On the Trails of the Inuit

Adapting GPS for Nunavut Hunters and Environmental Research

In the Arctic, learning about the location, conditions, and uses of trails over time and space reveals a great deal about the environment and relationship of the people to their land and ice. In this way, the Igliniit (Trails) Project is making change more visible with a new integrated GPS system for expert Inuit hunters, who log thousands of kilometers each year on dogsleds and snowmobiles.

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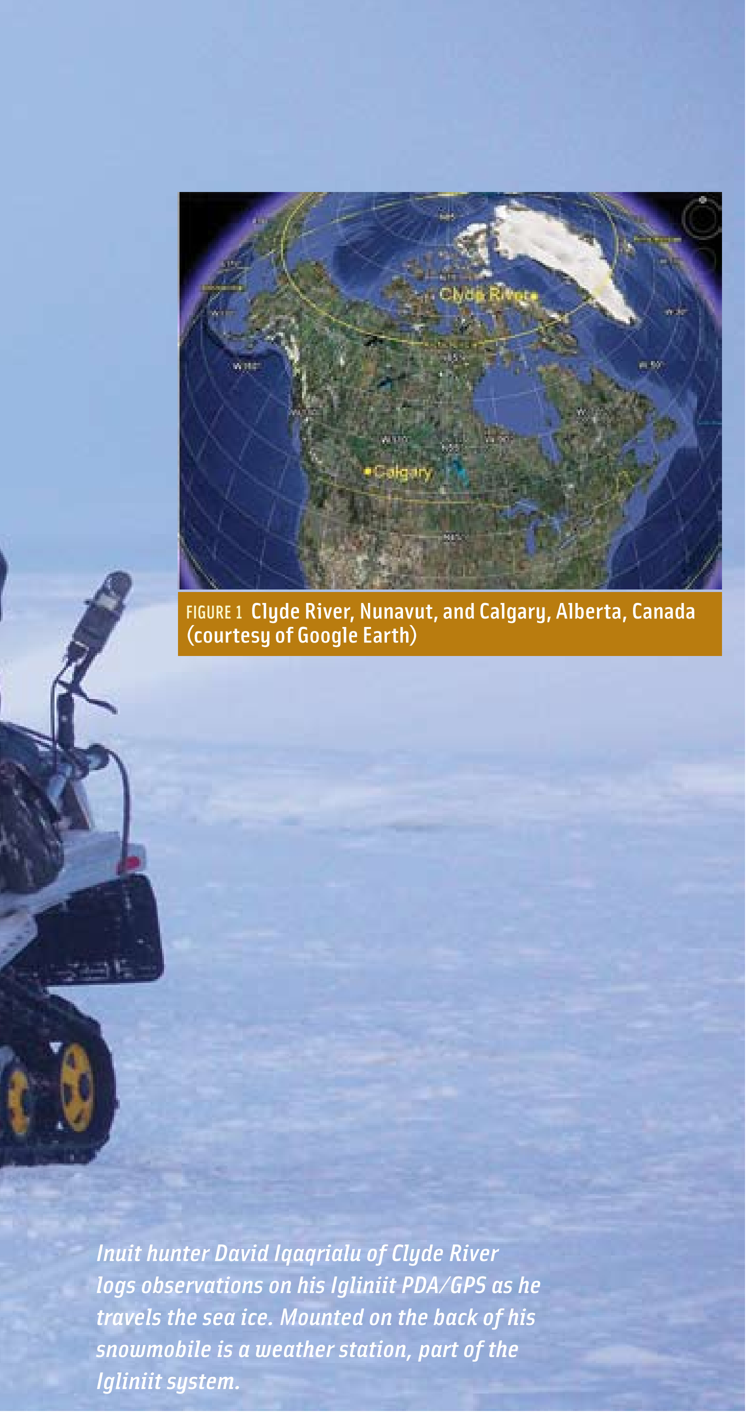
In Inuktitut, the Inuit language, "Igliniit" refers to routinely traveled trails. Countless trails are known and used by Inuit in Canada's far northern territory of Nunavut, a vast area the size of Western Europe filled with sea ice, fjords, and mountains.

