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Workshop Proceedings

Data Telemetry Technologies for Coastal Ocean Observations

St. Petersburg, Florida
April 30-May 2, 2003

Funded by NOAA's Coastal Services Center through the Alliance for Coastal Technologies (ACT)

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An ACT 2003 Workshop Report

A Workshop of Developers, Deliverers, and Users of Technologies for Monitoring Coastal Environments:

Data Telemetry Technologies for Coastal Ocean Observations

St. Petersbug, Florida
April 30-May 2, 2003

Sponsored by the Alliance for Coastal Technologies (ACT) and NOAA's Center for Coastal Ocean Research in the National Ocean Service.

Hosted by ACT Partner, the College of Marine Science at the University of South Florida in St. Petersburg, Florida.

ACT is committed to develop an active partnership of technology developers, deliverers, and users within regional, state, and federal environmental management communities to establish a testbed for demonstrating, evaluating, and verifying innovative technologies in monitoring sensors, platforms, and software for use in coastal habitats.

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ACT Workshop: Data Telelmetry Technologies for Coastal Ocean Observation

Executive Summary

The Alliance for Coastal Technologies (ACT) Workshop "Data Telemetry Technologies for Coastal Ocean Observations" was held in St. Petersburg, Florida, April 30-May 2, 2003, with sponsorship by the University of South Florida, College of Marine Science, an ACT partner organization.

The workshop was designed to summarize the existing telemetry technologies for coastal ocean observing systems and to address their shortcomings for the purpose of facilitating future technological advancements, with a focus on wireless technologies. Representatives from academia, industry, and government agencies were invited to participate in this three-day workshop. The goals of the workshop were to explore technologies now in place or soon to be available and to make strategic recommendations for the future development and application of technologies for the telemetry of data from coastal ocean observing systems.

A general consensus emerged that a wireless network encompassing all coastal waters of the US be developed and that such a network was possible using existing technologies. At the close of the workshop, participants voted on various recommendations for the data telemetry community. The priority recommendations included developing protocols and standards for data telemetry, establishing a forum where developers and users can arrive at a consensus on protocols and standards for a fully functioning network, defining the existing infrastructure that could be utilized in developing a coastal ocean network system, and determining both geological and technical boundaries of such a network. It was also suggested that ACT should serve as a clearinghouse for information on available technologies and facilitate the further development of fundamental technologies that would eventually be part of the coastal ocean network.

Alliance for Coastal Technologies

There is widespread agreement that an Integrated Ocean Observing System is required to meet a wide range of the Nation's marine product and information service needs. There also is consensus that the successful implementation of the IOOS will require parallel efforts in instrument development and validation and improvements to technology so that promising new technology will be available to make the transition from research/ development to operational status when needed. Thus, the Alliance for Coastal Technologies (ACT) was established as a NOAA-funded partnership of research institutions, state and regional resource managers, and private sector companies interested in developing and applying sensor and sensor platform technologies for monitoring and studying coastal systems. ACT has been designed to serve as:

- An unbiased, third-party testbed for evaluating new and developing coastal sensor and sensor platform technologies,

- A comprehensive data and information clearinghouse on coastal technologies, and
- A forum for capacity building through a series of annual workshops and seminars on specific technologies or topics.

The ACT workshops are designed to aid resource managers, coastal scientists, and private sector companies by identifying and discussing the current status, standardization, potential advancements, and obstacles in the development and use of new sensors and sensor platforms for monitoring and predicting the state of coastal waters. The workshop goals are to both help build consensus on the steps needed to develop useful tools while also facilitating the critical communications between the various groups of technology developers, manufacturers, and users.

ACT Headquarters is located at the UMCES Chesapeake Biological Laboratory and is staffed by a Director, Chief Scientist, and several support personnel. There are currently seven ACT Partner Institutions around the country with sensor technology expertise, and that represent a broad range of environmental conditions for testing. The ACT Stakeholder Council is comprised of resource managers and industry representatives who ensure that ACT focuses on service-oriented activities. Finally, a larger body of Alliance Members has been created to provide advice to ACT and will be kept abreast of ACT activities.

