Research and Technology Transfer at the Marine Institute, Memorial University of Newfoundland

By

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EXECUTIVE SUMMARY

What We Heard on the Major Research Questions

Question 1: How does the research and development programme at the Fisheries and Marine Institute compare with that of C-CORE along the TRL Scale for knowledge creation and technology transfer including the ability of MI's R&D activities to meet the identified needs of business?

Technology trajectories: at least to date, MI has a circulatory economy view of technology "TRL 4 to 6 and Back Again" as illustrated for instance in the physical presence and profile of the simulator technology. C-CORE by contrast is a research only entity and its TRL distribution reflects that. MI has a different pattern somewhat more self-limiting but also with more potential, particularly within SMEs. MI has a cogent view of technology transfer, it is internally consistent and reinforces its role in industrial training but compared to C-CORE it is not primarily designed to get technologies out into the commercial market place as innovation studies and public policy expect. It is more focused on having an impact of standard and regulation setting such Transport Canada, the IMO or the calibration of sustainable fisheries models for regulators.

Question 2: How do the company profiles of industrial partners of MI compare to that of C-CORE partners indicating relevant R&D activities and focus in the company profiles?

A re-current theme in the C-CORE firm interviews was the entrenched level of suspicion and hostility to the Memorial academic culture as embodied in the University's traditional IP policy which is focused on extraction of economic rents. The MI environment, relationship and culture are different. There are some non-disclosure issues from time to time in MI's applied research but in general IP issues are not an active issue. MI also has the advantage, because of its history and the DNA of its culture, of a much more relational than transactional approach to working with its industrial partners.

Question 3: How do the on-going curriculum and training programmes at MI contribute to Learning by Doing as a critical contribution to the dynamics of Innovation in Newfoundland and Labrador including how the value of R&D is represented in the contribution to innovation?

There are two issues identified in the recent innovation literature that fall in the Marine Institute's favour, as compared to traditional university institutions. First, as stated in the Introduction, in addition to the established channels of University Knowledge Transfer, namely Teaching and Scientific Research, recent attention has been identified to Interactive Knowledge transfer. This is obvious in the MI case, but less so in most universities. It also takes place outside of the formal IP policy. Second, the long-range impact of new inventions and processes is less from the discovery stage and more from Learning by Doing. This puts MI's curriculum delivery and industrial training efforts at a critical place in Memorial's contribution to the NL innovation ecosystem. There is much more that can be explored in this area for better outcomes for the NL economy.

Understanding the Marine Institute and Innovation

The Marine Institute is a significant player and major contributor to the Innovation Eco-System of Newfoundland and Labrador. Much of its contribution is somewhat below the radar screen of many observers and tends to be a more interactive form of knowledge creation than the typical discovery science activities of Memorial University. Many of its applied research projects are not things we first think of in the world of engineering and technology activities.

MI is part of an innovation ecosystem. The Flume Tank of MI's CSAR is what economists call a shared Public Good assisting local and international business. Their research priorities are: fishing gear design and testing; fish

development and the hydrodynamic testing of marine structures (non-fishing gear) such as turbines and structures used in exploration, development and production of oil and gas.

Interacting with Local Industry

MI has a more interactive relationship with local industry, not simply projects with beginnings, middle and ends. This set of relationships is vital to MI's finances but also a different way of linking academia and industry, particularly small businesses. The fishing industry is the largest client group but innovation here is most often diffused by word of mouth. The best way is to do research is on industry vessels. Fishermen are mostly in small communities in the under-65-foot fleet—there are 10,000 in the industry and they talk. MI researchers will design and test a new widget and then they go out on a boat and test it and the fisherman will talk and that is how industry gets the word out. MI uses tweets and Facebook.

MI also works directly with in-house company innovations. For example, large fish company has developed a patented system for the yellow tail fishery. It provides data right from ocean to the head office to allow them to make better estimates of the optimal time, temperature, where the fish are and better fishing plans in what parts of the Banks and at what time of year and the temperature at the time. There is a lot of involvement with MI during the capture and analysis of data tracking.

A fishing company years ago would just be looking at gear but now they are more into electronics on the nets and the collection and analysis of data. It has more to do with technology than just fishing. The Flume tank has had a huge influence on that development. Fish companies always test equipment and their theories there. Modern fish companies still typically contract out the science but have an internal department with engineers who are constantly refining their processes for onloading, offloading, cold storage, fuel consumption, anywhere they can shave off costs that are a potential benefit because of the narrow margins.

Companies say that partnering with MI is easier because they don't have IP issues as on the main campus.

MI also has non-commercial partners such as foundations in scientific research support, for training and for data collection to support initiatives in value-added and sustainable fishing. Here, the knowledge transfer is in both directions. Development of cod-potting in Fogo Island is an example. The Foundation was aware of experimentation using cod pots in Alaska that was consistent with their ocean ethics document and identified the first person to start using a pot on Fogo Island. Eventually pricing and distribution were worked out and the Foundation went on to try and develop single line fishing with markets in St. John's and Toronto for as much of this frozen fish as they can provide. The Foundation is now addressing getting rid of gill netting. The Foundation has other activities with Memorial but views MI as the key institution in that revival and renewal of the fishery

This case is of great interest to innovation researchers because it is an example of the contribution civil society actors can make to the innovation ecosystem.

Much can be learned from the new generation of fish companies locally and internationally striving for better harvesting techniques to add value to the product, to reduce wastage and to mechanize the processes that today are performed manually.

MI and Advanced Technology

MI has a cogent view of technology transfer, it is internally consistent and reinforces its role in industrial training but compared to C-CORE it is not primarily designed to get technologies out into the commercial market place as innovation studies and public policy expect. It is more focused on having an impact of standard and regulation setting such as Transport Canada, the IMO or the calibration of sustainable fisheries models for regulators.

MI also has a high and wide reputation for its work with Simulators for Marine Operations. Unfortunately, much of the simulator development has been built on tragedy.

Two major technologies steps flowed from the Ocean Ranger tragedy: the Ballast Control Simulator and the Bridge Simulator. There are in fact 24 simulators for different types of vessels, ports and environments. They use the simulators to test the limits of the technology. In oil and gas, it is the operating environment. They may contribute to modification of the technology. They are also used by equipment vendors to test new prototypes.

The technical expertise supporting the simulation centre are twofold: Naval architecture, particularly the hydro-dynamics properties of vessels. And, software coders both software engineers from the University and coders from local colleges.

MI's unique advantage for the future is in dynamic positioning in ice, developing prototypes of dynamic positioning systems to counter active ice loading. The objective in this area is to build a closed loop control system for the offshore, adapting for supply ships in fixed positions. It is a persistent problem in the offshore for supply ships working close in to drilling platforms.

The future ice issue will be how to moor a drill ship in the Arctic where there is shallow water and many ice flows. Deep drilling has limits of the margin of sway for the drilling pipe. Beaufort Sea operations require modification from deep water drilling.

Skills, Learning and Innovation

Economists of innovation attribute about 15% of the final efficiency or productivity impact of an innovation to the invention or discover science stage and 85% to the learning by doing that occurs through the diffusion and adoption of the innovation. MI's on-going role in education and training positions to uniquely contribute to this longer-range impact perhaps more than other academically oriented centres.

The Marine Institute has a long and deep contribution to training that underpins the technology developments that capture attention in the news media. "The important ingredient is that they can predict and prepare for the skills that will be needed in the medium and longer term for the four industrial units, OSSC, CSAR CMS, and SOT." This was a strong theme in most interviews with firms.

What Can Memorial Learn from MI?

MI is a part of Memorial and falls under its University governance. However, it is its own space. And, interviews suggest, it's contribution has not always been sufficiently appreciated. Part of this is the modern academic pecking order where research has become more highly ranked than teaching. Further, data provided to the authors suggests that if MI's industrial training activity was included for purposes of the Memorial FTE budget, MI is second only to the Medical School in term of total enrolment.

1. The Marine Institute and Knowledge Creation at Memorial

MI shares the same institutional space and uniqueness as other quasi-independent institutes within Memorial such as C-CORE. However, it has another unique feature. It started as a College and still delivers significant curriculum. For that reason, it has a more direct connection to Learning by Doing. This is critical because in innovation economics, about 15% of the net productivity or efficiency gains comes from invention, 85% comes from Learning by Doing. Much of the hype about Canada's "research intensive" universities focus on Primary Research. This is at most 15% of the pie. The major economic innovation contribution is in Learning by Doing. This may also make MI more like Engineering, which shares the same tacit knowledge orientation, rather than the Science side of the University. This distinction is important as strategic decisions are made over the next few years about expanding the research activities at MI.

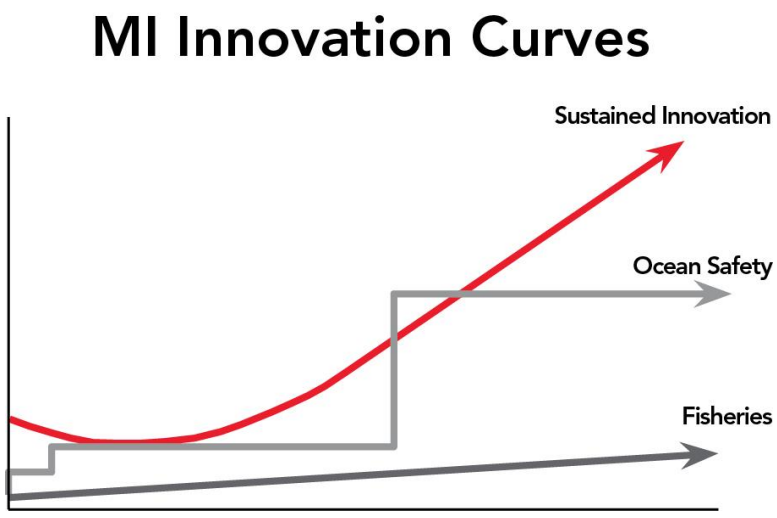
The Marine Institute probably is the closest fit with the academic studies for a functioning networked industrial policy agent. The established Tri-Council discovery research approach is not an easy fit with this role.

2. Technology Trajectories

MUN has recently completed a major effort at profiling its overall institutional capabilities to innovation in NL. In this and the previous study of C-CORE, the authors have applied the Technology Readiness Levels scales (TRLs) to give a more fine-grained and comparative frame for understanding the many moving parts in the system. Understanding technology trajectories is important to understanding where a technology and educational institution is going and where it may go in the future

As previously described, C-CORE is faced with managing multiple business units with different TRL trajectories. As described below, at least to date, MI has a circulatory economy view of technology which we have dubbed "4 to 6 and Back Again".

In the previous study, C-CORE is identified as a research only entity and its TRL distribution reflects that. MI has a different pattern somewhat more self-limiting but also with more potential, particularly within SMEs.



Step Functions: Ocean Safety: In this area, technology and innovation follow a step function driven by disasters. There is not an independent innovation curve.

Incremental Innovation: Fisheries: Traditionally the fisheries have followed a low, incremental process of innovation.