Nunavut also has abundant wildlife and is home to approximately 30,000 people, mostly Inuit, who live in 26 communities distributed around Nunavut's 1.2 million square kilometers (746,000 square miles) of land. All of the communities, except one (Baker Lake), are coastal.

Since 2006 environmental researchers, geomatics engineering students, and Inuit from Clyde River (Kangiqtugaapik) — a community (population ~820) on the far northeastern coast of Baffin Island (**Figure 1**) — have worked together in the Igliniit Project. Among their activities is the



Inuit hunter David Iqaqrialu of Clyde River logs observations on his Igliniit PDA/GPS as he travels the sea ice. Mounted on the back of his snowmobile is a weather station, part of the Igliniit system.

Photo: Edward Wingate

FIGURE 1 Clyde River, Nunavut, and Calgary, Alberta, Canada (courtesy of Google Earth)

design, production, and testing of a new tool for Inuit hunters — one that combines the virtues of a personal digital assistant (PDA), weather station, camera, and a handheld GPS navigator.

Designed to be easily and affordably mounted on snowmobiles or dog sleds — the regular modes of travel used by Inuit hunters — the integrated device does not attempt to replace traditional navigation or land skills. Inuit knowledge and skills related to navigation are highly complex and have been passed down over generations.

The Igliniit tracking system is merely a tool, one that can complement and be combined with Inuit knowledge, as other technologies such as snowmobiles and portable navigation devices (PNDs) already have been.

This article describes the first three years of the project, the technical problems and breakthroughs, the collaborative model and — not least — what happened when two markedly different communities discovered each other.

Building a Team

The idea for the Igliniit Project developed in Clyde River, where Dr. Shari Gearheard, a geographer and research scientist with the National Snow and Ice Data Center at the University of Colorado at Boulder, has worked with Inuit hunters and elders documenting environmental change since 1999.

Gearheard, who moved with her husband to Clyde River in 2004, and some of her Inuit research partners came up with the idea for creating a system that allowed hunters to log their observations of the environment as they traveled, so that the information could be mapped easily and immediately. Their findings could then be discussed and shared after the hunters returned from long (or short) journeys.

The Igliniit Project came to life when it joined several other northern projects to create ISIUOP, the Inuit Sea Ice Use and Occupancy Project. Led by Dr. Claudio Aporta at Carleton University in Ottawa, ISIUOP was successful in obtaining a grant from the Government of Canada International Polar Year program. With a focus on sea ice, the Igliniit Project was now ready to test its concept.

Gearheard contacted Dr. Kyle O'Keefe at the University of Calgary Geomatics Engineering Department for support with the technical side of the project. O'Keefe took on the challenge and used the opportunity to create a unique case study for the department's undergraduate senior-year design course.

Three different student groups over three different years of the course selected the equipment and worked on system integration and programming. The students built the system based on design requirements, ideas, and feedback from the hunters in Clyde River, a back and forth exchange that was facilitated by Gary Aipellee (lgliniit Project manager and translator) and Gearheard.

The hunters sketched ideas and concepts, asked questions, and provided critiques, while the students in turn asked their own questions and modified the system to accommodate the advice and requests from the new tool's intended users.

After a year and a half of development, the new system was introduced in January 2008 during the International Polar Year and tested by four hunters in Clyde River during the rest of the 2008 sea ice season (until early July). In the summer and fall of 2008 the students made further modifications to the units based on feedback from the hunters. Then the modified units were brought back to the community in January of 2009 for another year of testing, with two more hunters joining the team.

The Igliniit Tool

The Igliniit system is affordable and simple to mount. It is light and easy to carry and easy to operate.