ACT is committed to exploring the application of new technologies for monitoring coastal ecosystem and studying environmental stressors that are increasingly prevalent worldwide. For more information, please visit www.actonline.ws.

Goals for the Data Telemetry Workshop

The ACT workshop on data telemetry technologies for coastal ocean observations was convened April 30-May 2, 2003 in St. Petersburg, Florida. The focus of the workshop was on technologies for bringing data from remote ocean observation platforms back to the shore-based data network. The focus was narrowed further to concentrate on wireless technologies, as cabled observing systems are being treated extensively elsewhere (for example, see http://www.coreocean.org/SCOTS/). The workshop addressed the following goals:

(1) to explore technologies now in place or soon to be available for the telemetry of data from coastal ocean observing systems

(2) to make strategic recommendations for the future development and application of technologies for the telemetry of data from coastal ocean observing systems

Organization of the Data Telemetry Workshop

The workshop was sponsored by ACT and hosted by the University of South Florida (USF) College of Marine Science, an ACT partner institution, in St. Petersburg, Florida. This telemetry workshop was organized by Mark Luther at the University of South Florida. Robert Heinmiller from Omnet, Inc., served as the workshop's facilitator. Participants were invited to represent a broad range of technology developers, technology providers, and end-users of telemetry technologies, including both academic researchers and resource managers, as well as to provide geographic diversity. A list of participants and the workshop agenda appear as appendices.

Participants arrived Wednesday, April 30th for an evening reception and dinner. Thursday morning and early afternoon plenary presentations were given on the present state of data telemetry technologies by the following participants: David Meldrum from the Scottish Association for Marine Science, Scott McLean from Satlantic, Inc., Steve Piotrowicz from Ocean.US, Tom Herrington from Stevens Institute of Technology,

James Sprenke from NOAA, Eric Terrill from Scripps, and Michael Luby from Digital Fountain. A demonstration of a Sensor Web, an intelligent, wireless, sensor network, was given by Kevin Delin from NASA's Jet Propulsion Laboratory (http://sensorwebs.jpl.nasa.gov). Presentations in .pdf format and movies in .mpeg format of applicable discussion are available for download on the ACT website at http://actonline.ws/USFworkshop.html.

The participants broke into 3 working groups in the afternoon. Working group discussions focused on four subjects:

(1) *What technologies are currently available?*
(2) *What are the roadblocks?*
(3) *What is on the wish list?*
(4) *Where do we go from here?*

At the end of the day, the working group leaders summarized the results of the discussions of the three separate groups. On the evening of the second day, ACT's Director, Ken Tenore, gave a presentation on ACT's vision and direction. On the last day, participants reached a consensus on a master list of recommendations that were discussed during the workshop and voted to prioritize these recommendations.

Overview of Telemetry Options for Coastal Ocean Observations

The following is a summary of the presentations made in the plenary session compiled by Lauren Wetzell and Sherryl Gilbert. Specific claims as to data rates, costs, or other details of systems described are quoted as presented at the workshop and are subject to change. Mention of specific commercial products or services are for purposes of illustration only and are not meant to be an endorsement of a particular product or service.

The need for telemetry of coastal ocean observations has become more demanding. The problem at hand is how to get data back from remote platforms located some distance from population centers, either off shore or along the coast, so that they may be accessed from the land-based data network. For platforms in urban areas, cellular-based networks are possible. For systems within 30 nautical miles (nm) of populated areas, line-of-sight radio communications are possible. Satellite communications become necessary for greater distances. Currently, most data communication systems involve two components, above and below sea, to link back to the shore-based communications network (Figure 1).