A Sustainable Innovation Curve? However, there is a new generation of fish companies which suggest that a new innovation curve is possible. Private investment is being made into a new Sustainable Fisheries Research Chair. And, linking research and curriculum, for market access it is the important to get certification for policy objectives as well as market success. The industry partners for MI to get to a more sustainable curve probably lies with new sustainable fisheries companies and supply chain companies for the Offshore.

3. SME's and Shared Public Goods

In the public policy literature, the 'new' industrial policy focus stresses the importance of building the industrial commons of local innovations system with particular emphasis on the contribution of colleges and public research infrastructure in boosting the innovation performance of SME firms through access to shared public goods (equipment, labs, specialized knowledge pools).

The two Flume Tank cases referenced above are examples where access to Shared Public goods directly assists SME innovations in the fisheries and local technology supply chains.

However, more than just the technology, MI has by tradition and necessity, developed a broader and deeper relationship with local industry in NL, particularly with SME firms. Universities in general, have demonstrated a poor record to interaction and relationships with other than a small band of technically-specialized SME firms. Memorial has important things it can learn from MI about effectively developing and sustaining an University-SME network.

Strategic Choices for the Marine Institute

The Marine Institute has critical strategic choices and decisions to make soon. A somewhat provocative formulation of the question is: *Who does MI Want to be: A Research College or Memorial-Lite?*

As a useful comparison, C-CORE is a highly focused scientific research institution versus MI being traditionally anchored in industrial training. In terms of the academic literature, it is a difference of codified versus tacit knowledge. In this respect, MI is more 'like' Engineering: Learning by Doing than a Memorial Faculty of Science focused on Tri-Council discovery research grants.

"The College" has a lot of nostalgia in it. Everyone places importance on the unique character of its linkage to Industry. Even before Memorial became a research-intensive university, the Cod College was active on the R&D side of the electronics of the fishery.

The culture of MI is dominated by the imperative of Cost Recovery. The Administration always talks about starting the year $29M in deficit that it needs to make up and this drives much of its applied research activity. However, for an external observer, the same issue is faced by heads of other Memorial units who are expected to match their salary bases with grants and other revenue. In fact, most of the budget shortfall is made up by MI's industrial training side, not the research side. This reinforces the earlier point that the uniqueness of MI is that because of its industrial training side, it needs and manages long term interactive relationships with industry, including SMEs.

As MI moves toward a more research-orientation, the interviews showed that there is tension over transition to a more research oriented MI. There is a fundamental culture issue but also HR, compensation and work load issues.

As stated previously, MI is a hybrid, a college within a university. It could also be a polytechnic. However, either way, it faces problems in competing within the Tri-Council funding regime and is disadvantaged if not discriminated against. Even where it has clearance for new research chairs, the perfect fit of a candidate for MI and the Industry may not meet the traditional metrics like peer reviewed publications, etc. On the other hand, the college specific funding of NSERC, CCIP disqualifies MI because it comes under University governance.

Cost Recovery, the overwhelming imperative at MI, can be overdone and impede the innovation process within SME firms. They can lose focus on how to grow the pie. Generally, SMEs are individual technology focused. MNCs have a better sense of systemic innovation.

The School of Fisheries comes closest to a science-based Memorial-Lite model. MI needs to do both. A combination of the two approaches probably has the closest fit with the Fogo cod pot example.

Recommendations

We recommend that the Marine Institute undertake a systematic re-examination and reorganization of the current role of its research office. Several of the research offices with which we are familiar at larger universities have a dual administrative structure that includes provision of support for obtaining external research funding in one administrative unit and managing commercialization activities, such as negotiating contracts with external corporate funders, licensing intellectual property from the institution and supporting

start-up firms in a second administrative unit. We recognize that the Marine Institute is in somewhat of a unique position in that it technically falls under the jurisdiction of the Memorial research office for purposes of external research funding and of the Genesis Centre incubator. However, we believe that because of the unique nature of the Marine Institute it warrants having its own research office that could work collaboratively with the larger office at the University, but provide more direct supports to the researchers at the Institute. For this research office to function effectively, it would have to have its own strong Associate Vice-President for research based at the Institute. Having an expanded research office would also allow the Institute to provide more effective support to its members who are engaged in collaborative research activities or tech transfer activities with private sector firms in Newfoundland and Labrador. An expanded research office with a dual administrative structure would also be able to link more effectively into the ongoing support activities of the Genesis Centre, though this would require a change of mandate. An expanded research office based at the Institute would also be able to take on the task of better promoting the respective areas of expertise found at the Institute to existing and potential industry partners.

One of the initial tasks of this office could be to commence the negotiation process to resolve the ambiguities around the Institute's status as part research university and part community college. The critical issue that the Marine Institute needs to resolve is the question of its standing as either part of an accredited research institution namely the Memorial University of Newfoundland or as a recognized community college that is eligible for funding under NSERC's community college innovation program. As we have indicated at several points in the report, the fact that MI is considered as neither completely one or the other puts the institution in a tenuous Catch-22 position. Our first recommendation would be to undertake or to launch some kind a tripartite negotiation involving Memorial, the provincial government, and NSERC over how to resolve the Institute's eligibility for different kinds of research and commercialization funding programs. We believe that gaining recognition for the Institute as somewhat of a unique kind of hybrid institution somewhere between the existing Polytechnic model and the community college one would go a long way towards resolving some of the tensions and issues that came up at various points throughout our interview process.

From the interviews that we have conducted, it is also evident that there is a potential role for the Marine Institute to play in promoting more effective forms of networking and clustering among its existing and potential partners. In the extensive research that we have conducted on the nature of cluster organizations across Canada over the past 20 years, one of the consistent features that we have found is the potential role for innovation intermediaries to play in building networking linkages among firms based in specific industrial sectors within a geographical area. There are numerous instances of where innovation intermediaries have found it more efficient and more effective to fulfil their mandates by working with a collectivity of firms in the regional economy through some form of cluster organization. In some of the cases that we have studied these cluster organizations have already been in existence, but in other instances is the innovation intermediary itself which has played a critical role in bringing the firms together to create a cluster organization. The evidence from the interviews as presented in this report suggests that at least some of the partners of the MI view it as having the potential to play a more significant role in creating different forms of networking and linkages among its various partners. We believe this type of activity if successful would both raise the profile of the Institute among the broader community and serve to enhance its existing ties to its industry partners.

One other area that merits greater attention by the Marine Institute lies on the teaching side of its mandate. Several the interviews that we conducted drew attention to the need for more expanded and up-to-date work by the Institute on some of its teaching programs. We believe there is an enhanced role for the Institute to play in working with industry associations in the province to update and expand some of its existing curricular offerings. There might also be a potential opportunity for the Institute to create more co-op or experiential learning programs as part of its overall curriculum. In the research that we have conducted on co-op programs at other postsecondary teaching institutions, they have been found to be an effective mechanism for not only providing the students with hands-on learning experience, but they often constitute an indirect form of tech transfer between the teaching institution and its industry partners. The students on co-

op placement can provide an indirect but highly efficient means for linking the firm at which they are on placement with potential technical and research expertise at the Institute in the form of various professors that they have studied with. This side effect of co-op programs represents a form of reverse tech transfer in which the co-op students serve as a type of demand pull mechanism for linking potential research or technical needs of the firms back into the existing capabilities of the institution. While cooperative education programs are both time-consuming and expensive to implement and administer, their proven track record in enhancing linkages between postsecondary institutions and their industry partners suggests that this is well worth the investment in time and dollars.

INTRODUCTION & PURPOSE OF THIS REPORT

Background of the Marine Institute

Previous research by the authors on C-CORE focused on the unique features of the Newfoundland and Labrador economy, its institutions and the dense network of local relationships that comprise the NL innovation ecosystem.[1] A full appreciation of this dense network of local relationships is critical due to the social nature of the innovation process itself. It is also critical to understand the context and contribution of academic institutions and the research infrastructure of the Province in its relationship to the knowledge-based economy and the resilience of its traditional resource-based economy.

The previous report identified the Marine Institute as probably the closest fit with academic studies of a functioning networked industrial policy agent. By having a diverse set of independently operating entities, Memorial University is able to connect and leverage the research strengths of the university with the real world needs of industry and other end users. And it was the uniqueness of C-CORE as a university–industry bridging organization that piqued the interest of the authors, Peter Warrian and David Wolfe from the University of Toronto's Innovation Policy Lab.

We contextualized the work of Memorial's applied research efforts in the framework of NASA's Technology Readiness Levels (TRLs), which is the state-of-the-art concept in innovation policy theory. Increasingly, policy-makers in the US and Canada have been using the conceptual framework of technology readiness levels (TRLs) to allocate funds to projects in the later stages of the development process (Levels 3-7).[2] Originally developed in the 1970s and widely disseminated throughout the space sector, the TRL approach is used to provide a common framework for sharing reliable measures of a new technology's degree of maturity among technology researchers and program executives working on technology development initiatives. A set of definitions for the seven TRL's currently used by a federal program initiative is provided in Appendix 1.

Applying this framework, we found the gap traditionally left in the TRL scale that usually exists between universities—which tend to operate within TRLs 1-3: basic discovery, conceptualization, and proof of concept—and industries, which tend to the other end of the spectrum from demonstration to marketing. MI has program areas and expertise that generally range from TRL 4 to 6. C-CORE activities range from TRL 3 to TRL 9. Both MI and C-CORE play important but very different roles in filling gaps in the NL innovation ecosystem.

This gap—or the "valley of death" in the language of innovation policy theory—where public-funded ideas fail to make the transition to private-funded solutions —is often the site where many start-up firms or emergent technologies flounder and fail. Bridging this gap and supporting the successful transition from research to technology commercialization has long been a problem that both government and industry have tried to overcome. In many ways, the Marine Institute represents a working example of an effective innovation intermediary that we have analyzed in a previous report for one of the Ontario research and innovation centres. From this perspective, MI represents an innovative approach to the public–private collaborations championed by governments, past and present, through initiatives such as *Innovation Canada: A Call to Action* and the federal government's emerging *Innovation Agenda*.

Growing recognition of the gaps in institutions that promote the transfer of research and technical skills to the manufacturing economy has led to a greater awareness of the role that *innovation intermediary organizations* play in driving the innovation process (Bramwell, Hepburn and Wolfe 2012). Dalziel (2010)

1 Warrian, P. and Wolfe, D. (2016) C-CORE as a Networked Industrial Policy Initiative

2 Officials and entrepreneurs who use the framework have identified the transition to the use of prototypes in a simulated environment (Level 6) to the verification of prototypes in an operational environment (Level 7) as the key challenge in upgrading firm innovation capabilities.

defines innovation intermediaries as organizations or groups within organizations that support innovation, either directly by enabling the innovativeness of one or more firms, or indirectly by enhancing national, regional, or sectoral innovative capacity. Examples of innovation intermediaries include science, technology and business parks and incubators; industry associations; trade associations; research and technology development institutes; economic development agencies; chambers of commerce; research consortia; and international standards organizations (Dalziel and Parjanen, 2012; Dalziel, 2010). Despite their diversity, these organizations perform three core roles to enable innovation: 1) funding support, 2) networking; and 3) collaboration. They also contribute more general supportive functions that include encouraging technology transfer and innovation diffusion, promoting technology exploitation, providing business intelligence, and facilitating innovation management (Dalziel and Parjanen, 2012; Howell, 2006). Overall, these "bridge builders" play a key role in enhancing the innovative capacity of their jurisdictions, building trust between research and innovation actors (OECD, 2013; Dalziel and Parjanen, 2012).

