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H.R. Jackson and D.P. Potter, Editors

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Publications in this series have not been edited; they are released as submitted by the author.

Table of Contents

1. Executive Summary

Canada signed the United Nations Convention on the Law of the Sea in 2003. Article 76 of the treaty provides the rules for extending a country's territory beyond the 200 NM limit. The purpose of the Alpha Ridge Test of Appurtenance (ARTA) project was to determine if the Alpha Ridge is a natural prolongation of the continental margin north of Ellesmere and Axel Heiberg islands and to determine the position of foot of the bathymetric slope. Wide angle reflection/refraction (WAR) data and bathymetry were collected to meet the conditions of the treaty.

Data collection took place between March 22 and April 30, 2008. Eureka, Nunavut was the land base to which the fuel, explosives, camp, and scientific equipment were shipped. Because Eureka is 220 km from the coast, it was necessary to establish two camps on the sea ice in order for the aircraft to safely fly the distances required for data collection.

Three wide angle reflection/refraction profiles were run as planned (Fig. 1.1).The principle wide angle reflection /refraction profile was 350 km long, running north from the coast, and was shot as two line segments. In addition, a cross line of 174 km was established, and an initial test line was run near the mouth of Nansen Sound. For the Test Line, three shots were fired to 30 instruments that, due to the lack of ice motion, produced excellent data. These data provide the sedimentary and upper crustal arrivals useful in tracing the onshore velocities offshore. On the next portion of the line (the Inner Line), 11 shots were detonated to 115 instruments that also saved high signal-to-noise arrivals on 114 of 115 recorders. Following this, on the Outer Line 11 shots were fired to 115 recorders, all retaining data. On the Cross Line, 9 shots were fired to 114 recorders and all saved good quality data. In regions which saw appreciable ice movement, specifically on the Cross and Outer lines, the signal-to-noise ratio is reduced. In total, 3,635 seismic traces recorded. Arrivals from sedimentary layers all the way down through the crust to the Moho were observed. In addition, a CP140 Aurora air-dropped 15 geobuoys (seismic receivers) at the north end of the wide angle reflection/refraction line into which a total of 6 shots were fired. Three broadband seismometers were placed near the mouth of Nansen Sound to record the shots throughout the experiment as well.

A single channel reflection profile was also collected in the region about 23 km to the west (shown in Fig. 1.1) of the intersection Outer and Cross lines. At the site, a 10 in^3 airgun was fired for 14 days, which clearly revealed up to 1.0 second of sediment. Basement surface and sub-basement internal reflections were also observed. During the shooting period, the ice drifted nearly 27 km.

The hydrographic program consisted of measuring the bathymetry at every recorder position and gravity at every second position along the WAR profiles.

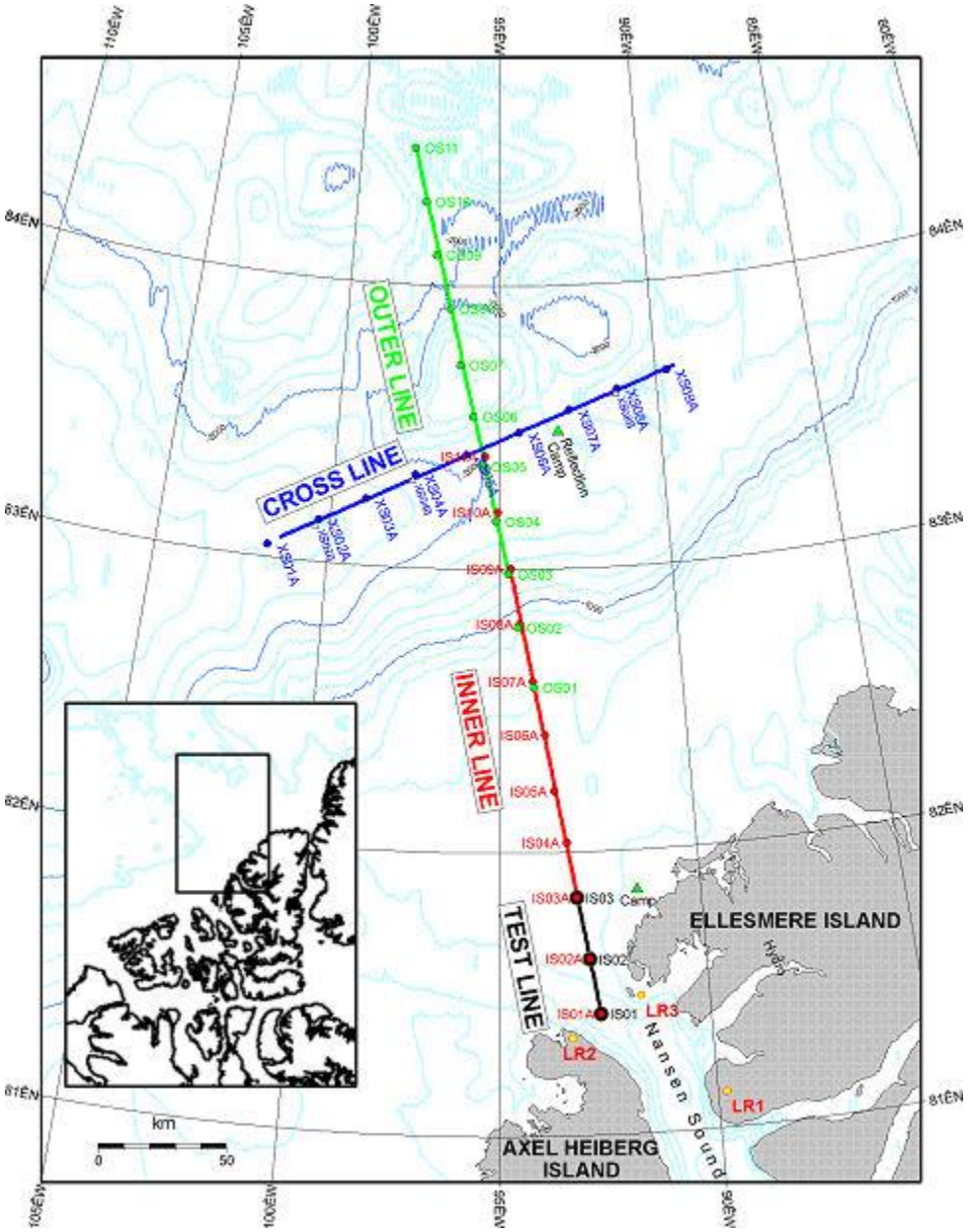


Figure 1.1: The location of the four wide-angle reflection/refraction lines shot as part of the ARTA experiment. The main line consists of two line segments, the Inner and Outer lines. Two on-ice base camps are indicated by small green triangles and the three land-based seismometers (LR1, LR2, and LR3) are also shown. Throughout the report, the "Reflection Camp" is referred to as the "North Camp" and the base camp (indicated simply as "Camp" in this figure) is referred to as "South Camp".

2. Expedition Diary

The Alpha Ridge Test of Appurtenance acronym is ARTA. It is serendipitous that it means truth in Old Persian. In Proto-Indo-European language its meaning is properly joined, right, true.

Julian Day 81 Friday March 21, 2008

- Halifax

John Shimeld, Patrick Potter and I left Halifax for Edmonton on route to Eureka for the ARTA field project. Late in February Jon Biggar, the Chief Hydrographer, and his crew flew to Resolute. Dave Maloley, who was in charge of flight operations, and his assistants left for Resolute as well. Jon Biggar's team (Rudy Cutillo, John Mercuri, Mike Black, Knut Lungberg and Rob Morrison) arrived in Eureka on March 3. For exact arrival dates and the list of all participants see the **Section 3. Participants**. At this point in time they have established the South Camp. This camp is located about 5 nm miles from the coast near Nansen Sound at 81.8589^{o}N, -91.5693^{o}W. In addition, a location for the North Camp had been chosen and the first load of equipment delivered to it.

The Hydrographic Camp location was chosen because there is 6000 ft lead with 6 feet of ice for a runway required for the heavy lift aircraft the Buffalo. This cargo plane is required to efficiently transport fuel from Eureka to the ice. However, this first year ice to be groomed for the runway has snow drifts that must be removed. The heavy lift aircraft available in the Arctic this year are on wheels, not skis, so the task of making a runway is especially difficult. In the initial planning stages a DC-3 on skis was to be contracted for the experiment but it was unavailable because of an accident in Antarctica.

Moving fuel to the camps comes at the following costs:

- From Eureka to the Hydrographic Camp is 250 nm return.
    - Twin Otter requires 3.5 drums to deliver 6 drums
    - Buffalo uses 7 drums to deliver 46 drums
    - (Therefore it takes 7.5 Twin Otter trips for 1 Buffalo load)

- From Eureka to the Reflection camp is a 4 hour trip
    - Twin Otter uses 7 drums to deliver 6

- From Eureka to a point on the Outer Refraction line
    - Twin Otter uses 9.5 drums to deliver 5 drums

The Twin Otter can land on the snow at the Hydrographic Camp without further preparations on the runway. Therefore, the Twin Otter moved an ATV with snow removing attachments to this ice camp. The snow that covers the lead is hard, wind driven. Unfortunately, the extreme cold of greater than -50^{o}C has hampered the snow clearing along the proposed runway. The temperatures at the camp are lower than those in Eureka and it has been exceptionally cold at Eureka. Last week the temperatures were between -49^{o}C and -40^{o} C. As well as removing the snow, the hydrographic team has to erect buildings to house the staff, critical for survival. There are now 3 heated buildings at the South Camp.

Julian Day 82 Saturday March 22, 2008

- Edmonton

The 13 of us traveling from various locations to fly to Eureka, met at 0800 hr at the First Air counter in the airport to learn that our flight had been delayed. The initial problem was related to the absence of the air crew, but was complicated by deteriorating weather conditions at Eureka. Before 1300 the Boeing 737 Jet left Edmonton for the 4 hour flight to Resolute where we refuelled. Here the temperature was about -30^{o}C and the winds were light. It was pleasant with bright sun glinting off the snow. Alain Belzile who was hand-carrying two Lacoste-Romberg gravity meters was picked up by Mike Christensen the Station Manager of the Polar Continental Shelf Project base. He was driven to the base in order to perform a gravity tie. It took less than fifteen minutes and he was back by the time the refuelling was completed.

We arrived in Eureka at 1900 the temperature was about -30^{o}C but felt colder due to the high winds that made for a landing with lots of action with the wings dipping one way and then the other. We were later told the ground crew was taking bets on whether we would be able to land. Dave Maloley and the UNCLOS team already on site met us and whisked us by truck to the Environment Canada building. Here the Station Manager, Al Gaudet, gave us a safety briefing that described the facilities and rules at Eureka. Dave Maloley arrived from the airport and announced that our personal baggage was still on the aircraft now heading south. The Load Master who flew up on the Jet with us had forgotten it. Hopefully, we will be reunited with our luggage tomorrow. As no one had anything to unpack, there was more socializing than usual. We were all anxious to talk to those who had been working to build the ice camps and get all the details.

Julian Day 83 Easter Sunday March 23, 2008

- Eureka sunny, clear, -34^{o}C and dropping during the day

"Eureka Sound" was named "Heureka Sound" on 30 April 1901 by Fosheim upon discovering this passage during the Sverdrup Expedition, 1898-1902.

Breakfast for the new arrivals was at 0800 hr. At 0830 we had our first meeting. It began with a safety briefing. Ken Asmus then gave us a weather report that indicated good flying conditions. Mike Gorveatt and Jorgen Skafte flew off to the site of the North Camp on the first flight of the day. They will have to erect shelters quickly and then build the rest of the camp. They plan to remain at this site throughout the experiment. At noon, Jon Biggar, Kirby Kleiter, and Bob Olsen went to the South Camp with a load of equipment. Kirby and Bob were just there for the day to shovel snow for the runway. Prior to leaving they ate a substantial lunch. They will be back tonight because the cooking and sleeping facilities at the South Camp are limited.

The Twin Otter that brought our baggage back from Resolute had been having pump problems and remained on the runway. It has a passenger, Ben Saunders, who will be flown to Ward Hunt Island to attempt the record for the time it takes to walk to the North Pole solo. He has been involved in several successful Arctic treks.

Isa Asudeh and crew: Minzghou Li, Thomas Funck, Ron Verrall, and Patrick Potter, are in the slightly-heated warehouse setting up the seismometers. The boxes were delivered to them by Sean. They have been brought inside and the shelving is being prepared for their storage.

John Shimeld was busy with Ken learning the system to download the weather information. Ken will be leaving in a few days and John will take over his duties. John also got the latest ice image from Ken and set up his and my Global Mapper program to display the camp and tracker positions as well.

Patrick is taking pictures of the people at Eureka station so that we can learn each other names.

After supper, Bob and Kirby returned from the South Camp. At the camp, the following buildings have been assembled: 2 Polar Chiefs and 4 Weatherhavens. In addition, the double length Weatherhaven was under construction. The individuals at the camp must shovel the runway to the ice as the plow on the ATV will not move the snow – it just comes to an abrupt halt. With the entire hydrographic team plus Bob and Kirby, they cleared about 100 ft by 75 ft. Only after the shovellers have cut it up in blocks is the plough-equipped ATV able to push it to the side. At least an 800 ft long runway is required for the SkyVan to land with the mini-Bobcat to prepare the runway for the Buffalo. The drag on the ATV only sculpts several inches off the snow and this is not enough to produce a runway suitable for the Skyvan or the Buffalo.

Troy McKerral, the pilot, described his impression of the North, or Reflection, Camp. The runway on a multi-year flow is rough and will require dragging. He opined that the Northern Campers, Jorgen, Mike and Greg, were organized and professional and should easily deal with the situation. Paul Rask, the other pilot, suggested using a palette behind the skidoo to smooth the runway. He says it would provide the perfect drag.

Since arriving at the camp today, the North Campers had three tents set up and would be doing a regular radio schedule as of 0700 hr tomorrow morning. They called in by Iridium telephone at 1900 and were notified to expect winds of 25 knots overnight.

Julian Day 84 Easter Monday March 24, 2008

- -42^{o}C clear and sunny at Eureka, winds to 15 knots at the reflection camp intermittent clouds

At the morning safety briefing and planning session, the wolf pack activities were discussed. No one is to take walks on their own. During any outings, spray, a baseball bat and a radio are the minimum requirements.

A military Hercules landed at 0330 this morning, disturbing the sleep of those that live at the runway: Dave Maloley, Shawn Swire, and Doug Briscoe. They have a busy morning ahead getting flights out to the South, or Hydrographic Camp with supplies and Bob and Kirby onboard to contribute to the shovelling of the runway.

The Twin Otter crew may be exchanging personnel today so Ken Asmus, our favorite weatherman, may be going south. He has transferred information on how to download all the weather products to John Shimeld. John promises to read the weather prognosis but is not expected to do an independent analysis. Ken will be in Inuvik and will watch our region and email us if he notices events that we should be aware of.

Isa Asudeh reported on his progress seating up the instruments, by the end of the day they should be ready for deployment. The Taurus seismometers are all inside and warming up slowly. The store room is not really warm enough. Bill Bristow, who operates the heating plant, is promising to get more heat to the area today. Isa has three items he plans to offer training in: the hand held GPS, the new trackers in the Cooler boxes, and the blaster boxes.

Lloyd Litwin updated the group on the blasters' activities. They have visited the explosive magazines

and looked at the products to ensure they match the order specifications. They tested the augers and learned an important trick in starting them - the priming pump must be pushed until it clicks. Two clicks and there is sufficient fuel start the engine. Tim is helping load the aircraft this morning.

During the day several Twin Otter flights were made by both aircraft to the South Camp (3 by Paul and 2 by Troy). The weather at the North Camp was not good enough for aircraft to land. As the day progressed, the weather deteriorated at the South Camp as well. We are concerned that all the hard work clearing the strip may be destroyed by the incoming storm.

The weather prognosis from Ken is not good. Snow and high winds are predicted at both ice camps. See below.

> FXCN24 CWNT 241934
> PROJECT ARTA FORECAST DISCUSSION ISSUED BY THE PRAIRIE AND ARCTIC STORM PREDICTION CENTRE AT 2:00 PM MDT MONDAY 24 MARCH 2008. THE NEXT SCHEDULED FORECAST WILL BE ISSUED AT 4:30 AM MDT TUESDAY.
>
> A RIDGE OF HIGH PRESSURE BUILDING IN FROM THE BEAUFORT SEA WILL STRENGTHEN WINDS ALONG THE WESTERN COAST OF ELLESMERE ISLAND EARLY TUESDAY MORNING. WINDS OF 30 KM/H GUSTING 50 KM/H ARE FORECAST TO DEVELOP AT THE ARTA SOUTH POINT BY MIDDAY ON TUESDAY. BLOWING SNOW IS EXPECTED AS WELL WHICH WILL RESULT IN NEAR BLIZZARD CONDITIONS AT THE SITE TUESDAY AFTERNOON AND TUESDAY NIGHT. AT THIS TIME THERE IS SOME UNCERTAINTY IN REGARDS TO HOW STRONG THE WINDS WILL GET AS ARTA SOUTH POINT SITE IS EXPECTED TO BE ON THE SOUTHERN EDGE OF THE STRONG WINDS AND BLOWING SNOW - SO STAY TUNED AS CONDITIONS COULD GET WORSE THAN FORECAST.

At supper, the discussion on the runway revealed that the GPS-measured length of the runway was 510 ft and at most 70 feet wide. Because the Skyvan that carries the mini Bobcat and the Buffalo that carries the bigger Bobcat and the fuel are on wheels not skis, the runway preparation is more arduous than usual. For a ski-equipped aircraft the snow must merely be leveled. A secondary problem at this point is that the snow from the runway has been piled on the sides and ends. This is a hazard and must be removed, but it has already hardened. In addition, the Skyvan requires 100 ft not 70 ft in width. The wing span of the Twin Otter is about 50 ft.

Bob and Kirby are driving the ATV and provide significant manpower and organization for the runway construction. There is a lot of work to be done in the huts that are set up as well. This includes setting up bunks, getting stoves running, as well as moving two buildings and their contents. The Herman Nelson heater is not kept inside and warm all night and the ATV is not run all night, so the start of work in the morning is delayed. This is not to criticize the enormous amount of work that has been going on at the Camp; the problem is whether we have the resources as a group to complete the runway. At what point do we alter our plans substantially? There is limited fuel and flying weather in a season and we must be careful not to fritter our resources so that we do not accomplish either the refraction or the hydrographic program.

There were 3 flights to the camp today and that of course interrupts camp and runway building activities. It is not simple to set up an ice camp.

Julian Day 85 Tuesday March 25, 2008

- -40^{o}C clear and sunny at Eureka, winds expected to pick up at South Camp

At the morning briefing and safety meeting, we learned that Jon Biggar had asked for only two people to assist with the runway today. He may have up to 800 ft cleared by now. The entire refraction team had been planning to assist in the clearing the runway of snow by shovelling. The change was made due to the forecasted deteriorating weather at the South Camp. So Bob and Kirby were assigned to fly on the first Twin Otter to the Camp with the expectation of staying there. The second Twin Otter will be used on activities not related to the project as much of our flying area is under the influence of increasing winds that may culminate in a blizzard this afternoon. Ken Asmus may leave on this aircraft when it finishes its flights to Ward Hunt Island and Alert military base. John Shimeld did not attend the briefing today because he had a cold and did not want to share it with the rest of the inhabitants of Eureka.

Isa has his crew assigned to completing the set up of the instrument boxes. This is going well but the room that contains the instruments is rather cold; probably freezing on the floor and +5°C at instrument height. The instruments should be at least 15°C for a successful long term deployment. As soon as the GPS units are located, training will begin on them. If the new instruments are not located, i.e. those compatible with the one in the helicopters, we have the GPS units that we used during the LORITA experiment.

Thomas reminded us that the North Camp is set up on an old floe and it was not known if they would be able to auger through it to get the airguns in to the water. I have not heard any information about this from the camp so I will ask Dave to enquire on the next radio schedule.

Tim's blasting crew is ready but can do any more training for Bob and Kirby while they are at the Camp working on the runway.

At the meeting Ruth went over the first segments of the science program that would be attempted as soon as the helicopters arrive: a 60 km segment of the Inner Line near Hansen Point at the mouth of Nansen Sound and the deployment of the 3 three component broadband seismometers. The arrival of the helicopters is delayed due to the lack of space at Eureka. Eureka station is full of people; there are the ARTA crew and pilots, the military and the Rangers, and another unexpected science group that is part of Environment Canada buoy deployment program.

At present, the ARTA program occupies 19 beds at the EC Eureka building (see below). Al Belzile and Dave Maloley are seeking ways of making space for the helicopter crews by heating a trailer at the runway for the mechanics, putting me in the room with the cooks and opening unused older buildings etc.

By noon the weather system did not seem to be coming in as fast as expected and another Twin Otter flight to the South Camp was planned.

Table 2.1: Staff locations – 25 March 2008

Ruth Jackson	Eureka – Environment Canada building
John Shimeld	Eureka – Environment Canada building
Tim Cartwright	Eureka – Environment Canada building
Lloyd Litwin	Eureka – Environment Canada building
Isa Asudeh	Eureka – Environment Canada building
Ron Verrall	Eureka – Environment Canada building

Ken Asmus	Eureka – Environment Canada building
Thomas Funck	Eureka – Environment Canada building
Mingzhou Li	Eureka – Environment Canada building
Joanna Edwards	Eureka – Environment Canada building
Tammy Stinson	Eureka – Environment Canada building
Cassandra Bluhm	Eureka – Environment Canada building
Patrick Potter	Eureka – Environment Canada building
Alain Belzile	Eureka – Environment Canada building
Dave Maloley	Eureka – Runway
Doug Briscoe	Eureka – Runway
Shaun Swire	Eureka – Runway
Mike Gorveatt	North Camp
Jorgen Skafte	North Camp
Greg Middleton	North Camp
Kirby Klieter	South Camp
Bob Olsen	South Camp
Jon Biggar	South Camp
Knut Lyngberg	South Camp
John Mercuri	South Camp
Mike Black	South Camp
Rob Morrison	South Camp
Aaron Carpenter	South Camp
Rudy Cutillo	South Camp
Flight crew Twin Otter	Eureka – Environment Canada building
Flight crew Twin Otter	Eureka – Environment Canada building
Flight crew Twin Otter	Eureka – Environment Canada building
Flight crew Twin Otter	Eureka – Environment Canada building
Flight crew Twin Otter	Eureka – Environment Canada building
Flight crew helicopter pilot	PCSP
Flight crew helicopter pilot	PCSP
Flight crew helicopter pilot	PCSP
Flight crew helicopter pilot	PCSP
Flight crew helicopter pilot	PCSP
Flight crew helicopter mechanic	PCSP
Flight crew helicopter mechanic	PCSP

Our principal problem is getting fuel to the refraction lines and hydrographic sites in as efficient a manner as possible. Ron Verrall suggested (and Troy McKerral, the Twin Otter pilot confirmed) that a frozen gravel strip might be found for the Buffalo. This means changes in priorities, getting consensus from the principle players, and redirecting resources. This is not readily done unless a high possibility of success is likely.

Alain Belzile has been in contact with his Ottawa office. He is planning to establish a new gravity station at Eureka in one of the newer buildings. He will be occupied tying the stations for several days.

At lunch, Thomas, Patrick, and I (Ruth) went for a walk at -38^{o}C. Not only is this a chance for a little exercise, but also it gives us the opportunity to test our Arctic clothing. I was definitely colder than Thomas, due to the inferior wind pants. I have thicker ones and will wear those until the temperature warms up by at least 15 degrees.

The instrument boxes stored in the warehouse are also not warming up sufficiently. Those boxes stored on the lower shelf are at 4^{o}C and the upper 8^{o}C. The temperature of the storage boxes should be up to 15°C.

After lunch, Dave called Ken and I to his office at the runway. The good news is that 5 helicopters have left Resolute on their way to Eureka to start our program. Even better news is that it appears that Jon Biggar has made significant progress on the runway. The storm did not materialize and they are

continuing to work at it. The Skyvan, which looks like a container with wings, is in the area so there is a possibility that mini Bobcat may make it to the ice.

After returning to the EC building I (Ruth) informed Isa, Thomas, Ron and Patrick that the helicopters for the experiment were on their way. We began planning for their use. After a thorough orientation in the morning one helicopter will fly to put out the broadband seismometers. Mingzhou and Ron will be doing this work. It will be Mingzhou's first time in a helicopter and Ron will be able to provide the experience required to navigate the pilot and the machine.

Julian Day 86 Wednesday March 26, 2008

- -40^{o}C clear and sunny at Eureka, winds expected to pick up at South Camp

At the morning briefing, the first safety issue was that unrestricted use of the internet had made it impossible for Dave Maloley to track the aircraft. The passwords will be changed and access will be available only on a few machines. Isa requires it to communicate with the Taurus instruments, John needs it to download the weather, and a third computer for emailing will be made available. I also need internet access for communication with Jacob and Dick. Later in the day Al Gallant came by to state his concern. It is not only our group using the computers; there are many military personnel and the staff.

All walkers were warned that the helicopter pilot saw three bears traveling north on their flight from Resolute to Eureka.

The weather report from Ken Asmus indicated that we were situated in a high being squeezed between two lows so the cloud cover and winds were dependent on local movement of the lows. There is a lot of warmer air at higher altitudes and concern that later in the week a major low would be developing over much of the Arctic. John Shimeld, who will taking over Ken's duties as forecaster is up and around today definitely recovering but not feeling well.

The three helicopter pilots (Steve McGreer (helicopter *FARE 407*), Orin Durey (*FCNG 206L*), and Jim Barry *(FPHO 206L)*) gave all of the scientific team a Safety Briefing. We went outside to the location of the three helicopters. After stressing that we take our time, and demonstrating how to enter and exit (i.e. staying low, staying away from the tail rotor, etc.) we were shown the position of the Emergency Locator Transmitter (ELT), medical kit, gun, and survival gear. The safety information has been put on the bulletin board.

After the outside familiarization, we continued inside with questions and answers about how our equipment would be loaded and unloaded into the aircraft. The GPS units in the helicopter are the same ones we brought and we will be loading the position of all fuel locations for them. The pilots want to fly over the caches to verify that the amount and kinds of fuel cashes have in them.

This is just the initial safety briefing, we plan to refresher courses. All staff who have not flown in a helicopter before such as Patrick and Mingzhou, will be paired with a more experienced individual and given more instruction with the aircraft in operation to learn how to deal with the noise. Ron Verrall spoke to the phenomenon that when the helicopter was running there was the feeling you should rush to accomplish the task at hand - do not. The helicopter and the pilots are there to serve you, not the other way around.

It is a busy day for those deploying the recorders; learning how the new GPS units operate and the software for the instrument trackers.

There is a rumour that Troy has located an 8000 ft runway on land-fast ice in a bay about 25 nm from the South camp. This should enable fuel cashing by the Buffalo that will dramatically conserve fuel use.

The active part of the experiment began at 13:00 Jim (pilot); Ron and Mingzhou left with the seismometers that are to be deployed for the entire experiment. John was busy loading Jim's and Ron's GPS with all the way points required for the trip. The blasters had to go to the runway to get their augers into a warm location so they would start when required.

The following information was sent to Don Mosher in order to prepare for the arrival of the Aurora (the military air craft that is prepared to drop the geobuoys):

Iridium to Iridium 00
Iridium to landline 011
The Iridium numbers for:
- Eureka Base
- Ruth
- Twin Otter DBH
- Twin Otter BBV
- Twin Otter KBC
- 407 FARE
- 206LR FCNG
- 206LR FPHO
- 206 FCWR
- 206 FVYM
- ARTA Camp South
- ARTA Camp North
- Radio Frequency 4472.5
- VHF 122.8
- PCSP land line
- Radio schedule 0700 1900
- Mosher tech office CP140

In addition, the following login information was sent:
1. ftp://nais.ec.gc.ca user name and password
2. ftp://cisclient.cis.ec.gc.ca username
3.Ice trackers: http://www.cartenav.com/icetracker/icetracker.php

The blasting and deployment teams are outlined in Table 2.2. They were selected so that an inexperienced person would be paired up with a more experienced one.

Table 2.2: Seismic Blasting and Deployment Teams

Role		
Chief Blaster	Tim Cartwright	
Blasters	Ron Verrall	Bob Olsen
Blasters	Tim Cartwright	Kirby Kleiter
Blasters	Lloyd Litwin	Mingzhou Li
Chief Deployer	Thomas Funck	
Deployers	Thomas Funck	Bob Olsen

Deployers	John Shimeld	Kirby Kleiter
Deployers	Patrick Potter	Tim Cartwright

To meet the requirements of the overall experiment it will be necessary to make a few changes. Mingzhou, who engineers the instrument boxes that protect the recording instruments, needs to participate in a deployment so that he can design to accommodate the Arctic conditions.

John Shimeld has located the GPS and has assigned one to a particular individual. He has loaded the Inner Line shot 1 to 3 and the instrument positions in all of our sets. He can also put this information in the helicopter pilots' identical units so that we have redundancy. We have no spare batteries; however, they can be charged overnight and last ten hours, and the helicopter's GPS, which is identical, has a power source.

Another military Hercules landed in Eureka today and sleeping accommodations are required for them. Lloyd will move to the bed that Ken occupied.

Ron and Mingzhou installed the first broadband seismometer at 81° 07.634N 89° 48.56W on the Hvitland Pennsiula south of Jugebord Fiord. It was placed on gravel, not bedrock because none could be located. Ron was concerned that high winds would blow it over. Rocks and snow were mounded over it and pictures taken of the installation. On return, the problems setting it up were discussed by Isa, Mingzhou, Thomas and Patrick. Based on this experience, two teams will fly out tomorrow to opposite sides of the mouth of Nansen Sound to place the seismometers on a suitable location in a manner so that they will withstand the elements for a month..

The great news for the Hydrographic Camp is that the Skyvan landed on the air strip at the Camp with hundreds of feet to spare and delivered the mini-Bobcat for snow removal. All the hard work done to build the runway had been rewarded. The pilot and the owner of the aircraft wanted to show the versatility of the plane and were particularly pleased to be able to deliver for us. They consider it an advertisement for the versatility of their plane. The mini-Bobcat is to be run 24 hours a day clearing the runway in preparation for the landing of the Buffalo. This will bring a larger Bobcat and allow the fuel to be cached here.

The Reflection Camp received several Twin Otter flights that delivered the seismic reflection equipment. They are planning to set it up as soon as possible.

Ken Asmus, our cheerful weather man, went south today. He will be missed.

Table 2.2.1: Flight distances

Place	Distance (km)	Distance (nm)	Twin Time
Eureka - South Camp	238	124	1 hr 15 min
Inner + Outer line	302	189	
South Camp OS1	80	50	
South Camp OS11	264	165	
North Camp OS 11	107	67	

Julian Day 87 Thursday March 27, 2008

- -39^{o}C clear and sunny at Eureka, warming up quickly through the day, the ice is not moving. Most of the Arctic Ocean is dominated by lows.

At the morning briefing there was a lively discussion; there is concern over the loss of the email privileges. However, the loss of email to the entire EC complex as a whole is more serious. I hope the ARTA crew will understand this. Most importantly, it is a safety issue that the aircraft must be tracked and the weather downloaded, and this has been interrupted by the number of downloads taking place for non-essential reasons.

The installation of the broadband seismometer was discussed with the group and the following improvements made: a tie-down to a "deadman" buried in the gravel will be added, a tile will be frozen to the ground for levelling the seismometer, and two teams will each put out one instrument to speed up the installation. The pick axes and bars for the tie-down operation were provided by Bill Bristow at Eureka.

Various loose ends were sorted out and some left unresolved resolved. The hand auger was sent back from the North ice camp so that Ron would have it for testing the ice thickness. The fifth GPS cannot be found; we know it was shipped from Dartmouth and is not in our container now. We can operate without it but it would better to have it.

(Tracking all the equipment shipped is not trivial. For example, Isa has boxes that were dropped off at the warm warehouse that belong at the runway and Sean was asked to move them back so that more equipment does not go missing.)

The South Camp will have a trained cook for the first time, which should improve morale. Joanne left on the Twin Otter this morning. The mini-Bobcat that arrived last night is not in operation – it runs for 5 minutes and then stops. It was running when it left Resolute. Did the flight disturb the fuels lines?

I spoke with Dave about the need for aircraft for the test line. The Bell 407 will take ten instruments and John to the Hydrographic Camp to brief Bob and Kirby on the refraction operation. The helicopter safety orientation can also be done when this fast helicopter arrives. In the slower aircraft, the 206LR, we will have the others; Tim, Lloyd, Ron, Thomas and Patrick, a total of six passengers.

Tim has the rope, augers etc. at the runway ready for tomorrow's program. He also wrote a draft of the safe operating procedure for the blasting operation.

The two teams of Ron and Mingzhou, and Thomas and Patrick left at about 1030 to fly to the west and east sides of the mouth of Nansen Sounds respectively to plant the three component broad band seismometers. They returned by 1600 after successful installations. This time, the seismometers are securely tied to the ground.

I called Don Mosher, and he made a number of requests, the most difficult of which is the beacon number for the aircraft. Dave Maloley can not give them to me directly, only the company can. Gerard will give me the helicopter beacon numbers and I will approach the Twin Otter pilots directly. They said they liked their privacy and actually did not know their beacon numbers.

The plan for tomorrow is to load the truck with Taurus in their protective black boxes prior to breakfast. The explosives, detonators, rope, etc. was flown to the camp this afternoon. The 206LR will

fly the refraction crew to the ice tomorrow morning. This evening Mingzhou has to train all involved in the use of the small computer that the records the tracker positions.

There was a lively discussion at the training meeting for the computer that tracks the Taurus boxes. It took a least an hour for a practical way of using the trackers to be found. It is the retrieving team that will carry the computers trackers and turn it only if one is lost. Because the equipment had only arrived within days of shipping, Isa and Mingzhou needed input about how to put them into use in a practical way in the helicopters.

Julian Day 88 Friday March 28, 2008

- -39^{O}C at the South Camp

Table 2.3: Personnel involved in trial line deployment

Aircraft	Pilot	Blasters		Deployers	
407 FARE	Steve McGreer	**X**	Ron Verral, Bob Olsen	**A**	John Shimeld, Kirby Klieter
206LR FCNG	Orin Durey	**Y**	Lloyd Litwin, Kirby Klieter	**B**	Thomas Funck, Bob Olsen
206LR FPHO	Jim Barry	**Z**	Tim Cartwright	**C**	Patrick Potter, Tim Cartwright

Plan for today's trial line

1) all personnel on 206lr on 206lr to Ice Camp - 6 people
2) Safety briefing for Bob and Kirby
3) Blasters to load shots using only two helicopter: teams are Ron and Bob, Lloyd, Kirby and Tim starting at shot 3
4) Return to ice camp
5) Deployers use helicopters as above 10 Taurus each, instructions for Bob and Kirby at starts at position 1, b at 11, c at 21
6) Return to Ice Camp switch GPS Ron needs Patrick's21-30, Lloyd needs Thomas 11-21, Patrick needs Johns 1-10
7) All blasters blast at all three holes Patrick joins Tim for pick up and photos
8) Blasters team pick up boxes, team **X** in 407 to far end of line, **Y** and **Z**
9) Return to Ice Camp unload boxes
10) People return to Eureka in helicopters, Taurus to follow in Twin Otter

The southern end of the line is shot 1 and position 1 for Taurus digitizer.

The plan today is to run a 60 km-long refraction line from the mouth of Nansen Sound towards the North. The instrumentation group under Isa's guidance was up at 6:30 to close the lids on the Taurus boxes. The boxes must be kept open as long as possible to warm before deploying. After the boxes were closed, they were moved to the truck for shipment to the airport to be flown to the Ice Camp on the first Twin Otter flight of the day. At 7:15 the blasters, deployers and helicopter pilots were briefed on the days plans. Instructions for the Trial Line were handed to everyone. The purpose of the line is to familiarize all participants with their tasks as well as to collect data on the Hansen Point volcanic formation. The safety message today was to "take your time, this is a learning exercise."

Everyone ate breakfast, packed lunch, put together their survival equipment for the day, and walk down to the helicopter ramp. The 407 was the first in the air. Its task was to sling the generator to the camp. The two 207LR followed at about 08:30 and 08:40 with the personnel for the refraction line.

After the helicopters left, Dave summoned me to his office and suggested I do a safety inspection at the Camp. Gerard was the pilot and on a bright day we traveled 124 NM miles to the South camp. The scenery was splendid. I was surprised on arriving at the camp to see all the helicopters that had started out earlier on the ground. John Shimeld was waiting for me as I exited the aircraft. He explained that the pilots would not fly the 12 NM to the start of line because they felt there was insufficient fuel. The three aircraft had topped up with fuel and had 2.5 to 3 hr of flying time so they theoretically could have flown the line and returned to Eureka with out refueling. Gerard asked the pilot of the 407 to load the explosives and prepare to start the line. The Twin Otter arrived with fuel and the helicopters were in the air. We will not finish the test line today.

I talked to Jon Biggar about the problem of the cook's sleeping in the same building as the food. If a bear wanders into the camp he would be attracted to the food. He agreed to build a separate building for the cooks. Crew waiting at the camp for their segment of the refraction line volunteered to help with the task. John Mercuri, their safety officer, John Shimeld, and I toured the camp on a safety inventory. The items we investigated included:

1) Distance between tents in case of fire was sufficient - 20 feet on the Ice camp.
2) Fire extinguishers - 2 in the kitchen by the door. Some tents were missing them, so more will be sent out. All extinguishers will be placed in the same location near the door in all huts.
3) Fire extinguishers will be placed at all refueling areas.
4) The first aid kit was on site but the cooks had forgotten its location, therefore one first aid kit will be moved to the kitchen.
5) All individuals arriving at camp will be given a tour and safety features pointed out.
6) The cooks will be shown how to operate the Iridium phones.
7) The garbage is incinerated.
8) We stressed the need for regular safety meetings.
9) Guns were distributed around the Camp; we suggested a list of their locations.
10) The Inuit bear monitors should be flown to the camp.
11) John carried bear spray in his pocket while working at the camp.

On the return trip from the South Camp we flew over the Hansen Point formation and I got a picture of a circular feature. We also saw 4 musk ox herds. It is difficult to imagine what they find to eat.

On return Dave talked about the fuel we had consumed - 300 drums so far, and we have not yet completed setting up the South or the North camps. Today the helicopter pilots ceased operations because they judged the fuel caches were insufficient. Before we complete the mission, we have a least 30 Twin Otter loads to clean up the camp at the end of the experiment. There are 14 Twin trips required before we can run the first refraction line. We have one Twin Otter assigned to the program and a second one that we have been using full-time; it will soon be required for other programs. We have used 175 hours of Twin time already and probably require 450 more before the end of the program. We have insufficient fuel to run the all refraction lines and the hydrographic program. It is still critical that the runway be built for the Buffalo; however, the return date for the Buffalo is not known, and it may not in fact happen. Dave promises to think about the issue. Can a Hercules fly more fuel from Yellowknife and land on a fiord with 80 drums of fuel? To do so would cost $200,000 a trip.

After the delayed start to the trial refraction line and adjustments to the teams (Patrick was to help Ron so that both Bob and Kirby could see the loading operation), Ron and Patrick left the ice camp. The location of the holes were found and the charges loaded. The blasters returned to camp and deployers went out. The maximum number of boxes per helicopter is 11 and two people are required. Even if the

number of personnel was reduced to one in each helicopter, not many more boxes could be put inside, and it would take more time to deploy them.

Prior to firing shots tomorrow, I gave Tim Cartwright, the Chief blaster, the document authorizing destruction of fish by means other than fishing in order to review the rules and regulations. I also notified the Canadian Rangers who will be starting their skidoo trek along Nansen Sound, that I would be blasting.

Flight plan: March 29, 2008 blasting and pick up

Aircraft	Pilot	Blasters	Deployers
206LR FCNG	Orin	Lloyd & Kirby	John
206LR FPHO	Jim	Tim & Bob	

1) At 0830, two 206LR leave Eureka with 3 people
2) Fly to camp pick up Bob and Kirby, leave John
3) Blast three holes
4) Return to camp rearrange team for pick up
5) Pick up 30 Taurus (recording instruments), bring to South Camp
6) Gather laundry from South Camp
6) Return to Eureka

Julian Day 89 Saturday March 28, 2008

- -34.8^{o}C in Eureka, sunny

The flight plan for the day was distributed to Dave and the helicopter pilots by 0730. The two aircraft were prepared to leave by 0830 and Dave was pleased to have the 407 for logistic activities.

Yesterday there was a minor accident at the South Camp. Thomas offered to help the kitchen staff while he waited for his rotation in the helicopters to deploy the Taurus. While cutting up the apples, he cut his thumb. It was duly bandaged and photographically recorded in Ron's newsletter number 4.

When I left the South Camp yesterday, the snow blower on the mini-Bobcat was not working; fortunately by supper time when the seismic team left it was again moving snow along the landing strip. The parts to fit the blower on the tracked ATV have also been sent to the camp. It is still critical for the program that a runway is established at the South Camp for the transport of fuel for the science operations.

A group of perhaps 20 Canadian Rangers left Eureka on their snowmobiles this morning. The Rangers are part of the Canadian Forces Reserve, located in remote, coastal and isolated communities of Canada. These Rangers were proudly flying Ranger and Canadian Flags from their snowmobiles. They are on a 16-day sovereignty patrol around Ellesmere Island. They will meet with a group that left from Alert. Those at the station who had free time were out to wish them well on their mission.

