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Canadian Arctic Underwater Sentinel Experiment (CAUSE)—Gascoyne Inlet Camp (GIC) 2017 field trial

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Defence Research and Development Canada

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IMPORTANT INFORMATIVE STATEMENTS

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Abstract

This document contains the trial plan that was developed for approval and conduct of the summer 2017 field deployment to Gascoyne Inlet Camp (GIC) on Devon Island, NU. This trial was successfully conducted during the period July 24–August 21, 2017.

Résumé

Ce document présente le plan d’essai, élaboré pour approbation et exécution à l’été 2017, du déploiement sur le terrain au campement de Gascoyne Inlet, sur l’île Devon, au Nunavut. L’essai, qui a eu lieu du 24 juillet au 21 août 2017, s’est déroulé avec succès.

Introduction

Field trial plans are required to obtain approval for field activities and to inform staff of the activities and schedule of the deployment. Following the field trial, the plan is a useful record of the objectives, location, participants, experiments, and logistics involved.

This trial plan describes a summer time deployment to the DRDC field camp at Gascoyne Inlet on Devon Island, NU. The trial was part of the Canadian Arctic Underwater Sentinel Experiment (CAUSE) that is a project of the All Domain Situational Awareness (ADSA) program.

The trial plan describes the general trial objectives and experiments, while the annexes include the detailed trial plans produced by Canmet Energy and Ocean Networks Canada. Annex C is a copy of the Nunavut Scientific Research License for the trial.

The trial plan follows immediately behind this page.

Conclusion

With the GIC 2017 trial completed, this reference document is intended to provide a permanent record of the field deployment that can be referenced in future documents.

Project CAUSE 99ac

CAUSE – GIC 2017 Field Trial

July 2017

DRDC Atlantic File: 4186-03

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V2017.07.12

DRDC | RDDC

Field Trial Plan Routing Sheet

Field Trial Name: CAUSE - GIC 2017 Field Trial

Field Trial Chief Scientist: Garry Heard

Initiation			
	Yes	**No**	**Signature/Date**
Are the Field Trial objectives consistent with the requirements of an S&T project or a Directed Client Support (DCS) Task covered under MARCORD 02-03?	☐	☐	Applicable PM
Field Trial Plan Review			
	Yes	**No**	**Signature/Date**
Does it require water space, a warship or submarine, USV, or UUV at sea?	☐	☐	NOLO
Does it involve evaluation of software, equipment, procedures or concepts of potential use to the RCN? Does this evaluation require an RCN warship or installation of equipment therein?	☐	☐	NELO
Does it require special facilities outside of DRDC? Does it involve equipment or personnel brought into Canada by a foreign nation?	☐	☐	CSO
Does it require airspace, air assets or UAV?	☐	☐	ALO
General Comments			
This trial will test technologies for Arctic surveillance capabilities as part of the CAUSE Project 99ac.			

CAUSE – GIC 2017 Field Trial

Chief Scientist: Dr. Garry J. Heard garry.heard@drdc-rddc.gc.ca

Project Manager: Erin MacNeil erin.macneil@drdc-rddc.gc.ca

Overview

This field trial will be conducted at the DRDC Atlantic Gascoyne Inlet Camp (GIC) on Devon Island, NU. The trial is being conducted to fulfill the requirements of the Canadian Arctic Underwater Sentinel Experimentation (CAUSE) project (99ac).

This trial will allow for the conduct a number of activities for the CAUSE project that have ties with NRCan CANMET Energy, Ocean Networks Canada, and Bedford Institute of Oceanography (BIO). In addition, it will also support DRDC experiments directly.

Collaboration with BIO has resulted in a joint request for ship support by the Canadian Coast Guard. DRDC and BIO will share time on the supplied vessel.

Trial activities will be carried out between 25 July and 25 August 2017.

Participation

DRDC Atlantic:

Trial Chief Scientist: Dr. Garry J. Heard

Twelve DRDC personnel will be needed for the conduct of the trial. A camp team will proceed north from approximately 25 July to the 22 August. A science team will join the camp team from approximately 1 – 18 August.

CCG Vessel:

CCGS HENRY LARSEN is expected to participate in the fieldwork. DRDC will pay for five sea days, while BIO will have seven days of research opportunity. The vessel is expected to begin the work with a crew change in Resolute on 9 August 2017. DRDC will then begin work on the ship 10—14 August and BIO will follow in the period 15—20 August.

NRCan CANMET Energy

Two CANMET Energy personnel will work under an MOU with DRDC on the installation of a power source for remotely deployed gear. The CANMET personnel will participate from approximately 4—8 August.

Ocean Networks Canada

Seven personnel from Ocean Networks Canada (ONC) will participate in the trial during the period 6—10 August. Three personnel will be in full attendance at the camp, while four personnel will only visit GIC for a four-hour period on the last day of activity. The three full-time personnel will be conducting work on the installation of a new split-pipe cable protection for the ice region along the shoreline. If this split-pipe protection is successful, costs of cabled underwater instruments in the archipelago would drop significantly since it would not be necessary to drill holes through the bedrock under the littoral zone in order to protect cables from ice abrasion.

Bedford Institute of Oceanography

BIO personnel are collaborating with DRDC in shared usage of the CCGS resource. BIO will conduct oceanographic measurements in support of both organizations. BIO is also collaborating with ONC on the split-pipe protection test and will be providing near real-time communications from a test instrument running on a cable through the split-pipe. BIO will also be updating and re-installing their DFO Arctic Oceanographic Observatory, which has a dry-end station, hosted in one of the GIC science huts. BIO personnel will join the CCGS in Resolute on 9 August and will depart from GIC on or about 20 August.

Danish Defence Force

An initial plan was for two observers from the Danish Defence Force to participate in the operation of the deployed seafloor arrays at GIC; however, it is uncertain if this site visit will occur.

Canadian Armed Forces

Two CAF personnel will participate in the field trial to serve as the bear watch team.

Contractor Services

A contract cook and cook's helper are being contracted for the duration of the trial.

Objectives

The objectives of this field trial are:

- Determine if the acoustic arrays deployed in July 2015 as part of the Northern Watch Technology Demonstration Project are still functional after a two-year continuous deployment.
- Collect data to support ambient noise estimation, propagation loss estimation, and low-frequency communications tests.
- Conduct short-term deployment of a Starfish Sensor Cube and two ICListen hydrophones in place of or in addition to the Northern Watch arrays as acoustic receivers.
- Conduct acoustic projector tows in support of propagation loss measurements.
- Conduct simulated target detection and tracking scenarios with the CCGS.
- Conduct a split-pipe protection test to evaluate the option for lower-cost and more rapid deployment of Arctic cables crossing the littoral zone.

- Establish a series of remote recording cameras to observe the ice motion along the shoreline and investigate their operation in an extreme environment as a precursor to live transmission of images from similar cameras. The cameras will be deployed to record the split-pipe and ice interaction.
- Conduct a long-term field deployment of a fuel cell based power system for intermittent operation of electronic systems in remote areas.
- Re-install a remote weather station in support of long-term environmental condition monitoring.
- Assist with the update and re-installation of the DFO Arctic Observatory.

Network Accreditation and Certification

Not applicable.

Experiments

This section briefly describes each of the planned experiments and activities to be conducted during the trial.

Land-based set-up

This sub-section provides some information regarding the equipment required and locations for it on land. Figure 1 illustrates some of the node positions and communication limits and ranges. The old and new science huts are denoted by waypoint markers on land near the top of the map image. The location of the BIRDSEYE site is denoted by a red waypoint marker on the ridge to the south of the camp.

BIRDSEYE or a Better Location

A **radio repeater** will be installed either at the BIRDSEYE site or at a preferred location on the peak across the inlet denoted by a blue waypoint marker. Radio communications are limited by the topography of the area. Yellow lines from the BIRDSEYE site indicate the angular limits of communications with the radio repeater installed there. Experience has shown that the repeater installed at BIRDSEYE has limited angular view and range due to the low altitude. If the repeater could be installed at the preferred location, then the angular view will be greatly increased as denoted by the orange lines. Radio ranges are expected to be much greater from the preferred site, as the antenna would be more than twice the altitude available at BIRDSEYE. There is no difficulty communicating the 2.45 km from the Camp to the preferred site, but installation of the repeater is extremely difficult without a helicopter. We may be limited to the BIRDSEYE site for the repeater with the result that most communications to the CCGS will have to rely on Iridium and email.

The BIRDSEYE site will host a **gateway repeater** that will allow us to communicate with the two gateway buoys associated with the Starfish Sensor Cube. The Benthos Modem will be located approximately 3.75 km from BIRDSEYE, while the high-speed gateway will be approximately 4.5 km. No difficulties are expected over these ranges, except possibly in severe weather conditions. Again, it would be best to install the gateway repeater at the preferred site.

The link from BIRDSEYE to the Camp is only 560 m; however, this short hop is more problematic than the links to seaward. The gateway repeater is composed of a third repeater buoy. As such, its location is critical as the antenna on the repeater must have a clear view of both the gateway buoys and the camp simultaneously. Since we cannot raise the repeater far above the ground, it will be necessary to position the repeater at the top of the ridge to provide clear line of sight to the endpoints.

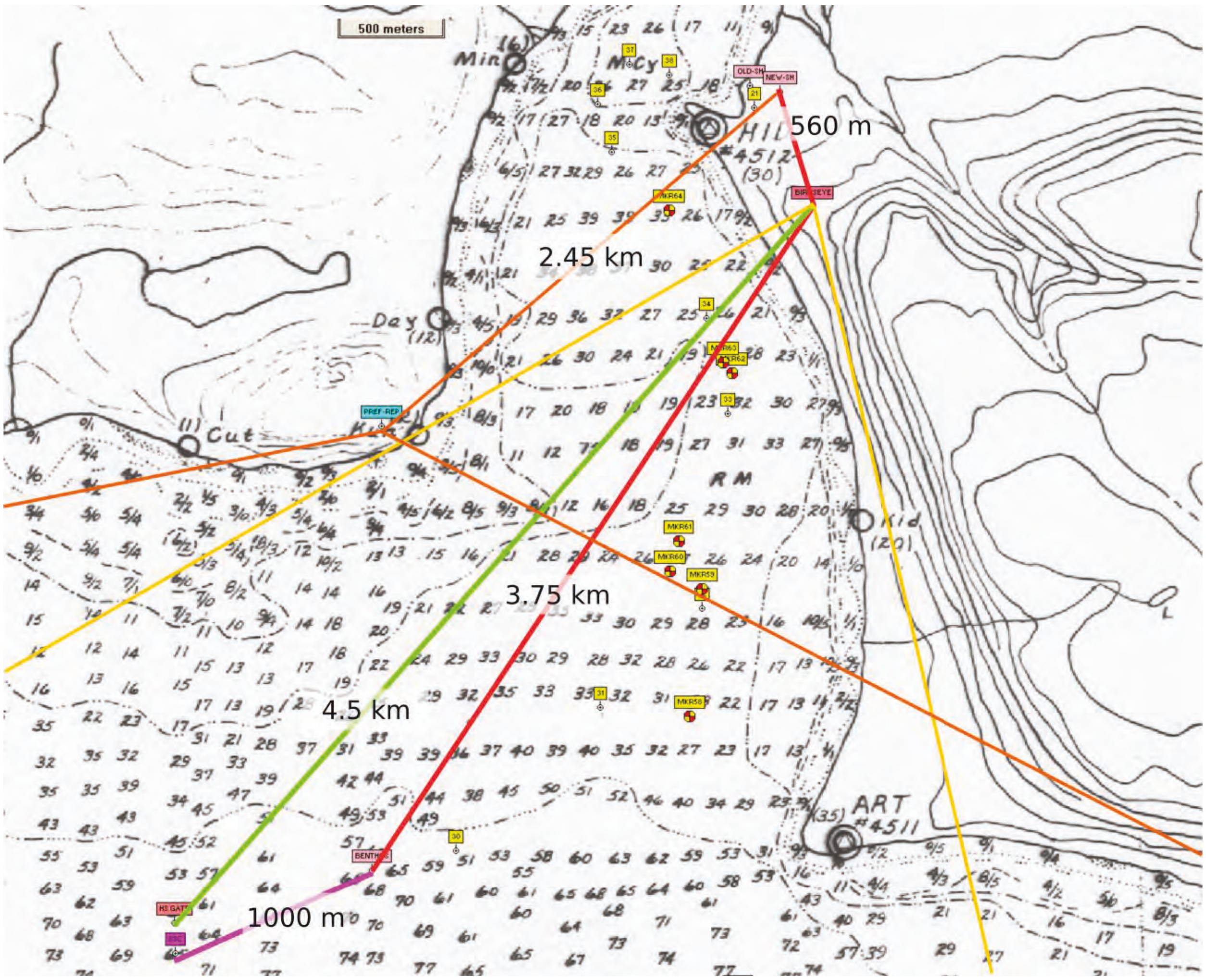


Figure 1. *Waypoint markers (in colour) designate nodes, cable lay tracks, and camp structures. Overlaid lines indicate communication ranges and radio limits of view.*

A third instrument is required to be installed at either the preferred site or the BIRDSEYE site. This instrument is an **AIS receiver** with Freewave data link to the camp. Installation of the AIS receiver at BIRDSEYE is known to be adequate, but far better coverage would be expected at the preferred site.

Old Science Hut

The old science hut will be used to host the DFO Arctic Observatory. The gear is already inside the hut, but will be replaced/updated with new equipment.

The camera systems will be mounted on the roof of the old science hut. There is an aluminum gantry and there will be batteries and solar panels to provide power for these THREE cameras. The cameras will primarily be used to observe the split-pipe and its interaction with the ice at the shoreline.

Note that one of the camera systems has a high-intensity LED lighting source.

The old science hut will support ONC gear related to the split-pipe trial as required.

The old science hut also supports the Iridium connected weather station, which is to be reconfigured.

New Science Hut

The new science hut will be used to operate and test the Northern Watch (NW) arrays. The STB gear will be installed here for the duration of the trial. The new hut will also be used to house the CANMET Energy power source for the NW arrays. The power source will likely be installed in the rear section of the hut.

Since the STB is the main Starfish controller and data recorder, the radio links will be terminated at this hut.

The new science hut will also be used for log taking and record keeping activities.

In water set-up

This sub-section provides information on the planned locations of the in-water nodes to be deployed and recovered during the trial. The NW arrays are already deployed and are a part of the sensor suite for the experiments.

Figure 2 provides an overall picture of the node deployments during the trial. There will be two ICListen hydrophones, a Starfish Sensor Cube with hi-speed gateway and a separate Benthos Modem Gateway, there will be a Star Oddi CTD sensor logging string, and the two already deployed NW arrays.

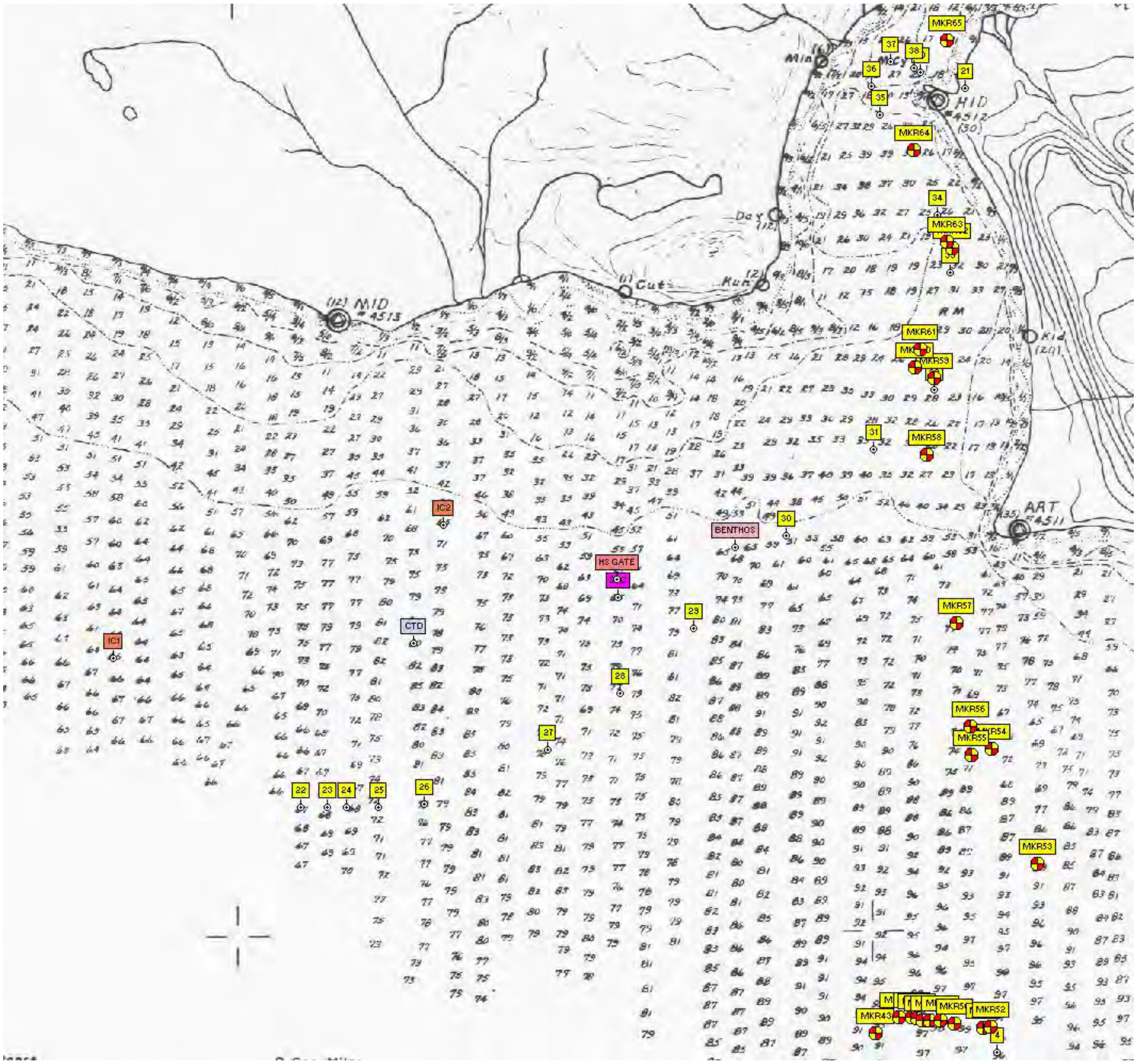


Figure 2. *The yellow and red-yellow markers indicate the two NW arrays and their associated cables. The cluster of red-yellow markers designate Array 1, which is not well laid out on the seafloor. Yellow markers22-26 designate Array 2, which is laid straight and true. The Starfish is denoted by the fuchsia coloured marker, the dark pink marker is the high-speed gateway, the light-pink marker is the Benthos gateway. The iCListen hydrophones are marked in orange and the CTD logger string is marked in light blue. Depths listed in the figure are in fathoms.*

The Table provides the planned locations of the nodes to be deployed and the actual nominal locations of the NW arrays. Table 2 provides the inter-node spacing of the nodes if they are deployed at the planned locations. Table 3 provides the sensor depths and water depths for each node.

