NOAA Technical Report NOS CO-OPS 057

Ocean Systems Test and Evaluation Program

Redundant Communications Solutions for PORTS® Acoustic Current Profiler Installations

Silver Spring, Maryland
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noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Center for Operational Oceanographic Products and Services

Center for Operational Oceanographic Products and Services
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

The National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) provides the National infrastructure, science, and technical expertise to collect and distribute observations and predictions of water levels and currents to ensure safe, efficient and environmentally sound maritime commerce. The Center provides the set of water level and tidal current products required to support NOS' Strategic Plan mission requirements and to assist in providing operational oceanographic data/products required by NOAA's other Strategic Plan themes. For example, CO-OPS provides data and products required by the National Weather Service to meet its flood and tsunami warning responsibilities. The Center manages the National Water Level Observation Network (NWLON), a national network of Physical Oceanographic Real-Time Systems (PORTS®) in major U.S. harbors, and the National Current Observation Program consisting of current surveys in near shore and coastal areas utilizing bottom mounted platforms, subsurface buoys, horizontal sensors and quick response real time buoys. The Center: establishes standards for the collection and processing of water level and current data; collects and documents user requirements, which serve as the foundation for all resulting program activities; designs new and/or improved oceanographic observing systems; designs software to improve CO-OPS' data processing capabilities; maintains and operates oceanographic observing systems; performs operational data analysis/quality control; and produces/disseminates oceanographic products

Ocean Systems Test & Evaluation Program

The CO-OPS Ocean Systems Test and Evaluation Program (OSTEP) facilitates the transition of new technology to an operational status, selecting newly-developed sensors or systems from the research and development community and bringing them to a monitoring setting. OSTEP provides quantifiable and defensible justifications for the use of existing sensors and methods for selecting new systems. The program establishes and maintains field reference facilities where, in cooperation with other agencies facing similar challenges, devices are examined in a non-operational field setting. OSTEP evaluates sensors, develops quality control procedures, and generates maintenance routines. Rigorous, traceable calibrations and redundant sensors assure the quality of the reference systems used in the field.

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EXECUTIVE SUMMARY

The Center for Operational Oceanographic Products and Services (CO-OPS) is committed to providing products and services that support safe and efficient marine transportation, sound environmental management, and effective emergency planning. Numerous CO-OPS products are part of the Physical Oceanographic Real-Time System (PORTS®). The PORTS® network contains a suite of instruments that measure and disseminate observations of environmental and meteorological parameters and has become a major decision support tool that integrates real-time environmental observations, forecasts, and other geospatial information.

Reliable data communication paths are critical to maintaining the high quality products that make up the PORTS® network. CO-OPS depends upon telephone lines, line-of-sight (LOS) radios, wireless Internet protocol (IP) and Iridium modems, as well as Geostationary Operational Environmental Satellites (GOES), to transmit data that serve as the backbone of PORTS® products. Most systems use at least one of two or more telemetry methods to ensure that real-time data reach CO-OPS servers. However, most acoustic current profilers within the PORTS® system do not have a redundant communication path because the message sizes are both large and frequent (transmitted every six minutes). Of the 38 acoustic current profilers that CO-OPS maintains, most contribute to PORTS® data, including the 15 that reside on aids to navigation (ATON) buoys.

Although installing redundant communications for all acoustic current profilers is ideal, a more immediate goal is to implement more robust communications on ATON profilers. The Ocean Systems Test and Evaluation Program (OSTEP) has several projects underway, some of which will help to achieve this goal by improving the data communications for both ATON and cabled acoustic current profilers. These projects include integrating the Sutron Xpert 9210B data collection platform (DCP) with Sontek and RDI acoustic current profilers, installing the Xpert DCP in the Nortek ATON profiler electronics box, using Iridium or wireless IP modems on ATON profilers, and developing the DCP Command receiver using the GOES system. These projects and technologies provide multiple options for redundant communications, allowing CO-OPS to use the technology that best fits the specific need, while maintaining high quality PORTS® products.

Implementation of these projects in appropriate situations will enhance PORTS® products; however, other challenges remain. Data sets of the ATON acoustic current profilers are too large for the bandwidth available on GOES, so efforts are underway to optimize instrument configurations that reduce the size of data sets. While existing products will not be affected by transmitting messages in subsets, making it work seamlessly with the CO-OPS ingestion process will take considerable effort.

