Newfoundland & Labrador Energy Innovation Roadmap

Oil & Gas HSE Addendum

Final Report

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Contents

1 Introduction

1.1 Report context and objectives

The Newfoundland and Labrador Energy Plan, published in September 2007, sets out a vision and the key principles by which the Province will develop its energy resources for the long term benefit of its people, while ensuring an appropriate environmental legacy for future generations.

The Energy Plan identified the need for innovation to unlock the potential of these energy resources and committed to the development of an Energy Innovation Roadmap or Roadmaps. The development of these Roadmaps is being coordinated by the Energy Innovation Roadmap Project Steering Committee (Department of Natural Resources, Research & Development Corporation, Department of Innovation, Trade and Rural Development, Department of Business and Nalcor Energy) in a two-phase process. The first phase involves the review and prioritization of energy sectors for roadmapping purposes. The second phase involves the development of innovation roadmaps for each of these prioritized energy sectors.

DNR engaged E4tech, partnered with Orion Innovations and Wade Locke Economic Consulting, to assist in completing the first of these two phases of work. This consulting team researched energy sector innovation opportunities and engaged with key stakeholders within Newfoundland and Labrador (NL) in order to develop recommendations for prioritization in the second phase of roadmap development. The team issued its findings and recommendations to DNR in August 2010.

World events impacting the oil and gas industry, specifically the NL Cougar helicopter crash and the BP oil spill in the Gulf of Mexico (GoM), have raised questions about offshore health and safety, deep water drilling and environmental protection and clean up (HSE). DNR has asked the consulting team to review their findings and recommendations in the light of these events to see if they have implications for the prioritization of energy sectors for the development of innovation roadmaps.

1.2 Project approach

The team completed this project during August and September 2010 based on in-house knowledge and public domain information. The team also solicited input through email and telephone meetings with various stakeholders from within the energy sector and NL innovation communities, focusing on offshore oil and gas.

1.3 Structure of this report

This document first revisits the recently completed innovation prioritization work to identify the role that HSE factors played in the consultation and resulting priorities. In chapter 3, we then examine the key features of the BP-Macondo-well incident and the Cougar helicopter crash, identifying the anticipated regulatory changes that are likely to result from these incidents. In chapter 4, we review the resulting innovation requirements that were identified during consultations with stakeholders and consider how these relate to the previously identified priorities in the recently completed work.

Chapter 5 assesses the innovation capabilities that were previously identified or came to light during interviews with NL innovators, allowing us to map areas of potential strength onto the areas of need from chapter 4. The final section draws together the implications from the report, focusing on the messages for the next phase of the Energy Innovation Roadmap exercise.

2 HSE in the Phase 1 Energy Innovation Roadmap

2.1 Input from consultees

Phase 1 of the Energy Innovation Roadmap required identification of priority, technological-innovation areas for NL, based upon the scale of the market for the innovation and the basis for NL competitive advantage. This involved numerous consultations including industry stakeholders over the period November 2009 to January 2010. During this time, the Cougar Flight 491 helicopter crash inquiry was under way, but the BP Macondo well incident had not occurred. Health, safety and environmental protection was a recurrent topic that was manifested in many of the discussions during Phase 1 consultations in several different ways:

- None of the consultees played down the importance of HSE as an area for technological improvement, though few offered any thoughts on the topic in the context of NL capacities and needs specifically.
- Most of the consultees identified the harsh environment in one form or another as a fundamental driver for innovation. Implicit in this is the need to minimise operational risks, all of which have an HSE dimension. Illustrations provided during the consultations include:
    - Better prediction of metocean conditions is needed to allow safe operations to be planned precisely;
    - Detailed asset integrity monitoring of oil and gas structures is needed to enable prediction of maintenance needs and continue safe and environmentally-responsible operations;
    - Techniques for ice management continue to be a priority, allowing safe operation in iceberg-prone waters.
- Several consultees cited the need to innovate for safety in Arctic conditions (as distinct from harsh seas), where normal safety systems may not be appropriate or sufficient. Specific examples included escape systems for ice-bound structures and lifeboat engines suited to pack ice.
- One consultee explicitly mentioned safety and risk management as vital since they affect staff retention, amongst other things. This was linked to a need for state of the art training facilities, but not specifically to technological innovation.
- A small number of consultees mentioned long range offshore logistics as a challenge, given the hostile environment. Innovative solutions may be appropriate.