One of the Twin Otters moving equipment for the program had to go back to Resolute and fortunately for the program will return today. Meanwhile the 407 slung equipment to Alexander Fiord to assist PCSP so that we could use their Twin Otter for as long as possible. The remote North Camp was supplied with fuel and other essentials today. More loads of equipment are still required at the South Camp. We cannot begin the Inner Refraction line until aircraft can place fuel and explosives along the

line. Thomas and I spent the morning preparing a detailed plan for the Inner and Outer Lines. We reduced the explosives charge weights to cut down on the number of trips for Twin Otter and helicopter. The plan is outlined in Fig. 2.1.

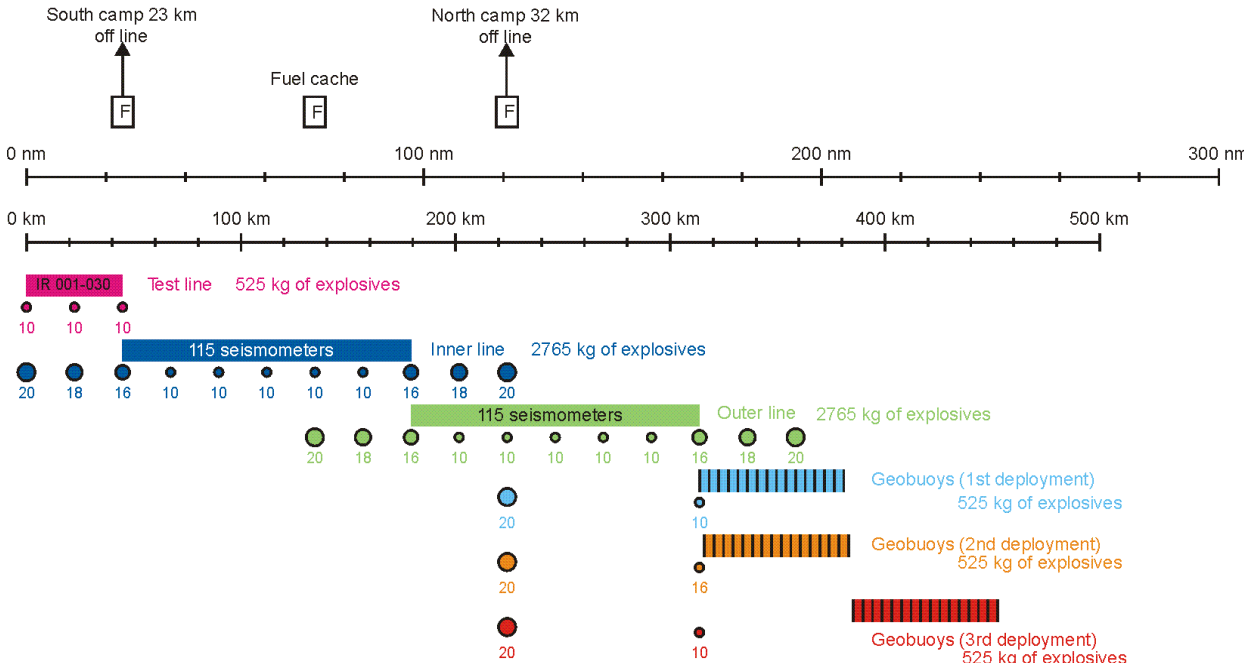


Figure 2.1: Shooting plan for Test, Inner, and Outer lines. The solid colour bars indicate the along-line locations of the seismometers for each line and the circles the location of the charges. The size of each circle represents the relative size of the charge and the number below the circle the number of charges to be placed.

While waiting for the blasting and retrieving team to return, several of us, Thomas, Isa, Alain, Patrick, and I, enjoyed the walked up to Dave's office at the runway to deliver the new and improved refraction plan so that Dave could accurately position fuel and explosives. The view from the hill out Slidre Fiord is a bonus.

At about 1600, the team arrived home from successfully firing three shots and retrieving 30 seismometers. The blasting boxes worked in the cold. Bob fired his first shot under the guidance of Tim who has it all on video. One of the seismometers had blown over; otherwise no major problems were encountered. The data on the first ten instruments were played back by supper-time and the signal to noise was excellent.

While John Shimeld was at the Camp, he noted that the tent for housing the cooks had not been set up. The real blow was that the mini-Bob cat is not operating again. If the runway is not created we are at risk for the program not being completed.

Julian Day 90 Sunday March 29, 2008

- -34.4ºC in Eureka, sunny; cloudy at the hydrographic camp

At the morning safety and briefing meeting, we discussed the use of the Iridium telephones. Thomas noted in the field he was not able to call out because the Iridium-to-Iridium code 00 was not explicitly

listed on the phone list. This error has been corrected. I am encouraging people to use the phone as practice. I also determined that my phone cannot be reached while in the building. Jon and I finally managed to contact each other and have arranged a 0815 phone schedule. For this, I will have to get dressed and stand outside. We also discussed the use of the helicopter radios. The hour-long flight out and back from the camp is a good time to get individual instruction from the pilot on their use.

The data from the 30 Taurus and the 3 shots had excellent signal to noise ratio. One seismometer blew over and the shooters did not record a position immediately at the shot hole. These were small problems and are easily corrected for the long line. It is a good start to the program.

Dave Maloley requested two individuals to fly out on the Twin Otter to the fuel cache to assist in shovelling a few drifts to increase the length of the runway. Alain Belzile and John Shimeld volunteered, and spent the morning hard at it. Alain was pleased to tell us he had broken his shovel. The longer the runway, the more fuel we can get positioned along the Refraction line. Two Twin otters are flying for the program today. The helicopter is moving gear for PCSP and we have the use of their Twin Otter. This sharing can only last a short time.

Dave Maloley has booked the Skyvan.

Julian Day 91 Monday March 31, 2008

- -34.4°C in Eureka, sunny; cloudy in Resolute

The major safety issue at the Hydrographic Camp has been corrected - a separate tent for the cooks has been set up away from the food. At our regular morning meeting, we discussed the principle that people only fly in the helicopters when authorized for their required work. The whereabouts of individuals must be known at all times by their program managers, and flights are authorized only as required by the scientific program. It is not appropriate to negotiate flights with the helicopter pilots for the joy of flying. This has also been discussed with the Gerard Hartley, the Chief Pilot.

Al Gaudet, the Eureka Base Camp manager, reminded us that water supplies are limited and they are being used at a greater rate than their worst predictions. Fewer showers and washing clothes less often is a necessity or the facility will run out of water.

This morning, Alain, Lloyd and Ron transferred to the South Camp. They will be preparing the ice trackers and setting up to load shots tomorrow along the Inner Line. The missing blaster boxes were found in the heated warehouse, along with the water purification kit, and together shipped to the Main Camp this afternoon. Dave was perturbed because he had people searching for their gear from Ottawa to Edmonton to Resolute and it had merely been misplaced.

The 1100 lb generator cannot be easily removed from the Twin Otter. Bill Bristow, the mechanic at Eureka, was asked to weld up hooks so it could be slung. To his, and our disappointment, this failed and the generator was rolled over. If the generator does not get to the camp then the helicopters cannot be sent out because they need to be heated when not in operation.

After lunch, four of us (John, Patrick, Thomas and myself, Ruth) walked up to the runway. Just as we reached the military section of the loading ramp, someone pointed to us. The reason did not become clear until she said there are two wolves following us. This provided a picture-taking opportunity. However, a skidoo went by after they had moved off by 100 ft, to feed them. I would rather not have

the wolves encouraged to get too close to the camp.

Once at the runway, we walked over to Dave's office. I wanted to give him the joint hydrographic and refraction plan. Dave Maloley, Thomas, and Jon discussed the details of the deployments with Dave. He needed clarification on the number of instruments to be shipped to particular caches. The decision was 60 at the South Camp and 55 at the fuel cache near IS7.

Now that email is available at the camp I am getting requests for equipment that has been left behind. I guess it is a useful addition to our communication system.

The generator was slung and loaded into the Twin Otter with a plan for unloading and moving it at the camp.

Weekly message March 23 to 30, 2008 ARTA

Note: To contact Ruth at Eureka call the Eureka land line, as my Iridium phone does not work in the building. A schedule for Iridium calls between Jon and Ruth has been established: 0815 and 2015.

The refraction team arrived Saturday March 22, 2008 in Eureka. On Saturday March 22, 2008 and work began assembling and setting up the recording and shooting electronics. The three component seismometers were installed at either side of the mouth of Nansen Sound and at 81° 07.634N 89° 48.56W on the Hvitland Peninsula on March 26 and 27 (see Fig. 1.1). On the following two days, a 50 km long wide-angle reflection/refraction line (30 instrument and 3 shot line) was run at the mouth of Nansen Sound. One of the intentions of this line was to familiarize everyone involved in the project in the shooting operations, from the helicopter pilots to the scientific team. This is an important safety measure. The data are superb with a high signal-to-noise ratio. The shots were fired on a windless day when the ice was not moving. This line segment extends the Inner Line to the south from 81° 52 N 92 ° 46W, 81° 49N 93° 03W to investigate the Hansen Point volcanics.

Fuel and explosive caching has been initiated for the rest of the Inner Line. A refraction experiment utilizing the geobuoys has been put together and sent to Don Mosher. The possible three deployments are a valuable addition to our core program but are independent of it.

The North Camp was established on the cross line at 83° 30N 93° 08W on March 23 on a large two-year old flow that is 7 ft thick. The runway is adequate for the Twin Otters to land. The seismic gear has been sent to the camp and they are preparing to fire the airgun.

At the South Camp, all the buildings are set up and the generator is up and running. The water melter and stove were slung to the Camp. The cooks arrived on-site on March 28 to prepare meals for the hard working individuals setting up the camp and working on the runway. Because the available heavy lift aircraft are on wheels, the runway must be cleared to the ice. At this time the air strip is 1800 ft long and 60 ft wide. The tracked ATV is clearing snow from the runway but the min-Bobcat is not operational. Spare parts have been sent for and may arrive mid-week..

Jon and Ruth are working on a science/hydrography plan, based on the logistics parameters supplied by Dave Maloley using obtainable fuel supplies and aircraft.

To the end of the financial year we have flown 2 Twin Otters 197 hours and 5 helicopters 88 hours.

Flight Plan April 1, 2008

Aircraft	Pilot	Blasters
407 FARE	Steve	Ron & Alain
206LR FCNG	Orin	Lloyd & Kirby
206LR FPHO	Gerard	Tim & Bob

1) As early as possible, all helicopters leave Eureka with spare parts
2) Fly to South Camp to pick up blasters
3) Fly to southernmost hole, 407 first to find thin ice and leave explosives, the two 206 LR follow with loading teams altering loading holes
4) Explosives and fuel are available at South Camp and at fuel cache
5) Continue loading until 11 charges positioned or duty day is over
6) Return to South Camp

Julian Day 92 Tuesday April 1, 2008

- -34°C in Eureka, sunny winds now blowing from the South; blizzard expected in Resolute

At the morning safety and briefing meeting, a number of safety items were brought up. The wolves tracking the walkers was mentioned, all walking will be done in groups with the full range of deterrents available to us (bear spray, horns, sticks and bats). The information that the wolves were being hand-fed was given by the station manager Al to the military. The military have posted signs that feeding the wolves is illegal.

Due to the upcoming deployment and retrieval, a number of issues related to long days in the cold and heavy instruments came up. Since individuals are wearing mukluks to protect their feet from the cold, their toes are not protected from heavy objects. In the next project we should purchase boots that are warm and have toe protection. It is difficult to get new clothing sent to us in Eureka before the project is completed.

The distribution of sleeping bags was a concern for those who will be flying more often now. Before getting on a Twin Otter, everyone must pick up a sleeping bag from Dave. We are also sending half a dozen extra bags to the South Camp.

The refraction team is now stationed in two places, with those involved in the maintenance of instruments and data processing at Eureka (Isa, Mingzhou, John, Patrick, Thomas and Ruth), and the blasting team (Tim, Lloyd, Ron, Bob and Kirby) at the ARTA south camp. The helicopters and their spares were moved to the South Camp as well today. The reflection team is stationed at the North Camp (Jorgen, Mike and Greg).

One Twin Otter is not operational today, as the pilot, Paul Rask, is at the limit of his flying hours. In addition, one of the helicopter pilots has ended his rotation and has to be flown south. This limits the

number of flights today. There is one flight scheduled to the North Camp, and equipment to be sent to the South Camp before the Twin Otter is to fly to Resolute for the crew rotation. Poor weather in Resolute may mean the plane cannot leave. Poor weather has also cancelled the Skyvan arrival at Eureka.

I talked to Jon on the Iridium phone this morning and asked that Tim be at the schedule to ensure that the refraction teams' efforts were coordinated. In particular, I wanted to know if Alain had agreed to work as the sixth person required for deployment. Tim had not made an arrangement for this. They also have to get poles to set up the ice trackers' antennae. They had not started working on this problem.

Thomas has a puffy and red finger in his left hand (not the thumb he cut at the ice camp). The military medic suggested soaking it, applied topical medicine and is giving him antibiotics.

I took the opportunity while visiting the military's building called Fort Eureka to describe the UNCLOS program. As soon as I went in the door I met an individual who had been at the Ice University. I talked to their commanding officer about the ARTA project and mentioned the support we were getting from the military with a deployment of an Aurora aircraft to Thule to fly three missions for our aircraft. I gave them a copy of our planned operations and raised the question if they were flying over our North Camp any way would they consider carrying badly needed fuel for the ARTA project. The commanding officer said he would discuss it with the person in charge of air craft operations.

Table 2.4: Explosive Inventory

Line	# of charges Pentolite	# of rolls Primacord	Weight of charges (kg)
Trial	30	3	525
Inner Line 1	158	17	2765
Outer Line 2	158	17	2765
Cross line	63	9	1102.5
Geobuoy 1	32	3	560
Geobuoy 2	32	3	560
Geobuoy 3	37	3	647.5
Total	**510**	**55**	**8925**

Primacord 17 G/M "Grams per Meter" Petn Orange or red (not White) 51 Boxes of 150 Meter no splices QTY 51 Boxes
Electric Super Seismic (ESS) Detonators (CAPS) 17 M Leads. Packaged for Passenger AirCraft. 1.4S Compatability QTY 100 Each
Pentolite, 17.5 KG, Moulded in a cylindrical Shape with Three (3) Holes, Max. Diameter 21CM, 8.3 Inches, BIO-Degradable (9,975 Kgs) **QTY 510** Each

Status report from Dave at 1846 is included here to indicate the complexity of the operation:

> *Ruth: Shots at inner 1-8 are loaded. Mike's compressor would not start up so I sent up booster cables to jump start it, should have results tonight if successful. May deploy*

boxes tomorrow, have to wait for fuel count, etc. from camp tonight. Blizzard in Resolute, will last until tomorrow evening, Skyvan on hold. Jon's new stove and grill have unserviceable propane regulators, I am searching for replacements to send out. Talk to you later tonight.

By means of several email exchanges and an Iridium telephone call, I have determined that 8 charges were successfully loaded. On the first charge Tim encountered problems. The auger broke, therefore he had to go back to camp. Then they broke the Primacord. It will have to be detonated with a booster charge and that will take an hour to prepare. It is still impressive that in half a day they were able to locate ice thin enough to unload the explosives, drill, and load 8 charges.

Tomorrow the plan is to finish loading the charges and to begin the deployment. Isa and Mingzhou are preparing the first 40 boxes to leave the warehouse at 0700. The deployers are there scheme for putting out instruments ready.

Julian Day 93 Wednesday April 2, 2008

- -33°C sunny at all ARTA locations

The instrument team had 40 sets of recording instruments at the load dock by 0700. The deployment scheme was sent to the ice camp for the helicopter pilots with the first Twin load of seismometers (also 40).

I missed my Iridium call to South Camp because I had not properly charged the batteries. It took me ten minutes to find the Iridium phone on the base and learn the secrets of its use to dial directly without the 00 prefixes: problem solved for the next time.

At the safety and briefing meeting the team was clear that there were no new safety issues after our lengthy discussions yesterday. The plan for the day is to send the recorders to the South Camp while the loaders finish the last three charges. The deployers will fly out on the second load (20 recorders + 3 people and gear) and will stay the night to save on Twin flights and make the operation more efficient. It will require two more loads to carry all the heavier boxes, and the fuel will require additional flights.

I discussed ordering more Primacord with Dave and he said it would be possible to have it shipped up on a food order on April 16. I called Terry and Cheryl and they will talk to the explosive ordering expert at Public works. A copy of the request was sent to Jacob. The reason for the order is to allow for running the cross line if the Aurora drops are successful. When we ordered the explosives initially, the Aurora flight was not scheduled.

Isa has an efficient operation preparing the Taurus recorders for deployment and closing boxes prior to shipping to their destination on the sea ice. After two-thirds of the boxes were at the land strip, the deployment team (Thomas - Chief Deployer, John and Patrick) were driven to the airport to take their Twin Otter flight to the Ice Camp. They had to wait until after lunch to start placing the recorders and seismometers at their predetermined location along the wide angle reflection/refraction profile. It took less than an hour for Tim and Patrick to place their instruments on the ice and return to camp at 1535. John and Thomas were not far behind. The three helicopters took off for their second deployment at 1624 and 1631. They plan to make that the last deployment of the day and to do two more tomorrow. The distances to fly are longer than today but they will get an earlier start because they do not have to wait for the blasters and they are stating from the Ice camp.

The Twin Otter was delayed in Resolute due to a blizzard. After the snow stopped there were large drifts against the hangar doors, further slowing the departure. The Skyvan, which was also held up by the weather, is on its way to Eureka as well. The deployment and retrieval of the Taurus would have been delayed if fuel was not strategically placed to support the helicopters. As soon as the second Twin arrives in Eureka, it will be loaded with fuel drums and sent to the South Camp.

Sean and Doug are going to be exceptionally busy tomorrow getting fuel drums that are required for the helicopters to three aircraft, two Twin Otters and the Skyvan. Dave's assistant regularly works 14 hours a day. They assured me it was no problem; they had already taken 60 drums off their pallets and had them ready for loading. The Skyvan, on wheels, will shuttle 10 drums at a time between Eureka and the South Camp. The Twin Otters can carry nine but are incapable of landing on the snow. A Twin Otter is scheduled to pick up the bear monitors from Grise Fiord tomorrow.

Al Gallant asked me to review his accountings for the room and board for the UNCLOS team since their arrival. His records matched mine and I kept a copy of his list. I also had to move Thomas' possessions into Patrick and John's room to make room for the Skyvan flight crew.

From my "office" in the kitchen I can see a fox scampering between the buildings.

Table 2.5: Inner Line Shot Table

Available shot times (hh:mm)	Shot points
Team Bob + Thomas (FCNG)	
XX:00	
XX:20	6, 7, 8
XX:40	
Team Tim + Patrick (FPHO)	
XX:05	
XX:25	3, 5, 5
XX:45	
Team Lloyd + Ron V (FARE)	
XX:15	
XX:35	1, 2
XX:55	

On the basis of a 1900 radio schedule from the North Camp, I learned that they are still having problems getting the compressor to run. It must be frustrating for them. The ice has not started to move yet, so data is not being lost, but the time it is taking to solve this problem is getting to be a concern.

Julian Day 94 Thursday April 3, 2008

- -33^{O}C sunny at all ARTA locations

The morning safety and briefing meeting in Eureka consisted of only three people: Isa, Mingzhou, and I. Isa and Mingzhou are going to the magnetometer building about half a km from the Base. They have signed out and taken a radio. They expect to be gone for 2 hours. At the 0815 radio schedule I had a poor connection with the South Camp. I asked Jon his plans for pulling out of the camp. He promised to email his thoughts. I need to start amending Dave's contract to cover the expenses.

I have located enough rope, pick handles and disks if we need to fire extra charges. The fourth helicopter for the shooting was assigned to us and the pilot went to the runway at about 0930 for his flight to the South Camp. He will be shooting the two inner shots and should reach his destination before all the boxes are out.

It is a busy day at the runway. The PCSP radio is not working and Dave has taken over the radio for them. We have three Twin Otters working for us today. Paul Rask, a particularly skilled Twin Otter pilot, is flying out to the North Camp with supplies and then beginning a search for a fuel caching site between OS5 and OS9 (Fig. 1.1). The Twin Otter based in Resolute will fly here via Grise Fiord to pick up Tom Kiguktak and Randy Pijamini, who will act as bear monitors for the Camp and assist with other camp duties. The third Twin Otter is shuttling fuel and supplies to the Camp. The Skyvan has not arrived yet.

As a matter of interest, at noon a DC-8 is suppose to fly over head in a spiral in a task associated with the Pearl laboratory. I just saw a Hecules C-140 flying low over the Base. Eureka is a busy airport this time of the year.

After lunch I was driven up to Dave's office. By overlapping the charges we shortened the line so OS11 is shifted to the south on my over view map. Paul Rask found a landing strip for the Twin Otter at 84.4945°N, 98.052°W. This will be the southern shot for the geobuoys and they will be dropped to the north of this position.

With four teams shooting the eleven-shot sequence was completed within 1.5 hours and the pickup began. The new blasting boxes are reliable and a vast improvement over previous years.

On the LORITA experiment on the Inner line we fired 6 shots to about 60 instruments for 180 traces. So far we have fired 3 shots to 30 recorders and 11 shots to 115 recorders for 90 and 1265 traces.

Julian Day 95 Friday April 4, 2008

- -28°C sunny at Eureka and South Camp

At the safety and briefing meeting, congratulations were offered for running the Inner Line, from loading the holes to picking up the boxes, in only 2.5 days. The deployment team and blasters (Bob and Kirby) who are back in the base at Eureka described their activities and made comments on the parts of the field operation that went well and areas where improvements could be made. The deployment went well due to the carefully laid out plan (distributed on paper to Pilots and science staff). Each team of two on the helicopters knew exactly which instruments they were laying out and picking up. Therefore, the communications between helicopters was minimized. I received an anonymous email from the camp asking whether the weight of the recorder boxes be reduced. (Obviously from a tired member of the team with a reasonable point to be considered.) The seats are still in the helicopters. We had discussed removing them with the helicopter pilots and engineers; however it was decided not to press the issue as we were managing with them in.

The five-minute shooting interval between four teams of blasters worked well. All shots were fired on the first attempt. It is noted that the Primacord is covered in plastic and not as strong as what was used for the LORITA experiment. We have experienced several cord breaks, and I fear for partial detonations.

Three teams may have been more time efficient; however with the twenty-minute period between shoot windows, travelling between locations would have been tight. Working with three teams would have been easier with thirty-minute shot rotation; however, recovering the recorders is faster with 4 teams.

Bob and Kirby thought the terminate pins on the blaster boxes would be better if they were farther apart. More space would prevent possible shortening of the bared wires. This is not a safety issue; it would just mean that the shot would not fire. This is a hassle for the shooters and the next generation of boxes should consider this improvement. Because Lloyd and Ron are at the South Camp and the email is not working we do not have the exact positions of the two southern shots. Because the ice is not moving, the deployed positions will be used for the initial creation of the SEG-Y files to check on data quality.

John Shimeld will store and manage the data.

The lack of internet this morning means Dave Maloley cannot track his aircraft fleet automatically and must use the radio and write down their positions. This will make a busy person even busier.

Cheryl sorted out the Pentolite and Primacord compatibility issue. Primacord 10(50) grain has a great success rate when shooting Pentolite. I ordered 5 boxes of 305 m from Dave Maloley. I now need a shipping address and get it to Cheryl.

The black boxes with the data recorders were brought to Isa's lab during the morning and he is warming them up before downloading the data. John and Patrick had to download all the instrument locations from a variety of GPS units. Thomas is preparing a plot of the Inner Line.

Isa and Thomas extracted the data from the Taurus recorders. The data quality is again excellent. On eight of the recorders, the shots are difficult to extract. It will take Isa at least a day to solve this problem.

Dave Maloley is hoping to run the refraction program as quickly as possible while the weather holds. He has the fuel and the explosives distributed for the Outer Line. He made the pilots make numerous flights today but tomorrow they will have fewer flights, so they will be rested for the extensive flying required during the deployment, shooting and instrument recovery. The Skyvan is making numerous trips from Eureka to the Ice Camp with fuel. The Twin Otters are then distributing to the appropriate caches along the lines.

During our evening discussion, Dave wanted the coordinates of the cross line so that Paul could be sent to search in the Twin Otter for a fuel cash at the west end of the cross line. Not only will it be useful for our program but also it will provide a cache for the bathymetric program for their line 3. This meant Thomas and I spent most of the evening adjusting instrument distribution and shots for the remaining lines.

The only problem I have with Dave's scenario to complete the refraction program as fast as possible is that we do not have sufficient Primacord to ignite the remaining charges for the military exercise. I have ordered the Primacord but I do not have it in hand.

Because the seismic crew is living in two locations, the South Camp and Eureka Base, it is often difficult to communicate important information. The location of the shots that blasters will need tomorrow morning was sent to them by email, USB stick and paper copy in the hands of passengers returning to the South Camp. We then tried calling and waiting for email responses. In the event we received no confirmation that they had the positions loaded in their GPS, Patrick was ready to take the first flight to the Ice Camp.

Julian Day 96 Saturday April 5, 2008

- -33.2ºC sunny at Eureka and South Camp

John Shimeld and Isa were up at 0630 as usual to ensure the pilots have the daily weather products by 0700. At breakfast I spoke with Dave about my concerns of running out of Primacord. He understood the problem clearly and will adjust flights to coincide with the delivery of the Primacord to Yellowknife. On Monday I will get Dave to talk to the supplier so they can coordinate the shipment.

Dave estimated the first flight today would be later than usual at 0930. This gave Patrick, Kirby and Bob a chance to organize their morning.

Because we are going to be busy today, the safety and briefing meeting was held early. No safety issues were brought up. The instruments should be deployed tomorrow, so it is necessary to remove the gel packs in order for them to warm up sufficiently to act as a heat source in tomorrow's deployment. Immediately after breakfast 690 of the 900 gel packs were removed from the black boxes and stored in the warm hall. It took about an hour with all hands pitching in.

Meanwhile, Isa was able to recover the data from 8 troublesome instruments. There is not the time to re-plot the sections before the next deployment. The priority now is to backup the available data and to prepare for the next line. Thomas and Mingzhou were busy most of the day removing the old battery packs from the black boxes and replacing them with new ones. Isa asked me to make sure that the blasters put new batteries in their shooting boxes. He will send the batteries out to them and he asked me to ensure that they actually use them.

When I called home today I enquired if they had been getting Ron's newsletter and John had not. I will talk to Nelly on Monday morning.

In the afternoon, five of the UNCLOS team went for a one-hour walk in the direction of the PEARL laboratory. We walked along the edge of the Slidre Fiord with a splendid view of Axel Heiberg Island across Nansen Sound. After our walk a reporter, Bob Weber from Canadian Press, spent time learning about the UNCLOS program. He took pictures of the seismometers and Isa gave him a thorough tour of the data recorders. After he writes the article, he will send it to me to check the technical details.

I had a long discussion with the deployers, Thomas, John, and Patrick, on how best to put the black boxes on the ice. There are a large number of possibilities with three helicopters, a Twin Otter and three runways. Eventually, we wrote up a scheme and vetted it with Dave. We printed off copies for all involved. The three team members at Eureka will fly in the Skyvan to the South Camp. There they will meet the rest of the team and transfer to the helicopters to begin putting the boxes on the ice. This

operation will take most of the day. There is no plan to shoot until the following day.

I got a drive up to the runway to give Dave a copy of the plan. On the way back in the truck, about 0.5 km from the main building at Eureka we saw the entire wolf pack, perhaps 15, on the road. I would have liked to have had my camera but I was pleased I was not walking.

In the evening Thomas, John, and Patrick were preparing for the next two days of strenuous activities of putting out and picking up the boxes. They also have to be certain that all items for the deployment are ready and organized for the day; garbage bags, shovels, trackers, and instructions. We all hope the weather holds; unfortunately, higher winds are predicted for tomorrow.

Julian Day 97 Sunday April 6, 2008

- -32.5oC sunny at Eureka and windy at South Camp

The Taurus instruments, in their black boxes (85), were on the loading ramp prior to breakfast waiting for the truck to take them to the airport. At breakfast Patrick had a health and safety concern. He reported a box of meat sitting by a radiator in the hallway: the cook from the South Camp may have left in behind. The kitchen staff was notified and the meat dealt with.

The 0815 Iridium call was successful and I was able to communicate with Jon about the weekly message. He will send me information by email later today. Tim thought it would be better to shoot tomorrow even if the boxes are all out today. It is windy on the ice and ice motion in response to the wind will increase the ambient noise. Ron was concerned about his newsletters not reaching their audience. I had contacted Darryl, who responded positively. Therefore, I forwarded the newsletters this morning. I also emailed Nelly and asked her not to forward them.

Isa and Mingzhou have to prepare the last 30 boxes for deployment by mid-morning. Patrick, John, and Thomas waited half an hour for their ride to the airport in spite of me calling twice to get updates on its arrival. They have a long hard day ahead of them and it is tiring to be waiting in the cold. The wait was the result of Dave's team (Sean and Doug) being busy at the airport getting the Skyvan and the Twin Otter fueled and loaded with cargo.

Isa made a number of improvements to the black boxes and their contents to make them more robust for shipping. He has taped the door of the Taurus' compact disk compartment shut so it cannot open. This was the cause of the only failure to record data on the Inner Line. He also wired all the latches on the boxes shut. He would like the handlers of the boxes to be more careful with them because he found a damaged wire from the antennae socket that took several hours to diagnosis and repair. He pointed out that in fact the Taurus were more delicate than a laptop computer because they write to flash cards. The two people moving our freight have been working hard for over a month often logging longer than fourteen-hour days. We are not sure how to fine-tune their generally exemplary performance.

Al Gaudet, the Station Manager, was upset today. A group of ten individuals were on their way to Eureka, and they had not booked ahead so he had to refuse to let them stay. The station is already over-flowing with groups from various organizations that had pre-arranged for their stay a year ago.

I walked up to the airport with Isa and Mingzhou, where we learned that low visibility at the North Camp had grounded the helicopters until the weather improved. The helicopters had just left the South Camp as we arrived at Dave's office. While at Dave's head quarters we got a fuel status report. At Eureka there are 464 full fuel drums, on the ice 140 full fuel drums. It will require an estimated 300

drums to clean up the South and North Camp sites at the end of the program. To date we have used 260 hours of Twin Otter time, consuming 455 drums of fuel. This inventory indicates the need to purchase more fuel. As a point of interest, fuel delivered to the South camp costs $1300 a barrel and $2300 at the Outer cache.

I was also given a data sample from the reflection system for John Shimeld to examine.

Ice fog in the vicinity of the North Camp prevented the helicopters from working safely in the region. Up to that point, the three teams had put out 58 instrument boxes. The situation with the stalled deployment was worsened by the oil leak that developed in the fast helicopter - the 407 FARE fondly called Alfa Roméo. At the 2015 call to South Camp, Jon kindly offered one of his helicopters to complete the line.

The copilot of the Skyvan developed a painful ear problem on landing at the South Camp. His screaming startled the pilot, they had to abort their landing come up to altitude and ease their way back to the runway. He will be sent South and a replacement flown in. No more fuel shuttling flights for the Skyvan until another pilot is available.

Julian Day 98 Monday April 7, 2008

- -31.7°C sunny at Eureka and good conditions at the North fuel cache with cloudy periods

In the morning the weather report was favorable although there is more cloud. The northern section of the Outer Line is the logistically the most difficult and scientifically critical. The remaining 35 instrument boxes were picked up from the warehouse and taken to the runway. They will be flown to the Northern fuel cache by Paul Rask this morning.

Paul is an exceptional pilot. His copilot says that at 2000 ft Paul can pick ice suitable for a landing strip. To determine whether a piece of ice is of suitable length to act as a runway, they fly low over the prospective strip, time the length it takes to travel over it and then land. On a good runway, the landing is nearly as smooth as on a conventional runway. The program hinges on the skills of a few such individuals.

I tried calling South Camp but there was no answer. I contacted Cheryl and got the name and phone number of the Primacord supplier. This information was passed to Dave Maloley to coordinate a flight with the delivery of the Primacord. Next, there was an email message from Morten Rasch asking Jorgen Skafte for his return date. I sent a message to Jorgen by radio and replied by email to Morten. This was followed by a request by Don Mosher for copies of the newsletters to keep his military counterparts informed of our progress. I expect they had already reached him but I sent them off again. The fourth inquiry was by Gordie Oakey who had concerns about his food order for Eureka for later in May. I tried to convince him to call Dave Maloley directly.

At 0900 the three teams of deployers left the South Camp to position the last half of the instrument boxes on the ice along the Outer Line. Because they are working at the northern end of the line, transit times are greater and it takes longer than the previous deployment cycle. At 1400 they were still putting boxes on the ice. As usual, there is urgency because the winds are expected to pick up tonight at the North Camp. The satellite trackers in the black boxes may be necessary to locate them.

Isa, Mingzhou and I walked up to the airport after lunch in the bright sun. The temperature has reached a pleasant -27°C. This gives us exercise and a chance to talk to Dave about the flight operations. The

Skyvan is busy shuttling diesel and jet fuel to the South Camp. I also learned that the Primacord would be in Yellowknife in time to meet the food flight from Yellowknife on Friday. The success of the military operation with the CP140 Aurora dropping ice pick seismometers requires that we have Primacord to fire charges.

I spent part of the day reading an open file report on the interpretation of data from the Ice Island experiments. I also plotted LORITA, ARTA and other regional refraction data sets to provide a frame work for understanding the ARTA data.

At 1600 the blasters were in position to start shooting. Unfortunately, they were not able to find shot number 7 and it was one of two shots without trackers. There are 4 trackers sitting in Dave's office. Eventually, after looking for 2 hours, all shots were found. Dave estimated a drift track from the other trackers. Isa extracted the positions from the Cartenav website and I plotted it with Global Mapper. We were plotting up the drift tracks when we got word from Dave that all the shots had been found.

Lesson learned: we will put Isa's trackers on the shots as well. The trackers radio their position constantly, so we will always know where they are. Always a little drama in the Arctic, the environment is unforgiving.

Dave is at his desk in the ATCO trailer from before breakfast to whenever the aircraft stop flying - always after 2100 and sometimes as late 2300. He sleeps in the trailer as well. He leaves the trailer briefly for breakfast but his lunch and supper are brought to him by Sean or Doug. For months he is capable of a sustained effort of monitoring the aircraft while flying, directing their fueling and fuel caching, ordering and organizing transport for goods from the south to support the science parties and the aircraft fleet and coordinating flights to several remote camps so that no unnecessary flights are made. Without his skill and knowledge of the Arctic and the confidence the pilots have in him, the ARTA project would not work.

Julian Day 99 Tuesday April 8, 2008

- -28.4°C sunny at Eureka; blowing snow low visibility at the North Camp

The weather report from the North Camp is blowing snow with 1 mile visibility and the aircraft are grounded until conditions improve. Also a result of the weather conditions, the tracking computers will have to be used to locate the instruments for retrieval. Therefore, Thomas, Patrick, John, and Lloyd, who are the best trained in the use of the tracking computers, will be doing this task when the weather improves. Last night after shooting, the team was able to pick up 20 recorders.

Our major safety issue today is monitoring the location of the shots. Isa has 6 boxes that he can put his Id-trackers into so that they can be placed at the shot points. He is preparing them today.

At breakfast, one of the Rangers approached me and mentioned that 9 Rangers would be staying at the South Camp tomorrow night. I checked and Jon is okay with this. He can provide meals for 9 but not more.

At the Northern Cache, northern end of the Outer Line (OS11), Tim said there was one charge, one roll of Primacord, and rope. This must be confirmed, because I need an accurate accounting.

The winds continue to blow at the North Camp. The helicopters were able to fly near the South Camp and hydrographers are able to work. Dave is paying attention to see how far north they are able to fly.

Two of our helicopters will soon need an inspection and one of the Twin Otter pilots, Paul Rask, has a limited number of flying hours left in his duty rooster. There are going to be crew rotations of the both Twin Otter pilots and several of the Helicopter pilots by the end of the week. Therefore, Dave is trying to use his flying time to the best advantage of the project.

When I called Jacob today he mentioned that Natural Resources Minister, Gary Lunn, is planning to visit the project. The timing is important; if too late the Camp will be torn down and if too early there will be no place to stay. I told the station manager so he could prepare.

Flying in spirals over head is a DC8 that is working with the PEARL group measuring the air quality. It is making circular con trails that will make for a picture with unusual clouds.

At 1330 the winds speeds were decreasing at the North Camp based on Jorgen Skafte's report. The helicopters were given the information and two of them left the North Camp to retrieve the recorders. Using the ID tracking computer and working until midnight the remaining 95 of the boxes were recovered. Thomas had his computer running when they reached the site and was able to see the boxes up to 9 km away. They had drifted 2.3 km at the northern end of the line.

Julian Day 100 Wednesday April 9, 2008

- -26.2^{o}C sunny at Eureka; North Camp winds to 20 km/h

The ice images changed dramatically from April 5, when we ran the Inner Line, to April 9, the day the boxes were flown to Eureka at the completion of the Outer Line. On April 5, the NOAA image shows leads to the north of our planned cross and one crack intercepting the cross line near the apex of our lines. On April 9, there was a dendritic pattern of leads surrounding our working area and cutting across the Inner Line at about the midpoint.

Of the many weather products provided for us the most popular are: Project ARTA forecast, clouds and weather, winds, experimental blizzard potential and the NOAA satellite images with our lines superimposed.

The call to Jon and company at South Camp revealed the position of the recorders: 41 at the North Fuel Cache, 31 at North Camp and 19 at South Camp. The seismic team that worked hard to finish the line were anxious to return to home base. They had planned to be there only one night and instead were there for three. Understandably, they are anxious to get back to clean clothes.

After a brief safety meeting with no issues brought up, Mingzhou went to prepare for a trip to the South Camp to update the ID trackers and pick up the blaster boxes. He was given Ron's memory stick, envelopes, and Lloyd's Team Saskatchewan jacket. .
Because Dave sent the Twin Otter to the North Fuel Cache and North Camp, the seismic team is waiting patiently at South Camp to get back to Eureka for clean clothes and showers.

At 1105, as predicted by Dave, the helicopter FPHO arrived outside Bill's garage (about to be a hangar) for its mandated maintenance. It had two blaster boxes onboard, which Mingzhou immediately retrieved. Then Isa and Mingzhou went to work carefully assessing the problems with the instruments.

I had a chance to talk to Gerard about the details of running the Outer Line. He mentioned he liked the teams to be kept consistent because the communication was better. Tim was tired after the blasting and the teams were rearranged. This was complicated by the difficulty of using the ID tracker computers in

the helicopters. It would have been better if the users had received more training on the use of the computers, but we did not receive the hardware until a few weeks before the experiment. I learned that the two ice trackers that did not work were not faulty - they were not turned on.

Gerard also commented on how the ice changed dramatically from the beginning to the end of the line. It went from being flat to pressure-ridged, changing the landscape completely and making it difficult to work in the area. Considering this, it was fortunate the line was completed in four days (five counting getting the boxes to Eureka).

Julian Day 101 Thursday April 10, 2008

- -26.7^{o}C sunny at Eureka;

The seismic deployment team rehearsed the sequence of events for the Outer Line. The major safety discussion was on the distance the helicopters should move away from the blasters when they are shooting. They must be far enough so there is no danger of the ice cracking and close enough to be within visual contact in case of bears or accident. Due to the presence of pressure ridges, this distance will vary with each shot.

We discussed the tasks that must be done now. A number of parameters from the experiment must be determined and distributed today. The position of the instruments at the mean time of the shots is required for data analysis and plots, and to provide a target for Jon Biggar's hydrographic team to get a bathymetric sounding.

Thomas downloaded the positions from the Taurus and Patrick converted them to a form that can be used in the GPS units. This was emailed to Jon at the South Camp. Isa has to back up the data from all 115 instruments that recorded data. He and Mingzhou must also prepare the black boxes for possible deployment tomorrow morning. Thomas was plotting the sections for the Outer line. The data are noisier than the Inner Line and the noise is spatially isolated due to ice movement in localized regions. In addition, shot number 6 may have been a partial detonation, as the amplitude of the shot is significantly less than all the others, the frequency higher and the limited range data are noisy.

Dave told us that the fuel and the explosives would be cached by noon and the blasters needed to be ready to load the holes. The position of the shots and charges was calculated by John and sent to the camp. Tim did not know the charge sizes for the cross line and Dave Maloley got the information to him. The line was to start near noon but ice fog was preventing the helicopters from leaving camp. Furthermore, the fog rolled into camp preventing two helicopters from returning.

Today Paul Rask and his copilot flew south to Resolute and will be replaced by a different team.

Jacob said plans were being made for Minister Gary Lunn's trip on 16 April. I have given this information to Dave who will need to coordinate any Twin Otter flights that will be needed to take the Minister to the South Camp. Jon Biggar was informed of this during the 2015 call.

The ice fog plagued operations today and one of the helicopters in particular that left the camp had difficulty returning. Dave Maloley coached it around the ice fog and it landed safely at about 2000hr. The cryopacks for the Black boxes were left out overnight to gather additional heat before packing up because they will not be needed until Saturday morning now.

Julian Day 102 Friday April 11, 2008

- -30.0^{o}C cloud at Eureka could not see across Slidre Fiord, less than 5 nm visibility at the South Camp, clear at North Camp

At the morning briefing and safety meeting, it was obvious the weather conditions have made flying unsafe. Shot loading will not go ahead until conditions improve. I sent an email to Tim and asked Dave Maloley on the radio schedule to look at his emails. I was concerned that he be aware of the partial detonation of charge 6. The email asked him to record as much information as possible about the Primacord and review how that charge was loaded. He replied that it had low tensile strength and was difficult to unroll. He will record all the information on the reels so we do not order it again and take care with loading the rest of the charges.