Table 1. Planned node locations.

Waypoint	Latitude	Longitude
IC1	74 37.1744	91 31.9430
IC2	74 37.726	91 26.739
SSC	74 37.412	91 24.010
HiSpeed Gateway	74 37.490	91 24.020
Benthos	74 37.619	91 22.144
CTD String	74 37.225	91 27.219
Array2 (Nominal)	74 36.54	91 28.29
Array1 (Nominal)	74 35.61	91 19.16

Table 2. Inter-node spacing in kilometres.

	IC1	IC2	SSC	A1	A2	CTD	Benthos G	HiSpd G
IC1	0	2.77	3.94	6.9	2.15	2.34	-	-
IC2		0	1.46	5.4	23.5	0.96	-	-
SSC			0	4.14	2.67	1.63	1.0	0.150
Array1				0	4.86	5.05	-	-
Array2					0	1.39	-	-
CTD						0	-	-
Benthos Gateway							0	-
HiSpeed Gateway								0

Table 3. Sensor depths in metres and the water depth in metres at the location.

Node Name	Sensor Depth	Water Depth
IC1	60 m	120
IC2	30 m	120
SSC	120 m	120
Array1	179 m	179
Array2	124 m	124
Benthos Gateway	75 m	120
HiSpeed Gateway	0 m	113
CTD	20 sensors (start at 20m depth with 6 m spacing)	146

Testing Operation of the previously deployed NW Arrays

Two sea-bottom deployed arrays were placed in Barrow Strait during the Northern Watch (NW) demonstration field trial in summer of 2015. These arrays have remained on the sea floor ever since—a two-year period. The intention has been to leave these arrays in place while they are functioning as a lifetime test. Unfortunately, our efforts to use the arrays last year were unsuccessful, as we could not get to GIC.

This year we intend to restart the arrays and test their functionality. If the arrays are working, they will actively be used in our data collections and they will become part of a larger experiment with the CANMET Energy power system.

Starfish, ICListen Deployment and Data Collection

In addition to the NW arrays, a Starfish Sensor Cube, two ICListen hydrophones, and a CTD logging string will be deployed. The acoustic receivers will augment or be used in place of the NW arrays. The CTD logger will provide continuous environmental information to support post-trial data analysis.

The Starfish Sensor Cube has a high-speed WiFi gateway cabled to it and an associated Benthos Modem Gateway approximately 1 km distant. Figure 2 shows the layout of the in-water sensors for this field trial.

All of the to be deployed nodes must be released from the CCGS vessel and recovered before the ship departs. This means that they may only have three days in the water unless we can delay some recoveries until into the BIO ship time. This will be negotiated on-site and depend on progress.

Ambient Noise Data Collection

All operational acoustic nodes will record data for as long as possible. Some activities will interfere with ambient noise sampling either by the presence of the CCG vessel or by being taken off-line during other work, such as the NW array power source installation.

While most of the sensor and environmental nodes will be deployed, operated for a few days, and then recovered, the NW arrays are intended to remain on the sea floor. These arrays, if operational, will be periodically powered by the CANMET Energy power system (see below). Data collected will become part of the ambient noise data collection. If the power system and arrays operate as hoped, we will collect a yearlong data set.

Propagation Loss Estimation

Over the past eight years, DRDC has attempted to tow an acoustic projector for the purpose of estimating the acoustic propagation loss at various frequencies from one side of the strait to the other (north-south) and for reasonable distance along the straight (east-west). Each time our efforts have been unsuccessful for a variety of reasons. We will attempt to make these measurements yet again this year.

A 219 moving coil, towed, acoustic projector will be placed on the CCG vessel and at a minimum the projector will be towed north-to-south and then south-to-north across the strait. A small comb of frequencies will be transmitted during each transit. The frequencies and levels will be chosen on site and will be monitored in real-time to ensure they are detected sufficiently well to allow for loss determination. Frequencies will be chosen in the band 70—1000 Hz and maximum levels are expected between 140—170 dB//1μPa @ 1 m. The maximum level will only be achievable with a single tonal.

If additional towing time is available we will also measure propagation loss along the strait for up to 100 km. Ideally, several runs across and along the strait will be completed; however, ship time is very short and the number of runs will be limited.

Collection of Test Data Sets

If sufficient ship time is available, then the CCG vessel will be employed as a target of opportunity. Run events will be designed to provide test data sets for auto-detection and target tracking algorithms. Ship tracks, AIS, and logged data will support these test data sets.

Split-Pipe Installation and Testing

A significant issue in the deployment of northern underwater installations with land-based components is the protection of cables running across the littoral zone. In winter, sea ice is pushed onto the beaches and cables are ground up or ripped out with the movement of the ice.

Many protection schemes have been tried, including buried cables, cement works, and drilled holes through the bedrock. Only the directionally drilled bedrock holes which run the cables from above the ice to a point deep enough to avoid all but the largest ice keels have been truly successful. Drilling these holes is logistically difficult and extremely expensive.

Recently, some success has been had using cables inside of a split-weighted pipe. The split-pipe approach when combined with a good site choice that makes use of a naturally protected beach area offers a potential for a much easier to arrange and far less expensive transition of cables into the water.

GIC offers a well-protected beach area that is an ideal site for testing the split-pipe approach. ONC, DRDC, and BIO will install a split-pipe cable to a mini-observatory based on a CTD instrument. An Iridium data link will be used to transmit the CTD data south. DRDC will install cameras to take pictures of the site for a yearlong period so that the ice motion and interaction with the split-pipe can be observed.

Array Power System for Enduring Operations

Working under an MOU with DRDC, CANMET Energy has designed and built a direct methanol fuel cell power source that will allow for periodic usage of the already deployed Northern Watch seabed arrays. The plan is to provide power to operate the arrays for five minutes, four times a day, for a year. Data will be stored and processed on-site, packaged and transmitted south using an Iridium data link.

Details of the plan for this power system are provided in Annex A.

The fuel cell power system is instrumented and data from the power system will be stored and transmitted. This is a high-risk test, as the fuel system has not had long-term tests in cold conditions. This power system is a unique application and to our knowledge the first ever attempt to operate such a system at an unmanned site for an extended period. Both data returned from the underwater arrays and the power source are important data sets. Successfully operating a fuel cell for a yearlong period will be a game changer for many remote applications.

Unfortunately, we do not *a priori* know the operational status of the Northern Watch arrays. These arrays will be tested on our arrival at GIC. If they are non-operational, a dummy load will be used in their place.

Weather Station

A battery-powered weather station has been operated for several years from the GIC. This weather station provides near real-time reporting via Iridium data packets. Unfortunately, it has not operated reliably and requires new batteries and servicing. An on-going effort will be made to improve the reliability of the remote weather station.

DFO Arctic Observatory

The DFO Arctic Observatory has operated from the old Science Hut at the GIC for a number of years. This observatory requires cable replacement, battery replacement, and hardware/software updates to allow it to resume operations. DRDC will assist BIO personnel as necessary to restore the observatory. The CCG ship will lay a new cable. Replacement processing/control and communications gear and batteries will be placed in the old Science Hut.

Schedule

The schedule for the trial as currently planned is illustrated in the timeline figure below. Some dates are subject to change depending on availability of ships, aircraft, and personnel.

			July									August																				
#	Name	Role	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	Chris Browne	Camp Manager		Travel		Resolute			Camp																					R		T
2	Jim Milne	Logistics in Resolute		Travel		Res																										T
3	Al Tremblay	Camp Manager Advisor		Travel		Resolute			Camp																					R		T
4	Dan Graham			Travel		Resolute			Camp																					R		T
5	Mike Simms			Travel		Resolute			Camp																					R		T
6	Joel Higgins			Travel		Resolute			Camp																					R		T
7	MS Dennis Allen	Bear Watch		Travel		Resolute			Camp																					R		T
8	OS Jake Dixon	Bear Watch		Travel		Resolute			Camp																					R		T
9	Cook	Cook		Travel		Resolute			Camp																					R		T
10	Cooks Helper	Cooks Helper		Travel		Resolute			Camp																					R		T
11	Garry Heard	Chief Scientist									Travel		R	Camp														R	T			
12	Stephane Blouin	Safety Officer									Travel		R	Camp														R	T			
13	Val Shepeta										Travel		R	Camp														R	T			
14	Derek Clark										Travel		R	Camp														R	T			
15	Chris Brannan	219 Operator									Travel		R	Camp														R	T			
16	Gary Inglis															Travel		R	Camp									R	T			
17	Ryan Flagg	Ocean Networks Canada												Travel		R	Camp					AUL Site Visits / Travel										
18	Scott McLean	Ocean Networks Canada												Travel		R	Camp					AUL Site Visits / Travel										
19	Ian Kulin	Ocean Networks Canada												Travel		R	Camp					AUL Site Visits / Travel										
20	Stephane Gunther	CANMET Energy										Travel		R	Camp					R	T											
21	Michael Leonard	CANMET Energy										Travel		R	Camp					R	T											
																					CCGS Henry Larsen											

Legend:

R **Resolute**

T **Travel**

Equipment

The main items of DRDC equipment for the field trial are listed in the table below. Annexes A & B list the equipment for CANMET Energy and ONC.

Coast Guard Ship	Camp / Charter Flight
- Starfish Sensor Cube (Item 1) - Deployment gear and 219 projector (Item 2) - Moorings, stands, anchors, miscellaneous equipment (Item 3) - Electronics Rack (Item 4) - Scientific Gear for 219 (Item 5) - Gateway buoys (3) (Item 6) - Gateway buoy, acoustic releases, accessories, miscellaneous (Item 7)	- STB gear for NW arrays and SSC - Split-pipe gear - Camera systems (3 in total with gantry) - NW dry-end gear - CANMET gear - New Camp Shed (~4000 lb) - Camp Food Order (~3200 lb) - ONC iridium buoy - ONC mini-observatory (CTD)

Records

A trial logbook will be maintained in electronic form. Data will be collected and stored on HDD for eventual storage on the US section data server.

Daily Reports will be prepared by the Chief Scientist (or Camp Manager, while Chief Scientist is not onsite) and submitted by email. Daily reports will contain the following information:

- Summary of safety, health and environmental concerns or incidents
- Summary of personnel onsite and planned personnel changes
- Activities in the last 24 hours
- Planned activities for the next 24 hours
- Issues requiring support / action from the lab

A trial report will be prepared by the Chief Scientist summarizing the work done during the trial, the progress made on trial objectives and lessons learned / best practices for future trials.

Overtime

Staff will be on travel status until arrival in Resolute. At this point, they switch to field trial status with extra pay determined according to past MOUs covering fieldwork on weekdays and days of rest. On departing Resolute southward, travel status will be resumed. Most staff who work compressed workweeks, will automatically return to normal daylight hours once on field trial status. All staff are expected to be in non-compressed work status for the field trial.

Security

Operations will be conducted in an unclassified manner. System operation will be shut-down as necessary to ensure that classified data is not collected

Physical security for the equipment is limited, but the trial is occurring in a remote location with few people in the area. Some equipment will be left operating in the camp for an extended period of time. This equipment will be unattended and will be refit or recovered in summer 2018.

Safety

In general, safety will be the responsibility of the Chief Scientist, Camp Manager and the designated Safety Officers as well as the masters of the individual vessels and aircraft.

Dr. Garry Heard is the designated Chief Scientist, Chris Browne is the designated Camp Manager, Al Tremblay is the designated Field Safety Officer for the camp, and Dr. Stephane Blouin is the designated Safety Officer for the science operations.

Camp Safety is addressed in the Gascoyne Inlet Camp Manual (Revision Date 28 Jun 2017) and the Gascoyne Inlet Camp Overview (Revision date 2017-06-21). This trial plan contains the required information for the Safety Plan in Appendix C from the Camp Manual. An onsite safety brief will be given to all incoming personnel shortly after arrival in Gascoyne Inlet Camp.

The Captain of the CCGS Henry Larsen is responsible for safety during activities onboard the ship, including deployment / recovery / operation of the sensors and acoustic source, and for activities conducted from the ship's boats.

The aircraft pilot is responsible for safety aboard aircraft and safety of the aircraft in the air and on the ground. Any work on or near the aircraft including loading unloading is conducted under the direction of the aircraft pilot.

The Safety policy and procedures of Polar Continental Shelf Project (PCSP) will apply while personnel are at the PCSP Facility in Resolute.

Refer to Annexes A & B for additional Safety and Health related information for CANMET Energy and ONC.

Using the guidelines developed in Occupational Health and Safety Hazard and Risk Assessment – MARLANT Defence Research and Development Canada – Final Report. Department of National Defence Contract HX 089015 – Call-Up 4. REA Project No. 14111.4 June 4, 2010, a hazard identification and risk assessment was made for this summertime Arctic field trial. In total, 129 risks were drawn from the reference as potential risks and hazards. Since many of the risks for different work areas are similar, there is a high degree of repetition with the result that the actual number of distinct risks and hazards are considerably less than 129. Of these listed risks covering all manner of work and activities, there are 23 that require MONITORING. Many of these risks related to exertion, falls, and electrical risks. Just two risks were identified as UNDESIRABLE. One of these undesirable risks is for electrical work and is out of context as it is judged against conduct by office staff, where in the field this work would be undertaken by trained technologists or experienced engineering/scientific staff. This leaves only one undesirable risk and it is the risk of getting on and off boats. This risk is often the highest hazard encountered by field workers and all DRDC staff are well experienced and familiar with this hazard. Special care will be taken to ensure that contractors, CAF members, and any other visitors encountering this hazard are prepared.

The list of identified risks and hazards will be provided to participants in a separate electronic document.

Medicals and Training

DRDC Personnel in GIC will have a current Standard First Aid Course (Level C, with AED or Wilderness First Aid) and have passed a Health Canada Field Medical Assessment. For non-DRDC personnel, it is the responsibility of their organization to ensure they are medically fit for field trial conditions, and it is recommended they have the Standard First Aid Course.

Personnel in GIC are individually responsible to ensure that they carry sufficient personal medications for the duration of the mission.

If personnel in GIC have a medical condition that would be relevant in an emergency, it is recommended that they provide that information to the Safety Officer/Camp Manager/Chief Scientist so that it can be passed on to medical personnel in the event of an emergency. (This information may be provided in a sealed envelope, marked as PROTECTED-B, which will only be opened when required.)

Personnel in GIC are individually responsible to ensure that they communicate the details of any food allergies to the Camp Manager well in advance of the trial so that accommodation can be made in terms of meal planning.

In the event of staff being evacuated from the camp for medical or other reasons, the Chief Scientist/Camp Manager is authorized to arrange emergency travel and to designate another member of staff to accompany the evacuee to medical treatment and make associated arrangements for subsequent evacuation to their home city.

A summary of medicals and training for personnel is maintained separately, by the Project Manager (Erin MacNeil).

Leadership and Command Structure

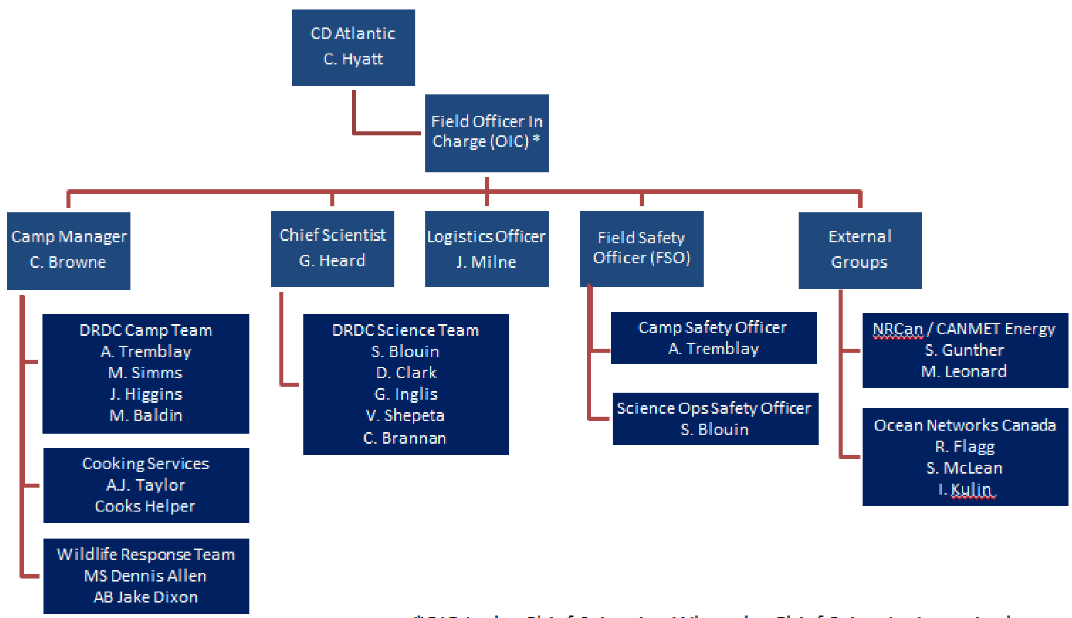
The Chief Scientist is the leader of the trial, and has the authority to make tactical decisions with respect to the trial, including the order and priority of trial activities, and assigning work to personnel onsite. The Chief Scientist will communicate and work with all trial stakeholders, especially the Camp Manager, to manage the trial. If a critical decision is to be made, such as to cancel early or abort the trial, where practical, the CD/Atlantic should be consulted. While the Chief Scientist is not in camp, the Camp Manager, will assume the role of leader of the trial, with the authority to make tactical decisions with respect to the trial.

