; moving images versus still images);

- degree of interaction between the user and the computer;

- extent of new material created specifically for this CD-ROM, versus existing material imported from other sources.

2. Design training program

The recommended process for developing a training program is described in Chapter X. The process involves a job-based situational analysis, definition of goals and competencies of the learning program, validation of the training project, definition of objectives and standards, and definition of essential course content and learning activities. The *Institut maritime du Québec* is best qualified to directly undertake this work, as their professionals are experienced in designing courses and training programs for the marine industry.

The situational analysis will require a round table of mariners who have already acquired the required skills and designation (i.e., masters who are certificated pilots). This group is very limited in number at present, as only six masters hold pilotage certificates for the LPA's jurisdiciton. Considering the practical difficulties of gathering all of these mariners together at the same time, the group gathered for the situational analysis may need to be supplemented with other masters or senior officers who have not yet obtained their pilotage certificates.

IMQ's normal practice is to hire an external facilitator to lead the situational analysis. The facilitator would be aided by an industry expert acting as an observer.

Based on discussions with IMQ representatives, we estimate that some thirty person days would be required for developing the situational analysis, competencies, validation, objectives, and standards. An additional ten days may be required for defining the specific learning activities/course content.

As part of the definition of the essential course content and learning activities, the most effective and appropriate methods for delivering various aspects of the training program would be identified. These could include self-study with a CD-ROM or printed material, group instruction in a classroom setting, and simulator-based training.

3. Organize program delivery

Following the development of the Common Body of Knowledge and the design of the training program (and upgrading hardware and software as described in the next section), steps must be taken to organize program delivery—i.e., to actually carry out the training. As noted above, IMQ is the most appropriate organization to develop the training program. As we will elaborate below, IMQ is the most appropriate operator of an upgraded simulator. Taking these two factors into consideration, we believe that IMQ is also the logical organization to assume direct responsibility for training delivery.

Delivering the training will involve establishing the timing and location for a training program, acquiring or dedicating the physical resources (teaching materials, training space), and identifying the human resources (instructors and technicians). Formal channels of communication related to pilotage certification training should be established between the deliverer of the training and various stakeholders (the Authority, shipowners, and candidates).

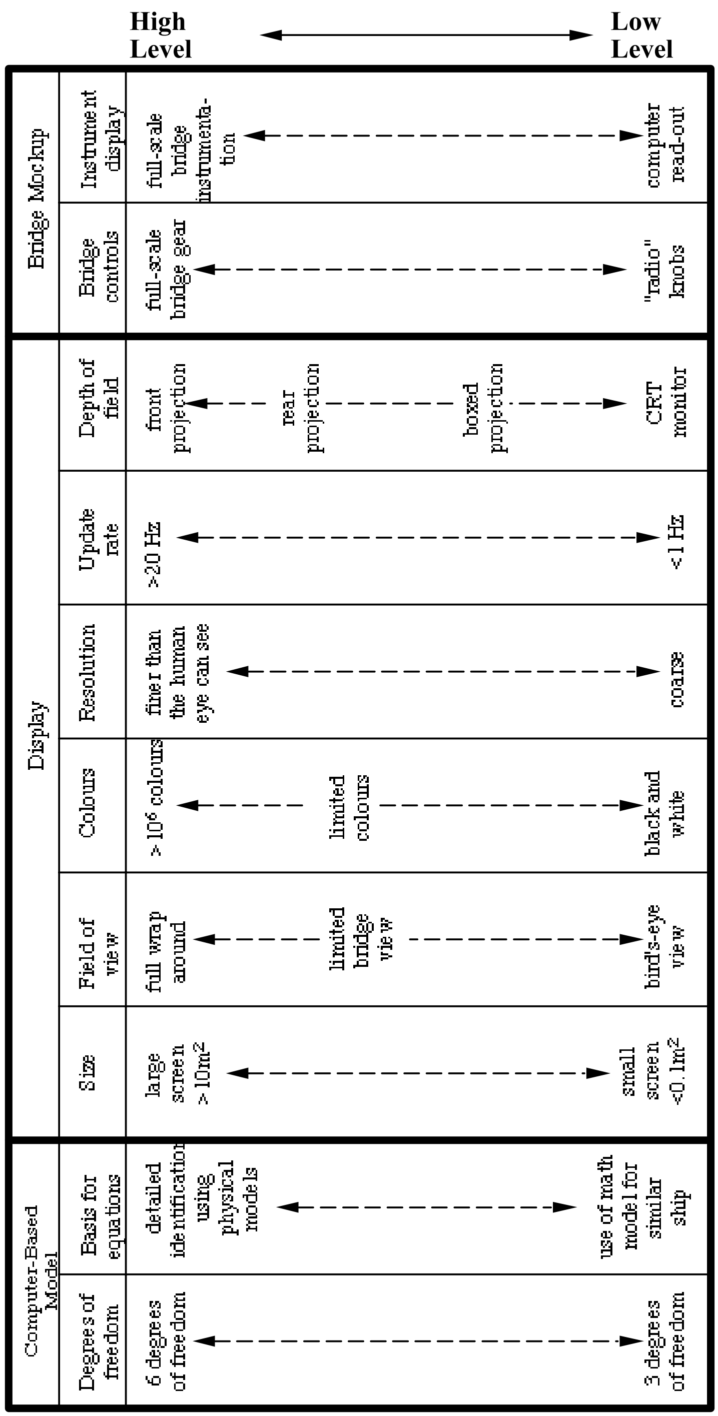
B. System requirements

Exhibit XII-1 indicates the range of sophistication available for the physical components of computer-based simulators with visual capability.[1] The levels of simulation can serve as a technical frame of reference for an assessment of the component's relevance and performance capabilities relative to the objectives of a training program.

A simulator may have strong capabilities in certain areas and weaker ones in others. In order to utilize the appropriate simulator, it is important to determine the appropriate strengths and limitations of each type and ensure that it is consistent with the training objectives.

To serve as a safe and effective tool for training and certification for pilotage, a simulator requires a fairly high degree of realism and accuracy. With this in mind, we describe below the system requirements that we foresee as necessary to modernize the training and certification process. We believe that each of the elements below is important, so that together they create an overall environment for the trainee that is both accurate and realistic. (In Chapter VIII we discussed at some length the need for both fidelity and accuracy, for ship-bridge simulators to be effective training tools.) The following system requirements are described.

Exhibit XII-1
Levels of sophistication for simulator physical components



Source: National Research Council, "Simulated Voyages-Using Simulation Technology to Train and Licence Mariners," p. 99, Washington, D.C., 1996.

- Marine navigation simulator
- Geographical databases
  - visual
  - environmental
  - other geographic features
- Mathematical ship models
- Physical environment
- Ship-bridge equipment

1. Marine navigation simulator

The marine navigation simulator coordinates the activity of the other modules (geographic, visual, and ship models), and is the basic platform of the system. It is important to note that marine simulation technology already exists in the province of Quebec, most notably at the Quebec City training centre of the Institut maritime du Québec. It is conveniently located at the midpoint of the LPA's jurisdiction, and already is used by licensed pilots and other mariners. If enhanced simulation technology is to be established in Quebec, we recommend that it should be established at IMQ's facilities in Quebec City. Discussions with IMQ representatives indicate that sufficient room exists to house the type of infrastructure envisaged.