In summary, HSE (in particular safety) was an underlying theme in many of the discussions about innovation priorities. The need for safe operating practices, rather than innovation, was underlined by several parties. Awareness of this need was, perhaps, heightened by the hearings into the Cougar helicopter crash at the time of the consultations. In contrast, however, none of the consultees identified oil and gas spill prevention, response and clean-up as a specific priority for innovation in the context of NL.

2.2 Recommended innovation priorities

The resulting innovation priorities, presented in the Innovations Priorities report, covered several areas of oil & gas. These areas included aspects of HSE, as shown in figure 1 below which shows the recommended priorities for roadmapping. Italic text indicates where HSE relating to offshore operations is a relevant theme (note that one onshore opportunity is also shown below).

Category		Barrier	Innovation Opportunity
A	Innovation opportunities with both a local and international value, that may be addressed by international innovators but where NL has, or can acquire an internationally competitive position.	*Harsh environment*	*Develop technologies and techniques that can be applied in increasingly harsh environments. Covering exploration, project development and production phases (including gas export innovations).*
		Arctic conditions	*(See also Harsh environment) – Focused innovation program featuring the safety, subsea and unmanned techniques that will unlock known and potential Labrador gas and also other Arctic oil & gas.*
		Subsea protection	*Develop and demonstrate cost effective subsea pipeline and facility protection solutions that can reduce future project costs.*
B	Innovation opportunities that have a significant local value and limited international value, where NL will have to lead the way if barriers are to be overcome and energy resources are to be exploited.	*Enhanced recovery*	*Intensify research into reservoir structures prevalent in NL. Model and then trial techniques for enhanced recovery.*
		Far offshore logistics	*Research and model logistics solution(s) for offshore NL. Consider supporting shared facility for whole industry.*
		Onshore seismic	Develop lighter seismic equipment and soft tire vehicles that can access sensitive areas when ground is not frozen.
C	Innovation opportunities that are being addressed by significant numbers of international innovators, where NL does not have an internationally competitive position, and is unlikely to acquire one.	*Lack of decommissioning experience*	*Predict decommissioning needs of NL structures, identify where similar abilities will be required internationally, and understand technical requirements.*

Figure 1: Innovation priorities identified in recently completed innovation priorities report

3 Shifting emphasis on oil and gas HSE

The Cougar Flight 491 crash and the BP-Macondo-well incident in the GoM continue to create attention around offshore issues related to the environment, deep water drilling and occupational health and safety. Although the extent and details of the potential implications are currently unknown, these events will clearly have an impact, not just upon the NL oil and gas sector but upon the whole global upstream oil and gas industry. Although it is unlikely that these events alone will have a macro level effect on the shift towards non fossil energy, it is likely that the accumulated effect of HSE challenges over time will contribute to the increased relative cost of oil and gas compared with non fossil energy.

3.1 Overview of the Gulf of Mexico incident

On 20 April, 2010 the *Deepwater Horizon* drilling platform exploded and subsequently sank in the GoM, the result of methane leaking out of the well, up through the drilling column and onto the drilling rig. It is suspected that a seal was not properly formed between the production and protection casings, a process the rig had just completed at the time of the incident[1]. A seal is typically formed by pumping cement between the casings and is meant to control the pressure from the oil and gas below. Additionally, the methane was routed from the riser onto the rig rather than being diverted overboard, according to the recently published BP report[2]. The sinking of the drilling platform bent and tore the riser allowing oil to leak out from the well.

Ongoing investigations are trying to fully ascertain the reason for the initial explosion which caused the catastrophe. Testimony to a federal hearing by a Halliburton official indicated that a variety of recommendations and standard practices were not followed during the cementing process, which immediately preceded the rig explosion[3].