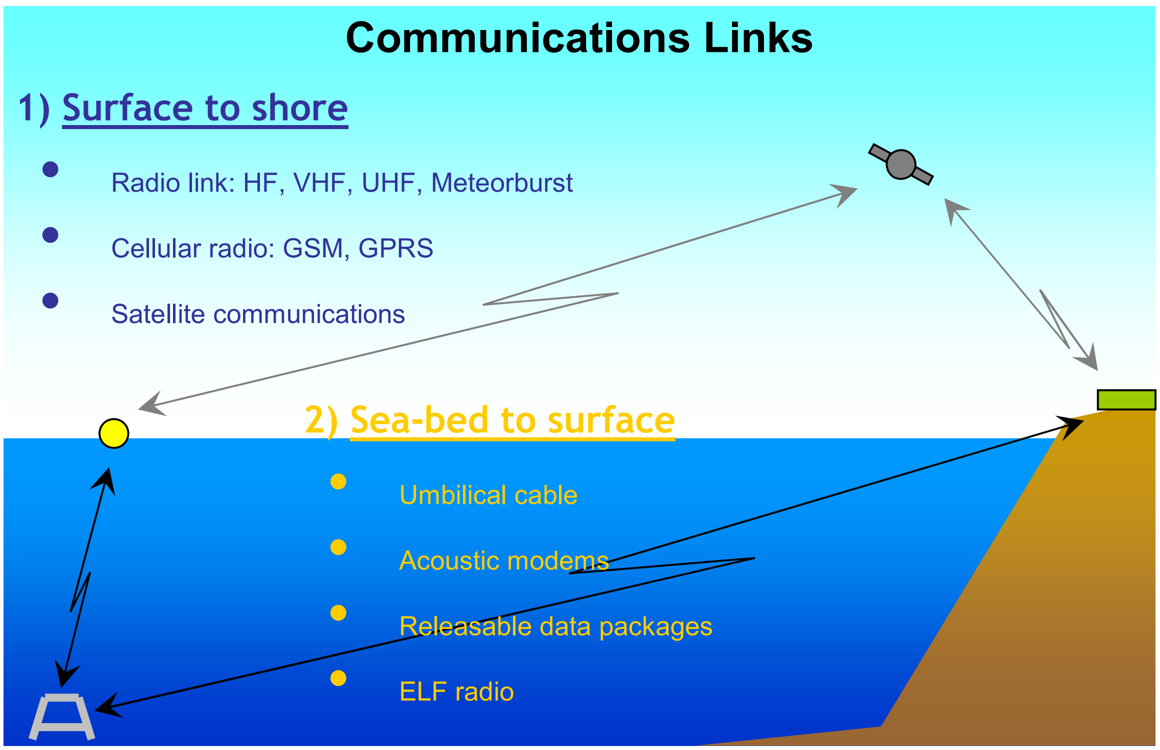

Figure 1: An illustration describing the two components, currently, involved in satellite communications. (*Dave Meldrum, Scottish Association for Marine Science*)

The surface-to-shore linkages are generally obtained by radio, cellular radio, or satellite communications. Linkages from the seabed-to-surface are usually obtained either by an umbilical cable, acoustic modems, releasable data packages, or ELF radio. Those systems using an umbilical cable are challenged with complex designs due to the wiring and cost of the massive cable. However, a protocol for networking sensors has been suggested as a solution. Acoustic modems serve as another method to communicate information in the water column. New modulation techniques promise improved performance. However, these energy intensive systems function better in deep water and they are subject to noise, shadow zones, multipaths, and reverberations.

In selecting above or below water systems, and especially for satellite systems, the user must consider the following options: bandwidth, timeliness, availability, geographical coverage, energetic and economical costs, physical size, reliability, and future applications. A summary of satellite links available for ocean observing systems can be accessed using the following link: http://www.dbcp.noaa.gov/dbcp/index.html. Overall, 32 systems are available in the DBCP catalogue of which 9 are operational, 2 are pre-operational, 3 are experimental, 3 are cancelled, and 15 are on hold. Reliability and future applications for satellites available to ocean science can be classified as secure or nonsecure. Argos, Inmarsat, and GOES are satellites considered to be secure, in the sense that they are mature systems with promise of longevity, where as Orbcomm, Iridium, Globalstar, New ICO, and Ocean Data Link are considered nonsecure, in the sense that their future is somewhat uncertain (Figure 2).

