Cabled Observing Stations for Remote Locations

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***Abstract*—Using experience and technologies developed for Ocean Networks Canada's (ONC) seafloor cabled networks we have developed a small scale observing station that can be easily deployed in remote locations such as Canada's high Arctic. These areas provide challenges in a number of areas; environmental, logistic and social. In this paper we will discuss how these challenges are met and some strategies that we use to help ensure successful deployments of these stations.**

The engineering of these projects required new technology to be developed to deal with the different environments. In some respects things are easier, the platforms currently deployed and planned for future deployment are all in shallow water and in seismically quiet zones. However, the remote location and extreme weather conditions in the Arctic provide new challenges. There are three main components to these system: 1) the underwater platform connecting all the instruments to 2) the relay station on shore that includes a weather station and camera and transmits all the data to 3) the shore station that buffers and forwards data to a data centre. The main challenge for the underwater component is to ensure that the ice does not interfere with the systems. The land-based relay tower uses wireless networking components that are vulnerable to environmental damage and vandalism. The final transmission of data from the shore station to the data centre is done through a commercial satellite-based channel that is also subject to weather and other environmental challenges, has relatively low bandwidth and is not 100% reliable.

The remote observing stations were designed to be relatively small and lightweight so that one or two people can easily deploy and recover the main sensor tripod using only a small boat and a diver. The major engineering obstacles for the arctic deployment were the extreme low temperatures experienced during the winter months and the formation (and especially the subsequent break-up) of surface sea-ice. The relay station is perhaps the most vulnerable link in the whole system. Data are generally not buffered before reaching the shore station so any failure of the system prior to that will result in data loss. The relay component is located beside the water and is more exposed to the elements. Once the data reach the shore station, servers buffer the data. Buffering protects data against network outages and allows large data sets such as video data to be sent later at a reduced bandwidth. Logistics requires careful planning as only limited supplies are available on site. Keeping the platforms relatively small not only reduces the overall cost of deployment and general maintenance but also allows for a greater amount of community involvement and personal interaction. Involving the community in the project significantly increases chances of success.

To date Ocean Networks Canada has deployed two observing stations, one at Brentwood College School (BCS) near Victoria, BC and one in Cambridge Bay, Nunavut, in Canada's high Arctic. The first installation, BCS, was a proof of concept and served as a test for the second installation in a remote location. More installations are being planned and refinements are in the works to improve the system. Using copper cable for data transmission limits the length of cable that can be used, this limit can be greatly extended by using fibre optic cables for data transmission. ONC has also designed new underwater interface cans to connect instruments to shore. These new devices will have the ability to support more instruments and provide better monitoring and control. They also allow greater flexibility in the variety of instruments that can be connected to the observing stations

Keywords—observatory, Arctic

I. INTRODUCTION

Ocean Networks Canada (ONC) manages a variety of observing stations whose flagships are the extensive cabled observatories, NEPTUNE Canada and VENUS. The basic components of these systems provide a model that can be used in wide variety of situations. Underwater instruments are deployed in areas of scientific interest on the ocean floor. These platforms are connected by cables to a landing station on the shore via a variety of instrument adapter, junction boxes and nodes. From the shore station the data are transferred to data centres for further processing, archiving and are made available to the world on the Internet. ONC has recently developed smaller stations that can be rapidly deployed in more remote locations, such as Canada's high Arctic. While the basic concepts are the same the remote locations provide unique challenges that must be overcome.

The first small-scale observing station was developed for a local school, Brentwood Bay College, which allowed us to design and implement a smaller, easily deployable station without the challenges of remoteness. Building on the experience gained with this system we then created a similar system that was deployed in Cambridge Bay. Remote locations often require different engineering approaches, high Arctic installations must deal with low temperatures and sea ice.

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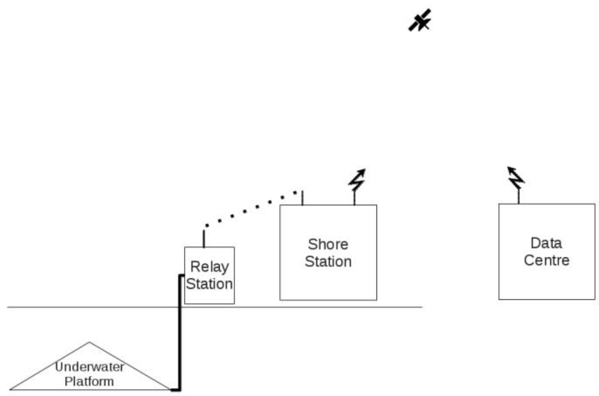

Fig. 1. Components for an observing station. The connection to underwater instruments is by cable containing power and communications links. Connections between land-based components may be wired or wireless.

