iSMART

Progress Report

Development of the National Network for Innovative Shipbuilding, Marine Research and Training - iSMART

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Members of the workshop organizing committee are Dr. Wei Qiu (Chair), Prof. Jon Mikkelsen (Co-Chair), Dr. Neil Pegg, Brian McShane, Dan McGreer, Leonard Pecore and Dr. Roger Basu.

The preliminary report was prepared by Dr. Roger Basu who serves as a consultant of Memorial University and assists the development of the iSMART National Network.

Highlights

- The iSMART National Network is being developed to (1) encourage collaborative and innovative marine research and training among Canadian universities/ colleges, research institutions, government agencies and the private sector that reflects the needs of the Canadian marine community and supports Canadian competitiveness on the global stage, and to (2) provide contractors with potential areas for investment that could generate long-term economic benefits for the broader marine sector in Canada while helping the contractors meet their obligations under the Industrial and Technological Benefits (ITB) Policy.

- This progress report outlines the findings of the initial workshop held at the University of British Columbia (UBC) in Vancouver on July 6, 2016.

- The current state of the marine sector and technological needs were presented at the UBC workshop from the perspective of the three stakeholder groups (government, academia and industry).

- Seven technology themes were identified as important to the marine sector: green ship technologies, marine simulation, advanced shipbuilding technologies, ship design issues (systems design and modeling), arctic technology, cyber security, and automation & control.

- The discussion around education and training at the UBC workshop focused on the incorporating industry experience into the education framework through work terms, internships and mentorship for students and early career professionals.

- The CARIC (Consortium for Aerospace Research and Innovation in Canada) model appears to have many of the features that would be desirable in iSMART and as such has been used as a basis for the development of the proposed model. The progress report highlights the proposed model, including overall goals, membership, governance, administration and financial support.

- The proposed iMSART model and the way forward will be discussed at the workshop to be held at Memorial University on September 26, 2016.

1 Introduction

The subject of this progress report is the development of a National Network for Innovative Shipbuilding, Marine Research and Training (iSMART). A staged approach is being followed to seek the input of stakeholders in a systematic way, i.e., mainly through two full-day workshops. The first workshop was held at University of British Columbia (UBC) in Vancouver on July 6, 2016. The report summarizes the objectives, the proceedings, and the key outcomes of the UBC workshop. A follow-on workshop to build on the accomplishments of the first workshop will be held at Memorial University of Newfoundland (MUN) in St. John's on September 26, 2016.

The motivation, the background, and the approach adopted in the development of the iSMART are also discussed. Based on the outcomes of the UBC workshop, the proposed iSMART network and the next steps to be taken towards the goal of a fully functioning network are presented in the report, which will be further discussed in the MUN workshop.

1.1 Motivation and Background

Canada is a maritime nation surrounded by three oceans. As such the marine sector is particularly important to Canada. This sector comprises several groups of stakeholders. Among the most important are shipbuilding, ship owners and operators, suppliers to the marine industry, engineering companies, government agencies and academia. Examples of sub-sectors of the marine sector include shipbuilding, offshore structures, industrial marine, in-service support, specialization support, marine manufacture/fabrication, and ocean technology.

With the renewal of the Canadian Navy and Coast Guard fleets, expansion of the northern water routes of the Arctic and emphasis on the environment green ship technology, the Canadian marine industry is expanding in many directions. However, at the same time, the sector is fragmented without a common or collaborative direction for the future of the industry as a whole. On the research front, while high quality research is being conducted at academic and research institutions across Canada, the research is primarily conducted in isolation not taking advantage of the great potential for pan-Canadian collaboration.

The motivation for iSMART stems from the belief that the relatively small marine sector in Canada, compared to its global competition, would be stronger for the future with the development of a strategic alliance to improve activities including research and education in Canada.

iSMART is an attempt to provide a framework within which collaborative applied research and development can be conducted with maximum benefit to Canada's marine sector. The collaborative effort through iSMART would position the Canadian marine industry competitively on the global stage. This would be achieved through the facilitation of high quality coordinated research by academia and industry, and the input into value added education and training to produce high quality engineers and naval architects.

The National Shipbuilding Strategy (NSS) is of particular interest in the strategic plan of iSMART because of opportunities for technology development and long-term economic benefits for shipbuilding and the broader marine sector within Canada. iSMART will make a concerted effort to identify project areas that provide opportunities for Canadian industry and academia to participate in the supply chains of multi-national contractors, fulfilling the Industrial and Technological Benefits (ITB) obligations through technology development and highly qualified personnel (HQP) training.