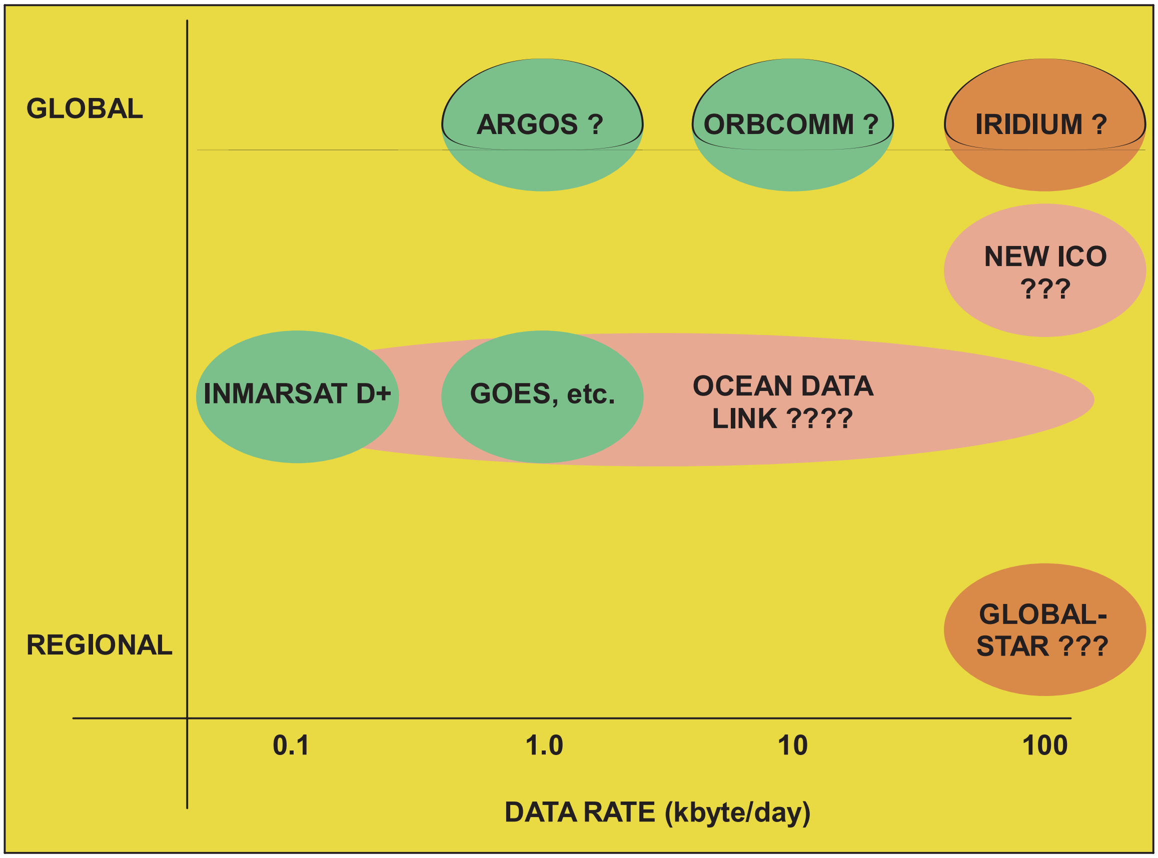

Figure 2: Several key features regarding satellite linkages. The question marks indicate non-secure systems. *(Dave Meldrum, Scottish Association for Marine Science)*

Argos, Iridium, and Orbcomm systems will be described in more detail. Currently, numerous satellite systems are either being constructed or designed. Most of these systems will be fully commercial while few systems will include marine data within their business plans and furthermore, marine data users will have little influence over system operation or cost. The satellite communication systems currently available to buoy operators are summarized in Table 1 on the following page.

Table 1: A summary of satellite communications currently available to buoy operators (GEO=geostationary and LEO=low earth orbiting). *(Dave Meldrum, Scottish Association for Marine Science)*

Satellite System	Transmission Type	Satellite Type	Throughput Rate
Inmarstat D+	Pager	GEO	< 1 kbyte/day
GEOS, Meteostat…	Messaging	GEO	< 5 kbyte/day
Argos	Messaging	LEO	< 5 kbyte/day
Inmarstat C	Messaging	GEO	< 10 kbyte/day
Orbcomm	Messaging	LEO	< 50 kbyte/day
Iridium	Voice	Big LEO	< 1 mbyte/day