The Macondo well was fitted with a blow-out preventer (BOP) that was designed to shut off the well on command or if communication was lost with the drilling platform — neither of which successfully occurred. The failure of these systems meant that there was no above sea means to shut the well and prevent oil and gas from leaking out from the heavily damaged riser.

Manual underwater shutting of the BOP was attempted by remotely operated underwater vehicles (ROV's) but failed. Oil leaked from the well head for nearly three months, creating the largest ever US oil spill.

As part of regulating US offshore drilling, the Minerals Management Service, (MMS) was responsible for applying the National Environmental Policy Act (NEPA) to offshore drilling activities. NEPA requirements are met by producing an environmental impact assessment (EIA) or through a categorical exclusion, whereby an activity has been determined through an appropriate public

[1] http://www.energybulletin.net/node/52879
[2] http://www.bp.com/sectiongenericarticle.do?categoryId=9034902&contentId=7064891
[3] http://www.nytimes.com/2010/08/25/us/25hearings.html?ref=gulf_of_mexico_2010

process not to raise environmental issues or concerns which require an EIA. The BP Macondo site was provided with a categorical exclusion[4].

Since this incident, however, this practice has been amended by a new directive that requires all new applications for permission to drill in the GoM to provide information on potential blow-out scenarios[5].

BP published its own findings on the Macondo well incident in September 2010 and the US Oil Spill Commission final report was released in November 2010[6]. The latter concluded that the incident was avoidable and “resulted from a series of identifiable mistakes made by BP, Halliburton, and Transocean”. Numerous recommendations were made and the legal ramifications continue.

3.2 Overview of Cougar Flight 491 crash

On March 12th, 2009, Cougar Flight 491, en route to Hibernia and Sea Rose platforms in the Grand Banks, crashed into the ocean killing 17 on board with only one survivor.

Eleven minutes before crashing, the pilots of Flight 491 reported a loss of pressure in the helicopter’s main gearbox[7].

The crew immediately changed course toward land. The Sikorsky S-92 helicopter is certified by the Federal Aviation Administration, which prescribes that the aircraft must provide a 30 minute run-dry time, meaning that the gear box could operate for 30 minutes from the time the flight crew recognizes a failure of the lubrication system[8]. Minutes after heading for shore, flight 491 crashed into the ocean, 55 kilometres east of St. John's.

It was discovered that the primary cause of the gearbox malfunction was the failure of two of the three titanium studs that secured the oil filter bowl assembly to the helicopter’s main gearbox. The Transportation Safety Board confirmed that the titanium studs broke in flight, resulting in the loss of oil pressure.

The same make of helicopter made an emergency landing in July 2008 in Australia, when the same gear box malfunction was caused by the failure of the studs securing the oil filter assembly[9].

The manufacturer, Sikorsky, issued an alert six weeks before the Cougar crash telling S-92 operators to replace the titanium studs with steel parts. However, the bulletin did not state compliance was

[4] http://www.doi.gov/news/pressreleases/loader.cfm?csModule=security/getfile&PageID=42036
[5] http://ohsonline.com/articles/2010/06/21/blowout-scenarios-now-mandatory-for-offshore-drilling.aspx?admgarea=news
[6] http://www.oilspillcommission.gov/final-report
[7] http://www.cbc.ca/fifth/2009-2010/cougar_491/timeline.html
[8] http://rgl.faa.gov/REGULATORY_AND_GUIDANCE_LIBRARY/RGFAR.NSF/0/9fb3a7912eece9fa85256613006cb715!OpenDocument
[9] http://www.thetelegram.com/News/Local/2010-08-26/article-1699645/Cougar-suing-Sikorsky/1

immediately essential, allowing for the modification to be made within one year or 1,250 flight hours[10].

Supreme Court Judge Robert Wells' inquiry to the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) was released on November 17, 2010 including 29 categories of recommendation[11].The NL Government's assessment of the report and its recommendations is continuing although the NL Government has accepted all 29 recommendations. In addition, the Transportation Safety Board's report on its investigation of the crash of Cougar flight 491 was released on February 9, 2011, recommending four key reforms[12].