Innovation intermediaries of the kind described above are becoming a critical component of the innovation system landscape, both in Canada and abroad, whether they operate as affiliated parts of a set of research institutions or as standalone organizations. While the main research role of universities has traditionally been seen as the conduct of basic research, they have come under increasing pressure in recent years to expand this role. MI in the local economy is a major opportunity for Memorial to develop this expanded role. A more comparative and historical perspective suggests that the role of the universities has never been limited to the performance of basic research. The changes that have impacted on the university system in recent decades are part of the broader trends in the shifting locations for the performance of basic and applied R&D. At issue is the changing nature of the relationship between the universities and the broader innovation system in which they are embedded, as well as the process of scientific investigation and discovery that underlies the knowledge production function (Gibbons, Limoges, et al. 1994). Since the early 1980s, private firms have expanded their research linkages with universities, partly in response to the rising cost of conducting R&D. This trend has been marked by the proliferation of a new range of university–industry technology transfer mechanisms, including: industry liaison offices (ILOs) in universities, research parks affiliated with universities, university–industry consortia, research institutes and centres of excellence, regional development organizations and spinoff firms. These mechanisms perform a wide range of functions, including the negotiation of industrial research contracts, the identification of opportunities for university research in the marketplace and the facilitation of licensing or patenting of research results or the spinoff of new firms (Charles 2006, European Commission, 2007, Geiger 2004, Geiger and Sa 2008, Holly 2010, OECD 2007, Yusuf 2007).

THREE MODELS OF KNOWLEDGE PRODUCTION & KNOWLEDGE TRANSFER

Model	Assumption	Main Theoretical reference	Reference Period	Instrument to promote knowledge production	Instrument to promote knowledge transfer
Public knowledge	Knowledge as information	Information economics; Linear model of innovation; Epidemic model of diffusion of innovation.	Since the 1950s	Public funding of knowledge production through government agencies and universities.	Public diffusion of research results
Appropriable Knowledge	Knowledge as information	Information economics; New institutional economics.	Since the 1970s	Application and enforcement of well-defined intellectual property rights.	System of intellectual property rights fosters efficient markets for technology transfer.
Interactive	Knowledge	Knowledge	Since the	Implementation of	Implementation of

knowledge	as tacit, sticky, localized, specialized, cumulative, recombined	economics; Resource theory of the firm, other approaches to the firm; Institutional economics; Non-linear innovation models.	1980s	mechanisms promoting interaction between agents to produce new knowledge.	mechanisms promoting interaction between agents to transfer existing knowledge.

Source: Geuna & Rossi (2015)

There is no simple, single policy answer to this question of how the university best transfers knowledge. What we observe is evidence of a clear move away from the model of "pure" public funding of research and a shift toward more complex forms of intervention in support of collaborative research between universities, firms and other organizations in the transfer of knowledge in many forms. The rise of Interactive Knowledge as described in the Table above and increasing presence of innovation intermediaries, such as the local example of the Marine Institute, are useful guide posts for the way forward. Furthermore, economists of innovation attribute about 15 per cent of the final efficiency or productivity impact of an innovation to the invention stage and 85 per cent to the learning by doing that occurs through the diffusion and adoption of the innovation. MI's on-going role in education and training positions it to contribute to this longer-range impact perhaps more than other strictly research oriented centres.

Objectives of the Study

The Research Questions in the Study are as follows:

1. How does the research and development programme at the Fisheries and Marine Institute compare with other research institutions along the TRL Scale for knowledge creation and technology transfer including the ability to meet the identified needs of business?
2. How do the company profiles of industrial partners of MI compare to that of other Memorial partners indicating relevant R&D activities and focus in the company profiles?
3. How do the on-going curriculum and training programmes at MI contribute to Learning by Doing as a critical contribution to the dynamics of Innovation in Newfoundland and Labrador?

EXPECTATIONS OF MI: WITHIN & WITHOUT

The Fisheries and Marine Institute (MI) of Memorial University identifies itself as Canada's most comprehensive centre for education, training, applied research and industrial support for ocean industries. It's location at the edge of the Atlantic Ocean, is critical to positioning MI as one of the most respected centres of marine learning and applied research in the world.

The Marine Institute provides more than 20 industry-driven programs ranging from technical certificates to master's degrees. In addition to undergraduate and graduate degrees, the Institute offers advanced diplomas, diplomas of technology and technical certificates. The Institute also offers a variety of short courses and industrial response programs with over 6000 industrial clients for training every year.

The Institute has three Schools – the School of Fisheries, the School of Maritime Studies and the School of Ocean Technology - and within these Schools a number of specialized centres and units. These centres and units lead the Institute, both nationally and internationally, in applied research and technology transfer and in the provision of training to a variety of industry clients. It also has a separate entity the Offshore Safety and Survival Centre offering industrial training, a certificate in firefighting and new research initiatives.

We begin our analysis of the Marine Institute by exploring the overall perceptions and expectations of MI on the part of its industrial partners and its own personnel. MI has a large footprint in the local industrial community and a distinctive 'brand'. Each set of interviewees, which included representatives from industry and from the Institute, were asked to rank the top four benefits they received from the engagement with MI as well as their assessment of the benefits received by the other party. The results are as follows.

The historical identity or 'brand' of the Marine Institute is founded on the twin pillars of industrial training and strong linkages to industry in Newfoundland and Labrador. This view is strongly supported by the research conducted for this report. However, there are important differences between the perspectives of industry and internal interviewees when it comes to current and future expectations about the role of the Institute. This divergence of perspectives is not presented for the purposes of division, but rather, to serve as the basis of creative discussion about a balanced view of MI going forward.

The study methodology was qualitative, based upon in-person interviews with individuals directly involved with MI and its client companies. Separate Interview Guides were used for Institute and industry personnel. All interviewees were asked a consistent set of questions about the benefits the industry or the Institute received from their on-going relationship, including their views about how their own side benefits and how they perceive that the other side benefits. They were asked to rank their top four choices. The interviews were recorded and then transcribed. All interviewees were informed that the interviews were confidential, with no attribution to a person or organization without their explicit written permission. A total of about 40 interviews were conducted, about 1/3 for University respondents and 2/3 from industry. Over 300 pages of transcripts have been accumulated.

The questions were as follows:

Benefits of MI-Industry Partnerships			
Benefits to the Industry Partner		**Benefits to University Partners**	
Leveraging R&D expenditures		Leveraging government funds	
Lower overhead costs on research		Direct funding of research costs	
Access to technical expertise		Access to technical expertise	
Access to equipment		Access to equipment	
Access to physical material		Access to Material	
Information about the knowledge (theory) frontier		Information about the knowledge (theory) frontier	

Information about the technical frontier		Information about the technical frontier	
Problem solving		Problem solving	
Source of product ideas		Source of interesting problems	
Connection to larger research community		Prestige/recognition within university	
Employment of knowledgeable researchers		Connection to larger research community	
Market respectability		Other	
Other			

How did each side view and prioritize the benefits? Each interviewee was asked to rank their top four items. 4 points were given to their top item, 3 for a second, etc. Below is the weighted score i.e. Access to technical expertise was top ranked at 3.43 out of a possible 4.0.

THE INDUSTRY VIEW

Benefits of MI-Industry Partnerships			
Benefits to the Industry Partner	**Weighted Score**	**Benefits to University Partners**	**Weighted Score**
Leveraging R&D expenditures	0.64	Leveraging government funds	1.64
Lower overhead costs on research	0.43	Direct funding of research costs	1.00
Access to technical expertise	3.43	Access to technical expertise	1.29
Access to equipment	1.36	Access to equipment	1.07
Access to Material	0.29	Access to Material	0.07
Information about the knowledge (theory) frontier	1.00	Information about the knowledge (theory) frontier	0.64
Information about the technical frontier	0.14	Information about the technical frontier	0.71
Problem solving	0.50	Problem solving	1.00
Source of product ideas	0	Source of interesting problems	1.00
Connection to larger research community	0.43	Prestige/recognition within university	0.93
Employment of knowledgeable researchers	0.36	Connection to larger research community	0.57
Market respectability	1.14	Other	0
Other	0.07		

The firms saw the major benefits flowing to themselves as:

- Access to technical expertise. Access to research and to qualified people.
- Access to equipment. Equipment and technology they themselves may not be able to afford.
- Market respectability. Linkage to MI contributes to reputation with customers and competitors.
- Information about the technical frontier. Perspective on latest development and what is coming next.

For MI, the firms saw the major benefits as:

- Leverage of government funding. Many public programmes now require private sponsors and contributors.
- Access to technical expertise. Important knowledge in industry outside of academia.
- Access to equipment. Companies may have specialized equipment the Institute cannot afford.
- Direct funding, problem solving, and a source of interesting problems.

THE MARINE INSTITUTE VIEW

Benefits of MI-Industry Partnerships			
Benefits to the Industry Partner	**Weighted Score**	**Benefits to University Partners**	**Weighted Score**
Leveraging R&D expenditures	2.57	Leveraging government funds	2.71
Lower overhead costs on research	0.71	Direct funding of research costs	2.57
Access to technical expertise	2.43	Access to technical expertise	0.71
Access to equipment	1.00	Access to equipment	0.57
Access to Material	0	Access to Material	0
Information about the knowledge (theory) frontier	0.43	Information about the knowledge (theory) frontier	1.29
Information about the technical frontier	0	Information about the technical frontier	0.29
Problem solving	1.14	Problem solving	0.14
Source of product ideas	0.43	Source of interesting problems	0.71
Connection to larger research community	0	Prestige/recognition within university	0.71
Employment of knowledgeable researchers	1.0	Connection to larger research community	0.29
Market respectability	0.29	Other	0
Other	0		

Respondents from the MI perceived that the major benefits flowing to the firms are:

- Leveraging R&D expenditures. Firms with limited R&D budgets get to leverage their dollars.
- Access to technical expertise.
- Problem solving. Firms most often are seeking an answer to a specific practical problem, not a theory-based issue.
- Access to equipment. Often this is testing and analysis machinery and technology the firms do not have or cannot afford.

Respondents from the MI perceived that the major benefits to themselves are:

- Leveraging government funds.
- Direct funding of research costs.
- Information about the knowledge frontier facing the industry.
- Technical expertise, problem solving and university prestige.

MI APPLIED RESEARCH PROGRAMMES

The Marine Institute has an impressive set of applied research centres. This section of the Report summarizes the centres' activities and describes both a typical project and an advanced project that includes factors they would like to see in the future of MI. Based on those summaries, the TRL framework metrics are applied to get a summary picture of MI's research activities. It also provides a set of data points for comparison with other research institutions and public policy objectives.