1. Satellite Systems

Argos

Argos is a global telemetry and geo-positioning satellite-based location and data collection system dedicated to monitor and protect the environment. This system was established in 1978 between three agencies: NOAA, NASA and French Space Agency (CNES). Currently, over 7 thousand Argos transmitters are operational globally where 2 satellites are simultaneously in service on polar, sun-synchronous, circular orbits, to provide real-time and full global coverage (http://www.argosinc.com). Traditionally Argos served as an oceanographic system with a 1-way blind transmitter. Today, Argos is advancing towards a more internet basis, operating at 401.65 MHz (clean part of the spectrum), and employing a 2-way transmitter system. The maximum message size is 32 bytes and the daily maximum is approximately 1 kbyte. Although the user's cost is high, one of the major advantages of the Argos system lies within the delivery of data being packaged and quality controlled.

Orbcomm

Orbcomm is a wireless telecommunications company utilizing today's email system for message delivery as the primary option for delivering data. The company provides near real-time 2-way digital messaging, data communications, and geo-positioning services using a global network consisting of 30 Low Earth Orbit (LEO) satellites with terrestrial gateways. Private and public networks, such the Internet, can be connected via these satellites and gateways (http://www.orbcomm.com). The company's major market share is asset tracking and remote monitoring. A 5W transmitter is used to provide communications where the location may be computed by the subscriber's mobile or GPS. The systems can send up to 8Kbytes in a single message. Although better through put can be achieved using 1-2K message sizes. In the store and forward mode, a Global Gram can be sent with a max payload of 229 bytes per transmission. The approximate maximum throughput is 50 Kbytes/day. If your application needs to send this amount of data you probably are better using Iridium. Orbcomm is best suited for smaller payloads. The European service rate is approximately $2 per day regardless of the data volume. The service has some limitations, including that it is not licensed world-wide and that it operates on the noisy side of the spectrum (138-150MHz). Additionally, the company has 2 working polar orbiting satellites operating in 'hybrid mode' resulting in additional loss of performance when operating within these extreme geographical areas. Orbcomm provides excellent coverage if the subscriber is near one of its five U.S. Gateway Earth Stations (GES's), three South American GES's, two European GES's, or the Korean, Malaysian, or Japanese Gateways. The data delivery is in the form of email, but it is not processed when it is sent back to the user, and for some customers that do not have backend software this can pose a problem. However, there are Orbcomm Value Added Reseller's such as SASCO that serve the marine industry. See SASCO at: http://www.sasco-inc.com. The satellite modems for Orbcomm start as low as $200.00 making it the least expensive satellite solution in the world. The leading manufacture of Orbcomm modems is Quake Global located in San Diego. You can check out their website at http://www.QuakeGlobal.com or ask USF about their BSOP project which uses the Quake Modem.

Iridium

Iridium is a satellite-based, wireless communication system providing complete coverage of the globe (86% landmass and ocean coverage). Using 66 LEO satellites operated by Boeing, Iridium provides mobile satellite voice and data transmission (http://www.iridium.com). The service operates along the L-band, approximately 1.5 GHz, which is a relatively clean part of the spectrum. Iridium is a 2-way system with a compact antenna and provides true real time service using a 10W transmitter and a dial-up modem with the maximum throughput greater than 1Mbyte/day. The subscriber's location may be computed by GPS. Commercial rates are about $1 per minute with a data rate of 2.4kbps. Similar to Orbcomm systems, the company's major weakness for operational users is that the sensor data is neither processed nor packaged for the end user. Overall, Iridium has an excellent potential for higher data volumes of up to 20 kbyte/sec at 10 cents per kilobyte or less. The subscriber can have interactive control of the mobile and the mobile can initiate communication when on the surface. Remote platform owners may find it advantageous to move from interactive connections to datagram (SBD) service. Several recommendations have been suggested for operational users when selecting satellite systems. For example, it is highly suggested that the user investigate the system's geographical coverage, data rates, and the system's anticipated lifetime. Additionally, the user should determine if the delays, outages, error rated, energy costs and financial costs are acceptable. Overall, the user is recommended to perform practical trials of the system before committing to their service.