IMQ's existing Norcontrol simulator (NMS 90 simulation control) is the same equipment in use at some other training centres such as Newfoundland's Centre for Marine Simulation. Thus, the existing system at IMQ can accommodate additional interfaces such as visual projection. Hence, we further recommend that upgraded simulator technology in Quebec should build upon the existing infrastructure, i.e., IMQ's existing Norcontrol-built simulator.

2. Geographical databases

IMQ currently has geographical databases covering the St. Lawrence's topography, navigational features, and environmental effects. A visual database must be added.

a) High quality visual aspect

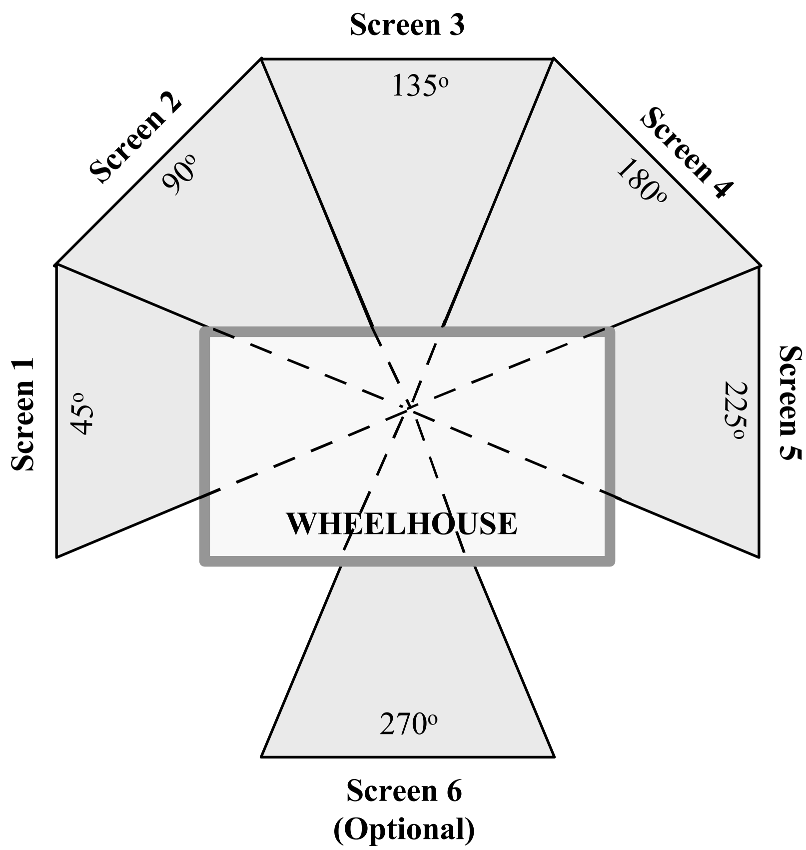
Three-dimensional, full-colour, computer-generated graphics simulate the external view that a mariner would see through the windows while standing on the bridge. The visual imagery would reflect not only the river and shoreline, but also other ("traffic") ships, and adjust light and atmospheric/visibility conditions to the scenario underway.

Several options exist to display a computer-generated image (CGI) for a marine simulator. These include projection onto cathode ray tubes (which would be framed as windows on the bridge simulator); projection onto several flat screens, located at a distance from the bridge cabin and angled to create a limited wrap-around view; or projection onto a circular screen that completely encircles the simulator.

Of these options, projection onto several flat screens is the most appropriate. Factors to consider include depth of field, adequate distance from the eye point to the screen, the need for a reasonably wide field of view, and cost. CRT monitors do not offer an adequate degree of visual resolution, an adequate size of viewing area, or adequate depth perception. A circular screen requires a very large space to house the bridge simulator and its screen; the circular screen at CMS in Newfoundland is set up with a radius of close to 10 m from the middle of the bridge. Not only is space a concern, but setting up a screen at such a distance from the viewing area inhibits the ability (and realism) of close-up projections, used when simulating docking, close-in manouvring, ship refuelling, and other such exercises.

Exhibit XII-2 illustrates how several flat screens can be set up. The standard projection technique provides a 45^o field of view for each projection channel, and thus for each screen. Angling five screens together allows a combined 225^o field of view, looking to port, ahead, and starboard. Adding an optional screen at the rear provides a total of 270^o. (Typically the rear screen is visible through a door at the centre back of the wheelhouse.)

Exhibit XII-2
Configuration of screens for visual projection



Either a front or rear projection system may be used, depending on the space available to configure the screens, and the amount of vertical depth of field to be shown. Front projection is less expensive, and can be used when there is adequate space, and when the vertical field of view desired is relatively shallow (e.g., 20°). This would be satisfactory for fairway pilotage situations. However, a deeper vertical field of view is required for close-in shiphandling manoeuvres. Given the fairly small number of potential LPA pilotage certificate candidates in any year, the simulator's capabilities should extend beyond fairway pilotage requirements, in order to serve a wider clientele. This will tend to increase the cost for visual projection hardware.

Large geomatic databases must be created in digital form, for visual display. For limited distance visual modelling (e.g., of a harbour), reconstructed scenes are prepared from actual photographs of the areas being modelled. Visual databases are generated by drawing terrain features and cultural objects from a Computer-Assisted Design (CAD) system. modelling lengthy coastlines presents a greater challenge. In fact, the length of LPA District I or District II exceeds the capacity of a single database, according to other simulator training centres; several databases will need to be created of adjoining sections of the River. (For example, MSI required eight visual databases to capture the complete Panama Canal, a distance of some 45 nautical miles.)

In addition to visualizing the water and coastline, the visual database must include aids to navigation, cultural objects, and traffic ships. Navigational aids present on the River would be represented within the visual scene, corresponding to their position on the electronic chart. Cultural objects that are used as unofficial ranges by local navigators should be added to the visual scene to promote realism. However, no technology can operate a database that attempts to include *all* cultural objects that are visible in reality. Traffic ships should have 3-D visual representations that can be viewed from any angle and any distance and will show the correct perspective.

Suppliers capable of creating a visual simulation database include existing simulator training centres capable of creating such databases in-house, and suppliers of visual simulation technology for other applications (e.g., aviation simulators). Examples of capable training centres include CMS in Newfoundland, which has a database of LPA District I used to train Mid-St. Lawrence pilots; MSI, which developed visual simulations for the St. Lawrence River (from Cape Vincent to St. Lambert lock), the Panama Canal, and other fairway pilotage environments; and the STAR Center in Ohio, which offers visual simulator training for first class pilotage endorsements for the Detroit, St. Clair, and St. Marys Rivers. ATS Aerospace, located in the province of Quebec, is an example of a supplier of visual databases for marine and aviation applications.

Creating an accurate visual simulation covering most or all of the LPA's waters will be an ambitious undertaking. Significant up front costs can be expected to develop and test a workable high quality database, covering a short distance. Up front costs will also be incurred to establish the interfaces required between the visual database, other equipment on the bridge (e.g., radar), and the Norcontrol simulator, so that the projected image corresponds to the ship's bearing and speed. When these interfaces are established, the incremental unit cost per mile to expand the scope of the databases (beyond a trial area, to cover longer distances) will be much lower.

b) Environmental effects

Environmental effects such as wind, tide, current, and ice are already maintained in a database by IMQ. These elements influence ship navigation and are an important part of simulator training. This database is apparently adequately detailed at present; only minor improvements may be required, for enhanced accuracy for pilotage scenarios.

c) Other geographic features

Bathymetry, navigational aids, and the coastline of the St. Lawrence River are maintained in an existing database and presented on the electronic chart. If additional precision is required, the data could be captured as part of the creation of the visual database, and incorporated so that each database is linked and coordinated. The underwater database consists of bathymetric data in the form of point positions, depth and bottom conditions. These data affect the mathematical ship model/bottom interaction.

