Near-Real-Time Wave/Current System

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Falmouth Scientific, Inc. (FSI), Cataumet, Massachusetts, USA, and Geofix, Florida, USA have developed and installed a system to monitor ocean waves and other data from a remote location, using off-the-shelf components. The system monitors ocean currents, temperature, tides and waves. Monitored variables are measured in near-real-time with data sent via a hybrid radio telemetry link to shore. This data provides the local port authority with information to pass to ships navigating entrance to the port and to determine when it is safe for ships to enter or leave the port.

System Description

Geofix and FSI have worked since late 1999 to engineer, integrate and install a complete wave/current monitoring/telemetry system for the harbor at Necochea, in the province of Buenos Aires, Argentina. FSI engineers designed the system using off-the-shelf components, comprising:

- a control/logging station
- radio-frequency data link (above surface)
- acoustic telemetry link (below surface)
- wave/current meter.

A diagram of the system is shown in Figure 1.

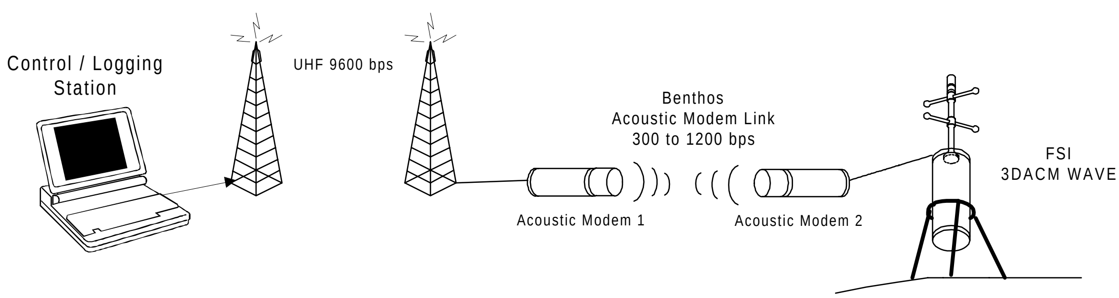

Figure 1 - System Diagram

The system was designed to provide rapid data telemetry to the harbor master, with a minimum of civil construction required. With the acoustic and RF telemetry employed, costly and intrusive underwater and surface cable runs were unnecessary.

Wave/Current Meter

The oceanographic data monitoring system is based on a Falmouth Scientific 3D-ACM Wave/Current Meter installed approximately one kilometer off-shore and shown in Figure 2 below. The 3D-ACM Wave uses a micro-machined pressure transducer for extremely accurate wave height measurement. With a user-selectable, 1- to 5-Hz sampling rate, the Wave unit provides detailed wave spectra. Software provided offers display/output in a variety of user-selectable formats, allowing the user to select the display functions suitable for the application.

The 3D-ACM Wave unit also incorporates an acoustic phase shift current meter for three-dimensional measurement of ocean current and orbital velocity, to determine wave speed and direction. The current meter operates by transmitting a 1 MHz acoustic signal in forward and reverse directions along four acoustic paths. These paths are defined by transducers installed on the ends of orthogonally arranged "fingers" shown in Figure 2 below. The phase shifts measured by the forward and reverse readings along these acoustic paths are used to resolve the three components of velocity (X, Y, Z). Readings along one of the acoustic paths will be contaminated by the wake from the center support strut; data from this path is not used in the velocity calculation. Since only three axes are required for a complete solution of the X, Y, and Z components of velocity, the meter provides an accurate determination of current flow without contamination by flow interaction with the center strut.

Figure 2 – 3D-ACM Wave/Current Meter

The 3D-ACM Wave meter was designed for operation to a maximum of depth of about 23 meters, which provides a good correlation between current, orbital velocity, and wave speed and direction. The design also incorporates a 3-axis magnetometer and 2-axis tilt sensor to determine tilt and magnetic direction, which provides N/S and E/W components for vector averaging.

For this project the 3D-ACM Wave design was updated to include internal processing of the data to minimize the amount of data transferred across the acoustic modem link and improve telemetry speed and reliability. With this novel system, all wave analysis is performed in the 3DACM Wave unit, including Peak Period, Significant Wave Height, Peak Frequency, Average Period, Minimum Wave Height, Maximum Period, Mean Zero, Mean Wave Direction, Tide, Average North Velocity, Average East Velocity, and Average Up Velocity.