From Calgary to Clyde River

Quite apart from the technical aspects discussed in this article, the Igliniit project has provided a rare opportunity for undergraduate students from Calgary to explore and learn about a very distinct region of their own country.

The communities of Clyde River, Nunavut and Calgary, Alberta could not be more different. Calgary is a typical North American city and Canada's fifth largest metropolitan area with a population of more than one million. It is a booming commercial center where a number of technology, oil and gas, manufacturing, banking and insurance companies are headquartered.

Many thousands of miles away, Clyde River is a small arctic hamlet situated across Baffin Bay from Greenland (which has a higher population density than the 10-year old Canadian territory of Nunavut.) Nearly all of Clyde River's 820 citizens are Inuit, and subsistence hunting is a major part of their livelihood.

The community has only a handful of cars and both visiting student teams have been fascinated by the use of dogsleds and the dogs' diet of seal meat. The human residents depend on the land and sea as well. Clyde River is supplied only by air and an annual sea lift, and meat from seals, caribou, polar bear, and fish provides a major source of healthy food and makes up a significant portion of the local diet.

Above: Laimikie Palluq and Calgary student Ryan Enns take the Igliniit system for a test spin on Palluq's dog team in January 2009. Note the weather station mounted on an old hockey stick at the back of the sled. Left: Inuit elder and hunter Jacopie Panipak gets to know the Igliniit system in 2008. Mounting hardware is in the foreground.

The University of Calgary undergraduates involved in this project have been intrigued by the differences, but also surprised by the similarities. For example, Clyde River youth are just as skilled as any kid in Calgary when it comes to Internet, iPods, and video games. In fact most of the children of the Inuit hunters help their fathers with technical troubleshooting, and were the first to load music into the systems.

The Igliniit system PDAs have been very popular with the hunters, not just for their data collection capabilities but for other features, including games and music. For example, some Inuit hunters helped build their touch-screen skills by playing solitaire on the Igliniit units.

Photos: Shari Gearheard

The tool consists of a GPS-equipped PDA and a weather station that records temperature, humidity, and pressure and automatically logs the location of the vehicle every 30 seconds. The resulting georeferenced waypoints can later be mapped to produce the traveler's routes along with recorded weather information.

FIGURE 2 **Igliniit user interface showing the first of five pages of icons.**

FIGURE 3 **Igliniit interface showing the sixth page as displayed in Inuktitut. Pressing the English toggle button switches the interface back into English language mode**

In addition, the system's customized PDA screen has a user-friendly touch interface in English and Inuktitut. The interface allows a hunter to press one or multiple icons that represent observations made at a certain point. These observations/icons were determined by the hunters themselves, and programmed by the students.

For example, the unit displays screens with icons that represent animals, such as polar bear, fox, caribou, ptarmigan, and so forth, as well as sea ice features including cracks, rough ice, icebergs, and more (see **Figure 2**). Other features allow a hunter to distinguish if an observation is a hazard (for example, thin ice or certain types of cracks).

A keyboard can be displayed to enable a hunter to note something that might not be part of the icon list. When the hunter makes an observation, it is logged in the system to be mapped later. A digital camera carried by the hunter provides georeferenced images that add to the documentation of the journey.

In the project's current phase, the group is working on generating maps of the data and toward automating the project. This aspect of the work is led by Carleton University.

As maps from the Igliniit system are overlaid and accumulated over time and space, the team hopes to achieve a valuable quantitative and qualitative picture of the land, sea ice, and how Inuit use both.

Combined with other methods of research, such as in-depth interviews with elders and other local experts, Igliniit data help add to the understanding of human-environment relationships. The information has application not only for sea ice studies, but also for potential use in wildlife studies, environmental monitoring, land use planning, and search and rescue activities.

Off the Shelf

In September 2006, before the project was even funded, the first group of four students began their consultations with Clyde River hunters to identify user requirements.