3.3 Changing oil and gas regulations

It has been asserted that the design and execution of BP's Macondo well site was risky and flawed and it is likely that other similar plans were also approved by the regulator, MMS[13]. Recommendations for stronger regulation and higher safety standards in offshore oil and gas drilling have already been made. However, general standards in Norway, the UK and Canada already exceed US standards, in some cases substantially. It is nevertheless anticipated that well designs and equipment will face more demanding guidelines.

There will probably be a need for companies to demonstrate increased well intervention and oil spill response capability. As a result of the BP Macondo incident and the resulting high cost of environmental damage, higher fiscal capability to pay for potential oil spills and the resulting impacts will be expected. It is also expected that it will take more time for permits to drill to be approved.

More broadly, it is likely that the GoM incident will increase the consciousness of the general public, media and regulators worldwide about the risks associated with oil and gas operations, for many years to come. Regardless of the existing status of regulations, tougher questions will be asked of oil and gas companies as they prepare to operate offshore, in particular, in sensitive environments such as the Arctic.

As noted in the previous section, the Cougar Flight 491 incident has already had a material impact on helicopter and safety operations in NL. For example, night flights have been restricted and search and rescue response times have been shortened.

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[10] http://www.winnipegfreepress.com/canada/breakingnews/cougar-helicopters-sues-manufacturer-and-feds-over-fatal-nl-chopper-crash-101565343.html
[11] http://www.cbc.ca/news/pdf/nl-chopper-recommendations-20101117.pdf
[12] http://www.tsb.gc.ca/eng/medias-media/majeures-major/aviation/a09a0016/mi-a09a0016.asp
[13] http://www.energybulletin.net/node/52879

4 Implications for technical innovation requirements

4.1 Overview

We spoke to a cross section of offshore oil and gas sector stakeholders, to further discuss their innovation priorities in the context of HSE. In our previous report, the analysis was conducted at a broader level - looking at innovation priorities across the whole energy sector. HSE-related innovation was a part of these discussions but was not a specific focus. For this report, our discussions with stakeholders went deeper into HSE priorities within the context of the Cougar 491 and BP Macondo incidents.

Within five of the existing innovation priority areas, four groups of HSE priority areas were identified, each with specific requirements for technical innovation. Within the four groups, a total of 12 HSE-related technical innovation requirements have been identified. It is possible that other requirements may exist, though this list was created drawing upon the views of a representative list of stakeholders with a good knowledge of the foregoing energy innovation prioritisation work. There was, however, frequent mention of many items on this list.

Many of these HSE innovation areas were already recognised to some extent by stakeholders prior to the BP and Cougar incidents and were elevated as a result of them. Figure 2 identifies the innovation opportunities cited by industry stakeholders during recent interviews in the context of the existing innovation priority areas. The following text provides more information about the innovation priorities as mentioned by oil and gas stakeholders.

✓= HSE innovation requirements fit into existing innovation priority areas

		HSE risk mitigation through design			**HSE risk mitigation during operations**		**Human protection**		**Oil spill response and clean up**				
Fit with existing priorities	**Existing innovation priority area**	BOP design and interface	Fewer personnel by use of subsea production	Fewer personnel by use of power supply from onshore	Training via advanced offshore simulators	Techniques for safe well intervention	Flight suits for cold water survival	Arctic weather work-wear	Blow out caps	Oil detection in ice	Radar tracking of spills	Low impact dispersants	Cold water cleanup
	Harsh environment	✓	✓	✓	✓		✓				✓		✓
	Arctic conditions	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓
	Subsea protection	✓											
	Far offshore logistics				✓		✓						✓
	Enhanced recovery					✓							
	Not previously covered								✓				

Figure 2: HSE-related innovation needs cited by stakeholders, mapped onto existing priorities

4.2 HSE Innovation Opportunities Identified from Consultation Discussions

HSE risk mitigation through design

Blow-Out Preventer (BOP) design and interface - There is research already underway for BOP design for Arctic environments. Additionally, the federal investigations into the BOP failure at the BP Macondo well highlighted the need for BOPs to be equipped with sensors or other tools to obtain accurate diagnostic information (for example regarding pressures and the position of blowout preventer rams). An additional focus is the need to be able to interface with BOPs using underwater vessels.