Inmarsat (InmarsatC, Inmarsat D+, Inmarsat Mini M)

Inmarsat is a mobile satellite communications operator that grew out of the maritime community's need for modern communication services. The company presently serves a broad range of markets. Starting with a user base of 900 ships in the early 1980s, it now supports links for phone, fax and data communications at up to 64kbit/s to more than 250,000 ship, vehicle, aircraft and portable terminals. That number is growing at several thousands a month. The satellites are controlled from Inmarsat's headquarters in London. Data on the status of the nine Inmarsat satellites is supplied to the SCC (Satellite

Control Center) by four tracking, telemetry and control (TT&C) stations located at Fucino, Italy; Beijing in China; Lake Cowichan, western Canada; and Pennant Point, eastern Canada. There is also a back-up station at Eik in Norway. Traffic from a user terminal passes via a satellite and then down to a land earth station (LES), which acts as a gateway into the terrestrial telecoms networks. There are about 40 LESs, located in 30 countries. Keystone of the strategy is the new Inmarsat I-4 satellite system, which from 2005 will support the Inmarsat

Broadband Global Area Network (B-GAN) - mobile data communications at up to 432kbit/s for Internet access, mobile multimedia and many other advanced applications. For additional information please visit www.inmarsat.com.

Globalstar

Globalstar is a provider of global mobile satellite telecommunications services, offering high-quality, low-cost voice and data services to businesses, communities and individuals around the world. Signals from a Globalstar phone or modem are received by the company's constellation of 48 Low Earth Orbiting (LEO) satellites and relayed to ground-based gateways, which then pass the call on to the terrestrial telephone network.

Additional services include the internet and private data network connectivity and position location. The company's data modem products can also be used for asset tracking and environmental telemetry applications. Globalstar intends to continue expanding its operations to provide service in the few remaining land areas not covered today, as well as across mid-ocean regions. Products and accessories will also continue to be developed and upgraded to make the service even more useful. Please visit www.globalstar.com for more information.

NOAA/NESDIS will be conducting a small study of the commercial satellite telemetry providers as part of its regulatory responsibility to prevent government competition with the commercial space sector. Candidates for this study include Inmarsat, Orbcomm, Iridium, and Globalstar. This written report will include future system plans, description, financial status, and a summary of the system products and services.

Several recommendations have been suggested for operational users when selecting satellite systems. For example, it is highly suggested that the user specifies the system's global regional coverage, data rates, and inquires about the system's anticipated lifetime. Additionally, the user should examine if the delays, outages, error rates, energy costs and financial costs are acceptable. Overall, the user is recommended to perform practical trials of the system before committing to their service.

2. Cellular

Cellular technology provides users with low equipment costs because of its already established network. It has large spatial coverage with a reliable already existing network. However, this technology has poor coastal ocean coverage and has a tendency to become overwhelmed by users during crisis, as happened during the events of 9/11/01. In addition, low to medium bandwidth can lead to low transmission speeds. This system also has a continuous operational cost associated with it. Older telephone systems use analog coding. The electrical variations induced into the microphone are transferred directly as electrical signals. The magnitude of the electrical signal is equivalent to the magnitude of the original signal. More modern telephone systems use digital coding. The electrical variations induced into the microphone are sampled, and each sample is then converted into a digital code. There are three standards for cellular communication presently in use. Advanced Mobile Phone Service (AMPS) is an older analog standard that is being phased out in most areas. True internet connectivity is provided over AMPS using Cellular Digital Packet Data (CDPD), with bandwidths of 19.2 kbit/sec. CDPD competes for limited analog cellular channels with voice traffic, leading to high latency during peak usage periods. Code Division-Multiple Access (CDMA) is a digital standard that works by converting speech into digital information, which is then transmitted as a radio signal over a wireless network. It uses a unique code to distinguish each different call, enabling many more people to share the airwaves at the same time. Global System for Mobile Communications (GSM) is an emerging international standard for digital cellular communications. Under the GSM standard, General Packet Radio Service (GPRS) enabled networks offer 'always-on', higher capacity, Internet-based content and packet-based data services. This enables services such as color Internet browsing, e-mail on the move, powerful visual communications, multimedia messages and location-based services (see http://www.gsmworld.com/technology/gprs/index.shtml).