While the focus for iSMART is Canada's marine sector, as it should be, there will be opportunities for Canadian research and development to find an audience in the rest of the world. This can be done on an informal basis and also a more formal basis with collaborations with other countries, or groups of countries.

Similar formalized collaborative ventures have been set up in Canada in other industries and have found considerable success. Collaboration with them and other international networks are another goal of iSMART. In setting up iSMART the lessons learned from these other arrangements will be applied.

1.2 Objectives of iSMART

In summary, the long-term goal of the iSMART National Network is to:

a. Encourage collaborative and innovative marine research among Canadian universities/colleges, research institutions, government agencies and the private sector that reflects the needs of the Canadian marine community and supports Canadian competitiveness on the global stage.
b. To undertake relevant applied research and contribute to the development of innovative technologies.
c. Improve marine-related educational programs to yield highly-qualified graduates for employment in Canadian industry and government.
d. Provide contractors with potential areas for investment that could generate long-term economic benefits for the broader marine sector in Canada while

helping the contractors meet their obligations under the Industrial and Technological Benefits Policy.

1.3 Approach

In the development of iSMART, it was considered important to engage the Canadian marine community, seek their input and gain a level of commitment to iSMART. After discussions with interested parties, the vehicle considered most likely to succeed was by engaging with the Canadian marine community in a workshop setting.

It was decided to hold two workshops for the development of the network. The primary goal in the first workshop was to introduce the concept when most of the audience had few preconceptions about such an initiative. After receiving the first round of input, the proposed iSMART concept would be further refined in terms of identifying the most relevant technology areas and proposing an organization and arrangement that would have the highest chance of success. The focus of the second workshop would be used to refine these two aspects further and lay out a plan for implementation of iSMART.

2 Overview of the UBC Workshop

The first workshop was held at UBC in Vancouver, BC on July 6, 2016 starting at 8 am and concluding at 5 pm. The agenda for the workshop is presented in Appendix A. The second workshop will be held at MUN on September 26, 2016.

A rudimentary concept for the National Network was developed prior to the UBC workshop and presented at the workshop. The overall objective of the one-day workshop was to establish the technology areas that the National Network should focus on and also solicit input on how the network should be organized. The workshop participants were carefully selected to be broadly representative of the Canadian marine community and were drawn, in approximately equal numbers, from industry, academia and government.

In broad terms, the morning session was devoted to providing a context for the discussions and ranged from a general overview of current trends in the world marine industry, how marine technology is developed in different countries, an overview of current capabilities in marine technology of Canadian universities, and finally presentations from industry and government on how the presenters' organizations currently satisfy their research and training needs. They also provided input on how the National Network could be organized.

The afternoon was divided into two sessions. The first half was devoted to identifying which marine research themes were considered most relevant for Canada, and the second half focused on establishing which organizational model would be most suitable for the National Network and also which was the best strategy to adopt for setting up the Network. In each case, breakout sessions were held in which groups of five or six participants brainstormed the issues and then presented their findings to the entire meeting.

2.1 Objectives of the UBC Workshop

The ultimate objective of the two workshops is to develop a strategic plan to guide the group towards the formation of iSMART. The objectives for the UBC workshop were twofold:

1. Identify and prioritize the marine technology areas that should be the focus of iSMART
2. Establish in a preliminary way how iSMART should be organized and what steps need to be followed in implementing iSMART.

The focus of the subsequent MUN workshop will be refine the recommendations of the UBC workshop and to develop an implementation plan.

2.2 Participation at the UBC Workshop

The participants are listed in Appendix B. A significant majority of the participants plan to be present at the MUN workshop providing a great deal of continuity. However, there will be some new participants in the MUN workshop who will provide their perspectives on iSMART.

3 Key Findings From UBC Workshop

This section summarizes the key findings of the UBC workshop based on the recommendations, suggestions and thoughts expressed by the participants of the workshop. No attempt has been made to be comprehensive but to focus on areas where a general consensus emerged in the discussions, principally in the breakout sessions, and the subsequent discussions that occurred in the afternoon sessions. Similarly key thoughts expressed by presenters in the morning session are also summarized.