Fewer personnel by use of subsea production- Production facilities can be installed on the seabed rather than on the surface and fluids produced via a platform or transported directly to the beach. However, the need for processing of fluids limits the extent of this. Moving equipment from the surface, or avoiding a surface installation altogether, is attractive from a safety perspective as fewer personnel are in potentially dangerous environments and so this remains a longer term objective.

Fewer personnel by use of power supply from onshore - Power could be sent to offshore facilities via undersea cable from onshore power generation equipment. This lessens the amount and complexity of equipment on board the platform, requiring fewer people on board and less frequent maintenance visits.

HSE risk mitigation during operations

Training via advanced offshore simulators- Large simulators are already available to simulate a variety of aviation and marine settings. Such simulators could be designed to train for specific helicopter and marine oil and gas emergencies. They could also contribute to wider innovation on the human factors and decision-making relating to HSE.

Techniques for safe well intervention- Well intervention can be both complex and risky. Techniques for intervention and well kill using non-traditional (i.e., non-rig-based) means are desirable.

Human protection

Flight suits for cold water survival- The need for further development of survival equipment was a recommendation of the Wells inquiry. With increased activity in cold-water areas, well designed survival suits will be an important part of safety in case of a flight emergency.

Arctic weather work-wear- Clothing will be required that can keep offshore workers warm and dry in cold and harsh environments, but still allows them to be functional, i.e., retaining hand movement and dexterity.

Oil response and cleanup

Blow out caps- In the case of a well blow-out, a cap is often used to close it off. It was identified that there is room for further technical innovation of blow-out caps.

Oil detection in ice - If oil spills or leaks beneath ice, particularly with snow cover, it can be very hard to detect and track where it is and is moving. Innovation in technology is needed to improve detection and monitoring under ice.

Radar tracking of spills - The tracking of oil in the ocean, especially in rough weather conditions, is difficult. Radar can potentially be used in this capacity but requires improvement.

Low impact dispersants - Dispersants, used to break up oil spills into very small particles, can be damaging to the environment, especially in large quantities. Low environmental impact dispersants would therefore be beneficial. Furthermore, there is a lack of understanding of how dispersants function in cold water and there may be room for innovation in this regard.

Cold water cleanup - In cold water, oil becomes thick and sticky and can be difficult to clean up using conventional methods such as booms, especially if the oil is under ice. Therefore, there is a need for technology that can clean up oil in cold and icy conditions.

It should also be noted that some stakeholders anticipated the need for improvements in procedures and systems related to HSE, though these do not entail technological innovation so are not discussed here.

The innovation priorities identified in this section are not recommendations for activity in NL as such, since they do not take into account the relative capabilities of NL innovators to satisfy the requirements. This is addressed in the following section.

5 Identification of innovation opportunities

5.1 NL innovation capabilities

As outlined in the main Innovation Priorities report, NL has areas of internationally competitive innovation capability relevant to the oil and gas sector, in particular related to technology and operation in harsh ocean and Arctic conditions.

There are a number of academic and research institutes with significant R&D infrastructure and resources. These include: NRC's Institute of Ocean Technology; MUN's Faculty of Engineering and Applied Science, Departments of Earth Sciences, Physics and Physical Oceanography, the Ocean Engineering Research Centre and 3-D Visualization Centre; College of the North Atlantic; Marine Institute; C-CORE; and Propel (formerly Centre for Marine CNG).

There are also a number of local technology-based companies, which have typically spun-out of academia, with innovation capabilities relevant to offshore oil and gas-related markets. These include monitoring, simulation and ocean engineering activities.

5.2 NL HSE innovation opportunities

While the high level priorities for innovation within the oil and gas sector have not changed as a result of these developments, an increased emphasis on HSE is likely to necessitate increased investment in HSE-related innovation within these high priority areas that may provide opportunities for NL.