Technology is changing rapidly; therefore, ensuring that CO-OPS uses the best and most cost-effective solutions for PORTS® data communications is a tremendous challenge. It requires flexibility and constant attention to make sure that products and services keep pace with the technology advances and the efficiencies they can provide. For example, two-way communications and supporting technologies are paramount to keeping pace with maintenance requirements for remote stations. Iridium modems can potentially play a key role in meeting these requirements, not only for acoustic current profilers, but also for other sensors, especially if the cost of Iridium continues to decline. Herein lies a key reason for CO-OPS to support the NOAA Office of Policy, Planning, and Evaluation effort, headed by Steve Piotrowicz, to secure a dedicated Iridium service similar to that of the Department of Defense (Personal communication May 2009).

Implementation of the recommendations and project improvements described in this report is critical to maintaining accurate and reliable information flow to the PORTS® network and brings CO-OPS a step closer to achieving the overall goal of establishing redundant data communication paths for acoustic current profilers.

1.0 INTRODUCTION/BACKGROUND

The Center for Operational Oceanographic Products and Services (CO-OPS) oversees an extensive network of instruments that collect, analyze, and disseminate integrated oceanographic and meteorological data. These data result in products that contribute to safer shipping and boating, more efficient port operation, more thorough emergency planning to ensure the safety of coastal residents, and improved environmental planning and protection. Several of these data products offer real-time, 24/7 data to shippers, port operators, emergency planners, coastal managers, and others throughout the U.S. and are part of the CO-OPS Physical Oceanographic Real-Time System (PORTS®).

PORTS® consists of a suite of instruments that measure and disseminate observations of water levels, currents, salinity, and meteorological parameters (winds, atmospheric pressure, air and water temperatures). Ultimately, PORTS® serves as a major decision support tool that improves the safety and efficiency of maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts, and other geospatial information. Instruments that collect these data are strategically positioned at 20 PORTS® systems, with 183 stations located at 50 of the Nation's largest ports.

The transmission of data from PORTS® stations can occur in several ways, depending upon the size of the data messages and how frequently transmission is required. Methods of data transmission used include wireless Internet protocol (IP), Iridium, and line-of-sight (LOS) radio modems, telephone lines, and Geostationary Operational Environmental Satellites (GOES).

The importance of reliable data communications for PORTS® cannot be understated. The PORTS® network of instruments depends on high quality communications to collect and distribute data, and many systems include redundant communication paths to ensure that PORTS® data are available to users. When communications fail, CO-OPS products cannot be delivered to those who depend on them for decision support. There are numerous points along the telemetry pathway where failure can occur—from the first data point collected through product delivery to customers. Each instrument and process occurring between these two paths must work properly for successful data transmission to occur.

Failures are often attributed to the data delivery part of the process; however, a study of the reasons for system downtime revealed that data delivery failures happened because the telemetry system did not transmit, and there was no secondary or redundant system to intervene. An April 2006 report funded by the National Oceanographic Partnership Program (NOPP) and issued by the Johns Hopkins Applied Physics Laboratory (Nichols et al. 2006) stated:

> Experience in recent coastal predictive skill experiments on both the east coast and the west coast have relied heavily on HF [high frequency] radar surface currents for

> adaptive sampling. HF radar systems consist of a series of remote shore sites with HF radio transmitters and receivers. In both cases, the greatest source of system downtime was traced not to the high technologies of the HF radar system, the computer analysis at the remote shore site, or the product production at the main control center and subsequent distribution via the web on the internet. The biggest source of downtime was the relative low technical solutions required for communications from a remote shore site to a central internet-equipped facility. Standard phone lines with dial-up modems and LOS radio modems were used. It was found that the most cost-effective means to improve system uptime was to add a redundant communication path to each remote location. This way, when one system goes down, the other is still available for remote access.

Current measurement systems are among those at greatest risk for data delivery failure because they often lack redundant communications. Fifteen acoustic current profilers mounted on aids to navigation (ATONs) provide current data within the PORTS® network. An additional 23 cabled systems also provide current measurements for PORTS® at some of the more than 200 National Water Level Observation Network (NWLON) stations. ATON acoustic current profilers generate large and frequent data messages, (every six minutes), making redundant communications prohibitively expensive, depending upon the telemetry method used. Also, the PORTS® interface board (Sprenke board) cannot manage more than one method of communication. If communication from the acoustic current profiler fails at any single point along the data transmission path, data transmitted during that time are lost. Determining the specific failure point can be difficult; however, implementation of a redundant (or at least a secondary) communication path seems to be the best way of preserving valuable PORTS® data. Absent a redundant telemetry method, implementation of more robust communications for ATON acoustic current profilers should be an immediate goal to ensure high quality PORTS® data.

