NEXT-GENERATION OCEAN OBSERVING SYSTEMS, PART 3: TWO-WAY, HIGH-SPEED, LOW EARTH ORBITING SATELLITE COMMUNICATIONS

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1. THE NEED FOR IMPROVED OCEAN-DATA COMMUNICATIONS

Oceanography is an observational science driven by data collected from ships, moorings, satellites, AUVs, etc. Oceanographers are now beginning to contribute to global-scale climate change studies, which requires distributing data to others in a timely way. Responsive, global-scale climate models and forecasting require comprehensive and timely data retrieval from observational networks, both remote sensing and in situ. While satellite-based remote sensing has revolutionized the practice of oceanography, the kinds of data that can be collected via satellite alone is limited. There is a growing recognition of the need for much more in situ data to support modeling and forecasting efforts.

A major impediment to timely ocean-observing contributions is the lack of an affordable communication infrastructure for retrieving observational data. Current data transmission services are not optimized for oceanographic data use and do not meet current and future needs. The timely harvest of data from in situ platforms must increase by orders of magnitude if scientists are ever to understand the complexities of the Earth's climate. A relatively high-volume, low-cost communications system with two-way capability is required.

The limited capabilities of ARGOS and GOES have been heavily utilized by the oceanographic community to return data in near real-time from long-term moorings. However, throughput is limited to a few thousand bytes of data per day; a complete data set has to wait for physical retrieval of the buoy. Although some applications demand real-time transmissions, most require only what we refer to as “real-enough time” data: data received on the same day in which it was collected, which is appropriately timely for most purposes.

Two-way communication is a new possibility of particular interest to oceanographers. Commands can be sent to a remote buoy to recover from failures or to change experiment parameters in response to interesting phenomena. This type of interactivity will become more critical as expanding global climate change research creates new opportunities for research that will require significantly greater volumes of oceanographic data.

2. WavSat SATELLITE COMMUNICATONS

Wavix has developed a data transmission system for its own ocean-observing systems, which it is making available to the community. WavSat Satellite-Data-Communications offers the potential of returning at least 500 kilobytes of data per day from each remote location directly to the interested researcher. In addition, the communications link is two way, allowing the researcher to send commands to the remote system to alter its operation in response to events observed in the harvested data stream.

The connection between the researcher and the remote observing system comprises four components: the WavSat communications-satellite constellation, the mobile terminal installed at the remote ocean-observing site, the shore-side Internet gateway and groundstation, and the Wavix Data Center.

2.1 *WavSat Satellite Constellation*

The WavSat Satellite Constellation consists of two, low-Earth orbiting (LEO) microsatellites (with masses of 10 to 100 kg) built and operated by Surrey Satellite Technology, Ltd. The system was developed in cooperation with Volunteers in Technical Assistance and SatelLife, two non-profit organizations bringing technology and health assistance to the people of developing countries.

The WavSat system was specifically designed to support the oceanographic community. Both satellites operate in polar orbits at inclinations of 65 and 90 degrees, giving the system global coverage. On-

Paper for *Proceedings of the 16th International Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology*, Long Beach, California, 9-14 January 2000.

board digital radios operate in the so called "Little LEO" UHF (uplink) and VHF (downlink) bands licensed for operation worldwide. Messages are sent between satellite and surface using packet (digital) radio technology; full-duplex operation is possible since uplink (to the satellite) and downlink are performed at different frequencies, with effective baud rates of 9600. Using the AX.25 Link-Layer Protocol, long used by radio amateurs, the communications channel is guaranteed error free.

The satellites operate in a store-and-forward mode, much like an electronic bulletin board. When a satellite passes overhead, data files are uploaded from the remote system to the satellite where they are stored in the file system, typically for several days, for later downloading by a Wavix groundstation. With orbital periods of about 90 minutes, each satellite is usefully visible 4 to 6 times each day. WavSat can transmit about 500 kbytes of data per day back to the researcher from each remote location, with an average latency of 1.5 hours.

2.2 *WavSat Remote Terminal*

The WavSat remote terminal is an autonomous, fully automatic, two-way digital radio. It is built around a compact, PC/104-format computer, providing a good compromise between size, power consumption, and performance. The terminal incorporates its own modem and RF circuitry for use with the digital-radio satellites. In operation the radio uses two omni-directional, quadrifilar antennas: the uplink antenna is about 1 m tall and 20 cm in diameter; the downlink antenna is 0.5 m tall with a 10-cm diameter.

A configurable serial port is the digital interface to the terminal for sending data and receiving commands. A data stream fed to the terminal is collected, packetized, and spooled internally for uplink to a passing satellite. Satellite-tracking software running on the terminal determines when the radio is to establish a data link for upload, and initiates that process. Simultaneously, any command files that are addressed to the remote terminal are downlinked from the satellite, unpacked into a standard format, and passed back out the serial interface to the host system.

2.3 *WavSat Groundstations*

In operation, the WavSat groundstations operate much like remote terminals, the major practical difference being that groundstations download large amounts of data being sent from many different sources, and uplink relatively fewer command files to various remote systems.

The groundstations also operate as Internet nodes so that all data can be sent to the Wavix Data Center as soon as it has been downloaded from the satellite, and so that commands to the remote terminal can relayed from the researcher's home location.

2.4 *Wavix Data Center*

When used in conjunction with Wavix oceanographic-data services, the Data Center is the staging area where all remote data are collected, verified, archived, and made immediately available to our subscribers.

When used with our remote-terminal communication services, the Data Center is the single network location from which all remote data are distributed, and through which all commands pass on their way to remote terminals. The Data Center creates virtual internet nodes for each remote terminal so that commands to any terminal are sent to it as simply as electronic mail.

3. THE FUTURE

An increasing awareness and concern over the human impact on climate change, plus recent changes in the oil industry, have created a significant demand for much larger quantities of data from remote ocean regions. Cost-effective, high-throughput satellite communications for remote data platforms will become increasingly important over time.

The ability to retrieve large amounts of data in real-enough time, coupled with an interactive data platform, will change the way remote oceanographic data collection is done, and enhance the utility of ocean-observing systems for industry. Until now, research programs have been constrained by the limits of one-way, low-volume data returns. Eliminating the data-transmission barrier will lead to a revolution in operational oceanography, allowing more dense data returns in real-enough time such that scientists can look at ocean processes in unprecedented detail.