The primary method for systematically eliciting the opinions of the participants was by posing a series of questions to the participants of the breakout sessions; these questions are reproduced in Appendix C. The questions were presented in forms together with possible answers. The purpose of the latter was to act as a catalyst for the brainstorming sessions. Participants were free to add their own answers to the questions. Using a quantitative scheme, the answers were ranked in terms of their perceived importance. This approach provided a flexible structure for the discussions that followed in the open session when each group presented their recommendations. The results from each breakout session are presented in Appendices D. Please note the responses that are bolded are items that were provided with the forms to each of the teams. All other responses were contributed by the participants.

In Section 3.1 the key thoughts that were gathered during the morning session are summarized. The main results of the breakout sessions are presented in Section 3.2.

3.1 Summary of Morning Session Presentations

The concept of iSMART was introduced. This included an explanation of why iSMART was needed and how the two workshops were going to help in further developing the concept.

An overview of the marine and offshore industries was provided, and the key message was that the marine industry currently faces challenges associated with general low economic growth in the world economy and also low energy prices. However, several other sectors such as the offshore renewable energy, cruise ship and ferry sectors are relatively healthy. Many opportunities exist for performing research of value to the Canadian marine industry and indeed to the world marine industry. Some are associated with regulatory changes while others concern the effort to make the design, construction and operation of ships and offshore installations more efficient.

A presentation was given focusing on relevant lessons for iSMART gathered from around the world. Particularly relevant were countries where the countries concerned were able to build and maintain a significant marine technology sector with world-class marine research, despite a shrinking shipbuilding sector. Similar examples from Canada were also identified. This was followed by several specific examples of initiatives relevant to iSMART. The activities of organizations such as Canada's NRC, C-CORE, and Canadian Academy of Engineering were outlined. The view of Canadians in regard to Canada's place in the marine world was discussed. Examples of initiatives broadly with similar intent of iSMART were presented.

A summary of the capability of Canadian universities in marine technology was presented including undergraduate and graduate training, research programs and the infrastructure available for conducting marine research. This indicates that considerable expertise resides in Canada in this sector although the need for better collaboration between institutions was noted.

This was followed by a series of presentations from the marine community (engineering companies, a Classification Society, and the Canadian Navy) who provided their perspectives. The methods used by the respective organizations to meet their research needs were outlined. More specific topics were also discussed including a recent history of the Canadian Navy and their current challenges in recruiting engineers to meet modern challenges such as cyber safety, and the problems associated with modern shipbuilding processes. Many of the presentations also provided their general view of the kinds of arrangement that perform collaborative research that may serve as models for iSMART. A range of existing initiatives were described including Cooperative Research in Ships (CRS), Ship Structure Committee (SSC), Naval Ship Research Program (NSRP), NSERC National Centres of Excellence, and Joint Industry Projects (JIPs).

3.2 Specific Recommendations Made By Participants

As outlined earlier, the afternoon session of the workshop was devoted to seeking input in two specific areas: 1) which technology areas should iSMART focus on, and 2) how should iSMART be organized to yield maximum research benefit. This input was sought from the workshop via breakout sessions. Worksheets were developed as a means for organizing input from participants. These worksheets and five main questions are presented in Appendix C. The response to each question is presented in five charts in Appendix D. The breakout teams are presented in Appendix E. The key results and conclusions from which are provided below.

3.2.1 Technologies

The first seven technology themes identified in order of importance are (some have equal importance with other themes):

1. Green ship technologies
2. Marine simulation
3. Advanced shipbuilding technologies
4. Ship design issues concerned with systems design and modeling
5. Arctic technology
6. Cyber security
7. Automation and control

The importance of the themes listed above is consistent with the opinions of the broad global marine community. The appearance of Arctic technology is of course a reflection of Canada's major interest in the Arctic.

3.2.2 Education and Training

In order of importance, the following features of education were considered important

1. Greater use of work terms
2. Curriculum improvements
3. Mid-career training
4. Preparing high school students (especially skills in math, physics and science) and middle school awareness/attraction
5. Practical shipyard experience

Several related issues were captured under each of the five items listed above and summarized in the paragraphs below:

The first item, **greater use of work terms,** included interest in fostering apprenticeships, formal internships and schemes for mentoring students and also early career naval architects and engineers.

Curriculum improvements included a number of related issues such as seeking innovations in education and experimenting with the curriculum. Also under this category were subjects such as a call for greater industry involvement, cross school collaboration, and greater emphasis on business aspects of the marine industry such as including subjects like project management in the curriculum.