In July 2008, the PORTS® manager submitted a Razor request to begin implementation of redundant communications methods for acoustic current profilers. Razor, the CO-OPS software configuration management system, provides for process management, issue/problem tracking, and version control-and-release management. The goal of the request is to augment the robustness of data communications within the PORTS® system. The request outlines the project deliverables, timeframe, and resources needed for successful implementation. The first deliverable includes an assessment of existing capabilities. The next is to identify stations or sensors within PORTS® that do not have a redundant method of data transfer. If possible, stations/sensors without a redundant method of transferring data should receive an additional communications method. The next deliverable is development of the capability to transmit acoustic current profiler data over GOES, and finally, to add that capability to all real-time acoustic current profilers (i.e. planned deployments outside of PORTS®).

Resources throughout each CO-OPS division are required to implement this Razor project. For example, over the six-month project duration, staff/Engineering Division (ED) in Silver Spring, MD will perform an assessment of existing capabilities and identify sensors without a redundant method of transferring data. OSTEP will develop the current profiler data collection capability via the Sutron Xpert data collection platform (DCP), as well as a program to transmit reduced current profiler data format. The Information Systems Division (ISD) will develop the capability to receive current profiler data over GOES in a reduced data format. The Oceanographic Division (OD) Coastal and Estuarine Circulation Analysis Team (CECAT) will develop a reduced data format for current profiler data to transmit over GOES.

The rapid development of data transmission technology requires the oceanographic community to examine potentially more reliable and less expensive ways to deliver products to consumers of PORTS® data. As a result, CO-OPS also faces the reality of the extensive organizational coordination required to stay abreast of the latest technology. Coordination and communication among CO-OPS divisions are crucial to the generation of high quality PORTS® data products. Reliable data communication paths are equally as vital to the delivery of those products. Thus, improving the reliability of data communications is a high priority for OSTEP in FY 09 and is evidenced in several projects already in progress. For example, OSTEP is pursuing a transition away from Sprenke boards on cabled acoustic current profilers and is instead adapting the Sutron Xpert DCP (which allows for multiple communication methods) for use within the electronics box. OSTEP has also tested Iridium Short Burst Data (SBD) modems for communication with remote sensors. Implementation of these projects will result in the replacement of LOS radios with the more robust wireless IP and Iridium modems. These and several other projects are complementary and parallel in purpose to the previously mentioned Razor request. The following sections outline the status of and strategy for these projects, as well as the resources and personnel required to reach the ultimate goal of providing redundant communication paths for acoustic current profilers.

1.1 Statement of the Issues to be Addressed

CO-OPS presently uses wireless IP modems as the communication method for most cabled acoustic current profiler installations. The modem is connected to a PORTS® interface board (Sprenke board), which provides power and communications to the profilers. Since this method lacks the capability to add a second communication path or to store data outside of the profiler, the addition of a DCP to the PORTS® acoustic current profiler system would provide these capabilities along with other possible improvements, such as the addition of a wind sensor.

LOS radio modems provide a reliable communication path and can be robust at short distances. However, since over time PORTS® users have requested information about currents further from the shore stations, the distances between the shore station and buoys in many cases have increased. Sometimes as a result, these longer distances have exceeded the design limits of LOS radios. As we anticipate the future needs of PORTS® users, it is essential to identify more robust methods of transmitting data.

PORTS® ATON acoustic current profilers record 20 current profiles in 1-meter (m) bins. Although some ATONs are located in deeper water, many collect profiles in 10 m of water or less. This not only results in unusable and meaningless data profiles that exceed the water depth, but it also requires more power and incurs greater costs by generating more frequent maintenance visits. Therefore, it is important to optimize acoustic current profilers' configurations to improve the reliability of data transmission, collecting only essential information, while ensuring that PORTS® products remain unchanged.