CENTRE FOR MARINE SIMULATION (CMS)

The Centre for Marine Simulation is involved in a range of training, educational and research and development activities using its suite of marine simulation capabilities. CMS was established in 1994 following the investment in two major technology steps emanating from the Ocean Ranger disaster: the Ballast Control Simulator and the Full-Mission Bridge Simulator. In total, CMS has 24 simulators for different types of vessels, ports and environments such as dynamic positioning in ice. CMS uses simulators to test the limits of industry technology. For example, in the oil and gas industry, it is the operating environment that is often being tested. In shipping the hydro-dynamic properties of vessels may be tested. A 'project' might be an assessment of operations and development of a design. CMS is not in the business of selling software.

Typical Project

A typical CMS project is to build simulation training for a new port terminal or a new vessel entering the port for clients such as a shipping company. This type of project would require mapping of the port and the hydro dynamics of the vessel. The new simulator supports future training. It does not become a separate commercial software product in the market place.

Advanced Project

CMS anticipates that there will be future requirements to support piloting training for ice navigation and ice management in the Arctic. This type of training would be relevant for both the oil and gas industry and the cruise ship industry. The development of such programmes will also be relevant for interventions in the International Maritime Organization (IMO) for developing ice navigation standards for international shipping.

CENTRE FOR APPLIED OCEAN TECHNOLOGY (CTEC)

CTec works on the development and application of technology to fisheries, shipping, offshore oil and gas, with applied research and development in two key areas: ocean mapping and ocean observation systems.

Typical Project

Smart Bay is a long-standing applied ocean observation system in Placentia Bay, Newfoundland and Labrador, which is coordinated through Ctec. The Smart Bay system includes ocean observing. Sensors are on buoys in Placentia Bay combined with a third-party forecasting model, this data is fed to a website in real time to provide information to the uses of Placentia Bay, including fishermen, the oil industry, marine transportation, recreation, municipalities and residents in support of better decision making. It applies to safety, efficiency, policy and environmental perspectives. One of the major uses of the project has been to provide real time navigational guidance to oil tankers coming through Placentia Bay into the refinery at Come by Chance.

Advanced Project

Ctec anticipates that there are new project opportunities related to the development of technology to deal with oil seeps through ROV, mapping oil and gas areas for undersea engineering and development of a sensor on the nose of a ROV to take water samples, analyze them on board, do tracking and then re-sample.

CENTRE FOR AQUACULTURE AND SEAFOOD DEVELOPMENT (CASD)

CASD serves clients in the seafood processing and aquaculture industries. The Centre has three main theme areas: seafood processing, aquaculture and marine bioprocessing. Services span the entire seafood value chain from post-harvest handling and holding technologies, equipment design and prototype development, product and process development, pilot scale processing of test market samples, and by-product utilization for the seafood processing sector. CASD's facilities include a food processing pilot plant, an aquaculture facility and a marine bioprocessing facility.

Typical Project

The automation of the seafood processing industry in Newfoundland and Labrador is being driven by aging as the average age of plant workers is approaching age 60. To address these challenges many projects are focusing on the use of new technology to access more new species and achieve better utilization of product. One example of a project is CASD working with a local processing company on the commercialization of automation technology for the processing of sea cucumbers.

Advanced Project

CASD anticipates that there will be opportunities that will be related to seafood processing improvements. Currently approximately 150,000 tons of waste is discarded each year in NL, following the processing of seafood. There is a great opportunity to focus on waste stream utilization i.e. further processing of the pieces that are now discarded. It is also expected that there will be opportunities that arise from the improvements in the ground fish stocks.

CENTRE FOR SUSTAINABLE AQUATIC RESOURCES (CSAR)

CSAR promotes the sustainable development of aquatic resources and protection of marine and freshwater environments. CSAR conducts applied research and development, as well as education and training to conserve and protect aquatic resources and habitats using an integrated, multi-disciplinary approach involving scientists, resource managers, harvesters and other stakeholders. The primary testing facility for CSAR is the Marine Institute's flume tank. With its sophisticated video recording, computer software, sensor equipment and special features, this advanced facility provides the basis for consulting and technical services to the entire marine industry.

Typical Project

A typical project for CSAR would be working on the development of a new trawl design developed with a NL trawl manufacturer. Trawl design effects the efficiency of the catch and fuel efficiency. The Centre would use CAD/CAM tools to develop proprietary trawl systems. The software models movement of the net through the ocean and models of the trawl are built at the Centre and tested at the Flume Tank.

Advanced Project

CSAR anticipates that there are project opportunities related to the red fish fishery. For example, the development of a new design for a midwater trawl that is set close to the bottom but 10-15 meters above it. The design maximizes the catch and preserves the seabed. The net also has sensors that report on depth but can also talk to one another.

CENTRE FOR FISHERIES ECOSYSTEMS RESEARCH (CFER)

The goal of the Centre is to better understand fish stocks and the productivity of Newfoundland and Labrador's marine ecosystem through fisheries research. The core focus of CFER's research is: surveys, stock assessments, sustainable fisheries, ecosystem structure and change, climate and fishers influence; species biology, ecology and behaviour.

Typical Project

A typical project for CFER is examining cod distribution and movement using satellite tagging technology. The latest generation of pop-up satellite archival tags are placed on large cod during research vessel surveys and the data is used to gain insights into cod movements and behaviours.

Advanced Project

CFER anticipates that there are project opportunities related to Atlantic halibut distribution, migrations and habitat use in the Gulf of St. Lawrence. This baseline biological information is gathered for the development of stock assessment tools and is used to improve stock management strategies.

OFFSHORE SAFETY AND SURVIVAL CENTRE (OSSC)

The Offshore Safety and Survival Centre (OSSC) offers a comprehensive range of safety and emergency response training courses to the offshore petroleum, marine transportation, fishing and land-based industries. Though primarily a training facility, the OSSC has an applied research unit that is uniquely positioned to carry out high quality research in emergency response, evacuation, survival and rescue.

Typical Project

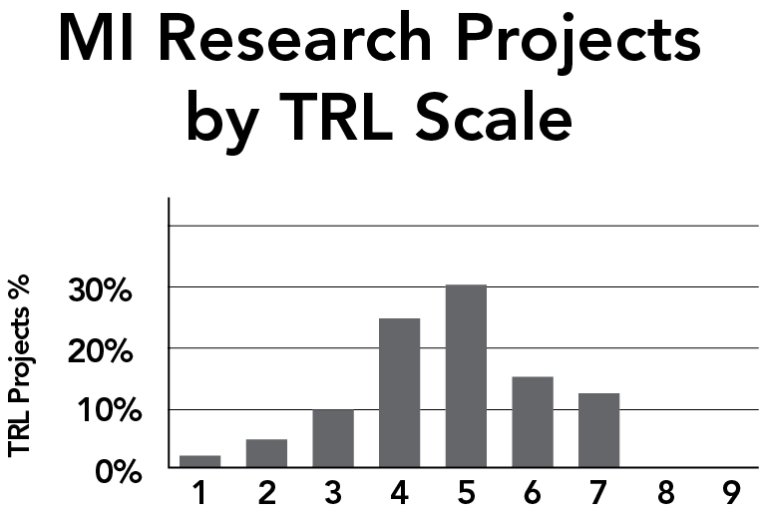
A typical project for the OSSC's applied research unit is the carrying out of full scale field trials, including sea trials on different types of vessels including new designs for life rafts and certification.

Advanced Project

The OSSC anticipates that there will be project opportunities related to human factors, for example investigating combining physical simulations with medical simulations to determine human factor issues in training of pilots, that is the motor mechanisms for pilots in emergency situations. The outcomes of this kind of research can inform regulatory decisions made by Transport Canada for application in offshore operating environments.

Mapping MI Research Projects to TRL Scales

The interview results for MI applied research projects can be used to make at least a first approximation of where the Institute's research programme fits in comparison to other university research institutes and the frameworks that governments are increasingly employing as criteria for funding decisions and project evaluations. The results are drawn from the interviews and summarized in the chart below.



Source: Data from Confidential Interviews with MI staff.

Firstly, the results in the table above confirm that MI, in contrast to C-CORE and other Canadian universities where similar analysis has been done, is clustered at the industry end of the TRL spectrum. A typical research-intensive university focuses on the Basic Science, TRL 1-3 end of the spectrum. The second observation is that MI research projects are quite tightly grouped at TRLs 4-5, but fall off thereafter. A significant, but smaller number of projects make it to the final prototyping stage, however these projects do not typically appear at the final stage of commercialization in the actual market. By contrast, the C-CORE TRL profile, consistent with their research-only mandate, for at least some of their centres, reaches much more completely into the commercial marketplace.

Our interviews indicate that the largest applied research projects at MI are in a way self-limiting. Most of the research efforts, even with more recent projects involving more of the 'science' end of the spectrum end up contributing either to development of a regulatory standard or cycled back internally to support industrial training efforts of the Institute. The bottom line is that the central tendency of MI's applied research programme will not result in products actually reaching out into the commercial marketplace.

WHAT WE HEARD

The following is a representative sample of comments and perspectives given in the over 300 pages of transcripts accumulated in the 43 interviews. In the authors' view, it is important for the reader to get direct exposure to the individuals' responses, presented in their own words. The list of interviewees followed initial suggestions from MI management, supplemented by additional interviews as the Authors deemed appropriate. The analysis and interpretation of the interview results comes later in the Report. A copy of the Interview Guide is provided in the Appendices to the Report.

What We Heard from Marine Institute Staff

IT WORKS FINE IN PRACTISE, BUT DOES IT WORK IN THEORY?

"There are remarkable people here who do things quietly and competently at the ground level. That work echoes up through and has an enormous impact on the success of the institute. That is remarkable and plays into our broader success. People have evolved into the roles and they find ways around things. That is how we work."

DO THEY SEE THEMSELVES AS DIFFERENT FROM MEMORIAL?

While people at MI see themselves as different from Memorial, the degree of difference and the nature of the difference seems to vary from centre to centre, as do the attitudes towards Memorial. But there are common threads.

At the Marine Institute individuals see themselves as living in a world of risk where they have developed strategies to help identify and mitigate risk for clients, whereas they see Memorial as an institution to be more risk averse.

In response to the demands of that "world of risk" the people at MI see themselves as more nimble than Memorial in their response to industry needs. That includes flexibility on IP, willingness to sign Non-Disclosure Agreements (NDAs) and surrender publication rights, and fast turnaround times for projects from initial identification of the issue, to leveraging of funds to completing of the research and reporting. It should be clarified that this is not just a matter of individual choice, but working under different systems of evaluation.

Another perceived difference is how research is driven and who is involved. Although it varies depending on the expertise of the directors, generally directors manage the researchers doing budgets, schedules and work plans. They do not lead the direction or the focus of research. They are also active in the identification of potential research projects as they "scheme" with clients to identify likely opportunities for which funding could be sourced and or leveraged for short-term one-off projects with clients. As a result, they see themselves as experts in leveraging money, in project management and in delivering measurable and meaningful results. The flip side of that coin though is that they see themselves as lacking in the areas of IP management, patenting and licensing.

There is also a difference in the resistance from some quarters in the business community from several businesses that see themselves in direct competition with MI. This appears to be less so with Memorial. Interestingly though, particularly in the more academic field of offshore safety, MI research could lead to policy changes for safety training that could lead to increased business for those companies which provide those training services.