Mid-career training is considered important particularly in view of rapid developments in many aspects of the marine industry.

An important issue raised was the topic of **preparing high school students** (in STEM subjects). An associated need is raising awareness in even younger students of engineering and naval architecture as a means for attracting more students to the profession.

Practical shipyard experience was mentioned as an important aspect in the education of naval architects and engineers. This could be regarded as a subset of the first item in the list.

3.2.3 Strategy and Roadmap Development

The features considered as key factors in developing a strategy for the implementation of iSMART were listed below in order of importance:

1. Emphasize research needs of Canadian marine industry
2. Form multi-university partnerships in Canada
3. Create/state a clear purpose and terms of reference
4. Technological business opportunities
5. Act as a clearinghouse for current funding sources

The first two items were considered by far the most important. Between them they were awarded more than half the points.

Emphasize research needs of Canadian marine industry - indicates the importance of focusing on the research requirements of Canada before considering other broader markets. Under this heading, the point was also made that the priority should be *applied* research and development.

Form multi-university partnerships in Canada – shows the importance in partnerships in multi-university setting/working closely with industry.

The meeting also considered that organizers should **create/state a clear purpose and terms of reference** for iSMART. This would help focus efforts and provide a direction to the activity needs to set up and implement iSMART.

3.2.4 Models for iSMART

During the morning presentations a number of existing models for collaborative research were described. Among these are the Cooperative Research in Ships, Ship Structure Committee, Naval Ship Research Program, NSERC National Centres of Excellence, and Joint Industry Projects, etc. A key input to this discussion was the recommendation to look into existing Canadian collaborative research arrangements employed in other industries. Principal among those mentioned are CARIC and AUTO21. The latter, while successful, has recently wound up operations.

The CARIC (Consortium for Aerospace Research and Innovation in Canada) model appears to have many of the features that would be desirable in iSMART. It is a

collaborative venture with partners from universities, the aerospace industry and government much like the arrangement envisaged for iSMART.

3.2.5 Next Steps

The final set of questions concerned the issues that should be given priority in initiating the process of setting up iSMART. The actions recommended by the participants in order of priority are:

1. Get buy-in from industry
2. Establish sources of funding
3. Develop membership for the National Network
4. Get buy-in from government

Ninety percent of the points were awarded to the four items listed above.

To **get buy-in from industry** was clearly considered the most important because there is a strong interest in research of most value to industry. Identifying **sources of funds** was considered the next most important. In regard to the third item, **develop membership for the National Network**, is in some senses restating the first objective.

4 Proposed iSMART – An Outline

An important issue discussed at the workshop was how the iSMART Network should be organized. As discussed under Section 3.4.2, the CARIC model seems the most promising. Studies have been carried out on the CARIC model after the UBC workshop.

The overall objectives of CARIC are broadly similar to those of iSMART. The obvious difference is that CARIC and iSMART serve different industries. Clearly, there are significant differences between Canada's aerospace and marine industries, and, as such, it is necessary to take full account of these if CARIC is to be a model for iSMART. The principal difference is sheer size – Canada is ranked third in the world's global civil aircraft production activity, but has a very small presence in world shipbuilding. Partly related to size, the aerospace industry in Canada appears to have well developed active trade associations at both national and provincial levels.

Technology development in the Canadian aerospace sector is older and better developed than in its marine equivalent. While CARIC has only been in operation for little over two years, it has a well-established antecedent in CRIAQ (Consortium de recherche et d'innovation en aérospatiale au Québec) which has a 14-year history. Given the youth of CARIC, it is reasonable to expect further evolution.

It would be desirable to develop the iSMART structure based on successful CARIC experiences. A summary of the CARIC structure is included in Appendix F in terms of its origins, structure and operations. An outline of a proposed structure for iSMART is presented below based loosely on the CARIC model. Note that the proposed iSMART structure will be a focus of discussions at the MUN Workshop.

4.1 A Proposed Model for iSMART

The path the development of iSMART may take is described below.

4.1.1 Overall Goals

An observation made at the UBC Workshop was that a clear purpose for iSMART was required. Tentatively, the following mission is suggested.

> *The purpose of iSMART is to provide a framework within which to conduct collaborative and innovative research, development and education relevant to Canada's marine industry.*

A more formal statement of the above, by drafting Mission and Vision Statements, will be finalized at the MUN workshop.