2.0 PORTS® DATA COMMUNICATIONS IMPROVEMENTS

The requirement for more robust PORTS® data communications is clear. PORTS® users and society as a whole derive numerous benefits from these products, and product improvement is essential to maintaining the quality and value of the PORTS® suite of instruments to the user community. To address the need for increasing the robustness of data transmission, especially for real-time current observations, CO-OPS has undertaken several efforts that improve data communications, including:

- DCP for acoustic current profiler installations
- Wireless IP modems for ATON acoustic current profiler installations
- Iridium modems for ATON acoustic current profiler deployments
- Iridium modems for stations beyond common terrestrial communications links
- GOES DCP Command capability via Sutron SBIR

The status and plans for each of these efforts are detailed in the following paragraphs.

2.1 DCP for Acoustic Current Profiler Installations

In August 2005, CO-OPS provided funds to Sutron Corporation to develop code supporting the ingestion of RDI acoustic Doppler current profiler data, and eventually expanding the effort to include Sontek acoustic current profilers. As a result, OSTEP integrated a Sutron Xpert 9210B DCP with both the Sontek and RDI acoustic current profiler systems. The DCP polls the profiler every six minutes, stores these full data sets in a daily file, as well as a file that the PORTS® data acquisition system (DAS) polls by a using one of two or more methods of communications (LOS radio, wireless IP, or Iridium modem, telephone, or an Ethernet connection). These daily files can be downloaded each night as a backup to the already transmitted data. The DCP can store up to four months of data. In addition to the acoustic current profiler data set, the DCP can also send back the battery voltages of the DCP, profiler, and communications equipment, as well as those of other sensors, depending on the amount of data space available. A test of the system using a Sontek side-looking profiler is now underway, and it will soon be installed at a field test site. In the future, the system will be able to transmit a subset of the data every six minutes via GOES, however, ED and OD must determine the subset of data that can be transported (the entire data stream is too large for a GOES message), while ensuring that existing products remain unchanged.

When implementing new and improved data communication methods, it is crucial to optimize the format of the data to be transmitted to ensure efficient delivery and decrease the likelihood of communication failure. Reducing the size of a data message, if possible, can result in more efficient, and in some cases less costly, data telemetry.

The size of the data collected by PORTS® ATON acoustic current profilers can be significantly reduced at most deployment locations. Currently, all PORTS® ATON profilers are configured to collect data in 1-m depth bins and record data from 20 bins, which is transmitted and stored in CO-OPS data bases. However, water depth at most ATON acoustic current profiler deployment locations is significantly less than 20 m, particularly at various Chesapeake Bay and Gulf of Mexico PORTS® locations. Also, when an acoustic current profiler is deployed on an ATON using the “clamparatus” device, the transducer head is located approximately 2 m below the sea surface (Bosley et al. 2005) and the instruments have a 0.4-m blanking distance, i.e., the first good depth bin of current data will be approximately 2.4 m below the water column. Consequently, good current data can only be collected at most deployment locations over a depth range significantly less than 20 m, and data recorded in extra bins that extend beyond the sea floor are meaningless, typically containing noise that results from the bottom-reflected acoustic current profiler signals.

Figure 1 contains plots generated using the CO-OPS C-MIST tool, which show contours of ATON acoustic current profiler data collected at Chesapeake Bay PORTS® ATON at York Spit; (a) echo intensity (dB), and (b) current magnitude (cm/s). In both plots, the bottom of the water column is significantly shallower than the range of the last recorded depth bin. These data provide an example of an operational PORTS® ATON acoustic current profiler system that is currently recording and transmitting extraneous data that contain only noise—no meaningful current measurements.

As part of the communication improvements proposed in this document, PORTS® ATON acoustic current profiler configurations should be optimized to reduce the size of data recorded, including only depth bins that contain meaningful current data. This involves determining mean water depth at a deployment site along with a typical tidal water level and range, and then changing the bin number setting in the acoustic current profiler configuration file accordingly. Reducing the size of transmitted ATON profiler data requires minimal effort during deployment planning. Such action can significantly improve not only the communication efficiency but also the capability of data access and analysis tools, such as C-MIST, and can also increase storage capacity of CO-OPS data bases.