Much of their work too, is heavily weighted on training as opposed to research. The CMS for example, conceived and funded based on a response to the Ocean Ranger tragedy, was developed with an

investment on behalf of the offshore industry and the federal and provincial governments. The aim was to ensure workers are better prepared for emergency situations. The flume tank project also budgets up to three weeks a year for support of training of MI courses such as ROVs.

Steeped in a strong applied research approach, numerous staff believe Memorial has the wrong attitude towards researchers at MI seeing them as a "poor cousin," a feeling exacerbated by their inability to access tri-council funding without cross appointments of students and professors to various departments and faculties on the Memorial Campus. MI is sometimes written into research proposals without even being consulted. This is because they are seen not as colleagues and experts by academics on the main campus, but as the location to access marine research infrastructure. They see researchers from Memorial using their facilities and afterwards publish their papers without acknowledging the role of MI, its facilities or its staff. There is a generally held belief that attitudes are slowly changing—with the President and the late Dr. Marceau leading the way because they want to be collaborators.

Or as one director put it, "We would love to have Memorial up here but it has to be as collaborative partners. And if we are not in there as a partner in the research initiative, I am on record as saying I will scuttle any research deals that involve our facilities or our expertise."

In the meanwhile, they continue to work with industry researchers as their clients rather than as their colleagues. "What we like in thinking about the centre as a business is that we have the ability to generate money that sticks. We wrap a TRL around a project for funding bodies. But at the most basic level, our success is on the shoulders of the people who are here day to day."

Those on staff with more academic backgrounds believe that a culture shift across the MI is necessary to "get the respect of the tri-council." But that is not entirely true since, of the 12 NSERC eligible researchers at MI, nine have funding from them. But those are mostly in fisheries. But in other areas, such as OSSC people are resistant to that kind of a shift. "They just don't get it yet about the need for academic integrity as far as publishing results and findings is concerned."

That being said, according to some staff, they have their own internal policies that are valued by some on the main campus, who respect their speed in responding in to industry. "Some divisions on St. John's campus are saying, 'Why are you guys so flexible?'—3-way cross appointment—right through to research grants with our own grants group in administration with a template for how we fund that."

HOW DO THEY SEE THE R&D NEEDS OF THE COMPANIES?

Driven by their business model, MI has evolved into three primary areas—specialized training, industrial projects and applied research. Most of the work they do is designed to support that mission. "We do this work on our own, we also work on behalf of our clients and, when we can, we do it as a fee for service or contract service, as a collaboration and sometimes even to promote our clients to third parties." However, in more recent years, they are expanding that mission as they endeavour to source NSERC and tri-council funding with the establishment of research chairs and the development of undergraduate and post graduate degrees.

While this shift to include academic programming is accepted as a part of the suite of services they provide, the commonly held view is that the applied research and the outcomes and solutions, even the IP they generate, are not the core academic objective. Staff question whether the methods that exist for handing academic problems and processes would even work in the outside world.

Generally, projects originate in one of two ways. Either a firm comes to them and say they have a problem needing a solution; or, MI staff see a trend and go to industry to say you need to be in on this, so work with us.

There are some clients that identified resource shortages as an issue. This may be helping to de-risk the earlier TRL phases, but not as early as main campus basic research at Memorial. "We fit with their need of getting across the Valley of Death. If they want a survey offshore and there is a question in it that may involve a commercial opportunity, or not, then we are an easy way to help de-risk their early stage investigation."

As one director put it, "Our work will take the product to TRL 5 or 6 and a commercial partner is ready to continue with the commercialization once we hand it over."

Prior to investing in the drafting of a proposal for funding they talk with industry representatives. For example, if the Province announces a new funding program they explore the opportunities with potential clients. "If we identify a project and develop a proposal and it is awarded, then we sign contracts, it lives for a year or two until the research is done and then the relationship is over." There is usually no follow-on research to assess implementation of findings or commercialization even if IP is generated.

This process of industry consultation, proposal development, short-term contract agreements and funding leverage is seen as "business development in a research context." The general strategy is, through broad consultation, attendance at trade shows and conventions, through a local, national and international network and through its own publications, MI endeavours to stay at the leading edge of "what is actually needed [by our clients] instead of what we think is needed."

One perceived limitation of MI's commercial industrial research projects is difficulties regarding publication for graduate and post graduate researchers, for instance publication of theses or academic papers. Another perceived limitation of these short-term one-off projects is measuring the impact. "How do you measure the success of research and training? We did a strategic NSERC project with a leading fish company for a specific species. But I have no idea whether that was a success in the long term. I believe it was, but we did not follow up." Even though there is perceived value in post –project follow-up and perhaps even potential new research, this is this is not part of the MI business model, even for the long-standing IRAP grants that the MI is so adept at administering and leveraging.

Industry partnerships are seen as the exception rather than the rule by some within MI. The criterion for making that judgement is identified as whether or not their collaborator shares in the risk. "More often than not, MI isn't working with them so much as it is working for them.… We call that applied research but we are competing for business." The work is recognized as contract consulting. "We do contracts for industry or there is a member of the project working group who is industry-based and that helps funders to rationalize the investment."

For convenience of reference and to clarify potential partners from those who remain perpetually clients, the administration of applied research divides marine industry clients into two distinct groups. Big Industry and Little Industry. The former includes oil and gas (O&G), large fishing, harvesting and processing operations, and bulk and container shipping. These are distinguished by the difficulty of patenting new processes and services and by their capacity to finance research and to form partnerships with MI. Little Industry includes the ocean technology industry and the inshore fishery, firms that are dependent on funding agencies and are most likely to remain as clients rather than partners of MI. "They are forever adolescent. Some get away into the next level of commercialization and growth but they are the exception."

MI also has a role as a research mediator between government and industry. For example, as one Director said, there is a high degree of distrust between Fish Harvesters and researchers because of the perceived errors of Department of Fisheries and Oceans scientists whose conclusions are often at odds with the needs of the harvesters. Having a body such as MI intervene, conducting research that is not encumbered by influence from government provides credibility to the findings. "We have stayed out of the policy field... We present the data and let the politicians figure it out."

Sometimes MI does not have the capacity to share the risks, especially where it involves upfront investment. "There can be an issue with us coming up with as little as $500,000.00."

At the same time, any real success in how MI manages IP to satisfy industry relationships will depend on a separation of IP policy and IP procedures. Many see policy in general as moving towards a model of research funding where industry collaboration is a prerequisite for approval. "What it comes down to is having the flexibility, regardless of what the policies state, to proceed on each project in a manner that best suits that project."

HOW DO THEY SEE THAT MI HAS TO CHANGE?

MI's vision 2020 document states that they will be a world ocean institute. But it is widely accepted that MI is already there with formal and informal connections and brand recognition around the world. Yet there are areas that they could open up more as an international leader and that involves a shift into a hybrid model for academia which will increase their ability to access academic funding.

"If we are to become global leaders we can't just have technical expertise. We need the research credentials but we don't have the research scientist to get that wow factor for Canada first, as well as NRC funds. CFER was our first step towards this model of industry-relevant projects with a reasonable ROI." Research directors at MI are also looking at research metrics around publications and H factors for MI scientists.

The recently awarded $9 million grant over five years to MI through the Ocean Frontier Institute is seen as a game changer for the institution. It will support the work of 50 grad students, including post docs. It will buy ship time for data collection. In addition to the 11 actively publishing principal investigators they will recruit another four positions and add two research chairs. "That means we may soon have 15 publishing scientists in SOF. That is up from two publishing scientists just six years ago in 2010. That has been accompanied by growth in citations and certifications." This growth in academic presence must be carefully negotiated with the technical staff who generally tend to be intimidated by these changes, perhaps feeling that their positions are threatened, when in fact, according to one director, their positions are more secure than ever.

Without ever being consulted, individual researchers at MI say they may get written into academic proposals when researchers from the main campus of Memorial are applying for funding but they are not viewed as lead partners. From the perspective of the MI researchers, that needs to change. MI leads international projects. However, this misperception is not universal. They are connecting industry with other partners. They are also getting requests to partner from others who traditionally are associated with pure research but are now coming to the table to partner in more practical applications of what they do. "They are looking for us to suggest potential areas of applied research where they might fit in." But for that to happen as a matter of process, there is a lot of work to be done.

The Institute doesn't have a mechanism for commercialization. It is not in the Institute. "We don't have the ability, we don't have the expertise, and so we defer to the university." The understanding is that the Genesis Centre was created to do that and "we don't' get involved with them. Should we have a version of the Genesis centre here?" This view may be sincerely felt but may be lagging the reality of change in Genesis to becoming an Incubator.

More substantive conversations on the commercialization procedures are necessary because, "we need policies that recognize that we are never going to reveal or share IP generated with industry client money. We can't present that at a conference—we may be allowed to use anonymous parts but the client has veto."

Historically training has been a large part of what MI's activity in simulation and in real situations with the use of modern equipment.

To continue to succeed participants feel that they need to make a culture shift that emphasizes research and increased knowledge transfer; hence the development of their Masters and Ph.D. programs. "NSERC is working hard to try to understand our structure. Their understanding is based on traditional universities, not a polytechnic institute. You can be a bit of both, but that is a brand new model for this country. The technology centres are different in other parts of Canada and not part of the university there." These views provide a clear reflection of the fact that MI's hybrid nature combines elements of a polytechnic with elements of the type of intermediary organization discussed at the outset of this report. In a general sense, the interviewees point to a perceived lack of clarity around the precise institutional nature of MI, which at this point, seems to be hampering its effectiveness as both an educational and an innovation institution.

Whatever the culture or policy of Memorial towards MI is supposed to be, the message received from policies and procedures is, "Stay in your office. Don't go out. And don't dare take a client to lunch or pay for their taxi. It is as if they have no appreciation for the reality that that is a part of doing business."

There is some resistance in the business community from those businesses that see themselves in direct competition with MI.

Regardless of which direction they go in terms of research and IP, there is a consensus that to advance MI's reputation as a viable international centre of marine research at all stages of the process they need a strong Associate VP of research. That person will require a deep understanding of "how the research game is played," how it is as it exists and where it is going, and what projects are most likely to get funding based on ongoing trends.

The more academically oriented among the staff feel acutely that even with the applied research, there needs to be more emphasis on dissemination. "If you are a university and the findings of the research are not disseminated, then for all intents and purposes that research does not exist."

There needs to be an interest in the staff to publish. It should be as integral to the research as the industrial partnering. "A culture shift is needed. Will that jive with values and priorities of the institution? That will have to be decided at the table."

What We Heard from Industry

MI INDUSTRY PARTNERS

As noted previously, MI's industrial partners tend to be SMEs or MNE's, each with their own needs and expectations of the institution.

SMEs were predominantly technology development companies. For most of those interviewed technological innovation was their raison d'etre.

MNEs were national shipping companies, international manufacturers, fabricators, O&G consulting support, an aerospace company, and large scale local and international fish harvesting and processing companies. All of these rely on technology to provide advantages in industries where the profit margin, by all accounts, is slim. And any innovations that can be introduced in processes are jealously guarded. The source of this innovation is often internal and may come from an innovation division or from employees who are encouraged to offer improvements in methodology and services.