4.1.2 Membership

The membership will need to be structured taking account of the wide range of organizations that are likely to become members of iSMART. One possible categorization system could be:

1. Shipyards
2. Suppliers to the marine industry
3. Engineering companies (consultants, designers, software companies and similar)
4. Universities and colleges
5. Research organizations
6. Government
7. Associated companies (trade organizations, professional societies, etc.)

It is desirable that a membership fee will not be required to become a member of iSMART. However, this will be discussed at the MUN workshop.

4.1.3 Governance

A Board of Directors, comprising directors representing the key stakeholder groups (industry, academia and government), will provide leadership of iSMART. Other committees, such as Technical Committee and Finance Committee, will be set up when, and if, they are necessary.

General governance aspects will be discussed at the MUN workshop.

4.1.4 Administration

Administrative needs will be modest initially, but will increase as iSMART begins to take shape. The management and administration structure including regional representatives will be discussed at the MUN workshop.

4.1.5 Financial Support

A core budget, roughly $5M/year for six years, will be requested from federal government agencies to support the iSMART network, its activities and projects. Majority of the core budget will be used to leverage industrial support for projects important to the marine industry. Additional funding will be sought to support short-term projects through traditional programs such as NSERC. A plan for securing financial support for iSMART will be another focus of discussion at the MUN workshop.

4.1.6 iSMART Projects

In terms of projects, at least initially a model similar to that used by CARIC can be used but this will likely be modified to reflect the particular needs of the marine industry. It does appear the CARIC practice of categorizing projects by Technology Readiness Level (TRL) (see Appendix F) might be useful for iSMART projects. The principle for project selection and implementation will be discussed at the MUN workshop.

5 The Way Ahead

Based on the material presented in Section 4, the primary objective of the MUN workshop will be to further refine the proposed iSMART model in an effort to establish iSMART as a functioning entity. The second objective is the identification of the immediate steps to start the process of setting up iSMART. This will be the basis of a plan and assignment of roles and responsibilities for those who will implement the plan.

5.1 Proposed Action Plan

In the *immediate short term*, core funding will be sought from government to launch the initiative supporting the operational costs and match funding for research endeavours. A proposal will be prepared within the *next three months* to seek core financial support from the federal government.

Strategies for short, mid and long terms are proposed utilizing traditional funding structures (national and regional funding agencies, large scale funding programs and industry matching contributions).

In the *short term*, iSMART will pursue research projects, led by universities and in collaboration with industry and government agencies, through various NSERC programs, such as NSERC Engage, NSERC CREATE, NSERC Collaborative Research Development (CRD). An NSERC CREATE application on research training/internship, led by universities and in collaboration with interested industrial partners, will be submitted in 2017.

In the *long term*, iSMART will support collaborative projects with its core funding, leveraged funds from industry, NSERC, provincial and regional funding sources.

Appendix A Agenda of UBC Workshop

National Network for Shipbuilding/Marine Research and Training **Strategic Preliminary Meeting** Wednesday July 6, 2016 Location: Robert H Lee Family Boardroom (second floor), Robert H. Lee Alumni Centre 6163 University Boulevard, Vancouver, BC <u>Agenda</u>		
8:00-9:15	Registration Breakfast Meeting • Welcome and roundtable introductions • Overview of two workshops and their objectives • Introduction to the National Network Concept • High-level review of current trends in marine and offshore industries	Led by: Jon Mikkelsen Wei Qiu Roger Basu
9:15-9:45	Technology Development in the Marine and Offshore Industries - Lessons Learned From Around the World	Speaker: Peter Noble
9:45-10:00	Canadian Research Experience and Capacity • Overview of the intellectual and physical research experience • Current capabilities of the proposed collaborating universities	Speaker: Wei Qiu
10:00-10.20	Networking Break	
10:20-11:40	Current Industry and Government Marine Research and Training Needs • Current methods for meeting research and training needs • Present and future technology gaps • Comments on the National Network concept	Speakers: Several *(Several senior representatives from industry and government have agreed to speak)*
11:50-1:05	Lunch with presentation on experience with the US NSRP (National Shipbuilding Research Program)	Speaker: Leonard Pecore
1:15-1:45	Identification of Research & Training Priorities, Challenges and Gaps in the Canadian Marine Industry • Prioritize technology and training that Canada should focus on	- *Working session (5 min overview/30 min breakout group brainstorming)* - *Breakout groups (5 or 6 people/group)*
1:45-3:05	Identification of Research & Training Priorities, Challenges and Gaps in the Canadian Marine Industry • Consolidate input from groups • Summarize overall findings	Group Facilitator - *Presentation by each breakout group* - *Large group facilitated discussion*
3:05-3:25	Networking Break	
3:25-4:00	Strategy and Roadmap Development • Each group to identify the best way to implement the National Network • Recommendations for the next steps	Group Facilitator *Working session (10-minute overview/ 25-minute group)* - Breakout groups (5 or 6 people/group)
4:00-5:00	Strategy and Roadmap Development • Large group facilitated discussion • Refine the proposed follow-up meeting agenda • Assignment of action items	Group Facilitator - *Presentation by each breakout group* - *Large group facilitated discussion*