The Inuit wanted to log positions and weather conditions continuously — including temperature, pressure, and humidity. They also wanted to make and log their own observations of the environment. And the system had to work in very cold weather — -40˚C/F and below.

The unit also had to be simple enough for almost everyone in the community to use; so, the system interface had to accommodate the special syllabic script of the Inuktitut language (**Figure 3)**, in addition to the roman orthography used in English.

The students selected and tested hardware for the data collection system. Most fourth-year geomatics engineering undergrads do not have electrical engineering or hardware design experience; so, the project supervisors decided to limit the project to commercial off-the-shelf products, which they hoped would also keep unit costs down.

With these requirements in mind, several initial designs involving handheld GPS receivers, personal digital assistants, and portable weather stations were considered. But most of these couldn't make it in the bitter weather of the sea ice season.

The custom interface and pressure, humidity, and temperature requirements eliminated several commercially available handheld GPS receivers with integrated weather sensors.

Eventually, the students converged on a ruggedized PDA as the most likely candidate for a customizable data-logger. The unit chosen has a minimum operating temperature specification of -30˚C (-22˚F) — not perfect, but the closest they could get to the operating temperature requirement given the project constraints. They also selected the 12-channel, L1 C/A-code CompactFlash card–based GPS receiver that is the PDA's standard companion. The unit provides postprocessed accuracy of two to five meters.

A suitable weather instrument was not identified until early in 2007. Again, due to budget constraints, the COTS requirement, and the need for full operation at -40 degrees, the student team identified and eliminated several possible weather stations before finding a satisfactory instrument.

The pocket weather meter that they selected was chosen for its cost, environmental specifications, and the availability of a serial interface. Although the interface did not support real-time data streaming as a standard feature, the manufacturer provided the team with documentation that enabled the students to implement real-time data logging using several unsupported features of the interface.

Photo: Shari Gearheard

Gary Aipellee leads the Clyde River group through discussions that provide input to the students for interface development

Inuit-Guided Software

In 2007, a second undergraduate project team developed most of the Igliniit software in collaboration with the Clyde River team. The hunters, Aipellee, and Gearheard met regularly to define the user interface and sent their suggestions to the students via Gearheard through email until they agreed on a final interface design.

Internally, the software consists of two serial port readers that communicate with the external weather sensor and the GPS receiver card (which appears to the operating system as a serial port). The students wrote the software in C++ language using the open-source wxWidgets library to develop the graphical user interface (GUI).

The user sees a single window with several buttons that are always available (located at the bottom of the screen, Figures 2 and 3) plus a horizontally scrollable area that contains five pages of toggle buttons and one page of display boxes.

Each button represents either an action or a type of observation, as shown in Figure 2. The user selects any combination of observation buttons and then presses "save" to record the time and position associated with each observation. Some important observations including "catch", "photo", "danger" and "overnight" are always visible, and the rest are available on one of the scrollable screens.

So, for example, a hunter would press "fish" if he observed a fish. The hunter would press "fish" then "catch" if he was successful fishing.

The sixth screen (Figure 3) contains display boxes for current position, speed, bearing, time, and weather information. An additional button toggles the language of the application between English and Inuktitut. The software logs user observations whenever the save button is pushed and keeps an automatic record of position and weather information in order to map the route traveled.

And that's not all — hunters can also play games and music included on the Igliniit system — and they do. The extra features prove handy for something to do while waiting out the weather at camp or keeping the kids busy at the family cabin. (See the sidebar, "From Calgary to Clyde River.")

Field Testing (with Plastic Food Wrap?!?)

For the Igliniit system's initial deployment in January 2008, two students traveled to Clyde River with four complete data collection systems. Preparing for this trip was a project in itself — the isolated community can't be reached by road; so, food and other supplies are prohibitively expensive to buy locally, and everything that could possibly be required for the deployment had to be brought by the students. (The village is supplied only by air and a once-a-year sea-lift.)

In addition to the PDAs and weather instruments, the students carried mounting hardware for the handheld computers and weather station serial interface cradles.