HOW DO THEY SEE MI, AS A TRAINING AGENT OR AS A RESEARCH INSTITUTE

Most representatives interviewed from MNEs saw MI as a training institute, but not just any training institute. They regarded MI as lending credibility to their operations in the eyes of regulators, particularly Transport Canada, and in providing market credibility in some niches.

Training is important in areas such as the development of new equipment for new species. "We started to fish sea cucumber not long ago—how do you cut that in a machine to maintain quality and add value to the product. Technology development and training for our divers."

MI was seen by some as exceptional in its ability to match skill to industry requirements as it changes over time. Therefore, it must be fluid. "The important ingredient is that they can predict and prepare for the skills that will be needed in the medium and longer term for the four industrial units, OSSC, CSAR CMS, and SOT." This was a strong theme in most interviews with firms.

Some other interviewees, at least in fish harvesting, had the exact opposite opinion, especially with regards to staff being uninformed about the most recent technological developments in relation to the fishery. "The school is paying so little that they are not attracting people who can earn $200,000+ out there. [The

instructors] they do attract are so removed from seagoing experience that they are seriously out of touch with the reality of the industry today. They need to get out into the industry and see what is going on."

For a clear majority of firms interviewed, MI is seen as a go to source for training and building mutually beneficial and progressive research partnerships. "We rely on them. They have a strength in systems and connections to Memorial that we don't have and they know that ground. They need us for ocean weather forecasting for smart bay and other projects."

Many attest to a relationship that has evolved over that time. "MI is an important part of our Network, not only in Canada, but globally. CMS and MI are highly regarded [within our global network] as an innovative organization with a fast response time to industrial needs and quick decision making all the way up the line."

One relationship that began with three people working on Smart Bay has since evolved into large projects in offshore R&D initiatives most recently for ExxonMobil. "And now we are actively looking together at other opportunities."

Equally universal was the multileveled nature of most relationships with information flow in both directions. "The primary level is a close working relationship with student programs for ocean mapping and ROV pilot training. We have hired technicians from that program. The co-op program allowed us to test the waters to see if we needed them."

It is not uncommon for companies in the marine sector to, "pull on MI in a number of ways." On the research side, they hire graduates to get the benefits of the latest academic literature and best practices. They use MI facilities such as MI's vessel. They may sit on one of the advisory councils. On the training side, they may use the offshore safety training facilities in St. John's and in Foxtrap.

Many voiced support for the perceived benefit of, "access to one of most highly respected fisheries institutions in the world." Again, and again firms spoke of the success of the process of working together to identify students' needs and the best ways to deliver that education and training.

For others, while knowledge transfer has been light they have been able to use MI's facilities to their advantage in one way or another for shipboard data collection and experience, and in other instances MI staff have benefited from exposure to cutting edge technology. "The advantage really has been simply access to the vessel. Besides the benefits of being able to get the data, the partnership got our staff outside their day-to-day activities. They regularly work with data from boats all over the world, but by being able to actually be on a vessel in operation made it real."

One of the most commonly identified benefits of working with MI for firms is access to technological expertise. "We have been working with them both as a consultant to support technology development… as well as we have always used their infrastructure tanks and that has been a good relationship."

Technology transfer appears to be providing benefits in both directions, with MI hiring senior R&D staff from some companies and then providing those same companies with fee-for-service access. "We like being able to access [our former R&D scientist's] expertise on contract as needed but not having the expense of a full-time salary. It also feels safer for protecting IP to approach a software developer in the educational system rather than in commercial operations." An added benefit for the technology companies is that the Big O&G operators with whom they work like to see them partnering with players like MI. "They are encouraging us to work with MI and with Memorial. It earns brownie points for them."

HOW DO THEY SEE MEMORIAL HELPING THEIR COMPANY, ON TRAINING OR THE RESEARCH SIDE?

Whether companies view MI as better able to help their companies on the training or the research side appears to be a function of the industry that they are in and the size of the business. For large shipping companies MI is seen solely as a source of cadets. They have their own internal divisions of innovation and have a deep knowledge of the funding sources and programs available to assist in research and development—which is largely confined to improving handling, shipping and storage processes.

MNEs in fishing and processing see MI's value as twofold. The institution is valued as a source of cadets—with the caveat that most graduates coming out of MI today have been prepared for working in the O&G industry and could be much better prepared for work with the advanced technology on the bridge of today's fishing vessels. These companies may or may not have their own division for innovation but are constantly seeking an innovative edge, introducing new technologies in trawling and processing and even storage. And it is in this area that MI garners a great deal of respect: "[Our relationship with] MI is collaborative. It's hard to say which way the knowledge is going sometimes but it is constantly evolving". MI is also perceived as "a place that produces good mechanics in contrast to Memorial."

However, MI is recognized as a location for research—sometimes just for the facilities, sometimes for the expertise available there. "At the start, we had more knowledge to transfer. But through communication with MI our company is building a full-size trawl; and we expect to know from the modeling how best to make it work for our new vessel. So we are already getting benefits from working with the trawls and the expertise in the shop here at MI is unreal. "

But as alluded to earlier the relationship with MI is multi-leveled. For example, some companies that serve MI as vendor see them not just as a customer but also as a research partner. "We sell directly to them. They buy simulators and they develop the software; they have area databases. But we are more than just a vendor. It is a dynamic relationship in which we have we have contracted them to develop models for us to sell to other clients."

ON THE TRAINING SIDE?

The ability to know what Industry needs—be closer to the industry—is critical for MI. And the perception is that they could do a better job of promoting the training that they offer; but there was also very strong evidence supporting their current expertise in delivering training and in training cadets.

In Nunavut for example MI delivers training through the local Nunavut Arctic College. They do all the course delivery for crew on vessels and the inshore fishery. They have an MOU with the local training agency there and, "99 % of the time they deliver what we need."

Rightly or wrongly, among the companies that view MI as trainers, the general perception is that knowledge transfer is limited in this environment. MI is seen for example as the deliverer of Transport Canada (TC) mandated courses for groups and some custom work for clients that they develop. "I guess the knowledge transfer is to the students. They have learned a lot about how we operate the college and they understand our output needs".

This understanding of output needs and a recognized ability to customise training contributes to the evolution of relationships. "Because of MI we have an in-house Basic Safety Training course that we deliver. MI Trained our 30 trainers. And they are travelling throughout the province delivering the in-house programs. MI also trained 12 trainers for our prior learning assessment and there are 12 of them across the province that go out and apply that program to fish harvesters."

Companies value their training relationship with MI and question moves by government that compromise it in any way—even if it causes them to lower their prices. "I didn't think it was right to fund a private sector company against MI's OSSC. If they are planning to do that they should cut OSSC altogether or come up with a new funding process. What it has done is forcing all of them—private and public to cut their prices."

ON THE RESEARCH SIDE?

MI is widely recognized as a go-to place for technical support, but not a priority place to go for networking with other universities or research entities. There are however, a few notable exceptions where this is contradicted. Often, they are characterised as one SME CEO put it as a "cul-de-sac of technical expertise."

What is the incentive from the MI side to enable us to contact other companies? Why would they assist in that? There should be incentives for them to support industry and to help facilitate the creation of those networks—even if it means their clients go elsewhere in the future".

MI is viewed favourably on the research side in comparison to other research supporting agencies. For several of the interviewed companies with experience with both institutions, "MI and C-CORE are chalk and cheese. The culture at MI grew out of applied research and the people there are much easier to deal with than those at C-CORE. "

This translates into a level of trust for MI that is not present in other "academic research" situations. "When I am dealing with MI, I can be open and comfortable with what we are doing. But when dealing with C-CORE I always have to be careful of what I say and be sure that I protect our business interests."

Also with MI, because of their access to facilities, joint research opportunities have been identified to collect and share research data with clients. "Through our relationship, we got the chance to put equipment on one of the company supply vessels."

One company with a 20-year history spoke of the value to them of the evolution of their research relationship. "When we first started, they were coming to us a bit more with an ideas for projects that they had in mind. We are an industry partner now, we are coming to them. The shift in our working together is that we have more experience in the way the funders work and the way research projects work."

In some sectors, such as the fishery, research support is not so much research as it is search and exchange of information with other groups. "I have to focus it down to local market and a lot of times with MI, and with CSAR and CFER people. Their innovation is not hitting on new stuff, not changing the game so much as it is building on what is happening elsewhere."

For new product funding and development, players in the NL market turn to MI. "Even though we are not equipped to do it, I can do research in-house depending on the nature of the product. But, if you need funding for new innovations, the funders want data collection. They want analysis and they want an interim and final report. I can make it, install it on the fishing vessels and get anecdotal reports, but it is hard to train fishermen about the importance of them collecting data. So to get that data I contract MI." "If it is something we have to develop and fine tune we usually come to MI, I mean come here and say, 'How do I get funding to do this?'." They know the people to talk to. And for some companies the research is a means to an end. "The funding, access to funders is the most valuable thing we get out of the relationship sometimes. "

Companies that rely on MI for research support sometimes do so because of a perceived lack of competence among local companies with whom they might otherwise partner. "We rely on laboratories and technology transfer—MUN and MI for skills and expertise—for most R&D projects there is a role for them."

There is a takeaway in this kind of work for MI students as well. For example, on the vessels where research companies deploy cutting edge technology, they enable MI to expose students to the technology that would otherwise be out of reach cost wise. "We make the equipment available and share data with them and that allows the next generation of graduates to see the benefits of the technology so when they work for us or another company they can say we need to be looking at that technology."

MI compared to Memorial is application focused. The real benefit is the experience of the research that they get—the professionals and the ROV student pilots. They have all the basic concepts and can help the company as they are cutting their teeth on new equipment.

The primary research and applied research approaches are of most benefit. These begin with pure academic activities but become "live" when they are introduced to industry. "MI has through its four industrial units, been able to bridge this gap successfully in the past and, in my opinion, is one of the principal reasons for its success inside a University culture. The results don't lie".

Part of the challenge of defining a single MI identity is that it is seen by some as both a trainer and as a research partner. One company held a technology transfer seminar with CSAR this past summer, using funding from CCFI and NRC. It was offered to shrimp fishermen and there were 50 plus participants from all over the province. Attendees came to find ways to fish shrimp more sustainably. "We went through the completed project and reviewed low drag fishing gear and methods to reduce seabed contact using pelagic doors so to let the bycatch go—bycatch reduction."

"I feel many of the units do that for students. MI provides a great staging ground for students that get to work on protects to build confidence fortify themselves—their attitudes—as they graduate to become more high skilled candidates who are open to research and innovation because they have experienced it first-hand".

WHAT DO THEY SEE IN MI'S FUTURE?

In the fishery in particular, there is a small seasonal window of six months to conduct research and collect data on the water. So, if it takes six weeks to get a research project request off the desk then that is not meeting the needs of the client. "Streamlining wouldn't hurt. I have had them take most of a season to approve some things and then they come to see why it is not implemented when the fishery was over. And then we have to apply for funding and start the whole dance over again. So sometimes for prototyping to happen, it is just as well to make it and have a few fishermen throw the nets overboard and see what happens."