The Camp Manager is the leader for the camp, and has the authority to make camp decisions, and in coordination with the Chief Scientist to plan camp activities and to assign work to the camp personnel. The Camp Manager has the authority to allocate the bunks within the camp.

The Camp Manager and Chief Scientist have the authority to manage communications bandwidth, including allocating and scheduling time for personal and business communications.

The Camp Manager and Chief Scientist have the authority to act on and report any infractions to the Alcohol and Drug Policies for the camp (see Camp Manual for policy details).

The Camp Manager and Chief Scientist are directed to make immediate contact with CD/Atlantic in the case of: significant safety, health or environmental incidents; significant loss or damage of equipment or infrastructure; significant interaction with the public, other agencies or foreign authorities; significant disciplinary issues; or significant security breaches.



*OIC is the Chief Scientist. When the Chief Scientist is not in the camp, OIC is the Camp Manager

Environmental

All work will be conducted in and around the Gascoyne Inlet Camp, Barrow Strait, and Resolute. While the work is being conducted in the summer, conditions in the far north are highly variable. Temperatures are likely to range from -10 to +20C and can change quickly. High winds are to be expected. Damp conditions, snow, and rain, are to be expected. Windbreakers and rain gear are important to have on hand. Clothing can be difficult to dry.

Obtaining freshwater at the GIC site has been increasingly difficult as the snowpack on the hills is diminishing. Drinking water will be flown in from Resolute if required. Water usage limits may restrict the options for laundry at the site.

An Environmental Assessment was been completed for the camp through the last major project to use the camp facility (Northern Watch Technology Demonstration Project), DND File # 1267-1431-08/09-01, titled “Due Diligence Environmental Screening for DRDC Northern Watch Technology Demonstration Project”, dated July 2008. The usage of the camp and the planned science activities for this trial are of a smaller scale and within the scope of work that was considered for the previous environmental assessment. As such this assessment has been considered for this trial. The assessment report contains 7 recommendations to mitigate environmental impact; four of the recommendations apply to activities being conducted during this trial.

The four applicable recommendations are listed below, with the planned mitigation for the 2017 trial:

1. DCC Recommendation: To prevent fuel spills from negatively impacting surface water or soil quality, fuel drums should be stored on tarpaulins in a depression; this will contain any potential spills so that they may be pumped back into drums. Spills kits should be kept on site, in all locations where fuel is stored. Also, a spill contingency plan has been developed for the NWTD Project and this should be communicated to all NWTD personnel by the Camp Supervisor. At the conclusion of each field trial, all unused fuel with the exception of approximately 700 L of stove fuel and 100 L of diesel fuel left behind for use in the generator by local hunters and trappers, should be removed from the site

   2017 Arctic Trial Mitigation: as standard practice for the camp, fuel is stored in berms and the spill contingency plan (contained in Appendix M of the Camp Manual) is followed. Due to logistics constraints and the ongoing use of the camp, all unused fuel will not be removed from the camp at the end of each trial.

2. DCC Recommendation: To prevent sewage or grey water from negatively impacting surface water quality, sewage should be incinerated in propane powered toilets and the resulting ash treated as garbage and flown to Resolute Bay for disposal. Grey water should be screened to remove large debris and then drained into the ground, which consists of loose rock/gravel and will act as a natural filter.

2017 Arctic Trial Mitigation: propane toilets were used during the Northern Watch project and were found to have challenges that made them impractical for use in this small camp setting. The camp will bag solid human waste and return to Resolute for disposal. Grey water will drained into the ground as above.

3. DCC Recommendation: To prevent All Terrain Vehicles (ATVs), used as transport by NWTD personnel between the camp, Cape Liddon, and the airstrip, from negatively impacting vegetation, ATV traffic should follow predetermined routes, which avoid vegetated areas. If journeys away from the pre-determined routes are necessary, these should be kept to a minimum and NWTD personnel should be instructed by the Camp Supervisor to avoid vegetated areas.

   2017 Arctic Trial Mitigation: this recommendation has been included in standard practice for the camp, and will be managed by the Camp Manager.

4. DCC Recommendation: Not applicable to this trial (relates to Cape Liddon location)

5. DCC Recommendation: To reduce negative impacts on receptors such as marine mammals during the underwater array calibration project component, source levels less than 185 dB//1 µPa @ 1 m should be employed for all experiments. In addition, signals will be limited in duration to the minimum necessary for the purpose. Speed of the tow vessel will be limited to approximately 4-8 kts, and transmissions should be stopped if whales are observed within 300 m of the vessel.

   2017 Arctic Trial Mitigation: this recommendation will be followed during the trial.

6. DCC Recommendation: Not applicable to this trial (relates to use of lasers)

7. DCC Recommendation: Not applicable to this trial (relates to use of lasers)

ADM(IE) is not responsible to manage the camp infrastructure, including obtaining the required land and water use permits. DCC manages the permits on ADM(IE)'s behalf. It has been confirmed with Tamara VanDyke, DCC, that land and water use permits are in place for 2017.

Communications

Iridium phones will be used for business and personal calls (subject to contract limitations).

Internet with limited bandwidth and download capabilities is expected to be available for email and network access.

Hand portable radios will be used between the vessel and shore. Camp HF and VHF radios will be used for contact with Polar Continental Shelf Project and aircraft.

As many as five or six data systems at the camp will be using Iridium to send data packets south. A schedule has been created to help limit interference. The table below shows the available options for minimal interference.

ONC Option #1 - 3h interval which follows DFO 4 times per day (with a reasonable gap)

Time (UTC)	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200
DFO	0010	0110	0210	0310	0410	0510	0610	0710	0810	0910	1010	1110	1210
DRDC	0020	0120	0220	0320	0420	0520	0620	0720	0820	0920	1020	1120	1220
CanMet	0030	0130	0230	0330	0430	0530	0630	0730	0830	0930	1030	1130	1230
ONC	0040	0140	0240	0340	0440	0540	0640	0740	0840	0940	1040	1140	1240
Free Time	0050	0150	0250	0350	0450	0550	0650	0750	0850	0950	1050	1150	1250

ONC Option #2 - 3h interval with identical tranmission pattern to Option #1

Time (UTC)	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200
DFO	0010	0110	0210	0310	0410	0510	0610	0710	0810	0910	1010	1110	1210
DRDC	0020	0120	0220	0320	0420	0520	0620	0720	0820	0920	1020	1120	1220
CanMet	0030	0130	0230	0330	0430	0530	0630	0730	0830	0930	1030	1130	1230
ONC	0040	0140	0240	0340	0440	0540	0640	0740	0840	0940	1040	1140	1240
Free Time	0050	0150	0250	0350	0450	0550	0650	0750	0850	0950	1050	1150	1250

ONC Option #3 - Same as Option #2 with CanMet every 8 hours

Time (UTC)	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
DFO	0010	0110	0210	0310	0410	0510	0610	0710	0810	0910	1010	1110
DRDC	0020	0120	0220	0320	0420	0520	0620	0720	0820	0920	1020	1120
CanMet	0030	0130	0230	0330	0430	0530	0630	0730	0830	0930	1030	1130
ONC	0040	0140	0240	0340	0440	0540	0640	0740	0840	0940	1040	1140
Free Time	0050	0150	0250	0350	0450	0550	0650	0750	0850	0950	1050	1150

Time (UTC)	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
DFO	1210	1310	1410	1510	1610	1710	1810	1910	2010	2110	2210	2310
DRDC	1220	1320	1420	1520	1620	1720	1820	1920	2020	2120	2220	2320
CanMet	1230	1330	1430	1530	1630	1730	1830	1930	2030	2130	2230	2330
ONC	1240	1340	1440	1540	1640	1740	1840	1940	2040	2140	2240	2340
Free Time	1250	1350	1450	1550	1650	1750	1850	1950	2050	2150	2250	2350

Only Undesirable schedule since it follows both CanMet or DFO with every transmission attempt

Time (UTC)	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200
DFO	0010	0110	0210	0310	0410	0510	0610	0710	0810	0910	1010	1110	1210
DRDC	0020	0120	0220	0320	0420	0520	0620	0720	0820	0920	1020	1120	1220
CanMet	0030	0130	0230	0330	0430	0530	0630	0730	0830	0930	1030	1130	1230
ONC	0040	0140	0240	0340	0440	0540	0640	0740	0840	0940	1040	1140	1240
Free Time	0050	0150	0250	0350	0450	0550	0650	0750	0850	0950	1050	1150	1250

Personnel

This field activity will involve a total of 16 DRDC personnel. The participants are listed below in two teams. The Camp Team will be the first to arrive and will be passengers on the Charter Flight with much of the gear. The Science Team will arrive later and leave before the camp is closed. The Science Team will travel by commercial air to Resolute.

Since this trial is not being held within 2 hours of medical treatment, in accordance with DRDC SOP, medicals ARE required for the personnel. All DRDC personnel are to be trained in standard first aid or better.

CANMET Energy and ONC personnel are listed in the respective trial plans, see Annexes A & B.

Camp Team

1. Jim Milne — LogO, in Resolute
2. Chris Browne — Camp Manager
3. Al Tremblay — Support to Camp Manager
4. Mike Simms — Mechanical Technologist
5. Mark Baldin — Electronics Technologist
6. Joel Higgins — Mechanical Technologist
7. Cook — Contractor
8. Cooks Helper — Contractor
9. MS Dennis Allen — Bear Watch
10. AB Jake Dixon — Bear Watch

Science Team

11. Garry J. Heard — Chief Scientist
12. Stephane Blouin — Defence Scientist

13. Derek Clark Computer Specialist
14. Val Shepeta Electronics Technologist
15. Chris Brannan Electronics Technologist
16. Gary Inglis Engineer

Danish Observers

17. TBD
18. TBD

Contact Information

Role	Name	Contact
CD/Atlantic	Calvin Hyatt	Office: (902) 426-3100 x114 Cell: (902) 441-5026 Home: (902) 444-2030 Calvin.hyatt@forces.gc.ca
Associate CD/Atlantic	Cdr Craig Bradley	Office: (902) 426-3100 x159 Cell: (902) 401-5983 Craig.bradley@forces.gc.ca
Chief Scientist	Garry Heard	Cell: (902) 830-2437 GovBB: (902) 441-1624 Garry.heard@gmail.com Garry.heard@forces.gc.ca
Camp Manager	Chris Browne	Cell: (902) 452-6355 Gov BB: (902) 448-5801 Chrislbrowne@gmail.com Christopher.browne@forces.gc.ca
Support to Camp Manager	Al Tremblay	Cell: (902) 719-9053 Atremblay777@gmail.com
Logistics Officer (Resolute)	Jim Milne	PCSP number: (867) 252-3872 milneiceshelf@gmail.com
Project Manager CAUSE	Erin MacNeil	Cell: (902) 441-5403 erinandandy@eastlink.ca
Project Manager Camp	Andrew MacInnis	Cell: (902) 440-2987 Email: asmacinnis@yahoo.ca

Signatures

Project Manager: Name Erin MacNeil — Signature

Section Head: Name Dan Hutt — Signature

Centre Director: Name Calvin Hyatt — DR. CALVIN HYATT CENTRE DIRECTOR Signature

Distribution

- Calvin Hyatt CD
- Hutt, Dan H/US
- Laura Bertino H/TS
- R. (Lex) Stuart H/TD
- Richard Pederson
- Erin MacNeil
- Andrew MacInnis
- Sean O'Grady
- CR
- Stephane Blouin
- Sean Pecknold
- Garry Heard
- Derek Clark
- Val Shepeta
- Mark Baldin
- Mike Simms
- Chris Brannan
- Gary Inglis
- Joel Higgins
- Chris Browne
- Jim Milne
- Al Tremblay

Annex A. CANMET Energy Trial Plan

Installation and Commissioning of a Power and Energy System for Underwater Acoustic Arrays (CAUSE) – Trial Plan

I. Objective

The objective of the site visit is to deploy a power and energy system for the Underwater

Acoustic Arrays deployed at Gascoyne Inlet for year-long operation under the CAUSE project. This system will also be designed to enable the collection and transmission of data (to CanmetENERGY-Varennes) from the underwater arrays. The following milestones for the project have been established:

Step 1: System Design

Step 2: Installation at Gascoyne Inlet during summer 2017

Step 3: Energize the arrays with the alternative power and energy system

Step 4: Successfully collect data through an automated controller

Step 5: Transmit the compiled data to CanmetENERGY-Varennes

Step 6: Demonstrate unattended system operation into the polar night

II. Travel and Gascoyne Inlet Visit date schedule

From	To	Date	Notes[a]
Ottawa	Resolute Bay	August 1st	Commercial; to be arranged by CanmetENERGY
Resolute Bay	Gascoyne Inlet	August 2nd or 3rd	To be arranged by DRDC personnel (Jim Milne/Al Tremblay)
→ Onsite and Planned Installation Dates at Gascoyne Inlet: August 4th to 8th ←			
Gascoyne Inlet	Resolute Bay	August 8th or 9th	To be arranged by DRDC personnel (Jim Milne/Al Tremblay)

Resolute Bay	Ottawa	August 10th	Commercial; to be arranged by CanmetENERGY

[a] Accommodations for CanmetENERGY personnel to stay at NRCan'sPolar Continental Shelf Program (PCSP) facilities to be arranged by DRDC personnel (Jim Milne/Al Tremblay)

III. CanmetENERGY Personnel visiting Gascoyne Inlet

Michael Leonard, Project Engineer, IETS

Office Phone: 450-652-4623

Email: michael.leonard@canada.ca

Stephane Günther, Mechanical Engineer, IETS

Office Phone: 450-652-5542

Email: stephane.gunther@canada.ca

IV. System Equipment

The overall system is composed of two parts as below

(i) Power and Energy System

- 4 x 1.6 m^2 solar PV panels (1.1 kWp) (4 x 1.65 m^2 panels)
- 1 x Insulated enclosure for fuel cell and solar controller (L: 52" x W: 52" x H: 63" – to be assembled onsite, 400 lbs)
- 1 x 110 W Direct Methanol Fuel Cell (SFC, EFOY-PRO-2400 Duo)
- 2 x 28 L methanol cartridges and 2 x 60 L methanol cartridges
- 2 x 12 V 165 Ahr AGM Batteries (Battery Genergy, EV12-156)

(ii) Underwater Acoustic Array Processing Equipment

- 1 x Insulated enclosure for Underwater Acoustic Array Processing Equipment (L: 36" x W: 36" x H 72"; 400 lbs)
- 1 x Iridium Satellite for data transmission

V. Equipment Delivery Logistics to Resolute Bay

The following system and supporting equipment will be sent on commercial cargo flight (arranged by CanmetENERGY) from Montreal to Resolute as follows:

Phase 1:

Week of July 3rd

Fuel Cell Enclosure, Methanol Cartridges, Batteries, Solar Panels, Racking

- 2 pallets;
- 400 lbs each,
- Each pallet ~ L: 60”, W: 40”, H: < 48” – exact dimensions still to be determined.
- Note: Methanol is class 3 flammable liquid and will be identified.

The following system and supporting equipment is to be sent at a later date, ideally, *on the available DRDC charter scheduled July 27th, 2017 from Ottawa to Resolute* or if necessary Commercial Cargo the week of July 24th, 2017 from Montreal to Resolute. If by Commercial Cargo, CanmetNERGY will arrange this.

Phase 2:

Week of July 24th, 2017

Acoustic array enclosure, acoustic array processing equipment, controller, iridium satellite, specialized tools for installation.

- 1 pallet
- 400 lbs
- ~L: 80”, W: 42”, H: 42” – exact dimensions still to be determined
- Tool box, 200 lbs ~ L: 36”, W: 36”, H: 24” – could be shipped as checked luggage

Phase 3:

The following will be brought as checked luggage: EFOY PRO 2400 Duo Fuel Cell

VI. Planned Work and Installation Plan

On-site the following schedule outlines the planned installation steps:

Task		03-Aug			04-Aug			05-Aug			06-Aug			07-Aug			08-Aug			09-Aug		
		M	A	E	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E
A	Arrive Gascoyne Inlet		■	■																		
B	Setup work area/tools			■	■																	
C	Assess/identify best installation method					■	■															
D	Install solar PV panels							■	■													
E	Install Fuel Cell								■	■												
F	Install Acoustic Array Controller/Processing Equipment										■											
G	Install Iridium Satellite Antenna											■										
H	Electrical connections between equipment						■	■	■	■	■	■										
I	Testing and validation											■	■	■	■	■						
J	Clean up work area														■	■	■					
K	Depart Gascoyne Inlet																■	■	■			

VII. On-site Support needed from DRDC

(i) Personnel

- Some personnel support may be needed to move the equipment and fuel cell enclosures into place in the science hut during August 8th and 9th.
- Technical support (e.g. Derek /Garry) may also be required if the underwater acoustic array is unable to communicate with the data monitoring system. The system will be tested prior to departure to minimize this risk.