II. Observing Station Components

A. Underwater Platform and Instruments

Instruments are mounted on an underwater platform which is then deployed as a unit. An observing station may have one or more platforms, auxiliary platforms are used to separate acoustic instruments that may interfere with each other or to place instruments in different areas of interest. The platforms are connected to shore equipment by cables for power and communications (serial and/or Ethernet).

The basic instruments on our currently deployed small platforms are: a Wetlabs Water Quality Meter (WQM) that measures water properties including temperature, pressure, conductivity, dissolved oxygen, turbidity and chlorophyll, an underwater camera with lights and a weather station on shore.

Fig. 2. Platform deployed at Brentwood College School, BC

Ocean Networks Canada, a University of Victoria initiative

The high Arctic installation also includes a Shallow Water Ice Profiler (SWIP) and a shore mounted security camera. The 2013 maintenance run will see the weather station updated, a precision barometer installed and an Automatic Identification System (AIS) transponder for tracking ship locations added to the shore station. Existing underwater instruments will be supplemented by a hydrophone and a fish tag receiver.

B. Relay Station

The relay station on shore links the underwater instruments with the shore station containing servers and data storage systems. This component consists of power supplies, power control, network and serial communication equipment. Mains electrical power is converted to lower voltage DC power for the relay station components and to supply power to the underwater equipment. There are network connected relays that permit power to be applied to, or disconnected from various devices, both above and below water. Ethernet and wireless Ethernet switches provide a communications path for data and control commands between the instruments and the shore station. In the current implementation there are also serial connections between the relay station and the instruments.

C. Shore Station

The shore station contains servers to pre-process the data and storage to buffer the data to protect against network disruptions. The Arctic shore station is located in the main government building in the centre of Cambridge Bay, the Helen Maksagak Centre, which has line-of-sight visibility to the dock. We were fortunate in being allowed not only to use space in the building for our servers but also to be able to mount antennas on the roof. Data are transmitted to our data centre at the University of Victoria where they are made available to the world.

III. Challenges and Solutions

A. Underwater Platform

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Fig. 3. Platform on dock at Cambridge Bay ready for deployment.

The smaller observing platforms have been deployed close to shore in shallow water which makes deployment significantly easier than deep open ocean platforms. Temperature is not a problem for the underwater equipment as water temperature drops only 1 or 2 degrees C below zero and instruments are deep enough to not be encased in ice

The major engineering challenges in an Arctic environment are dealing with ice formation and breakup and in particular at the interfaces between air-ice and ice-water. Cables must be protected where they emerge from the water to prevent damage by the ice. In the spring as the ice breaks up there is the potential of large chunks of ice physically damaging underwater components. The simplest solution is to locate the platforms at sufficient depth that ice will never reach them, however it is not certain what the minimum safe depth is and other factors, such as cable length and dock location, must also be considered when positioning a platform. The platform was installed using a small boat and a single diver at a depth of 6.4m off, and a bit to the side, of the end of the dock. Using plastic for the structural components of the platform not only reduced weight but means that it will not corrode the way many metals would

Locating the instrument platform near the dock made power and networking relatively easy, the main disadvantage of the location is the fact that large barges and tug boats also use the dock during the summer. Hopefully this will result in nothing more than silt deposition on the systems. In the worst case, the system will be serviced soon after the barges have visited and instruments can be cleaned or repaired. Weights have been attached to the legs and to the cables to try and prevent shifting of the platform.

The platform and all the instruments are still functioning at the time of writing 10 months after installation, they have survived a winter and the spring breakup of the ice. The next challenges will be the arrival of the barges.