Fortunately, the weather station interfaces included a threaded mount for use with a tripod making it possible to use commercially available camera mounts.

Unfortunately, the otherwise rugged interface cradle couldn't handle the wet spring sea-ice conditions. The solution? Students wrapped the interfaces with a self-adhesive plastic food wrap.

Before the systems were installed on the snowmobiles, the hunters and students spent the first day getting to know each other, practicing the application, and becoming familiar with the PDA operating system.

Then they were ready to go. The hunters, most of whom are also master mechanics (out of necessity), installed the systems on four snowmobiles and took them outside for a test drive in favorable weather.

Ironically, temperatures during the first week were unusually warm, around -15˚C (5˚F) — warmer than Calgary during that time.

Figure 4 shows the route of the first test using Google Earth. An accompanying photo shows where the snow machines turned around at the easternmost point of the trajectory. Two of the four systems worked well during this test, one failed due to a loose battery, and the other due to a loose connection in the GPS receiver CF-slot.

FIGURE 4 Trajectory recorded in first field test plotted in Google Earth. The dark dot at the eastern most point is an island called Umiujaq (see photo), a local landmark.

Taking a break on the sea ice near Umiujaq, at the turnaround point at the easternmost point in the trajectory shown in Figure 4.

Working Out the Bugs

After the two students returned to Calgary, the hunters continued using the equipment for the remainder of the season. A minor problem occurred almost immediately. During the installation, one of the PDA power supplies was damaged, and it took several weeks for the replacement part to arrive by mail.

By the following week, the weather had returned to normal and the PDAs began to freeze. Though the PDA is specified to operate at -30˚C, the screens froze at around -27˚C. The team tried to solve the problem after discovering an Internet article posted by someone in Iqaluit, Nunavut's capital, who was troubleshooting a frozen GPS unit. They suggested placing an electric snowmobile handlebar heater between the GPS receiver and its mounting cradle.

Once again, the team experienced the difficulties of isolation: parts had to be ordered from Calgary and mailed to Clyde River. By the time the heaters arrived, the weather had warmed again, and several of the hunters were uncertain about using the heaters because of concerns that doing so might drain the snowmobile battery or damage the electrical systems.

Q&A with Clyde River hunters David Iqaqrialu (left), Laimikie Palluq, and Jacopie Panipak during first year of testing

Initial data sets contained some useful information, but user observations were missing sporadically from the log. An unknown bug in the software seemed to cause the discrete data (entered by the user through the interface) to not be logged all the time. Unfortunately, this software bug couldn't be reproduced in Calgary and, as a result, went unfixed.

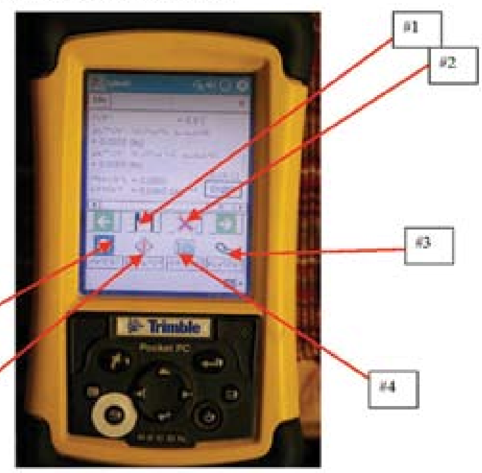
After about one month of deployment, the team encountered another problem. Some of the power and data cables were not weathering very well and cracking in the cold temperatures. In one case, a hunter's dog chewed a cable. Again, replacements had to be sent by mail.

By May 2008, after a season of sea ice travel with constant bumps in rough terrain, the mounting hardware started to break. Large bumps caused some wire connections to fail and GPS cards to dislodge. During consultations the hunters had warned the team about how rough their travel can be, and, indeed, the pounding took a toll on equipment.