(ii) Equipment

- Bob-cat in order to transport the pallets from the airfield to the science hut
- One bob-cat to move pallets of equipment
- 2 x 6' ladders to install the PV panels

VIII. Risk

- The level of risk associated with personnel travel and the delivery and installation of the equipment is considered LOW, however, it is recognized that planned delivery to Resolute and Gascoyne Inlet may be affected by weather conditions.
- All efforts are being made to test the system under laboratory conditions prior to deployment. However, because of the aggressive timeline for delivery of the equipment to Resolute and Gascoyne Inlet, it is only possible to test the power and energy system and the Underwater Acoustic Array Processing Equipment separately. These two

components will be integrated onsite and the risk associated with this is considered LOW.

- Once installed, the overall system will be connected to the underwater arrays via the existing telemetry cable to enable control and data collection. The risk associated with this is LOW.
- Once the data has been collected, it will be transmitted to CanmetENERGY-Varennes via Iridium satellite. This risk associated with this is LOW.
- Upon installation and commissioning of the system, it will be left to operate onsite unattended throughout the year. As the long-term low-temperature performance of the fuel cell is unknown, the risk for failure is deemed to be MED. In the event of failure, data collection and transmission will continue until the batteries have been exhausted (approximately 3 days).

IX. Health and Safety

(i) Personnel

- Both Michael Leonard and Stephane Günther have first aid training and have certifications to work in confined spaces as well as on ladders.
- There are no dietary restrictions.
- Please note that this will be the first time both Michael Leonard and Stephane Günther will be working in an Arctic environment
- Onsite safety briefs will be provided by DRDC personnel.

(ii) Equipment

- Methanol is a class 3 flammable liquid. This will be contained in a sealed plastic 28L and 60L cartridges and will be labelled as such; work in the area with high heat or sparks should and will be avoided. MSDS will be included in/attached to the enclosure.
- Some of the equipment components are heavy and thus may pose a safety hazard if a person gets pinched during the transport or being moved for installation. Steel toe work boots will be worn at all times as well as working gloves when lifting equipment to avoid cuts.
- Ladders will be used to install the solar panels. There is the risk of falling off the ladder. If any work to be done on the roof is required, the person will be tied in with a harness.
- The power system will be drawing 12 V and up to 50 amps. Any work to be done on the electrical panel of the fuel cell enclosure will require that the

power be turned off to avoid risk of electrocution (Insulated tools and insulated gloves will be worn, when working inside the cabinet).

The emergency points of contacts for the CanmetENERGY personnel have sent in a separate email.

Annex B. ONC Trial Plan

Note: Created by auto-formatting a PDF document. Appearance and layout are degraded.

Ocean Networks Canada Innovation Centre

ALL DOMAIN SITUATIONAL AWARENESS ARCTIC UNDERWATER LAB

CABLED OBSERVATORY DeploYMeNt FIELD PLAN

ONC-DN-2017-05

DRAFT Revision A [2017-03-30]

OCEAN NETWORKS CANADA

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ADSA ARCTIC UNDERWATER LAB

CABLED OBSERVATORY DEPLOYMENT FIELD PLAN

Revision: Revision B: [2017-03-30]

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Prepared For: Department of National Defence

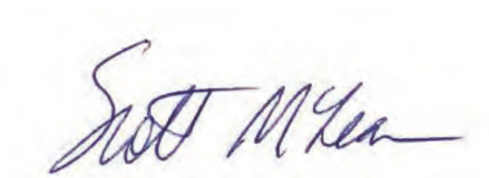
DRDC Atlantic
9 Grove Street

Contract Number: W7707-175911/001/SV

Deliverable: 6.1

Study Contact: Scott McLean

Ocean Networks Canada Innovation Centre
Technology Enterprise Facility Rm160



Approved By: ___________________________

Scott McLean,

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Document Version Control

Version	Date	Name	Change

1 INTRODUCTION

1.1 Purpose

This field plan report is project Deliverable 6.1 under Task 5.1 (Kick-Off Meeting and Field Plan) provides a comprehensive overview of how ONC will deliver on the Gascoyne Inlet deployment portion of the Arctic Underwater Laboratory project with DRDC. It presents pre-deployment and deployment timelines, detailed deployment steps, anticipated required resources, and (where possible) contingency plans for mitigating specific risks to delivery. The field plan also includes related Arctic travel under Deliverable 6.2, Task 5.1 for site assessments for the conceptual design study for full scale implementation of cabled observatories.

1.2 Acronyms

Acronym	Description
AML	AML Oceanographic - instrument manufacturer
AUL	Arctic Underwater Laboratory
AUV	Autonomous Underwater Vehicle
BIO	Bedford Institute of Oceanography
CAF	Canadian Armed Forces
CCGS	Canadian Coast Guard Ship
CTD	Instrument for measuring Conductivity, Temperature, and Depth
DFO	Department of Fisheries and Oceans and Coast Guard Canada
DRDC	Defence Research and Development Canada
MTC	Marine Technology Centre
NEPTUNE	North East Pacific Time-series Undersea Networked Experiment
ONC	Ocean Networks Canada
PICC	Pacific International Cable Consulting
QA/QC	Quality Assurance and Quality Control
SBE	Sea Bird Electronics – instrument manufacturer
VENUS	Victoria Experimental Network Under the Sea

2 Project Background

2.1 Arctic Underwater Laboratory (AUL)

The DRDC AUL project with ONC is intended to advance the integration of two well established technologies (subsea cabled observatories and Autonomous Underwater Vehicles – AUVs), a critical first step before realization of persistent and continuous subsea surveillance capability at strategic locations in the Arctic. ONC and DRDC will select four (4) Arctic chokepoint areas and produce a conceptual design study for each as potential candidates for the installation of a cabled observatory/surveillance and research network. The DRDC facility located in Gascoyne Inlet on Devon Island was identified as a test site for where a cabled observatory will be implemented. The primary goal is to test a simplified installation process and cable landing protection system for remote Arctic locations. The establishment of a flexible, scalable and robust infrastructure of this nature will directly support the ongoing development of knowledge, tools, processes and strategies essential for safeguarding the Canadian Arctic.

This installation test of a subsea cabled observatory at Gascoyne Inlet is being conducted in parallel with, and in support of, the conceptual design study for four identified chokepoints to assess feasibility for cabled observatory deployment. The major benefit of the test is that it will help determine whether the proposed protection method will work to protect cable landing sites from some of the unique Arctic deployment challenges such the risk of ice scours at the observatory locations. Success of the method would significantly decrease the cost of some deployments while utilizing the minimal equipment availability for installations and the need for a rapid deployment capability.

2.2 Location Summary

Gascoyne Inlet is located on South West corner of Devon Island in Nunavut, Canada. Devon Island is considered to be the largest un-inhabited island on the planet.

Transportation to the DRDC Northern Watch base camp, located near the entrance of Gascoyne Inlet on the eastern coast, is via charter flight from the community of Resolute Bay. Since, this approximately one hour (one way) flight is the most efficient means of transporting personnel or equipment. The deployment installation described here assumes a minimal amount of logistical support and details all of the equipment needed. The exception to this being proposed support from the Canadian Coast Guard Ship (CCGS) Henry Larsen, which will be expected to transport two crates (50m) of split pipe in addition to what will be brought up via charter flight from a pre-staged location in Cambridge Bay.

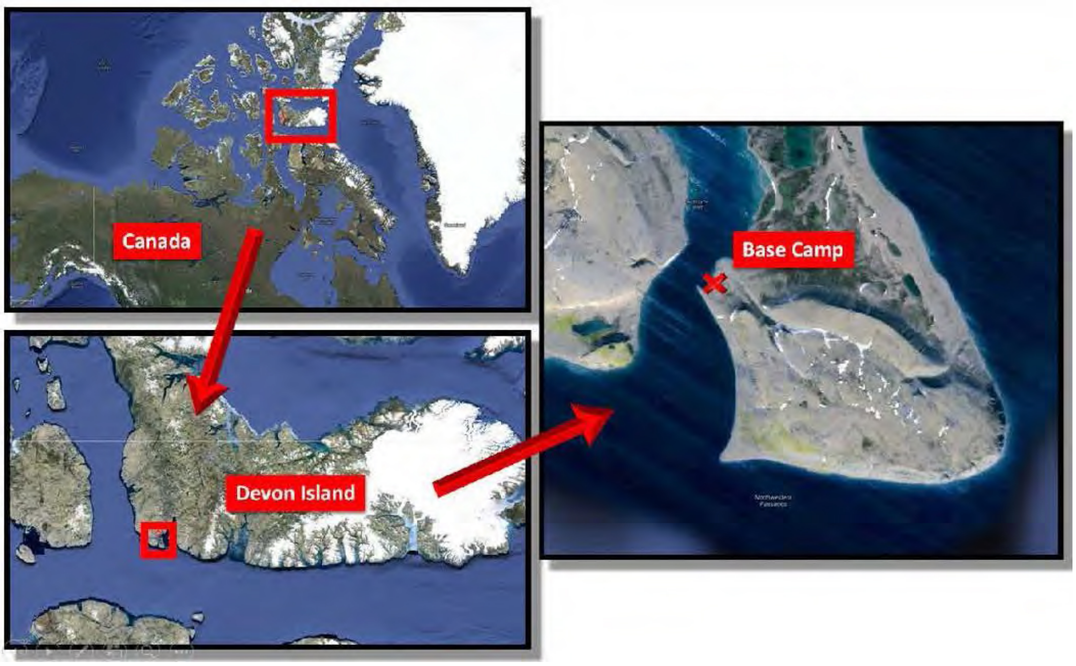

Figure 2-1 Northern Watch location on Devon Island

The camp itself is situated on a low plateau close to the water includes several semi-permanent buildings. There is a small, protected bay to the south of the camp, which is the intended deployment test-site for the cabled observatory.

Figure 2-2 DRDC Gascoyne Inlet Northern Watch Base Camp

Figure 2-3 DRDC Gascoyne Inlet Northern Watch Base Camp

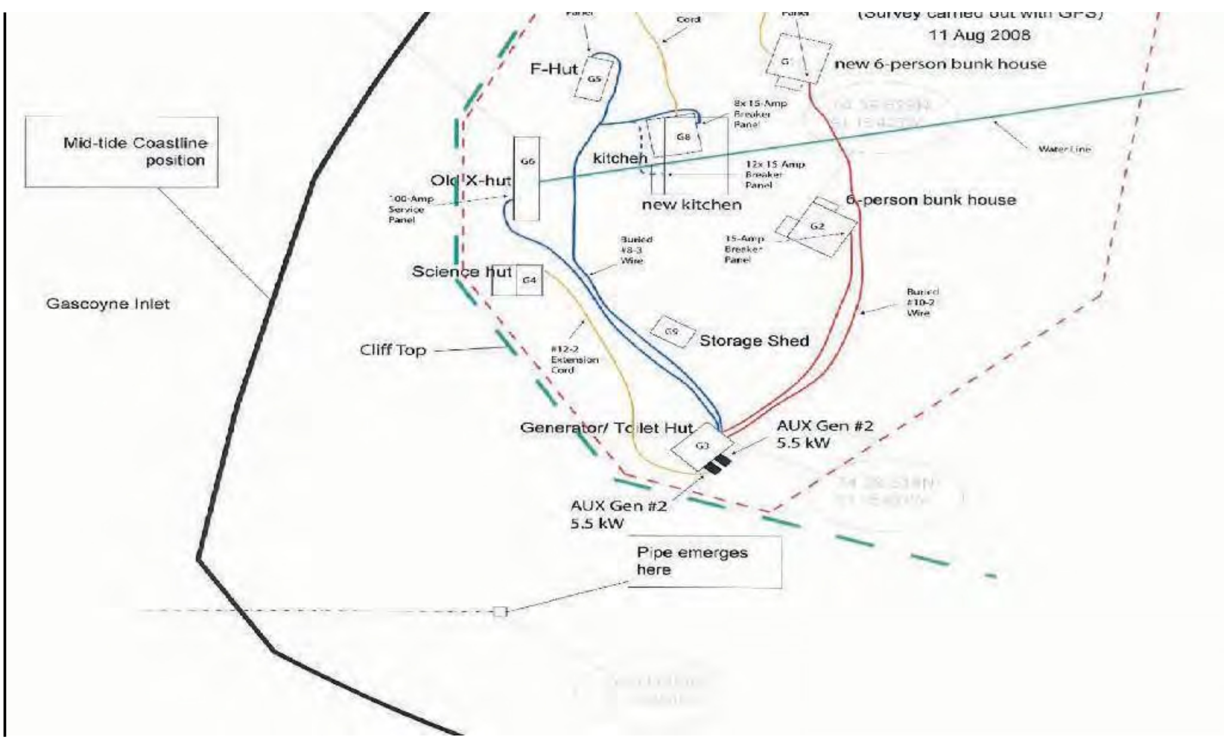

Figure 2-4 Gascoyne Inlet Camp Layout Diagram

Figure 2-5 Camp Image and Sketch from Project Kick-off meeting

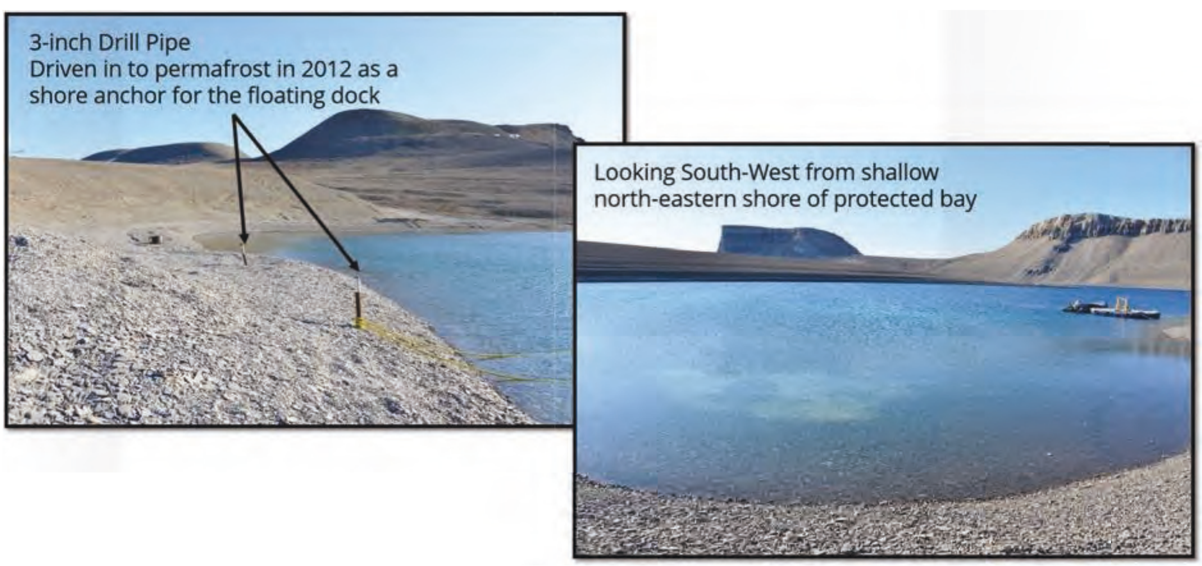

Figure 2-6 Ground view from the small protected bay to the south of the DRDC camp

3 Project Details

3.1 Goal Statement

3.1.1 Project Task 5.2, Deliverable 6.3 – Observatory Installation

As described in the Project Proposal, this task will deploy a subsea cabled observatory at the location selected in task 5.1 (Gascoyne Inlet). This task includes: final design of the system; physical installation of the system at the selected location; and operation of the system for one year. The deployment will use an articulated pipe shore landing technology and a simplified installation process in an attempt to minimize the resources required to deploy the system. The system will be operated for one year to gain further knowledge of operations in this environment and to validate the shore landing technology and simplified installation process. The Observatory will include an instrument platform with a representative instrument (i.e. CTD).

Design, build and deploy a cable landing protection system for a subsea cabled observatory. An ideal system will include a representative instrument (i.e. CTD) and real-time data communication in order to validate full operational capability. Monitor and evaluate the deployed cabled observatory for a period of one year to sufficiently evaluate the deployed technology.

3.1.2 Project Task 5.1, Deliverable 6.2 – Design Study

A secondary goal of this project is Task 5.2, Deliverable 6.2, to complete site assessment visits to key Arctic choke points identified by DRDC for the Conceptual Design Study. This includes assessment of Resolute Bay and Gascoyne Inlet for a large scaled cabled observatory between the two sites for test and evaluation of persistent AUV monitoring systems. Assessments also include evaluation of sites for smaller scale Community Observatories at locations including: Qikiqtarjuak, Grise Fiord and CFS Alert.

3.2 Project Scope Task 5.2, Deliverable 6.3

The following requirements are listed and differentiated from the project objectives in order to define the overall scope of the project.

3.2.1 Requirements:

- A cable armouring system known as “split pipe” will be deployed in order to determine whether it will withstand harsh arctic environmental conditions such as sea-ice;
- The split pipe must be deployed safely and without the use of divers or heavy equipment. This test is to help determine whether such methods can be reliably deployed at a relatively low cost, anywhere in the arctic; and
- The full system must be deployed for at least one full winter season.

3.2.2 Objectives:

- The deployment should include a means of determining if and when the cable armouring has failed;
- The split pipe should, if possible, protect an actual instrument cable to help prove the ability to safely deploy such a system and the full ability to actually protect the cable throughout an entire season; and
- The deployment should, if possible, include an instrument that can communicate data back to ONC on a regular basis throughout the year/winter-season. This can then be used to help determine if and when the armour fails, and also helps to prove the full deployment method; it also takes advantage of an opportunity to gather some potentially useful environmental data.