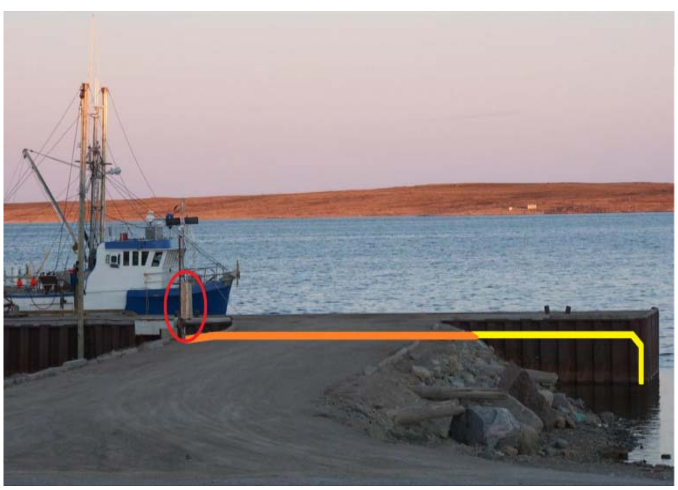

Fig. 4. Above water cable route from relay station along the dock. The cable is either buried or protected by steel pipe. The steel pipe extends underwater and protects the cable from ice formation.

Fig. 5. The relay station in the process of assembly at Cambridge Bay dock.

B. *Relay Station*

In remote locations this component is perhaps the most vulnerable to environmental damage and vandalism. A double enclosure was constructed and mounted on a wooden pole beside the town dock to contain the equipment. The sensors for the weather station were mounted above the enclosure on the same pole along with the antennas for wireless Ethernet connection to the shore station in town. The Arctic relay station had to be designed to handle temperature ranging from lows near -50°C to highs over 25°C. Where ever possible extended temperature components were used, these generally have an operating range from -40°C to 75°C. To maintain the internal temperature of the enclosure within the acceptable operating range of the internal components, an enclosure heater was used and the enclosure was insulated. Even with the insulation the temperatures do not get too hot during the summer months.

Unfortunately we lost the anemometer on the weather station to vandalism soon after installation. A new weather station with no moving parts will be installed later this summer to mitigate against this risk.

C. *Shore Station*

The shore station is unaffected by the external environment, however the remoteness of the location means that network bandwidth is lower and connectivity is not as reliable as in other locations. The connection between the relay station and the shore station uses industrial wireless Ethernet components with externally mounted antenna. These worked during the winter even with the cold, wind and snow. Buffering data on local storage and sending the data when connectivity is available ensures that network interruptions to the data centre do not result in data loss. The ability to buffer the data also helps in dealing with bandwidth issues in that we can buffer data such as large images and video clips. Video is recorded at regular intervals for a short period of time, the recorded video is then sent to the data centre as a file over a longer period of time.

The network limitations and remote location also pose challenges for monitoring and control of the observatory. The systems are therefore designed to run autonomously as much as possible and to use the most reliable components available. There is sufficient network connectivity to allow connections to the components for trouble-shooting and basic maintenance. Hardware failures are more difficult to deal with, we have established relations with the local community that are invaluable when issues arise that cannot be dealt with remotely.

D. Logistics

Another challenge of deploying observing stations in remote locations is simply the logistics and getting equipment and personnel to those areas. Travel is more expensive, facilities and supplies are usually more limited. Keeping the platforms small and simple reduces the overall cost of shipping, deployment and general maintenance. Another important factor is community involvement, whether the observatory is a part of a school or launched from a government dock, success depends not only on the support from the local community for the initial installation but also for the ongoing lifetime of the project. People in the communities can be the friendliest, most helpful people with invaluable local knowledge and involving the community in the project will significantly increase chances of success.

IV. Variations and Future Directions

The model we are using for undersea observatories has proved a reliable system for collecting and archiving data from underwater instruments. The model is configurable for a variety of locations from large cabled systems to smaller, more remote installations. Within the framework of the current model there are options that may extend the range of locations where these smaller systems can be deployed. Replacing copper Ethernet cables with optical fibre would greatly increase the maximum length of cable and thus the distance from the dock/shore of the instrument platform. In less remote areas it is also possible to use cellular telephone networks to transmit data from observing stations to the data centre, this allows stations to be deployed with even less support infrastructure required. In a similar vein we are working on systems that combine the relay station and shore station into a single package and can be plugged into any instrument or instrument platform. All that is required is a method of transmitting the data back to the data centre.

Easy to deploy and relatively low cost mini-observatories have the potential to open up many near shore, shallow water areas for instrumentation. Working with schools and other community groups is a mutually beneficial way to extend the range of locations from which Ocean Network Canada gathers data and will contribute to increased observation and monitoring of the oceans in remote areas of Canada.

V. References

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