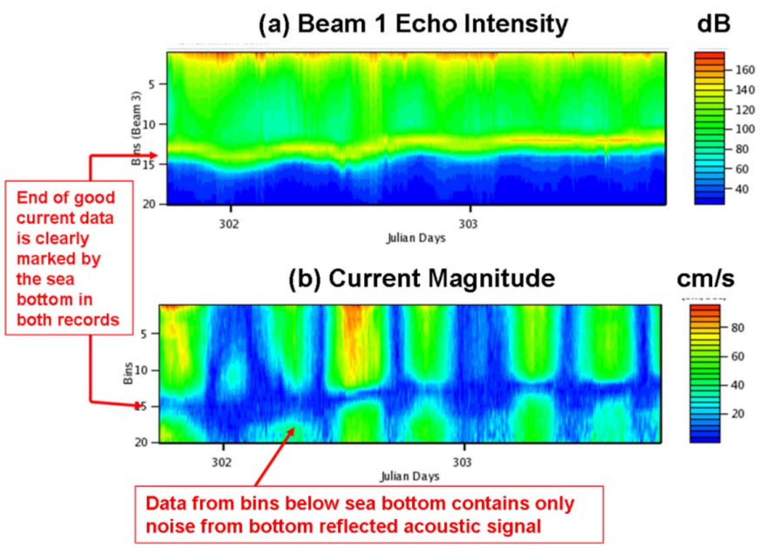

Figure 1. Sample contour plots of data collected by a Chesapeake Bay PORTS® ATON acoustic current profiler at York Spit (ID: cb0201). Data were accessed and plots generated using CO-OPS C-MIST online analysis tool; (a) beam 1 echo intensity and (b) current magnitude contour. In both records, it is clear that the sea bottom is significantly shallower than the range of the final recorded depth bin (bin 20), indicating that extraneous data, beyond the range where meaningful current measurements can be obtained, were recorded, transmitted, and stored in CO-OPS databases.

While reducing the size of the data packet can improve transmission efficiency, reconfiguring the way that GOES messages are transmitted could also improve the ability to transmit 6-minute data. To accomplish this, the National Environmental Satellite, Data, and Information Service (NESDIS) anticipates reducing the guard band between each GOES channel to double the number of GOES IDs available. This may allow CO-OPS to access 1200-baud assignments with 6-minute cycles, permitting the transmission of an entire current profile. Although this has not yet been accomplished, GOES capacity and capability indicate that it is possible. NESDIS is ultimately responsible for granting permission and implementing such changes.

2.2 Wireless IP Modems for Aton Acoustic Current Profilers Installations

Another improvement underway is OSTEP's and the Chesapeake Instrument Laboratory's (CIL's) work on installing an Xpert 9210 DCP in the ATON acoustic current profiler electronics box. This installation eliminates the need for a shore station and the LOS system. Stevens Institute (Jeremy.Turner@ Stevens.edu, 201-216-5223) was the first to employ this method, but results were mixed. The system worked as expected, but the deployment time was brief due to battery life limitations imposed by the modified setup. In the Stevens design, raw data were sent to a computer via the wireless IP modem and then decoded and processed. In the CO-OPS system, the goal is for the DCP (presently located at the shore station) to be installed on the buoy. This method allows the local storage of data, which can then be used to backfill missing data caused by communications or ingestion problems, and permits optimized data decoding and transmission, which reduces power consumption.

OSTEP has purchased a set of lithium battery packs that will extend the deployment length to six months or more, depending on the number of packs installed. The CIL has also obtained a newer Raven EV-DO modem to replace the standard Raven IP modem used at the Stevens Institute system. Unfortunately, recent testing indicates that the newer modem seems to require the same or more power. A prototype system is currently being tested at the CO-OPS Chesapeake facility. There is still an opportunity to consider alternative decoding schemes (perhaps using Nortek Aquapro software as the core decoder) to reduce power consumption. For example, raw binary data that are currently decoded in DCPs could be transmitted and then decoded later in the data path. Such decoding schemes would need to be developed and implemented in Silver Spring.

Verizon will introduce the next generation of wireless IP modems (fourth generation or 4G) on a limited basis in 25-30 U.S. cities at the end of 2010. These modems will be capable of downlink data rates of up to 200 megabytes per second and uplink speeds of 50 megabits per second, and the system will also be fully IPv6 compliant. Verizon’s tests in urban settings resulted in downlink speeds of 50 megabits per second and 25 megabits per second for uplinks. The present 3G system has a downlink speed of 14 megabits per second and an uplink speed of 5.8 megabits per second. CO-OPS/ED has discussed beta testing 4G stand-alone modems at selected locations with Verizon and Sierra Wireless (equipment manufacturer).