3. Point to Point Radio

Line of sight (LOS) technology provides users with a high bandwidth that is power efficient for larger transmissions. There is also no cost associated with these transmissions. However, users are limited by both range and antenna height. Two commonly used radios are the FreeWave spread spectrum radio-modems, which provide RS233 serial communications at up to 115 kbit/sec over ranges of up to 100 km, and the Cisco wireless Ethernet transceivers, which provide 802.11 wireless Ethernet over ranges of up to 32 km. Appropriate use of repeaters can greatly extend the range of LOS radio communications. There are many other packet data radio modems and transceivers on the market. It was noted that here is a new standard emerging for long-range wireless Ethernet, termed 802.16, that may be appropriate for coastal observing system networks.

4. Underwater Acoustic Communications

Benthos

The ATM 88x modem is the newest generation of underwater modem from Benthos. The modems will transmit anything typed at an attached keyboard. They will likewise transmit anything received over an RS232 com port. The units can be put into a sleep mode, to be awakened with either acoustic or com port data. The ATM 88x will transmit at any available signaling scheme, up to 15,360 bps. The ATM 89x units, using an attached floating point based DSP on a daughter board, can receive these high speed data. The daughter board currently is available with the deckbox. Range rate compensation for relative speeds up to 6 kts is provided for all signaling schemes. A distant modem can be reached via another modem when the intermediate unit is put into a relay mode. Every message received by this unit is automatically retransmitted to the intended unit. We can provide conversion among frequency bands and modulation schemes to suit particular requirements. For example, one may wish to achieve long range (5-7 km) in open sea, which would argue for the low frequency (LF) band, but translate the message to the high frequency (HF) band for reception by nearby divers.

5. Software Algorithms

Software algorithms are necessary for ensuring that data are delivered accurately and efficiently over potentially unreliable communications networks. One such solution that was presented at the workshop is from Digital Fountain. The driving force behind Digital Fountain's speed, predictability and control is the company's patented Meta-Content technology, a networking innovation that dramatically simplifies the processes required to completely and perfectly deliver data over any network, regardless of impairments like packet loss and delay. The original document is cut into slices and sent in sequence. Every slice must be received in order-lost slices are re-sent. Since TCP cannot continue with too many missing slices, it responds to loss by lowering the send rate. Digital Fountain's technology is shown to overcome these obstacles in a highly efficient manner (see http://www.digitalfountain.com/calc/adv.htm for additional information).

Current Technological Impediments

There is a clear need for advancement in telemetry systems. While current technologies are useful, significant limitations and short-comings exist. The following list addresses these issues.

1. *Individual solutions to individual problems*

   Technologies unique to each organization or agency tend to stay within that particular organization or agency. Currently, no common national oceanographic network exists.

2. *Lack of agreements and standards*

   The coastal oceanographic community currently lacks any standardized format or code for communicating real-time oceanographic data.

3. *Bandwidth*

   Bandwidth is not only a problem for deep ocean projects. Surface observations are delayed by either the inadequate throughput of static platforms or the bottleneck effect of too many users at once with dynamic platforms (eg. 9/11).

4. *Cost*

   High maintenance costs are associated with coastal observation sites, including set-up, sustaining, and repairing damaged instrumentation.

5. *Reliability*

   In addition to tackling security risks associated with wireless networks, users often deal with intermittent connectivity.

6. *Coverage*

   Satellites densely cover equatorial and mid-latitude regions, however, polar regions are poorly spatially resolved. Poor temporal resolution is also an issue. LOS radio technologies suffer from limited range, while cellular communications (which employ LOS technologies) have limited coverage areas.

7. *Long term stability of providers*

   Several satellite providers are in tenuous business positions. Technologies become obsolete and are discontinued (i.e., CDPD).

8. *Economics of scale*

   The ocean observing community at present is too small to exert much influence over the wireless communications market.

Workshop Recommendations

The following recommendations are the result of discussions during the workshop. It was generally agreed that the US coastal ocean observing community should strive to establish a wireless network that would encompass all the coastal waters of the US. Most of these recommendations address steps needed to establish such a network. Some of these recommendations are directed specifically to ACT and others are for the data telemetry community at large. Recommendations are listed in order of priority as determined by votes cast by all workshop participants.