Most of the innovation requirements outlined in Section 4 related to HSE within the oil and gas sector are likely to be met by international innovators within oil and gas companies, their suppliers, and specialist research and academic institutions.

However, NL is well placed to exploit the likely increased expenditure on HSE-related innovation in areas of niche specialist capability, in particular related to harsh ocean and Arctic conditions.

Discussions with various stakeholders identified specific well-established capabilities of relevance to the innovation needs identified in Section 4. These include, for example, oil spill detection, response and clean-up in ice environments (C-Core), and safety response and evacuation simulation (Marine Institute). The latter could also provide further opportunities in understanding human factors and decision-making, which require closer investigation during roadmapping. These are shown relative to identified innovation priorities in Figure 3 below, and are shaded in dark blue.

NL has specialist knowledge, capabilities and infrastructure that is very relevant to other areas of innovation need. These include for example the testing of flight suits and arctic weather work-wear. Similarly, NL is able to deploy specialist knowledge and infrastructure in support of organizations developing chemicals, tools and techniques for oil spill clean-up in cold water environments. These opportunities to support or collaborate in innovation are shaded in pale blue in Figure 3 below.

There are numerous other areas of innovation activity within NL that have relevance to HSE in the oil and gas sector such as offshore and marine safety and ocean environmental risk modelling and engineering; and design and operation of underwater gliders and remote operated vehicles (MUN). Although these do not necessarily map directly to the 12 innovation needs identified in Section 4, they do fit with the 6 existing priorities and are HSE innovation opportunities.

Fit with existing priorities

	HSE risk mitigation through design			HSE risk mitigation during operations		Human protection		Oil spill response and clean up				
Existing innovation priority area	BOP design and interface	Fewer personnel by use of subsea production	Fewer personnel by use of power supply from onshore	Training via advanced offshore simulators	Techniques for safe well intervention	Flight suits for cold water survival	Arctic weather work-wear	Blow out caps	Oil detection in ice	Radar tracking of spills	Low impact dispersants	Cold water cleanup
Harsh environment	✓	✓	✓	✓		✓				✓		✓
Arctic conditions	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓
Subsea protection	✓											
Far offshore logistics				✓		✓						✓
Enhanced recovery					✓							
Not previously covered								✓				

✓ - Identifies where HSE innovation requirements fit into existing innovation priority areas

Indicates high NL strength

Indicates medium NL strength

Figure 3: HSE-related innovation needs matched with areas of NL strength

6 Implications for phase 2 of the innovation roadmap

The two major HSE-related events that were the subject of this report are likely to have a significant impact on the NL offshore oil and gas sector. However, the majority of the short to medium term effects will be upon the processes and systems that companies must follow, since these incidents appear to be largely due to failures in these areas.

Technological innovation can and will play a part in helping oil and gas companies to meet and exceed stricter regulations. Discussions indicated several areas where new technology will be instrumental to identifying and mitigating HSE risks. Most of the stakeholders were keen to point out that these innovation needs fall within the broader scope of the previously identified innovation priorities. Our subsequent review of responses supports this in almost all cases.

Our discussions also included a number of oil and gas innovators, who offered their views of how their work could respond to perceived HSE innovation requirements of the oil and gas sector. In some cases, there was a good fit of current NL capacities/activities with the actual requirements, in others there was an aspiration to evolve to meet needs as they may arise.

Overall, the previously identified innovation priorities do not appear to have been fundamentally altered by the two incidents. What has changed is the relative importance of innovation areas within the general priorities. An example is the heightened significance of oil spill-related innovation within the previously defined category of Arctic innovation.

NL has some areas of known strength in the newly-defined innovation areas including, for example, oil spill detection and tracking in ice environments, and safety response and evacuation simulation. NL also has specialist knowledge and capabilities that are relevant to other areas of innovation need, including, for instance, the testing of flight suits and arctic weather work-wear and support for oil spill clean-up in cold water environments.