2.3 Iridium Modems for ATON Acoustic Current Profiler Deployments

Due to their small size and low power requirements, the Iridium Short Burst Data (SBD) modems (9601-D SBD data-only modems from NAL Research) are ideally suited as a reliable communication path for acoustic current profilers. The 9601-D is a single purpose modem that provides limited two-way communications. It quickly and automatically registers with the Iridium satellites when powered up and is designed to permit power cycling of the unit. This feature is important because it extends battery life by using power only when needed for data transmission. SBD modems produce packetized transmissions that have a maximum SBD Mobile Originated message (MOM) size of 340 bytes and SBD Mobile Terminated message (MTM) size of 270 bytes. The Iridium system requires a portion of the message size (e.g. time of transmission, modem IMEI, transmission start and stop); the rest of the packet is used for data.

CO-OPS currently has two SBD modems in service that provide 6-minute data from NWLON stations located in Guam. Additionally, one SBD modem installed on an ATON buoy transmitted acoustic wave acoustic current (AWAC) data twice hourly for 10 months. SBD test results from buoy- and land-based platforms demonstrate a >99.7% successful transmission of data.

MTM SBD (two-way) should result in a similar transmission success. Power cycling of the modem is not affected, since the Iridium system holds SBD MTM until the intended modem registers with the satellite network. The worst case delay with the transmission to a buoy would be six minutes. This small packet communication would be formatted and could easily be adapted for Iridium in conjunction with the GOES DCP Command (see section 2.5). SBD enables limited two-way transmission that offers a reliable and robust communications link with remote stations.

In the spring of 2009, the USACE Cold Regions Research and Engineering Lab (CRREL) provided funds to Sutron for development of DCP Command-based MTM SBD to control the Sutron monitor series of DCPs, which the CRREL use in remote environmental monitoring applications. CO-OPS collaborated to provide a test modem and other assistance. Sutron demonstrated full remote command of the DCP and is currently adapting this capability to operate using the Xpert series of DCPs. Once DCP Command is available, OSTEP will test and demonstrate it on our development stations at the FRF in Duck, NC, which provides an opportunity to test DCP Command protocols before the GOES DCP Command becomes available.

When an Iridium modem is implemented in an ATON acoustic current profiler system, communications will improve; however, because the large power requirements of ATON current profilers remain a challenge, CO-OPS needs to continue collaboration with acoustic current profiler manufacturers on system enhancements that increase battery capacity. Iridium presents an additional limiting factor due to the cost of transmission. NOAA’s primary source of Iridium data service is through commercial providers.

CO-OPS has limited access to Iridium service provided through the Department of Defense’s (DoD’s) dedicated service. The major advantage for DoD is in the unlimited data plans. The DoD costs are estimated at $350 per month per unit or $4,200 per year per unit. CO-OPS’ best case scenario for the commercial option would cost more than twice that amount per year per unit. For 6-minute ATON transmissions, a DoD-like agreement would offer the best value from a set operational price point perspective. Steve Piotrowicz from NOAA’s Office of Policy, Planning, and Evaluation has been working to secure a DoD-like agreement for NOAA and/or the National Science Foundation (NSF) (Personal communication, May 2009).

The number of transmissions and amount of data being transmitted in a particular deployment must be identified to determine which Iridium option would be the least expensive. For example, the DoD Iridium services have a comparatively higher charge per month if few data are transmitted; however, DoD unlimited data plans could represent a significant savings if large data quantities were transmitted.

2.4 Dial-up Iridium Modems for Stations Beyond Common Terrestrial Communications Links

Dial-up Iridium modems (A3LA-D from NAL Research) have been successfully deployed in remote test systems located at Wake Island and Guam in the Pacific Ocean and Mona Island, Puerto Rico. Since other back-up communication options either proved to be cost prohibitive, physically impossible, or unreliable due to the remoteness of these locations, Iridium offered the only alternative cost-effective option for a back-up communications system in these and other remote locations. The polar orbit of Iridium satellites provides the true global coverage that is essential in high and extremely high latitudes, where the angle required to transmit a signal makes GOES transmissions impossible. Iridium also provides an option where phone or cellular service is spotty or non-existent. The best service provider package for Iridium dial-up is commercial, with a rate of $14 per month per unit, plus a per-byte data transmissions fee and the cost of an international call whose rate depends on the phone plan selected. The DoD cost is $100 per month. Since the modem is not actively being used most of the time, commercial service is the least expensive option.

The Iridium dial-up modem has proven to be reliable. The one noted issue is an intermittent inability to establish the connection. From all indications, the problem is at the interface of the phone lines to the Iridium gateway. CO-OPS has a development IP address for Iridium at the Chesapeake facility and has also secured commercial Iridium service for that address to begin direct IP transmission testing. Any development on the commercial Iridium service can be transferred to our DoD-serviced modems. The connection issue will hopefully be resolved in the near future.