The on-shore Control/Logging Station is based on a laptop computer operating Falmouth Scientific, Inc. 3DACM97 software. The software sets up polling events that determine how often to poll the 3D-ACM WAVE for oceanographic data. The Control Station uses the PC clock to determine when to poll for data.

Hybrid RF/Acoustic Telemetry Link

The telemetry system between the offshore Monitoring Station and the on-shore Control Station includes a radio link and underwater acoustic modem link. Pacific Crest UHF modems were used to establish the radio link. These modems provide a true 9600 bps transfer rate, so there are no time delays between the laptop and acoustic modem. Datasonics/Benthos underwater modems were installed at the monitoring site and at the intermediate radio site. The underwater acoustic link can transfer data at rates up to 1200 bps.

Encoding techniques are used to reduce the bit errors caused by acoustic noise and multi-path, which in turn reduces the baud rate of the link.

Data Collection

For this project, the FSI 3D-ACM Wave unit is configured to take 1 Hz readings for nine minutes at 20-minute intervals. Wave height, direction, current speed and direction, and temperature data are communicated at 9600 baud via RS-232 and are stored in the local Datasonics/Benthos underwater modem.

Data downloading is initiated from shore by the laptop PC, which sends a command via the UHF modems to the Datasonics/Benthos surface unit and its underwater modem. Underwater acoustic signals provide 600 baud data polling and downloading between the two underwater modems.

Incorporation of the Datasonics/Benthos acoustic modem link offers reliable long-distance data acquisition without running cables. As part of this project, FSI also developed a new error-checking software module for the 3D-ACM Wave unit acoustic modem link.

Figure 3 shows characteristic data results as received at the on-shore Control Station.

Time	Wave Height (m)	Wave Direction (°)	Temp. (°C)	Current Speed (cm/s)	Current Direction (°)
12:45:57	0.417	103.9	11.07	9.0	49.4
13:00:57	0.467	114.1	11.07	6.0	59.0
13:15:57	0.433	96.3	11.05	6.0	45.0
13:30:57	0.454	105.9	11.07	3.0	45.0
13:45:57	No Data				
14:00:57	0.424	116.5	11.07	1.0	180.0
14:15:57	No Data				
14:30:57	0.490	99.0	11.09	1.0	225.0
14:45:57	0.451	117.2	11.08	4.0	236.3
15:00:57	0.371	108.4	11.08	6.0	210.9
15:15:57	0.393	119.4	11.12	4.0	206.57
15:30:57	0.322	126.7	11.09	5.0	233.13

Figure 3 – Control Station Data Sample

Summary

The Oceanographic Data Collection system provided by Geofix/FSI for the Necochea port offers the harbor master an effective tool for understanding true current and wave information in near-real time, allowing safer, more cost-effective port management. Using off-the-shelf components, Geofix was able to offer a low-cost, relatively simple, rugged system that is readily serviceable. With its flexible design, the system provided for Necochea can be readily replicated in other ports, giving commonality of design between several locations.

Authors' Biographies

John Duchesney is Engineering Manager at Falmouth Scientific, Inc. Mr. Duchesney earned BSET and BSEE degrees from Wentworth Institute of Technology and spent several years as Research/Product Engineer with Datasonics, Inc. and as Senior Project Engineer for Present Advanced Instruments, Inc. before joining FSI in 1997.

Ned Lassiter owns and operates Geofix Limited and Hydrotech Inc., specializing in positioning systems, general oceanographic and light geophysical equipment. He is former general manager and owner of Hydronav S.A. where he was responsible for rig moves, site surveys, and seismic positioning for major oil companies working in Spain through the mid-1980s. Mr. Lassiter graduated from Louisiana State University.

Joanna Phillips, Sales Manager for FSI, recently joined FSI from Accusonic Technologies, Inc. where she was National Sales Manager for the multi-path transit-time flowmeter product line. Ms. Phillips has degrees from Harvard College and B.U. School of Law.