Appendix B List of Participants (UBC Workshop)

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Appendix C Workshop Breakout Session Questionnaire

Vancouver Workshop- July 6, 2016

Breakout Session (1:15-1:45pm):

Identification of Research & Training Priorities, Challenges and Gaps in the Canadian Marine Industry

The broad objectives of this session are to:

a. Identify the types of research and training that the Network should focus on.
b. Identify training gaps and needs in Canada

1. *Which broad technologies are the most important and which also present the best opportunities for research? Add technologies you consider important. Please distribute 25 points between the listed technologies to indicate priority.*

Technology	**Points**
Advanced Shipbuilding Technologies	
Green Ship Technologies	
Marine Safety	
Marine Simulation	
Ocean Energy	
Automation and Control (unmanned ships, AUV, etc)	
Advanced Materials	

Please bring the completed table to the open discussion following the breakout session. Also note key points made during the breakout session discussions.

2. *What can be done to improve the education and training of naval architects and engineers in Canada? Add items you consider important. Please distribute 25 points.*

Proposals	**Points**
Formal internships	
Greater use of work terms	
Early career training	
Mid-career training	
Curriculum improvements	

Note key points made during the discussion.

Breakout Session (3:25-4:00pm):

Strategy & Roadmap Development

The objectives of this session are to

a. Identify the National Network organization that is most likely to deliver the desired outcomes in regard to marine research and training
b. Outline the necessary steps that need to be taken to attain the previous objective

1. *What features in an overall strategy are desirable in meeting the goals of the National Network? Please add to the list of Strategic Approaches. Distribute 25 points between the different approaches according to priority.*

Strategic Approaches	**Point**
Focus on needs of Canadian shipbuilding	
Form multi-university partnerships in Canada	
Form multi-university partnerships internationally	
Emphasize research needs of Canadian industry	
Set priorities based on international technology priorities	

2. *What models for the National Network would work best in your opinion? Propose an entirely new model as necessary. Please distribute 25 points between the models to indicate priority.*

National Network	**Proposed Modification**	**Point**
JIPs		
CRS		
SSC		
Proposed NN model		
Modified CRS		
Modified SSC		
Modified NN Model		

3. *What are the most important next steps in setting up the National Network. Propose other steps you consider important. Please distribute 25 points between the steps to indicate priority.*

Next Steps	**Points**
Get buy-in from industry	
Get buy-in from academia	
Get buy-in from government	
Establish sources of funding	
Develop membership for the National Network	

Appendix D Breakout Session Worksheets

The spreadsheets presented in the following pages correspond to the questions shown in the questionnaires in Appendix B.

There are two questions under the heading “Identification of Research & Training Priorities, Challenges and Gaps in the Canadian Marine Industry” and three questions under the heading “Strategy & Roadmap Development”

The five spreadsheets summarize the response from the five breakout groups. The results have been added and the items prioritized. In several instances the breakout groups have identified issues that were not prepopulated in the spreadsheets.

Technology	Group 1	Group 2	Group 3	Group 4	Group 5 (Cdn)	Group 5 (global)	Group 5 Average	Total	Ranking
Green Ship Technologies (noise pollution, energy storage (batteries, LNG and electic hybridization)		3	9	3	2	5	3.5	18.5	1
Marine Simulation (numerical modeling/validation)		3	4	4	5	5	5	16	2
Advanced Shipbuilding Technologies		3	5	2	7	1	4	14	3
Overall design process/ integrated ship/ efficiency/systems modeling/ship systems design integration*	4	1		4	5	5	5	14	3
Arctic technology/ modeling / arctic ship engineering		4	4	4				12	4
Cyber security/ shipboard/Infrastructure (ship/shore interface)	11	1						12	4
Automation and Control (unmanned ships, AUV, etc) drones		2	3	1	2	5	3.5	9.5	5
Ocean Energy	4			2	1	1	1	7	6
Ship maintenance/In-service Support**	6	1						7	6
Marine Safety		3		1	2	2	2	6	7
Asset integrity management/Ship Data model management		2		3				5	8
Advanced Materials				1	1	1	1	2	9
Regulatory challenges		2						2	9
	25	25	25	25	25	25	25	125	

** These were grouped together - they have a common theme around improvements in the design process including technological advancements

* The notes indicate that the reference here is to ship maintenance at sea - reduce need to go to drydock

Education and Training	Group 1	Group 2	Group 3	Group 4	Group 5	Total	Ranking
Greater use of workterms/apprenticeship/formal internships/mentoring/ apprenticeship	7	15		6.25	7	35.25	1
Curriculum improvements/ innovations/experimentation/ modernization/industry involvement/foundations/ electrical/project management/cross school collaboration/ improved coordination		6	13	6.25	6	31.25	2
Mid-career training/ mastery/ advanced degrees (Research education)	8		10	6.25	1	25.25	3
Prepare highschool students (math physics science)/ middleschool awareness/attraction	10	2		6.25		18.25	4
Practical shipyard experience*					10	10	5
National conference/ workshops (professional development)**		2	2			4	6
Early Career training					1	1	7
	25	25	25	25	25	125	

* this could this fit with "Greater Use of Workterms" with specific exposure to shipyard during workterm/ internship experience
** This could fit with mid-career training. The idea of national conference/ yearly workshop received a very good response from the overall group during the discussion although breakout groups may not have specifically identified it.

Strategy & Roadmap Development	Group 1	Group 2	Group 3	Group 4	Group 5	Total	Ranking
Emphasize research needs of Canadian marine **industry**/Focus on needs of Canadian marine industry/Broaden the scope/ Canadian marine industry and research/Applied research and development	9	10	8	5	8	40	
Form multi-university partnerships in Canada/ partnerships with industry / establish all three sectors / multi sector partnership/	8	2	8	5	9	32	
Form multi-university partnerships internationally		1	4			5	
Set priotities based on international technology priorities		1				1	
Focus on needs of Canadian shipbuilding*							
*Create/state a clear purpose and terms of reference***		9				9	
*Technological business opportunities***	8					8	
*Act as a clearinghouse for current funding sources***					8	8	
*Identify and coordinate regional groups***			5			5	
*Understanding IP rights/control***				5		5	
*Centre of expertise - known internationally***		2				2	
*Recognition of potential international markets***				10		10	
	25	25	25	25	25	125	

* Shipbuilding was deemed too narrow and replaced with "marine" - this was a consistent message

** These responses do not clearly fit into combined/suggested categories. More suitably classified as action items but do raise some key points. To be addressed in the development of the network scope and terms of reference.

Clear identification of what the marine industry is - clear identification of the network boundaries

National Network Models	Proposed Modification	Group 1	Group 2	Group 3	Group 4	Group 5	Total	Ranking
Modified NN Model		25			25	25	75	
JIPs			8				8	
Modified SSC			8				8	
Modified JIP (include public sector)			5				5	
NSRP			2				2	
SSC			1				1	
Modified CRS			1				1	
CRS							0	
Proposed NN model							0	
CRIAQ				*			0	
Centre of Excellence				*			0	

Models noted in discussion and brakout groips: CRIAQ, CARIC, AUTO 21, APC, NSRP, Centres of Excellence
CARIC model raised indepentently by a few groups
Need a clear purpose/ set priorities
PPP rather than University centric (Group 1)

Next Steps	Group 1	Group 2	Group 3	Group 4	Group 5	Total	Ranking
Get buy-in from industry	13	5	12	10		40	1
Establish sources of funding/ clearinghouse/ Establish sources of short term funding	4	4	8	5	15	36	2
Develop membership for the National Network (assumes buy-in from industry/academia/government)		4		5	10	19	3
Get buy-in from government	8	3		5		16	4
Define the purpose/ terms of reference*		7				7	6
Model development (i.e., Auto 21)			5			5	7
Get buy-in from academia		2				2	8
	25	25	25	25	25	125	

* Raised in the strategy and roadmap development as a key point

Appendix E Breakout Teams

Team	1	2	3	4	5
Leader	David Benoit	Leonard Pecore	Jon Mikkelsen	Peter Noble	Darren Larkins
Member	James Bond	Joe Rousseau	Paul R. McClelland	Luis Aguiar	Mike Fitzpatrick
Member	Brad Buckham	Claude Daley	Zuomin Dong	Andrew Gerber	Jason Gu
Member	Derek Davis	Catherine Dutton	Jeff Rafuse	Jerome Rodriquez	Chris Kesson
Member	Bill Jackson	Neill Pegg	Dan McGreer	Richard Greenwood	Richelle Boit
Member	Randall McGregor	Charlie Nisbet	Jon Vieth	Lawrence Mak	Rick Warner
Member			Sherry Scully		

Appendix F Overview of CARIC

CARIC (Consortium for Aerospace Research and Innovation in Canada) is relatively new and started operation in April 2014. It was a joint initiative of the Consortium for Research and Innovation in Aerospace in Québec (CRIAQ) and the Aerospace Industries Association of Canada (AIAC). CARIC is modeled on CRIAQ which was founded in 2002. CARIC is intended to be a national organization whereas CRIAQ is a provincial organization. CRIAQ's partner in the CARIQ initiative is AIAC, a very active trade organization representing the Canadian aerospace industry.

The key features of the organizational and operational structure of CARIC are summarized below in terms of:

1. Overall goals
2. Membership
3. Governance
4. Administration
5. Finances
6. Initiation and execution of projects

Each aspect listed above list is briefly described below:

F.1 Overall goals

As stated on the CARIC website the mission, vision and values of the organization are as follows:

Mission

- Generate and foster dialogue and collaboration between players in the aerospace industry.
- Provide financial support to launch R&D projects in partnership with these players.

Vision

Strategic, financial and administrative support encourages the industry and research community to work together to achieve excellence and compete on a global scale.

CARIC, provincial associations and member need to collaborate to give the aerospace industry a regional reputation, a strong Canada-wide presence and international market prominence.

Values

CARIC has chosen to focus its governance, growth and funded projects on the following six values:

- Collaboration
- Innovation
- Creativity
- Credibility
- Agility
- Result-oriented

F.2 Membership

The membership of CARIC is divided into a number of categories:

Original Equipment Manufacturers (OEMs)

These are major players and are in most cases exclusively in the aerospace business. There are four companies under this category: Bell Helicopter, Bombardier, CAE and Pratt & Whitney Canada.

Intermediate Companies

A mix of large companies in which aerospace is just part of their business activity, and smaller organizations where aerospace is their primary business

Small and Medium Enterprises (SMEs)

A range of smaller companies mostly service providers to aerospace. Currently there are 58 members under this category.

Universities & Colleges

Virtually all Canadian universities and colleges with aerospace or allied programs are members.

Research Organizations

Mostly government research agencies and quasi-government organizations

Associated Members

Mostly industry trade organizations

F.3 Governance

The highest governing body of CARIC is the Board of Directors drawn from the membership. The senior-most positions are the President, the Vice-Chair Industry and a Vice-Chair University. There are several other committees:

- Executive Committee
- Scientific Committee

- Finance Committee
- Code of Conduct Committee
- Conflicts of Interest Policy Committee.

F.4 Administration

A President/CEO supported by a Vice-President, four Regional Directors and two other Directors heads the management team of CARIC. There are six administrative staff who look after, among things, finances, projects and communications.

F.5 Finances

In regard to finance the initial operating budget for CARIC was reported to be $3.75 million per year. Once fully operational it was anticipated that the budget for collaborative research projects could reach more than $20 million per year.

F.6 Initiation and execution of projects

The initiation and execution of projects appears to follow standard practice for typical research and technology development projects. A key concept employed in evaluating and financing CARIC projects is the maturity of the technology that is being developed in the project concerned. The maturity level is often expressed in terms of the so-called Technology Readiness Level (TRL)[1].

CARIC appears to divide projects in two categories – low TRL and medium TRL projects. Funding arrangements differ as do project approval procedures.

[1] A TRL score is used to represent the level of maturity of a particular technology development. There are several scales for assigning maturity but a common one ranges from "0" to "9", the first representing technology development at the earliest stages. At the other end of the scale a score of "9" represents technologies that are ready for incorporation in production.