1. Protocols and standards for data telemetry need to be developed and agreed upon. The data telemetry community needs to establish an underlying level of uniformity in data telemetry techniques including but not limited to bandwidth requirements, data storage, instrument communication, data compression, connectivity, and networking. There needs to be a forum where developers and users establish what these protocols and standards should be for a fully functioning network.

2. ACT may serve as a clearinghouse for information on available technologies.

   Although the present goal of ACT is to serve as a clearinghouse for existing work on sensor technology, the participants' consensus recommends ACT expand or redefine its mission to include the networking technologies necessary to get data back from some defined coastal hot spot. This suggestion adheres to ACT's primary mission because the development of communications from the sensors to the shore, or from sensor to sensor, are fundamentally part of the sensor platform and it is consistent with the goal of having a truly integrated system. The group's interest lies in populating this clearinghouse with useful and current information for others to draw from. Additionally, this clearinghouse should be moderated to ensure accuracy of the information.

This clearinghouse can also serve as an online center for the discussion and dissemination of information about development efforts in coastal wireless technology. Users can begin populating the knowledge base as a way to initiate this forum. This clearinghouse can be a continuingly updated picture of technologies that are currently available, but not a library of engineering "fixes" or "work-arounds". Furthermore, the clearinghouse should serve as a forum where users share technological advancements on current projects, problems and associated solutions to these projects, and what kinds of advancements need to be made. This forum can exist in the form of a "chat room," however, a moderator would be recommended.

3. First develop simple and robust technologies, eventually working towards technologies on the near horizon, pushing the envelope of innovative and emerging technology. Initial efforts should focus on durability and longevity in creating the baseline network. This initial effort would serve as a platform for new technological advancements.

4. Identify the existing infrastructure functionally designed for global network systems including wireless and /or fiber optics communications. First, users and developers need to investigate and catalog existing technologies that lead to a globally functioning network. Efforts should be made towards international compatibility to achieve this goal.

5. *Define Boundaries*

   Geographical boundaries: Workshop participants suggested for the entire coastal zone to extend out to the Exclusive Economic Zone (EEZ). Working with this boundary will result in several technologies having to overcome related limitations, however, efforts are strongly recommended to reach this specific geographical goal.

   Technological boundaries: Is the focus on above-water, wireless communications? What about cabled systems? Focus on networking technologies, procedures, protocols, and problems with moving data from the sensor to the landside network.

6. Autonomous network functions / sensor platforms. A network could be developed that covered all coastal waters of the US such that a sensor platform could automatically connect to the network, configure itself, and begin communicating data. For example, a network could have transparent integration among shore-based LOS radio and/or satellite communications where an instrument platform or data communications interface would automatically search for the best available carrier. Then this platform (or interface) could connect to a network such as Iridium, GSM/GPRS, or 802.11/16 (also know as WiFi).

7. Leverage commercial technology and then identify niche technology gaps unique to the ocean observing community. Identify the issues lacking interest, resulting in no financial support, to those outside the ocean observing community (i.e., problems that no one else will solve).

8. Define organizations at the state and regional levels instead of in a larger federal forum. Incorporating finances, geography, and politics would help build long term and political plans.

9. Integrate local networks into national operational networks. Using networks that incorporate standard formats would be cost effective because of the already existing database (eg. NOAA's national program).

10. Fund a real study. For example, the National Oceanographic Partnership Program (NOPP) could fund efforts aimed at adopting/adapting wireless technologies for data gathering in the coastal zone. This study would not include instrumentation, rather focus efforts towards pushing forward the telemetry technology.

11. ACT should sponsor a follow-up workshop to facilitate communication from users to manufacturers.

Acknowledgments

ACT would like to thank the following people for their invaluable assistance in organizing the telemetry workshop. Sherryl Gilbert and Lauren Wetzell for their long hours and hard work in arranging all the local logistics and in compiling the final workshop report, Vembu Subramanian for taking care of the audio-visual and computer equipment during the workshop, Howard Rutherford, Executive Director of the Pier Aquarium, for hosting the opening reception and dinner, Kristy Sopkin for producing video and audio tapes of the workshop presentations and discussions, and Sudsy Tschiderer of the USF Campus Activities Center for assistance with local arrangements. The success of the workshop is due in large part to the tireless efforts of these people.

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