The shots and charges are marked with garbage bags. We are concerned that we do not have enough for the cross line. Patrick will count and refold all that we have and Jon Biggar can lend us some of his heavy duty bags. When the cross line is finished, all bags will be returned to him for reuse. Dave will have Doug and Shawn deliver all the bags we have here to the warehouse and Patrick will prepare them for deployment.

Thomas was making base maps of the deployments and shots. I got him the most recent and earliest position of the North Camp. It has moved perhaps 2 nm. I also replied to Mike and Greg's query about shutting down the seismic gear when the ice stops moving - we need the gear on all the time because otherwise we cannot detect when the ice starts moving. This might result in a data gap. Besides, redundant data are valuable and it could take 12 hours to start the system again. John sent them a note with a plot that indicated channel 3 was not working as well as the others. He also requested that I enquire if they needed spare parts, which I did.

Isa is preparing for the deployment for the Cross Line. All the cryopacks must be returned to the black boxes and the Taurus instruments tested to see if they are operating. Then they will be shut down until we are sure the instruments are going to be deployed. At 1430 Isa will show the deployers how to interrogate the boxes in the field to get their vital signs. This will be necessary if the boxes are left on the ice for multiple days before shooting occurs.

Patrick prepared files of the position of the receivers at the average time of the shots for the test line, Inner and Outer lines. I put them in my Global Mapper map file.

The conditions on the ice were not good for flying all day. The Skyvan did not leave Yellowknife due to bad weather conditions in Resolute and Cambridge Bay. The good news is that the Primacord has been delivered to the aircraft.

Thomas spent the day playing back the data for the outer line. He gave me copies of the plots of the locations and the record sections. He spent time looking at the amplitudes on the partial detonation and determined that at most, one charge ignited. Patrick updated our digital photo album and spent some time folding garbage bags for the next deployment. Isa and Mingzhou have the seismometers ready to deploy at an hour's notice.

Al Gaudet let me know that on Sunday there will be no hot breakfast. Brunch will be served at 1130 and supper will be at the regular time

Julian Day 103 Saturday April 12, 2008

- -30.0^{o}C sunny at Eureka, ice fog at South Camp

Weather is the single most important issue today for safety and the commencement of the cross line. Unfortunately, there is a low pressure system to the south and the winds are moving the ice to the west, opening up an extensive series of leads. These leads produce the dreaded ice fog that makes flying the helicopters dangerous. Following the scheduled 0700 hr radio communication, the camps were called again at 0815. The weather is deemed adequate for the Twin Otter to fly to the ARTA Camp. The helicopters are waiting.

Isa will be working on a permanent broadband seismometer installation at the Polar Environment Atmospheric Research Lab (PEARL). Therefore he will take the morning to go up there to begin the setup. He will borrow one of the Taurus instruments to test the setup and then put it back in its black box for the Cross Line. Once we finish data acquisition it will be taken to PEARL and left there.

At Eureka, we have 65 black garbage bags that are ready to mark the position of the shots and the recorders. I will email the camp to get there tally. Jon said he would lend us any shortfall we might have and we will give him all our bags for reuse once we complete our work.

Thomas will spend the day picking the arrivals to begin the interpretation phase of the project. Patrick will edit the expedition diary and update the picture gallery. John is anxious to get more seismic reflection data from the North Camp because he has done all the processing he can to the 600m of data he has received to date.

At 1115, a preplanned call took place between the North Camp's seismic reflection crew, John, and I. The hydrohole for the airgun is enlarging significantly and the building may have to be moved - each time the gun fires, the building floods. Mike's estimate was four days to accomplish this task. Since Jorgen must leave on April 25 to return to work in Denmark, Mike wonders if it is worth the effort. John asked them to lower the gun from 5 to 17 ft beneath the ice and fire every minute and a half.

I would prefer to have the seismic reflection profiling continue now that it has started and the ice is moving. I talked to Dave and he does not think there is room for people to overnight. I could bring Tom and Randy out to help with the move during the day and have them flown home to the South Camp at night. If it can wait until after the cross line is finished, Bob and Kirby could be sent as well. This would minimize the downtime. The camp then could be packed up on or about April 24. This would provide significantly more data than is available now.

When Isa returned from setting up the broadband seismometer at PEARL, he asked if he could leave the Taurus installed there. This means there will be 114 not 115 instruments on the Cross line. If this is the only setback we face, it is "beneath the noise", and readily acceptable.

The blasters will finish loading the nine holes tonight. It was slower than it might have been because the 407 helicopter was not operational. The 206 helicopters could carry only 14 charges, not 21, so there was a lot of ferrying back and forth to the explosives cache. Isa and Mingzhou are preparing the boxes for deployment tomorrow morning.

Tammy, the cook's assistant, was in for a shower today and wanted to go home on May 1 rather May 8. This is probably appropriate for the staging down of the camp.

Julian Day 104 Sunday April 13, 2008

- -28.7^{o}C fair visibility at Eureka, clear at South Camp

Just after 0700 Dave arrived in the dining room and, to our pleasant surprise, announced that flying conditions on the ice were good. The wind is now from the northeast and is perhaps closing up the cracks, reducing the ice fog. However, there is a major lead parallel to the shoreline that is growing. The entire ice pack may shear and significant motion may begin. The North Camp may have to be brought in sooner rather than later. This is a shame because the data they are collecting is useful. The 8.5 km of data that was collected this week was processed by John. It shows about 0.5 seconds of transparent and stratified sediments overlying a well-developed basement horizon with internal dipping events

Because only two helicopters are available and fresh produce must be ferried to the South Camp, only Thomas and Patrick were on the first flight. John updated their GPS units and provided data on the drift of the shots based on the latest tracker information. This was also emailed to Tim. John followed on the second flight. It is hoped that the spare part for the 407 will be installed today, otherwise it will be tedious to deploy 57 recorders each from two helicopters.

The first 40 recorders left the warehouse at 0900 and the passengers were picked up for the first flight. By about 1300, all boxes were either at their caching location or on their way. Today we have three Twin Otters delivering instruments to the caches and the Skyvan bringing groceries and fuel to the camp. It takes three Twin Otter loads to get the 115 recorders out to the ice.

Today the Ranger patrols returned with the fanfare of an aircraft load of dignitaries and press. I was surprised to meet Benoit Beauchamp. I had him look at the fossils in the rocks that were lying on the road to PEARL and he said they were Jurassic bivalves and that I could quote him on that.

At noon, Mike called on the Iridium telephone from the North Camp. I told them that the data quality was excellent. The plan is to pack up the camp when Jorgen leaves April 25 if the ice does not become too unstable before then. I hope to get to the camp tomorrow to show them the data and discuss options for moving the air gun tent.

The deployers worked until 2000 to get the recorders on the ice. We hope for flying weather tomorrow morning.

Julian Day 105 Monday April 14, 2008

- -30.1^{o}C fair and sunny at Eureka

This morning, the flying conditions are favorable, however blowing snow is predicted for this afternoon. The helicopter that came in for its scheduled maintenance will not be ready to go until this afternoon. This will interfere with Jon's hydrographic program today.

At the 0815 radio schedule I learned that the helicopter pilots were sure that there would be no flying until conditions improved. The ice fog that the pilots encountered when flying back to the South Camp from the deployment on the Cross Line has made them especially aware of the problem. Our number one concern is safety, so we will not fly until the weather improves.

During the call, I talked to Jon about his need for the North Camp weather report. He relies on it for his helicopter flights now, but as the season progresses, for safety reasons he will not venture so far from camp. We need to coordinate our plans accordingly.

I talked to Al Gaudet about the possibility of our Minister's visit on Wednesday. He can rearrange rooms to accommodate 7 people if he must. I emailed Jacob and reminded him that it is necessary to have proper Arctic clothing to go to the Ice Camp and to count the number of crew as well as passengers when estimating numbers.

Isa finished rewriting the Ice Tracker positions in a user-friendly file just as Dave called saying they were needed at South Camp because the weather had cleared and they were going to try flying. I emailed immediately. I had to track down the Skyvan pilots. I tried to arrange a radio/Iridium schedule with Don Mosher but Dave was busy getting the aircraft moving. I sent Don an updated schematic of the charges and geobuoy layout, accompanied by positions. The email states that the radio schedule will follow.

The blasters were at the line by early afternoon. There was a problem with one of the helicopters finding the fuel cache, perhaps due to a misunderstanding or reversal of digits in the positions. This was sorted out and shooting began. Shot 9 was detonated successfully and then the problems started: shot 8 was a partial. I was willing to have one failed shot and then I got word that shots 2 and 4 were partial detonations as well. This means the three shots must be reloaded and fired. The five extra rolls of Primacord ordered from a different manufacturer arrived on the Skyvan after the shots were loaded along the line. This new prima cord will be sent to the ice tomorrow morning along with 21 charges. I hope the weather cooperates.

The latest news is that Minister Lunn is planning to fly to Eureka on Wednesday, arriving at 1700. He will then fly to the ARTA Camp and return by 1100. Just in case, Al has a plan for individuals to stay at Eureka if weather or late arrivals require it. I also got notice that freelance TV video producer Julian Sher and Herrie Ten Cate are arriving in Eureka and expecting to travel to the ARTA camp.

I called Julian as requested, and learned he is arriving on Saturday from Resolute. He would like to spend two days in Eureka and three at the ARTA Camp. I said the weather was the controlling factor. Herrie Ten Cate arrives on Wednesday and has four people in his crew. They do interactive screening. They would like to take part in the hydrographic operation.

During the 2015 call I talked to Thomas about the partial detonations. Each team had one so the culprit is likely the Primacord. The charges are evenly distributed along the line, so the shots tomorrow might make for two close parallel lines. Tim was concerned about the Primacord and I hope the new order from DynoNobel will be more effective. John Shimeld had a productive visit at the North Camp and learned that the melting problem in the airgun tent is related to the stove; raising it and opening the door reduce the problem. Since data production is going well it would be ashamed to abandon it now. Greg is bored and he had a chance to go out today to participate in a shot. Mike is willing to stay until Jorgen goes. I gave Jon a heads-up about the three sets of press he will be receiving.

Julian Day 106 Tuesday April 15, 2008

- -31.8°C fair Sunny at Eureka, cloudy at the South Camp

DRAFT / PROPOSED ITINERARY #2b – Challenger/charter
The Honourable Gary Lunn, Minister of Natural Resources

Visit to Eureka and Ice Camp

April 16-17

Note: Minister will be accompanied by one staff member and XX media members, including CP Photographer and CBC Radio journalist based in Iqaluit.

Wednesday April 16 – DEPART Ottawa

08:00 a.m. Minister Lunn departs Ottawa for Iqaluit via Challenger

11:00 Arrive in Iqaluit
11:15 Depart Iqaluit on chartered Falcon 10 Jet with fuel stop in Pond Inlet
15:30 Arrive in Eureka
15:45 Depart Eureka via Twin Otter
16:45 Arrive at South Camp
17:00 – 19:00 Meet Ice Camp scientists and other field personnel including Inuit bear monitors (20-25 people in total) Tour of facilities; Debrief on activities
19:00 Depart South Camp via Twin Otter
20:00 Return to Eureka
20:00 – 21:00 Tour Environment Canada weather station ; View seismic equipment
21:00 Depart Eureka on Falcon 10 Jet

Thursday, April 17

01:00 Return to Iqaluit
01:15 Depart Iqaluit for Ottawa via Challenger
04:00 Arrive Ottawa

The Cross Line is covered with clouds this morning. The prognosis is that it should clear by noon and the three shots will be reloaded and fired. Thomas thinks that even with the missing shot points 2, 4 and 8 we can get valuable information out of the Cross Line. At least we have data from the two outer shots and nowhere are we missing two shots in a row. If it turns out that the recorders have drifted off line when we re-fire the three shots, we will actually have a second Cross Line that might turn out to have some value with two shots (2,8) that are 130 km away and shot in between. I am not too upset about yesterday's problems and hope that we have no noise from moving ice.

The clouds cleared earlier than predicted and I took the first Twin Otter trip via South Camp to the North Camp with fuel and explosives. At the South Camp the explosives were distributed to three helicopters, each to load one seven-charge hole and fire it. I spoke to Jon about deciding when his camp would be torn down as the aircraft must be booked ahead of time. Since Randy and Tom have been working on the runway it is possible to bring a cargo aircraft called a Buffalo. This will make evacuating camp more time- and fuel- efficient. The hydrographers are now occupied taking soundings, their main task.

After a quick lunch, we flew 40 minutes to the North Camp. The main reasons for the visit were a safety audit, to congratulate them on the data quality and to determine the timing of packing up the camp.

Mike Gorveatt, the safety officer, and I reviewed the positions of the fire extinguishers, first aid kits and defibrillator, guns and ammunition, extra sleeping bags and beds, distribution of the tents. Their individual buildings are well separated from each other and in two groups, 300 meters apart in case of fire.

I had a copy of the processed reflection profile from the first week that John provided me with. It was easy to point out the seabed, a probable bottom simulating reflector, basement and perhaps a fabric within basement. Mike and Greg were pleased to see that their labours were producing results.

The final item of discussion, the breakdown of camp, was based on the return of Jorgen, the camp manager, to Denmark, the remoteness of the camp and the possibility of ice pack shearing along a major system of leads, as well as the need for the hydrographers to get weather forecasts and to refuel. The last day of seismic operation will be 19 April. The next morning the gear will be disassembled. The first Twin Otter load will be available by late afternoon that day. Mike will stay on in Eureka to sort equipment and send it back to its appropriate destination. Greg will return directly to the GSC in Victoria.

During our discussion, we heard two of the three shots for the Cross Line being fired. Not long after, John and Lloyd arrived in by helicopter to await the news that the final shot had gone off. Jorgen called Dave and learned that all the shots had been fired. Instrument recovery began and was complete that evening - three deployments of 115 instruments with no losses. The ice at the west end of the line was not moving during the shots so we hope the data quality will be good.

I also had time to discuss with Jorgen and Mike of their impressions of how the work had gone this year and how it could be improved. I hope it will be recorded in their section of the expedition report. I returned to Eureka on the Twin Otter along with 32 recorders. On arrival there were messages about the Minister's planned visit. I responded to them and assembled a handout. The wide angle refraction experiment has been a success.

Julian Day 107 Wednesday April 16, 2008

- -33.3°C Sunny at Eureka and South Camp, poor weather to the south in Iqaluit and Resolute

Dave has planned 3 Twin Otter trips to the western fuel cache, the North Camp and South Camp to pick up boxes and deployers. During my morning call to the South Camp, I asked for shot times so Isa can play back the data. I also talked to individuals about their departure date. They will send me an email confirming the names this morning.

The Minister of Natural Resources, Gary Lunn was expected at 1400 hr. I found it difficult to get information on his aircraft's location. I had requests from his press secretary to print out and distribute, and handouts for the press and emails to answer. I wanted to coordinate the departure of the seismic group from the ice camp after the Minister got there. I finally gave up. The Minister was delayed until 1930 due to problems refuelling in Hall Beach. He was determined he was going to fly to the ARTA Camp and stay overnight. Dave Maloley did not think it was a good idea.

Upon his arrival, I got Gary Lunn together with Dave Maloley and they seem to get on well. Jacob Verhoef arrived on the same aircraft appropriately dressed in a parka supplied by Technical Field Support Services. The Minister, Jacob, and the press were flown to the South Camp and had a flight in the 407 helicopter. The Minister stayed as late as he could and seemed to thoroughly enjoy himself. He was extremely supportive of the program. He is trying to get us a gift of a load of fuel from the military.

I had three new roommates for the evening: two from the press and one the Ministers assistants.

Julian Day 108 Thursday April 17, 2008

- -31.3°C Sunny at Eureka and at the South Camp

There was a lot of activity in the Eureka Base kitchen with Isa, John, Patrick, Ron and Lloyd preparing to catch the chartered plane that Canadian Network for the Detection of Atmospheric Contaminants (CANDAC) had flown its personnel up on. Because there was little notice and this was a great opportunity to get home directly without a stop in Resolute Bay, bags were quickly packed, and flight arrangements and hotel accommodations secured. At the same time, the Minister and his entourage, including Jacob were eating breakfast and preparing to depart.

At our briefing meeting this morning, Thomas, Mingzhou, and I discussed how to lighten the Taurus boxes. After moving only three, I had sore muscles. Thomas had back problems after spending a day moving them and Lloyd expressed his discomfort with the weight of them earlier in the program. Mingzhou said it might be possible to use capacitors to replace half the batteries and there may be more efficient cryopacks to keep the Taurus warm. These two items are the bulk of the weight.

Since we have completed the standard refraction survey, four helicopters are available to the hydrographic service and they had a busy day flying today. I went over the schedule for the CP140 Aurora. I sent a summary to Tim by email. I also prepared a package of information to send to the South Camp so that he could tell the blasters what they would be doing. I asked for comments. Furthermore, I discussed the overall plan with Dave and we both agreed that the starting time was two hours too early. It takes two hours for the Twin Otter to get to the northern fuel cache. Tomorrow at 0900 I will ask Don Mosher to make the schedule two hours later and the telephone schedule will be at 0715. I will send an email to Jacob asking him to contact Don Mosher and authorize Dave Maloley to call the aircraft on my behalf.

During the 2015 call I asked Jon if he was willing to have four reporters at camp for the day. He replied: "Yes, if they are not staying the night and they must be warned that the helicopters are not working near the camp so there will be little possibility of using them."

I talked to Tim about the Aurora schedule and he suggested three hours later. I reminded him about the expedition report and the safe operating procedure document for blasting. I also mentioned we would want to put a recorder at the northernmost shot site.

Julian Day 109 Friday April 18, 2008

- -27.8°C Sunny at Eureka with winds to 5 knots, cloud cover and low visibility at South Camp

Today the focus was on planning for the CP140 Aurora flights. Thomas and I chose the general location for the shots and receivers. He plotted the location to check that we had made no errors and then converted the locations in a form that could be readily plotted. I talked to Don Mosher about our constraints for flying in the morning and he had his constraints at Thule due to the rules for the opening the airport. We decided on call times and the first call will take place tomorrow at 1500. He mentioned that the last day the Aurora would fly was April 25. I thought it would be in Thule until April 29. This means that the seismic participants can fly south on the April 26 if they have all the other tasks done like retrieving the broadband seismometers.

After discussion with Dave to ensure that the connection flight between Eureka and Resolute would be available, the list for flying on April 26 includes: Jorgen, Thomas, Mingzhou, Tim, Bob, Kirby, Greg and I. On April 30 the following individuals will leave: Joanne, Tammy, Mike and Alain. The hydrographers will probably head home on about May 10. The last three out will be Dave, Sean and Doug. This information was given to Nelly so she could book flights and hotel accommodations.

The weather was not printed out at breakfast because Mingzhou, who was taking over from Isa, needed to develop his own system for sorting and plotting the many products provided to us.

In the morning at breakfast, Dave reported that flying was not possible out of the South Camp for helicopters but was better to the north. Perhaps Tim could get one charge loaded today. At 0815 conditions had worsened at the South Camp.

After my hour-long conversation with Don Mosher, I sent the geobuoy and shot positions to him. The shot locations went to Tim.

The Reel-to-Reel crew was disappointed that they could not fly directly to the South Camp and take part in the bathymetric data collection. I have spoken with Dave Maloley and Jon and they will try to get them to Camp and let them participate in a bathymetric reading near the Camp. There may be a flight to camp on Sunday.

The weather at the South Camp did not allow flying all day. After supper, Dave thought it might clear up by 21:00: too late to send the helicopters. The Twin Otters were in the air today finding runways and caching fuel for the hydrographic program.

Thomas is working on the data processing report for the expedition report and Mingzhou is preparing all the recording equipment to be shipped home. Everyone has been informed of the departure date and are preparing for it.

Julian Day 110 Saturday April 19, 2008

- -27.2^{o}C at Eureka, overcast at the South Camp

The morning was hectic as usual. Mingzhou had the weather reports out in plenty of time. Dave arrived in for breakfast with a thumbs down for flying for the helicopters. The Reel-to-Reel media group was a little disappointed so they planned to go to PEARL laboratory. They were just packing up to go to PEARL when the message came that a Twin Otter was going to the South Camp and there was space. They reversed directions and got ready to go within 5 minutes. They understood the flight opportunity situation clearly. I suggested they pack as if they were staying overnight. Thomas reminded them to ask for a sleeping bag to be put onboard.

Meanwhile we were trying to have our morning safety and briefing meeting. The remaining detonators must be sent to the ARTA Camp for safe disposal. Mingzhou is busy packing up all the equipment so that it will fit on two pallets. I have sent emails out to find a number of items that have been dispersed to the South Camp and with individuals. Thomas is backing up data today and cleaning up directories and disk space.

At the 0815 radio schedule, Jon asked about the Arctic scarves the Minister was to give away; they are souvenirs that individuals really want to have. Dave Maloley promised me he would get them distributed. Due to the interest in ARTA souvenirs, a better plan is to give Dave the logo and he will have t-shirts with logos and caps made up and distributed.

Ron sent the final newsletter to me for review. There were a couple of changes to be made to reflect recent conditions events that had taken place since he had left. I was interested to know that explosives have been detected on the computers of John and Patrick and that letters of explanation are needed.

Today, the CP140 Aurora left Greenwood for Thule. It made it as far as Iqaluit before it broke down. A second Aurora will be sent to Iqaluit tomorrow and they plan to be dropping geobuoys by 1230 our time. In the meantime, Tim in the 407 has loaded the charges that are required for the geobuoys. Don Mosher from Defense Research Development Corporation (DRDC) called at 1600 to confirm the plans. He will call again at 0715 tomorrow morning for a weather update.

After lunch, Thomas and I walked towards PEARL and were offered a drive. We wanted to walk and so refused it. Later we saw a large tractor heading up the road. The truck had gone off the road and had to be rescued. In addition, the Twin Otter had a generator problem and it was being repaired just outside of Dave's office. If the Twin Otter did not get repaired in a timely fashion then Herrie's media group would be spending the night at the South Camp.

Dave now thinks he will use the Buffalo, a smaller cargo aircraft, and not the Hercules, for shipping goods and fuel at the end of the program. This means there will only be room on the aircraft for the Taurus, but not the black boxes. So a box must be built to store the Taurus in for shipping and Mingzhou must extract all of them from the black boxes.

During the 2015 call, Tim said there was a lot of open water at the beginning of the geobuoy drop and sonobuoys might be more appropriate than geobuoys. He had to move the shots slightly off line. Without a doubt, offline shots are superior to no shots at all.

At 2045, the Twin Otter from Resolute carrying the two CBC reporters, could not land due to poor visibility at Eureka. The Twin Otter will try again tomorrow. After all their delays the reporters must be rather tired and frustrated. While I was waiting, I plotted record sections to ensure I had a complete set of data plots.

Julian Day 111 Sunday April 20, 2008

- -29.2^{o}C at Eureka, overcast at the South and North camps.

The weather was not suitable for the helicopters to make it to the shot points today and the Aurora flight was cancelled for the day. The CP140 will fly from Iqaluit to Thule today now that it is operational. The seismic crew is on stand by.

At our safety and briefing meeting, we began with a discussion of the risks of wearing outside shoes in the warehouse. When you come back inside, the film of snow melts and produces a friction free surface. Both Thomas and I have been sliding around. Please remove boots and put shoes on.

Thomas will continue interpreting the wide angle data starting at the northern end of the line and working south. Mingzhou prepared a Taurus for deployment today but it will not be used. Due to battery shortages, he will turn it off until needed. Thomas suggested that Patrick's spare batteries for the computer used with the ID tracker may not have been used. Mingzhou will check this possibility out. Jon Biggar needs a laptop with an operating system older than Windows 2000. Mingzhou found one and I asked Dave to pick it up and send it out to camp. Mingzhou has to sort the equipment for air lift, sea lift and recycling, make lists, design, and pack.

After lunch Thomas, Mingzhou and I walked up to Dave's office to get an update on flying activities. Cloud cover prevented any of the helicopters flying today. Then we walked down to the empty explosives magazine in the valley at the end of the runway. Thomas took pictures of them so that I

would have documentation. During the afternoon Julian Sher and Doug Munro filmed the seismic group working on the warehouse preparing the Taurus boxes for shipping and interpreting the wide angle reflections and refractions.

After supper I was surprised to see Greg arrive from the North Camp. Since the seismic reflection system was pulled down quickly he took the first opportunity to fly south. It must have been a grueling month on the camp working 12 hour shifts and having little contact with any one. Unfortunately we were not aware of his flying south and he missed a Twin Otter flight to Resolute by 10 minutes. There are no more plans for flights south until Friday.

Dave Maloley made plans for the CBC duo to fly to the South Camp tomorrow morning. They would have the evening to prepare. Dave also will be available on their return trip for an interview.

During the 2015 Iridium call to South Camp, I verified with Tim that all the shots for the three deployments had been loaded. We are ready. Will the weather cooperate?

Julian Day 112 Monday April 21, 2008

- -29.2 at Eureka, good visibility at the ARTA Camp, Aurora in the air

At breakfast, Dave announced the Aurora was over Alert; it had started to fly without our calling for it, and the helicopters at the ARTA Camp would have to be scrambled. It takes two hours for the helicopter to reach the northern shot point. It also takes about two hours to complete the geobuoy/sonobuoy drop. Although it is a bit confusing this morning, at least the Aurora is in the air and the helicopters can be launched. I hope all the aircraft can rendezvous and the shots are successfully fired into the air drop recorders.

At the safety meeting we were concerned that Greg did not sign out a radio to walk up to the runway. He will be gently reminded as soon as we see him.

The plans for the day are for Mingzhou to continue packing up the instrumentation in the Taurus boxes. The batteries have been removed and put on pallets for shipping south and recycling. The Taurus are bubble-wrapped and being placed in a wooden crate for flying south. The ID trackers have to be removed from the black boxes and put in a crate. The seismometers in the black boxes have to be removed their pins put in them to stabilize them for travel. Isa would like the broadband seismometers back as soon as possible. Mingzhou does not think he can carry them home. Their individual boxes are bound to be tipped sideways destroying the contents. Thomas is still ray-tracing to match the arrivals to develop an earth model. This will be the last computer to be packed up.

By 1100 we expected the geobuoy drop to begin. The communications were not easy. All information was transmitted via the Twin Otter flown by Troy. All of the helicopters were in position to shoot, when we got word that another 8 geobuoys were to be dropped. We waited until about noon. With difficulty, the message that the Aurora was ready was sent out. Tim fired a shot at 1155, Bob at 1200. Just before its shot window, the third helicopter was discovered to have left position and headed toward the western fuel cache. By this time it was 45 minutes from its shot location. The other two helicopters rushed to the mid shot point. Since 407 would arrive first, the 206 was sent back to South Camp to pick up a hydrographer and begin sounding. At 1245 Tim fired the third and last shot for the day. The Aurora was released to fly back to Thule. We learned later that the helicopter that was supposed to be firing the middle distance shot had been sent to do soundings.

Tim's email indicated that only 30% of the geobuoys telemetered data. He thinks the ice was so thin they may have just fallen through. Because the geobuoys are extending a profile we already acquired, there is not much I can do to move the line.

On the call to Jon in the evening, he reported that he had had the best day of sounding ever. He thinks his team is into full swing and that they may be finished by the end of the week. However, he may have to allow several of his pilots rest as they are reaching the maximum number of hours they are allowed to fly in a cycle.

The Aurora will not fly tomorrow, so Thomas and Minghou will go to the South Camp by Twin Otter and transfer to the 407 to pick up the broadband seismometers. Mingzhou has completely packed up the black boxes today. Greg helped him move them out on the loading dock. The loading dock is now so full he cannot put anything out there until the pallets are moved. Tim's message re: geobuoys

> *Hi Ruth,*
>
> *AU03 , 11:55 local, 84 27.379 98 21.236 Tim*
> *AU01 , 12:00 local, 82 35.966 94 04.839 Bob*
> *AU02 , 12:45 local, 83 24.158 94 56.888 Tim*
>
> *All shots were seen by the Aurora, but they were a bit confused by the travel time from Shot 1.*
>
> *The confusion by Helicopter CNG is unexplainable. We were broadcasting everything that was going on up north through the Twin, so I have no idea what they thought they were doing. They found themselves out by the Western cache at shot time, having to refuel.*
>
> *Only 30% of the darts worked. They redeployed 8 spares, but I don't think they picked up another channel.*
>
> *Hopefully tomorrow will yield better results. The weather was perfect over the entire area today.*
>
> *Tim.*

Julian Day 113 Tuesday April 22, 2008

- -29.7° at Eureka, snowing at South and North camps

The weather system in our area of operation in dominated by a low. Thomas and Mingzhou will not be able to pick up the broadband seismometers today. In case the weather prevented the science staff from picking them up, a map and locations are provided for Dave and his people.

At 0900 I talked with Don Mosher who explained that the IcePicks were either falling through the ice because it was too thin or burying themselves in the snow and shorting out the antennae. We decided to let them chose the location for the instruments, moving north or south as required and off line by

several hundred meters. They are down to 28 geobuoys. They will deploy them all on the next run. By tomorrow they will know if more can be sent up. If not, we will fire all charges at a 10 minute interval.

Late in the afternoon, Mike and Jorgen were flown in from the North Camp. The camp has been totally dismantled and cleaned up. Now that Jorgen, Mike, Greg and the two CBC reporters are ready to leave, a Twin Otter has been organized to send them to Resolute tomorrow at 1530.

I was out on the shoreline this afternoon with the reporter, Julian, and his camera man, Doug, who were videotaping me for an UNCLOS special. They also filmed Thomas, Mingzhou and myself walking up to the runway as part of their story.

Thomas has begun picking the arrivals on the cross line and has a model of the earth's crust for the North-South line.

I called Jacob today and updated him on the status of the program. I expect most of the seismic group to be south by Monday. The hydrographers are making great progress and hope to have completed their work by the end of the week, provided the weather cooperates.

Today the Twin Otters were able to fly but the helicopters were grounded. The weather will probably not improve by tomorrow. The Aurora has a mission to fly to the pole so will be in the air at any rate. If by chance the helicopters can fly they will divert to our program. Dave will give them the word whether the geobuoy drop is possible at 0715.

It is invigorating to be collecting data to extend Canada's continental shelf and to learn how effective it has been for Australia. See the news release below.

> ***UN CONFIRMS AUSTRALIA'S RIGHTS OVER EXTRA 2.5 MILLION SQUARE KILOMETRES OF SEABED***
>
> *Minister for Resources and Energy Martin Ferguson today welcomed findings from the United Nations Commission on the Limits of the Continental Shelf in New York confirming Australia's jurisdiction over an additional 2.5 million square kilometres of seabed.*
>
> *The Commission's findings confirm the location of the outer limit of Australia's continental shelf in nine distinct marine regions and Australia's entitlement to large areas of shelf beyond 200 nautical miles.*
>
> *The decision means Australia now has jurisdiction over an extra 2.5 million square kilometres of continental shelf, which is almost five times the size of France, seven times the size of Germany and almost 10 times the size of New Zealand. It gives Australia the rights to what exists on and under the seabed, including:*
>
> *· Oil resources;*
>
> *· Gas resources; and*
>
> *· Biological resources, such micro-organisms, which could be used in medicines.*
>
> *"This is a major boost to Australia's offshore resource potential and also to our ability to preserve the marine environment on the seabed," Minister for Resources and Energy Martin Ferguson said.*

"It demonstrates that Australia's effective engagement in law of the sea matters delivers results. In many respects Australia has also led the way for other countries looking to confirm their continental shelf boundaries through the Commission. The Government will move quickly to proclaim the outer limits of the Australian continental shelf into law on the basis of the recommendations of the Commission."
"The recommendations are further proof of the substantial benefits Australia has derived from ratification of the 1982 Convention on the Law of the Sea by the previous Labor Government. It's also a strong indication of the real and practical benefits of engaging constructively with the United Nations and its agencies."

The Minister praised the contribution of Government officials from Geoscience Australia, the Department of Foreign Affairs and Trade and the Attorney-General's Department in preparing Australia's detailed submission to the Commission.

"This is the culmination of over fifteen years of cutting edge work by a range of Government agencies and I would like to record the Government's recognition of their contribution to this important outcome," said Mr Ferguson.

Julian Day 114 Wednesday April 23, 2008

- -29.4° at Eureka good flying conditions, Aurora in the air

The low dominating our area was pushed away by a series of highs. The Aurora will do the final geobuoy drop today. Tim and the blasters are ready. I asked them to be particularly careful on the last sequence and to concentrate on their task.

There is a possibility the land seismometers will be picked up as well, so Thomas was preparing for the task. He had a number of questions to ask of Dave about the particular activities. Isa called and is concerned that the installation of the long term seismometer is now not working at PEARL because they upgraded internet. Mingzhou's highest priority will be correcting that problem if he can.

The Aurora flight and drops took place in the morning. Eight units were successfully deployed and three shots were fired into them. The ice conditions from the end of the Outer Line to 13 km northward are not suitable for a geobuoy drop so there is a gap in the data here.

Thomas and Mingzhou went on the Twin Otter to pick up the land stations after Mingzhou had corrected the problems with the permanent installation at PEARL related to upgrades in the network.

Greg, Jorgen, and Mike will leave for Resolute on the Twin Otter this afternoon along with 4 other people from other group, the CBC (Julian and Doug), and two from the Damocles group.

The Twin Otter departed after supper to go to South Camp, by which time Thomas and Mingzhou will be back to camp. Then the Twin Otter took them, along with Tim, Bob and Kirby, to the Nansen cache to pick up the boxes and empty drums and then to Eureka.

The Twin Otter with the remaining six of the seismic group will leave for Resolute tomorrow at 14:00.

Julian Day 115 Thursday April 24, 2008

The morning was spent furiously packing and cleaning prior to flying south to Resolute for the rest of the seismic crew: Thomas, Mingzhou, Tim, Bob, Kirby, and Ruth. The Twin Otter left just after lunch and we had a scenic flight to Resolute. In Resolute the wind was blowing and the snow drifting. We borrowed the truck and drove into the hamlet of Resolute and then returned to the PCSP base. The wind was howling and it seemed we had flown North not South. All the power poles are guyed against the winds.

I had the opportunity to talk to Mike Christensen about PCSP role in the UNCLOS project and their worries about the ice conditions in the North for future programs.

Julian Day 116 Friday April 25, 2008

Tim, Thomas, Minzhou, and I flew south to Iqaluit. Bob and Kirby were to fly to the west tomorrow. The winds were still high and we were all pleased that the aircraft left Resolute at 06:60 to fly south. The conditions were not good enough to stop in Nanisivik, so we arrived early in Iqaluit. In Iqualuit we met Rene Forsberg headed North for his gravity survey. His aircraft did not leave that day because weather conditions had worsened in Resolute. Thomas had to wait for his connecting flight. Mingzhou, Tim, and I flew south. The three of us were home that day.

3. Weekly Reports

March 31- April 6, 2008 Weekly message from ARTA field project
Refraction program: The weather has been clear, cold (-30°C range), sunny, and stable. With limited fixed wing aircraft support, Dave Maloley positioned the fuel and explosives on the ice so that we could start the Inner Line. On Tuesday in the early afternoon., we began drilling and loading 11 shots. By noon the next day, the charges were loaded and the seismic recorders were flown to the ice for deployment. The recorders were positioned by noon the following day. Four teams fired the 11 shots between 1340 and 1510, i.e. within 1.5 hours. The test showed that the new blasting boxes are reliable, which is a vast improvement over previous years. The instruments were picked up and the line completed on Thursday. The Inner Line required 11 shots, fired to 115 instruments, taking a total of 2.5 days. High quality data were recorded on 114 of the recorders.

With the additional support of the Skyvan, a small cargo aircraft, and a second Twin Otter, fuel and explosives were placed strategically on the sea ice for the refraction and hydrographic programs. The fuel and explosive caching for the Outer Line was accomplished on Friday. On Saturday, 11 charges on the outer line were loaded. Cloudy conditions Sunday on the ice delayed the deployment of the seismic recorders until afternoon; this step is just underway.

General Notes (RUTH?)

- The South Camp is operational, runway maintenance/construction continues and sounding/gravity and seismic program started, good weather
- Mar 31 Monday – Twin Otter loads with explosives and fuel for seismic ops, HF radio and Iridium phone/email working, constructed 12 by 28 shelter for the two cooks, our second skidoo operating now, Cat generator transported by Twin Otter late evening, damage to generator on loading, propane gas regulators for cook stove and grill are unserviceable
- April 1 Tuesday – Twin Otter load with equipment and skid for snow melter, Cat generator running, started seismic program today, 3 helicopters now at camp, safety and protocol meeting that evening
- April 2 Wednesday – Twin Otter in with seismic geophones and equipment, seismic ops continue for inner line, water filtering system operational, parts for Bobcat and Herman Nelson arrive
- April 3 Thursday – seismic ops continue, 2 CHS helicopters arrive in camp, two Grise Fiord Inuit arrive for wildlife monitors, Skyvan started shuttling fuel to camp, Bobcat operating again
- April 4 Friday – Skyvan shuttling fuel all day, Bell 407 helicopter to pick up North Pole walker Ben Saunders north of Ward Hunt Island, helicopters being outfitted for sounding ops
- April 5 Saturday – Skyvan shuttling fuel, CHS sounding/gravity program started, problems acquiring soundings due to multiyear ice, deep snow and frozen slush layer on ice
- April 6 Sunday – Skyvan shuttling people and fuel, slow start for CHS sounding ops, sounding equipment to cold to operate, seismic team on standby because of weather to deploying geophones for outer line

Plans: Skyvan continues shuttling fuel for ops, sounding/seismic program continues, camp and runway maintenance and good flying weather

Reflection Camp (North Camp): The seismic reflection system began operating at 10:00 on Saturday.

Data has been sent to the base at Eureka Base for vetting.

Fuel status: At Eureka there are 464 full fuel drums, on the ice 140 full fuel drums. It will require an estimated 300 drums to clean up the South and North Camp sites at the end of the program. To date we have used 260 hours of Twin Otter time that consumed 455 drums of fuel. This inventory indicates the need to purchase more fuel.

April 7-13, 2008 Weekly message from ARTA field project

Refraction program: By Sunday afternoon April 7 the seismic recorders were all on the ice along the Outer line. The firing of the charges took place in a 3 hour window. It took longer than on the first line due to ice drift of about 2 km that made the shot locations more difficult to find. By the end of the day the first 20 recorders had been retrieved. Blowing snow and the availability of only two helicopters slowed the pick up of the Taurus seismometers. They were back at Eureka base on Wednesday where the data were examined. All 115 instruments recorded data.
The data are of good quality and readily interpretable except near regions where ice motion is taking place. Unfortunately, shot number 6 was a partial detonation and did not produce arrivals. The Primacord has low tensile strength and sticks to itself when it is spooled.

On Thursday fuel and explosive caching began for the Cross Line. Operations were stopped on Friday because ice fog generated by open water in many leads made it unsuitable for flying in the helicopters The ice fog cleared by noon on Saturday and the 9 holes on Cross Line were loaded. The loading was slower than on the other lines because the 407 helicopter is not operational. The 206 helicopters can only carry 14 charges at a time and this necessitated many trips from the cache to the line. On Sunday morning the deployment of the instruments along the Cross Line began but with only 2 helicopters. The spare part for the 407 was delivered to the South Camp this morning and the 407 was put to use.

Reflection Program: During the week the seismic reflection system ran continuous except for a few hours for a compression shut down. The track length is 8.5 km. The reflection profile shows about half a second of transparent stratified sediments overlying a well-defined basement arrival with hints of dipping internal reflections. The hole for the airgun is enlarging due to the bubble and warming temperature. This may require the tent the airgun is in to be moved.

Hydrographic program highlights: South Camp running, runway maintenance/construction continues, sounding/gravity and seismic program continues, Bell 407 helicopter non operational waiting for parts, good weather with the exception of one day

South Camp: Weekly Summary: April 7 to 13
April 7 Monday – Skyvan shuttling people and fuel and Twin Otter caching fuel for helicopters, one CHS helicopter lent to NRCan for the day to complete outer seismic line, electronic equipment removed from helicopter for operations, shower construction continues, different scenarios tried to eliminate noise on the HF radio, spot sounding/gravity ops with hydrographers Knut and Mike, late night helicopters returned to camp at 21:30
April 8 Tuesday – Skyvan shuttling people and fuel, CHS helicopters spot sounding/gravity ops, one helicopter returned to camp with oil leak, repaired and back out, NRCan helicopters retrieving the seismometers on outer line, late night helicopters return to camp at 23:50
April 9 Wednesday – CHS helicopters spot sounding/gravity ops, Twin Otter recovering seismometers, problems again with propane regulators and shower unit, Tom and Randy our wild life

monitors out on patrol by skidoo, observed the Rangers skidoo tracks, bear tracks and Muskox on shore, one helicopter to Eureka for regular maintenance
April 10 Thursday – CHS helicopters spot sounding, weather turned, fog moved into survey area, one helicopter encountered ice on blades, both helicopters return to camp, seismic operations started but turned back because of weather, helicopter sent for maintenance returned to camp from Eureka after 300 hour check
April 11 Friday –standby for weather, fog, camp chores, oil changed on both generators, camp shower is working
April 12 Saturday – waiting for weather to clear, fog, Twin Otter in with fuel, 2 personnel out, survey operations started after lunch, CHS helicopters spot soundings, NRCan helicopters drilling and loading holes on cross line, changed CDGPS beam from West Central to East Central and started receiving GPS corrections, late night last helicopter in camp at 22:30
April 13 Sunday – Skyvan shuttling people, fuel and food, standby for better weather in AM, CHS helicopter to Eureka for regular maintenance, 300 hour service, other CHS helicopter spot sounding/gravity ops, parts for Bell 407 helicopter arrive/installed and working, rotation of helicopter pilots, NRCan helicopters deploying seismometers on cross line

Plans: Skyvan shuttling fuel/camp items for ops, sounding/gravity/seismic program continues, if good weather continues the NRCan team could complete their initial program by midweek, camp and runway maintenance and good flying weather

April 14-April 20 Weekly message from ARTA field project

Refraction program: On April 14, nine shots were fired into 114 recorders, unfortunately there were 3 were partial detonations. This was deemed due to the quality of the Primacord in the original order. Primacord from DynaNobel was used to detonate the 3 reloaded holes so the Cross Line was successfully completed with 11 shots. The charge sizes were reduced to 122.5 kg from 175 kg to conserve explosives for the geobuoy drop. There was sufficient energy to record arrivals over the entire 174 km length of the line. The data are of good quality except in locations where the ice was moving. On the sections degraded by noise, the arrivals can be traced through significant portions so the data are readily interpretable. All data from the three profiles have been processed and the modelling has started.