Some companies, particularly those who were represented in the interview by graduates of MI, questioned why students weren't involved in research? "I spent four years in the nautical science program and not once did I set foot in the flume tank—me or the rest of the people in the program. And we were only on the bridge of the full motion simulator once. And that was after we had graduated and were in for the last technology section".

Companies also recommended, as part of the initiative to better embrace the fishery as a viable industry and promote relevant skill development, that MI make students more aware of the opportunities in the offshore fishery including the kind of work and the benefits.

To respond quickly and get word out about what the skill sets are and what MI can do innovatively, several companies recommended that MI evaluate how they are promoting themselves. "They need to do a better job of promoting themselves. I very nearly engaged a company from Norway to do a large training project when MI has the capabilities but I could not get any information about it. And one day, just by chance an MI staff member mentioned that they did that training for companies in US and EU." But there was nowhere in the Marine Institute network that that expertise was either identified as an area of expertise or offered as a service.

There are also possibilities in training to encourage people to work and think creatively. As one fish processor put it, "We want to pay people for using their heads, not their hands. In China, you pay $2 per hour. That is a dollar per hand per hour. Here you pay $15 an hour so what is the incentive to process here if they are just using their hands? Why pay this? How do you get around the seasonal nature of the industry? With employees who are interested in using their head to remain employed".

Regarding IP, though it is of little concern to some companies, it is of vital interest to others. "If that could be clarified and contracting mechanisms in place with MI. It just seems to me like it could be clearer and open and streamlined."

Regarding the industry partnerships as a whole: "I would like to see more consultation with industry as much as they can and not to compete with industry because that is a shame. As we have seen in other institutions affiliated with the university. There should also be more of an onus on MI to help clients and partners build business and research networks that reach beyond their walls".

Regarding theory versus practical knowledge, MI does have the BTech degree. "There is a great incentive for ROV pilots who can go back and do that a few years after they get their diploma because they only have a

limited number of courses to complete. But the problem is a lot of the skills they learn for that degree are managerial instead of theoretical-- project manager and related skills, but they still can't tell you the theory behind why a circuit works".

Some interviewees questioned the motivation of MI to work together with industry and expressed concern that there was a need for more motivation for MI to work together with industry. Should it be a financial incentive? I don't know. "But we have found one way to add motivation. We give them access to our equipment in exchange for access to their boats when we need it. And we give then access to technology and access to data. Makes sense to researcher and but not managers. "

Some companies regularly tap the Marine Institute for product and service ideas. However, it is complicated: "NL companies are jumping off from the state of the art but you have to know what stage state of the art is at and you have to know what is going on elsewhere. Otherwise you are spending too much time reinventing the microchip".

Another research dilemma companies face frequently is: "Do you go for the available funding on a program that is being done elsewhere—perhaps even at an advanced stage compared to the proposed local project OR do you say no to local funding and go for the advanced research elsewhere?"

For MI partner firms, the priority is the more practical application of technology so you get the skill base that is essential—not just academic skills; but also the equally important technical know-how to develop a product. For example, a local engineering firm went to the University of Plymouth in UK: "We went there and the naval arch department had specialized in moorings. It is not sexy but it has a lot going on—wave energy related and other cutting edge things so basically a major university made something so practical a basis of practical approach that would be right up the alley for someone at MI to tackle."

Joint promotion is also a future opportunity: "From the simulator side, there has been on-going dialog and discussion to do some joint trade show work promoting both our radar products and MI's simulator".

On the other hand, firms believe that MI needs a method for students to increase their skill in certain areas for new graduates and should work with industry to promote more formal mentoring processes. The senior engineering community could do much more to formalize a mentoring regime or process available to the new graduates and also to developing an apprenticeship program for nonprofessional programs and technical skills programs. And, if they are to support the employment of cadets in the fishery "It is critical that MI update the curriculum to make cadets conversant with the 'mind-boggling' technology now found aboard fishing vessels and develop an apprenticeship program for nonprofessional programs and technical skills programs."

Some suggested this type of curriculum revision ought to be left to the direction of the industrial governing bodies rather than individual producers. "I haven't opened the new graduate tool box but I suspect there are items missing. But we haven't communicated what we need to the Institute. It is not for one company to do that. That is the job of the industry association. And they are not doing it. They are not telling them what we need. I can't go as a single company and say do this and do that. It is time to get over the problems created by family owned business."

There is another role that should be considered for MI and that is one "as a kind of intermediary when it comes to flowing government funds to projects for demonstrating and showcasing new prototyped technologies. MI has vessels and facilities they could possibly be a partner that provides the offshore that the government flows the money through to offer the demo and showcase of technologies".

However, as noted several times above, MI's industrial training is seen by some industry clients to be technically lagging.

There are opportunities to do more on the outreach side than just recruitment and training of cadets. "On the research side, I have talked with one of their leaders up there. If I see him he usually picks my brain. But there is

not much in it for me. The school's outreach could be a lot better. I do get the conversation between the placement office and myself they keep me up to date. But that is it."

However, for many, the priority remains on the training and placement side: "The innovation we are interested in here with MI is in educational programming and delivery. We are always looking to new ways to deliver training that bridges gaps in geography and affordability. In the past, we looked to community-based training but now we are moving towards innovatively delivered and programmed distance and technology based learning and are interested in continuing to work with MI on that".

Interviewees did say that the weakness of MI right now is the Master's level program—there are no research capabilities on the training side. In the marine operations side the bachelors and graduate programs are not designed to take on a research program. It is discouraged. The Masters program has 2 approaches: two years plus a thesis or the ten courses. The latter is recommended to the college students. The problem with the thesis for graduate students at MI is figuring out how you get at the resources to provide the opportunity for research and analysis.

On the marine training side:

"I am not sure how MI should go about doing this but it is very important that they adjust their approach to training mariners. They need to approach the fishing industry to put cadets on the offshore vessels. The past 25 years they have been focused on the oil industry and now that has has all gone away. We are getting calls from people with high levels of seniority, looking to come to work as first mates, captains, engineers. So I am taking guys 45 years old, who are at sea all their lives, with no fishing experience but high rank but doesn't know what he is doing in the deck side. Some of the things that that the fishing industry doesn't do well is filling the gap between inshore and offshore."

"For the engineering program, especially on modern vessels, they need more of a focus on automation and electronics and a big component on refrigeration—container ships as well as fishing vessels depend on refrigeration. They gloss over a lot of this stuff. Having an engineer with that knowledge is phenomenal. To get that they take industrial electronics training and putting them on the vessels and calling them the engineers. They also need hydraulics. Basically, they just need more exposure to shipboard technology."

"One of the things that the MI could help with, they run the pre-sea training. During that course, they could put in a week or two of mending nets to benefit both offshore and inshore. Nets are more precise in the offshore. "

"Two main areas—higher level factory food processing—too focused on shore based processing and we have people here to do that –food handling—they need to be expanded. Over the last couple of years, we send to NS and NB to train and we'd like to do it here but it is not offered at convenient times. Need to expand, publicized and run more often. If they could do that more would come for training."

Summary

The following is a summary of what we heard under each of the major Research Questions.

Question 1: How does the research and development programme at the Fisheries and Marine Institute compare with that of C-CORE along the TRL Scale for knowledge creation and technology transfer including the ability of MI's R&D activities to meet the identified needs of business?
Technology trajectories: at least to date, MI has a circulatory economy view of technology "TRL 4 to 6 and Back Again" as illustrated for instance in the physical presence and profile of the simulator technology. C-CORE by contrast is a research only entity and its TRL distribution reflects that. MI has a different pattern somewhat more self-limiting but also with more potential, particularly within SMEs. MI has a cogent view of technology transfer, it is internally consistent and reinforces its role in industrial training but compared to C-CORE it is not primarily designed to get technologies out into the commercial market place as innovation

studies and public policy expect. It is more focused on having an impact of standard and regulation setting such Transport Canada, the IMO or the calibration of sustainable fisheries models for regulators.

Question 2: How do the company profiles of industrial partners of MI compare to that of C-CORE partners indicating relevant R&D activities and focus in the company profiles?

A recurring theme in the C-CORE firm interviews was the entrenched level of suspicion and hostility to the Memorial academic culture as embodied in the University's traditional IP policy which is focused on extraction of economic rents. The MI environment, relationship and culture are different. There are some non-disclosure issues from time to time in MI's applied research but in general IP issues are not an active issue. MI also has the advantage, because of its history and the DNA of its culture, of a much more relational than transactional approach to working with its industrial partners.

Question 3: How do the on-going curriculum and training programmes at MI contribute to Learning by Doing as a critical contribution to the dynamics of Innovation in Newfoundland and Labrador including how the value of R&D is represented in the contribution to innovation?

There are two issues identified in the recent innovation literature that fall in the Marine Institute's favour, as compared to traditional university institutions. First, as stated in the Introduction, in addition to the established channels of University Knowledge Transfer, namely Teaching and Scientific Research, recent attention has been identified to Interactive Knowledge transfer. This is obvious in the MI case, but less so in most universities. It also takes place outside of the formal IP policy. Second, the long-range impact of new inventions and processes is less from the discovery stage and more from Learning by Doing. This puts MI's curriculum delivery and industrial training efforts at a critical place in Memorial's contribution to the NL innovation ecosystem. There is much more that can be explored in this area for better outcomes for the NL economy.

FUTURE OPTIONS: A RESEARCH COLLEGE?

The MI leadership, staff and their industry advisory committee have important choices before them about what kind of institution they wish to become as they deepen their commitment and involvement in research activities. A provocative suggestion is the option for MI's Future to be either a 'Research College' or do they become Memorial-Lite? There might be a third option, not raised in any of the interviews, of constituting MI as a campus of Memorial providing industry-related collaborative research, both basic and applied, that contributes to full commercialization of products and processes in partnership with government funders and industry partners.

Through our interviews, we came to the view that "The College" has a lot of nostalgia in it. Everyone attaches importance to the history of MI as the Cod College in addition to the unique character of its linkage to Industry. But it is also the case that even before Memorial became a research-intensive university, the Cod College was active on the R&D side of the electronics of the fishery with respect to early developments in signals processing and the first over the horizon radar.

Across Canada, college applied research has grown exponentially over the years into a viable and complementary component of a healthy innovation ecosystem in Canada. While college applied, research has a decades-long history in Quebec through the College Centres for Technology Transfer (CCTT), as well as in pockets in British Columbia and Alberta (at the British Columbia Institute of Technology and the Southern Alberta Institute of Technology respectively), it was not until 2007 when the federal government launched the 2007 Science and Technology Strategy that college applied research was given formal federal funding. This was a one-time, $27M allocation for all colleges across Canada (and there are over 150). Since then, college applied research funding has expanded into over $50M in annual funding supporting applied research conducted in partnership with private and public sector partners.

College applied research in Canada performs a necessary function in the national innovation system. Colleges are innovation intermediaries, linking to both private and public sector partners to enable innovation. This means functioning as demand-driven innovation services organizations where industry and community partners can access the skills and expertise of their faculty and students, state of the art machinery and equipment, and their markets and networks. Colleges also work with university partners, helping them to get PhDs, patents, publications, and products out the door. In short, college applied research performs a necessary function in the continuum of research in Canada.