Unfortunately the warmer, wetter conditions proved too much for the plastic food wrap. The improvised weather station interface waterproofing no longer worked.

For the last few weeks of the 2008 season, the hunters continued to take photos and use their Igliniit systems. Some also used regular GPS units to log travel, and the team met weekly to discuss their experiences.

During that time they put together a comprehensive report to the Calgary team, outlining their likes, dislikes, and wish list for the next year. The hardware issues were serious,


Reviewing the Permanently Displayed Buttons:

#1 - Save – Press this button each time you want to save an observation. You must press "save" after the icons you select to make sure information is stored properly on the map. All icons require you to press save afterwards, including these icons on the bottom of the screen.

#2 – Cancel – If you press this button, it will delete the last observation you made.

#3 – Catch – Press this button to log where you made a catch. Use this button along with the icons for different animals. For example, if you catch a seal, you would press the icon for "seal", then the "catch" icon, then "save".

#4 – Photo – Press this button to mark the location of where you took a photo.

#5 – Danger – Press this button if you want to mark an observation as dangerous. For example, you might press the icon for "crack" in the ice, and then "danger" if it is a dangerous crack, then "save".

#6 – Overnight – This button might be useful on long trips. Press it to mark the location of where you camped for the night.

FIGURE 5 **A sample English user manual page**

Custom insulated bag (left) with main access flap open. (at right) Insulated bag with main flap closed and heating element installed in the open screen cover. Photos by Edward Wingate

but they also thought the setup procedure for the whole system was too complicated.

For example, many steps had to be repeated if the PDA lost power since several components were being stored in volatile memory, including the font used to represent Inuktitut.

As a temporary measure, a simplified user manual was developed in both English and Inuktitut. A sample page of the user manual is shown in **Figure 5**.

The Wish List

The list of improvements and changes the hunters requested included:

1. Make a simpler operating system interface for the Igliniit application.
2. Make the system deployable on a dog team
3. Solve the frozen PDA problem
4. Make sure that the user-entered data was recorded to file.
5. Make the Inuktitut font stable (the font periodically disappeared in two of the units)
6. Add a map display
7. Develop or obtain more rugged serial cables and mounting hardware
8. Develop a more rugged 12V battery adaptor

The hunters also asked for several additional icons to be added to the observation list.

A third group of three students began working on these refinements in September 2008, and the system changes (described next) are currently being field tested through June/July 2009 by the hunters in Clyde River.

Refining the Hardware

The students first tried two approaches to solve the problem of freezing. They found a way to heat the PDA internally with a modified snowmobile handlebar heater that fit an AA battery form factor. The heater was installed in an optional PDA AA battery boot that was modified to allow the PDA to be powered externally along with the heater.

They placed the heated PDA in a temperature chamber cooled to -40˚C. It was tested on low and high settings. Unfortunately, at the low setting, the heater was unable to heat the PDA sufficiently to keep the whole screen from freezing, and, at the high setting, the heater melted the soft plastic part of the battery boot.

The three students then tried a second approach. They designed an insulted bag for the entire PDA. The three-layer prototype consisted of a ballistic nylon shell, a layer of microfiber insulation and an internal layer of nylon that included a fold-back flap for accessing the screen.

They attached a flat handlebar heater to a thin aluminum plate and inserted it into a pocket in the screen flap. This provided direct heat to the PDA screen when the flap was closed. Accompanying photos show the bag open and closed, with the heating element installed and the screen flap open.

Further controlled tests were conducted to find out whether the bag could keep the PDA warm with and without the use of the heater. A live GPS signal was re-radiated inside the temperature chamber to confirm reception of GPS signals through the bag.

The controlled-condition test results were very promising. The bag alone maintained the PDA screen at a temperature above -10˚C for several hours without active heating. With heating, a constant screen temperature of -10˚C was maintained for more than eight hours in an external temperature of -40˚C.