On April 19 the CP140 left Greenwood for Thule. It made it as far as Iqaluit where it had mechanical problems. A second Aurora brought parts front the south and the first was ready to fly on Sunday morning. Unfortunately, on April 20 there was considerable cloud cover at the northern end of the refraction line so the geobuoy drop was postponed. At present the Aurora is in Thule with a fan problem in the cockpit.

Reflection program: The airgun system fired continuously for the week. On the night of April 19 the system was shut down. The camp has been dismantled, the majority of the gear will be back in Eureka by Sunday evening.

Julian Sher has begun his documentary on the wide angle reflection/refraction component of the UNCLOS program.

Highlights of the hydrographic program: Natural Resources Canada (NRCan) Minister Gary Lunn visits camp, "Out in the Cold" production company visits camp to film operations, sounding/gravity and seismic program continues, 136 spot soundings (345 to date) and 58 gravity stations (168 to date)

April 14 Monday – Skyvan shuttling people and fuel, helicopter pilot rotation, weather delay in AM,

single CHS helicopter spot sounding/gravity ops, seismic team fire ARTA cross line explosives, and three stations misfire

April 15 Tuesday – weather delay in AM, 2 CHS helicopters spot sounding/gravity ops, seismic team reloading 3 holes and firing, recovering seismometers, helicopters return to camp at 11PM

April 16 Wednesday – 2 CHS helicopters spot sounding/gravity ops, one helicopter returned to camp with computer problems, repair and out working, seismic team departs camp for Eureka second CHS helicopter with computer returns to camp, NRCan Minister Gary Lunn and associates arrive at camp 10PM, media greet and meet, departed midnight for Eureka

April 17 Thursday – 4 CHS helicopters spot sounding/gravity ops, completed outer seismic line wildlife monitors perform snowmobile patrol of area

April 18 Friday – weather day, fog and low ceiling, tried testing the XSVP system (expendable sound velocity probes) and the only Windows 2000 computer in camp failed which is the only computer the system will communicate with, not a total loss: the boys tried jigging for cod in freshly drilled hole

April 19 Saturday – weather delay in AM, 3 CHS helicopters spot sounding/gravity ops working on ARTA cross line, helicopter pilot rotation, "Out in the Cold" production company visits camp for the day to film operations

April 20 Sunday – weather day, camp duties, Twin Otter fuel caching from camp

Plans: Sounding/gravity/seismic program continues, the NRCan team will complete their program by midweek, camp and runway maintenance and start the process of camp demobilization

Table 3.1: Refraction Program Calendar

Monday						Sunday
March				21 Halifax- Edmonton	22 Edmonton Eureka	23 unpack
24 set up	25 set up	26 broadband seismo	27 broadband seismo	28 deploy Test L	29 shoot retrieve	30 fuel caching
31 explosive caching	**April** 1 Loading charges Inner L	2 load deploy	3 deploy blast pick up	4 fuel explosive caching	5 load OuterL	6 deploy
7 deploy shoot pick up	8 blowing snow pick up	9 flying boxes to Eureka	10 explosive fuel caching	11 ice fog	12 load XLine	13 deploy
14 detonated 9 shots 3 partials	15 3 shots recover recorders X Line completed	16 Minister's visit	17 John, Isa, Patrick, Lloyd, Ron, leave	18 no flying for helo	19 loading charges packing	20 cloudy no CP140 flight modeling
21 Aurora in air	22	23	24	25	26	27

4. Participants

NRCan

Gary Lunn
Minister – NRCan
visitor

Jacob Verhoef
Director – UNCLOS
visitor

Jacob's Truck
Ford F-350
visitor

Ruth Jackson
ARTA Scientific Advisor
Mar 22 – Apr 25

Isa Asudeh
Seismic Instruments
Mar 22 – Apr 17

John Shimeld
Instrument Deployment
Mar 22 – Apr 17

Patrick Potter
Instrument Deployment
Mar 22 – Apr 17

Alain Belzile
Gravimetry
Mar 22 – Apr 30

Tim Cartwright
Blaster
Mar 22 – Apr 25

Thomas Funck
Instrument Deployment
Mar 22 – Apr 25

Mingzhou Li
Seismic Instruments
Mar 22 – Apr 25

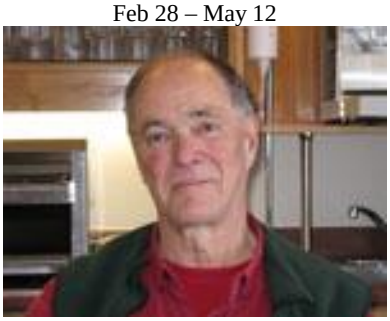
Greg Middleton
North Camp Tech.
Mar 22 – Apr 25

CONTRACTORS

Dave Maloley
Head – Logistics
Feb 28 – May 12

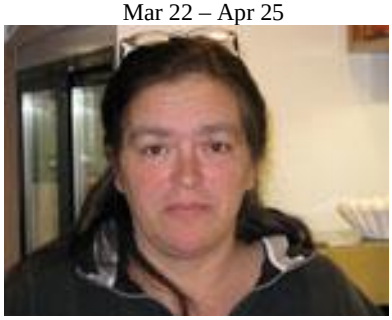
Bob Olsen
Blaster
Mar 22 – Apr 25

Kirby Kleiter
Blaster
Mar 22 – Apr 25



Ron Verrall
Ice Expert
Mar 22 – Apr 17

Lloyd Litwin
Blaster
Mar 22 – Apr 17

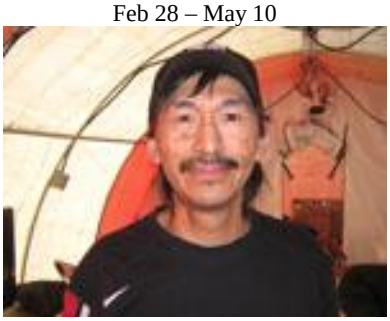


Tammy Stinson
South Camp Cook
Mar 3 - ???

Doug Briscoe
ARTA Logistics Support
Feb 28 – May 10

Shawn Swire
ARTA Logistics Support
Feb 28 – May 15

Joanne Edwards
South Camp Cook
Mar 10 – Apr 30



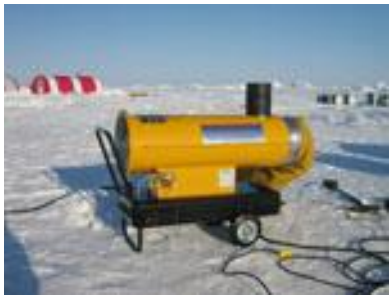
Tom Kiguktak
Wildlife Monitor
Apr 3 – May 10

Randy Pijamini
Wildlife Monitor
Apr 3 – May 10

Cassie Bluhm
Cook
???

Mike Gorveatt
Reflection Seismics
Mar 6 – May 1

Jorgen Skafte
North Camp Chief
Mar 6 – Apr 26



Herman Nelson
Thermal Facilitator

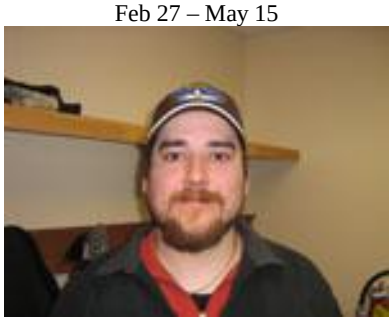
CHS

John Mercuri
Hydrographer
Feb 27 – May 15

Jon Biggar
Hydrographic Chief
Feb 27 – May 15

Mike Black
Hydrographer
Feb 27 – May 15

Knut Lyngberg
Hydrographer
Feb 27 – May 15



Rob Morrison
Hydrographer
Feb 27 – May 15

Rudy Cutillo
Electronics Technician
Feb 27 – May 15

EUREKA STAFF

Andre Bouchard
Eureka Station SAO

Al Gaudet
Eureka Station SPM

Jane Fonger
Eureka Station MetTech

Bill Bristow
Eureka Station MDG

Mike MacNeil
Eureka Station HEO

Kelly Spokes
Eureka Station MetTech

Daryl McLaughlin
Eureka Station Cook

Donna White
Eureka Handy Person

Ken Asmus
ARTA Weather/Ice Support
Mar 6 – Mar 26

CANDAC STAFF

Oleg Mikhailov
CANDAC – U. of T.

Matt Okraszewski
CANDAC – U. of T.

Rebecca Batchelor
ACE – U. of T.

PILOTS/ENGINEERS

Russ Hepburn
Twin Otter Pilot

Wayne Waldner
Twin Otter Pilot

Brent Meldrum
Twin Otter Co-Pilot

Wes Cruickshank
Twin Otter Mechanic

Joe Persicone
Twin Otter Co-Pilot

Paul Rask
Twin Otter Pilot

Jason Preston
Twin Otter Co-Pilot

Troy McKerral
Twin Otter Pilot

Steve Martyniuk
Twin Otter Mechanic

Orin Durey
Helicopter Pilot

Gerard Hartery
Helicopter Pilot

John Inis
Helicopter Pilot

Jake Doyle
Helicopter Engineer

Keith Bauld
Helicopter Engineer

Steve McGreer
Helicopter Pilot

Jim Barry
Helicopter Pilot

Dave Evans
Helicopter Engineer

Jim Watson
Helicopter Pilot

Shanne Kochan
Helcopter Pilot

Steve Lodge
Helcopter Pilot

5. Refraction and Teleseismic Instrument Report

A set of 119 Taurus instruments were shipped for ARTA project. Of these, 116 were intended for refraction deployments and 3 for teleseismic sites. The teleseismic instruments were deployed in large containers with several layers of insulation, six battery packs, ice packs and a heating element connected to a solar panel. Guralp 40T broadband seismometers were installed at all three sites.

Each of the 116 refraction Taurus units were housed in a new cooler box with improved design from LORITA, along with 8 ice packs, two battery packs, a GPS tracker and a pouch for an L4 geophone. Each had a unique ID printed on the outside in large letters. This ID was, in fact, the last three digits of the static IP that was assigned to each Taurus. A full list of cooler box ID, Taurus SN, IP and geophone SN is given in Table 5.1.

Table 5.1 - List of ARTA Taurus Cooler instrument boxes

Cooler ID	Taurus SN	IP	Geophone SN	Comments
101	562	192.168.0.101	5085	
102	410	192.168.0.102	7144	
103	422	192.168.0.103	7109	
104	420	192.168.0.104	9299	
105	536	192.168.0.105	7085	
106	540	192.168.0.106	9301	
107	421	192.168.0.107	6784	
108	484	192.168.0.108	5077	
109	411	192.168.0.109	7175	
110	544	192.168.0.110	9296	
111	560	192.168.0.111	7198	
112	553	192.168.0.112	7125	
113	542	192.168.0.113	7118	
114	475	192.168.0.114	8518	
115	477	192.168.0.115	8502	
116	480	192.168.0.116	7028	
117	524	192.168.0.117	5088	
118	458	192.168.0.118	7171	
119	481	192.168.0.119	5087	
120	541	192.168.0.120	8509	
121	549	192.168.0.121	7148	
122	565	192.168.0.122	6786	
123	543	192.168.0.123	7086	
124	408	192.168.0.124	7160	
125	550	192.168.0.125	9293	
126	567	192.168.0.126	7083	
127	535	192.168.0.127	8496	
128	570	192.168.0.128	5817	
129	399	192.168.0.129	7106	
130	569	192.168.0.130	8495	
131	527	192.168.0.131	7071	
132	449	192.168.0.132	7158	
133	445	192.168.0.133	9292	
134	443	192.168.0.134	7127	
135	456	192.168.0.135	8519	
136	454	192.168.0.136	7166	
137	452	192.168.0.137	7076	
138	453	192.168.0.138	8567	

139	442	192.168.0.139	7189	
140	451	192.168.0.140	7079	
141	455	192.168.0.141	7088	
142	573	192.168.0.142	7157	
143	499	192.168.0.143	7159	
144	752	192.168.0.144	7203	
145	431	192.168.0.145	7161	
146	428	192.168.0.146	8517	
147	429	192.168.0.147	7137	
148	489	192.168.0.148	7078	
149	820	192.168.0.149	7119	
150	471	192.168.0.150	7172	
151	380	192.168.0.151	7111	
152	381	192.168.0.152	7151	
153	393	192.168.0.153	7087	
154	394	192.168.0.154	7126	
155	416	192.168.0.155	5080	
156	419	192.168.0.156	7188	
157	423	192.168.0.157	7094	
158	424	192.168.0.158	8505	
159	435	192.168.0.159	7154	
160	437	192.168.0.160	7101	
161	404	192.168.0.161	7100	
162	465	192.168.0.162	8568	
163	466	192.168.0.163	7104	
164	469	192.168.0.164	7120	
165	470	192.168.0.165	7185	
166	457	192.168.0.166	7179	
167	473	192.168.0.167	7080	
168	490	192.168.0.168	7173	
169	496	192.168.0.169	7108	
170	526	192.168.0.170	7135	
171	305	192.168.0.171	7116	
172	427	192.168.0.172	7132	
173	525	192.168.0.173	7184	
174	529	192.168.0.174	7174	
175	530	192.168.0.175	7121	
176	531	192.168.0.176	5084	
177	533	192.168.0.177	9287	
178	538	192.168.0.178	6785	
179	551	192.168.0.179	8494	
180	555	192.168.0.180	8572	
181	151	192.168.0.181	5081	
182	198	192.168.0.182	6787	
183	109	192.168.0.183	7098	
184	203	192.168.0.184	7123	
185	209	192.168.0.185	7168	
186	210	192.168.0.186	8497	
187	447	192.168.0.187	7114	
188	572	192.168.0.188	7192	
189	204	192.168.0.189	7128	
190	1123	192.168.0.190	7176	
191	214	192.168.0.191	9288	
192	215	192.168.0.192	8500	
193	218	192.168.0.193	8570	
194	219	192.168.0.194	8504	
195	239	192.168.0.195	7156	
196	240	192.168.0.196	7105	
197	242	192.168.0.197	5072	
198	247	192.168.0.198	5820	

199	249	192.168.0.199	6590	
200	252	192.168.0.200	7130	
201	254	192.168.0.201	7205	
202	253	192.168.0.202	6779	
203	256	192.168.0.203	7107	
204	258	192.168.0.204	5813	
205	260	192.168.0.205	8569	
206	262	192.168.0.206	7206	
207	268	192.168.0.207	7180	
208	407	192.168.0.208	5821	
209	482	192.168.0.209	7133	
210	486	192.168.0.210	5075	
211	430	192.168.0.211		Never deployed (damaged in shipping).
212	444	192.168.0.212	7170	
213	468	192.168.0.213	7187	Failed once
214	537	192.168.0.214	7096	
215	539	192.168.0.215	7134	
216	561	192.168.0.216	8498	Installed at PEARL before last deployment
220	558	192.168.0.220		Teleseismic
221	559	192.168.0.221		Teleseismic
222	563	192.168.0.222		Teleseismic

Instrument Quality Check

Prior to each deployment, all Taurus instruments were connected to a Local Area Network (LAN) and key configuration details were checked. All refraction Taurus instruments needed to be in Buffered Mode to preserve power, at sample rate of 100 samples per second, with many days or recording available on Flash Cards and GPS engine working properly. Example of this quality control is shown in Figure 5.1.

Data Delivery

One of the 116 Taurus instruments (Cooler ID 211, Instrument SN 430) was damaged in shipment and was not deployed. The remaining 115 were used in the test and main deployments, as summarized in Table 5.2. The data recovery rate for ARTA was a tremendous 99.74 per cent as only one of the 377 deployments failed to record due to fact that the Taurus instrument was shaken to destruction during the transportation phase of the deployment.

Table 5.2. ARTA Deployment statistics. Only one out of 377 deployments of instrument cooler box failed to record, a %99.74 success rate.

Deployment	# of coolers Deployed	Data Recovered	Data Loss	Comments
Test	30	30		
Dep1	115	114	Cooler 213 Instrument SN 468	Flash Card device door opened due to shaking during transportation, media disconnected.
Dep2	115	115		
Dep3	114	114		Instrument SN 561, from cooler 216 was installed at PEARL observatory
Teleseismic	3	3		Recorded March 26 - April 24, 2008
Total	377	376	%0.26	

For the teleseismic deployment, one of the three Taurus units was programmed at 20 samples per second and

the other two at 50. Details of teleseismic configuration are given in Table 5.3.

Table 5.3 - ARTA Teleseismic Deployments

Site Name	Location	Bo ID	Taurus SN	Sample Rate	Input Impedance	Gain	DC Filter	Sensor	Comments
LR1	81.127232N 89.809192W 232m	220	558	50	Low	1.0	No	40T	
LR3	81.48492N 91.630296W 19m	221	559	50	Low	1.0	No	40T	
LR2	81.343136N 93.27968W 194m	222	563	20	Low	1.0	No	40T	1 GB Flash Card

Minor GPS problem

While the test deployment and deployments 2 and 3 did not have any bad GPS during the blasting sequence, there was a GPS problem due to a faulty GPS antenna during deployment 1. As a result, both location and time for six shots listed in table 5.4 were not precise. However, examination of data prior to these shots shows that the location of the Taurus instrument did not change during this time. This antenna was fixed prior to next deployment, see data quality check shown in Figure 5.2.

Table 5.4 - Correct GPS positions were not available for the following traces for deployment 1 due to a bad GPS antenna. However, the correct GPS fixes taken between 2008-04-03 at 17:00:37Z and 2008-04-03 at 17:46:37Z, show location at 82.484216N 93.897776W that did not change during the blasting sequence.
Reference files: dep1.sorted.hdr and Taurus529-ID174-GPSTime-2008-04-03-17-00-00.csv.

Deployment	Raw SEGY File Name	Cooler Box ID	Taurus	GPS Mode
Dep1	_20080403_191950.sgy	174	529	Free Running
Dep1	_20080403_192950.sgy	174	529	Free Running
Dep1	_20080403_193450.sgy	174	529	Free Running
Dep1	_20080403_193950.sgy	174	529	Free Running
Dep1	_20080403_190450.sgy	174	529	Free Running
Dep1	_20080403_200950.sgy	174	529	Free Running

Data Store Files

During the ARTA deployments, a single Flash Card was used for each Taurus instrument. After each deployment, the data on each card were stored and secured on a server hard disk. The essential data for each Taurus are stored in a proprietary Nanometrics format called the Store files. Store files for each deployment were archived. Particularly, Store files for the last deployment, deployment three, are the most complete as they contain all data for all deployments. These files are archived, in several copies. A full list of these files is given in Table 5.5. In addition to waveform data, for example in SEGY format, state of health (SOH), configuration and other data can be retrieved from the Store files.

Table 5.5 - List of ARTA Store files. Each file contains all data (waveform, configuration and State of Health) recorded during test and main deployments from start to the end of the survey (March 28 to April 17, 2008), see Figure 5.3 for an example of data availability. Last 3 lines show Teleseismic data Stores.

Date	Time	Size (bytes)	Taurus Store File
2008-04-16	22:30	206,569,508	taurus_0109_001.store
2008-04-16	22:30	203,423,780	taurus_0151_001.store
2008-04-16	22:30	216,006,692	taurus_0198_001.store
2008-04-16	22:30	199,229,476	taurus_0203_001.store
2008-04-16	22:30	208,666,660	taurus_0204_001.store
2008-04-16	22:30	212,860,964	taurus_0209_001.store
2008-04-16	22:31	219,152,420	taurus_0210_001.store
2008-04-16	22:31	204,472,356	taurus_0214_001.store