3.3 Personnel

For ONC to deliver on the complete feasibility study, a total of seven people will visit the Gascoyne Inlet Base Camp. Only the three ONC personnel will be present for the actual observatory deployment; the other four people are external consultants and will only visit the camp for ~4hrs on the final deployment day before departing with the ONC team for Resolute Bay:

3.3.1 ONC Team

ONC Staff will be involved in both project Task 5.1 (Deliverable 6.2), the Conceptual Design Study for an observatory that connects Resolute Bay with Gascoyne Inlet with power and fibre optic communications and docking sites to test and evaluate persistent AUV systems in Barrow Strait and project Task 5.2 (Deliverable 6.3), observatory installation at Gascoyne Inlet to test and evaluate Arctic cable deployment techniques.

Scott McLean: Mr. McLean is the Director of the ONC Innovation Centre, a national centre of excellence with a role to expand the use ocean observing technology in Canada and internationally. Mr. McLean has 30 years of experience with ocean technology specifically with expertise in sensor system and observatory design, economic development, commercialization and technology transfer. In 2013, the Innovation Centre developed a program called Smart Ocean Systems™ that integrates sensor systems, monitoring infrastructure and ocean analytics to provide solutions for public safety, marine safety and environmental monitoring. The first prototype for this system was the Cambridge Bay Observatory. The system is now being expanded to cover six sites along the BC coast including ports in Prince Rupert and Vancouver. The Innovation Centre also works with marine cable and installation companies to provide feasibility studies and consulting services in Canada and internationally for organizations interested in developing subsea cabled systems for scientific research applications.

Ian Kulin: Mr. Kulin is a graduate of Dalhousie University (TUNS) and a LEEDS Accredited Professional Engineer. He joined ONC in January of 2012 as the Engineering Director for NEPTUNE Canada and moved into the position of Marine Operations Director in 2014 for all of ONC. Concurrently, he has worked since 2009 at the University of Rhode Island Graduate School of Oceanography (GSO) as an Engineer on Dr. Robert Ballard's E/V Nautilus team. GSO work included all E/V Nautilus vessel upgrades, maintenance and future planning as well as development of a new instrument package for the Integrated Ocean Drilling Program (IODP). Prior to working on the Ballard team, Ian worked over 18 years managing various engineering projects in more than ten countries on four continents.

Ryan Flagg: Mr. Flagg is the Observatory Support Engineer for Ocean Networks Canada (ONC). He implemented ONC's first cabled "Community Observatory" in 2011 and led the installation ONC's first arctic observatory (Cambridge Bay, Nunavut) in 2012. He has helped lead every subsequent maintenance operation and continues to assist with community engagement and to take part in research and instrument testing in Cambridge Bay. Ryan is actively helping to propose, plan for, and implement new monitoring initiatives throughout the north and along Canada's other coastlines.

Outside of ONC, Ryan has served as a Marine Engineering Systems Operator with the Canadian Armed Forces Navy Reserves for fifteen years.

3.3.2 External Consultants

The external consultants will be involved in Project Task 5.1, Deliverable 6.2, the Conceptual Design Study for an observatory that connects Resolute Bay with Gascoyne Inlet with power and fibre optic communications and docking sites to test and evaluate persistent AUV systems in Barrow Strait.

This will involve site visits to Resolute Bay and Gascoyne Inlet.

Mike Wilson: Mr. Wilson is the CEO of Pacific International Cable Consulting (PICC). PICC offers professional consulting services in submarine cable route engineering, manufacturing/QA processes and installation related to the marine environment from the land terminal station to the coastline to the deep sea.

PICC's deep and varied expertise with the full spectrum of cable laying technologies, products, processes and global providers will be an invaluable addition to the team as it completes the conceptual design studies for the identified chokepoint sites, and the preparation and oversight for the physical implementation of the subsea cabled observatory.

Three people (TBD) from IT International Telecom Inc. (IT): IT is an ISO certified, international marine network provider, providing turnkey design, installation and maintenance of marine cable systems and related subsea infrastructure. This includes single to multi wavelength un-repeatered systems, installation of multi wavelength repeatered systems and submarine oceanographic instrumentation and sensors.

3.4 Pre-Deployment

The following is a timeline summary of the tasks that need to be accomplished leading up to the actual deployment. The table is followed by more detailed descriptions of each task. The term "system" here refers to the combination of the instrument, underwater connector, and subsea cable.

Table 3-1 Pre-Deployment Target Dates

Target Date	Task
17 Apr	Instrument selection and testing complete
24 Apr	Ship system – arrives at BIO for testing
8 May	Receive Instrument from BIO
29 May	Complete purchasing of installation hardware
5 Jun	Final instrument/system testing complete
12 Jun	Pack cable & hardware and ship for loading aboard CCGS
26 Jun *	Load Hardware on to CCGS
3 Jul *	Scheduled Departure of CCGS
31 Jul	Complete database updates
3 Aug	Estimated Arrival of CCGS at Resolute Bay

* These dates are estimates based on the typical loading and departure dates of the CCGS Sir Wilfred Laurier. Schedule for CCGS Henry Larson TBD

Instrument selection and testing complete: An AML Metrec-X CTD was purchased in 2016 in anticipation of having to complete the installation that same summer. The delay in the contract has pushed the deployment to 2017. The AML CTD is still available and ready, but it would require design modification (by AML) in order to accommodate new requirements not to interfere with DFO programs at on the BIO shore station at Gascoyne. Since the DFO system works with a SeaBird 37 Microcat CTD instrument, it is the lowest risk option for DFO, so ONC has opted to deploy an SBE system. ONC will charge an SBE instrument to this project, which will adapted to accommodates the use of an external power source (subsea battery) for the instrument.

Ship system – arrives at BIO for testing: BIO personnel need to ensure the final system will communicate properly with their shore station electronics without interfering with their other cabled equipment. Testing at BIO should ideally include testing of data transmission from the BIO shore station to Oceans 2.0.

Receive Instrument from BIO: Once BIO tests are complete and confirmed successful, the full system needs to be shipped back to ONC (MTC) where final pre-deployment testing and integration can take place.

Complete purchasing of installation hardware: Hardware (e.g. split pipe, chain, rope, floats, etc.) should be purchased with enough time to either have them received directly by East Coast DFO/DRDC personnel or to be shipped from ONC. Emphasis here is on heavy equipment that cannot or should not be brought up on commercial flights.

Final instrument/system testing complete: The instrument, cable, and battery will be tested following ONC's standard qualification procedures and deployed in either one of the test tanks at MTC for as long as possible. This includes data verification/validation.

Pack cable & hardware and ship for loading aboard CCGS: Pending more information regarding the schedule of the CCGS, as much heavy and non-critical equipment as possible should be shipped to DFO for loading and transport north. The instrument should be boxed up and transported separately with the three person ONC installation team. Ideally, the cable and external battery will travel with them as well. This avoids the risk of not being able to deploy the instrument at all if the CCG vessel cannot be loaded in time or there are unforeseen delays.

Load Hardware on to CCGS: Loading of the ship will need to be completed by East coast DRDC personnel on the scheduled (TBD) loading date.

Complete database updates: Oceans 2.0 ready to receive data from instrument system via BIO shore station electronics. On-site communications with ONC will be limited to Satellite phone so all preparation work should ideally be completed prior to the three person ONC installation team departing Victoria.

Estimated Arrival of CCGS at Gascoyne Inlet: The CCGS is scheduled to arrive in early August where it will be met by both DFO and DRDC personnel at Gascoyne Inlet.

3.5 Logistics Considerations

As much of the equipment and hardware (detailed below) as possible will be transported to the site accompanying the ONC field team. The focus of these luggage/air-freighted items will be on items and tools that are critical to accomplishing the minimum scope of the project. Experience has shown that while luggage/air-freight items may arrive 24 hours later than expected, items traveling by ship in to the arctic may be several days, weeks, or even months late. The deployment will therefore only depend on the 25m of split pipe ONC has pre-staged in Cambridge Bay that will be air lifted to Resolute Bay with the ONC team. This split pipe will be sufficient to deliver the minimum scope of the test deployment tasking. CCGS sealift to transport two crates (50m) of split pipe armour to the Gascoyne Inlet site (or Resolute Bay as a secondary delivery site) will be used to augment the 25m of split pipe that ONC plans to transport from Cambirdge Bay. This extra split pipe can either be used to increase the scope of the test or can be left on site (Gascoyne Inlet or Resolute Bay) for future deployment.

Table 3-2 Travel date key considerations

2017 Dates	Considerations
3 Aug	Expected arrival and crew-change date of CCGS in Resolute Bay
3-23 Aug	Operational dates of DRDC camp at Gascoyne Inlet
3-10 Aug	Expected CCGS assistance for DFO program
10-15 Aug	Expected CCGS assistance for DRDC program

Note that it is expected that DRDC will have all necessary deployment permits in place prior to the ONC team arriving on site.

3.6 Travel

Travel is planned in three segments for the ONC deployment team:

- North Bound – Victoria, BC to Resolute Bay, Nunavut;
- Arctic Site Visits – Resolute to Eureka to CFS Alert to Grise Fiord to Resolute, Nunavut; and
- South Bound – Resolute to Victoria.

Note that transportation of personnel and equipment between Resolute Bay and Gascoyne Inlet will be conducted using charter flights to be arranged and administered by DRDC.

3.6.1 North Bound:

A commercial flight will be taken to Cambridge Bay and a "Kitikmeot Air" charter will be taken from Cambridge Bay to Resolute. Flights from Victoria to Cambridge Bay require an overnight stop in Edmonton (sometimes Yellowknife), land seven days a week at either 1225 or 1345. The reason for this approach (versus commercial flights straight to Resolute Bay) is to be able to pick-up heavy equipment and hardware in Cambridge Bay where it can then be transported via aircraft to Resolute. From Resolute Bay, equipment, ONC staff and consultants will be transferred to Gascoyne Inlet by DRDC chartered flights.

3.6.2 ArcticSiteVisits:

Once the deployment work at Gascoyne Inlet is complete, the ONC field team will depart Gascoyne Inlet for Resolute Bay. The team will spend at least one full day in Resolute with industry consultants, assessing the community and surrounding area for feasible cable landing sites. From there, the ONC team will travel to several more sites:

- Eureka – The charter flight must stop here to refuel but the ONC team will spend additional time (~4 hours) studying the shoreline and visiting the PEARL site;
- Alert – ONC personnel plan to spend between 24 and 48 hours in Alert;
- Grise – ONC personnel will spend between 24 and 48 hours in the community of Grise Fiord. A refuelling stop will need to be made in Eureka; and
- Resolute – The ONC team will finally travel back to Resolute before heading home to

Victoria Total flying time is estimated at 8.6 hours for 2-3 people and up to 900-lbs of gear/luggage.

Commercial flights from Resolute to Victoria leave 6 days per week and do not require any overnight stops.

Figure 3-1 Site visit locations for cabled observatory assessment

3.6.3 South Bound:

Commercial flights from Resolute to Victoria leave 6 days per week and do not require any overnight stops.

3.6.4 Estimated 2017 Travel:

Table 3-3 Estimated Travel Dates

Target Date	Task
3 Aug, Thu	Depart Victoria for Resolute Bay (North Bound)
5 Aug, Sat	Arrival at Resolute Bay
6 Aug, Sun	Arrival at Gascoyne Inlet field camp
6-10 Aug	Installation operation, Gascoyne Inlet
9 Aug, Wed	Industry consultants arrive in Resolute Bay
10 Aug, Thu	Industry consultants arrive for site visit (~4hrs). Depart Gascoyne Inlet for Resolute Bay
11 Aug, Fri	Resolute Bay - Assess site feasibility with industry partners/sub-contractors
12 Aug, Sat	Depart Resolute for Alert - Stop in Eureka for 2 to 4 hours. Re-fuel and conduct site assessment (including PEARL)
13 Aug, Sun	Depart Alert for Grise Fiord
15 Aug, Tue	Depart Grise Fiord for Resolute
16 Aug, Wed	Depart Resolute (South Bound)

Estimated travel dates are based on several factors:

1. DRDC Personnel must have the Gascoyne Inlet field camp operational
2. DFO personnel are expected to be on site prior to the ONC installation team arriving in order to make sure the shore station is operational and ready to connect to the cabled instrument
3. Ideally the CCGS Henry Larson will be available to deliver the additional split pipe directly to the site in addition to the operational support they are planning on providing to DFO. Failing this, enough hardware (25m of split pipe plus installation support tools/hardware) will be shipped via charter flights to fulfil project needs.

3.7 Deployment Site Overview

The minimum amount of split pipe expected for the deployment is 25m (one crate) ,which will be flown via charter flight from Cambridge Bay to Resolute Bay and Gascoyne Inlet. This is the minimum deployment and is reserved as the back-up should a larger installation not be possible. Given the project's access to a CCGS as a resource for transporting heavy goods, the intended deployment will be for a total of 75m of split pipe divided between two installation areas. The first (primary) installation area will include a cabled instrument platform connected to the DFO shore station in the camp's "Science Hut". The split pipe and cable will extend into the small protected bay to the south the camp with an intended entry point several meters to the east of the current anchor points for the camp's floating dock.

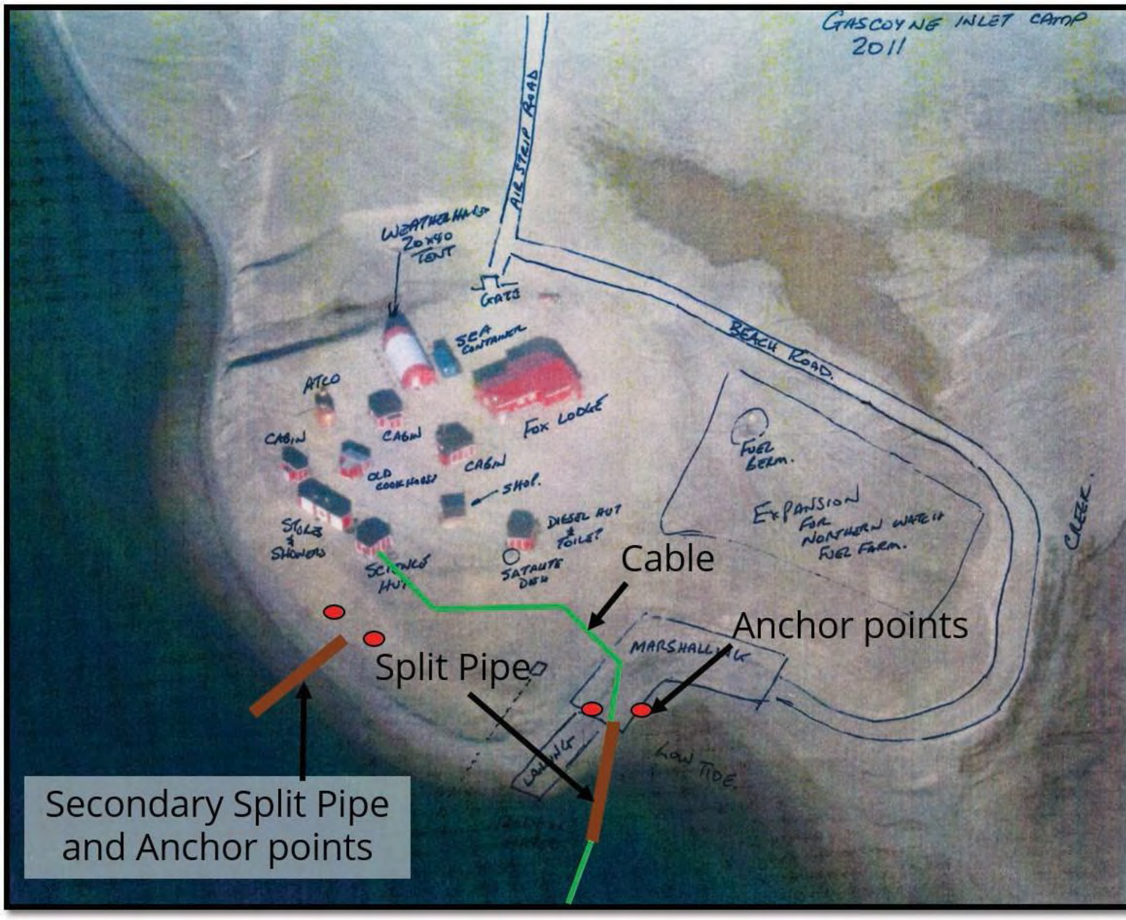

Figure 3-2 Top down view of DRDC camp showing cable and split pipe plan

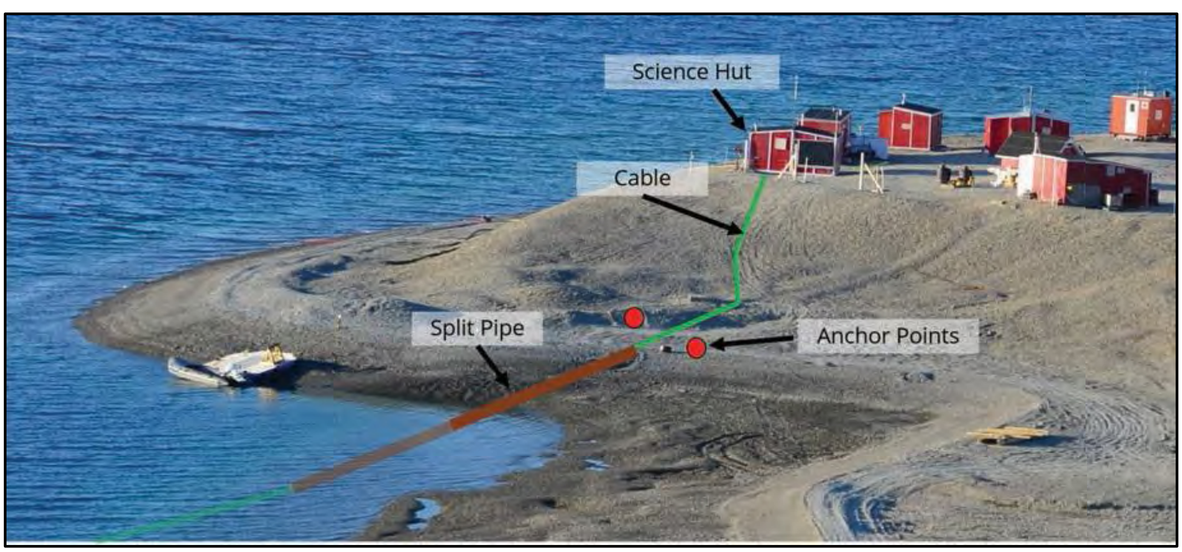

Figure 3-3 Northward view of DRDC camp showing cable and split pipe plan

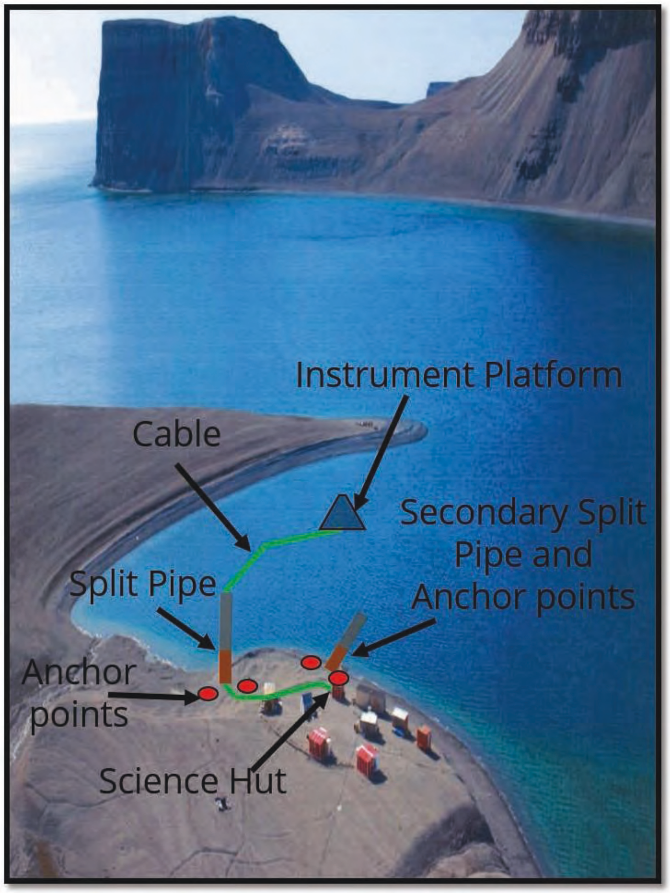

Figure 3-4 Southward looking top-down view of DRDC camp showing split pipe and cable plan