The bag was modified to attach permanently to the mounting hardware, with the mounting cradle inside the bag (so that the PDA unit could be easily mounted and unmounted). Additional hardware developments included mounting brackets with shorter lever-arms that should work better over rough terrain.

The team also replaced several PDA batteries and built custom serial and power cables using materials more suitable for cold weather.

Improving the Software

The students removed unwanted software from the PDA and simplified the application launch procedure.

The aforementioned software bug that failed at times to write hunters' observations to file could still not be reproduced in Calgary. However, the team made several software modifications that insured immediate file writing.

Because the group had spent most of the Fall 2008 semester working on hardware improvements, they decided to defer the addition of a map display until after deployment in January 2009.

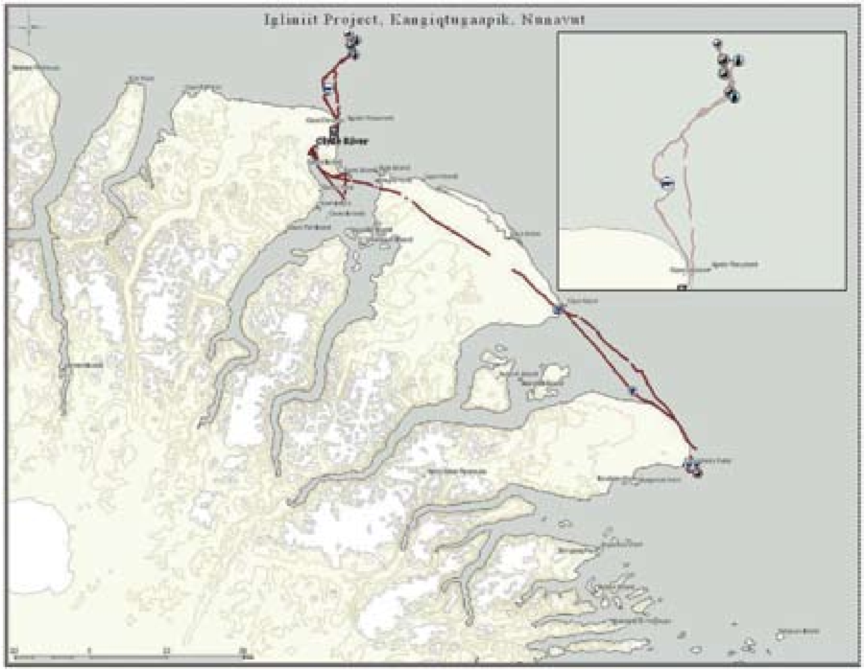


FIGURE 6 A draft map reflects one approach to representing Igliniit data. (The team is still experimenting with how to best map the data for various uses.) The map shows continuously logged trajectories and user observations. Observations shown include seals, polar bears, polar bear tracks, and thin ice.

The Second Season

In January of 2009 came the third team's turn to prepare for and undertake the rigorous one-week trip to Baffin Island.

The three students worked with the hunters to install complete systems on six snowmobiles and two dogsleds and began testing on January 23.

With lessons learned from 2008, they brought spare PDAs along. One extra unit stayed in Clyde River and another returned to Calgary with the students for continued troubleshooting and debugging.

They also brought a whole lot of spare parts.

The students and hunters hope that improved hardware, the PDA insulator bag, and minor software modifications will lead to improved data collection this sea ice season.

A Journey in Progress

The focus this season is on developing the technology and getting it to work reliably. **Figure 6** shows a sample trajectory from the 2008 ice season displayed on a map of the Clyde River area. Once more data from the 2009 season is available, the hunters will discuss the best ways to represent the data and how the maps and data should be used.

The Igliniit Project is funded to run through 2011. If developed and tested successfully, the technology may be useful in many Arctic communities and beyond for a range of activities such as environmental monitoring, land use planning, and search and rescue.