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2008-04-16      22:31    207,618,084        taurus_0215_001.store
2008-04-16      22:31    202,375,204        taurus_0218_001.store
2008-04-16      22:31    220,200,996        taurus_0219_001.store
2008-04-16      22:31    212,860,964        taurus_0239_001.store
2008-04-16      22:32    201,326,628        taurus_0240_001.store
2008-04-16      22:32    204,472,356        taurus_0242_001.store
2008-04-16      22:32    205,520,932        taurus_0247_001.store
2008-04-16      22:32    201,326,628        taurus_0249_001.store
2008-04-16      22:32    223,346,724        taurus_0252_001.store
2008-04-16      22:32    205,520,932        taurus_0253_001.store
2008-04-16      22:32    203,423,780        taurus_0254_001.store
2008-04-16      22:33    220,200,996        taurus_0256_001.store
2008-04-16      22:33    213,909,540        taurus_0258_001.store
2008-04-16      22:33    223,346,724        taurus_0260_001.store
2008-04-16      22:33    238,026,788        taurus_0262_001.store
2008-04-16      22:33    204,472,356        taurus_0268_001.store
2008-04-16      21:58    229,638,180        taurus_0305_001.store
2008-04-16      21:58    214,958,116        taurus_0380_001.store
2008-04-16      21:58    209,715,236        taurus_0381_001.store
2008-04-16      21:58    211,812,388        taurus_0393_001.store
2008-04-16      21:58    214,958,116        taurus_0394_001.store
2008-04-16      21:58    239,075,364        taurus_0399_001.store
2008-04-16      21:58    203,423,780        taurus_0404_001.store
2008-04-16      22:34    250,609,700        taurus_0407_001.store
2008-04-16      21:59    253,755,428        taurus_0408_001.store
2008-04-16      21:59    244,318,244        taurus_0410_001.store
2008-04-16      21:59    247,463,972        taurus_0411_001.store
2008-04-16      21:59    213,909,540        taurus_0416_001.store
2008-04-16      21:59    228,589,604        taurus_0419_001.store
2008-04-16      22:00    242,221,092        taurus_0420_001.store
2008-04-16      22:00    244,318,244        taurus_0421_001.store
2008-04-16      22:00    254,804,004        taurus_0422_001.store
2008-04-16      22:00    205,520,932        taurus_0423_001.store
2008-04-16      22:00    208,666,660        taurus_0424_001.store
2008-04-16      22:00    205,520,932        taurus_0427_001.store
2008-04-16      22:01    220,200,996        taurus_0428_001.store
2008-04-16      22:01    213,909,540        taurus_0429_001.store
2008-04-16      22:01    239,075,364        taurus_0431_001.store
2008-04-16      22:01    209,715,236        taurus_0435_001.store
2008-04-16      22:01    205,520,932        taurus_0437_001.store
2008-04-16      22:01    210,763,812        taurus_0442_001.store
2008-04-16      22:02    222,298,148        taurus_0443_001.store
2008-04-16      22:34    204,472,356        taurus_0444_001.store
2008-04-16      22:02    212,860,964        taurus_0445_001.store
2008-04-16      22:34    203,423,780        taurus_0447_001.store
2008-04-16      22:02    229,638,180        taurus_0449_001.store
2008-04-16      22:02    216,006,692        taurus_0451_001.store
2008-04-16      22:02    218,103,844        taurus_0452_001.store
2008-04-16      22:02    220,200,996        taurus_0453_001.store
2008-04-16      22:03    233,832,484        taurus_0454_001.store
2008-04-16      22:03    210,763,812        taurus_0455_001.store
2008-04-16      22:03    292,552,740        taurus_0456_001.store
2008-04-16      22:03    230,686,756        taurus_0457_001.store
2008-04-16      22:03    286,261,284        taurus_0458_001.store
2008-04-16      22:04    201,326,628        taurus_0465_001.store
2008-04-16      22:04    220,200,996        taurus_0466_001.store
2008-04-16      22:34    177,209,380        taurus_0468_001.store
2008-04-16      22:04    204,472,356        taurus_0469_001.store
2008-04-16      22:04    207,618,084        taurus_0470_001.store
2008-04-16      22:04    209,715,236        taurus_0471_001.store
2008-04-16      22:04    202,375,204        taurus_0473_001.store
2008-04-16      22:05    304,087,076        taurus_0475_001.store
2008-04-16      22:05    313,524,260        taurus_0477_001.store
2008-04-16      22:05    248,512,548        taurus_0480_001.store
2008-04-16      22:05    274,726,948        taurus_0481_001.store
2008-04-16      22:34    261,095,460        taurus_0482_001.store
2008-04-16      22:06    319,815,716        taurus_0484_001.store
```

2008-04-16	22:34	241,172,516	taurus_0486_001.store
2008-04-16	22:06	239,075,364	taurus_0489_001.store
2008-04-16	22:06	208,666,660	taurus_0490_001.store
2008-04-16	22:06	250,609,700	taurus_0496_001.store
2008-04-16	22:07	406,847,524	taurus_0499_001.store
2008-04-16	22:07	254,804,004	taurus_0524_001.store
2008-04-16	22:07	397,410,340	taurus_0525_001.store
2008-04-16	22:07	220,200,996	taurus_0526_001.store
2008-04-16	22:07	214,958,116	taurus_0527_001.store
2008-04-16	22:08	451,936,292	taurus_0529_001.store
2008-04-16	22:08	270,532,644	taurus_0530_001.store
2008-04-16	22:08	219,152,420	taurus_0531_001.store
2008-04-16	22:08	216,006,692	taurus_0533_001.store
2008-04-16	22:08	250,609,700	taurus_0535_001.store
2008-04-16	22:09	364,904,484	taurus_0536_001.store
2008-04-16	22:35	310,378,532	taurus_0537_001.store
2008-04-16	22:09	342,884,388	taurus_0538_001.store
2008-04-16	22:35	203,423,780	taurus_0539_001.store
2008-04-16	22:09	312,475,684	taurus_0540_001.store
2008-04-16	22:10	262,144,036	taurus_0541_001.store
2008-04-16	22:10	257,949,732	taurus_0542_001.store
2008-04-16	22:10	247,463,972	taurus_0543_001.store
2008-04-16	22:10	339,738,660	taurus_0544_001.store
2008-04-16	22:10	309,329,956	taurus_0549_001.store
2008-04-16	22:11	251,658,276	taurus_0550_001.store
2008-04-16	22:11	295,698,468	taurus_0551_001.store
2008-04-16	22:11	306,184,228	taurus_0553_001.store
2008-04-16	22:11	386,924,580	taurus_0555_001.store
2008-04-16	22:12	284,164,132	taurus_0560_001.store
2008-04-16	22:12	247,726,116	taurus_0562_001.store
2008-04-16	22:12	249,561,124	taurus_0565_001.store
2008-04-16	22:12	264,241,188	taurus_0567_001.store
2008-04-16	22:12	247,463,972	taurus_0569_001.store
2008-04-16	22:13	292,552,740	taurus_0570_001.store
2008-04-16	22:35	210,763,812	taurus_0572_001.store
2008-04-16	22:13	213,909,540	taurus_0573_001.store
2008-04-16	22:13	216,006,692	taurus_0752_001.store
2008-04-16	22:13	213,909,540	taurus_0820_001.store
2008-04-16	22:35	213,909,540	taurus_1123_001.store
2008-05-20	09:48	568,328,228	taurus_0558_001.store
2008-05-20	09:44	610,271,268	taurus_0559_001.store
2008-05-20	12:07	315,621,412	taurus_0563_001.store

Generation of SEGY files

After instruments were returned to staging area from each deployment, they were all connected to the LAN. On return from the arctic field, the ice packs were normally frozen and instrument temperatures were below zero Celsius. Once the instruments warmed up to temperatures well above zero, the web server on each instrument were turned on. A new Nanometrics Inc. software package, called Apollo Project (AP), was installed on the Linux server. The AP has a unique and useful feature called the Discovery. Once Discovery is configured and activated, the software can "sense" all Taurus units that are connected to the LAN and automatically connect to their server, ready to retrieve data. Other than the routine configuration items, such as location of output files, the AP software needs to know the time of each shot for each deployment. After each deployment, the shot times were input to the AP software and it was instructed to create SEGY files from 10 seconds before shot time to 140 seconds after. In a couple of minutes, all SEGY files were generated and written to storage media.

Table 5.6 - ARTA SEGY file list, all created from 10 seconds before to 140 seconds after each shot.

Deployment	File Date	File Time	File Size, bytes	SEGY file name
Test	13-04-2008	16:58	1,127,040	_20080329_162450.sgy
Test	13-04-2008	16:58	1,127,040	_20080329_165950.sgy

Test	13-04-2008	16:58	1,127,040	_20080329_170550.sgy
Dep1	13-04-2008	16:58	6,870,960	_20080403_182450.sgy
Dep1	13-04-2008	16:58	6,870,960	_20080403_183950.sgy
Dep1	13-04-2008	16:58	6,870,960	_20080403_184450.sgy
Dep1	13-04-2008	16:58	6,870,960	_20080403_184950.sgy
Dep1	13-04-2008	16:58	6,870,960	_20080403_185450.sgy
Dep1	13-04-2008	16:58	6,870,960	_20080403_190450.sgy
Dep1	13-04-2008	16:58	6,870,960	_20080403_191950.sgy
Dep1	13-04-2008	16:58	6,870,960	_20080403_192950.sgy
Dep1	13-04-2008	16:58	6,870,960	_20080403_193450.sgy
Dep1	13-04-2008	16:58	6,870,960	_20080403_193950.sgy
Dep1	13-04-2008	16:58	6,870,960	_20080403_200950.sgy
Dep2	13-04-2008	16:58	6,931,200	_20080407_210450.sgy
Dep2	13-04-2008	16:58	6,931,200	_20080407_211450.sgy
Dep2	13-04-2008	16:58	6,931,200	_20080407_214450.sgy
Dep2	13-04-2008	16:58	6,931,200	_20080407_214950.sgy
Dep2	13-04-2008	16:58	6,931,200	_20080407_221450.sgy
Dep2	13-04-2008	16:58	6,931,200	_20080407_222450.sgy
Dep2	13-04-2008	16:58	6,931,200	_20080407_223450.sgy
Dep2	13-04-2008	16:58	6,931,200	_20080407_225950.sgy
Dep2	13-04-2008	16:58	6,931,200	_20080407_231950.sgy
Dep2	13-04-2008	16:58	6,931,200	_20080407_234450.sgy
Dep2	13-04-2008	16:58	6,931,200	_20080408_000950.sgy
Dep3	16-04-2008	20:09	6,870,960	_20080414_175950.sgy
Dep3	16-04-2008	20:09	6,870,960	_20080414_182950.sgy
Dep3	16-04-2008	20:08	6,870,960	_20080414_185950.sgy
Dep3	16-04-2008	20:08	6,870,960	_20080414_192450.sgy
Dep3	16-04-2008	20:08	6,870,960	_20080414_193450.sgy
Dep3	16-04-2008	20:09	6,870,960	_20080414_195450.sgy
Dep3	16-04-2008	20:08	6,870,960	_20080414_200450.sgy
Dep3	16-04-2008	20:05	6,870,960	_20080414_202450.sgy
Dep3	16-04-2008	20:05	6,870,960	_20080414_203450.sgy
Dep3	16-04-2008	20:05	6,870,960	_20080415_194450.sgy
Dep3	16-04-2008	20:05	6,870,960	_20080415_201050.sgy
Dep3	16-04-2008	20:05	6,870,960	_20080415_204950.sgy

SEGY headers and instrument location data

ARTA refraction survey, like LORITA and others, was unique since the recording instruments were place on moving sea ice. As a result, it was essential to know the exact location of each instrument at the time each shot was detonated. The Taurus instrument deploys a GPS engine, mainly for precisely timing the recording samples. The GPS also provides precise location. The location of the instrument is captured once every minute and written to the data Store files. The location of the Taurus at shot time is extracted by the AP software and is written to the header of the SEGY files, along with other key information such as sample rate, number of samples, time of the starting sample and other key information. As well, the instrument SN is also written to the header.

Lookup table and role of field data

Due both to the nature of the ARTA refraction survey and the sophistication of the new generation of refraction instrument and software, it is no longer necessary to relate field location names to Taurus ID numbers for creation of final SEGY files. In the past this relationship was essential since the instrument itself was unable to tell its own location at the time of each shot. The ARTA field location

names that were given to each location were useful only for deployment and retrieval of Taurus instrument and were not required for data processing. If, for whatever reason, the field locations need to be correlated to the Taurus SN or ID, then it is assumed that deployment crew created a table relating field locations such as IR050, IR055, IR060, etc, to Taurus Cooler Box ID's given in Table 5.1, above. From there, field locations can relate to Taurus SN which appears in the heard of SEGY files.

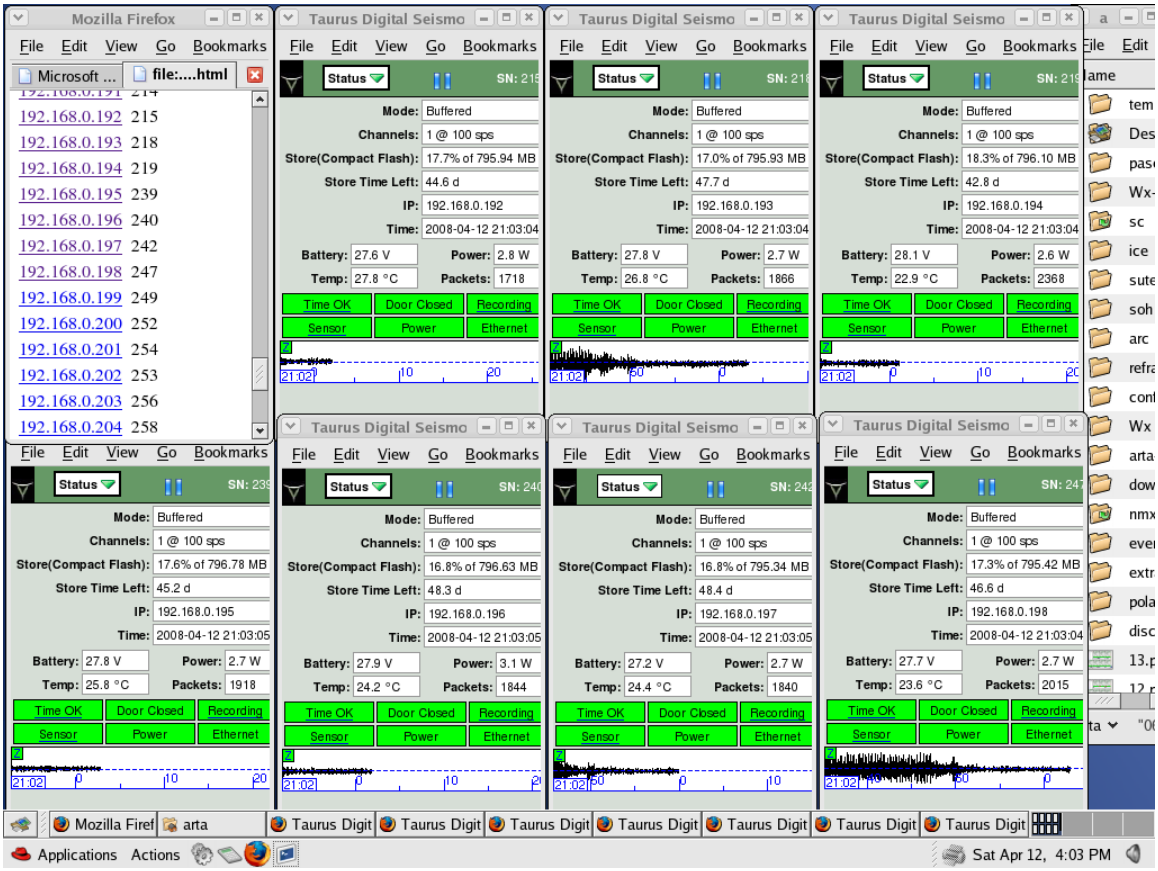


Fig 5.1 Example of quality check before instrument cooler boxes were dispatched to the field. Each Taurus is checked for key parameters such as recording mode (Buffered), sample rate (100), Store Time Left (more than 40 days), battery volt (more than 27 VDC), current temperature (more than 24 C). All Tabs are green and waveform data are showing.

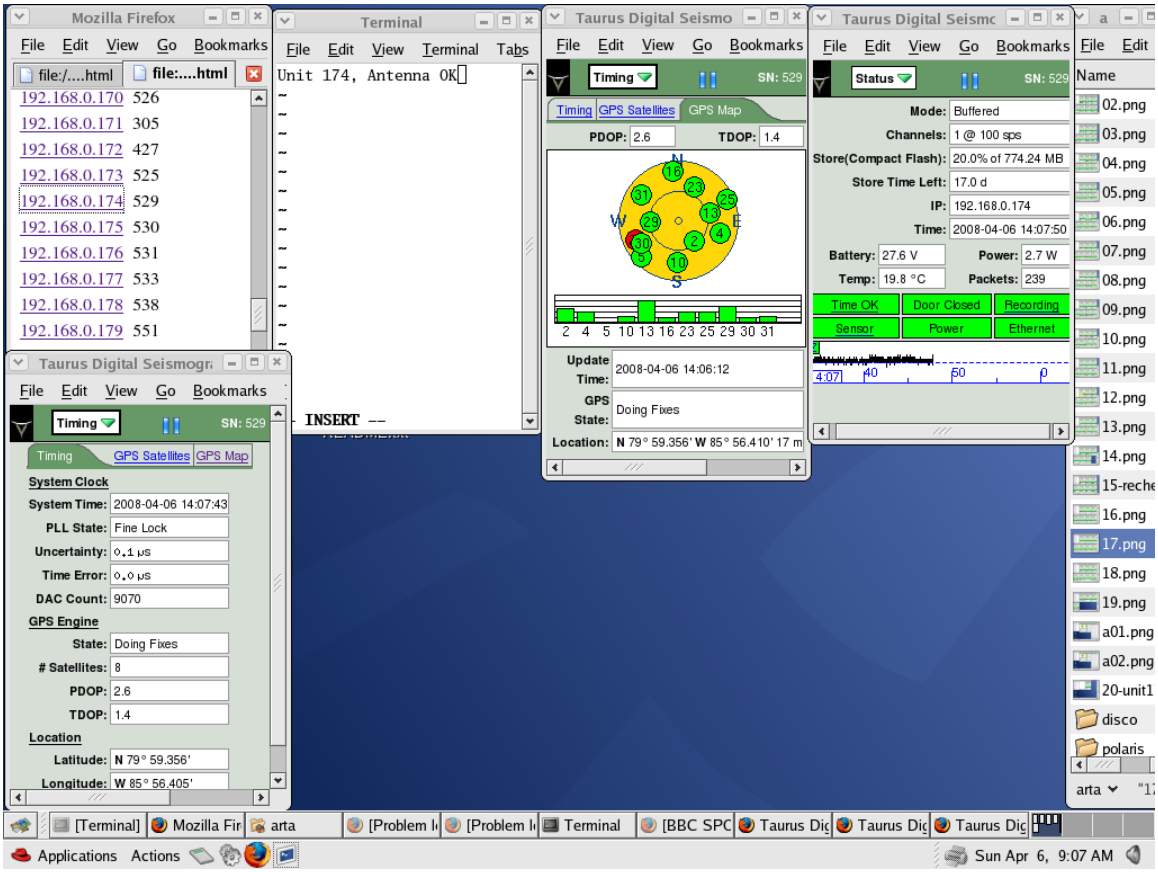


Fig. 5.2 An example of verification of instrument after repair. Here, GPS antenna is fixed for Taurus SN 529 and images show GPS Map with more than 8 satellites and Timing in File Lock.

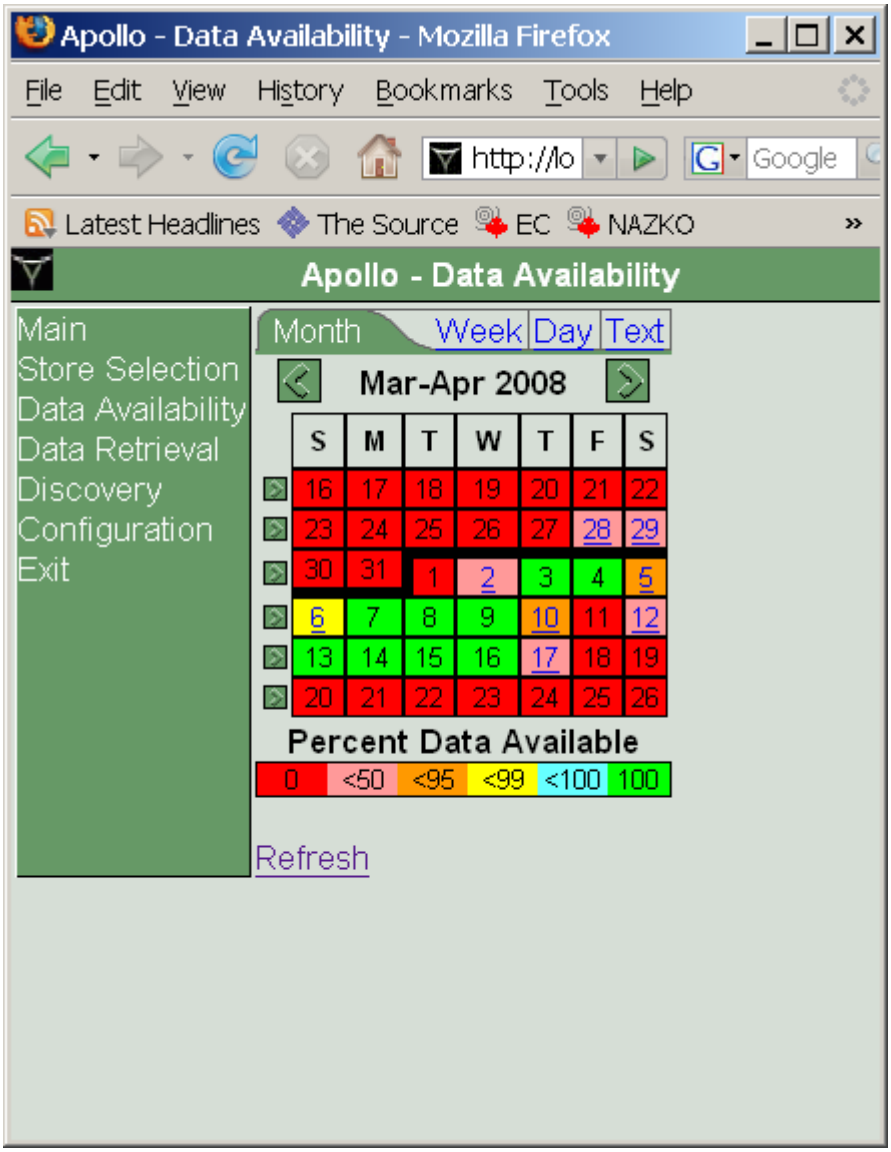


Fig. 5.3 Example of data availability screen for one of the final store files, showing 100% data available (green color) during main deployments (April 3-4, 7-9 and 13-16). Full data were also available during test deployment (March 28-29).

6. Processing of Refraction Seismic Data

Thomas Funck

6.1. Introduction

The ARTA refraction seismic experiment consisted of two main components. During the first phase of the project, data were collected by means of Taurus seismometers deployed along the main north-south line extending from Nansen Sound, across the Artic shelf and onto the Alpha Ridge, and along a cross line on the ridge (Fig. 6.1). In the second part of the program, the main line was extended farther northward using geobuoys deployed by an Aurora aircraft of the Canadian military. The geobuoys were developed and provided by Defence Research and Development Canada. Explosives (pentolite in 17.5 kg moulds) were used as seismic source. All shots were also recorded by three-component seismometers deployed at the mouth of Nansen Sound on Axel Heiberg Island, on Ellesmere Island, and on Small Fjeldholmen Island.

Data from the geobuoys and the land seismometers were not processed during the field work in Eureka, Nunavut. The geobuoy data will be provided by the military in digital format and the land seismometers were retrieved so late that only a data backup could be carried out. The location of the land seismometers are given in Table 6.1, shot locations and times are specified in Tables 6.2 through 6.7.

Table 6.1. Location of Land Seismometers (GPS location of sensor at deployment and retrieval).

Station name	Location	Longitude	Latitude	Elevation
LR1	Hvitland Peninsula (Ellesmere Island)	89.809333°W 80.809167°W	81.127233°N 81.127217°N	200 m / 229 m
LR2	Cape Stallworthy (Axel Heiberg Island)	93.278622°W 93.279633°W	81.343118°N 81.343117°N	173 m / 191 m
LR3	Small Fjeldholmen Island (off Ellesmere Island)	91.629600°W 91.630350°W	81.484850°N 81.484933°N	0 m / 9 m

Table 6.2. Shots on Test Line.

Shot	Longitude (°W)	Latitude (°N)	Depth (m)	Day (YMD)	Time (UTC)	Size of charge	Comments
IS01	92.593121	81.425988	100	20080329	17:06:00	175 kg	
IS02	92.808728	81.620511	100	20080329	17:00:00	175 kg	
IS03	93.080753	81.838616	100	20080329	16:25:00	175 kg	

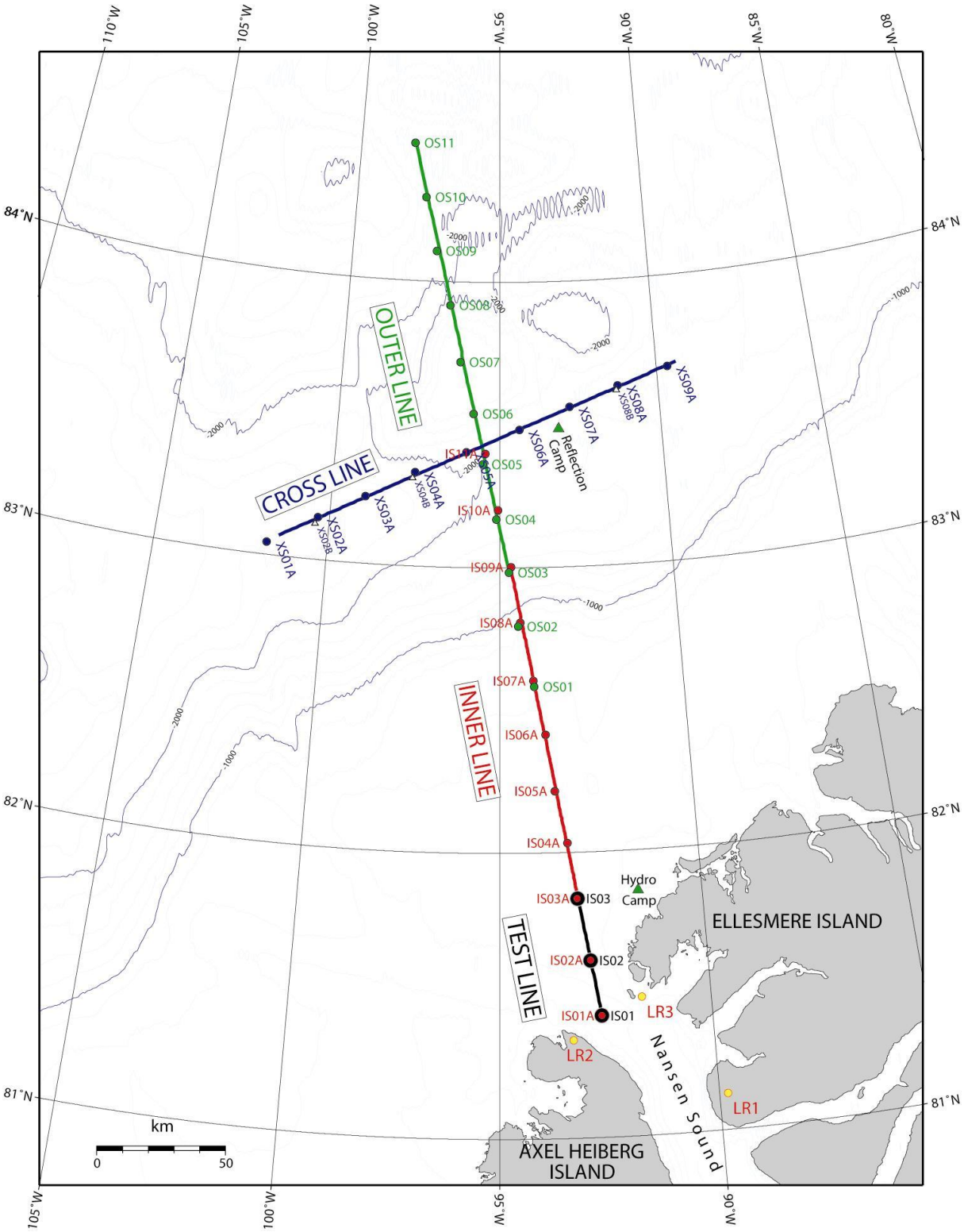


Fig. 6.1 Location map of the four refraction seismic lines of the ARTA experiment. The main line consists of the Test Line (black), Inner Line (red), and Outer Line (green), the Cross Line is shown in blue. Shot locations are indicated by circles and white triangles. The segments of the lines with seismometer deployments are marked by solid lines. Yellow circles show the location of the land seismometers.

Table 6.3 Shots on Inner Line.

Shot	Longitude (°W)	Latitude (°N)	Depth (m)	Day (YMD)	Time (UTC)	Size of charge	Comments

IS01A	92.593550	81.425683	100	20080403	13:55:00	350 kg	
IS02A	92.808467	81.621617	100	20080403	14:35:00	315 kg	
IS03A	93.082245	81.839072	100	20080403	13:25:00	280 kg	
IS04A	93.287747	82.033240	100	20080403	13:45:00	175 kg	
IS05A	93.567105	82.215873	100	20080403	14:05:00	175 kg	
IS06A	93.779467	82.414650	100	20080403	14:40:00	175 kg	
IS07A	94.080783	82.604270	100	20080403	14:20:00	175 kg	
IS08A	94.414053	82.807507	100	20080403	13:40:00	175 kg	
IS09A	94.667178	83.002903	100	20080403	15:10:00	280 kg	
IS10A	95.041182	83.202283	100	20080403	14:30:00	315 kg	
IS11A	95.424580	83.399380	100	20080403	13:50:00	350 kg	

Table 6.4 Shots on Outer Line.

Shot	**Longitude (°W)**	**Latitude (°N)**	**Depth (m)**	**Day (YMD)**	**Time (UTC)**	**Size of charge**	**Comments**
OS01	94.063683	82.583483	100	20080407	22:35:00	350 kg	
OS02	94.476783	82.795233	100	20080407	23:19:59	315 kg	Fired manually
OS03	94.729650	82.983050	100	20080407	21:50:00	280 kg	
OS04	95.094450	83.169583	100	20080407	21:05:00	175 kg	
OS05	95.500167	83.363167	100	20080408	00:10:00	175 kg	
OS06	95.811167	83.538733	100	20080407	22:25:00	175 kg	Misfire
OS07	96.246817	83.719533	100	20080407	23:45:00	175 kg	
OS08	96.620817	83.917967	100	20080407	23:00:00	175 kg	
OS09	97.133483	84.107433	100	20080407	22:15:00	280 kg	
OS10	97.570900	84.294467	100	20080407	21:45:00	315 kg	
OS11	98.063500	84.482450	100	20080407	21:15:00	350 kg	

Table 6.5 Shots on Cross Line.

Shot	Longitude (°W)	Latitude (°N)	Depth (m)	Day (YMD)	Time (UTC)	Size of charge (kg)	Comments
XS01A	101.750453	83.044312	100	20080414	19:25:00	122.5	
XS02A	100.348027	83.148567	100	20080414	19:55:00	122.5	Misfire
XS03A	98.986125	83.236435	100	20080414	20:25:00	122.5	
XS04A	97.551152	83.328872	100	20080414	19:35:00	122.5	Misfire
XS05A	96.011688	83.404288	100	20080414	20:05:00	122.5	
XS06A	94.379722	83.483717	100	20080414	20:35:00	122.5	
XS07A	92.808325	83.559805	100	20080414	19:00:00	122.5	
XS08A	91.267085	83.626440	100	20080414	18:30:00	122.5	Misfire
XS09A	89.655813	83.680163	100	20080414	18:00:00	122.5	
XS02B	100.415840	83.124815	100	20080415	20:11:00	245	
XS04B	97.619073	83.307802	100	20080415	20:50:00	245	
XS08B	91.318340	83.610202	100	20080415	19:45:00	245	

Table 6.6 Shots for First Geobuoy Deployment.

Shot	Longitude (°W)	Latitude (°N)	Depth (m)	Day (YMD)	Time (UTC)	Size of charge (kg)	Comments
AU01A	94.080650	82.599433	100	20080421	17:00:00	245	
AU02A	94.948133	83.402633	100	20080421	17:45:00	175	
AU03A	98.353933	84.456317	100	20080421	16:55:00	140	

Table 6.7 Shots for Second Geobuoy Deployment.

Shot	Longitude (°W)	Latitude (°N)	Depth (m)	Day (YMD)	Time (UTC)	Size of charge (kg)	Comments
AU01B			100	20080423	16:00:00	175	*
AU02B			100	20080423	15:40:00	350	*
AU03B	98.218483	84.413933	100	20080423	15:50:00	315	

* No position was taken with a handheld GPS prior to the shot. See general report by Ruth Jackson for the location of the helicopter prior to shot and for the last known position of the ice tracker (equipped with GPS) located next to the explosives.

6.2. Processing Flow

After retrieval of the seismometer boxes, Isa Asudeh downloaded the seismic data from the Taurus instruments to his Linux computer. He created SEED files for each shot, which were subsequently converted to SEGY format and transferred to the UNIX computer of Thomas Funck, who was in charge for the further processing using *Seismic Unix* processing software. The raw SEGY files are stored on the data DVD in the directory *segy-raw*, file names are *_YYYYMMDD_HHMMSS.sgy* (with the start of the record time specified by *YYYY*=year, *MM*=month, *DD*=day, *HH*=hour, *MM*=minute, *SS*=second; e.g. _20080407_214450.sgy). The start of the record was chosen 10 seconds before the shot time (in case of the manually fired shot OS02, 10 seconds before the full minute were initially chosen). Record length is 90 s on the Test Line, and 150 s on all other lines. Sampling rate is 10 ms

(100 Hz). The receiver coordinates are already written to the appropriate header words of the original SEGY file. The geographical coordinates for each receiver and a given shot were extracted from the headers and saved as separate file in the *GMT* directory (file names *receivers-at-[shotname].xy*).

In the next processing step, shot-receiver offsets were calculated using the Generic Mapping Tools (GMT) routine *project* (with the 1984 World Geodetic System as reference ellipsoid). On the cross line, offsets to the west of the shot obtained a negative sign, those to the east are positive. On the other lines, negative offsets were used for receivers to the NNW of the shots. At the same time, traces were sorted according to increasing receiver number. Since the receiver number is not written to any header word, the receiver coordinates were actually used as sorting criteria. Also the shot coordinates were written to the SEGY headers. These temporary files are stored on the data DVD in the directory *segy-tmp*, file names are *shot-[shotname].sgy*.

Some seismometers recorded the seismic signals with a reversed polarity, which was noticed by inspection of the initial raw plots. Affected were the traces with the header words *tracf* (=trace number within field record) 109, 203, and 542. The polarity of these traces was changed and the files are stored on the data DVD in the directory *segy-tmp*, file names are *shot-[shotname]-pol.sgy*.

In a final processing step, the source depth of 100 m was added to the SEGY headers and an appropriate description of the experiment and the shots was included in the EBCDIC headers. These final files are stored on the data DVD in the directory *segy-final*, file names are *shot-[shotname].sgy*. Please note, that these SEGY files still start 10 seconds before the shot time and that an appropriate static correction has to be applied before plotting.

For quality control, record sections were created for all shots (see appendix) after applying a static correction of 10 s to the final SEGY files. Plots are displayed with a reduction velocity of 6 km/s, in some cases with 7 km/s to ensure the seismic energy lies within the display window ranging from 0 to 10 s. For the plots, traces were debiased and a band pass filter from 1 to 6 Hz was applied. Traces are scaled by AGC with a window length of 15 s. Some traces close to the shots are omitted in the plots, when the geophones where oversaturated. The plots are saved as postscript files and are stored on the data DVD in the directory *plot*, file names are *record-[shotname].ps*.

6.3. Special Processing

For some shots additional processing was necessary to obtain the final SEY files. In this section, all these special cases are described.

On the Inner Line, the instrument at position IR132 (Taurus ID/header word "*tracf*" 468, seismometer box number 213) did not record any data due to problems with the flash card. The data for this instrument are omitted in the SEGY files.

The GPS antenna for the instrument at position IR095 (header word *tracf* 529) on the Inner Line, failed some hours before the first shot, preventing the recording of the receiver position at the shot times. The instrument had almost no drift (helicopter position at deployment and retrieval of the instruments are 93.898668°W, 82.484185°N, and 93.897416°W, 82.484166°N, respectively, which corresponds to a drift of 18 m). For this reason, the last good instrument position before the breakdown of the GPS antenna was used for this instrument (93.897712°W, 82.484216°N).

The shot OS02 was fired manually due to problems with the shooter box. It was attempted to shoot at the full minute and the exact shot time was subsequently determined by means of the water wave arrival. Both for OS02 and the neighbouring shot OS03, water wave arrivals become horizontal on a plot with a reduction velocity of 1461 m/s (Fig. 6.2). The time difference between the direct wave between OS02 and OS03 (Figs. 6.3 and 6.4) was used to determine the exact shot time for shot OS03,

which is estimated to be April 7, 2008 at 23:19:59.300 UTC (±10 ms). The final SEGY file for shot OS02 was corrected accordingly so that the record window starts exactly 10 s before the actual shot time as is the case for all other shots.

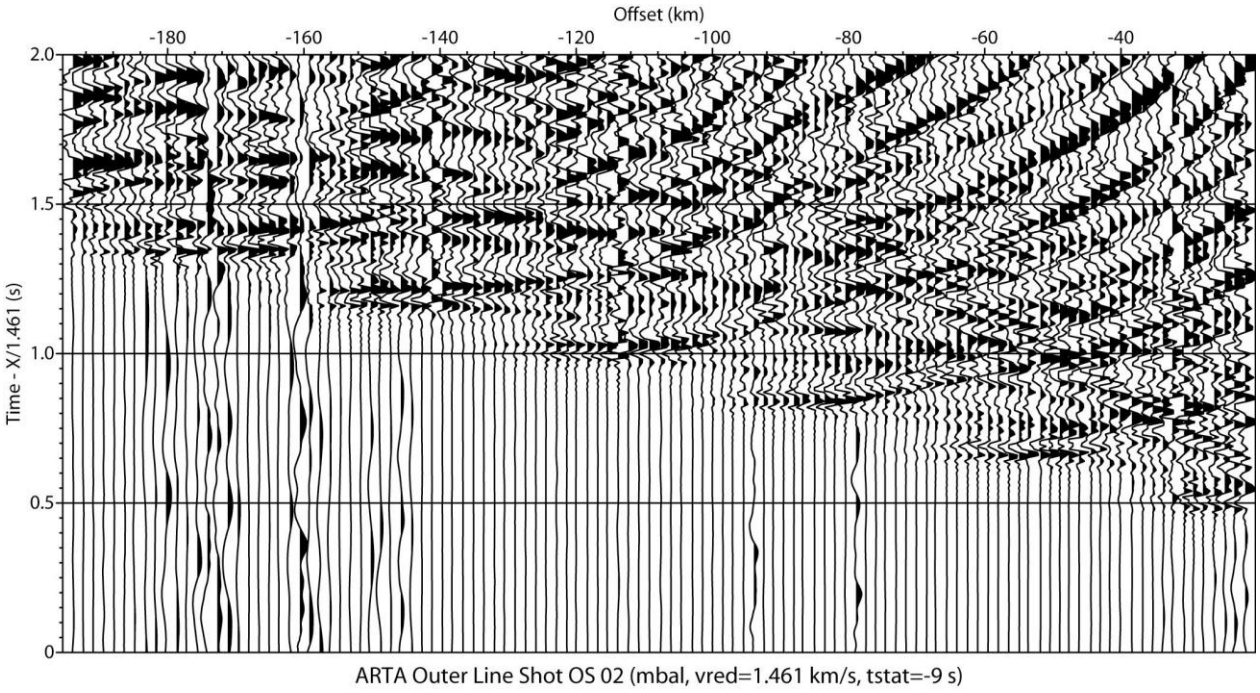


Fig. 6.2 Record section of shot OS 02 displayed with a reduction velocity of 1461 m/s.

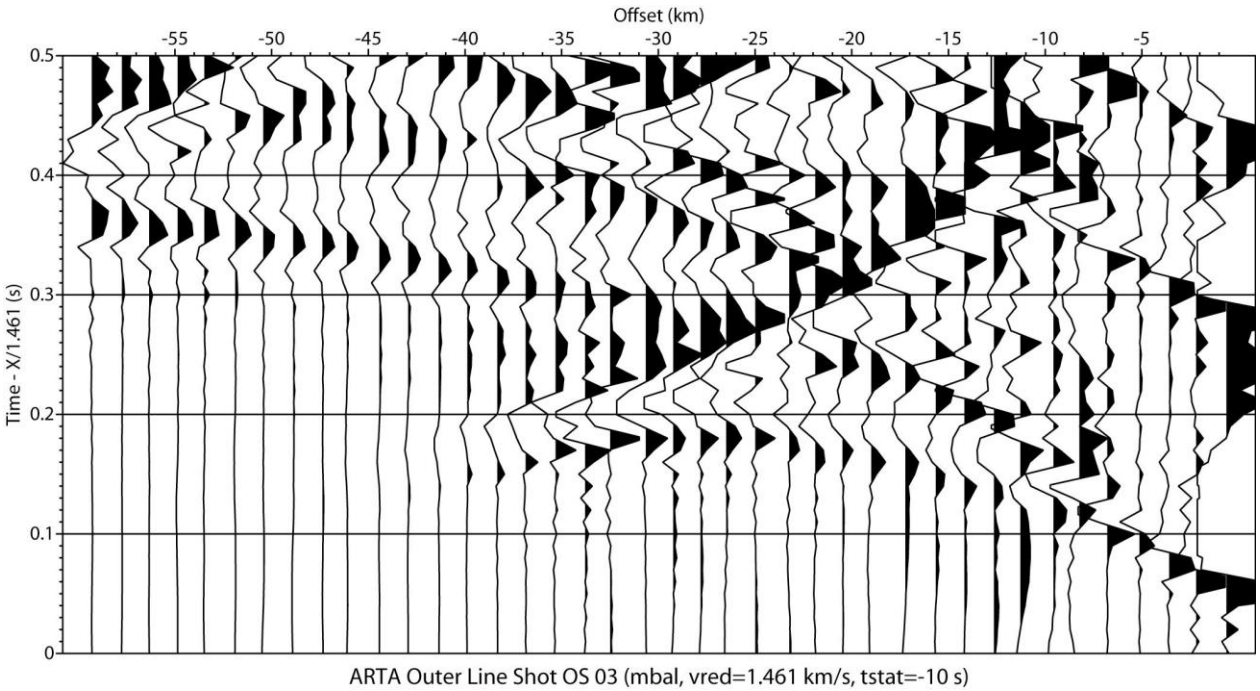


Fig. 6.3 Detail of record section of shot OS03 displayed with a reduction velocity of 1461 m/s after a static correction of -10 s. This plot was used as reference to determine the shot time for shot OS02.

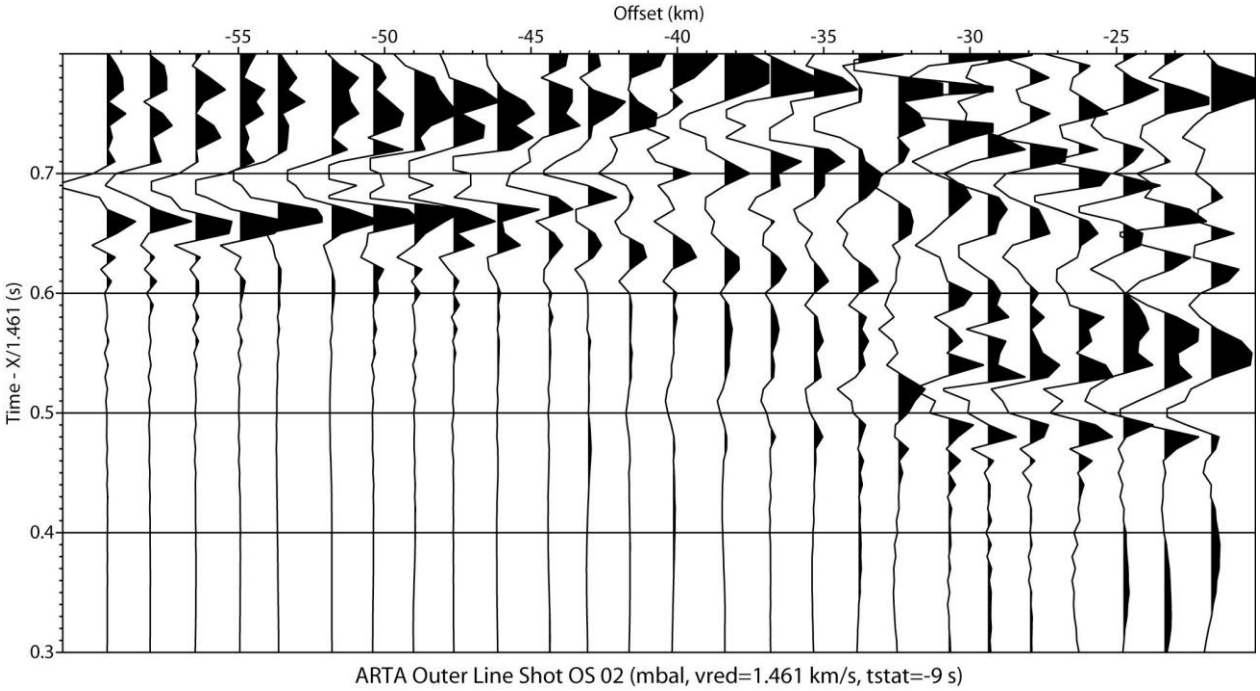


Fig. 6.4 Detail of record section of shot OS02 displayed with a reduction velocity of 1461 m/s after a static correction of -9 s. This plot was used as reference to determine the shot time for shot OS02 (using signals close to offsets of 30 km).

6.4. Misfires

Shots OS06, XS02A, XS04A, and XS08A are misfires. Here only the Primacord exploded without setting off the charges that were located at a depth of 100 m. With three misfires on the Cross Line, it was decided to reload the holes with seven extra charges (corresponding to 122.5 kg) and repeat the shots a day later. Since the holes were drilled right next to the original holes, the new shots XS02B, XS04B, and XS08B likely set off the older charges as well, resulting in a total amount of 245 kg of explosives for these shots. Due to the movement of the ice between the first set of shots (XS01A through XS09A) and the later shots (XS02B/04B/08B), both receivers and shot location drifted some 2.8 km to the southwest, which may result in some minor inconsistencies for the travel time modelling of the data.

Although only the Primacord exploded at the misfired shots, the nearby geophones did record a signal and therefore the corresponding record sections are included in the appendix. The strength of the signal with the misfires is more than two magnitudes lower than for the regular shots and another difference is the frequency content of those shots. The misfires with the Primacord happen more frequently than with the regular shots (Fig. 6.5).

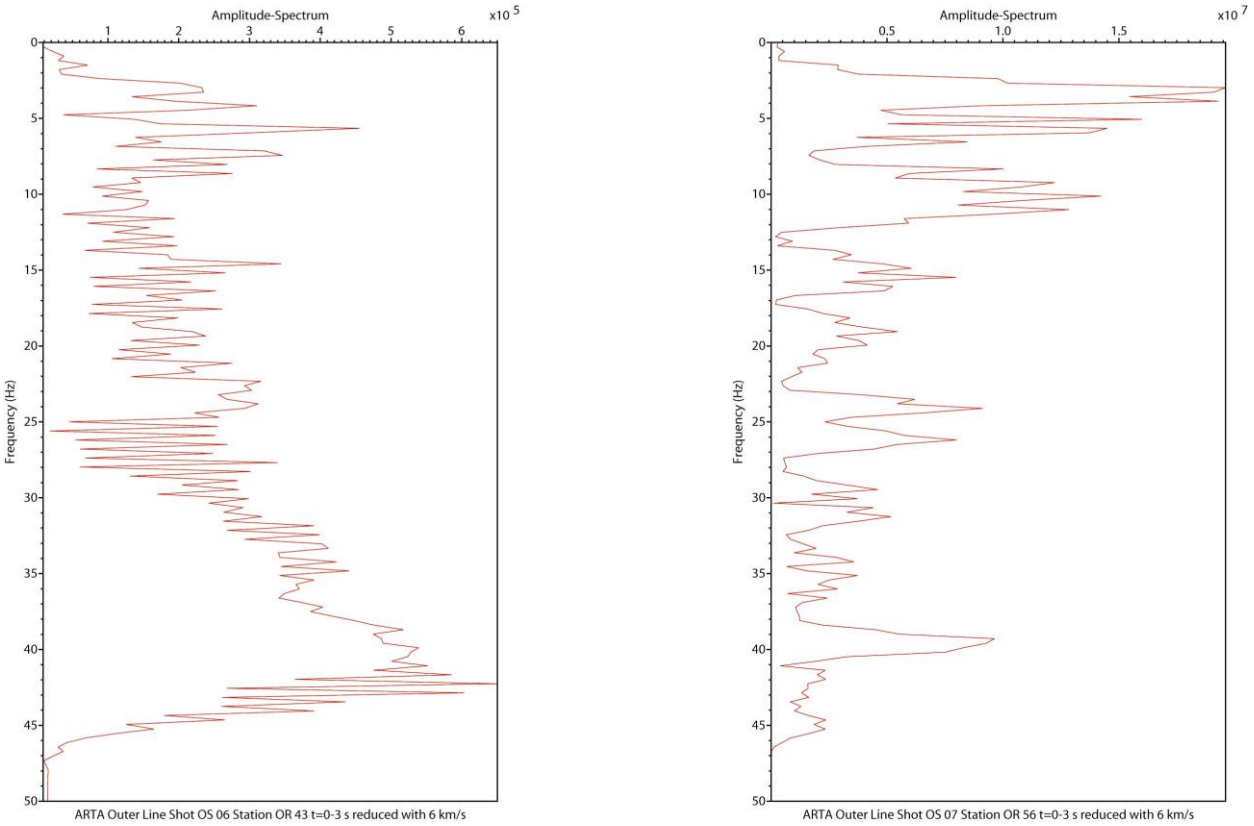


Fig. 6.5 Amplitude spectrum of water wave for shot OS06 (left) and for shot OS07 (right). While the maximum energy is around 3 Hz for OS07, it is at 43 Hz for shot OS06.

6.5. Noise by ice movement

Record sections for the Outer Line and the Cross Line (see appendix) are characterized by some receiver segments with a reduced signal-to-noise ratio. This is attributed to some substantial ice movement during the shooting. The amplitude spectrum of the ice-noise (Fig. 6.6) shows the

maximum energy in the frequency range from 1 to 5 Hz, where also the major energy of the crustal refractions (P_g phase) lies. Therefore, filtering the ice-noise is not a real option. However, in some cases a 5-Hz high-pass filter made some of the seismic energy visible underneath the ice-noise with a distortion of the waveform as trade-off. On the Cross Line, the ice-noise is not as severe as on the Outer Line and weak signals can be correlated through the noisy segments.

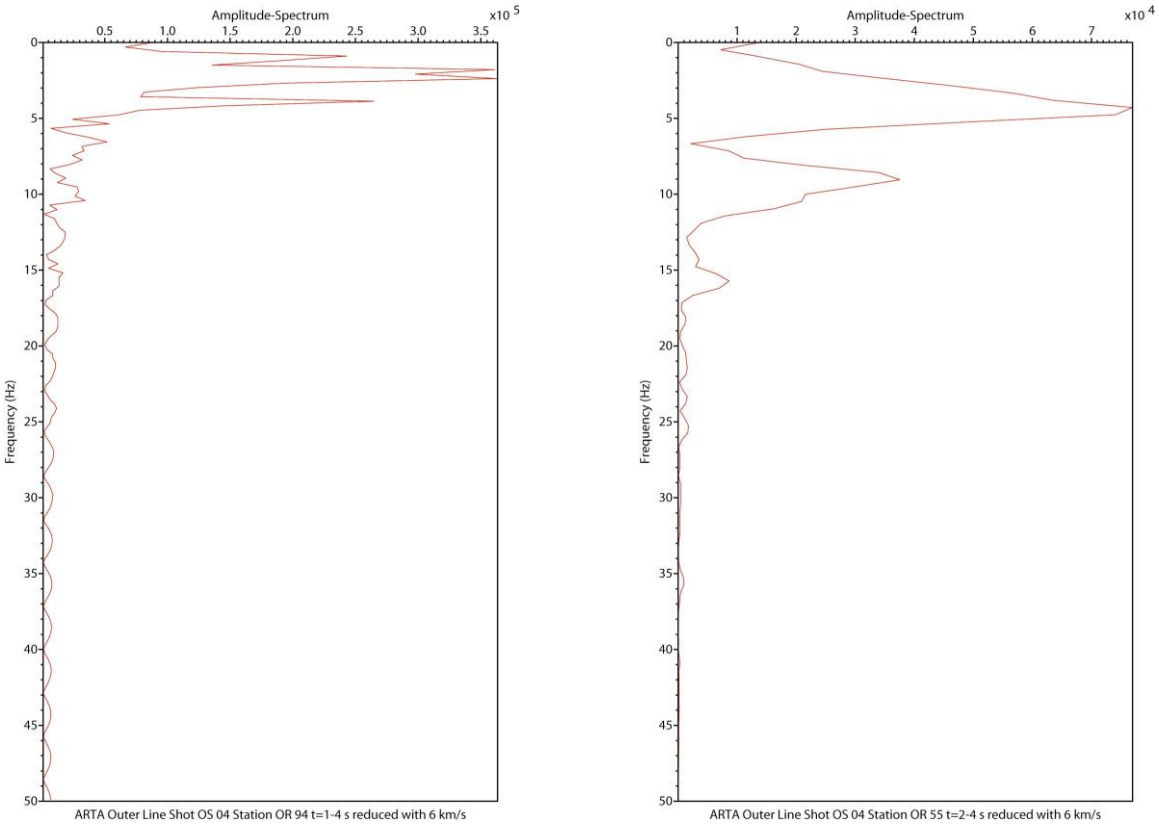


Fig. 6.6 Amplitude spectrum for a receiver with ice-noise for shot OS04 (left) and for a receiver with a high-amplitude P_g phase for the same shot (right).

6.6. Data backup

The raw, temporary and final SEGY finals are saved on the data DVD as discussed above along with the plots of the record sections and the location maps. In addition, navigation files, processing scripts and GMT scripts are included on the data DVD.

One raw SEGY file is not included on the DVD (file _20080415_201050.sgy) because the file got corrupted during the final organizing of the backup. No attempt was made to recreate the file at the end of the field program because the temporary and final SEGY files include the same data traces, just with some additional header words set and a different sorting of the traces. If desired, the original SEGY file can be recreated from the SEED files that are backed up separately.

6.7. Location maps

For orientation purposes, location maps for all four seismic lines are shown below.

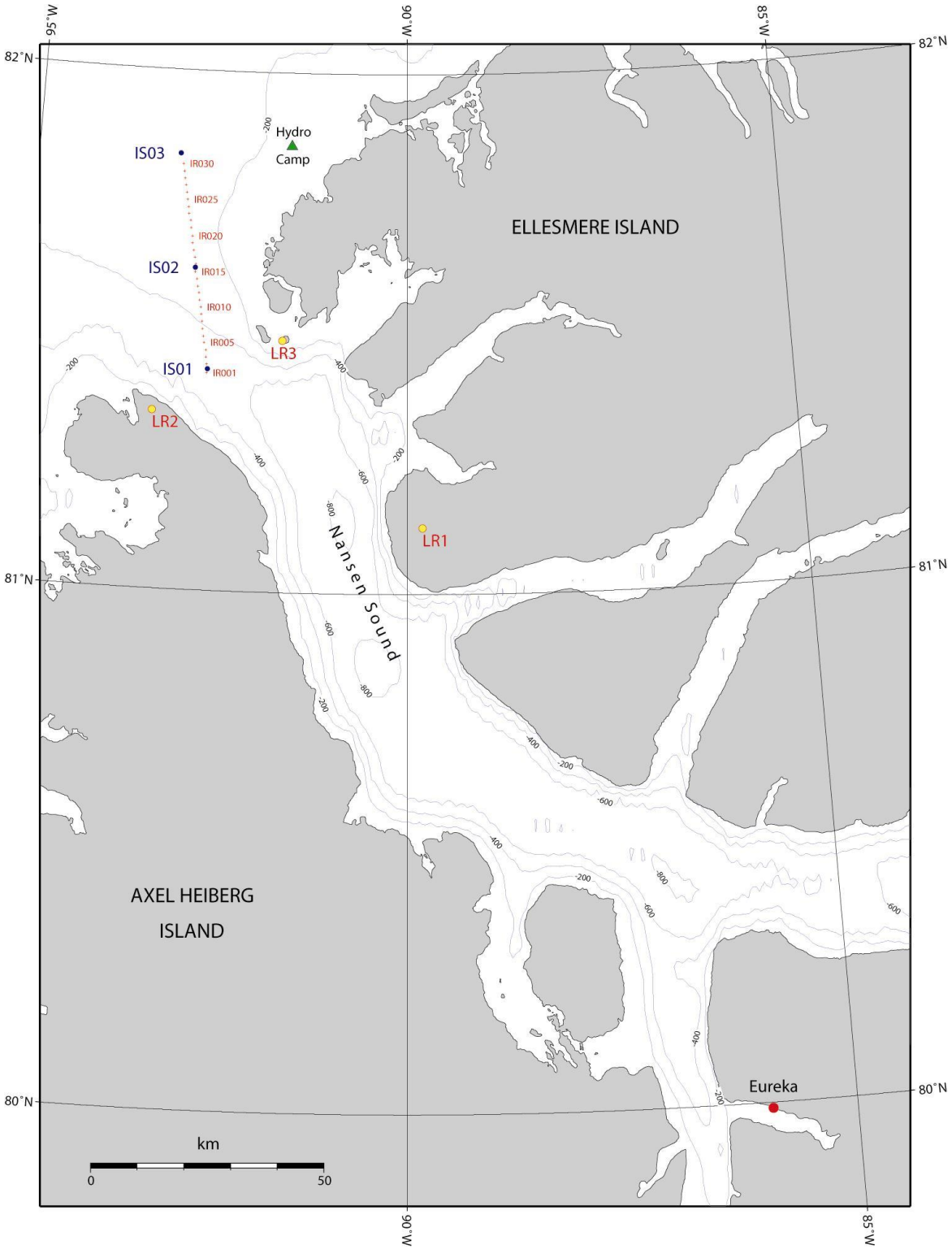


Fig. 6.7 Location map of the Test Line. Red crosses show the receiver locations and black circles indicate the shot positions. Land seismometers are marked by yellow circles.

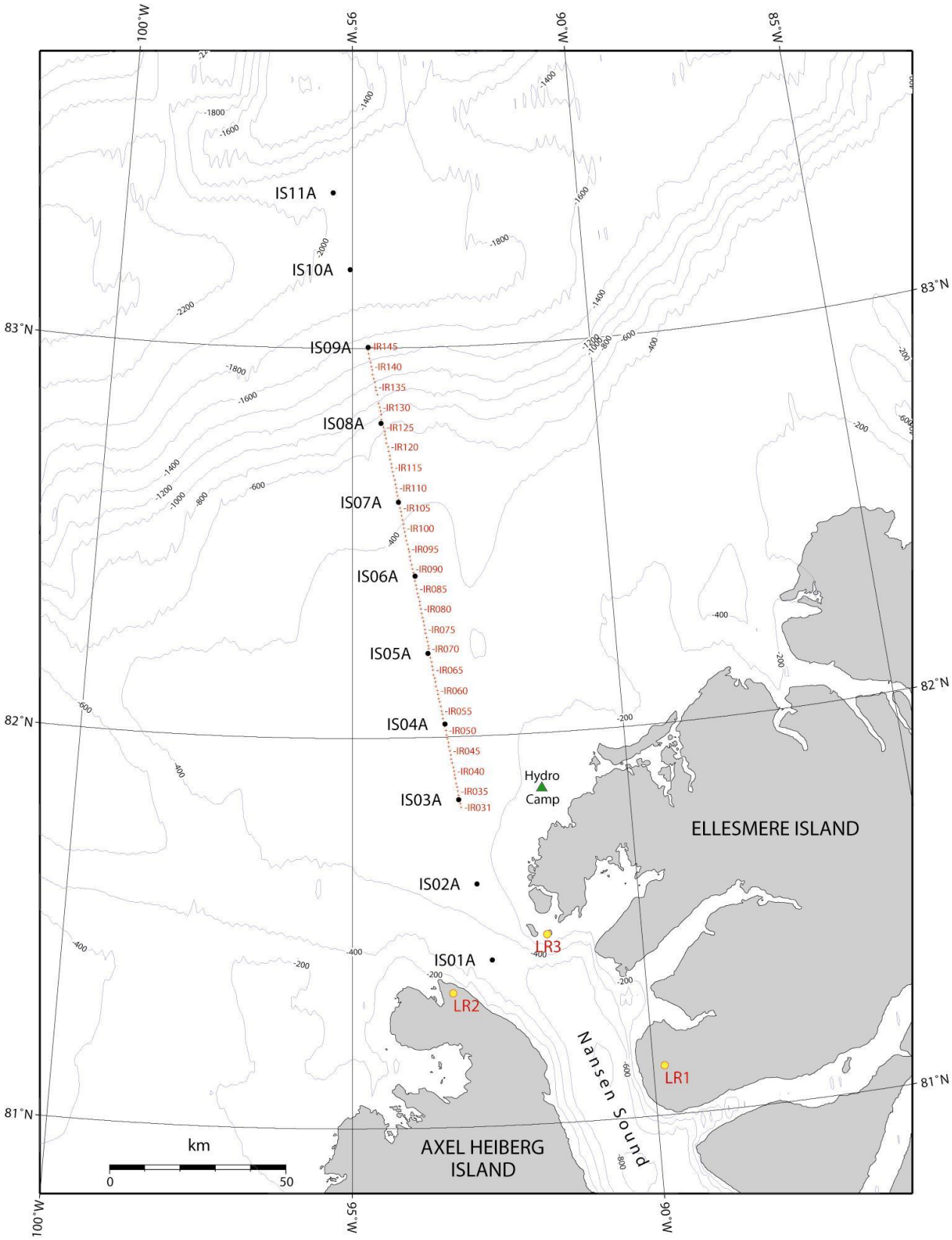


Fig. 6.8 Location map of the Inner Line. Red crosses show the receiver locations and black circles indicate the shot positions. Land seismometers are marked by yellow circles.

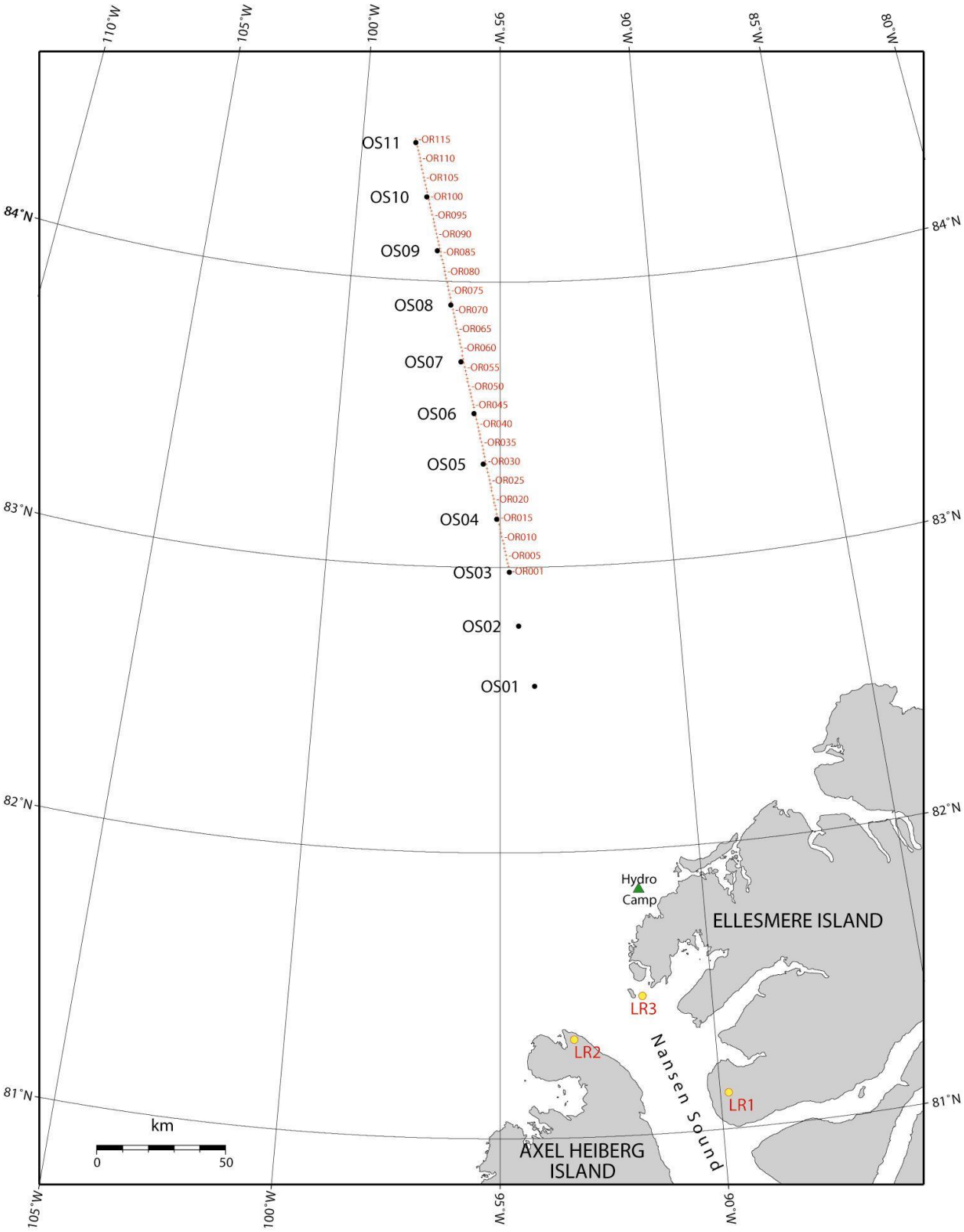


Fig. 6.9 Location map of the Outer Line. Red crosses show the receiver locations and black circles indicate the shot positions. Land seismometers are marked by yellow circles.

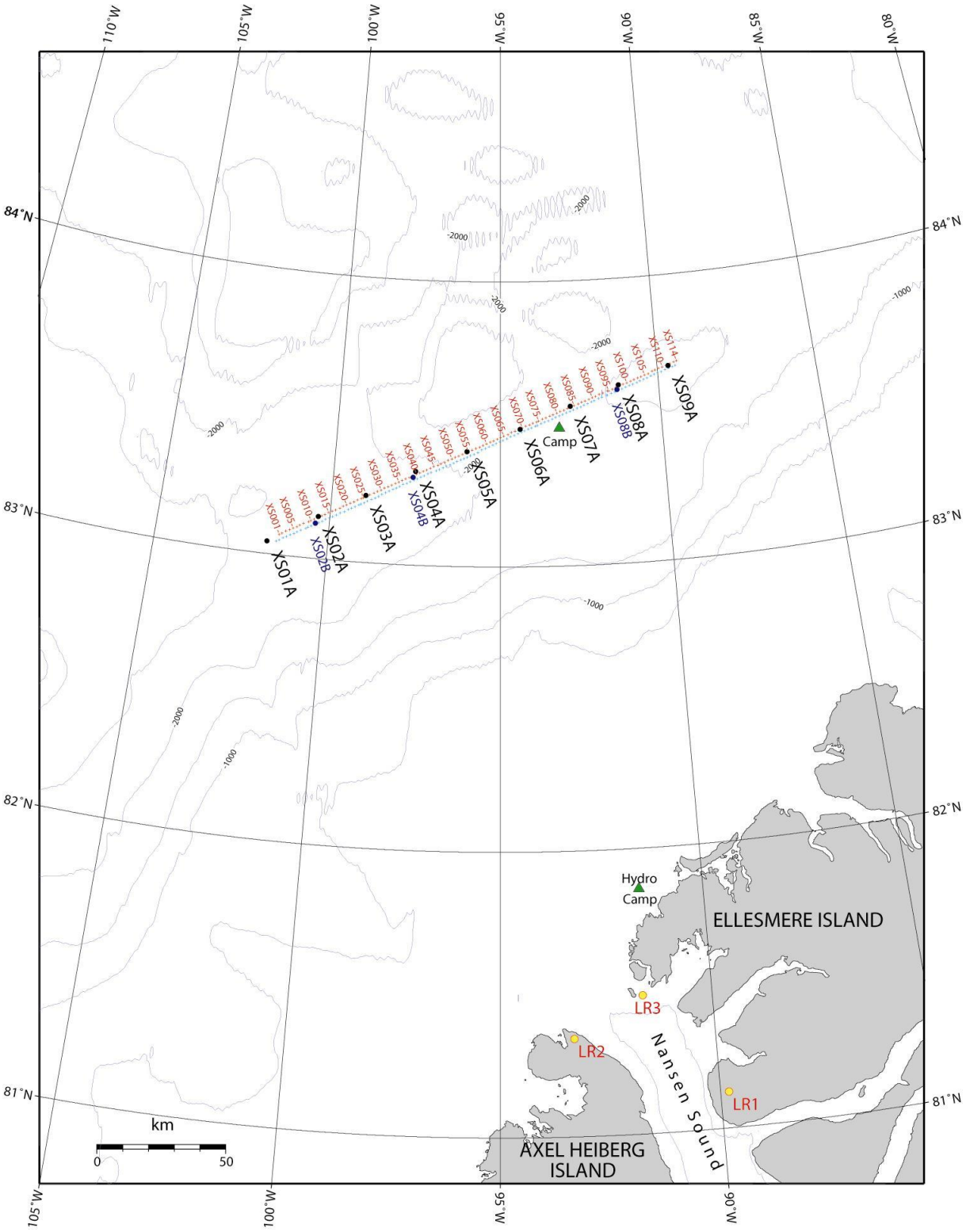


Fig. 6.10 Location map of the Cross Line. Red and blue crosses show the receiver locations during the shooting of the A and B shots, respectively. Black and blue circles indicate the positions of the A and B shots, respectively. Land seismometers are marked by yellow circles.

7.Navigation/GPS waypoints

Once the endpoints of survey line segments had been established, the planned shot and instrument locations were calculated using the attached FORTRAN program (xxx.f) which uses Ron Verrall's algorithm (see LORITA report Appendix). The program interpolates a desired number of stations between the endpoints along a great circle path. The various lines can be described as follows:

Inner Line (Test)	3 Shots	30 instruments
Inner Line	11 Shots	115 instruments
Outer Line	11 Shots	115 instruments
Cross Line	9 Shots	114 instruments

The geographic coordinates (ASCII text) of the planned shot and instrument locations were imported into Global Mapper GIS (http://www.globalmapper.com/) for plotting and verification. The locations were designated using the following naming convention:

Inner Line	Shots (IS)	Instruments (IR)
Outer Line	Shots (OS)	Instruments (OR)
Cross Line	Shots (XS)	Instruments (XR)

Leading zeroes were added to receiver and shot numbers so that waypoint lists would be consecutively ordered once uploaded to GPS units. For example, outer line shots were numbered OS01-OS11 and receivers were OR001-OR115.

Waypoints for receiver and shot locations were exported from Global Mapper in GPX format and uploaded via GPS Utility to our each team-member's GPS unit (Garmin GPSMAP 276C https://buy.garmin.com/shop/shop.do?pID=233#). Our GPS units were similar to the Garmin GPSMAP296 units used by the helicopter pilots.

Actual shot locations differed from the planned locations, as blasting teams (Verrall) sought out thinner ice to drill through for loading explosives in the shot holes. When Verrall's advance team found a location with thin ice near the planned shot location, the explosives were unloaded, a CarteNav (http://www.cartenav.com/) satellite "ice-tracker" was deployed and a GPS waypoint taken marking the actual shot hole location.

In a similar way, deployed instrument locations differed from planned ones due to landing conditions, visibility and ice surface constraints, e.g. leads, pressure ridges, drifting snow etc. Instrument deployers marked the actual location for each deployed instrument by taking a GPS waypoint and making note of the station number, instrument number, waypoint and time.

The contents of each GPS unit was downloaded via GPS Utility at the end of every day and archived along with photocopies of each team's notes. This information, together with the notes from the field teams, the positions of the loaded shot holes and the deployed instrument locations were compiled and edited using GPS Utility, each location now designated with an "A", e.g. XR076A for "cross line, instrument station 76, deployed location"; B, C, D etc. were used for subsequent updates to positions as the ice became more mobile with shifting winds and milder weather. These new locations were then uploaded to the field teams' GPS units in preparation for shooting and subsequent instrument recovery.

Cartenav beacons

To monitor the geographic position of explosives on the sea ice during the field program 20 TS-1500 satellite beacons were purchased from Cartenav Solutions Incorporated of Halifax, Nova Scotia.

The beacons each contain a global positioning satellite (GPS) receiver, an Iridium satellite communications transceiver, and a microprocessor, which are all powered by 8 Saft 3.6 volt lithium 'D' cells. All components are rated for operating temperatures between -40 and +30°C. By switching the Iridium transceiver on only briefly (< 1 minute) once an hour, the ETS-1500 units have an estimated battery life of 40 to 60 days at -40°C.

The components are housed inside a small orange box (34 x 30 x 15.5 cm) connected with 1.8 m long cables to a combined GPS antenna/Iridium transceiver which is mounted on a 1" diameter aluminum pole. The mass of each beacon including batteries, antenna, and pole is 6 kg.

Once per hour, the beacons obtain GPS fixes and communicate information about their geographic positions and state of health, via the Iridium satellite network, to a Cartenav computer. Each beacon reports: serial number, time (UTC), latitude, longitude, linear distancemoved since last report, total operating time since (seconds), time elapsed during Iridium transmission (seconds), and time elapsed during GPS fix (seconds). During the field program, ARTA participants and supporting personnel were able to access these data through two separate World-Wide Web interfaces:

1) https://www.sattrax.net/etuser
2) http://www.cartenav.com/icetracker/icetracker.php

The following is a sample of the Cartenav data:

asset,time,lat,lon,distance,totalOn,deltaOn,gpsOn
GSCA04,04/14/2006 00:01:12,83.414093,-56.228500,0.156,009551,024,008 GSCA04,04/14/2006 01:01:35,83.412369,-56.232925,0.201,009575,024,030 GSCA04,04/14/2006 02:01:12,83.410599,-56.236923,0.205,009631,056,006 GSCA04,04/14/2006 03:01:18,83.409134,-56.241730,0.175,009655,024,010 GSCA04,04/14/2006 04:01:18,83.408508,-56.244781,0.080,009679,024,010 GSCA04,04/14/2006 05:01:18,83.408707,-56.245743,0.025,009721,042,010

For more information on the Cartenav beacons, see the LORITA field report: GSC Open File 5391; Field Report for LORITA (Lomonosov Ridge Test of Appurtenance).

Shot times and locations were recorded upon firing and shot tables compiled. Seismic instrument boxes were equipped with ID-trackers that both recorded and transmitted GPS location. The tracking software (GPStracker), run on a small tablet PC from the helicopter, identified each instrument uniquely at a range of ~10 km. This aided in locating the instruments after having drifted sometimes as much as 3 nm in a single day as well as helping to determine the station number, ensuring that no stations were overlooked. As helpful as the ID-trackers were, large black garbage bags filled with snow were still used at each instrument location to improve visibility from the air.

During instrument recovery, it was helpful, at least initially, to take a waypoint upon pickup, so as to determine the direction and amount of ice drift which had taken place since deployment. Thus giving an approximate range and bearing of the drifted positions from the "deployed" locations that recovery teams had loaded in their GPS units. The GPS trackers recorded the exact location of the instrument continuously so it was not necessary to take a GPS waypoint upon pickup.

Table 7.1 Table of shot point locations

TEST LINE SHOT LOCATIONS

F	ID--------	Latitude	Longitude	Symbol----	T	O	Alt(m)	Comment (local time)
W	IS03B	+81°50.3170'	-093°04.8452'	Airport	I	E	7.8	29-MAR-08 11:04:17 SHOTTIME: 11:25
W	IS02B	+81°37.2307'	-092°48.5237'	Airport	I	E	11.9	29-MAR-08 11:44:59 SHOTTIME: 12:00
W	IS01A	+81°25.5593'	-092°35.5873'	Waypoint	I	E	16.2	29-MAR-08 13:26:59 SHOTTIME: 12:06

INNER LINE SHOT LOCATIONS

F	ID--------	Latitude	Longitude	Symbol----	T	O	Alt(m)	Comment (local time)
W	IS01A	81.42595	-92.5929	Waypoint	I	E	-32.6	4/3/2008 13:55
W	IS02A	81.621	-92.8094	Waypoint	I	E	-274.6	4/3/2008 14:35
W	IS03A	81.839072	-93.082245	Waypoint	I	E	4.7	4/3/2008 13:25
W	IS04A	82.03324	-93.287747	Waypoint	I	E	1.3	4/3/2008 13:45
W	IS05A	82.215873	-93.567105	Waypoint	I	E	-2	03-APR-08 14:05 DELAYED SHOT? (~2 SEC)
W	IS06A	82.41465	-93.779467	Waypoint	I	E	-3.2	03-APR-08 14:40 DELAYED SHOT? (~4 SEC)
W	IS07A	82.60427	-94.080783	Waypoint	I	E	2.8	4/3/2008 14:20
W	IS08A	82.807507	-94.414053	Waypoint	I	E	5.2	4/3/2008 13:40
W	IS09A	83.002903	-94.667178	Waypoint	I	E	9	4/3/2008 15:10
W	IS10A	83.202283	-95.041182	Waypoint	I	E	7.3	4/3/2008 14:30
W	IS11A	83.39938	-95.42458	Waypoint	I	E	23.4	4/3/2008 13:50

OUTER LINE SHOT LOCATIONS

F	ID--------	Latitude	Longitude	Symbol----	T	O	Alt(m)	Comment (local time)
W	OS01	82.61004	-94.07817	Waypoint	I	E	-428.3	SHOT TIME 17:35:00
W	OS02	82.79994	-94.38276	Waypoint	I	E	-652.7	SHOT TIME 18:19:59 (FIRED MANUALLY)
W	OS03	82.98964	-94.70376	Waypoint	I	E	-1510	SHOT TIME 16:50:00
W	OS04	83.1791	-95.04251	Waypoint	I	E	-1923	SHOT TIME 16:05:00
W	OS05	83.36831	-95.40051	Waypoint	I	E	-1976	SHOT TIME 19:10:00
W	OS06	83.55725	-95.77943	Waypoint	I	E	-1370	SHOT TIME 17:25:00 MISFIRE
W	OS07	83.74589	-96.18112	Waypoint	I	E	-1245	SHOT TIME 18:45:00
W	OS08	83.93421	-96.60768	Waypoint	I	E	-2047	SHOT TIME 18:00:00
W	OS09	84.12218	-97.06143	Waypoint	I	E	-1933	SHOT TIME 17:15:00
W	OS10	84.30975	-97.54503	Waypoint	I	E	-1718	SHOT TIME 16:45:00
W	OS11	84.4969	-98.06145	Waypoint	I	E	-1804	SHOT TIME 16:15:00

CROSS LINE SHOT LOCATIONS

F	ID-------	Latitude	Longitude	Symbol---	T	O	Alt(m)	Comment (local time)
W	XS01A	+83°02.6587'	-101°45.0272'	Waypoint	I	E	5.7	14-APR-08 14:12 SHOTTIME 1425
W	XS02A	+83°08.9140'	-100°20.8816'	Waypoint	I	E	11.7	14-APR-08 14:45 MISFIRE 1455
W	XS02B	+83°07.4889'	-100°24.9504'	Waypoint	I	E	4.5	15-APR-08 15:11 THOMAS MISSED SHOT TIME!
W	XS03A	+83°14.1861'	-098°59.1675'	Waypoint	I	E	4.2	14-APR-08 15:14 SHOTTIME 1525
W	XS04A	+83°19.7323'	-097°33.0691'	Waypoint	I	E	1.3	14-APR-08 14:21 MISFIRE 1435
W	XS04B	+83°18.4681'	-097°37.1444'	Waypoint	I	E	-12.9	4/15/2008 15:50
W	XS05A	+83°24.2573'	-096°00.7013'	Waypoint	I	E	5.4	14-APR-08 15:10 SHOTTIME 1505
W	XS06A	+83°29.0230'	-094°22.7833'	Waypoint	I	E	3.5	14-APR-08 15:36 SHOTTIME 1535 EARLY?
W	XS07A	+83°33.5883'	-092°48.4995'	Waypoint	I	E	3.3	14-APR-08 13:47 SHOTTIME 1400
W	XS08A	+83°37.5864'	-091°16.0251'	Waypoint	I	E	29.4	14-APR-08 13:13 MISFIRE 1330
W	XS08B	+83°36.6121'	-091°19.1004'	Waypoint	I	E	20.3	4/15/2008 14:45
W	XS09A	+83°40.8098'	-089°39.3488'	Waypoint	I	E	12.6	14-APR-08 12:48 SHOTTIME 1300

FIRST GEOBUOY DEPLOYMENT SHOT LOCATIONS

AU01A	94.08065	82.599433	4/21/2008 12:00
AU02A	94.948133	83.402633	4/21/2008 12:45
AU03A	98.353933	84.456317	4/21/2008 11:55

SECOND GEOBUOY DEPLOYMENT SHOT LOCATIONS

AU01B	94.071333	82.597833*	4/23/2008 11:00
AU02B	94.837833	83.382166*	4/23/2008 10:40
AU03B	98.218483	84.413933	4/23/2008 10:50

* positions obtained from helicopter trackers

8.Shot and instrument location lists

The receiver positions quoted in the following pages correspond to the following times selected from the range of times in the shooting window:

Test line Shot IS02 March 29, 2008 17:00:00 UTC
Inner line Shot IS07A April 3, 2008 19:20:00 UTC
Outer line Shot OS1 April 7, 2008 22:35:00 UTC
Cross line A Shot XS01A April 14, 2008 19:25:00 UTC
Cross line B Shot XS02B April 15, 2008 20:11:00 UTC

Table 8.1: Shot and Instrument Locations

TEST LINE - RECEIVER POSITIONS

F	ID	Latitude	Longitude	Symbol	T	O	Alt(m)	Comment
W	IR001	+81°25.1098'	-092°35.9304'	Waypoint	I	E	-504.1	UNKNOWN POINT FEATURE
W	IR002	+81°26.1034'	-092°36.3446'	Waypoint	I	E	-492.7	UNKNOWN POINT FEATURE
W	IR003	+81°26.9155'	-092°37.1717'	Waypoint	I	E	-480.1	UNKNOWN POINT FEATURE
W	IR004	+81°27.7152'	-092°37.5163'	Waypoint	I	E	-462.2	UNKNOWN POINT FEATURE
W	IR005	+81°28.5763'	-092°39.0403'	Waypoint	I	E	-437.8	UNKNOWN POINT FEATURE
W	IR006	+81°29.3040'	-092°39.7464'	Waypoint	I	E	-414.1	UNKNOWN POINT FEATURE
W	IR007	+81°30.1690'	-092°40.6675'	Waypoint	I	E	-388	UNKNOWN POINT FEATURE
W	IR008	+81°31.0027'	-092°41.4235'	Waypoint	I	E	-360.9	UNKNOWN POINT FEATURE
W	IR009	+81°31.8370'	-092°42.1123'	Waypoint	I	E	-340.5	UNKNOWN POINT FEATURE
W	IR010	+81°32.6290'	-092°42.9787'	Waypoint	I	E	-326.2	UNKNOWN POINT FEATURE
W	IR011	+81°33.4493'	-092°43.9992'	Waypoint	I	E	-312.7	UNKNOWN POINT FEATURE
W	IR012	+81°34.3123'	-092°44.8286'	Waypoint	I	E	-300.2	UNKNOWN POINT FEATURE
W	IR013	+81°35.0112'	-092°46.0229'	Waypoint	I	E	-292.7	UNKNOWN POINT FEATURE
W	IR014	+81°35.8949'	-092°47.0232'	Waypoint	I	E	-283	UNKNOWN POINT FEATURE
W	IR015	+81°36.6744'	-092°48.4752'	Waypoint	I	E	-279.2	UNKNOWN POINT FEATURE
W	IR016	+81°37.5898'	-092°48.4392'	Waypoint	I	E	-270.3	UNKNOWN POINT FEATURE
W	IR017	+81°38.3515'	-092°49.3397'	Waypoint	I	E	-266.3	UNKNOWN POINT FEATURE
W	IR018	+81°39.1752'	-092°50.5440'	Waypoint	I	E	-262.5	UNKNOWN POINT FEATURE
W	IR019	+81°39.9941'	-092°51.7829'	Waypoint	I	E	-255.7	UNKNOWN POINT FEATURE
W	IR020	+81°40.8019'	-092°52.3046'	Waypoint	I	E	-249.7	UNKNOWN POINT FEATURE
W	IR021	+81°41.7230'	-092°53.5877'	Waypoint	I	E	-247.6	UNKNOWN POINT FEATURE
W	IR022	+81°42.5894'	-092°54.2784'	Waypoint	I	E	-246.7	UNKNOWN POINT FEATURE
W	IR023	+81°43.3661'	-092°55.7381'	Waypoint	I	E	-248.4	UNKNOWN POINT FEATURE

W	IR024	+81°44.1322'	-092°56.4648'	Waypoint	I	E	-248.4	UNKNOWN POINT FEATURE
W	IR025	+81°44.9746'	-092°57.4416'	Waypoint	I	E	-249.7	UNKNOWN POINT FEATURE
W	IR026	+81°45.7757'	-092°58.3992'	Waypoint	I	E	-249.9	UNKNOWN POINT FEATURE
W	IR027	+81°46.6339'	-092°59.3683'	Waypoint	I	E	-249.1	UNKNOWN POINT FEATURE
W	IR028	+81°47.4144'	-093°00.3010'	Waypoint	I	E	-247.4	UNKNOWN POINT FEATURE
W	IR029	+81°48.2347'	-093°01.2120'	Waypoint	I	E	-241.6	UNKNOWN POINT FEATURE
W	IR030	+81°49.0834'	-093°02.3462'	Waypoint	I	E	-235.8	UNKNOWN POINT FEATURE

INNER LINE - RECEIVER POSITIONS

F	ID	Latitude	Longitude	Symbol	T	O	Alt(m)	Comment
W	IR031	+81°49.0910'	-093°02.2925'	Waypoint	I	E	-235.7	UNKNOWN POINT FEATURE
W	IR032	+81°49.7294'	-093°03.1685'	Waypoint	I	E	-234.5	UNKNOWN POINT FEATURE
W	IR033	+81°50.3510'	-093°03.5914'	Waypoint	I	E	-233.9	UNKNOWN POINT FEATURE
W	IR034	+81°50.9717'	-093°04.4707'	Waypoint	I	E	-233.4	UNKNOWN POINT FEATURE
W	IR035	+81°51.6235'	-093°05.5867'	Waypoint	I	E	-233.7	UNKNOWN POINT FEATURE
W	IR036	+81°52.2518'	-093°05.9861'	Waypoint	I	E	-234.3	UNKNOWN POINT FEATURE
W	IR037	+81°52.7818'	-093°06.7925'	Waypoint	I	E	-234.6	UNKNOWN POINT FEATURE
W	IR038	+81°53.5910'	-093°07.5965'	Waypoint	I	E	-232.6	UNKNOWN POINT FEATURE
W	IR039	+81°54.1190'	-093°08.2334'	Waypoint	I	E	-230.7	UNKNOWN POINT FEATURE
W	IR040	+81°54.6826'	-093°08.9126'	Waypoint	I	E	-228.8	UNKNOWN POINT FEATURE
W	IR041	+81°55.2950'	-093°09.2813'	Waypoint	I	E	-226.9	UNKNOWN POINT FEATURE
W	IR042	+81°55.9752'	-093°10.4923'	Waypoint	I	E	-224.5	UNKNOWN POINT FEATURE
W	IR043	+81°56.5603'	-093°11.3462'	Waypoint	I	E	-222.3	UNKNOWN POINT FEATURE
W	IR044	+81°57.1915'	-093°12.0082'	Waypoint	I	E	-220.3	UNKNOWN POINT FEATURE
W	IR045	+81°57.8381'	-093°12.7421'	Waypoint	I	E	-226.1	UNKNOWN POINT FEATURE
W	IR046	+81°58.5038'	-093°13.6416'	Waypoint	I	E	-232.7	UNKNOWN POINT FEATURE
W	IR047	+81°59.1317'	-093°14.2862'	Waypoint	I	E	-239.9	UNKNOWN POINT FEATURE
W	IR048	+81°59.6851'	-093°15.0480'	Waypoint	I	E	-245.1	UNKNOWN POINT FEATURE
W	IR049	+82°00.3206'	-093°15.8875'	Waypoint	I	E	-251.2	UNKNOWN POINT FEATURE
W	IR050	+82°00.9768'	-093°16.6094'	Waypoint	I	E	-258.1	UNKNOWN POINT FEATURE
W	IR051	+82°01.6382'	-093°17.8229'	Waypoint	I	E	-264.7	UNKNOWN POINT FEATURE
W	IR052	+82°02.2397'	-093°18.4901'	Waypoint	I	E	-272.4	UNKNOWN POINT FEATURE
W	IR053	+82°02.8478'	-093°19.4770'	Waypoint	I	E	-279.6	UNKNOWN POINT FEATURE
W	IR054	+82°03.5117'	-093°19.7424'	Waypoint	I	E	-288.6	UNKNOWN POINT FEATURE
W	IR055	+82°04.0402'	-093°20.5210'	Waypoint	I	E	-293.9	UNKNOWN POINT FEATURE
W	IR056	+82°04.7059'	-093°21.4123'	Waypoint	I	E	-300	UNKNOWN POINT FEATURE
W	IR057	+82°05.4274'	-093°22.2317'	Waypoint	I	E	-306	UNKNOWN POINT FEATURE
W	IR058	+82°05.9582'	-093°23.2003'	Waypoint	I	E	-309.2	UNKNOWN POINT FEATURE
W	IR059	+82°06.6168'	-093°24.1205'	Waypoint	I	E	-313.3	UNKNOWN POINT FEATURE
W	IR060	+82°07.1621'	-093°24.5846'	Waypoint	I	E	-317	UNKNOWN POINT FEATURE
W	IR061	+82°07.8341'	-093°25.9267'	Waypoint	I	E	-319.8	UNKNOWN POINT FEATURE
W	IR062	+82°08.4845'	-093°26.6510'	Waypoint	I	E	-323.2	UNKNOWN POINT FEATURE
W	IR063	+82°09.0792'	-093°27.2251'	Waypoint	I	E	-326.1	UNKNOWN POINT FEATURE
W	IR064	+82°09.6326'	-093°28.4050'	Waypoint	I	E	-328.6	UNKNOWN POINT FEATURE
W	IR065	+82°10.3853'	-093°28.7645'	Waypoint	I	E	-333.4	UNKNOWN POINT FEATURE
W	IR066	+82°10.9267'	-093°29.5920'	Waypoint	I	E	-335.8	UNKNOWN POINT FEATURE
W	IR067	+82°11.6155'	-093°30.3134'	Waypoint	I	E	-341.1	UNKNOWN POINT FEATURE
W	IR068	+82°12.2290'	-093°31.3066'	Waypoint	I	E	-345.7	UNKNOWN POINT FEATURE
W	IR069	+82°12.8899'	-093°32.1797'	Waypoint	I	E	-350	UNKNOWN POINT FEATURE
W	IR070	+82°13.6128'	-093°32.8565'	Waypoint	I	E	-354.7	UNKNOWN POINT FEATURE

W	IR071	+82°14.1163'	-093°33.5890'	Waypoint	I	E	-357.6	UNKNOWN POINT FEATURE
W	IR072	+82°14.7216'	-093°34.3632'	Waypoint	I	E	-360.9	UNKNOWN POINT FEATURE
W	IR073	+82°15.3504'	-093°35.0246'	Waypoint	I	E	-364.1	UNKNOWN POINT FEATURE
W	IR074	+82°16.0435'	-093°36.2510'	Waypoint	I	E	-366.7	UNKNOWN POINT FEATURE
W	IR075	+82°16.5922'	-093°36.8424'	Waypoint	I	E	-368.3	UNKNOWN POINT FEATURE
W	IR076	+82°17.2570'	-093°37.4779'	Waypoint	I	E	-369.3	UNKNOWN POINT FEATURE
W	IR077	+82°17.8992'	-093°38.6040'	Waypoint	I	E	-367.8	UNKNOWN POINT FEATURE
W	IR078	+82°18.4704'	-093°39.4032'	Waypoint	I	E	-366.2	UNKNOWN POINT FEATURE
W	IR079	+82°19.1054'	-093°40.1933'	Waypoint	I	E	-364.1	UNKNOWN POINT FEATURE
W	IR080	+82°19.7909'	-093°41.0074'	Waypoint	I	E	-360.2	UNKNOWN POINT FEATURE
W	IR081	+82°20.3856'	-093°41.8718'	Waypoint	I	E	-356.8	UNKNOWN POINT FEATURE
W	IR082	+82°20.9698'	-093°42.3648'	Waypoint	I	E	-354	UNKNOWN POINT FEATURE
W	IR083	+82°21.5760'	-093°43.6872'	Waypoint	I	E	-351.8	UNKNOWN POINT FEATURE
W	IR084	+82°22.1770'	-093°44.3818'	Waypoint	I	E	-349.8	UNKNOWN POINT FEATURE
W	IR085	+82°22.8672'	-093°45.1512'	Waypoint	I	E	-346.8	UNKNOWN POINT FEATURE
W	IR086	+82°23.4571'	-093°45.8990'	Waypoint	I	E	-344.7	UNKNOWN POINT FEATURE
W	IR087	+82°24.0941'	-093°46.9829'	Waypoint	I	E	-343.1	UNKNOWN POINT FEATURE
W	IR088	+82°24.7445'	-093°48.0288'	Waypoint	I	E	-340.7	UNKNOWN POINT FEATURE
W	IR089	+82°25.3656'	-093°48.6346'	Waypoint	I	E	-340.1	UNKNOWN POINT FEATURE
W	IR090	+82°25.9584'	-093°49.5576'	Waypoint	I	E	-342.4	UNKNOWN POINT FEATURE
W	IR091	+82°26.5738'	-093°50.3357'	Waypoint	I	E	-344.2	UNKNOWN POINT FEATURE
W	IR092	+82°27.2510'	-093°51.7838'	Waypoint	I	E	-347.5	UNKNOWN POINT FEATURE
W	IR093	+82°27.9062'	-093°52.8302'	Waypoint	I	E	-353.5	UNKNOWN POINT FEATURE
W	IR094	+82°28.5643'	-093°53.1691'	Waypoint	I	E	-358.9	UNKNOWN POINT FEATURE
W	IR095	+82°29.0530'	-093°53.8627'	Waypoint	I	E	-363.8	UNKNOWN POINT FEATURE
W	IR096	+82°29.7432'	-093°54.8026'	Waypoint	I	E	-371.5	UNKNOWN POINT FEATURE
W	IR097	+82°30.3216'	-093°56.1178'	Waypoint	I	E	-378.6	UNKNOWN POINT FEATURE
W	IR098	+82°30.9941'	-093°56.9342'	Waypoint	I	E	-385.7	UNKNOWN POINT FEATURE
W	IR099	+82°31.6862'	-093°57.7618'	Waypoint	I	E	-391.4	UNKNOWN POINT FEATURE
W	IR100	+82°32.2464'	-093°58.8782'	Waypoint	I	E	-396	UNKNOWN POINT FEATURE
W	IR101	+82°32.8733'	-093°59.3818'	Waypoint	I	E	-400	UNKNOWN POINT FEATURE
W	IR102	+82°33.5232'	-094°00.3907'	Waypoint	I	E	-404.3	UNKNOWN POINT FEATURE
W	IR103	+82°34.1309'	-094°01.2269'	Waypoint	I	E	-408.5	UNKNOWN POINT FEATURE
W	IR104	+82°34.7736'	-094°02.0016'	Waypoint	I	E	-413.5	UNKNOWN POINT FEATURE
W	IR105	+82°35.3990'	-094°03.1166'	Waypoint	I	E	-418.7	UNKNOWN POINT FEATURE
W	IR106	+82°35.9856'	-094°03.8074'	Waypoint	I	E	-423.3	UNKNOWN POINT FEATURE
W	IR107	+82°36.6826'	-094°04.6843'	Waypoint	I	E	-428.8	UNKNOWN POINT FEATURE
W	IR108	+82°37.2634'	-094°05.6784'	Waypoint	I	E	-433.6	UNKNOWN POINT FEATURE
W	IR109	+82°37.8384'	-094°06.4901'	Waypoint	I	E	-438.2	UNKNOWN POINT FEATURE
W	IR110	+82°38.4653'	-094°07.2053'	Waypoint	I	E	-443.2	UNKNOWN POINT FEATURE
W	IR111	+82°39.0523'	-094°08.1014'	Waypoint	I	E	-448.4	UNKNOWN POINT FEATURE
W	IR112	+82°39.6470'	-094°09.0206'	Waypoint	I	E	-452.6	UNKNOWN POINT FEATURE
W	IR113	+82°40.2998'	-094°10.0430'	Waypoint	I	E	-457.1	UNKNOWN POINT FEATURE
W	IR114	+82°40.9502'	-094°11.4125'	Waypoint	I	E	-461.7	UNKNOWN POINT FEATURE
W	IR115	+82°41.5915'	-094°11.9294'	Waypoint	I	E	-464.5	UNKNOWN POINT FEATURE
W	IR116	+82°42.1762'	-094°12.7114'	Waypoint	I	E	-466.3	UNKNOWN POINT FEATURE
W	IR117	+82°42.9038'	-094°13.9133'	Waypoint	I	E	-467.8	UNKNOWN POINT FEATURE
W	IR118	+82°43.4443'	-094°14.6606'	Waypoint	I	E	-470.8	UNKNOWN POINT FEATURE
W	IR119	+82°44.1062'	-094°15.7690'	Waypoint	I	E	-474.3	UNKNOWN POINT FEATURE
W	IR120	+82°44.7931'	-094°16.5802'	Waypoint	I	E	-476.1	UNKNOWN POINT FEATURE

W	IR121	+82°45.3533'	-094°18.3341'	Waypoint	I	E	-495.9	UNKNOWN POINT FEATURE
W	IR122	+82°46.0555'	-094°18.7277'	Waypoint	I	E	-526.2	UNKNOWN POINT FEATURE
W	IR123	+82°46.6349'	-094°20.2781'	Waypoint	I	E	-555.5	UNKNOWN POINT FEATURE
W	IR124	+82°47.1869'	-094°20.1446'	Waypoint	I	E	-578.1	UNKNOWN POINT FEATURE
W	IR125	+82°47.8234'	-094°21.8131'	Waypoint	I	E	-633.3	UNKNOWN POINT FEATURE
W	IR126	+82°48.4555'	-094°22.7030'	Waypoint	I	E	-689.9	UNKNOWN POINT FEATURE
W	IR127	+82°49.0104'	-094°23.9774'	Waypoint	I	E	-743	UNKNOWN POINT FEATURE
W	IR128	+82°49.8216'	-094°24.3494'	Waypoint	I	E	-825.2	UNKNOWN POINT FEATURE
W	IR129	+82°50.2858'	-094°25.1347'	Waypoint	I	E	-874.7	UNKNOWN POINT FEATURE
W	IR130	+82°50.8978'	-094°26.2104'	Waypoint	I	E	-939.3	UNKNOWN POINT FEATURE
W	IR131	+82°51.5501'	-094°27.3542'	Waypoint	I	E	-1000.2	UNKNOWN POINT FEATURE
W	IR133	+82°52.8509'	-094°29.1739'	Waypoint	I	E	-1113.1	UNKNOWN POINT FEATURE
W	IR134	+82°53.4730'	-094°30.3062'	Waypoint	I	E	-1151.3	UNKNOWN POINT FEATURE
W	IR135	+82°54.0365'	-094°31.1376'	Waypoint	I	E	-1180.4	UNKNOWN POINT FEATURE
W	IR136	+82°54.7661'	-094°31.9781'	Waypoint	I	E	-1216.4	UNKNOWN POINT FEATURE
W	IR137	+82°55.3075'	-094°33.2366'	Waypoint	I	E	-1248.4	UNKNOWN POINT FEATURE
W	IR138	+82°55.9358'	-094°34.1736'	Waypoint	I	E	-1286.9	UNKNOWN POINT FEATURE
W	IR139	+82°56.6270'	-094°34.6877'	Waypoint	I	E	-1328.3	UNKNOWN POINT FEATURE
W	IR140	+82°57.1498'	-094°35.8949'	Waypoint	I	E	-1365.9	UNKNOWN POINT FEATURE
W	IR141	+82°57.7718'	-094°37.1189'	Waypoint	I	E	-1406.4	UNKNOWN POINT FEATURE
W	IR142	+82°58.4189'	-094°38.3659'	Waypoint	I	E	-1447.8	UNKNOWN POINT FEATURE
W	IR143	+82°59.1456'	-094°39.4373'	Waypoint	I	E	-1492.6	UNKNOWN POINT FEATURE
W	IR144	+82°59.7230'	-094°40.1755'	Waypoint	I	E	-1525.6	UNKNOWN POINT FEATURE
W	IR145	+83°00.2928'	-094°41.1845'	Waypoint	I	E	-1556.9	UNKNOWN POINT FEATURE

OUTER LINE - RECEIVER POSITIONS

F	ID	Latitude	Longitude	Symbol	T	O	Alt(m)	Comment
W	OR001A	+82°59.3150'	-094°43.3776'	Waypoint	I	E	-1508.9	RECEIVER
W	OR002A	+83°00.1478'	-094°45.2914'	Waypoint	I	E	-1558.4	RECEIVER
W	OR003A	+83°00.8842'	-094°46.7232'	Waypoint	I	E	-1596	RECEIVER
W	OR004A	+83°01.6930'	-094°48.0677'	Waypoint	I	E	-1631.8	RECEIVER
W	OR005A	+83°02.5747'	-094°49.5936'	Waypoint	I	E	-1672.5	RECEIVER
W	OR006A	+83°03.3307'	-094°51.1632'	Waypoint	I	E	-1716.9	RECEIVER
W	OR007A	+83°04.0358'	-094°52.3642'	Waypoint	I	E	-1755.5	RECEIVER
W	OR008A	+83°04.9603'	-094°53.2579'	Waypoint	I	E	-1793.6	RECEIVER
W	OR009A	+83°05.6717'	-094°54.9182'	Waypoint	I	E	-1812.1	RECEIVER
W	OR010A	+83°06.4637'	-094°56.7154'	Waypoint	I	E	-1829.8	RECEIVER
W	OR011A	+83°07.2494'	-094°57.8789'	Waypoint	I	E	-1848.2	RECEIVER
W	OR012A	+83°08.0779'	-094°59.6554'	Waypoint	I	E	-1867.9	RECEIVER
W	OR013A	+83°09.0043'	-095°01.4419'	Waypoint	I	E	-1889	RECEIVER
W	OR014A	+83°09.7915'	-095°02.6933'	Waypoint	I	E	-1905.9	RECEIVER
W	OR015A	+83°10.5552'	-095°03.1747'	Waypoint	I	E	-1920.6	RECEIVER
W	OR016A	+83°11.2483'	-095°05.2690'	Waypoint	I	E	-1933	RECEIVER
W	OR017A	+83°12.1613'	-095°07.4458'	Waypoint	I	E	-1948.2	RECEIVER
W	OR018A	+83°12.9677'	-095°08.3616'	Waypoint	I	E	-1957.1	RECEIVER
W	OR019A	+83°13.6584'	-095°09.9706'	Waypoint	I	E	-1963.7	RECEIVER
W	OR020A	+83°14.4086'	-095°11.1773'	Waypoint	I	E	-1970	RECEIVER
W	OR021A	+83°15.1541'	-095°12.6226'	Waypoint	I	E	-1974.4	RECEIVER
W	OR022A	+83°16.1208'	-095°14.6266'	Waypoint	I	E	-1979.5	RECEIVER
W	OR023A	+83°16.8053'	-095°15.7896'	Waypoint	I	E	-1982.3	RECEIVER

W	OR024A	+83°17.6026'	-095°17.4168'	Waypoint	I	E	-1984.5	RECEIVER
W	OR025A	+83°18.4219'	-095°18.9288'	Waypoint	I	E	-1984.6	RECEIVER
W	OR026A	+83°19.1995'	-095°20.4082'	Waypoint	I	E	-1982	RECEIVER
W	OR027A	+83°20.0112'	-095°22.0070'	Waypoint	I	E	-1978.7	RECEIVER
W	OR028A	+83°20.7926'	-095°23.4010'	Waypoint	I	E	-1976.5	RECEIVER
W	OR029A	+83°21.6235'	-095°25.1520'	Waypoint	I	E	-1976.8	RECEIVER
W	OR030A	+83°22.4083'	-095°26.6150'	Waypoint	I	E	-1978	RECEIVER
W	OR031A	+83°23.2958'	-095°28.2518'	Waypoint	I	E	-1980	RECEIVER
W	OR032A	+83°23.9568'	-095°29.5896'	Waypoint	I	E	-1982.1	RECEIVER
W	OR033A	+83°24.7627'	-095°30.8429'	Waypoint	I	E	-1979.9	RECEIVER
W	OR034A	+83°25.5758'	-095°32.3894'	Waypoint	I	E	-1977.1	RECEIVER
W	OR035A	+83°26.3419'	-095°33.9216'	Waypoint	I	E	-1969.9	RECEIVER
W	OR036A	+83°27.1680'	-095°36.0634'	Waypoint	I	E	-1939.4	RECEIVER
W	OR037A	+83°27.9062'	-095°37.1035'	Waypoint	I	E	-1912.8	RECEIVER
W	OR038A	+83°28.6747'	-095°38.8829'	Waypoint	I	E	-1866.4	RECEIVER
W	OR039A	+83°29.4149'	-095°40.4534'	Waypoint	I	E	-1811.2	RECEIVER
W	OR040A	+83°30.2434'	-095°41.8128'	Waypoint	I	E	-1744.6	RECEIVER
W	OR041A	+83°31.0718'	-095°43.4717'	Waypoint	I	E	-1634	RECEIVER
W	OR042A	+83°31.8432'	-095°45.0437'	Waypoint	I	E	-1525.9	RECEIVER
W	OR043A	+83°32.6237'	-095°46.7635'	Waypoint	I	E	-1438	RECEIVER
W	OR044A	+83°33.5602'	-095°48.4358'	Waypoint	I	E	-1358.5	RECEIVER
W	OR045A	+83°34.2197'	-095°50.0304'	Waypoint	I	E	-1314.2	RECEIVER
W	OR046A	+83°35.0074'	-095°52.1650'	Waypoint	I	E	-1279.8	RECEIVER
W	OR047A	+83°35.8234'	-095°53.4624'	Waypoint	I	E	-1248.4	RECEIVER
W	OR048A	+83°36.5438'	-095°55.0142'	Waypoint	I	E	-1230.5	RECEIVER
W	OR049A	+83°37.3094'	-095°56.7950'	Waypoint	I	E	-1216.4	RECEIVER
W	OR050A	+83°38.0976'	-095°58.4933'	Waypoint	I	E	-1204.3	RECEIVER
W	OR051A	+83°38.9309'	-096°01.0675'	Waypoint	I	E	-1202.1	RECEIVER
W	OR052A	+83°39.6787'	-096°02.5133'	Waypoint	I	E	-1200.5	RECEIVER
W	OR053A	+83°40.4856'	-096°03.8318'	Waypoint	I	E	-1201.1	RECEIVER
W	OR054A	+83°41.2675'	-096°05.4298'	Waypoint	I	E	-1204	RECEIVER
W	OR055A	+83°42.0326'	-096°07.1578'	Waypoint	I	E	-1208.8	RECEIVER
W	OR056A	+83°42.9115'	-096°09.1238'	Waypoint	I	E	-1219	RECEIVER
W	OR057A	+83°43.6944'	-096°10.8547'	Waypoint	I	E	-1229.2	RECEIVER
W	OR058A	+83°44.4696'	-096°12.6850'	Waypoint	I	E	-1238.4	RECEIVER
W	OR059A	+83°45.4013'	-096°12.7574'	Waypoint	I	E	-1255.1	RECEIVER
W	OR060A	+83°46.2082'	-096°14.8958'	Waypoint	I	E	-1267	RECEIVER
W	OR061A	+83°47.0122'	-096°17.2018'	Waypoint	I	E	-1277.7	RECEIVER
W	OR062A	+83°47.8008'	-096°18.5155'	Waypoint	I	E	-1289.2	RECEIVER
W	OR063A	+83°48.6461'	-096°20.2474'	Waypoint	I	E	-1308.5	RECEIVER
W	OR064A	+83°49.3661'	-096°22.1294'	Waypoint	I	E	-1324.2	RECEIVER
W	OR065A	+83°50.1480'	-096°24.2155'	Waypoint	I	E	-1408.1	RECEIVER
W	OR066A	+83°51.0389'	-096°26.1950'	Waypoint	I	E	-1556.4	RECEIVER
W	OR067A	+83°51.7474'	-096°27.7262'	Waypoint	I	E	-1649.4	RECEIVER
W	OR068A	+83°52.5365'	-096°29.4062'	Waypoint	I	E	-1734.5	RECEIVER
W	OR069A	+83°53.3477'	-096°31.3910'	Waypoint	I	E	-1846	RECEIVER
W	OR070A	+83°54.1310'	-096°33.1258'	Waypoint	I	E	-1939.1	RECEIVER
W	OR071A	+83°54.9206'	-096°34.9968'	Waypoint	I	E	-1997.4	RECEIVER
W	OR072A	+83°55.7189'	-096°37.0435'	Waypoint	I	E	-2044.4	RECEIVER
W	OR073A	+83°56.5565'	-096°38.7960'	Waypoint	I	E	-2045.3	RECEIVER

W	OR074A	+83°57.3053'	-096°40.6325'	Waypoint	I	E	-2041.7	RECEIVER
W	OR075A	+83°58.1357'	-096°42.5218'	Waypoint	I	E	-2028.3	RECEIVER
W	OR076A	+83°58.9272'	-096°44.2550'	Waypoint	I	E	-2010.2	RECEIVER
W	OR077A	+83°59.7552'	-096°45.6557'	Waypoint	I	E	-1993.1	RECEIVER
W	OR078A	+84°00.5933'	-096°47.9011'	Waypoint	I	E	-1973.4	RECEIVER
W	OR079A	+84°01.3195'	-096°49.8605'	Waypoint	I	E	-1957.3	RECEIVER
W	OR080A	+84°02.1360'	-096°51.5491'	Waypoint	I	E	-1955.5	RECEIVER
W	OR081A	+84°02.9083'	-096°53.3597'	Waypoint	I	E	-1958.4	RECEIVER
W	OR082A	+84°03.7272'	-096°55.2773'	Waypoint	I	E	-1964.9	RECEIVER
W	OR083A	+84°04.5202'	-096°57.5088'	Waypoint	I	E	-1968.6	RECEIVER
W	OR084A	+84°05.3299'	-096°59.6597'	Waypoint	I	E	-1968.4	RECEIVER
W	OR085A	+84°06.1315'	-097°01.0267'	Waypoint	I	E	-1950	RECEIVER
W	OR086A	+84°06.8328'	-097°03.3581'	Waypoint	I	E	-1933.9	RECEIVER
W	OR087A	+84°07.5874'	-097°05.5253'	Waypoint	I	E	-1929.8	RECEIVER
W	OR088A	+84°08.3986'	-097°07.4122'	Waypoint	I	E	-1944.4	RECEIVER
W	OR089A	+84°09.1906'	-097°09.5136'	Waypoint	I	E	-1956.8	RECEIVER
W	OR090A	+84°09.9749'	-097°11.5325'	Waypoint	I	E	-1967.1	RECEIVER
W	OR091A	+84°10.7539'	-097°13.2970'	Waypoint	I	E	-1981	RECEIVER
W	OR092A	+84°11.5421'	-097°15.4531'	Waypoint	I	E	-1985.7	RECEIVER
W	OR093A	+84°12.2683'	-097°17.2214'	Waypoint	I	E	-1958.1	RECEIVER
W	OR094A	+84°13.0493'	-097°18.9595'	Waypoint	I	E	-1924.1	RECEIVER
W	OR095A	+84°13.9186'	-097°21.5318'	Waypoint	I	E	-1849.3	RECEIVER
W	OR096A	+84°14.6395'	-097°23.8152'	Waypoint	I	E	-1770.3	RECEIVER
W	OR097A	+84°15.3950'	-097°26.6222'	Waypoint	I	E	-1692.9	RECEIVER
W	OR098A	+84°16.1899'	-097°28.0603'	Waypoint	I	E	-1656	RECEIVER
W	OR099A	+84°17.0261'	-097°30.1637'	Waypoint	I	E	-1620	RECEIVER
W	OR100A	+84°17.7850'	-097°32.3098'	Waypoint	I	E	-1660.3	RECEIVER
W	OR101A	+84°18.5904'	-097°34.5874'	Waypoint	I	E	-1715.7	RECEIVER
W	OR102A	+84°19.3598'	-097°36.1133'	Waypoint	I	E	-1756.3	RECEIVER