Figure 3-5 Photos of floating dock and shore slope during different times of the tide cycle

The final split pipe installation should extend 2 to 5 m past the High-tide line to account for sea-ice that will be pushed up the shore during the initial freeze-up and also serve to protect the cable from ice blocks pounding and washing against the shore during the melt period. Ice is expected to reach approximately 2m thick (most of which is realized as draft, extending below the water line) and tides have been reported as being approximately 5m. The split pipe must therefore cover a minimum of a 7m *vertical* distance in order to protect against first-year sea ice that is only moving due to tidal forces. To protect against ice scour that is likely to occur below the "low ice line", the split pipe armour should extend a further 5-15m total distance to get as deep and as far away as practical from the coastal ice zone. The instrument cable needs to extend past the deep end of the split pipe 2-3 times the platform deployment depth. Deployment depth is expected to be 15-25m so the expected length of "free-cable" is 50m.

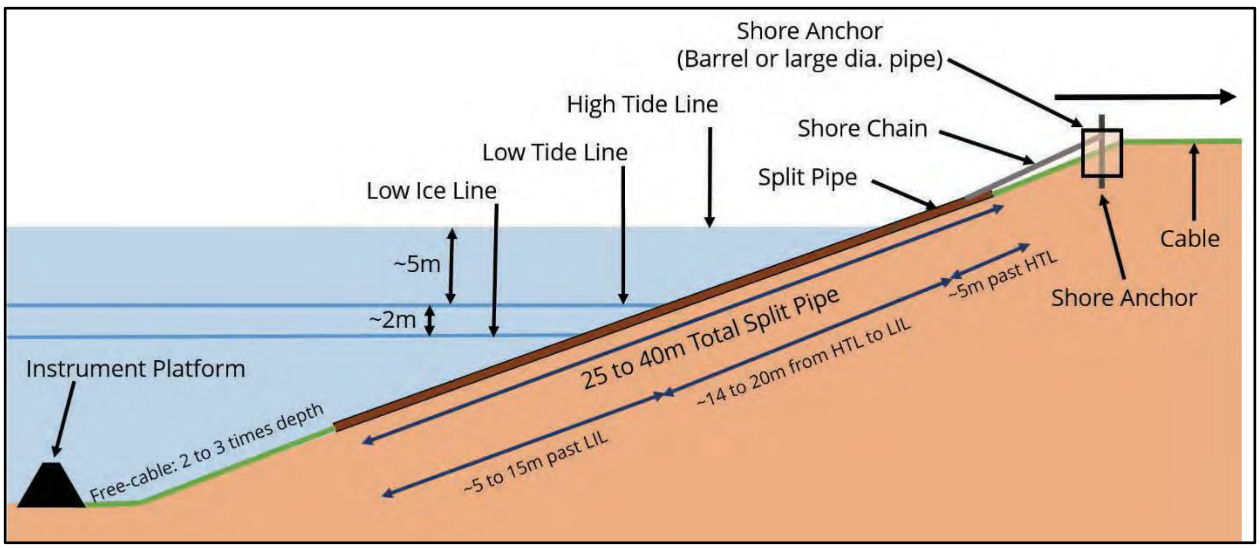

Figure 3-6 Deployment Summary

The secondary deployment site will not have a cable or instrument platform. Its intent is to simply test the resilience of the split pipe when deployed on a different area of the coast, which is much more exposed to currents and drifting ice than the primary deployment. If possible, images of this secondary location will be captured throughout the year by the stationary cameras that DRDC is intending to deploy. Other than a post-season survey of the site in 2018, this will be the only means of recording how well the split pipe performs throughout the year.

Figure 3-7 Shore line of secondary deployment area (looking north along western edge of camp)

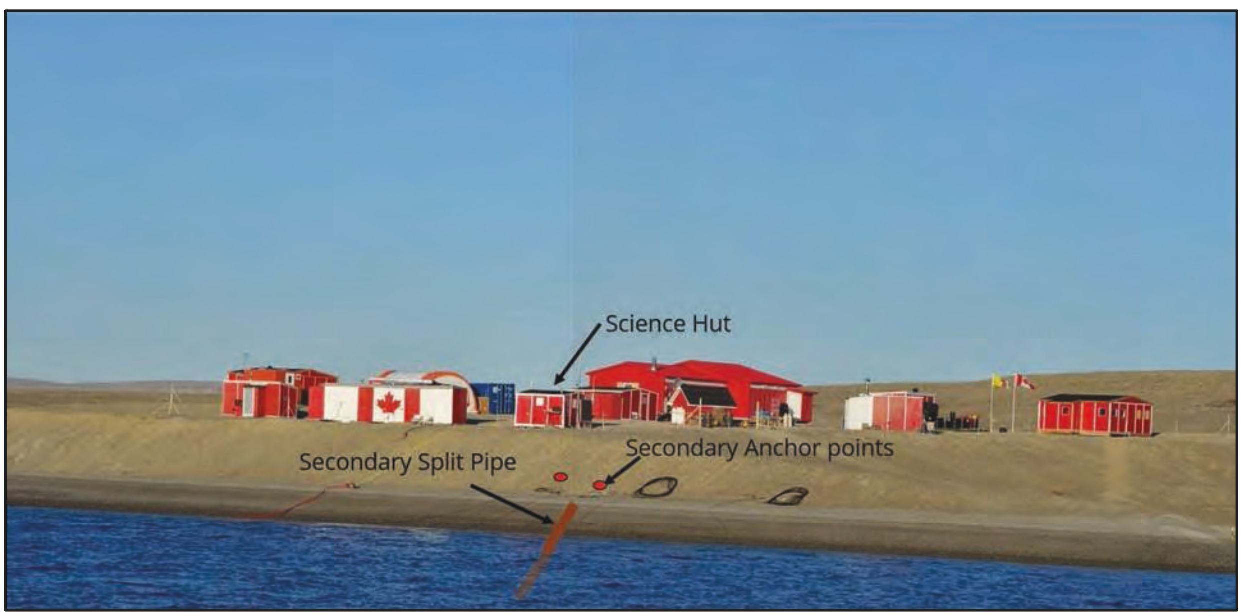

Figure 3-8 Looking east toward the camp and the planned secondary split pipe location

3.8 SplitPipeDeploymentMethod

3.8.1 Concept

Articulating split pipe is a cable armouring system that is commonly used to help telecommunication cables safely cross coastal intertidal zones. It consists of interlocking sections that are split down their length to allow them to be assembled around cable (versus having cable always needing to be pulled through) and allow for long lengths to be assembled one section at a time. The piecemeal nature makes it relatively easy to transport potentially long sections and the articulating segments make the armour ideal for conforming to a wide range of coastlines and bathymetric features.

The sections are easily attached using two standard bolts which can be easily done from shore and which is typically done by commercial dive teams for underwater segments. The technique shown/described here shows how a substantial length of split pipe armour can be assembled on shore or on a small vessel and deployed without the use of SCUBA. The mechanical advantage afforded by using a system of floats and line and the inherent friction at each turning point allows for a long, heavy length of armour to be lifted lowered to the seafloor using minimal effort from a small surface vessel.

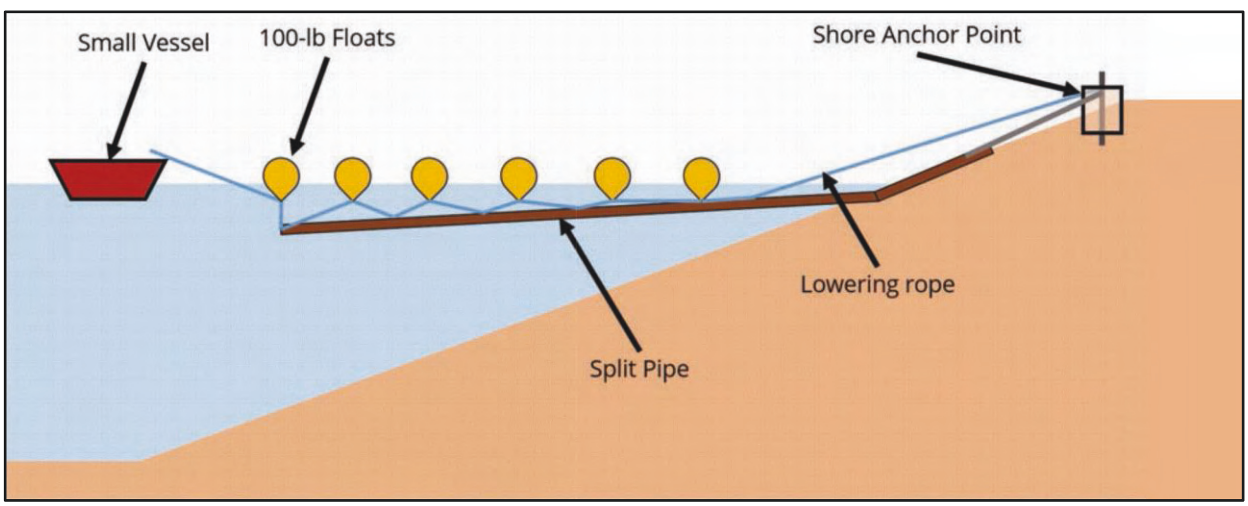

Figure 3-9 Floating Split Pipe Assembly Concept

For minimal person-effort from the deployment team, the armour, floats, and lowering rope can be assembled along a shoreline at low tide. The high tide can then be used to float all or most of the assembly, which can then be towed in to location. Where shoreline features or access prevent this from happening, the entire assembly can take place from onboard the deployment vessel and then towed in to location (example below).

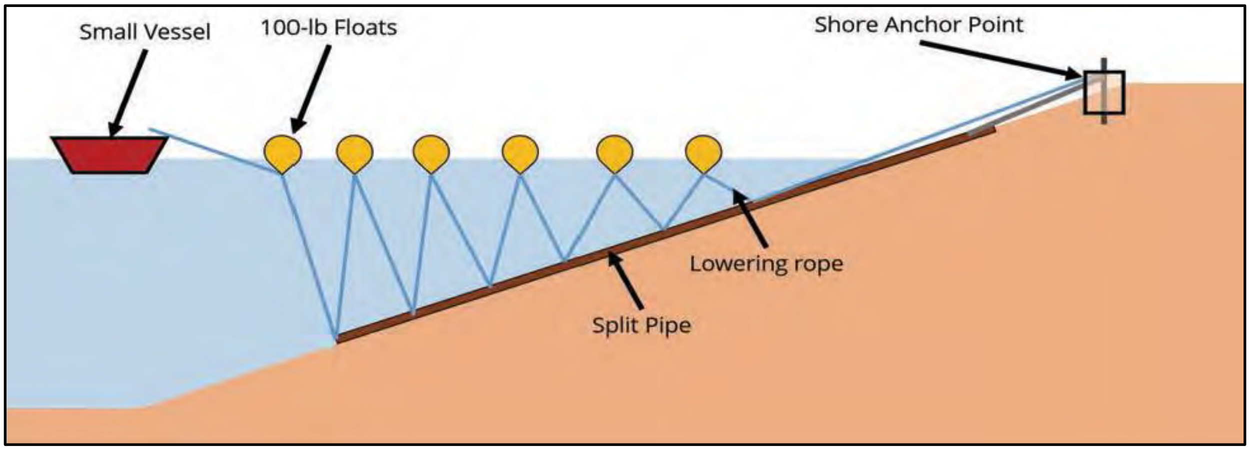

Figure 3-10 Split Pipe Assembly Lowered to Seafloor

The above diagram helps to illustrate how the overall length of the lowering rope will increase dramatically as the overall length of split pipe is increased and also as the slope angle of the deployment zone increases.

3.8.2 Considerations

The brand of split pipe being considered here weighs ~1250-lbs per crate. One crate holds 25m of split pipe (100 pieces) with an assembled weight of ~50-lb/m. Having smaller floats attached at every bolt point (0.5m) is likely impractical as it increases the overall number of floats and length of rope needed and also increases the likelihood of tangled lines. Using fewer larger floats is preferred but due to the split pipe's ability to articulate, floats need to be close enough together to prevent excessive drooping between lift points.

The following table illustrates the increased need for rope (and floats) needed to employ this method. Note that this is a simplification since shorelines should not be expected to have a constant slope angle. The numbers here help to demonstrate the practical upper limit of employing this method from a small surface vessel operation. Numbers highlighted in red are past the 1,200ft (~366m) length of a full spool of line. Calculations are based on having 1 float for every 1.5m section of split pipe and include 5m of additional line as a minimum amount for tying off at shore and line- handling at the deep end:

Table 3-4 Calculated rope lengths and number of floats for various generic deployment scenarios

# of Floats	Shore Angle Pipe (m)	15°	18°	20°	23°	25°	28°	30°
14	20	70	83	92	105	113	126	134

17	25	108	129	143	163	177	196	118
20	30	156	186	206	235	254	282	300
24	35	212	253	280	320	346	384	409
27	40	277	330	365	417	451	501	534
30	45	350	418	462	528	571	634	675

3.8.3 Experience/Test

In anticipation of this project the method of diver-free split-pipe deployment was trialed in the spring of 2016 by ONC. The deployment took place on the coast of Saturna Island, BC. While weather was favourable for the single day installation, the specific location posed its own challenges:

- Currents were quite strong making it difficult for the small deployment vessel to hold station. Operations took place during the narrow slack-tide time window; and
- The shoreline was a steep rocky shoreline with no practical road access. For this reason, the split pipe (and eventually the cable and instrument frame) were deployed almost entirely from the small vessel and floated in to position.

While this scenario was by no means an ideal setting, it demonstrated that the method could be used in more extreme conditions than had originally been intended. The split pipe was loaded on to the vessel in pieces along with all of the necessary lines and floats.