3. Mathematical ship models

IMQ's existing ship models will need to be upgraded. IMQ currently uses mathematical ship models provided by Norcontrol, the simulator's Norwegian-based manufacturer. According to IMQ officials, these models are inaccurate. This has been confirmed by officers familiar with the vessels on which the models are based. IMQ staff have attempted to modify and improve the accuracy of the models, with very limited success. Problems encountered by IMQ include limited support from Norcontrol; the fact that another organization (the Danish Maritime Institute) was also involved in developing the models, making communication more difficult; and the fact that the supporting documentation underpinning the models are written in Norwegian.

The CSA purchased several off-the-shelf mathematical ship models from Norcontrol, and has worked over the past six years to improve the models' accuracy. These CSA-owned models may be a possible source. However, they may also have some of the difficulties mentioned above.

Given the importance of enhancing realism in the simulator, it is imperative that the models perform better than the IMQ-owned models do now. The optimal solution appears to be for IMQ to develop new models themselves. This would allow the greatest flexibility for continuous improvement and the modelling of additional ship types in future. IMQ staff are capable of creating such models with the support of a naval architect to define hydrodynamical equations that model shiphandling characteristics.

"Own-ship" types that could be modelled include the following:

Ro/ro ship
Bulk carrier
Self-unloader
General cargo carrier

Each ship can be modelled in loaded or ballast condition. Other types of ships could also be modelled to represent traffic ships, including container ships, Very Large Crude Carriers (VLCCs), ferries, and fishing vessels.

4. Physical environment

The physical environment needs to be upgraded compared to the existing set-up at IMQ's blind pilotage simulator. Ideally, when entering a simulator, one should have the strong impression of entering an actual ship's bridge. At the very least, one should not be distracted by obvious indications that the environment is less than realistic.

The training centre will therefore need a bridge cabin of appropriate size and proportion, realistic appearance, built of materials typical of an actual ship's bridge. The cabin need not be anywhere near as large as on an actual commercial ship; that would be prohibitively expensive, and goes beyond what is necessary to produce adequate realism. However, the cabin should be large enough for a bridge team of several persons to comfortably move around, and for the trainee to move around as he/she normally would when consulting several instruments or different views.

Another environmental aspect that should be included in a simulation is sound. Ship engine and ambient sounds should be piped in to the wheelhouse for added realism.

Simulating motion is not required or justified for pilotage training on the St. Lawrence. The waters of the LPA's jurisdiction are protected and the physical effects felt on the bridge of a commercial ship are not strong. The cost and space required for a hydraulically-mounted wheelhouse cannot be justified for pilotage training for the LPA.

5. Ship-bridge equipment

IMQ's limited task ("blind pilotage") simulator facility is heavily used between December and April each year. This matches the time period when a new multi-task simulator would be in greatest demand. To continue training equal numbers of students in blind pilotage, and to handle additional trainees for the visual simulator, additional equipment will be required for a new visual training simulator. The simulator would permit interactive training sessions, whereby trainees in the limited task and visual simulators can each follow the same scenario at the same time, and interact with each other's ship.

The type of equipment required for ship-bridge simulators will vary according to the objectives of the training course. Exhibit XII-3 indicates the relevance of various types of ship-bridge equipment for simulator training.[2]

Exhibit XII-3
Relative importance of ship-bridge equipment for simulator training

Key:

● Essential
❍ Will grow in importance
◗ Moderately important
❁ Nice to have
❖ Not applicable or of limited utility

Ship-Bridge Equipment	Navigation and Piloting Functions						
	Piloting						
	Shiphandling	Conning	Watchkeeping	Navigation	Voice Communications	Rules of the Road	Notes
Engine Controls	●	◗	◗	❍	❖	◗	
Propulsion Indicators (RPM, pitch)	●	●	●	◗	❖	◗	
Speed Log (Doppler)	◗	◗	◗	◗	❖	❍	
Auxiliary Propulsion Controls	●	❍	❍	❍	❖	❍	Bow thruster
Engine Room Alarms	◗	❍	◗	❍	❖	◗	
Steering Console	●	●	●	●	●	●	
Rudder Angle Indicator	●	●	●	❍	❖	●	
Rate of Turn Indicator	◗	◗	❍	◗	❖	◗	
Master Gyro Readout	❖	❍	❍	❍	❖	❖	
Bridge Wing Gyro Repeaters	●	●	●	●	❖	●	
Magnetic Compass	❍	◗	●	●	❖	❍	
Visual Bearing Capability	◗	●	●	●	❖	●	
Automatic Pilot	◗	◗	●	◗	❖	◗	
Nautical Charts	●	●	●	●	❖	◗	
Chart Table	●	●	●	●	❖	◗	
Radar	❍	●	●	●	❖	●	Radar essential for restrict-
Automatic Radar Plotting Aid	❖	●	●	●	❖	●	ed visibility and for esti-
Loran	❍	◗	●	●	❖	◗	mating distances of night
Electronic Positioning System	❍	◗	●	●	❖	◗	GPS, DGPS
Electronic Charting System/ECDIS	❁	❁	❁	❁	❖	❁	
Depth Indicator	◗	◗	●	●	❖	❍	
Wind Speed and Direction Indicator	●	●	❍	❍	❖	❖	
VHF Radio	❍	◗	●	❍	●	●	Essential for communica-
Internal Ship's Communications	◗	◗	●	◗	●	●	tions with assist tugs
Navigation and Signal Lights Panel	❍	❍	●	❍	❖	◗	
Whistle/Fog Signals	❍	◗	●	❍	❖	●	Essential as backup to
Reference Publications	❖	◗	●	●		●	VHF radio for signals to
General and Other Alarms	❍	●	●	●	❖	❖	assist tugs
Station Bill and Ship Placards	●	●	●	●	❖	●	
Clock(s)	●	●	●	●	●	●	

Source: *National Research Council, "Simulated Voyages-Using Simulation Technology to Train and Licence Mariners," p. 102, Washington, D.C., 1996.*

Note: *Canadian mariners consider ECDIS to be much more important than indicated in this table.*

Bridge equipment used in the simulator should be commonly found on board Canadian-flag ships. The set-up in the wheelhouse should be modular, so that consoles and panels may be rearranged, removed, or replaced to mimic various types of bridge layouts. Instrument displays and ambient lighting should be adjustable to match external light conditions being simulated. Required bridge instrumentation and equipment for pilotage training includes the following.

engine controls
propulsion indicators
auxiliary propulsion controls (bow thrusters)
steering stand
rudder angle indicator
nautical charts
chart table
wind speed and direction indicator
clock
radar
automatic radar plotting aid (ARPA)
electronic chart display information system (ECDIS)
differential global positioning system (DGPS)
intercom (communication with bow and stern and engine room)

Additional equipment could be acquired eventually if the simulator is used for training purposes other than pilotage (e.g., watchkeeping, navigation, communications, Bridge Resource Management).

C. Program development and system costs

The system costs to modernize the pilotage certification process are determined to a large extent by the degree of accuracy and realism required. This is valid both for hardware and software costs. For hardware costs, cost variability is influenced by the degree of realism of the simulated wheelhouse construction; by the sophistication of individual bridge instruments acquired (e.g., radar, ECDIS); by the number of different bridge instruments and equipment acquired; and by the type of projection system used. For software, cost variability is a function of the degree of precision and detail of various databases and models, which in turn is largely a matter of the amount of time dedicated to creating them.

It is important to achieve a reasonably high degree of realism when the new process for simulator-based training and certification is introduced. It is important for two reasons: for accuracy and safety, and to encourage the system's acceptance by mariners and the marine community as an effective training tool, both for experienced officers as well as for those with little experience.

While a reasonably high degree of realism upon introduction is important, two factors should be considered. First, realism can be improved in incremental stages. This approach is used at present at IMQ and other centres, whereby databases (e.g., cultural objects in the visual scene), models (e.g., mathematical ship models), and the training process are continually refined and enhanced over time. Second, no simulator, no matter how sophisticated, will match reality; to expect so is unrealistic. Therefore, stakeholders' *expectations* must also be realistic. Stakeholders need to accept the fact that a simulated version of reality is still an effective tool for training and certification.

1. Cost breakdown

We estimate that the total cost to acquire, develop, or upgrade the required hardware and software will total between $1.4 and $2.4 million. The range depends on several factors discussed below. Exhibit XII-4 summarizes these costs.

Our sources for cost information include quotations prepared by suppliers of equipment; information and advice from other simulator training centres; and discussions with industry stakeholders.

Exhibit XII-4
System costs

Cost Item	Range	
	Low	High
Common Body of Knowledge	47,000	127,000
Training program development	15,000	20,000
Training program delivery	5,000	5,000
Visual hardware (six channels)	630,000	1,145,000
Visual simulation software	250,000	311,000
Mathematical ship models	41,000	78,000
Bridge equipment	265,000	430,000
Instructor operating system	71,000	105,000
Environmental database	7,000	15,000
System integration and installation	35,000	117,000
Total:	$1,366,000	$2,353,000

The cost to develop a Common Body of Knowledge is based on an estimate of the number of person days required for consultation with mariners and other stakeholders and for preparing written material, document reproduction and other expenses, and the cost to produce a CD-ROM. We estimated the cost to prepare a written Common Body of Knowledge to be $27,000. The cost to develop a CD-ROM depends on the sophistication of the media employed, and could range from $20,000 to $100,000 or more.

We estimate that the cost to develop a training program will be approximately $15-$20,000. Organizing the delivery of the training program would involve minimal capital costs; we estimate a nominal amount of $5,000 for organizing the start-up.

While the cost to acquire hardware is quite firm, the modelling costs are "softer." Creating the digitized visual database is a specialized task, whose cost depends on the level of precision and realism sought.

The visual CGI hardware cost depends mainly on the projection system used and the screen set-up. The lower end of the range represents a forward-projection system with a shallow vertical field of view. The higher end of the range represents a rear-projection system with a deep vertical field of view. The choice of set-up depends on the space available and the importance placed on the vertical field of view.

The visual simulation costs shown here assume that all of District I, and portions of District II are included in a visual database. The level of visual detail is comparable to that provided currently in existing piloting courses offered to CSA members' officers covering the St. Lawrence Seaway. The software costs will depend on:

- degree of detail and precision;
- the length of the LPA jurisdiction to be modelled;
- the number of "own ships" and "traffic ships" to be modelled;
- degree of difficulty encountered when integrating various system components.

2. Additional costs to consider

In addition to the costs of developing a training program and acquiring or developing hardware and software, certain other costs will be incurred before an upgraded simulator can be used for pilotage training and certification. Additional costs may include the following.

- Building and infrastructure modification (e.g., upgrading the electrical and air conditioning services).
- Developing scenarios and exercises for pilotage training and certifying.

- Labour costs if additional instructors, operators or technicians are required at IMQ.

- Ongoing development work to enhance the capability and accuracy of databases and models.

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[1] *National Research Council, "Simulated Voyages-Using Simulation Technology to Train and Licence Mariners," p. 99, Washington, D.C., 1996.*
[2] *Ibid, p. 102.*

XIII

Implementation Schedule

In this chapter we propose an implementation schedule to modernize the pilotage certification process in the Laurentian region. The main phases for implementation are the following:

Agree on approach
Obtain funding
Develop Common Body of Knowledge
Create or modify databases and models
Acquire and install hardware
Revise training program and certification process
Improve process over time

To facilitate implementation, we recommend that the Steering Committee for this study remain in place with the mandate to oversee implementation.

A. Agree on approach

Following from the findings and recommendations of this report, members of the Steering Committee and other interested stakeholders will need to agree on the fundamentals of modernizing the pilotage certification process in the Laurentian region. In particular, the Authority, Transport Canada, IMQ, and shipowners (with input from pilotage certificate candidates) should reach agreement among themselves on the following basic points.

- The existing pilotage certification process should be modernized and improved.
- A Common Body of Knowledge for pilotage certification should be developed, with the cooperation of various stakeholders including the Authority, shipowners, and masters.
- The appropriate role of simulators, for training and for certification, in the short term and the longer term.

- The system requirements and specifications to be developed for upgraded simulator hardware and software.

- The budget required to develop material, create courses, and acquire or develop hardware and software.

B. Obtain funding

Funding will be needed to carry out the specific tasks outlined in this report to modernize the process. The required level of funding that we foresee is in the range of $1.4 to $2.4 million. Sources of funding could include shipowners, the Authority, the provincial government (*la Société québecoise de développement de la main d'oeuvre*), and the federal government (Human Resources Development Canada manpower training).

C. Develop Common Body Of Knowledge

As discussed in Chapter XI, a Common Body of Knowledge should be developed as an important early step in modernizing the pilotage certification process. Developing this Common Body of Knowledge will take several months to prepare and validate, after general agreement is obtained to cooperate in its preparation.

D. Create or upgrade databases and models

Creating a visual database of the Laurentian region could be accomplished by:

- contracting with a marine simulator centre experienced in developing such databases; or

- contracting with a local geomatics specialist, with substantial involvement of IMQ staff.

The former approach would take approximately six months for each LPA district, assuming one specialist is dedicated to the task. This is the length of time that representatives of other training centres suggested that they would require, if asked to prepare a visual database of either district. While this approach may be more economical in the short term because these centres are "up the learning curve," it would still require significant input from a competent authority of the LPA's waters.

The latter approach would take longer; however, it presents several advantages. First, subsequent revisions or upgrading could be more easily accomplished with a homegrown system. Second, it allows greater reliance on a wider range of Quebec-based mariners and other stakeholders, and easier access to their experience and knowledge. A cooperative arrangement with an advisor from an external marine simulator centre could optimize the approach.

The length of time to accomplish this task depends, of course, on the length of the River that is modelled. Starting with just LPA District II would help to accelerate the process, rather than modelling Districts I and II at the same time (unless resources are doubled within a given time frame).

Mathematical ship models and upgrades to other environmental databases can be completed within the same time frame required for the visual database. Six months should be sufficient time for IMQ to create its own ship models.

E. Acquire and install hardware

The main elements to acquire and install are: the projection system for the visual database; the mock-up of a wheelhouse; and bridge instrumentation and equipment. Acquiring and installing the hardware can be expected to take approximately four months, to define specifications, place orders, take delivery and install equipment.

When the hardware has been installed and the software created, then each element (models, databases, instruments, and equipment) will need to be integrated. This requires establishing proper interfaces with the original Norcontrol simulator. Several weeks may be needed to establish interfaces and integrate the various systems. Some cooperation from Norcontrol may be needed to accomplish this task efficiently.

F. Revise training and certification process

A modernized training program would use as its building blocks the newly-created Common Body of Knowledge and the capabilities of an upgraded marine simulator. A period of two months will be needed to follow the course development process described in Chapter XII. This will result in the creation of training objectives and standards and course materials.

Simulator-based scenarios must then be developed. The scenarios will be based on the training program objectives, and will be created in such a way that standards to be tested on the simulator can be assessed. Throughout this phase, close communication will be needed with the Steering Committee: for eventual agreement on specific aspects of a revised training program; for the simulator scenarios developed for training and certifying; and agreement on what will constitute adequate performance in all aspects of the certification process, including simulator-based testing.

The questions of when a simulator should be introduced for certification purposes, and what proportion of the exam process should be carried out on a simulator are very important. We believe that a simulator should be part of the validation process as soon as an upgraded simulator is installed and used for training. That is, the first pilotage certificate candidate(s) who use(s) a simulator as part of a formal training program should also be tested via the simulator. Supporting this assertion, we note the following.

- Revamping the certification process for competency-based learning requires a method of demonstrating performance; the simulator can accomplish this.
- If one has sufficient confidence in the accuracy and safety of a simulator to use it as a training tool, then one should have equal confidence in the simulator's accuracy and safety for use in testing.
- Potential candidates may be unwilling to attempt to obtain a certificate if a simulator is used for training but not validating—many may prefer to wait until a simulator is also used for validation.

We believe that the simulator's role in certification should grow over time as examiners become more familiar with the simulator's capabilities and as they gain experience in observing candidates' performance on a simulator.

G. Improve process over time

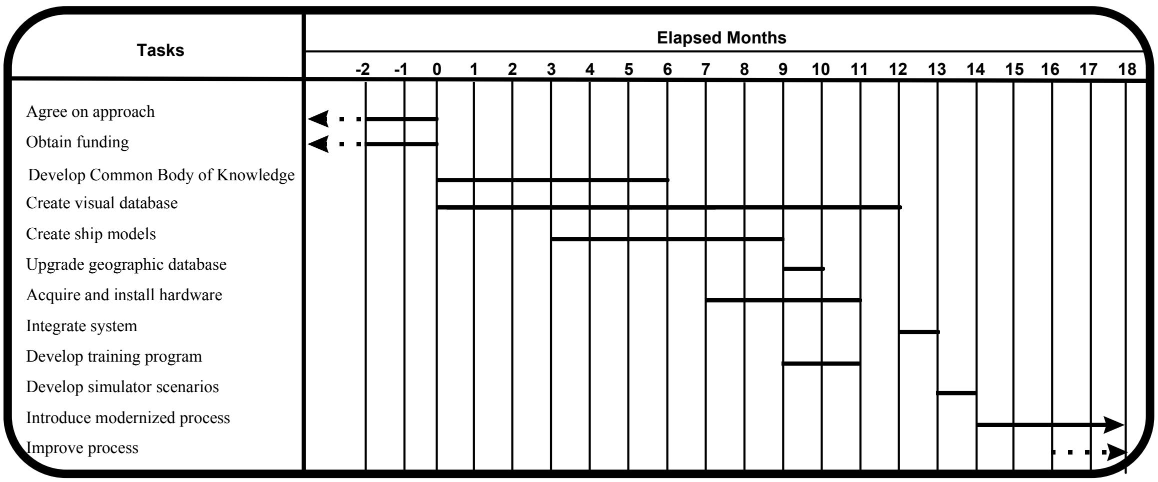
Even when a modernized approach has been developed and put in place, the implementation process never really ends. The various databases and models can be incrementally improved over time, for example by adding cultural objects to the visual scene, or by adjusting ship model equations based on input from ship masters. Also, the training program, simulator scenarios, and certification process can all be gradually improved over time, based on the feedback of trainees and the observations of the Authority and other stakeholders.

H. Schedule

Exhibit XIII-1 illustrates the timing required for implementation. Several phases can be developed at the same time. We believe that a concerted effort will be needed to achieve this implementation schedule. A project leader should be appointed to oversee all aspects. Also, the schedule assumes that resources will be dedicated to certain tasks full-time to accomplish them in the time proposed (e.g., create visual database, develop training program, integrate system).

The time required to agree on an approach and obtain funding is indeterminate at present. The schedule below counts the elapsed time to implement a revised process *after* agreement and funding are in place.

Exhibit XIII-1
Implementation schedule



XIV

Conclusions And Recommendations

In this chapter we summarize the conclusions and recommendations that we have reached regarding modernizing the pilotage certification process, based on our investigations, interviews, literature reviews, analysis, and synthesis of findings.

A. Greater recognition is needed of candidates' work environment, experience, and technology

The work environment differs significantly between licensed pilots and pilotage certificate candidates. Licensed pilots are trained to be able to pilot any ship, including foreign-flag ships which might never have visited Laurentian Pilotage Authority (LPA) waters before, with foreign-speaking crew, and limited shipboard technology. Pilotage certificate candidates are concerned with just one ship—their own ship. Certificate candidates are thus very familiar with the vessel they would pilot, including its handling behaviour, equipment, and crew.

Experience to date indicates that pilotage certificate candidates have sought restricted certificates, limited to trips only. They have not been seeking certificates for harbours in the St. Lawrence River, only through trips.

Many potential certificate candidates have navigated safely for years in the restricted waters of the St. Lawrence above Montreal, and in the Great Lakes, without incident and without a licensed pilot. By definition, potential certificate candidates also have extensive experience in LPA waters.

Many ships in the Canadian-flag fleet are very well equipped with sophisticated technological aids for positioning and navigating. Most relevant ships owned by members of the Canadian Shipowners Association (CSA) have DGPS, and 95% are equipped with electronic charts. All masters and deck officers in CSA members' fleets will have received BRM training by the spring of 1998, and CSA members are in the process of undergoing ISM certification for their fleets.

The above factors should be considered within the context of the pilotage certification process. The existing process does not make adequate allowance for these factors.

B. The certification process needs to be revised

Pilotage certificate candidates lack a structured process to follow in exam preparation. No training program exists to guide them in their efforts.

Laudable efforts have been made in recent years to bring a greater degree of fairness to the certificate exam, including appointing a Transport Canada representative to the Board of Examiners, adding a CSA-nominated Observer, recording and transcribing oral exams, and introducing the chart drawing requirement, which can be objectively graded. However, fairness should not be confused with appropriateness or reasonableness.

Despite these improvements in fairness, we find that the exam process for certificate candidates is inappropriate. The exam is based upon a syllabus that consists of open-ended topics, with no objectives or standards defined. The exam places far too much emphasis on knowledge and not enough on performance. Unfortunately, the aspect of the exam that attempts to test performance (i.e., certain elements of the oral exam) is the most subjective part of the exam. All of the findings lead us to conclude that the pilotage certification process needs to be modernized.

C. The modernization process requires several steps

Modernization consists of a series of reforms that could be undertaken. We recommend that the process be modernized by the following steps.

- Creating a Common Body of Knowledge, pooling the pilotage knowledge and techniques of all stakeholders, to develop a consistent source available to all.
- Establish a structured process for certificate candidates to follow for training, including access to materials.
- Create a training program using a competency-based program development approach (rather than based on content).
- Define specific objectives for pilotage certificate candidates: move away from an open-ended, knowledge-based syllabus to more concrete, performance-oriented objectives with associated standards to achieve.
- Introduce the use of a marine navigation simulator for training candidates.
- Introduce the use of a marine navigation simulator as part of the certification process.

D. We recommend the use of marine navigation simulators

Marine navigation simulators are continually improving in accuracy and realism. They still need development to appropriately simulate ship behaviour in shallow water, close-in shiphandling situations. However, their use is appropriate and well-established for fairway pilotage situations. Marine navigation simulators are used by many licensed pilot groups in North America, Europe, and elsewhere. Licensed pilots use simulators both for training and for evaluating. The use of simulators for licensing or certifying is gradually becoming more accepted by regulatory bodies, including the U.S. Coast Guard, the Department of National Defence, and the Port of Rotterdam.

We believe that marine simulation is a safe, useful, and important element to modernizing the pilotage certification process in the Laurentian region. The marine simulator at *l'Institut maritime du Québec* (IMQ) could be upgraded to meet the system requirements that we believe are necessary to achieve an adequate degree of realism and accuracy.

Costs to create a modernized process for pilotage certification include costs for designing a training program, preparing pedagogical materials, and acquiring or developing hardware and software. Total development costs would range from $1.4 million to $2.4 million. This does not include ongoing operating costs to deliver a modernized program.

If an upgraded, full-mission bridge (FMB) simulator is installed at IMQ, we recommend that IMQ staff create databases, visual scenes, and mathematical models, rather than rely on outside contractors. This approach costs more initially, but allows flexibility in the long run to serve the changing needs of clients and to gradually improve the accuracy of the system.

The cost-effectiveness of installing and operating an FMB simulator at IMQ must be weighed against the alternative of using an existing FMB-equipped marine simulation centre for training and testing LPA pilotage certificate candidates. We do not believe that a FMB simulator would be cost-effective if it is only used for LPA pilotage certificate candidates. It may become cost-effective if used also for other purposes, such as Bridge Resource Management training, training licensed pilots, and training or certifying cadets and mariners upgrading their certificates of competency.

The time required to implement a modernized program for pilotage certification, including installing an FMB simulator at IMQ, will be at least 18 months from the time when approval and funding are in place. This assumes that IMQ staff create their own software, and that certain resources are dedicated on a full-time basis when required.

Finally, we recommend that members of the Steering Committee created for this study should continue to work together to oversee the implementation of a modernized process for pilotage certification.

Appendix A

Syllabus For Pilot's Licence And Pilotage Certificate Between Les Escoumins And Montreal

(Not available in electronic format/ Non disponible en format électronique)

Appendix B

Interview List

Interview List

	Organization	Name	Title
Marine Simulation and Training Centres	Danish Maritime Institute	Peter Sorenson	Head of Training
	Institut maritime du Québec	Jean-Guy Bouchard	Director, Québec
	Institut maritime du Québec	Johanne Cormier	Pedagogical Consultant
	Institut maritime du Québec	Raymond Giguère	General Director, IMQ
	Institut maritime du Québec	Robert Gordon	Instructor
	Institut maritime du Québec	Robert Pelletier	Director
	Institut maritime du Québec	Alain Victor	Instructor
	Marine Institute	Jacek Pawlowski	Director
	Marine Institute of Technology (Baltimore)	John Trimmer	Instructor
	MarineSafety International	Howard Burdick	Director, Newport
	MarineSafety International	Tom Garrigan	Director
	MarineSafety International	Gene Guest	Director, New York
	MarineSafety International	Larry Reimer	Instructor
	MarineSafety Rotterdam b.v.	Jan Bakker	Manager, Marketing
	MarineSafety Rotterdam b.v.	Peter Groeneveld	Nautical Instructor
	MarineSafety Rotterdam b.v.	Jan Sinke	Manager, Special Projects
	Maritime Simulation Centre of the Netherlands	Noël Bovens	Project Manager
	Maritime Simulation Centre of the Netherlands	J.H. de Jong	Training Department
	Seamen's Church Institute	Richard Beadon	Instructor
	Simulation Training and Research (STAR Dania)	Greg Wood	Director
	Simulation Training and Research (STAR Toledo)	Harry Crooks	Director
	Southampton Institute - Warsash Maritime Centre	J.S. Habberly	Head of Simulation
Pilotage Authorities	Laurentian Pilotage Authority	Clément Deschênes	Director of Operations
	Laurentian Pilotage Authority	Jean-Claude Michaud	President
	Pacific Pilotage Authority	Robin Heath	Director of Operations

	Organization	Name	Title
Pilots	Corporation des pilotes du bas Saint-Laurent	Louis Rhéaume	Vice-President
	Corporation des pilotes du bas Saint-Laurent	Paul Yvan Viel	President
	Corporation des pilotes du Saint-Laurent central	Charles Dugall	President
Shipmasters	Algoma Central Marine	Joe Fraser	Captain
	Algoma Central Marine	J. Wilhelm	Captain
	Canada Steamship Lines	Scott Klegg	Captain
	Oceanex	Jean-Marc Belley	Captain
	Oceanex	Richard Belley	Captain
	Oceanex	Georges Côté	Captain
	Upper Lakes Shipping	Ross Armstrong	Captain
Shipowners and representatives	Algoma Central Marine	Jim Pound	Director, Marine Operations
	Association des armateurs du Saint-Laurent	Benoît Massicotte	General Manager
	Canada Steamship Lines	John Pace	V-P, Fleet Management
	Canadian Shipowners Association	Réjean Lanteigne	Manager, Marine Operations
	Groupe Desgagnés inc.	Rosaire Desgagnés	President
	Groupe Océan	Richard Bernier	Vice-President
	Oceanex	Michel Parent	Fleet Superintendent
	Shipping Federation of Canada	Ivan Lantz	Manager of Operations
	Shipping Federation of Canada	Frank Nicol	President
	Shipping Federation of Canada	Sonia Simard	Executive Assistant
	Transport Nanuk	George Tousignant	Director of Operations
	Upper Lakes Shipping	John Greenaway	Director of Operations
Other	Air Canada	Sterling Little	Manager of Flight Training
	Canadian Coast Guard	René Grenier	Commanding Officer
	Canadian Hydrographic Services (DFO)	Steve McPhee	Director-General
	Department of National Defence	Tom Esbaw	Lieutenant Commander
	Geomatics Industry Association of Canada	Ed Kennedy	President
	WTH Systems Inc.	Alain Royal	President

Appendix C

Comparative Analysis Of LPA Syllabus For Licensing With The Ministry Of Transport Certification Syllabus And With Simulated Electronic Navigation Courses Syllabus

Comparative Analysis Of LPA Syllabus For Licensing With The Ministry Of Transport Certification Syllabus And With Simulated Electronic Navigation Courses Syllabus

L.P.A. Nov. 13, 1996 Syllabus **Section 3 (p. 2)**	M.O.T. Reference	Not included in M.O.T. Reference
3.01	EXN1 8.7, p. 37-8	Electronic charts
3.02	EXN1 8.7.1 & .7 & .10, p. 37-8	
3.03	EXN1 8.7.6 & .21, p. 38 / 9.7.9, p. 48	
3.04 a, b, c, d	EXN1 8.7.6 & .22, p.37-8	
3.04 e	EXN1 8.7.13, p. 38. / SEN 1A s.1.4	
3.05	EXN1 8.7.13, p. 38. / SEN 1B s.6	
3.06	EXN1 8.7.7, p. 37-8	
3.07	EXN1 10.8.36 & .37, p. 61 SEN1A 5.5 & 6. SEN2 7.1 & 2,	DGPS? ECDIS? AIS?

L.P.A. Nov. 13, 1996 Syllabus **Section 4 (p. 3)**	M.O.T. Reference	Not included in M.O.T. Reference
4.01	EXN1 8.10.18, p. 43	
4.02	EXN1 9.13.2, p. 52	
4.03	EXN1 9.13.2, p. 52 / 10.16.1&.2&.3&.4, p. 66-7	
4.04	EXN1 9.10.5&.6&.10, p. 50	
4.05	EXN1 8.10.18, p. 43 / 9.10.1&.10, p. 50	
4.06	EXN1 10.16.2, p. 66	
4.07	EXN1 8.10.18, p. 43 / 9.13.2, p. 52 / 10.16.2, p. 66	
4.08 a,b,c,d	EXN1 8.10.8, p. 41 / 9.13.2&.3, p. 52-3/ 10.16.2, p. 66	
4.09	EXN1 8.10.18, p. 43 / 9.10.1, p. 50 / 9.13.2, p. 52 / 10.16.2 p. 66	
4.10	EXN1 8.10.6, p. 41 / 9.13.3, p. 52-3 / 10.16.3, p. 66-7.	
4.11	EXN1 8.10.18, p. 43 / 9.12.6, p. 52 / 9.13.2, p. 52 / 10.15.12, p. 66 / 10.16.2, p. 66 / 11.12.8&.14, p. 74	
4.12	EXN1 9.13.2, p. 52 / 10.16.2, p. 66	
4.13	EXN1 8.10.6, p. 41 / 9.13.3, p. 53 / 10.16.2&.3, p. 66-7	
4.14	EXN1 8.10.5, p. 40 / 9.12.2&.6, p. 51-2 / 10.16.3, p. 66-7 / SEN 1A s.11 / SEN 1B s.3 / SEN 2	
4.15	EXN1 8.10.18, p. 43 / 10.15.10, p. 65 / 11.12.2&.3, p. 73	
4.16	EXN1 8.10.18, p. 43 / 10.15.6, p. 65 / 10.16.2, p. 66	
4.17	EXN1 8.7.6, p. 41 / 9.13.2, p. 52 / 10.16.3, p. 67	

L.P.A. Nov. 13, 1996 Syllabus **Section 5 (p. 5)**	M.O.T. Reference	Not included in M.O.T. Reference
5.01	EXN1 8.9.1, p. 39 / 8.10.21&.22, p. 43	Micro-climates
5.02	EXN1 10.15.5, p. 65	
5.03	EXN1 10.16.4, p. 67	
5.04	EXN1 10.16.4, p. 67	
5.05	EXN1 10.16.4, p. 67	
5.06	EXN1 10.16.4, p. 67	
5.07	EXN1 8.9.2, p. 39 / 10.10.12, p. 62	

L.P.A. Nov. 13, 1996 Syllabus **Section 6 (p. 6)**	M.O.T. Reference	Not included in M.O.T. Reference
6.01	EXN1 10.12.1, p. 63 / 11.10.13, p. 72	
6.02	EXN1 11.10.13, p. 72	
6.03	EXN1 11.10.13, p. 72	
6.04	EXN1 11.10.13, p. 72	
6.05	EXN1 9.8.8, p. 48-9 / 10.12.1, p. 63 / 11.10.9, p. 72	
6.06	EXN1 8.8, p. 38-9 / 10.9.2, p. 61	
6.07	EXN1 8.7.20, p. 38	
6.08	EXN1 10.12.18, p. 63	
6.09	EXN1 8.7.20, p. 38 / 8.9.5, p. 39	
6.10	EXN1 8.7.20, p. 38 / 8.9.5, p. 39	
6.11	EXN1 8.7.20, p. 38 / 8.9.5, p. 39	
6.12	EXN1 10.12.10, p. 63	
6.13	EXN1 11.10.11, p. 72 / SEN 1B, s.7 / SEN 2 s.6.3	
6.14	EXN1 8.10.7, p. 41 / 10.12, p. 63 / 11.14.1, p. 75	
6.15	EXN1 10.16.4, p. 67	

L.P.A. Nov. 13, 1996 Syllabus **Section 3 (p. 12)**	M.O.T. Reference	Not included in M.O.T. Reference
3.01	EXN1 8.7, p. 37-8	Electronic charts
3.02	EXN1 8.7.7&.8, p. 37-8	
3.03	EXN1 8.7.15&.16&.17&.23, p. 38	
3.04	EXN1 8.7.1 & .7 & .10, p. 37-8	
3.05	EXN1 8.7.6 & .21, p. 38 / 9.7.9, p. 48	
3.06 a,b,c,d	EXN1 8.7.6 & .22, p. 37-8	
3.06 e	EXN1 8.7.13, p. 38 / SEN 1A s.1.4	
3.07	EXN1 8.7.13, p. 38 / SEN 1B s.6	
3.08	EXN1 8.7.7, p. 37-8	
3.09	EXN1 10.8.36 & .37, p. 61 SEN1A 5.5 & .6 SEN2 7.1 & .2	DGPS? ECDIS? AIS?

L.P.A. Nov. 13, 1996 Syllabus **Section 4 (p. 14)**	M.O.T. Reference	Not included in M.O.T. Reference
4.01 a,b	EXN1 8.10.18, p. 43	
4.02	EXN1 8.10.18, p. 43 / 10.16.2, p. 66	
4.03	EXN1 8.10.18, p. 43 / 9.13.2, p. 52 / 10.16.2, p. 66	
4.04	EXN1 8.10.18, p. 43 / 10.16.2, p. 66	
4.05	EXN1 9.13.2, p. 52	
4.06	EXN1 9.13.2, p. 52 / 10.16.1&.2&.3&.4, p. 66-7	
4.07	EXN1 9.10.5&.6&.10, p. 50	
4.08	EXN1 8.10.18, p. 43 / 9.10.1&.10, p. 50	
4.09	EXN1 9.10.1, p. 50	
4.10	EXN1 10.16.2, p. 66	
4.11	EXN1 8.10.6, p. 41 / 9.13.3, p. 53	
4.12	EXN1 10.16.1, p. 66 / 11.14.1, p. 75	
4.13	EXN1 8.10.18, p. 43 / 9.13.2, p. 52 / 10.16.2, p. 66	
4.14	EXN1 8.10.18, p. 43 / 9.13.2, p. 52 / 10.16.1, p. 66	
4.15	EXN1 11.14.1, p. 75	
4.16	EXN1 9.12.7, p. 52 / 10.15.12, p. 66 / 11.14.1, p. 75	
4.17 a,b,c,d	EXN1 8.10.8, p. 41 / 9.13.2&.3, p. 52-3 / 10.16.2, p. 66	
4.18	EXN1 8.10.18, p. 43 / 9.10.1, p. 50 / 9.13.2, p. 52 / 10.16.2 p. 66	
4.19	EXN1 8.10.6, p. 41 / 9.13.3, p. 52-3 / 10.16.3, p. 66-7	
4.20	EXN1 8.10.18, p. 43 / 9.12.6, p. 52 / 9.13.2, p. 52 / 10.15.12, p. 66 / 10.16.2, p. 66 / 11.12.8&.14, p. 74	
4.21	EXN1 9.13.2, p. 52 / 10.16.2, p. 66	
4.22	EXN1 8.10.6, p. 41 / 9.13.3, p. 53 / 10.16.2 & .3, p. 66-7	
4.23	EXN1 8.10.5, p. 40 / 9.12.2&.6, p. 51-2 / 10.16.3, p. 66-7 / SEN 1A s.11 / SEN 1B s.3 / SEN2	
4.24	EXN1 8.10.18, p. 43 / 10.15.10, p. 65 / 11.12.2&.3, p. 73	
4.25	EXN1 8.10.18, p. 43 / 10.15.6, p. 65 / 10.16.2, p. 66	
4.26	EXN1 8.7.6, p. 41 / 9.13.2, p. 52 / 10.16.3, p. 67	

L.P.A. Nov. 13, 1996 Syllabus **Section 5 (p. 17)**	M.O.T. Reference	Not included in M.O.T. Reference
5.01	EXN1 8.9.1, p. 39 / 8.10.21&.22, p. 43	Micro-climates
5.02	EXN1 10.15.5, p. 65	
5.03	EXN1 10.16.4, p. 67	
5.04	EXN1 10.16.4, p. 67	
5.05	EXN1 10.16.4, p. 67	
5.06	EXN1 10.16.4, p. 67	
5.07	EXN1 8.9.2, p. 39 / 10.10.12, p. 62	

L.P.A. Nov. 13, 1996 Syllabus **Section 6 (p. 18)**	M.O.T. Reference	Not included in M.O.T. Reference
6.01	EXN1 10.12.1, p. 63 / 11.10.13, p. 72	
6.02	EXN1 11.10.13, p. 72	
6.03	EXN1 11.10.13, p. 72	
6.04	EXN1 11.10.13, p. 72	
6.05	EXN1 9.8.8, p. 48-9 / 10.12.1, p. 63 / 11.10.9, p. 72	
6.06	EXN1 8.8, p. 38-9 / 10.9.2, p. 61	
6.07	EXN1 8.7.20, p. 38	
6.08	EXN1 10.12.18, p. 63	
6.09	EXN1 8.7.20, p. 38 / 8.9.5, p. 39	
6.10	EXN1 8.7.20, p. 38 / 8.9.5, p. 39	
6.11	EXN1 8.7.20, p. 38 / 8.9.5, p. 39	
6.12	EXN1 10.12.10, p. 63	
6.13	EXN1 11.10.11, p. 72 / SEN 1B s.7 / SEN 2 s.6.3	
6.14	EXN1 8.10.7, p. 41 / 10.12, p. 63 / 11.14.1, p. 75	
6.15	EXN1 10.16.4, p. 67	

Appendix D

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Appendix E

Selected Course Outlines For CSA Fleets

(Not available in electronic format/ Non disponible en format électronique)

MarineSafety International

- **CSA Piloting**
- **CSA Shiphandling**
- **CSA Emergency Shiphandling**

Appendix F

MarineSafety International License Upgrade Course

(Not available in electronic format/
Non disponible en format électronique)

Appendix G

MSI Simulator-Based Evaluation Sheets

(Not available in electronic format/ Non disponible en format électronique)

Appendix H

Selected Course Outlines—STAR Center

(Not available in electronic format/ Non disponible en format électronique)

Appendix I

Alternate Training Process

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Alternate Training Process

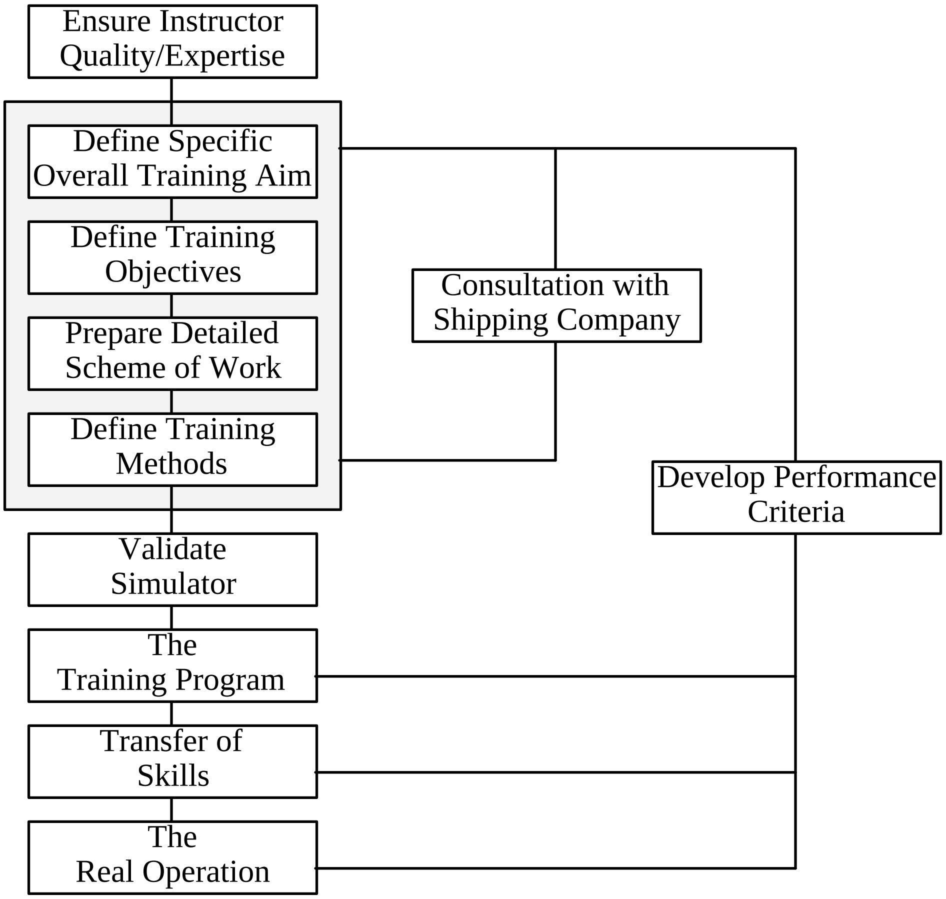
This appendix presents an alternative approach to the training process, as described by the U.S. National Research Council. [1]

Simulation technology is acknowledged by many as an effective means of bridging the gap between knowledge and performance. In this section, we discuss where simulation technology fits into an effective training process.

A simulator does not train mariners on its own; it is the way the simulator is used that yields the required benefit. An effective training program addresses the student's training needs with respect to knowledge, skills, and ability as well as incorporating the principles of effective learning. It applies the appropriate training tool to the specific level of training.

Exhibit I-1 illustrates the elements of the overall training process.

Exhibit I-1
The training process



The training process is an iterative process whereby training managers continually test innovations and improve training methods. It takes an incremental approach that involves altering various elements of the process, assessing the results, and then revising the program as necessary. This yields simulator programs with clearly defined objectives, well designed training and application scenarios, and qualified instructors.

The following steps should be taken to develop an effective training process.

- Determine training needs. This can be accomplished by identifying gaps or missing elements of the trainee's required and actual knowledge, skills, and ability.

- Determine specific training objectives. These objectives identify each attitude, skill, and block of knowledge the trainee should have on successfully completing the course.

- Develop performance measures. These measures determine whether or to what degree trainees have obtained the objectives.

- Determine training methods. This includes the level of simulation required for effective training and the type of simulator to be employed.

- Identify training resource requirements. These should be correlated with the training objectives.

- Develop a detailed course outline. This must meet the course objectives and should match specific instructional techniques to the course content.

- Identify assessment requirements and develop assessment methodologies.

- Establish instructor qualification, selection, training, and certification requirements to ensure quality of instruction and successful curriculum implementation.

- Validate the simulator, the simulation, and the curriculum. This is necessary to ensure continued relevance and suitability.

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[1] *National Research Council, "Simulated Voyages - Using Simulation Technology to Train and Licence Mariners," p. 69, Washington, D.C., 1996.*