Unlike the SBD-only modem, the dial-up modem provides a number of options. It can function as an SBD modem with a 1960-byte MOM and 1850-byte MTM capability, a standard modem (i.e. dial-up), Direct IP, and RUDICS. It can also serve as a telephone with an adaptor. This modem provides true two-way communications. Software such as Procomm and Xterm can be used to communicate with the DCP, including the transfer of software and data files to and from the DCP. However, the dial-up modem is twice the size and cost of the SBD modem and consumes three times the power, making it impractical for locations where space is limited and/or power is constrained by the lack of solar charging.

The next generation of dial-up modems is now available and features an integrated power supply for 3.5-36 Vdc with two external LEDs added to indicate power and signal strength. The modem offers full broadband capability for use with new satellites; however, it also consumes one-third more power than the model it replaces.

2.5 GOES DCP Command via Sutron SBIR

Sutron Corporation received a Small Business Innovation Research (SBIR) Phase I grant to develop a robust link from GOES to the DCP (SBIR Abstracts 2007) with the following attributes:

- Immune from local interference
- Low power consumption
- Low cost

- Reliable
- Provides useful amount of data with minimum wasted bandwidth
- Meets NTIA (National Telecommunications and Information Administration) regulatory requirements that ensure that NESDIS will retain the frequency assignment for DCP Command protocol
- Designed to work with low-cost antennas
- Contains capability of adding adaptive filtering techniques without further hardware changes

Sutron has now received and completed an SBIR Phase II grant and has demonstrated successful two-way communications through the existing GOES satellite transponder. As a result, the Satellite Telemetry Interagency Working Group (STIWG) continues to solicit contributions to support the development of a prototype ground system at Wallops Island, Virginia. Approximately $50K of the $100K needed to build the prototype has been obtained. The upfront costs associated with the development of DCP Command are more than offset by the ultimate realization of almost no recurring costs (other than those already associated with the DCS operations). In contrast, Iridium has low start-up costs, but the guaranteed monthly recurring costs remain. STIWG representatives (and presumably the associated agencies), the NOAA SBIR community, and GOES DCS staff all fully support the implementation of DCP Command.

3.0 GENERAL HANDOFF TO OPERATIONS

Project implementation results in moving from the test and evaluation phase to operations. The transition to operations is a critical time and the handoff must be seamless to ensure that data products continue to be available. The dial-up Iridium modem project described in section 2.4 is now ready for handoff to operations. Although the present test sites do not involve acoustic current profilers, Iridium is a viable solution in certain circumstances. The following paragraphs describe tasks that are critical to becoming operational, whether the Iridium modem is associated with an acoustic current profiler or a water level sensor.

3.1 Dial-up Iridium Modems Handoff to Operations

Field tests of dial-up Iridium modems have been successful and are now ready for transition from test to operational status. The next step is to select a person from the CIL to be in charge of the handoff to operations. Additionally, the responsibility for billing must be transitioned to FOD. The responsible person (s) must be designated as administrator (s) on the commercial account so that they can make changes or additions to the account as required by the service provider. Once these contacts are established, a letter informing NAL Research of the change must complete the transition. This releases the modems from ED to operations personnel and account billing to FOD.

3.2 ISD Responsibilities Handoff

OSTEP envisions continued use of wireless IP modems and/or telephone lines to provide the full acoustic current profiler data sets. The introduction of alternative GOES or Iridium SBD data subsets requires data ingestion and processing that have a different format, presenting new challenges for ISD. Once OSTEP provides the new data formats, ISD will be responsible for invoking new routines when toggling to the alternative communications methods that utilize the data subsets, as well as integrating them into existing products.

3.3 OD Responsibilities Handoff

Alternative communications methods such as GOES and Iridium SBD have a limited bandwidth and can only provide data subsets (rather than the full acoustic current profiler data sets now collected). These data subsets will be carefully chosen so that CO-OPS products remain unchanged. OD must work closely with OSTEP and ISD to ensure that these products remain robust and are backed by sufficient QA/QC.

4.0 CONCLUSIONS/RECOMMENDATIONS

Reliable data communications are critical to ensuring that PORTS® data are available to those who depend upon them for safe and efficient navigation and emergency management. To achieve maximum reliability, CO-OPS requires redundant systems for transmitting data from acoustic current profilers in case of primary communication system failure. However, acoustic current profilers have not had redundant systems in the past for several reasons, among which are large data sets, frequent transmissions, and the use of equipment that does not accommodate multiple communication methods.