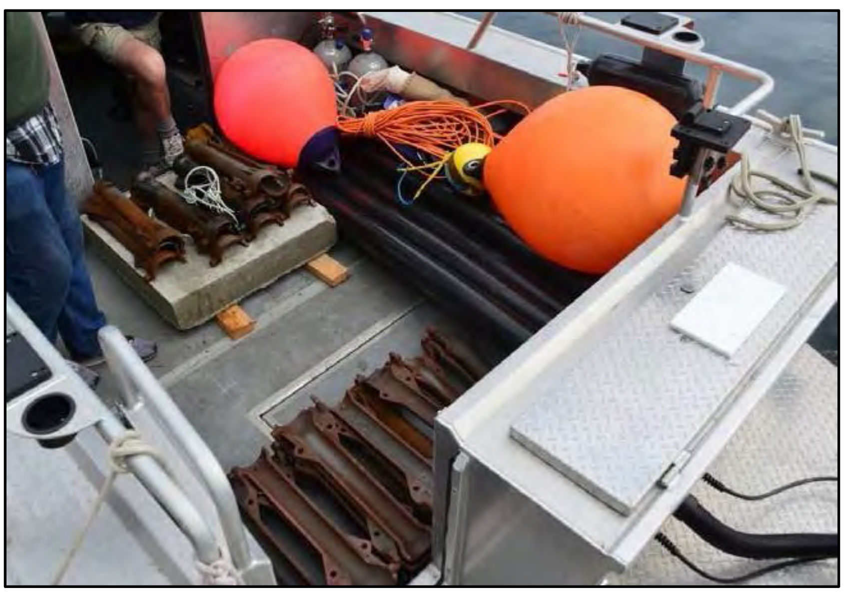

Figure 3-11 10m of split pipe, floats, lines, and instrument mooring block loaded in small vessel

Figure 3-12 Assembly of split pipe and floatation/lowering system off stern of small vessel

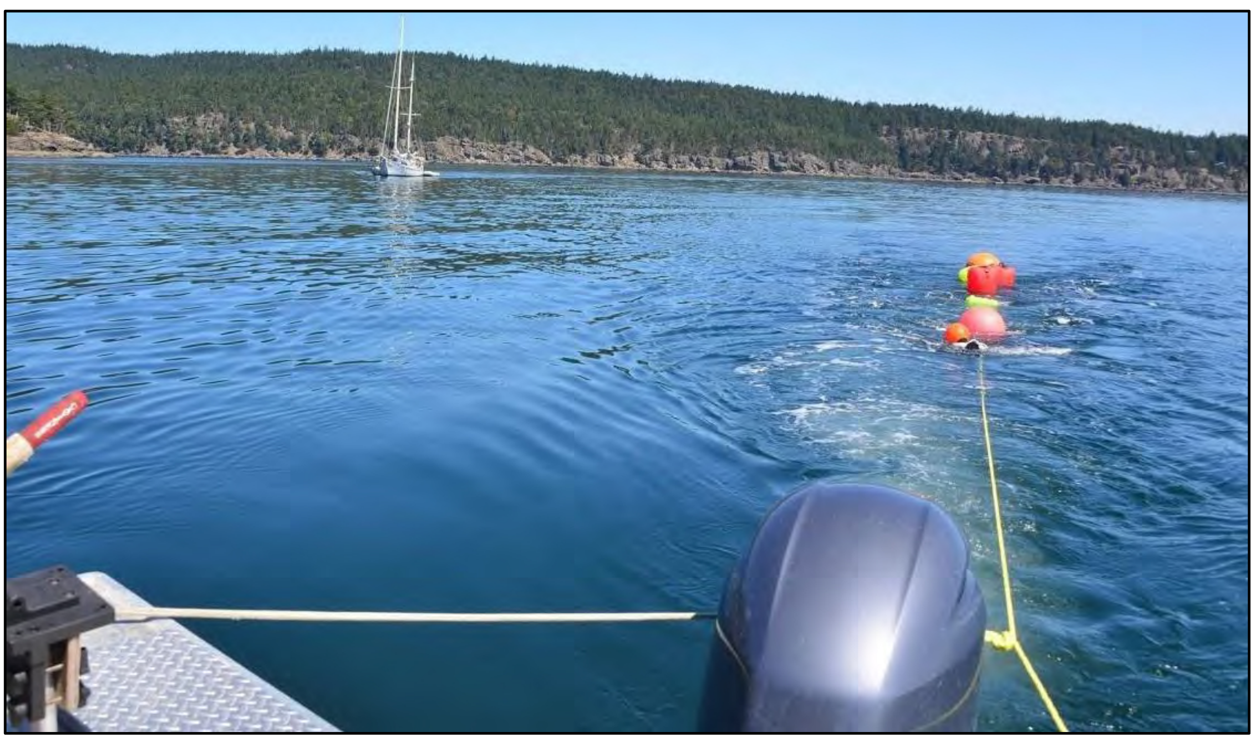

Figure 3-13 Towing the assembled 10m length of split pipe to deployment location

3.9 Deployment Steps

The actual deployment of the split pipe and cabled instrument will include the following steps and their associated tasks:

1. Arrival in Gascoyne via charter aircraft:
    a) Tour of facility and accommodation;
    b) Briefing on site rules/conduct; and
    c) Note tide state (height, time, rising/falling) for planning purposes.

Figure 3-14 Aircraft landing site near Gascoyne Inlet camp

2. Receive and/or unpack and organize gear:
    a) Check over tools and equipment to ensure still in working order;
    b) Inspect instrument and cable for signs of physical damage;
    c) If necessary, move split pipe and tools to near deployment area in preparation for assembly; and
    d) Start filling/pressurizing floats.

Figure 3-15 Proposed Staging Areas

3. Assemble instrument frame and test instrument (example shown below):
    a) Test instrument using test-cable and laptop. Record results;
    b) Tech/check external (subsea) battery and record voltage/condition;
    c) Assemble instrument frame;
    d) Mount instrument and external battery;
    e) Secure subsea recovery line;
    f) Secure temporary recovery line and float. Tape coil for transport;
    g) Prepare frame for strain relief of cable as necessary; and
    h) Photograph.

Figure 3-16 Example Instrument Frame and CTD – Subsea battery and recovery system not shown

4. Prepare instrument cable for pull-through:
    a) Waterproof dry end of cable using tape, plumber's putty, and plastic bags;
    b) Protect waterproof connector from damage;
    c) Strain relieve cable for attachment to pull-line;
    d) Unwrap cable in preparation for un-spooling; and
    e) Layout cable to ensure and additional red-rubber protective hosing as necessary. Cable should be protected for entire transition zone (armoured portion), for 2m+ next to instrument platform, and for 10m+ in-land of dry end of armour.

5. Mark out key deployment points:
    a) Cable/Split-pipe entry route;
    b) Cable route to shore station;
    c) Low tide line;
    d) High tide line;
    e) Top edge of split pipe (2m to 5m in-land of high-tide); and
    f) Shore anchor points for split pipe.

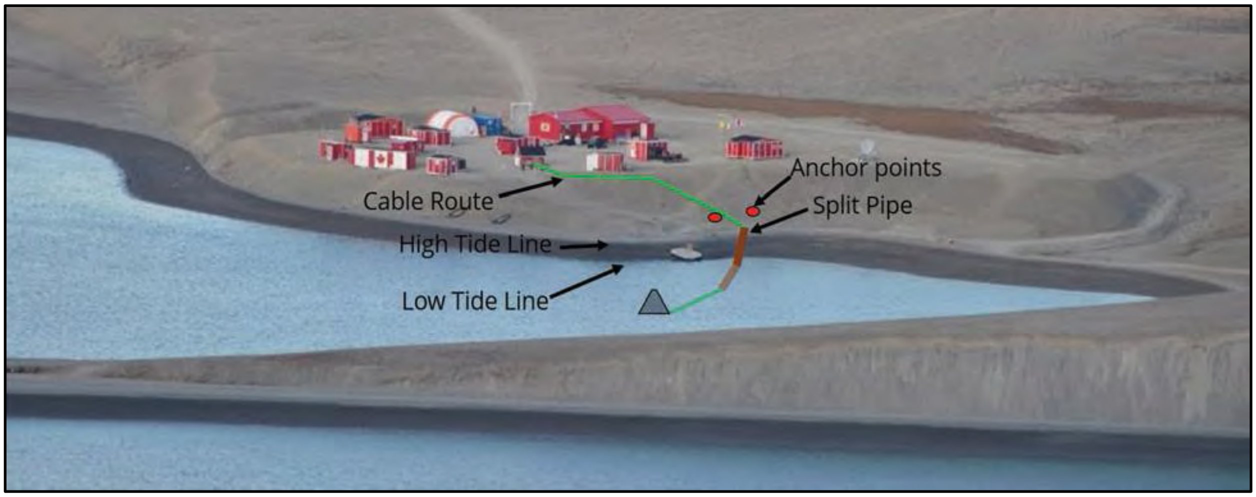

Figure 3-17 Cable Route Overview

6. Set anchor points and attach chain:
    a) Dig away loose top layer of rock;
    b) Drive steel spikes in to permafrost using sledge-hammer or jack-hammer;
    c) Attach shackle and shore-anchor chain;
    d) Place barrel (or large dia. pipe) over anchor post with chain passing through;
    e) Fill barrel with rock; and
    f) Record location, photograph deployment, and note challenges.

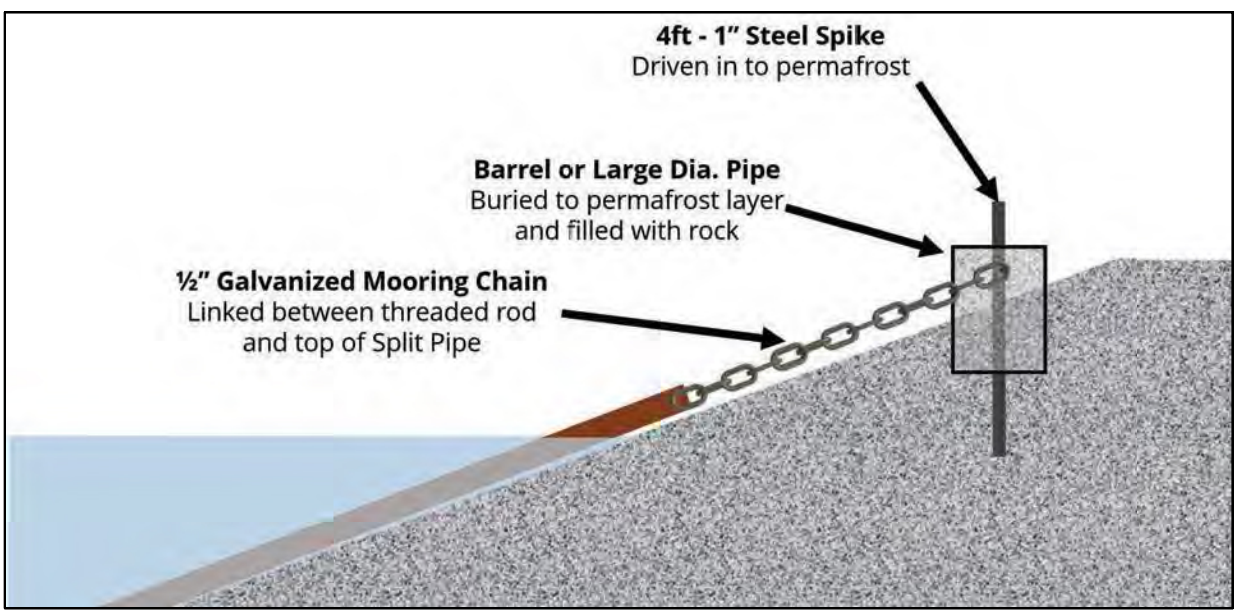

Figure 3-18 Shore Anchor Summary - Side View

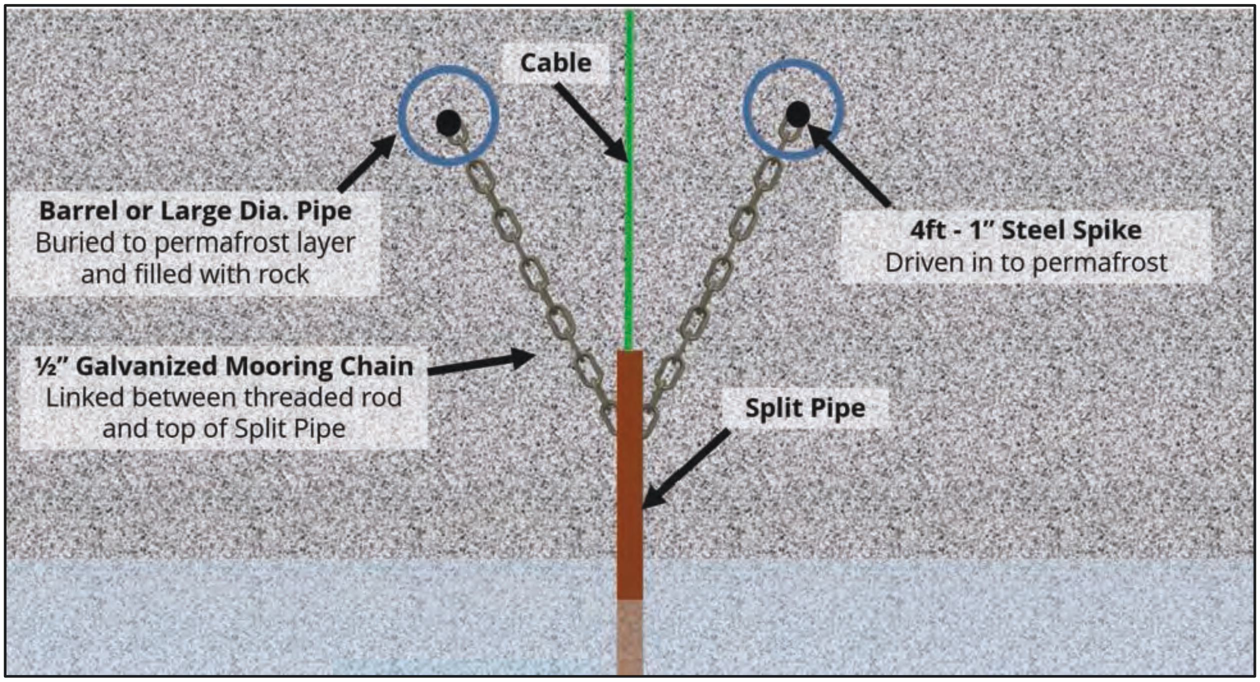

Figure 3-19 Shore Anchor Summary - Top View

7. Assemble split pipe with pull-line, lift points, tow lines, and anchors/chains. Ideal to start this step at high or mid tide during descent:
    a) Secure dry end of pull-line to anchor point;
    b) Lay out bottom-halves of split pipe pieces starting with upper-most dry piece at the end of the extended length of shore-anchor chain;
    c) Lay pieces in approximate direction of deployment. Curve toward a route that lays parallel to the tide line;
    d) Lay pull-line in interlocked lower-halves of the split-pipe;
    e) Add top halves of split-pipe with pull-line captured down the length;
    f) Secure a small "stopper" float to the deep-end of the pull-line; and
    g) Bolt all split-pipe holes. Starting at high-tide line, one bolt-hole per every third section (1.5m) should have a bolt with a threaded eye.

8. Prepare lowering rope and floats:
    a) Feed lowering rope through threaded eyes;
    b) Secure shore-end of lowering rope to upper-most threaded eye and to a shore- anchor point (as a back-up);
    c) Secure a small "safety" float to the deep-end of the lowering rope. This will prevent the loss of the end in the event of a "drop" of the armour;
    d) Tie a slip-knot in the lowering rope on the deep side of the deepest threaded eye. In the loop of the slip-knot, secure a shackle and 100-lb float. This will

double as the last float and a stopper knot for keeping the lowering rope taught until it the armour is ready to be lowered; and

e) Starting at 1 to 2 meters below high-tide line, a small shackle and 100-lb float should be secured to the lowering rope between every threaded eye.

9. Trench in split pipe on descending tide:
   a) Use a shovel and/or pick dig the split-pipe down to the top of the permafrost; and
   b) With waders and/or dry suit, trench below the low-tide line.

10. Inflate floats at low tide:
    a) Fully inflate and seal floats; and
    b) Prepare and tidy all lines in preparation for high tide.

Figure 3-20 mooring-style float for lifting split pipe

11. Deploy split-pipe:
    a) Once the split-pipe is floating, tow it to the desired deployment angle;
    b) Either lower split pipe immediately or wait for tide to fall if desired/necessary
    c) To lower split pipe, one line-handler should pull up on the anchor ropes to relieve tension from the lowering rope. The shackle and float can be roved from the slip- knot and the knot release. Tension is now taken on the lowering rope. Pay out the lowering rope under control with line handler(s) assisting as necessary using either the lowering or anchor ropes
    d) Once down, confirm location/route is desired. Lift and move if necessary (not ideal as this will likely be very difficult)
    e) Ensure pull-line is intact and floating
    f) Record time and location

12. Pull instrument cable:
    a) Return to shore to load cable and instrument frame in to vessel;
    b) Attach the dry-end of the cable to the floating end of the pull-line;
    c) Attach a second (back-up) pull-line to the installed pull-line in case the cable

breaks free. Note, do NOT attach the back-up pull-line to the cable;

d) Once secure, pull the cable through the split pipe. The cable should be fed from the small boat or (potentially) from the opposite shore;
e) Pull the cable all the way until it will reach easily inside the shore station building with an excess of ~5m cable coiled inside the building; and
f) There should be 2 to 3 times the deployment depth worth of cable between the end of the split pipe and the instrument platform (~50m).

13. Deploy instrument frame with recovery line
    a) If not already complete, connect the underwater cable to the mounted instrument and strain relieve the cable to the frame;
    b) Pull excess cable through from the dry-end until there is ~5-10m of cable more than is needed to bring the instrument frame to the surface at high-tide;
    c) Use a doubled over temporary recovery line (with small float) to lower the instrument in to the water. Use the boat to put a small amount of tension on the instrument cable while lowering the instrument to the seafloor;
    d) Record time and location;
    e) Survey deployment condition and record results; and
    f) Move instrument frame if necessary.

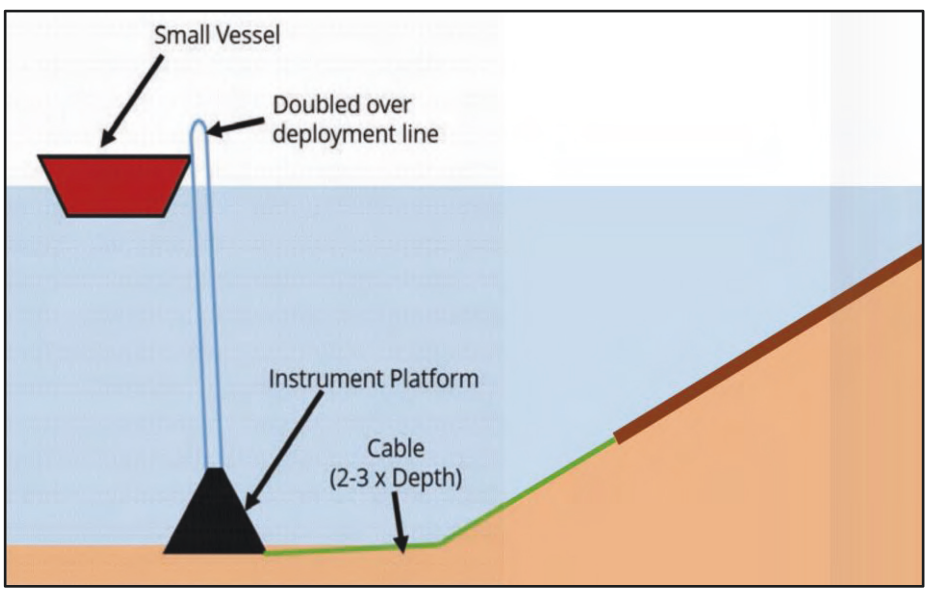

Figure 3-21 Frame deployment illustration

14. Connect cable to shore station and test system:
    a) Connect the cable to a laptop to ensure the instrument is operating properly;
    b) Record time results;
    c) Disconnect from laptop and connect the cable to the shore-station; electronics via a terminal block or other suitable weak-point connector;
    d) Test connectivity and communication of the whole system; and
    e) Record time and results.

15. Finish deployment:
    a) Strain relieve the dry end of the cable to the two shore-anchor points;
    b) Remove temporary recovery line from instrument platform;
    c) Ensure split pipe is fully buried and site is tidy;
    d) Bury dry/shore portion of cable;
    e) Survey full system (photographs and written notes);and
    f) Ensure DRDC shore cameras are deployed with correct field of view.

16. Demobilization:
    a) Assess and pack excess materials, hardware, and equipment/tools. Some may be left on site and some will be designated for transport back to Resolute, Cambridge Bay, and/or Victoria;
    b) Arrange for transportation from Gascoyne Inlet to Resolute;
    c) Contact industry partners and charter service (for Arctic Site Visit travel portion) to update on status; and
    d) Pack and prepare personal equipment. Depart.

Each of the above deployment steps has an estimated amount of time and effort associated with it and is summarized in the table below along with what tools/equipment and hardware are needed and what deployment day they are expected to take place on:

Table 3-5 Deployment summary and schedule

Step	# Per	Hrs	Equipment and Hardware
Day 1 (6 Aug 17)			
1	3	3	N/A
2	3	2	Screwdrivers, pry-bar, knife
3	1	1	Instrument, subsea-battery, frame, cable, subsea-recovery line, instrument test-cable, laptop, temporary (surface) recovery line, small float, electrical tape.
4	2	1	Electrical tape, plumber's putty, small plastic bags, strain-relief twine, packing foam, cable, red-rubber hose, tie-wraps
5	2	1	Measuring tape, marker rods and/or marking tape
Day 2 (7 Aug 17)			

6	2	3	Shovel, pick, threaded-rod, nuts, shackles, surface anchor chain, sledge hammer, barrel (or large dia. pipe), notepad/laptop, camera, handheld GPS.
7	2	3	~40m split pipe, ~160 bolts & nuts, ~28 threaded eyes, wrenches, anchor rope(s), pull-line, 3 small floats, 3 shackles.
8	2	2	Lowering rope, small float, shackle, ~24 100-lb floats, ~24 small shackles.
9	1	1	Shovel and/or pick, waders or dry suit
10	1-2	1	Air pump
11	3	1	Small boat, notepad/laptop, camera
12	3	1	Small boat, deployment line, 2 anchors, 2 anchor chains, 4 shackles.
			May need knife and 2 thimbles (for anchor rope)
Day 3 (8 Aug 17)			
13	3	2	Small boat, cable, tape, strain-relief twine, 2nd pull-line
14	3	2	Frame mounted instrument and battery, connector grease, “kim-wipes”, alcohol, canned air, tie-wraps, electrical tape, red-rubber hose, strain-relief twine, deployment line, small float, notepad/laptop, camera, handheld GPS, underwater video camera (if possible).
15	1	2	Laptop, notepad, wiring diagram, terminal block, screwdriver
16	2	2	Strain relief twine and line, small boat, shovel, pick, notepad, laptop, handheld GPS, camera.
17	2	3	Notepad/laptop, camera, packing supplies, satellite phone
Day 4 & 5 (9/10 Aug 17) – Weather days or repeat Days 2 & 3 for second deployment			

The post-deployment report should include (at a minimum) the following information:

1. Images of site and of equipment upon receipt/arrival;
2. Instrument data files and test notes from on-site dry test of instrument;
3. Images, descriptions (with a focus on necessary alterations to the intended deployment plan), and GPS coordinates of all deployed equipment:
    a. Shore anchor points;
    b. Shore anchor chains;
    c. Split pipe;
    d. Cable and protective outer hose;
    e. Frame mounted instrument and battery;
    f. Strain relief points; and
    g. Shore station connection and wiring.
4. Instrument data files and test notes from on-site wet test of instrument;
5. Any and all configuration and communication files and notes;
6. Any underwater imagery and video; and
7. Shore based images from stationary DRDC cameras.

3.10 EquipmentandHardware

The following tables detail the equipment and hardware needed for deploying up to two separate lengths of split pipe with a total length of up to 75m (nominally a 40m main deployment and a 35m secondary). A trial of only 25m in length would be possible even if the CCGS were prevented from delivering materials (provided enough lead time) in which case some of the quantities below could be reduced:

Table 3-6 Summary of deployment equipment, tools, and hardware

Equipment/Tools	Qty.	Description
ONC Responsible		
Screwdrivers	6	Assorted styles and sizes for opening crates, closing float valves, and working on electronics
Knife	3	At least one per person on ONC field team
Depth sounder	1-2	Handheld unit for surveying deployment site
Laptop	2+	At least two laptops total for the ONC team must be able to connect to instrument and cable
Tablet (optional)	1	Loaded with new "Community Fishers" app for creating field log (potentially with images)
Notepad	1-3	Write-in-rain notepad and pens/pencils
Instrument Test-Cable	1	Pre-built cable for dry testing instrument on site prior to deployment
Measuring tape	1-2	Retractable measuring tape for measuring cable protection points and key site locations
Handheld GPS	1	For documenting
Camera	1+	For documenting
Underwater cam (optional)	1	Drop-cam or go-pro with housing and line for subsea surveys of platform, cable, and armour
Small floats	4+	Lightweight rigid foam net floats. ~3" x 6"
100-lb floats	20	Inflatable dive lift-bags or "polyform" buoys for floating up to 30m of split pipe at ~50lb/m. Intend to use one float per 1.5m (provides safety factor)
Small Shackles	20	3/8" (or equivalent) Stainless Steel shackle for attaching each float to the lowering rope
Air pump	2	Electric. Used for inflating lift bags/buoys
Wrenches	10+	Minimum: 4 x 9/16 (frame bolts), 4 x ¾" (split pipe), and 2 adjustable (shackles and as spares)
Pry bar		For breaking up permafrost and trenching in armour
Waders/Dry suit	1+	For trenching in split pipe below low tide line
Pull line	3 x 60m	3/8" Blue-polysteel. 3 lengths wanted so that there is a back-up and to have a potential pull-line left in place
Deployment line	2 x 60m	3/8" Blue-polysteel. Assumes 30m deployment depth,

		doubled over for recovery after deployment.
Lowering Rope	300m+	½" Blue-polysteel. May bring a full (1,200 ft) coil. 300m assumes a floating length of 30m of split pipe at a max average shore angle of 30 degrees.
Satellite Phone	1	For communications back to ONC and others
Sledge and/or Jack-hammer	1	For driving anchor rods. ONC will consult with DRDC regarding the potential use of an electric jack-hammer; If deemed feasible, spike driving attachments will be needed
DRDC Responsible		
Small vessel	1	Small outboard vessel with DRDC operator and safety equipment
Shore machinery	1	Includes small bobcat and/or other motorized vehicles. Not required for plan but potentially useful
Shovel	1	For digging anchor points and trenching cable
Pick	1	For digging anchor points and trenching cable
Hardware	Qty.	Description
ONC Responsible		
Instrument	1	CTD
Subsea Battery	1	Nortek battery for powering CTD
Acoustic Release	1	Pop-up float system with recovery line, spare parts, all associated hardware and electronics
Cable	100m+	"Falmat" subsea cable and subsea connectors for connecting CTD & battery to shore station
Disconnect Cable	1	Short length of cable with underwater connector. To be deployed without locking sleeve to create break-away point for cable. Possible to use test cable
Terminal block & Wiring diagram	1	For attaching dry-end of cable to shore station.
Frame	1	Will be in multiple pieces to accommodate shipping and will include all bolts, nuts, and zincs.
Split Pipe	25-75m	25m minimum. Planning on 2 crates (50m) aboard CCGS for nominal 40m main deployment and possible 35m secondary deployment. Must include 4 x ½" bolts and nuts for every 1m of split pipe
Threaded eyes	20-60	½" thread galvanized. One needed for every 1.5m of split pipe plus spares and two extras for the end
Steel spikes	8	4-ft long x 1" steel anchor spikes

Shore chain	4 x 5m	½" galvanized long –link. 2 lengths of 5m needed per installation for attaching shore end of split pipe to anchor points
Shackles	16	½" galvanized shackles
Electrical Tape	5+ rolls	Super 88 – for rope splices/knots, red-rubber hose, strain relieving, etc.
Strain-relief twine	2 rolls	300 lb+ breaking-strength green marine-twine
Marking rods/tape	10 / 1 roll	Used for marking key locations during deployment planning and execution.
Plumber's putty	2 tubs	Used for protecting connector, sealing building holes, and potentially sealing split pipe end.
Small plastic bags	3+	Used for protecting ends of cable and storing garbage and debris
Tie-wraps	100+	Several packs of various sizes for cable strain relief, holding red-rubber hose, etc.
Red Rubber hose	150ft+	5/8" inside diameter Red-rubber fuel hose
Underwater Connector Supplies	1 set	Includes 1 tube of grease, 1 box of lint-free wipes, 1 small bottle of alcohol, and 2 cans of compressed air.
Cable splicing supplies		Includes equipment and compounds necessary for splicing an underwater cable or re-terminating an underwater connector in the field. This is just in case the main cable or connector are damaged and need to be repaired
Packing supplies	1 set	Packing tape and/or plastic wrap and felt pens
DRDC Responsible		
Anchor Barrels	4	Clean barrels (or large dia pipe) for burying into rock at shore anchor points

3.11 Risk Mitigation

Table 3-7 Summary of major deployment risk mitigation strategies

Risk	Mitigation Strategy
1. The original intended deployment length of 25m of split pipe may be inadequate to get to deep/safe water	• The current plan is to purchase 3 crates (75m) of split pipe and have it loaded on to the CCGS for shipment directly to Gascoyne Inlet. This shipment will include other heavy/bulky deployment hardware.
2. CCGS unavailable to support operations	• 25m of split pipe has been staged in Cambridge Bay where it can potentially be flown via charter flight to Resolute/Gascoyne. This would provide enough to meet minimum scope
3. Inclement weather delays travel and/or on-site operations	• The current operations plan includes an extra 1.5 days on site to carry out the planned deployment. These days can be used to deploy a second test-length of armour if possible
4. The split pipe will be pulled/carried out of position by moving sea-ice during the winter season	• The split pipe will be attached via mooring chain to two separate shore anchor points; steel rods will be driven in to the permafrost layer and also buried within clean oil drums • The split pipe will be trenched in to the broken rock as deep as possible (likely to the ~24" deep permafrost layer) where it should freeze in to place beneath the rock
5. The instrument platform and/or cable will be dragged away by ice scouring or marine vessel	• The cable will be strain relieved to the same shore anchor points that the split pipe will be anchored to • There will be a weak-link connector between the shore station and main cable. Should the shore anchoring fail, this will disconnect before the shore station can be damaged.
6. The split pipe will be lowered in to the wrong location either by accident, due to inaccurate site surveying, or due to a need to let go of lines	• The lowering rope system (including the floats) uses a stop knot/float to prevent the system from coming apart unexpectedly. As long as the ropes are intact, the lowering rope can be tensioned at low-tide and the whole system should float enough by high-tide to allow the position to be adjusted. • DRDC has offered use of the shore machinery (small bobcat, etc.) if required. These could be used on the opposite shoreline of the bay to help tow/drag the split pipe in to position.

3.12 Safety

On-site safety is considered to be the overall responsibility of the DRDC personnel running the camp; ONC personnel will comply with all safety regulations and recommendations laid out by the DRDC personnel and shall follow their direction in the event of any emergency. However, ONC personnel shall have (at a minimum) the following training and equipment:

- First Aid Training– At least one member of the ONC field team will have current Medical First Responder training. The other two members will have a familiarity with first aid training, procedures, and equipment;
- Communications Training – All ONC personnel will be familiar with the use of their own Satellite phone. At least two members will have been trained in Marine and/or Aircraft communication procedures;
- Personal Equipment – All ONC personnel shall have their own clothing appropriate for the range of expected climate/weather and the work required of them. This is to include safety boots, work gloves, warm mittens, parkas, and layered under clothing. Note that ONC expects DRDC to provide marine safety equipment (such as PFDs) for meeting the safety regulations associated with small vessel operations; and
- Team Equipment - Satellite phone, small first aid kit, waders and/or dry suit.

3.13 DRDC Contribution Summary

The following is a summary of what resources and support DRDC is expected to provide for this operation:

1. Delivery of additional split-pipe via the CCGS Henry Larson;
2. All necessary permits to allow for site access, installation of hardware, and associated research activities (e.g. Nunavut Impact Review Board – NIRB);
3. Permission/access to all Federal Government sites including CFS Alert;
4. All necessary charter flights for personnel and equipment between Resolute Bay and Gascoyne Inlet;
5. Camp operations (including the provision of electrical power and fuel for machinery as necessary) and safety management;
6. Camp support staff for assisting as required with physical labour and use of machinery;
7. Small vessel, operator, and marine safety equipment; and
8. Various items of equipment and hardware:
    a. Four clean barrels (for shore anchor points);
    b. Shore based machinery as required (e.g. bobcat); and
    c. Shovel, Pick, and Sledge/Jack hammer.

3.14 ONC Roles and Responsibilities

The following is a description of the roles and responsibilities of the ONC field team members:

ROLES	RESPONSIBILITIES
Project Sponsor & Stakeholder Manager (Scott McLean)	• Responsible to ONC Executive for the overall delivery and success of the project • Handle the escalation of risks and issues both internally and in the front of DRDC • Provide direction on strategic aspects of the project • Work with ONC functional areas to ensure proper staffing of the project • Responsible for the oversight of the financials of the project • Responsible to the client for audits to the project • Responsible for the overall relationship with DRDC • Respond to DRDC's need for information • Responsible for gathering project critical information from DRDC and for understanding their expectations • Assist with installation duties as directed by the Installation Lead
Observatory Operations Lead (Ian Kulin)	• Responsible for coordinating timelines and resources • Responsible for communications between the Project Sponsor and Manager and the rest of the Observatory Operations Team regarding standard processes • Review all installation and field safety plans and provide feedback to the Installation Lead • Attend all project site visits • Provide input as a SME to the final Study/Report project deliverable via draft submissions as directed by the Project Sponsor. • Assist with installation duties as directed by the Installation Lead
Project Manager & Installation Lead (Ryan Flagg)	• Provide oversight for the project and the delivery of the solution(s) • Ensure overall project process and deliverable quality • Prepare the Installation/Deployment plan and design documents by collaborating with others as necessary. • Provide technical expertise and assessment of the project • Ensure the solution implemented addresses the project's and associated project objectives • Coordinate internal project meetings and track project activity and expenses • Monitor issues and risks associated with the targets and milestones of the project, and suggestion and manage risk mitigation actions

Annex C. Scientific Research License

Nunavummi Qaujisaqtulirijikkut / Nunavut Research Institute
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SCIENTIFIC RESEARCH LICENSE

LICENSE # 02 044 17R-M

ISSUED TO: Erin MacNeil
Defense Research & Development Canada
9 Grove Street
Dartmouth, NS B3A 3C5 Canada

TEAM MEMBERS:

AFFILIATION:

TITLE: Defence Research and Development Canada (DRDC) Gascoyne Inlet

OBJECTIVES OF RESEARCH:
The DRDC Northern Watch Technology Demonstration Project will demonstrate an Arctic maritime surveillance capability to the Department of National Defence and other concerned federal departments. This is a multi-year undertaking and is based at Gascoyne Inlet. The surveillance demonstration system will be unmanned, semi-autonomous, and remotely controlled through a satellite system connection to one of the DRDC centres. In preparation for the for the technology demonstration annual trips to the Gascoyne Inlet camp will be required. Once the team has arrived to the camp their main tasks will include: conduct routine camp maintenance and conduct testing on equipment. The on-site team for the 2017 field season is expected to range from 10 to 20 persons, with the normal load being approximately 15 people. The duration of their time on site is expected to be 31 July 2017 – 1 September 2017.

TERMS & CONDITIONS:
The holder of the licence will be bound by the terms and conditions of the Nunavut Impact Review Board Screening Decision Report and the Department of Culture & Heritage archaeological sites terms and conditions. These terms and conditions will form part of this licence.

DATA COLLECTION IN NU:
DATES: July 31, 2017-September 01, 2017
LOCATION: Gascoyne Inlet, Devon Island

Scientific Research License 02 044 17R-M expires on December 31, 2017
Issued at Iqaluit, NU on May 30, 2017

ME Thomas

Mary Ellen Thomas
Science Advisor

SCIENTIFIC RESEARCH LICENCE

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This document contains the trial plan that was developed for approval and conduct of the summer 2017 field deployment to Gascoyne Inlet Camp (GIC) on Devon Island, NU. This trial was successfully conducted during the period July 24–August 21, 2017.

Ce document présente le plan d’essai, élaboré pour approbation et exécution à l’été 2017, du déploiement sur le terrain au campement de Gascoyne Inlet, sur l’île Devon, au Nunavut. L’essai, qui a eu lieu du 24 juillet au 21 août 2017, s’est déroulé avec succès.

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Arctic; CAUSE; arrays; acoustics