Acknowledgments

The Igliniit Project is part of the larger Inuit Sea Ice Use and Occupancy Project (ISIUOP). ISIUOP involves several other Inuit communities and researchers and is coordinated by the Geomatics and Cartographic Research Centre (GCRC) at Carleton University in Ottawa, Canada.

The project is one of Canada's contributions to the International Polar Year (IPY) and to the Sea Ice Knowledge and Use (SIKU) Project, which is a larger IPY collaboration among several countries.

Eleven undergraduate students contributed to this work: 2006-2007: Desmond Chiu, Sheldon Lam, Andrew Levson, and Jeremy Park, 2007-2008: Brandon Culling, Josiah Lau, Tina Mosstajiri, and Trevor Phillips, 2008-2009: Michael Brand, Ryan Enns, and Edward Wingate.

Six hunters work on the Igliniit Project, four since the beginning: Apiusie Apak, David Iqaqrialu, Laimikie Palluq, and Jacopie Panipak. Jayko Enuaraq and Amosie Sivugat joined the team starting 2008/2009. Gary Aipellee is a project coordinator, researcher, and interpreter from Clyde River who has played a crucial role in facilitating the entire project since the earliest stages. (Thank you, Gary!!)

The project would not be possible without the support of the University of Calgary, Carleton University, the Government of Canada IPY program, the Hamlet of Clyde River, the Clyde River Hunters and Trappers Association, the Ittaq Heritage and Research Centre, and the Nunavut Research Institute.

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Manufacturers

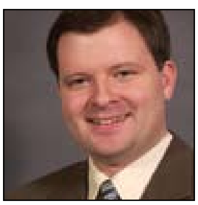
The Igliniit Trails system incorporates a TDS (Trimble) Recon PDA and the XC Pathfinder GPS receiver from **Trimble**, Sunnyvale, California, USA, and a Kestrel 4000 pocket weather meter from **Nielsen-Kellerman**, Boothwyn, Pennsylvania, USA. The PDA application software was written in Microsoft Embedded Visual C++, **Microsoft Corporation**, Redmond, Washington, USA, and the user sees a Windows Mobile application. The microfiber insulation used in the cold-proofed improvised PDA bag was Thinsulate, from **3M**, Minneapolis, Minnesota, USA. The food wrap used to seal the PDA interface connections was Glad Press'n'Seal from the **Glad Products Company**, Oakland, California, USA.

[redacted]

Photo: Cynthia Panipak

The Igliniit team in Clyde RIver, January 2009. Back row from left: Ryan Enns, Jayko Enuaraq, David Iqaqrialu, Laimikie Palluq, Edward Wingate, Amosie Sivugat, Jacopie Panipak. Front row from left: Michael Brand, Gary Aipellee, Apiusie Apak, Shari Gearheard

Authors



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Shari Gearheard is a geographer and research scientist with the National Snow and Ice Data Center at the University of Colorado at Boulder. Since 1995, she has worked with Inuit communities on projects that link Inuit and scientific knowledge of the environment and environmental change. Gearheard lives and works full time in Clyde River, Nunavut.

Gary Aipellee is a professional interpreter/translator and a researcher and coordinator for the Igliniit project.

Apiusie Apak, Jayko Enuaraq, David Iqaqrialu, Laimikie Palluq, Jacopie Panipak, and **Amosie Sivugat** are expert hunters from Clyde River.

Desmond Chiu, Sheldon Lam, Andrew Levson, and **Jeremy Park** were undergraduate students at the University of Calgary in 2006-2007. Together they researched and selected the best possible hardware options available to the Igliniit Project.

Brandon Culling, Josiah Lau, Tina Mosstajiri, and **Trevor Phillips** were undergraduate students at the University of Calgary in 2007-2008. Together they developed the main software application used in this work and managed the deployment of the project in the first field season.

Michael Brand, Ryan Enns, and **Edward Wingate** are University of Calgary undergraduate students currently working on the project. They were recently in Clyde River to deploy their improvements to the system for a second season of field testing.

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