Research Funding

The major support for research college funding is the Community College Innovation Programme (CCIP) under NSERC.

MI has been told in the past by NSERC that it is not eligible for CCIP because it is under the Memorial governance structure. At the same time, MI has had difficulty filling funded research chairs because the appropriate candidate to meet its needs may not have the publication record traditionally used for Tri-Council funding criteria. This in at least one identified case created a Catch-22 for MI.

On the other side, CCIP is directly purposed to build college research capabilities. MI is a hybrid institution, a college within a university, but another hybrid is Emily Carr University in BC, which elected to join the CCIP pool likely because they recognized the need to develop their capacity.

SSHRC started a college program a year and a half ago – it was a pilot program on social innovation. Only colleges could apply, SSHRC did not use the terms and conditions of the CCIP but rather created their own. A

college could apply to the College and Community Social Innovation Program as well as into the general university pool of SSHRC funding. This might also be an option for MI.

The way the system in Canada works, a college declares eligibility for a certain category – either college or university. If college then they are not eligible to apply for other NSERC awards, and vice versa. BCIT for example, is in the university pool. Emily Carr University is in the college pool.

A key consideration here is that the CCIP is capacity development funding. One would elect to go into the CCIP pool if one wanted to develop research capacity. There is a staged model of engagement:

- Ad hoc project funding to get started (used also throughout the spectrum)
- 2 year Innovation Enhancement awards (IE) to develop capacity
- 5 year Innovation Enhancement awards (IE) to develop capacity to a higher degree
- Technology Access Centre (TAC) funding – TAC funding is 5 year renewable.
- There are also joint CCIPP IE 5 year awards coupled with CFI awards (CFI is capped at $2.5M). Colleges can apply to the regular CFI as well.
- There are also Industrial Research Chairs for Colleges, which like TACs are significant and intended to be based on demonstrated capacity already developed. They also have renewable funding but require strong industry cash contributions.

Logic Model for a Research College

Whatever MI decides to do on the research funding side, it would be well advised to consider the Logic Model from George Brown College to see how best to position itself within the innovation ecosystem. Even if MI is not a formal "College", there are important lessons to be learned from other best practices in Interactive Knowledge Transfer and Learning by Doing by more systematically linking research and training in a holistic way that blends curriculum, student skills and the profile of their client companies with the internal resource allocations and processes within George Brown. See below.

Purpose	**Foster innovation literacy in students while improving firm-level innovation**		
Participants	**Students**	**Firms**	**Measure**
Inputs	Faculty with interest in applied research. Funding to support student engagement in applied research. Projects and placements with firms. Business development to support firm engagement.	Projects and innovation support needed.	Students: GISAT (pre/post project engagement measurement). Firms: TO Next survey.
Activities	Project involvement through curricula, paid work, internship.	Project engagement and support of students' learning.	Activities are defined with the taxonomy (above) as per applied research services offered by colleges.
Outputs	Students produce products, prototypes, services for firm partners, as linked to learning outcomes.	Products, prototypes, services created for market entry.	Skills articulated (students) against output metrics (firms) collected as part of applied research activity.
Immediate outcomes	Students gain innovation literacy skills; can articulate these and demonstrate proficiency.	Firms commercialize new products or services.	Students: Awareness of skills acquisition; Number of students engaged in applied research. Firms: Successful market entry of new product or service.
Intermediate Outcomes	Graduates gain jobs as a result of gaining innovation	Firms that employ (or start-ups started with) students	Students: Number and jobs or start-ups.

	literacy skills.	with applied research experience have greater innovation capacity.	Firms: Number of employees hired.
Ultimate Outcomes	Graduates are more likely to start a company or work on innovations within a company.	Partner firms innovate, conduct R&D, and bring new products and services to market.	Students: GISAT measured over time, as linked to employer innovation performance. Firms: Greater likelihood of participating in innovation and enhancement of Canadian innovation system.

CONCLUSIONS

From the research done for this Report, it is possible to state some initial observations and suggestions about the Marine Institute and its contribution to innovation in Newfoundland and Labrador.

Major Themes

MI follows a generally similar pattern of technology transfer as other parts of the University but heavily concentrated at the mid-range end of the TRL Scale, with little in the traditional university discovery science TRL 1-3 range.

What clearly distinguishes MI is its role in knowledge transfer as opposed to technology transfer as such. This builds on its long tradition of industrial training.

Further, MI plays a unique role in the NL Innovation eco-system through its impact on SME firms in industrial training and IRAP assistance in enhancing the cognitive capacities and network capabilities of SME firms.

Culture and Change at the Marine Institute

The MI leadership always talks about starting the year $29M in deficit. In fact, MI makes up the balance, 2/3 on the Industrial Training side, 1/3 on the Research side. For an outside observer, the same budgetary and revenue issue is faced by heads of other Memorial units who are expected to match their salary bases with grants and other revenue.

What the operating deficit challenge has done is embed a deep commitment to Cost Recovery in the norms and incentives of the instruction. It has by necessity created an entrepreneurialism in the institution and its staff and by necessity it has led to the close interaction and relationships with private industry that is evident to all.

MI as a Hybrid Educational and Research Institution

The uniqueness of MI is that because of its industrial training side, it needs and manages long term interactive relationships with Industry, including SMEs. It is inherently involved in the Interactive learning channel of the University

MI is hybrid, a college or perhaps a polytechnic within a university. It faces problems under the Tri-council funding regime and is disadvantaged if not discriminated against. Even where it has clearance for new research chairs, the perfect fit of a candidate for MI and the Industry may not meet the traditional metrics like peer reviewed publications, etc. On the other hand, the college specific funding of NSERC, CCIP disqualifies MI because it comes under University governance.

Managing the Transition

There is tension over transition to a more research oriented MI. There is a fundamental culture issue but also HR, compensation and work load issues.

As referenced previously, MI is faced with the challenge of making up the $29M operating deficit issue it faces every year. In fact, industrial training pays 2/3 of the bill and research about 1/3.

At another level, the institution is bi-cameral in that about 80% of its regular students are in Maritime Studies and 80% of the research is in the Fisheries School. There are an additional 200 graduate students at MI, but the main drivers of the Budget lie with the former two factors.

This Report is not about HR issues, but it is clear that there are imbalances and feelings about the work schedules, status and compensation for the 'teaching' side as compared to the 'research' side of the institution. Other colleges and universities have found ways to balance these expectations and demands.

RECOMMENDATIONS

We recommend that the Marine Institute undertake a systematic re-examination and reorganization of the current role of its research office. Several of the research offices with which we are familiar at larger universities have a dual administrative structure that includes provision of support for obtaining external research funding in one administrative unit and managing commercialization activities, such as negotiating contracts with external corporate funders, licensing intellectual property from the institution and supporting start-up firms in a second administrative unit. We recognize that the Marine Institute is in somewhat of a unique position in that it technically falls under the jurisdiction of the Memorial research office for purposes of external research funding and of the Genesis Centre for purposes of commercialization and tech transfer. However, we believe that because of the unique nature of the Marine Institute it warrants having its own research office that could work collaboratively with the larger office at the University, but provide more direct supports to the researchers at the Institute. For this research office to function effectively, it would have to have its own strong Associate Vice-President for research based at the Institute. Having an expanded research office would also allow the Institute to provide more effective support to its members who are engaged in collaborative research activities or tech transfer activities with private sector firms in Newfoundland and Labrador. An expanded research office with a dual administrative structure would also be able to link more effectively into the ongoing support activities of the Genesis Centre, though this would require a change of mandate. An expanded research office based at the Institute would also be able to take on the task of better promoting the respective areas of expertise found at the Institute to existing and potential industry partners.

One of the initial tasks of this office could be to commence the negotiation process to resolve the ambiguities around the Institute's status as part research university and part community college. The critical issue that the Marine Institute needs to resolve is the question of its standing as either part of an accredited research institution namely the Memorial University of Newfoundland or as a recognized community college that is eligible for funding under NSERC's community college innovation program. As we have indicated at several points in the report, the fact that MI is considered as neither completely one or the other puts the institution in a tenuous Catch-22 position. Our first recommendation would be to undertake or to launch some kind a tripartite negotiation involving Memorial, the provincial government, and NSERC over how to resolve the Institute's eligibility for different kinds of research and commercialization funding programs. We believe that gaining recognition for the Institute as somewhat of a unique kind of hybrid institution somewhere between the existing Polytechnic model and the community college one would go a long way towards resolving some of the tensions and issues that came up at various points throughout our interview process.

From the interviews that we have conducted, it is also evident that there is a potential role for the Marine Institute to play in promoting more effective forms of networking and clustering among its existing and potential partners. In the extensive research that we have conducted on the nature of cluster organizations across Canada over the past 20 years, one of the consistent features that we have found is the potential role for innovation intermediaries to play in building networking linkages among firms based in specific industrial sectors within a geographical area. There are numerous instances of where innovation intermediaries have found it more efficient and more effective to fulfil their mandates by working with a collectivity of firms in the regional economy through some form of cluster organization. In some of the cases that we have studied these cluster organizations have already been in existence, but in other instances is the innovation intermediary itself which has played a critical role in bringing the firms together to create a cluster organization. The evidence from the interviews as presented in this report suggests that at least some of the partners of the MI view it as having the potential to play a more significant role in creating different forms of networking and linkages among its various partners. We believe this type of activity if successful would both raise the profile of the Institute among the broader community and serve to enhance its existing ties to its industry partners.

One other area that merits greater attention by the Marine Institute lies on the teaching side of its mandate. Several the interviews that we conducted drew attention to the need for more expanded and up-to-date work by the Institute on some of its teaching programs. We believe there is an enhanced role for the Institute to play in working with industry associations in the province to update and expand some of its existing curricular offerings. There might also be a potential opportunity for the Institute to create more co-op or experiential learning programs as part of its overall curriculum. In the research that we have conducted on co-op programs at other postsecondary teaching institutions, they have been found to be an effective mechanism for not only providing the students with hands-on learning experience, but they often constitute an indirect form of tech transfer between the teaching institution and its industry partners. The students on co-op placement can provide an indirect but highly efficient means for linking the firm at which they are on placement with potential technical and research expertise at the Institute in the form of various professors that they have studied with. This side effect of co-op programs represents a form of reverse tech transfer in which the co-op students serve as a type of demand pull mechanism for linking potential research or technical needs of the firms back into the existing capabilities of the institution. While cooperative education programs are both time-consuming and expensive to implement and administer, their proven track record in enhancing linkages between postsecondary institutions and their industry partners suggests that this is well worth the investment in time and dollars.

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APPENDIX 1: TECHNOLOGY READINESS LEVELS

TECHNOLOGY READINESS LEVELS IN THE EUROPEAN COMMISSION[3]

Technology Readiness Level (TRL)	Description
TRL 1	Basic principles observed
TRL 2	Technology concept formulated
TRL 3	Experimental proof of concept
TRL 4	Technology validated in lab
TRL 5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7	System prototype demonstration in operational environment
TRL 8	System complete and qualified
TRL 9	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

3 EARTO (European Association of Research and Technology Organizations), 2014. "The TRL Scale as a Research & Innovation Policy Tool, EARTO Recommendations". April 30, 2014.