W	OR103A	+84°20.1230'	-097°38.5814'	Waypoint	I	E	-1780.4	RECEIVER
W	OR104A	+84°20.9501'	-097°40.8202'	Waypoint	I	E	-1797.3	RECEIVER
W	OR105A	+84°21.7109'	-097°42.8323'	Waypoint	I	E	-1799.6	RECEIVER
W	OR106A	+84°22.5331'	-097°44.9568'	Waypoint	I	E	-1800.1	RECEIVER
W	OR107A	+84°23.3635'	-097°47.2886'	Waypoint	I	E	-1800	RECEIVER
W	OR108A	+84°24.1070'	-097°49.1410'	Waypoint	I	E	-1800	RECEIVER
W	OR109A	+84°24.9797'	-097°51.6038'	Waypoint	I	E	-1800	RECEIVER
W	OR110A	+84°25.7117'	-097°53.4336'	Waypoint	I	E	-1800.1	RECEIVER
W	OR111A	+84°26.5066'	-097°55.5034'	Waypoint	I	E	-1800	RECEIVER
W	OR112A	+84°27.3216'	-097°57.8314'	Waypoint	I	E	-1800.9	RECEIVER
W	OR113A	+84°28.1040'	-098°00.1747'	Waypoint	I	E	-1803.2	RECEIVER
W	OR114A	+84°28.8730'	-098°02.5642'	Waypoint	I	E	-1805.9	RECEIVER
W	OR115A	+84°29.6578'	-098°04.5610'	Waypoint	I	E	-1804.6	RECEIVER

CROSS LINE - RECEIVER POSITIONS - DAY 1

F	ID	Latitude	Longitude	Symbol	T	O	Alt(m)	Comment
	1	83.07192	-101.428528					
	2	83.076984	-101.34188					
	3	83.085848	-101.23924					
	4	83.091184	-101.140576					
	5	83.09892	-101.041024					

6	83.105248	-100.939864
7	83.112048	-100.851888
8	83.118728	-100.75052
9	83.126648	-100.60596
10	83.1312	-100.549048
11	83.137336	-100.455128
12	83.144648	-100.35876
13	83.150704	-100.243808
14	83.157216	-100.152392
15	83.164728	-100.050584
16	83.170144	-99.942992
17	83.176456	-99.85532
18	83.18356	-99.739456
19	83.190872	-99.644336
20	83.196376	-99.537696
21	83.203864	-99.430208
22	83.209888	-99.326216
23	83.217136	-99.229496
24	83.223096	-99.126304
25	83.226416	-99.05888
26	83.231368	-98.961136
27	83.238568	-98.878984
28	83.24508	-98.75572
29	83.251144	-98.65512
30	83.256992	-98.551056
31	83.264256	-98.450352
32	83.27004	-98.345432
33	83.276672	-98.243736
34	83.283496	-98.130456
35	83.288776	-98.034984
36	83.294824	-97.933656
37	83.302136	-97.836032
38	83.30688	-97.726784
39	83.312912	-97.627504
40	83.318728	-97.521912
41	83.324712	-97.416736
42	83.330168	-97.312504
43	83.33556	-97.21788
44	83.342504	-97.11028
45	83.348216	-97.002192
46	83.353904	-96.8826
47	83.358872	-96.78772
48	83.365	-96.684144
49	83.37152	-96.572424
50	83.376664	-96.47032
51	83.382312	-96.365576
52	83.388056	-96.267072
53	83.393376	-96.15276
54	83.398984	-96.04876
55	83.403768	-95.964528

56	83.408952	-95.851488
57	83.4146	-95.7442
58	83.42056	-95.630264
59	83.426008	-95.524888
60	83.431632	-95.416952
61	83.437336	-95.309056
62	83.443056	-95.196736
63	83.448776	-95.0876
64	83.454496	-94.976936
65	83.459216	-94.885008
66	83.46492	-94.75724
67	83.471928	-94.65348
68	83.476344	-94.534992
69	83.482376	-94.419808
70	83.487592	-94.31476
71	83.49268	-94.215608
72	83.497648	-94.100584
73	83.502744	-93.990704
74	83.50812	-93.873032
75	83.510448	-93.810232
76	83.516904	-93.692032
77	83.521552	-93.582568
78	83.52684	-93.46596
79	83.531656	-93.354344
80	83.536832	-93.242552
81	83.542008	-93.125488
82	83.546888	-93.015976
83	83.552056	-92.89916
84	83.556736	-92.786056
85	83.561648	-92.684632
86	83.566904	-92.560736
87	83.571408	-92.448144
88	83.575968	-92.343704
89	83.581184	-92.220768
90	83.586048	-92.112072
91	83.590504	-92.00936
92	83.596952	-91.876776
93	83.601144	-91.77076
94	83.606896	-91.62356
95	83.607176	-91.590672
96	83.612328	-91.469824
97	83.61732	-91.35044
98	83.621704	-91.23132
99	83.626576	-91.11916
100	83.631064	-90.99964
101	83.635752	-90.879544
102	83.640008	-90.771536
103	83.644632	-90.643288
104	83.648824	-90.540648
105	83.654064	-90.41872
106	83.657408	-90.302728

107	83.6642	-90.1754
108	83.6686	-90.071416
109	83.67356	-89.960408
110	83.676024	-89.839448
111	83.681344	-89.712792
112	83.685392	-89.59536
113	83.690128	-89.4694
114	83.693336	-89.372712

CROSS LINE - RECEIVER POSITIONS - DAY 2

F	ID--------	Latitude	Longitude	Symbol------	T	O	Alt(m)	Comment
	1	83.04712	-101.493392					
	2	83.0522	-101.407008					
	3	83.061056	-101.304664					
	4	83.066392	-101.206328					
	5	83.074104	-101.107168					
	6	83.08044	-101.006376					
	7	83.08724	-100.918672					
	8	83.093912	-100.817688					
	9	83.101928	-100.674424					
	10	83.10676	-100.617792					
	11	83.112888	-100.52416					
	12	83.120184	-100.428168					
	13	83.126248	-100.313576					
	14	83.132768	-100.22248					
	15	83.140272	-100.120992					
	16	83.14568	-100.013808					
	17	83.152016	-99.926712					
	18	83.159136	-99.811344					
	19	83.167136	-99.710992					
	20	83.173192	-99.594896					
	21	83.180664	-99.487832					
	22	83.186688	-99.3842					
	23	83.193936	-99.287824					
	24	83.19992	-99.184944					
	25	83.203248	-99.11776					
	26	83.208192	-99.020312					
	27	83.215392	-98.938528					
	28	83.22192	-98.81564					
	29	83.227968	-98.715432					
	30	83.233824	-98.611776					
	31	83.243024	-98.514744					
	32	83.248856	-98.41032					
	33	83.255528	-98.309136					
	34	83.262392	-98.196432					
	35	83.267712	-98.101432					
	36	83.2738	-98.000576					
	37	83.281152	-97.90348					
	38	83.285944	-97.794768					
	39	83.292016	-97.69596					

40	83.297864	-97.590864
41	83.303928	-97.486192
42	83.30944	-97.382112
43	83.314808	-97.287776
44	83.321736	-97.180384
45	83.327432	-97.072592
46	83.334016	-96.929304
47	83.338952	-96.834576
48	83.345032	-96.731144
49	83.351512	-96.61952
50	83.356616	-96.517664
51	83.362232	-96.412992
52	83.368456	-96.313032
53	83.373864	-96.1988
54	83.379472	-96.095104
55	83.384248	-96.01108
56	83.389432	-95.898376
57	83.395088	-95.79136
58	83.401056	-95.677752
59	83.410376	-95.556392
60	83.416032	-95.44876
61	83.42176	-95.340976
62	83.427496	-95.229064
63	83.433256	-95.120272
64	83.439016	-95.010008
65	83.443744	-94.91844
66	83.449488	-94.791128
67	83.456608	-94.687744
68	83.461032	-94.569584
69	83.467088	-94.454704
70	83.472296	-94.349936
71	83.4774	-94.251088
72	83.482376	-94.136336
73	83.48748	-94.026752
74	83.492872	-93.90936
75	83.495208	-93.846696
76	83.50168	-93.728856
77	83.506336	-93.619624
78	83.511632	-93.5034
79	83.516464	-93.392056
80	83.521648	-93.28056
81	83.526832	-93.163808
82	83.531728	-93.054608
83	83.536912	-92.938064
84	83.5416	-92.825288
85	83.546528	-92.724088
86	83.551784	-92.60056
87	83.556304	-92.488312
88	83.560864	-92.384144
89	83.566112	-92.261528
90	83.570976	-92.153088

91	83.575448	-92.050648
92	83.581904	-91.918424
93	83.586112	-91.81272
94	83.59188	-91.66596
95	83.59216	-91.633128
96	83.59732	-91.512584
97	83.602336	-91.393536
98	83.606736	-91.274688
99	83.611608	-91.162824
100	83.616104	-91.043664
101	83.62084	-90.922504
102	83.625104	-90.81476
103	83.629728	-90.686912
104	83.63392	-90.584496
105	83.639176	-90.462824
106	83.642536	-90.347144
107	83.649336	-90.220144
108	83.653736	-90.116448
109	83.658712	-90.005704
110	83.661176	-89.885064
111	83.666512	-89.758712
112	83.670552	-89.641552
113	83.675304	-89.51596
114	83.678512	-89.419536

9.Seismic Reflection Acquisition Report

Mike Gorveatt and Greg Middleton

9.1. Report

The purpose of the ARTA field seismic program is to acquire data on the nature of the Earth's crust beneath the Ellesmere Island margin and Alpha Ridge.
During the ARTA Seismic Refraction Program, single channel seismic data was collected at a Northern Seismic Ice Camp, referred to throughout this document as "North Camp". The North Camp was situated near the middle of the ARTA Refraction work area (83.49°N, 92.83°W). The single channel seismic data was collected with a 10 cubic inch sleeve gun as the sound source and three IKB hydrophones suspended under the ice as receivers. The full system was housed in two tents. One of the tents contained the electronics and another housed the sound source and compressor.

The tent for the sound source (Figure 9.1) contained a compressor, air bottles, sleeve gun, hydro hole and the GPS navigation antenna. The tent was a 3.66 x 3.66 meter Polarhaven with zippered doors in each end. It was erected directly on the ice to help stabilize the equipment inside and to help reduce unwanted vibration. Exhaust from the compressor was vented to the outside by flex pipe and fresh outside air was drawn into the tent from the outside with another flex pipe. Dry, fresh outside air was drawn into the compressor in an effort to reduce the humidity in the compressor and therefore reduce the chance of getting water vapour in the sleeve gun and causing misfires.

The compressor system was a Jordair Compressor Model K100DH. The air compressor in this system is a Baurer IK-100II which can manufacture 85 litres per minute (3 cubic feet) of high pressure air. The compressor was driven by a 6.5HP Yanmar Diesel engine.

Pressurized air was piped to a bank of four high pressure storage bottles and through a pressure control valve which was set to 1600 lbs. Before passing on to the airguns, the air was treated by a water separator filter fitted to the outlet of the compressor and then injected with non-toxic anti-freeze (no-tox II) which was attached to the outlet of the storage bottles.

Navigation data was collected by a Novatel GPS receiver from an antenna secured to a pole mounted outside the compressor tent and sent from there to the REGULUS II navigation system in the electronics tent (64 m away). From there, the signal was fed to the GSC DIGS for positioning. The camp travelled a total of 26.1 kilometres at an average speed of 0.0725 km/hr. (Fig: 9.5)
The airgun was suspended from a four-way steel bridle attached to a 6 mm braided nylon rope fastened to a point over the hydro hole. The hydro hole was approximately 75 cm in diameter and was made with a 25 cm gasoline-powered ice auger. Five 25 cm. holes where drilled in a circle and chiselled out the make the working hole. A wooden frame was manufactured over the hydro hole to support the sleeve gun.

Fig 9.1: ARTA Compressor Tent

Fig: 9.2 ARTA Electronics Tent

110 volt electrical power for the compressor tent and the electronics were supplied by a 3700 watt Yanmar air cooled diesel generator model YDG 3700 EV-E. This provided lots of power and worked continuously; the backup was not required.

The electronics were housed in a 5.5 by 5.5 meter Polarhaven tent (Figure 9.2) situated 68.58 m north of the Compressor tent. This tent housed all the electronics required to collect our single channel seismic data. The two tents were connected by four cables:

- 110 volt electrical power supply from the generator located outside the compressor tent to the electronics tent,
- navigation feed, carrying the GPS signal from the receiver in the compressor tent to the Regulus II system in the electronics tent,
- an airgun firing line which carried the shot signal from the AGC firing box to the sleeve gun and the, and
- the blast phone lead-in cable. The blast phone was left suspended in the sleeve gun hole at a depth of 75 meters. This made it easier to calibrate a new gun or a change in gun depth when required.

The reflection data stream was collected by the three IKB hydrophones suspended 4.6 m under the surface and 1.83 m below the bottom of the ice. These hydrophones were placed 3.96 m apart and to the north side of the electronics tent which placed them 74.68 m from the sleeve gun.

The electronics consisted of the Regulus II navigation system which received the navigation from the Novatel receiver and sent the data through a Network switch to the GSC DIGS. The timing for the sleeve gun was supplied by the MITS timing system which sent the trigger signal to the GSC DIGS through the digital interface box and to the trigger box for the sleeve gun. The trigger box then amplified the trigger and sent it to the sleeve gun. The data received by the hydrophones was sent the SCU-6 box through the digital interface and on to the GSC DIGS to be integrated with the navigation, recorded, and saved (Figure 9.3).

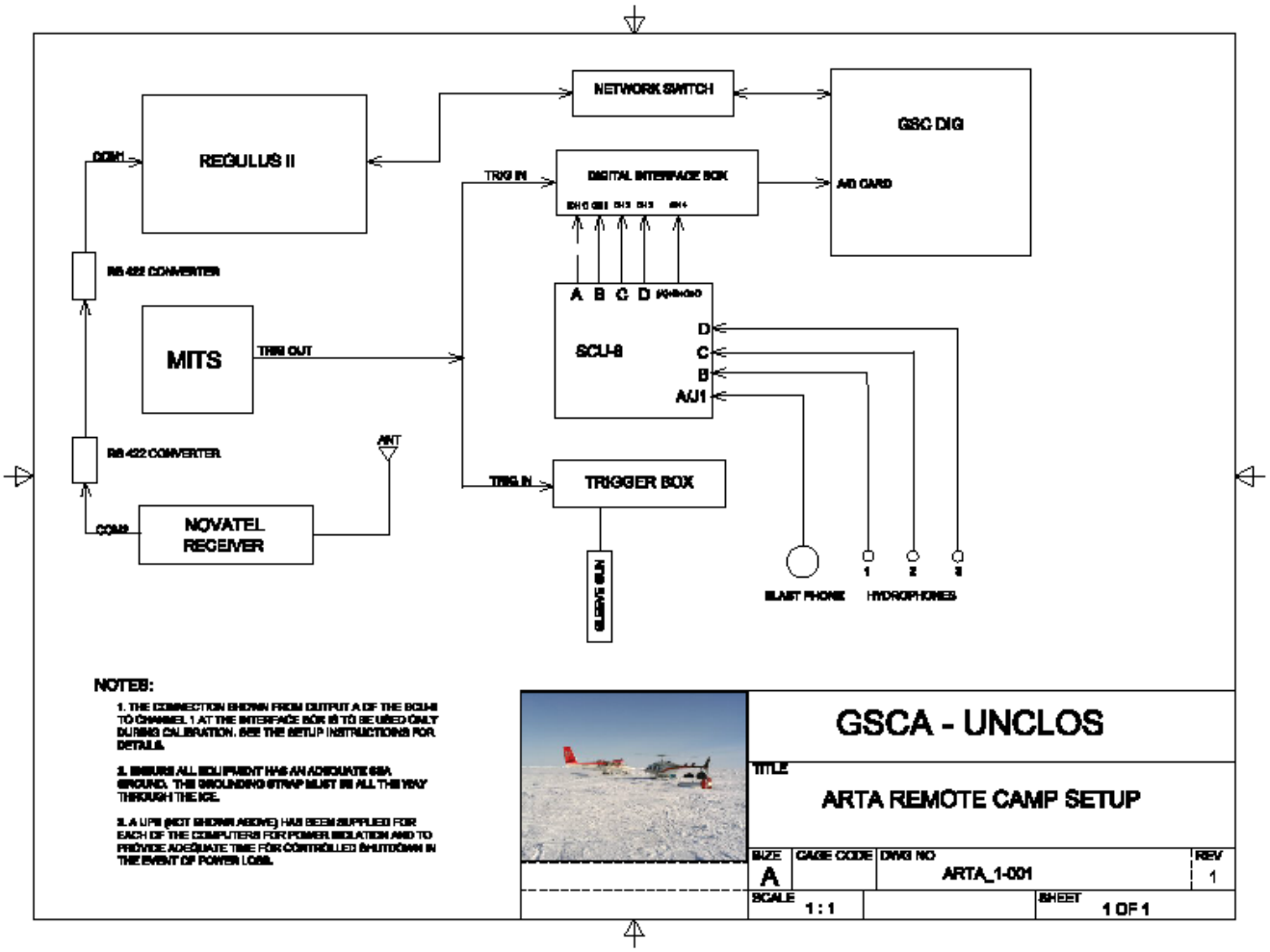


Fig: 9.3 ARTA Electronics Setup

The sleeve gun was fired every 60 seconds with an air pressure of 1600 lbs at a depth of 2.12 m beneath the base of the ice. The data was received by the hydrophones and sent to the GSC DIGS with no gain applied to the signal. The blast phone data was recorded when the sleeve gun was first deployed to 2.12 m. and also when the gun was lowered to 2.91 m. below the base of the ice on day 103 at 1640 hours and again when it was lowered to 3.67 m on day 104 at 1640 hours. Data was collected from Julian day 96 to Julian day 110 with only 1% down time.

The trigger interval that was sent from the MITS to the Trigger box was was set to 1 ms. The settings on the GSC DIGS are as follows:

- sample rate – 2 kHz
- sample interval – 500 μs

- sample count – 12000
- sample duration – 6000 ms
-

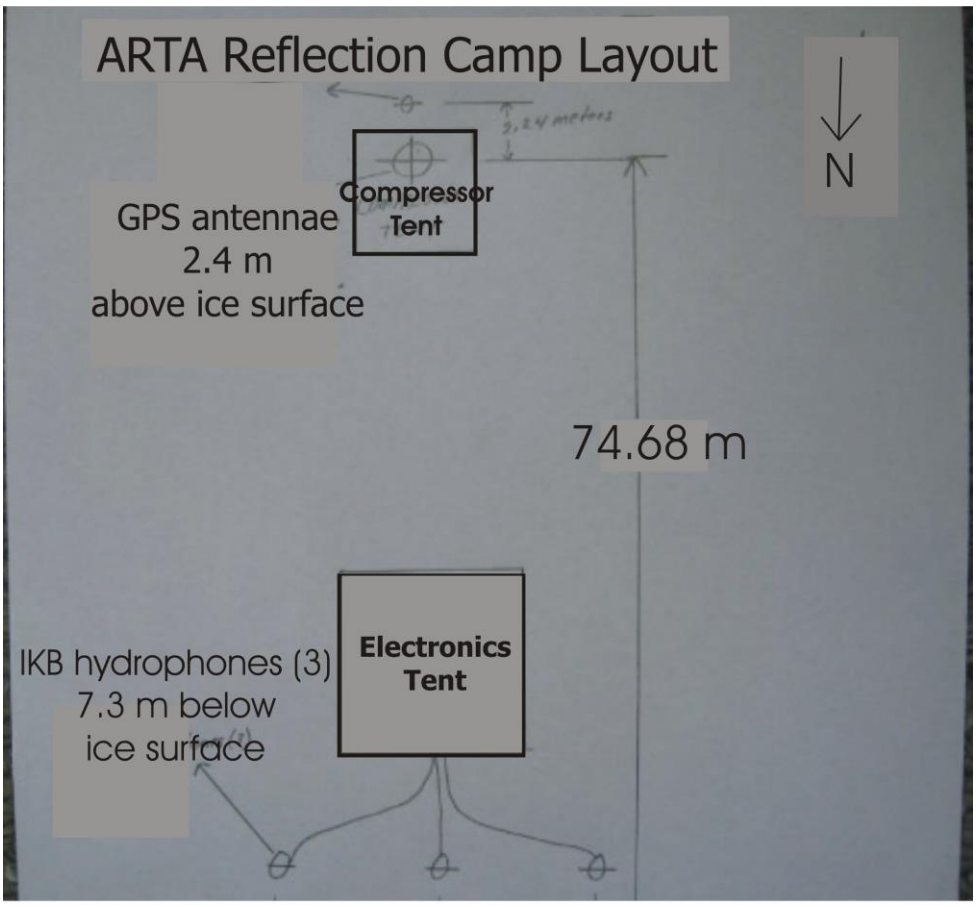


Fig: 9.4 ARTA North Camp Layout

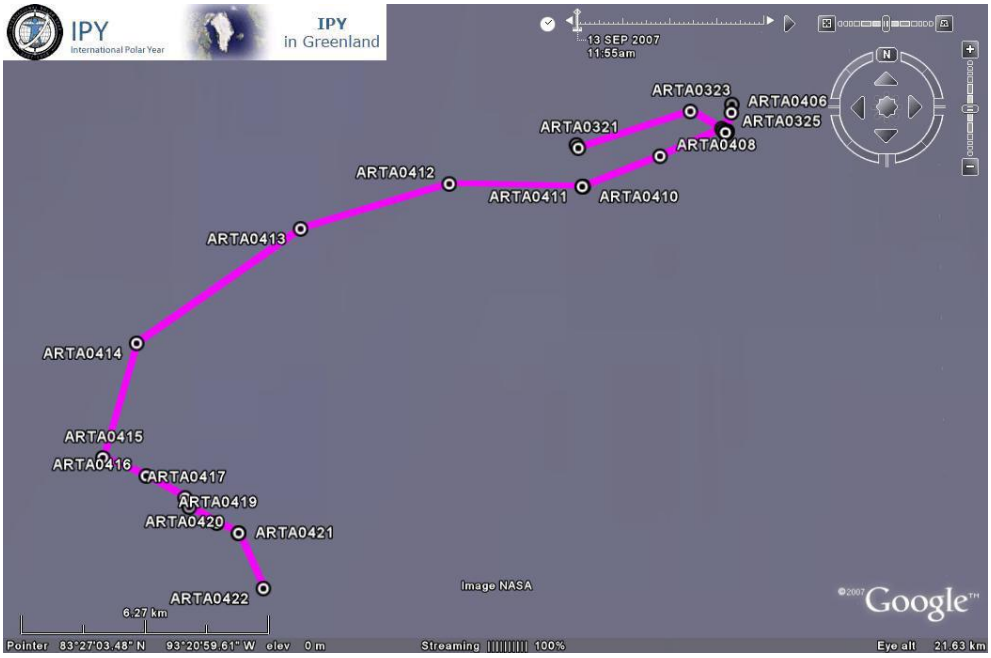


Fig: 9.5 ARTA Track

9.2. Recommendations:

1) Compressor tent must be raised off the ice with a 2X4 lumber sub-floor to prevent flooding of the work area.
2) Equipment batteries must be sent as dry charged units with the acid sent separately.
3) Mechanical equipment must be integrated and packaged properly. Whoever is using this equipment on the project must be able to prepare it to their specifications before shipping.
4) Satelite phone with docking station and omnidirectional antenna with long lead located in the electronics tent and two-way radios for each person so contact can be made 24 hours a day.
5) Pre-made runway markers; wind sock and runway drag.
6) Must have a heated tent as a garage if the project is working in weather colder than -30°. The increased productivity would far surpass the extra weight of the equipment to erect this tent.

10. Geobuoys Timeline

10.1. Pre-Expedition Time Line

17 Jan 08 – BN (Briefing Note) staffed to DG DRDC Atlantic

23 Jan 08 – DRDC Atlantic to A/CAS – e-mail, informal request (feeling the ground)
17 Jan 08, BN included

(approx 18) Feb 08 – Memo – ADM(S&T) to CDS

17 Mar 08 – indications of cost waiver from DND to NRCan look good

20 Mar 08 – Letter – NRCan to MND

9 Apr 08 – MND cost waiver OK (no official correspondence on this)
Incremental costs would be past on to NRCan (such as TD, Airfield fees, DRDC Atlantic personnel fees)
Basic CP-140 Aurora operating costs to be waived

16 Apr 08 – News release NRCan/DND cooperation in support of UNCLOS

18 Apr 08 – Tasking message received

19 Apr 08 – CP140 Aurora Blk II aircraft departs 14 Wing with Don Mosher

25 Apr 08 – Aircraft returns from deployment.

10.2. CP140 SITREP

19 April 2008
12:30Z Wheels up depart 14 Wing, Greenwood for Thule Airbase, Greenland.
16:06Z Diverted to Iqaluit, Nunavut to repair an engine oil actuator.
20:05Z Land Iqaluit, Nunavut.
- CP140 from 14Wing, Greenwood diverted to Iqaluit to deliver part.
- Replace actuator and fly first mission out of Iqaluit.

20 April 2008
12:30Z Called Eureka.
2. Helios's and Twin Otters unable to fly today due to weather. Mission scrubbed for today.
13:50Z Take off to re-position the aircraft to Thule AB, Greenland.
3. Called PAN PAN PAN due to flumes in the aircraft.
16:23Z Landed safely at Thule AB.
4. CTR screen burnt out, disconnected and isolated.

21 April 2008

11:40Z Take off
12:30Z Called Eureka and mission is a go.
13:10Z Ice Shelf at CFS Alert transmitting GPS UTC time signal.
13:44Z Five minute recording of UTC time signal on Tape Track #10.
15:05Z Started deploying Geobuoys.
5. Deployed 24 buoys with only 34% serviceability.
6. 1st 16 buoys had only 30% serviceability.
7. 2nd 8 buoys had a 50% serviceability.
8. On 2nd drop concentrated on outer ice and more selective of ice dropping into.
9. Total of 7 working buoys.
10. Multi-year ice with lots of ice ridging, deep snow on ice and many new refrozen leads.
16:55Z Fired charge #1 (Arrival 16:55:22Z)
17:00Z Fired charge #2 (Arrival 17:02:56Z)
17:45Z Fired charge #3 (Arrival 17:??:??Z)
17:55Z Off station
19:55Z Land Thule AFB
22:30 De-briefing

10.3. Issues

1. Too much time flying over alert getting UTC time stamp. It appears to be placement of antenna on the ground being too close to the Ice Shelf building.
2. Ice recognizance used a lot of fuel (low altitude flying).
3. Did not use the EO/IR sensor crew concerned that if could not retract would not be able to fly.
4. Helio for middle shot not in place and Helio "ARE" having to fly back to middle shot took 45 minutes. The Aurora used up fuel which it would have used doing On-Tops of buoys.

10.4. Lessons Learned

1. Dropped all 16 buoys on line without questioning serviceability.
2. Geobuoy RF turned on once CAD fired good for only 40-50 seconds.
3. Geobuoy RF appeared to stop upon impact with ice (unserviceable units).
4. Possible one parachute failure.
5. Need to be more selective of ice.
6. Geobuoy RF range only 10 nm.
7. To operate a transmitter in Thule need to apply 60 days in advance.
8. You can operate Iridium phones and GPS antennas at Thule without any issues.
9. Only place to get email is to buy time at the Community center which is only open from 15:00-21:00L daily except Wednesdays.
10. Iridium phone connectivity varies with time of day and the need to stand out in the cold to use phone limits information exchange and planning.
11. Very hard to pick good ice from 1000 feet.
12. Use EOIR camera to confirm buoy flights and spiking into the ice.
13. Deploy only 15 buoys and use the 16 receiver channel to monitor RF strength.

10.5. Diary

22 April 2008
12:30Z Called Eureka today scrubbed due to weather.

- Air crew rest day.

14:00Z Called Eureka and spoke to Dr. Ruth Jackson about next mission requirements.
16:30Z Caught lift over to CFS Alert on CC130.

- Installed second GPS UTC time transmitter.

20:30Z Returned to Thule AFB.

23 April 2008

11:40Z Take off
12:18Z Ice Shelf at CFS Alert transmitting GPS UTC time signal.
12:30Z Called Eureka and mission is a go.
12:55Z ATR on TT10 (RF2). Received UTC Time signal out to 33nmi.
13:00Z Five minute recording of UTC time signal on Tape Track #10 completed.
- Fast forward the ATR tape to separate out time stamp from data.

13:57Z Started deploying Geobuoys.
- Deployed 1st Geobuoy at 2000 feet, 5 degrees of pitch and 170 knots air speed to see if we would get better serviceability (more time for buoy to stabilize in flight).

- Deployed 15 buoys with only 60% serviceability.
- Deployed 14 buoys from 700 feet and able to pick better ice.
- Six buoys lost in the same ice patch as yesterday.
- Beyond that patch of ice buoy serviceability went up to 90%.
- Good EOIR pictures of the buoys leaving the aircraft and spiking into the ice.

15:40Z Fired charge #1 ("PHO" confirms fired shot at 15:41 and saw on grams 15:43:09Z)
15:50Z Fired charge #2 ("ARE" fired off northern charge and saw on grams 15:50:29Z)
16:00Z Fired charge #3 ("CNG" fired off charge and saw on grams at 16:02:39Z)
16:13Z Stop recording
16:30Z On top buoys RF8, 3, 4.
16:39Z Eureka called and did SitRep with Ruth Jackson.
17:23Z Completed two flyovers of NRCan's ice camp and took good EOIR and still camera pictures.
18:02Z Five minute recording of UTC time signal on Tape Track #15
19:52Z Land Thule AFB
21:30Z De-briefing.

24 April 2008

13:00Z CP140 take off to conduct required Block II aircraft instrument trials at the North Pole.
13:30Z Collected ATR tapes (rewound), crew logs, etc.
19:00Z Send email to DRDC Atlantic.
20:30Z Meet aircraft as returned from North Pole shot.
22:30Z De-brief and plan return home flight.

25 April 2008

11:00Z Contact Alert
12:00Z Major Rich Kohli contacted by Greenwood PR to call a reporter at the Chronicle Herald (Mr. Chris Lamby 902-426-2811-2207) at 12:30Z.
12:05Z Tried contacting Karen S. at DRDC Atlantic left message.
12:15Z Tried contacting Karen S. at DRDC Atlantic left message.
12:20Z Spoke to DG about any new press releases and confirmed the message DRDC wanted put out.
12:25Z Spoke with Major Rich Kohli about message we wanted to put across to the reporter.
12:30Z Major Kohli has 20 minute phone interview

- Capabilities of CP140

- Why the CP140
- Implications and legalities
- Foreign country activities in the North
- Did we detect submarines (asked 3 times)
- CP140 requested by DRDC Atlantic
- DRDC has liaison officer on board the aircraft
- Mission in support of NRCan
- For pictures have to go through DRDC Atlantic

13:00Z Catch base taxi to aircraft
13:10Z Thank you to BoxTop folks for all of their support.
14:02Z Take off
19:30Z Land at 14 Wing, Greenwood
21:30 Arrive home Lake Echo

10.6. Geobuoys NRCan-DND Lessons Learned

Disclaimer – the intent of this document is to simply identify areas/processes that were successful or that may require improvements. It is not intended to "point fingers" at any specific organizations or individuals.

Background:
The following Lessons Learned are complied in order to ensure smooth and effective Interdepartmental cooperation in the event that subsequent activities were to arise.

Synopsis:
United Nations Convention on the Law of the Sea (UNCLOS) allows coastal nations to establish up to 12nm of territorial waters, a 200nm wide economic jurisdiction and, under special circumstances, sovereign rights to the seabed and resources contained beyond the 200nm limit. To extend beyond 200nm each country must prove that its continental shelf surpasses that limit or that undersea ridges are part of their continental shelf. Submissions to a UN Commission for an extended shelf in the Arctic are expected from five countries (USA, Canada, Denmark, Norway and Russia), and Canada has a submission deadline of the end of 2013.
NRCan and DFO are conducting a survey of the Alpha Ridge in March/April 2008, operating out of Eureka, Ellesmere Island. They have chosen the locations of the land and ice camps to maximize the survey coverage, based on logistic constraints (helicopter range and number of acoustic listening instrument that can be deployed). Nevertheless, the quality of the survey could be significantly enhanced if the lines could be extended further. This would allow Canada to define its outer limits to the maximum possible, as is 'mandated' by Canada's Oceans Act and would give Canada the exclusive rights to all the potential resources in that region.

DRDC Atlantic was requested to review and provide recommendations to NRCan regarding any existing technologies that could be employed to help Canada's submission for the Arctic. Thus far, one promising option is available which involves a device known as the Geobuoy launched from a CP-140 Aurora.
NRCan is willing to prepare a formal request for the subject CP-140 support, at the appropriate level, but asked for an indication if it would be favourably received. DRDC Atlantic would provide support to the exercise.

Chronological Events:

17 Jan 08 BN (Briefing Note) staffed to DG DRDC Atlantic

23 Jan 08 E-mail – from DRDC Atlantic to A/CAS, query as to the potential use of one CP-140 Aurora in support of NRCan, following a formal Interdepartmental request.
(17 Jan 08, BN included)

18 (approx) Feb 08 Memo – from ADM(S&T) to CDS

17 Mar 08 E-mail – from SJS staff with indications of cost waiver from DND to NRCan are favorable

20 Mar 08 Letter – from NRCan to MND, requesting formal Interdepartmental support

9 Apr 08 MND accepts cost waiver (no official correspondence available)
However, Incremental Costs would be transferred to NRCan (such as TD, Airfield fees, DRDC Atlantic personnel fees)
Basic CP-140 Aurora operating costs are to be waived

16 Apr 08 News release NRCan/DND cooperation in support of UNCLOS

18 Apr 08 Tasking message received

19 Apr 08 CP140 Aurora Blk II aircraft departs 14 Wing with Don Mosher (DRDC Atlantic)

25 Apr 08 Aircraft returns from deployment.

7 May 08 Hot Wash-up with NRCan & DRDC Atlantic

Interdepartmental Process

- Lengthy staffing process to reach interdepartmental cost estimates and subsequently cost waiver approval. This is done at the Ministerial or Deputy Minster level.
- DRDC Atlantic & NRCan not in receipt of reply letter from DND to NRCan regarding cost waiver approval.
- Although preliminary face-to-face meetings were held between DRDC Atlantic and NRCan staffs, CF personnel should be identified early enough to be included in the planning with the NRCan Chief Scientist.

Command & Control (C2)

- Aircraft departed on 19 Apr 08. Tasking order received on 18 Apr 08.
- DRDC Atlantic staff accompanied CP-140 Aurora crew to act as liaison between NRCan and Aurora crew.

Logistics:

- Short timeline meant that some co-ordination with Thule AFB regarding logistics and NRCan experiment was incomplete and had to be resolved on the fly.
- UNCLOS tasking was assumed to follow Box Top processes and agreements pre-determined with Thule AFB. Separate logistical coordination should have been made.
- Mission on-station time was severely restricted by the requirement to hold Iqaluit as an alternate airfield from Thule.

Tactical Employment (Data Collection)

- EO/IR sensor must be used to monitor descent and impact of Geobuoy.
- Geobuoy serviceability linked to snow and ice conditions - recce of proposed drop locations and relaxed tolerance re-placement improved serviceability.
- Initially, the serviceability of Geobuoys was assessed too quickly - different criteria than sonobuoys and infrequent training with Geobuoys.
- Due to the lack of usage of Geobuoys, it would be beneficial for the CP-140 Aurora to conduct a practice mission with suitable number of Geobuoys to attain proficiency in their placement in order to achieve a suitable serviceability rate.

Technical

- RF telemetry was half of that anticipated – potentially due to shadowing from ice ridges and or transmitters covered by snow. Geobuoy reception range was significantly less than expected (average 8nm with marked lobing) which forced the aircraft to remain within 5nm of the center of the pattern.
- The transmission characteristics observed precluded reliable mark-on-tops.
- Potential acoustic interference from helicopter operations - implications unknown as yet.
- Geobuoy positions from ballistics computer in agreement with actual position to within 60 m - less than NRCan tolerance
- Position of antenna to broadcast UTC from ground station in CFS Alert is important and consequently affected CP-140 on-station time. (Required to meet NRCan tolerance).
- All participants should use UTC
- All A/C should have transponders
- Future seismic survey operations could be considered using the seismic modified Difar sonobuoy thereby increasing the coverage provided by the CP-140 Aurora.

Location of Geobuoys

Table 10.2 Location of Geobuoys

RF #	Corrected Ice Pick Position based on OTPI position			
	Latitude (N)		Latitude (W)	
	(deg)	(min)	(deg)	(min)
1	84	31.86	98	10.18
5	84	40.13	98	32.78
14	84	58.96	99	37.23

16	85	2.99	99	50.89
18	84	35.29	98	25.66
19	84	38.56	98	29.91
23	84	53.39	99	13.86
31	84	41.96	98	43.10
1	84	44.47	98	52.95
2	84	46.09	98	58.03
3	84	48.36	99	1.38
4	84	50.42	99	7.28
5	84	52.31	99	12.08
6	84	54.57	99	21.38
8	84	59.39	99	36.40

11. Gravity Report

In December 2007, Dr. Jacob Verhoef, GSC Atlantic and Richard MacDougall, CHS, met with Denis Hains, GSD and Marc Véronneau, GSD in Ottawa to discuss feasibility in conducting gravity surveys (on-ice, shipborne and airborne) for the UNCLOS Project. It was decided that GSD would participate by supplying personnel and instrumentation for the gravimetric portion of the project. The first phase is the on-ice survey done simultaneously with bathymetric and seismic measurements in the spring of 2008. A second phase is the shipborne gravity survey in the Beaufort Sea. Future phases are presently under discussion.

Prior to conducting the on-ice gravity survey, the UNCLOS project hired Roy Cooper, retired employee from NRCan, to train GSD and CHS personnel in operating damped Lacoste & Romberg (L&R) gravitymeters. Mr. Cooper has several years of experience in conducting on-ice gravity surveys in the Arctic. Philip Salib, GSD Gravity Standards Officer, and Alain Belzile traveled with Roy Cooper to give the two-day training in Burlington. The CHS employees to receive training were Rob Morrison in Ottawa and John Mercuri and Michael Black in Burlington. By the same opportunity, Alain Belzile met with Jon Biggar, CHS Field party leader, to discuss required equipment and activities.

On March 20th, Alain Belzile left Ottawa for Edmonton with two "warm" L&R meters. The next day, he met with Dr Ruth Jackson and her scientific team. The group left Edmonton in the morning of March 22nd on a charter aircraft to Eureka, with a stop over in Resolute. While travelling from Ottawa to Eureka, Alain Belzile took readings at control gravity stations in Ottawa, Edmonton, Resolute and Eureka for the calibration of the meters and verification of the scale factor of the instruments. He established a new gravity control station in Eureka where the cold climate would not be a factor since he would have to take several readings in Eureka. Furthermore, he established a temporary control station at the ice-camp when he reached it. At that time, the hydrographers took over and started taking gravity readings at every second station on the seismic line and at every third station on the hydrographical lines. While Alain Belzile had to care for the instruments, conduct gravity ties between the ice-camp and Eureka, process the data and set-up a third instrument that was shipped from

Ottawa in early April. Two hundred and fifty sites were observed during the survey. GSD's software PCGrav was used to process the data. A pre-analysis was done on site using software Surfer. A final quality control of the data will be done at GSD's office in Ottawa.

Alain Belzile returned on May 1st from Eureka to Ottawa with a stop-over in Iqaluit. As on his way up, he took reading at control stations in Resolute, and Ottawa in order to close the loop.

Overall, everything went very well. The instruments worked properly even in extreme cold weather. The four CHS operators were meticulous and took good care of the instruments in the field. Gravimeters are very sensitive instruments.

12. Weather and Ice Support

Introduction

Canada ratified the International Convention on the Law of the Sea (UNCLOS) in November of 2003. Article 76 of UNCLOS specifies a mechanism for defining the continental margins beyond the 200 nautical mile limit. In order to be able to assert sovereign rights beyond 200 nautical miles, a country has ten years to collect the appropriate information and submit a claim to the United Nations Commission on the Limits of the Continental Shelf (CLCS). Canada can exercise specified sovereign rights out to a distance of 350 nautical miles or further, if Canada can claim the **Alpha Ridge** as a natural prolongation of Canadian territory. These rights include powers over mineral and biological resources on and below the seabed and jurisdiction in matters related to environment and conservation.

Canada has the possibility of claiming the **Alpha Ridge**, a submarine mountain range, as a natural prolongation of their territory. In order to determine the ownership of the Alpha Ridge, a joint Canada field experiment was conducted in March -May 2008 on the ice north of Axel Heiberg and western Ellesmere Island. The main activity involved the stringing of a number of explosive charges below the ice and detonating them in sequence to assess the geology and geomorphology of the seabed.

Operations were based in Eureka (NU) with 10-13 people, as well as 20 at a temporary camp on the ice. The camp was required due to the distance from Eureka to the Alpha Ridge study area. Helicopters transported personnel and scientific instruments, supplies and other necessary field supplies/equipment to the on ice study area from the base camp at Eureka. The field program took place from mid-March through to early-May 2008. The 3 main project phases were projected as follows:

- Startup/Arrival at ice site (ca. 7 days)
- Execution of experiment (ca. 46 days)
- Cleanup and departure (ca. 7 days).

Figure 12.1 shows the planned shot lines, and the location of the ice camps that were set up for the project:

- The main ice camp was built at 81 51 30.2N 91 34 09.3W about 5KM north of Ellesmere Island east of Nansen Sound. The camp was located on the sea ice pack next to a very long flat refrozen lead and incorporated a 3500 ft runway.

A Northern camp, also know as the "reflection" camp was established at 83°29.575N 93°11.167W on a large Multi Year ice floe.

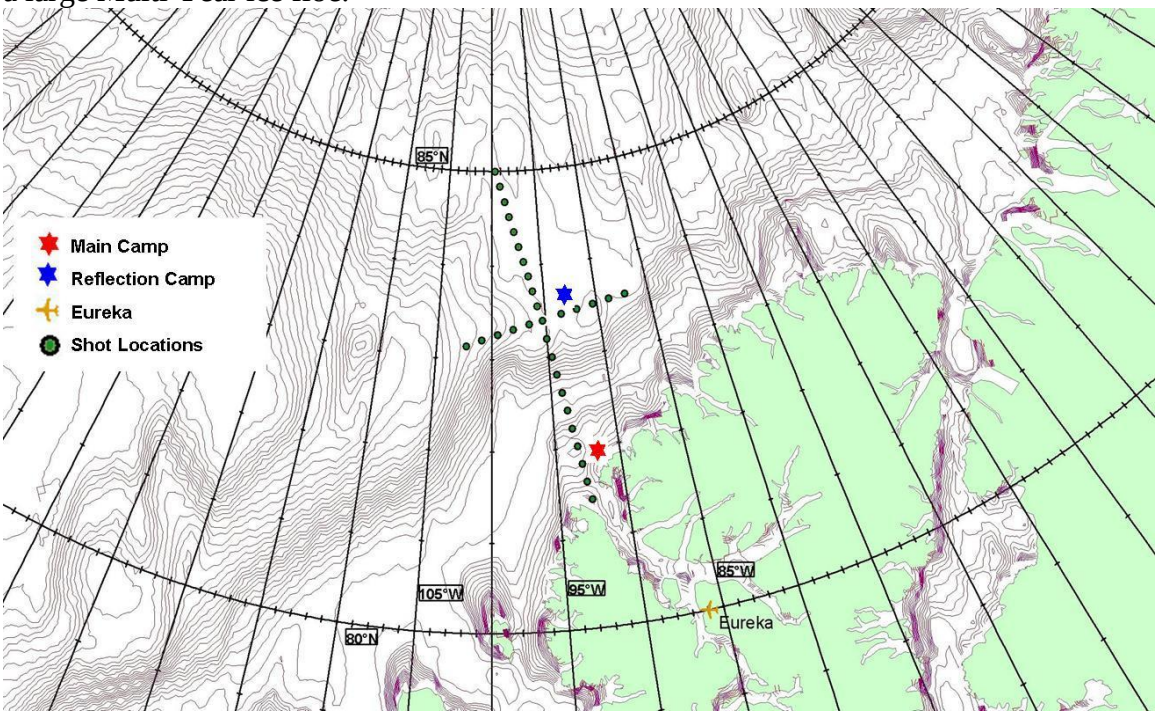


Figure 12.1 Seismic data was acquired with individual data loggers spaced at 1.3 km over 200 km at a time, shooting at 11 locations for each of the three sections. The line along the Alpha Ridge is 450 km long, and was in two sections; the line crossing westwards is 200 km long and was acquired in one section.

12.1. ARTA Project Team

Key contact members of the ARTA Project Team were as follows:

- ARTA Project Management: Dr. Ruth Jackson, NRCan (for Canada)
- ARTA flying operations/logistics manager: Dave Maloley

12.2. ARTA Weather and Ice Support Team

The following contributed to the provision of weather and ice support to ARTA:

- Canadian Ice Service(CIS) Operations Manager: **Marie-France Gauthier**
- Prairie and Arctic Storm Prediction Centre (PASPC) Program Manager / PNR lead IPY Arctic Meteorologist **Edward Hudson**
- ARTA Weather and Ice Support Manager: **Bruce Ramsay**
- ARTA Weather and Ice Support Management back-up: **Dan Fequet**

- ARTA On-site support: **Ken Asmus**
- ARTA SAR data ordering: **Celine Fabi**
- ARTA ice analysis: **Jay Fielding**
- ARTA Eo imagery consultant: **Matt Arkett**
- ARTA tracker operations and data management: **Amanda Reinwald/Kerri Warner**
- ARTA ftp site management: **Rob Jawaral**

12.3. ARTA Weather Support

MSC, though CMC, HAL and PASPC, provided the following weather information in support of ARTA:

- NOAA AVHRR image products on a daily basis throughout the ARTA field operations period from both the Edmonton and Resolute facilities.
- Early initiation and expansion of the Graphical Weather Forecast (GFA) on request area to include the ARTA area. The ARTA area was covered 1 March to 13 May
- Twice daily weather forecasts for the ARTA area of operations at locations as follows:
    i. 81.8°N 92.8°W ARTA South Point
    ii. 83.4°N 95°W ARTA Intersection
    iii. 85°N 100°W ARTA North Point and
    iv. Eureka
- Twice daily sets of surface wind visualizations generated in Edmonton using data from the Canadian Regional numeric weather prediction model
- Twice daily sets of blizzard potential visualizations generated in Edmonton using data from the Regional numeric production model
- A "North Pole" view of relevant numerical weather prediction products available on the CMC "VizaWeb" site
- One meteorological buoy providing air temperature, air pressure and position made available for deployment in the ARTA area
- Dedicated ARTA ice buoy and related Service Argo support
- Weather "hot line" support from Edmonton
- A Campbell Scientific Weather Station was provided by CIS to the ARTA project for deployment at the remote reflection camp. Ken Asmus provided training on the set-up and operation of this weather station to Jorgen Skafte, Camp Manager. This station was operational for the duration of the camp deployment and regular weather reports were received for the use of the Logistics Manager at Eureka and forwarded regularly to PAPSC Edmonton.

12.4. ARTA Ice Support

MSC, through CIS, provided the following ice information in support of ARTA:

- Eastern regional ice analyses issued by Canadian Ice Service
- Special ice analyses of SAR images for ARTA
- Ice motion "Tracker" products showing ice motion fields between pairs of SAR images

- Dedicated on-site ice and weather briefing support in Eureka (Ken Asmus)
- Ice "hot line" support from Ottawa

12.5. RADARSAT-1 SAR Data Support

The use of RADARSAT-1 in support of ARTA was a key component in the overall environmental support provided.
In order to gain an understanding of the ice regime developing during the fall/winter of 2007/2008 in the ARTA area of operations, the following RADARSAT ScanSAR wide imagery were acquired, primarily through the Alaskan Satellite Facility (ASF) in Fairbanks, Alaska:

- Dec. 1 07 @ 21:53 – orbit 63031
- Dec. 7 07 @ 21:49 – orbit 63117
- Dec. 28 07 @ 21:36 – orbit 63417
- Jan. 1 08 @ 21:20 – orbit 63474
- Jan. 4 08 @ 21:32 – orbit 63517
- Jan 12 08 @ 20:58 – orbit 63631
- Jan 17 08 @ 21:53 – orbit 63703
- Jan. 25 08 @ 21:19 – orbit 63817
- Jan. 31 08 @ 21:45 – orbit 63903
- Feb. 10 08 @ 21:53 – orbit 64046
- Feb 17 08 @ 21:49 – orbit 64146
- Cycle 187 (to be sent to ASF on Jan 7 08)
- Feb. 24 08 - @ 21:43 – orbit 64246
- Mar. 1 08 @ 22:10 – orbit 64332

Figure 12.2 is an image generated by SPA (Satellite Planning Application) showing the ARTA coverage area (dashed trapezoid) used by CIS RADARSAT acquisition planning (Celine Fabi), and an example coverage (solid blue square) for the acquisition on December 7th:

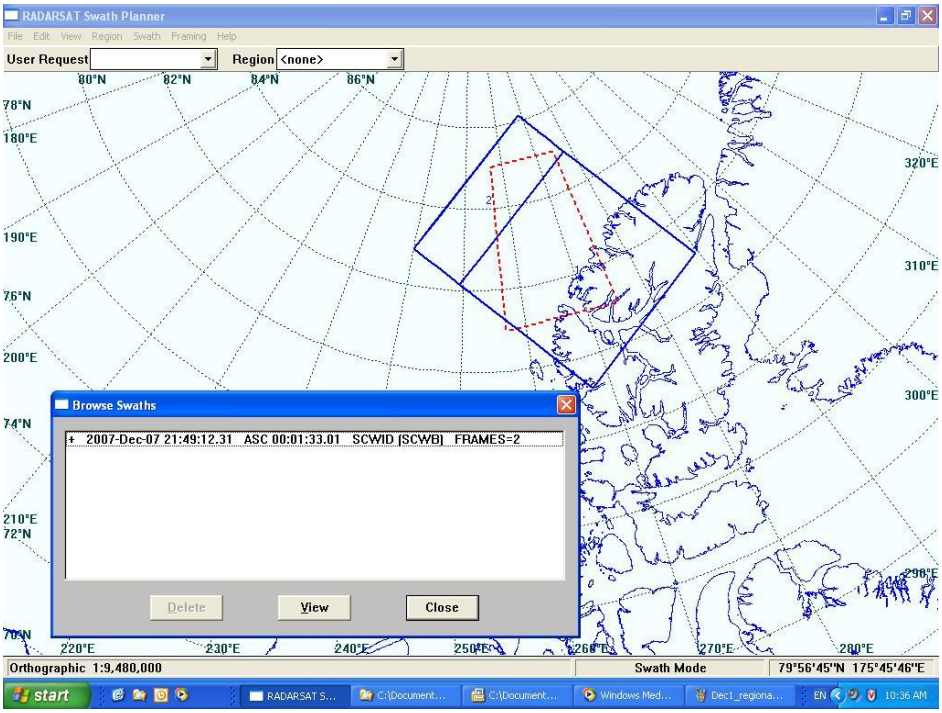


Figure 12.2 The ARTA project area.

Once operations at Eureka commenced, CIS acquired approximately 4 images per week on an opportunity basis. The following is the final RADARSAT-1 operational acquisition list:

- Mar. 7 @ 22:35 - orbit 64418 - Friday
- Mar. 8 @ 22:06 – orbit 64432 - Saturday
- Mar. 14 @ 22:30 – orbit 64518 - Friday
- Mar. 15 @ 22:02 – orbit 64532 – Saturday
- Mar. 20 @ 14:36 – orbit 64599 - Thursday
- Mar. 21 @ 22:27 – orbit 64618 - Friday
- Mar. 22 @ 21:57 – orbit 64632 - Saturday
- Mar. 23 @ 21:28 – orbit 64646 – Sunday
- Mar. 25 @ 22:10 – orbit 64675 – Tuesday
- Mar. 26 @ 15:01 – orbit 64685 – Wednesday
- Mar. 28 @ 22:22 – orbit 64718 - Friday
- Mar. 29 @ 21:52 – orbit 64732 - Saturday
- Mar. 30 @ 21:24 – orbit 64746 – Sunday
- Apr. 1 @ 22:06 – orbit 64775 – Tuesday
- Apr. 4 @ 22:17 – orbit 64818 - Friday
- Apr. 5 @ 21:49 – orbit 64832 - Saturday
- Apr. 8 @ 22:02 – orbit 64875 – Tuesday
- Apr. 10 @ 21:03 - orbit 64903 - Thursday
- Apr. 10 @ 22:43 - orbit 64904 - Thursday
- Apr. 11 @ 22:14 – orbit 64918 – Friday
- Apr. 12 @ 15:05 – orbit 64928 – Saturday
- Apr. 12 @ 21:44 – orbit 64932 – Saturday
- Apr. 13 @ 14:36 – orbit 64942 – Sunday
- Apr. 14 @ 20:47 – orbit 64960 – Monday

- Apr. 14 @ 22:27 – orbit 64961 – Monday
- Apr. 15 @ 15:18 – orbit 64971 – Tuesday
- Apr. 15 @ 21:57 – orbit 64975 – Tuesday
- Apr. 16 @ 21:28 – orbit 64989 - Wednesday
- Apr. 17 @ 20:59 – orbit 65003 - Thursday
- Apr. 17 @ 22:39 – orbit 65004 - Thursday
- Apr. 18 @ 22:10 – orbit 65018 - Friday
- Apr. 20 @ 21:12 – orbit 65046 - Sunday
- Apr. 21 @ 22:22 – orbit 65061 - Monday
- Apr. 23 @ 21:24 – orbit 65089 - Wednesday
- Apr. 24 @ 22:35 – orbit 65104 - Thursday
- Apr. 25 @ 22:06 – orbit 65118 - Friday
- Apr. 28 @ 22:18 – orbit 65161 - Monday
- Apr. 29 @ 21:49 – orbit 65175 - Tuesday
- May 1 @ 22:31 – orbit 65204 - Thursday
- May 2 @ 22:02 – orbit 65218 – Friday
- May 5 @ 22:11 – orbit 65261 - Monday
- May 8 @ 22:27 – orbit 65304 Thursday
- May 9 @ 21:58 – orbit 65318 Friday

12.6. Delivery of Weather and Ice Products

Communications to/from Eureka is limited. However, the ARTA project entered an agreement with CANDAC, a University consortium that undertakes R&D out of Eureka. Under this agreement, the ARTA project had access to 380Kb of bandwidth at Eureka for the project. This line was available for downloading weather and ice files via near high-speed Internet rates.

CIS provided an Ice-Vu laptop for the downloading, viewing and manipulation of weather and ice products at Eureka. In order to reduce the size of the files, imagery was compressed using "MrSid" – a commercial software tool.

The Ice-Vu system enabled decompression and viewing of products, and the overlap of all geo-registered products. This provided superior resolution and information extraction capabilities at Eureka. In addition, animation of all CMC "VizaWeb" products was available.

CIS maintained two ftp sites that were available for ARTA support.

a) An ARTA ftp site as follows:
   ftp://nais.ec.gc.ca

   This site was read-only for field personnel.

b) Additional Arctic products were available on the CIS-maintained / Edward Hudson managed ArWx IPY ftp site: **ftp://cisclient:cisclient@cisclient.cis.ec.gc.ca/IPY-API/ArWx**. This site is read-only for field personnel.

Both CIS and PNR posted weather, AVHRR, and ice products on the ARTA ftp site and PNR posted weather and AVHRR products on the ArWx IPY site in support of ARTA. All products were available

for downloading and viewing at Eureka.

Products were posted in 8 folders on the ARTA ftp site, as follows:

- CMC Products
- Weather Products
- Surface Wind Products
- Ice Products
- NOAA AVHRR Products
- RADARSAT Products
- Drifting Buoy Products
- MODIS Products
- Other Satellite Image Products

Products were posted in the appropriate folders as follows:

CMC Products

[dtg]_wis741.gif	CMC 00Z surface analysis
[dtg]_wis742.gif	CMC 06Z surface analysis
[dtg]_wis743.gif	CMC 12Z surface analysis
[dtg]_wis744.gif	CMC 18Z surface analysis

Weather Products

[dtg]FPCN15CWNT.txt	Public forecast for the high arctic area of Nunavut issues by PASPC
[dtg]FPCN55CWNT.txt	Extended public forecast for high arctic Nunavut issued by PASPC
FXCN24CWTNT.txt	Eureka + ARTA area public forecast issued by PAPSC – 2 x per day (0430MST and 1400MST)
[dtg]GFA37ARCT00.gif	Graphical Arctic region clds and wx, as well as frlv / turbc / icing Issued by CMAC-W
[dtg]GFA37ARCT12.gif	Graphical Arctic region clds and wx, as well as frlvl / turbc / icing Issued by CMAC-W Four times daily.

Surface Wind Products

Arta_GEM_arta_<date>_##.gif	Wind prog visualizations for ARTA area – from GEM model – produced by PNR Twice daily

Ice Products

- not used during support to ARTA

NOAA AVHRR Products

arta.ellesmere .<date>.<time>.gif	NOAA AVHRR images from Resolute Bay HRPT station – via Edmonton
arta2, arta3, arta4 .<date>.<time>.gif	NOAA AVHRR images from Edmonton HRPT station

RADARSAT Products

<date>-<time>-arctic_ocean_.exe	An auto uncompress file. Clicking the .exe will uncompress a .sid and a .sdw file, both with the same naming convention as the .exe file – CIS
RA[dtg]_RA[dtg]_m2.jpg	Final RADARSAT Tracker product with 2nd image of pair underlain – CIS
Radarsat_Acquisition_List.txt	Table of scheduled RADARSAT data orders
Radarsat_<date>.jpg	Radarsat image with the ARTA cross overlay
RA[dtg]_RA[dtg].trk2 RA[dtg]_RA[dtg].trk2 RA[dtg]_RA[dtg].aux RA[dtg]_RA[dtg].dbf RA[dtg]_RA[dtg].shp RA[dtg]_RA[dtg].shx	The tracker shapefile along with associated files
arta<date>.gif	RADARSAT image analysis for ARTA operational area

Drifting Buoy Products

dailymap.basin-2008-date.jpg	Daily ice buoy motion map of Arctic Basin waters – from IABP web site http://iabp.apl.washington.edu

Modis Products

<date>_<region>.exe	An auto uncompress file. Clicking the .exe will uncompress a .sid and a .sdw file, both with the same naming convention as the .exe file – CIS

Other Satellite Image Products

- as needed

In addition, Blizzard visualizations were posted to IPY ArWx ftp site rather than the ARTA ftp site to make them globally available:

Blizzard Visualizations

NorthPole_BurrowsWinter_Blizzard_<date>_##.gif	Blizzard prog visualizations for Canadian artci including ARTA area – from GEM model – produced by PNR Twice daily

FTP Support

The maximum speed of the Internet connection into the weather and ice support office at Eureka was found to be about 360 Kb/sec. When Ken was busy preparing the briefing early in the morning, he had nearly full access of the bandwidth and could download all products without difficulty. During the day and evening, speeds vary considerably depending on loading. Overall, there were little or no issues with Internet communications into Eureka.

The ARTA ftp site was monitored regularly and the folders were purged weekly in order to insure only 1 week of products were on the site at any given time. This was done in order to save space on the ftp site for incoming products. The data that was purged from the ftp site was saved into an archive database that will be available on DVD.

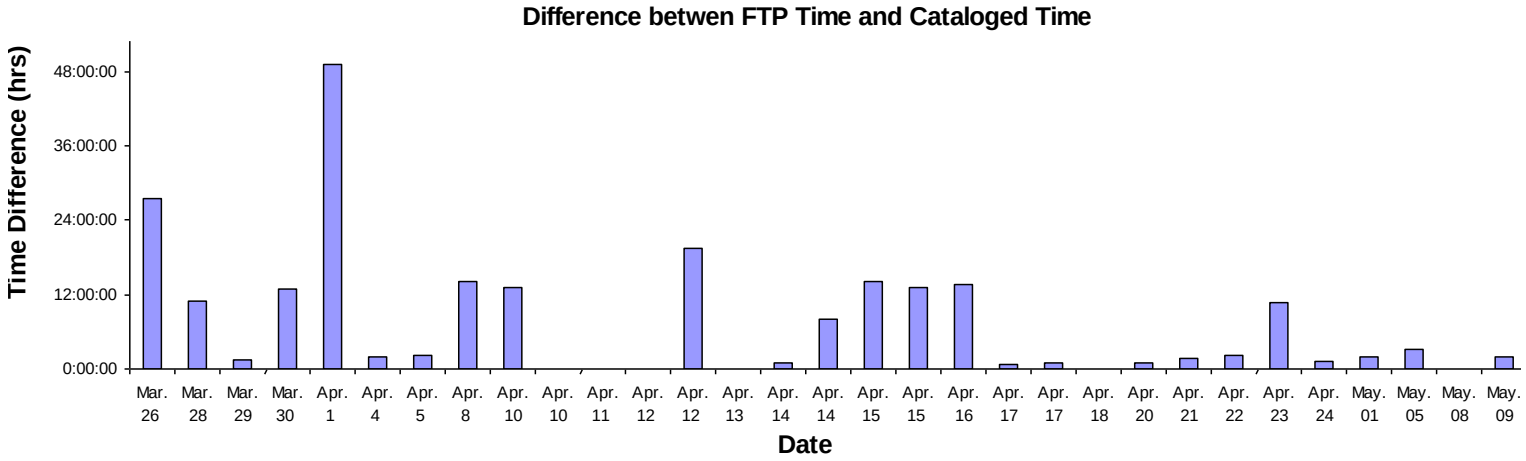
The following outlines the number of each of the products that were made available on the ARTA ftp site during operational use:

Folder Name	Products	Number of Products put into the Folders During Operational Use
CMC Products	CMC 00Z surface analysis	108
	CMC 06Z surface analysis	108
	CMC 12Z surface analysis	108
	CMC 18Z surface analysis	108
Weather Products	FPCN15CWNT Public forecast for the high arctic area of Nunavut	318
	FPCN55CWNT Extended public forecast for high arctic Nunavut	318
	FXCN24CWTNT Eureka + ARTA area public forecast	212
	GFA37ARCT00 Graphical Arctic region clds and wx, as well as frlv / turbc / icing	427
	GFA37ARCT12 Graphical Arctic region clds and wx, as well as frlvl / turbc / icing	427
Surface Wind Products	Wind prog visualizations for ARTA area	654
NOAA AVHRR Products	ARTA2 NOAA AVHRR images from Resolute Bay HRPT station – via Edmonton and Ed	682
	ARTA3 NOAA AVHRR images from Resolute Bay HRPT station – via Edmonton and Ed	1198
	ARTA4 NOAA AVHRR images from Resolute Bay HRPT station – via Edmonton and Ed	1336

	Ellesmere NOAA AVHRR images from Edmonton HRPT station	893
RADARSAT Products	An auto uncompress file that opens as a Mr.Sid image	95
	Final RADARSAT Tracker product	78
	Radarsat image with the ARTA cross overlay	42
	The tracker shapefiles	78
	RADARSAT image analysis for ARTA operational area	20
Drifting Buoy Products	Daily ice buoy motion map of Eastern Arctic waters	72
MODIS Products	An auto uncompress file that opens as a Mr.Sid image	2
Other Satellite Image Products	Data as needed	12

The Radarsat products were monitored very closely in terms of the times in which they were posted onto the FTP site in relation to when the Radarsat images were acquired. For every Radarsat image that came in, three times were recorded; the satellite acquisition time, the time the image was catalogued at CIS and the time the image was placed on the FTP site.

The following graph shows the difference between the time the image was catalogued (available) at CIS and the time that the Radarsat image was put onto the ftp site. Aside from two of the earlier images, the images were all placed on the FTP site within 24 hours of being catalogued. Generally, the images were placed on the ftp site from an hour to 12 hours of being catalogued. By mid-April, the images were consistently being put onto the ftp site within only a few hours of being catalogued at CIS.



The graph below shows the difference between the time that the Radarsat image was acquired by the satellite and the time that the image was placed on the ftp site. Again, aside from two of the earlier images, all of the images were placed onto the ftp site within 24hours of being acquired by the satellite.

12.7. On-Site Support at Alert

Ken Asmus arrived in Eureka on March 8th and remained onsite until 26 March. Upon arrival, he

established the Ice and Weather Support office, and set up and tested the Internet connection through the bandwidth provided by CANDAC. Ken initiated Ice and Weather briefings on Monday March 11. Starting at 0530 in the morning, he would download and prepare all the latest ice and weather information products available, begin to study the overall weather situation and review the local conditions and satellite imagery. Around 0700 the aircrews would stop by the "office" and get an update on the current conditions and forecast for the day in the area of operations. Ken would confer with the logistics manager at breakfast especially if there were any weather conditions that may cause problems for the day. A full daily briefing package was prepared and presented just after breakfast at 0800. A verbal update was done just after lunch at 1230 and a second update briefing package was prepared for just after dinner at 1830 (all times EST or CDT as the camp did not change time at daylight savings switchover).

The briefing package comprised the following info:

- 06Z surface analysis
- Metar/Taf's for Eureka, Alert, Resolute and Griese Fiord
- FXCN24 Project ARTA Public Forcast
- 12Z and 18Z GFA products
- Wind prognosis for 12Z, 00Z and 12Z following day
- Upper Wind forcast for 3000 and 600 feet
- Blizzard Potential maps for 12Z current day and others as required
- FPCN15 Public Forcasts for Resolute and Griese Fiord
- The most current AVHRR imagery available at briefing time
- Animated wind forcasts
- VIZAWEB 4 panel 2-day forcast products
- Any available Radarsat imagery/analysis/tracker products

Ken departed Eureka on March 26th. By that time, he had ensured that Dave Maloley and John Shimeld (ARTA Team) were set up and had access to all the available weather and ice info. They continued to provide weather and ice information to the pilots and the ARTA team after Ken's departure.

All reports from the field team attest that Ken was an invaluable resource for ARTA, particularly during the first two to three weeks of the project. Ken's expertise, experience and dedication were greatly appreciated.

12.8. Weather and Ice Conditions During ARTA

At the start of the field project, the weather in Eureka was essentially clear, calm and very cold (from -40 to -48C). On March 22 the weather changed with the constant high pressure ridge over the pole weakening a bit and moving to the west, allowing the passage of a low pressure system from over the pole. There was low cloud formation, stronger winds and reduced visibility in essentially ice crystals/ice fog with the passage of this low pressure system to the west of Ellesmere Island. This situation, however, only lasted a few days.

By early April, leads had opened up in the ice pack. This created some difficulties for flying operations by the second week of April, particularly helicopter sorties, due to local ice fog development. Large leads continued to open and close during the month, but overall ice conditions did not jeopardize the ice camp at all.

For field operations, the ice conditions were particularly difficult this year. Most of the ice in the near shore area was very broken up and ridged and very few good refrozen flat leads for aircraft operations. The pilots were also concerned with the refrozen leads that were available to them due to the amount of open leads early in the project in the area. They were not comfortable that these refrozen leads were thick enough for landing operations. But once the field camps were deployed, the ice motion was reduced to a minimum (except near the end when leads opening up were contributing to fog and low cloud).

The consistent northeastern winds were a key factor in keeping the ice pack reasonably stable. The ARTA reflection camp only drifted 27.2 kms along a relatively constant southwestward track for the 15 days of the reflection activities. Any consistent south to southeast winds would have severely jeopardized on-ice activity during this year's project.

12.9. Recommendations

- As the project was highly dependant on the weather and ice situation, future such projects should definitely include a coordinated weather and ice support program.
- It is recommended that the assignment of a weather and ice specialist for the full duration of the field project would be the most effective way of providing weather and ice support.
- Visible/Infra-red AVHRR data is the most useful product for weather and ice support. The new AVHHR station upgrades at Resolute, including additional bandwidth, will provide higher resolution capability Arctic AVHRR data for future projects.
- The addition of higher resolution MODIS Visible/Infra-red image data would be very useful for future projects
- We feel that RADARSAT SAR imagery is still useful addition to the suite of imagery provided to support field operations. With RADARSAT-2 becoming operational shortly, the use of the onboard recorders and downlinking of data to the Gatineau receiving station will make the delivery process much more reliable than in the past. The addition of higher resolution modes as well as selective polarization on R2 could also improve the information content we have seen to date with R1
- An investment of funds to upgrade the CIS Tracker system would provide more reliable and regular ice motion information for both planning and operational support.
- The regular addition of a synopsis section to the FXCN public weather product would be very useful for system and synoptic weather pattern change information.
- Contact phone numbers to Edmonton for weather information, and to Ottawa for ice information is very valuable for advice during difficult environmental conditions.
- Regular project newsletters, put out by Ron Verrel for ARTA, were distributed at both PASPC Edmonton and CIS in Ottawa. They proved to be extremely effective tool for keeping all informed and for focusing interest and effort on project support. They were definitively very motivational.

13. TASK HAZARD ANALYSIS

Task Hazard Analysis #XXX

Handling and Firing Explosives in the Arctic

BASIC STEPS	HAZARDS (Known or foreseeable)	CONTROL MEASURES	PERSONAL PROTECTIVE EQUIPMENT	TRAINING
Handling / Shipping Explosives	Loss or damage during shipment.	Loading and unloading by trained shipper, aircraft loadmaster, or under the direct supervision of blasting tech.		TDG_SKD_2, Blasters license
		Inventory to follow shipment from origin to magazine(s). Report missing inventory to authorities immeadiately.		TDG_SKD_2, Blasters license
	Explosion	Follow all laws and regulations applicable to handling explosive materials.		TDG_SKD_2, Blasters license.
		Minimize exposure risk to non essential personnel, buildings and equipment.		TDG_SKD_2, Blasters license
	Lack of training	Supervisor to ensure suitability to task.		TDG_SKD_2, Blasters license, OHS
	Inhalation of fumes, dust.	Never breath dust or vapors from explosive materials.	Mask, for confined areas.	WHMIS
	Contact with skin	Keep explosive material away from food, eyes, and skin.	Wear protective gloves at all times.	WHMIS
	Impact or Static Discharge	Explosive materials and components must remain in approved shipping containers at all times.		TDG_SKD_2, Blasters license.
		Electrically ground storage facilities or transporting aircraft before loading explosives		TDG_SKD_2, Blasters license.
		Detonators must remain in shipping containers at all times. Must never be carried loose, within clothing, or in unmarked containers.		TDG_SKD_2, Blasters license.
		Keep loading area clear and free of tripping hazards.		OHS
		Always load and unload explosive materials carefully. Wear proper PPE	Wear non-slip footwear	OHS
	Slippery surroundings	Follow instructions from manufacturers MSDS for clean up.		Blasters license, WHMIS
		The preferred method of destroying	Gloves, Natural fiber	

	Spilled material	spilled explosives is by burning in an open unconfined area. Do not allow smoking or open flame in the work area. Separate magazines from other magazines, buildings, or work areas as per industry guidelines	clothing, non sparking tools.	Blasters License. Blasters license
Storage of explosives	Ignition sources. Explosion	Never store near uncontrolled, or common access (traffic) areas. Never store other materials or equipment within magazines. Magazine must not be moved when loaded. All materials must appear and be controlled through a master inventory, to be signed off by the magazine controller. This log must be secure, but available for inspection at all times.		TDG_SKD_2, Blasters license. TDG_SKD_2, Blasters license. TDG_SKD_2, Blasters license. TDG_SKD_2, Blasters license. Blasters license.
	Poor Inventory control Theft. Uncontrolled access. No MSDS or registry of emergency procedures Fire	Never store empty containers within the magazine. All magazines must comply with Federal regulations and be locked at all times, to protect the explosive material from weather, fire, and theft. A written “Key Control Plan” must be implemented. Only the magazine controller may have access to the key(s). Always locate perimeter signs (“EXPLOSIVES—KEEP AWAY” or other) on all for sides of storage sites. Make all camp personnel aware of magazine locations. Have MSDS sheets and emergency procedures posted near explosive storage sites. Never attempt to fight a fire involving the magazine, or the explosive materials. Vacate the area immeadiatly. Smoking or open flame is not permitted within 15m of the magazine. Never use any explosive materials unless completely familiar with the safe and correct procedures for their use and disposal.		Blasters license Blasters license Blaster’s license, WHMIS
Loading Shot holes		Materials are NOT to be unpacked, deployed or opened until loading is imminent. Never on an aircraft, or other vehicle.		Blaster’s license