In summary, OSTEP supports the Razor request submitted in July 2008 and, through this report, responds to it by documenting the status of OSTEP efforts to increase the robustness of PORTS® data communications, as well as the ultimate goal of implementing redundant communications for PORTS® acoustic current profilers. The projects described in this report offer creative ways to customize potential improvements to deliver PORTS® data in the most cost-effective and efficient way. OSTEP offers several conclusions and recommendations that may help in the effort to do so.

Conclusions

- The selection of a primary and an alternate method of communication for acoustic current profilers depends upon several factors, including access to power, sensor location (remote or not), and type of sensor (ATON versus bottom-mount or side-looking).
- We have demonstrated that acoustic current profilers can be interfaced to Sutron Xperts.
- No product degradation will occur because of our conclusions or recommendations.
- Most communication systems do not have enough bandwidth to send an entire data set; therefore each message must be reduced in size without loss of essential data.
- Potentially, the number of GOES channels could be doubled if the guard band (or the spaces between each channel) is tighter. This would free a lot of transmission space, and although it has not yet occurred, the capacity and capability indicate that it is possible. GOES transmits 300-baud messages for hourly and for the 6-minute transmissions. GOES can also transmit 1200-baud messages; however, no 1200-baud, 6-minute transmit interval allocations have yet been assigned.

- Technology is rapidly changing. The changes create a challenge to ensure that we are using the best and most cost-effective solutions for PORTS® data needs.

Recommendations

- **Support and Implement the Five Suggested Communications Improvements in Section 2.0 of this Document**

  Implementing the improvements described in section 2.0 as soon as possible will help us to achieve our goal of more robust communications for PORTS® acoustic current profiler installations.

- **Support Acquisition of a Dedicated Iridium Service for NOAA**

  CO-OPS should support the NSF/NOAA effort, headed by Steve Piotrowicz of NOAA's Office of Policy, Planning, and Evaluation, to secure communication services that would provide two-way, real-time communications from multiple platforms by using a dedicated Iridium service for NOAA.

REFERENCES

Nichols, R.A. et al. April 2006. An integrated wireless coastal communications network, Johns Hopkins University Applied Physics Laboratory.

Bosley, Kathryn Thompson, PhD; Chris McGrath, Jennifer P. Dussault; Mark Bushnell, Michael J. Evans, Geoffrey W. French, Karen Earwaker. May, 2005. Test, evaluation, and implementation of current measurement systems on aids-to-navigation, NOAA Technical Report NOS CO-OPS 043, Center for Operational Oceanographic Products and Services, NOS NOAA, Silver Spring, MD.

U.S. DEPARTMENT OF COMMERCE National Oceanic and Atmospheric Administration, Small Business Innovation Research Program, FY2007Abstracts.pdf. [Internet].

Acronyms

ATON	aid to navigation
CECAT	Coastal and Estuarine Circulation Analysis Team
C-MIST	Currents Measurement Interface for the Study of Tides
CO-OPS	Center for Operational Oceanographic Products and Services
CRREL	Cold Regions Research and Engineering Laboratory
DAS	data acquisition system
DCP	data collection platform
DCS	data collection system
DoD	Department of Defense
ED	Engineering Division
FOD	Field Operations Division
GOES	Geostationary Operational Environmental Satellites
HF	high frequency
IMEI	International Mobile Equipment Identity
IP	Internet protocol
ISD	Information Systems Division
LED	light-emitting diode
LOS	line-of-sight
LRGS	local readout ground stations
MOM	mobile-originated message
MTM	mobile-terminated message
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NOPP	National Oceanographic Partnership Program
NOS	National Ocean Service
NSF	National Science Foundation
NTIA	National Telecommunications and Information Administration
NWLON	National Water Level Observation Network
OD	Oceanographic Division
OSTEP	Ocean Systems Test and Evaluation Program
PORTS®	Physical Oceanographic Real-Time System
QA/QC	quality control/quality assurance
RDI	RD Instruments
ROS	Reliable Operating System
RUDICS	Router based Unrestricted Digital Interworking Connectivity Solution
SBD	Short Burst Data
SBIR	Small Business Innovation Research
STIWG	Satellite Telemetry Interagency Working Group
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey