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INSTRUMENTATION: MEASUREMENT PROCESSING & ANALYSIS

Real-Time Current Measurements Improve Vessel Safety and Port Efficiency

The ATON System Provides Port Decision Makers With a Reliable and Cost-Effective Alternative in Real-Time Current Monitoring

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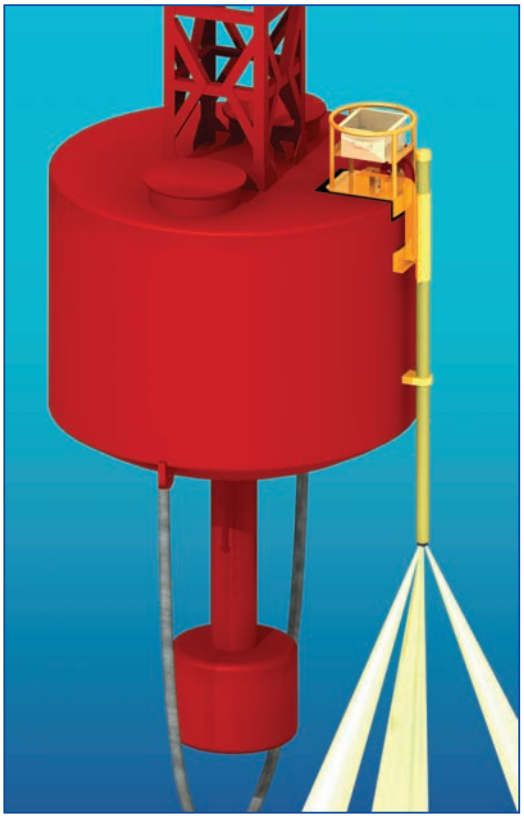
Technicians install an ATON System on a USCG navigational buoy in the Chesapeake Bay. (Photo courtesy of Spencer Oceanographic Services.)

Nearly every major shipping port in the United States and many abroad are outfitted with a network of real-time oceanographic and atmospheric sensors, providing critical information to vessel pilots, harbor managers and support craft. In the United States, 17 of the 20 largest ports by tonnage are outfitted with some type of real-time current monitoring system. Heavily laden commercial vessels navigate in narrow dredged channels and are seriously influenced by local currents, which can often exceed three knots. Real-time current velocity measurements in the shipping channel are imperative for safe navigation by pilots and may be used by harbor managers and decision makers for containment and cleanup in the event of a hazardous materials spill.

Because of often complex harbor bathymetry and current circulation patterns, it is advantageous to directly observe current velocity measurements in the shipping channels. This is a difficult demand that is not easily met with traditional bottom-mounted instruments or dedicated surface buoys that are usually deployed outside of navigable channels. Long underwater cables required for bottom-mounted sensors are certainly rugged, but are also quite expensive to install and are susceptible to being dragged and damaged. Furthermore, installation and maintenance of these traditional systems requires the use of divers and sup-



Design concept of a deployed ATON System. (Photo courtesy of Oceanscience Group.)

port vessels with significant lifting capacity. With an increasing emphasis on reliability and cost-effectiveness, an alternative method of measuring and reporting real-time current measurements was sought.

ATON System

The solution to real-time current observations in the navigation channel has become known as the ATON System, after the U.S. Coast Guard (USCG) aid-to-navigation (ATON) buoys that it attaches to.

The initial design of this system was conceived in 2000 through a collaboration between NortekUSA (Annapolis, Mary-land), an acoustic Doppler current profiler manufacturer, and the Oceanscience Group (San Diego, California), a designer and manufacturer of oceanographic support hardware.

The ATON System is a robust and cost-effective integration of an acoustic Doppler current profiler, data transmitting device and power system. A specially designed mounting frame called the "Clamparatus" secures the system components to standard USCG ATON buoys. The system is lightweight and can be installed from a small boat. This initial design concept was quickly recognized by the National Oceanic and Atmospheric Administration's (NOAA) Center for Operational Oceanographic Products and Services as a "potentially rewarding technology." Soon afterward, the Maryland Port Authority provided developmental funding to advance the system to an operational status.

In 2002, NOAA was successful in securing authorization from the USCG 5th District Aids to Navigation Branch for the installation of a prototype system on a navigational buoy at the mouth of the Chesapeake Bay, near Cape Henry, Virginia. This authorization was contingent on requirements that the payload did not impede the utility or maintenance of the buoy and that the buoys would not be cut, drilled or welded in any way to accommodate the equipment. Further prototype design criteria included requirements for modularity and low weight for ease of installation, a low physical profile to minimize any effect on the USCG buoy profile and demonstrated reliability of the electronic components and sensors.

With support and contributions from NOAA, the USCG, port authorities and several commercial companies, these systems are now being installed directly onto USCG channel buoys. Today, ATON Systems are providing real-time current information at many U.S. ports, including the Chesapeake Bay, New York Harbor, New York; San Francisco Bay, California; Mobile, Alabama; Gulfport, Mississippi; and Galveston, Texas.

Real-time information is accessible to a wide array of users through a variety of methods. Commercial and academic groups typically post velocity profiles, time series and vectors on password-protected or public Internet sites. NOAA distributes the real-time data through the Physical Oceanographic Real-Time Systems (PORTS®) channels, including public Web sites and voice dial-up services.

ATON System Components

Each ATON System is comprised of four primary components: a Nortek Aquadopp profiler, the Clamparatus mounting assembly, the power management system and a half-duplex communications device for connecting with the user.

Nortek Current Profiler. Since buoyed navigation channels are typically less than 25 meters in depth, a one-megahertz Nortek Aquadopp profiler is used to measure current speed and direction in one-meter cells below the buoy.

A common measurement configuration averages velocity data over five minutes and reports a real-time current profile every six minutes. Recent experiments indicate that the five-minute average interval may be reduced to about two minutes—providing longer deployment durations with negligible loss of data quality.

The profiler also records data to its internal flash memory, which is downloaded during routine maintenance visits, scheduled at six to nine-month intervals based on location.

Oceanscience Clamparatus. The Oceanscience Clamparatus is used to mount the ATON System components to the navigation buoys.

The device consists of an aluminum frame for securing the stainless steel electronics and a battery box above the buoy deck and a fiberglass shaft holding the current profiler at a measured depth.

The Clamparatus is secured with a proprietary clamping system to a single hoisting eye on the buoy deck. Mounting does not require any alteration of the buoy and is performed at sea in a matter of minutes.

For corrosion resistance and appearance, the Clamparatus is coated to match the buoy and will accommodate three standard ATON buoy sizes: six by 20-foot, eight by 26-foot and nine by 35-foot dimensions.

Power. Electrical power is provided by two 126-amp-hour alkaline battery packs which are housed in the topside enclosure.

In order to maximize the system deployment duration, Nortek has developed a power management and control system that forces the sensors and communications device to go into sleep mode when not actively operating. At timed intervals, the control device will check the profiler and communications systems for activity before

"Today, ATON Systems are providing real-time current information at many U.S. ports."

issuing a wake-up command.

While early tests without power controls allowed for four to six-month deployment durations using 100-milliwatt radio modems for data broadcasts, improvements in power management now permit six to nine-month deployments while using more powerful one-watt transmitters.

Data Communications. Depending on the site location, data are transmitted to the user through one of three available communications systems. The earliest systems utilized radio frequency (RF) modems operating in either 902 to 928-megahertz or 2.4-gigahertz frequency bands to transmit the data to a dedicated shore-based receiver. Transmission distances of up to 12 miles have been achieved consistently when using one-watt transmitters.

IP modems operating over a code division multiple access (CDMA) network (such as a cell phone network) have been employed in research installations so that data are transmitted directly from the buoy to a networked PC anywhere in the world. Iridium (Bethesda, Maryland) satellite-based data transmission systems are also being designed and tested for deployment locations beyond the range of RF radios or CDMA networks. With this potential global coverage capability, deployment locations will no longer be limited by the communications systems, allowing users to instrument sites of the highest commercial or oceanographic interest.

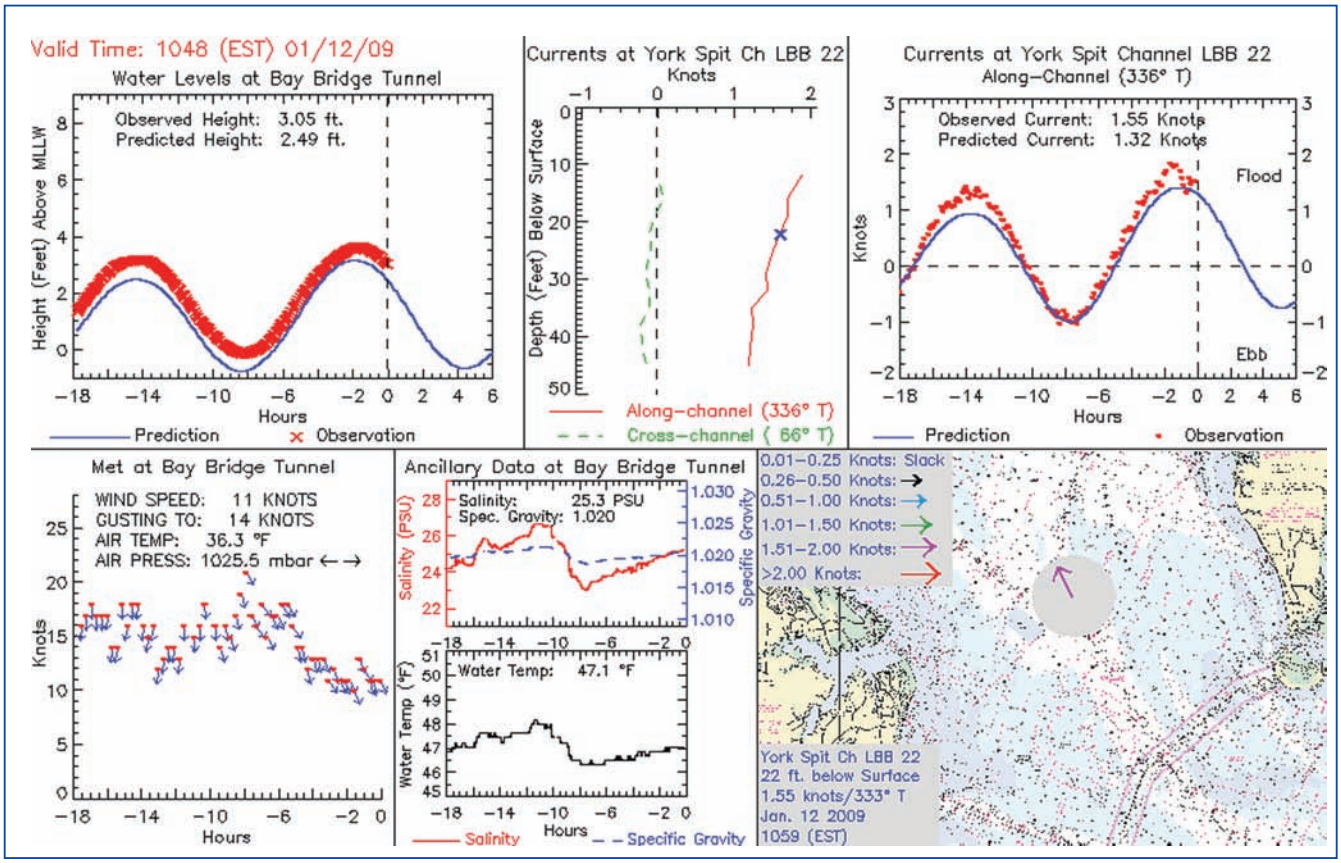
At sites where multiple data communication choices are available, selection becomes a matter of cost-effectiveness over the long term.

Performance Validation

ATON Systems are in wide operational use by NOAA as well as a variety of academic and private groups. However, the road to acceptance was long and paved with many validation experiments and modifications.

One of the early challenges was to quantify the magnetic influence of the iron buoy hull on the adjacent current profiler compass. Specialized software and field procedures were developed for calibrating the compass throughout the full range of buoy orientations. This calibration procedure is performed during each deployment, and a calibration file is uploaded to the profiler for the correction of raw directional data. The Nortek software also provides a calibration quality assessment, which allows the installation team to evaluate results on-site and determine if a particular calibration run meets the quality requirements.

As the initial assignment for the ATON System would be in support of NOAA programs, the development team was tasked with demonstrating the system's reliability in reporting current speed and direction with an accuracy of 0.1 knots and 15°, respectively. During 2003 to 2004, numerous field



A typical NOAA PORTS display of ATON System current, water level and meteorological data provides pilots with information on present conditions. (Photo courtesy of NOAA CO-OPS.)

"ATON Systems are in wide operational use by NOAA as well as a variety of academic and private groups. However, the road to acceptance was long and paved with many validation experiments and modifications."

experiments were performed to compare data sets from ATON-based profilers with data from collocated bottom-mounted profilers. Comparison tests ranging from 20 to 120 days long were performed at tidal river and harbor inlet sites, as well as one offshore location not dominated by tidal flow.

The results show that for all deployments, current velocities compare well in corresponding depth cells with a mean difference of about 0.06 knots. However, differences in the reported current directions were larger. The mean of the difference in the reported current directions from the many experiments ranged from 11.5º to 27.8º. As expected, directional differences were largest as the tidal current reversed, during periods of weak and variable flow.

Further analyses were performed to quantify the directional differences when velocities were greater than 0.25 knots. This analysis resulted in a mean directional difference of about 9º. Finally, an overall distribution analysis showed that 69 percent of the directional differences were within 10º of zero, and 89 percent of the differences were within 15º. Based on these results, the ATON System performance was determined to be suitable for operational use in support of NOAA PORTS observations.

Conclusions

The ATON System has proven to be an operationally robust and valuable asset to vessel pilots and port and harbor managers in a variety of busy waterways across the United States. When compared to the equipment and maintenance costs of more traditional real-time current monitoring systems, the system is clearly an attractive option for enhancing coastal oceanographic monitoring networks. Studies show that these measurements, implemented with a full set of ocean and meteorological observations, such as water level and wind speed, have led to more economically productive ports. Combined with its ability to provide valuable information in support of spill responses and search and rescue missions, the ATON System is rapidly becoming standard equipment for any major shipping port or inland waterway.

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Acknowledgments

While many groups have contributed to the development of the ATON System, the authors would like to offer particular recognition to Dr. Kathryn Bosley, Mark Bushnell and John Stepnowski at NOAA's Center for Operational Oceanographic Products and Services (CO-OPS); Malcolm Williams at NortekUSA; Ron George at Oceanscience; Lee Gordon Consulting; and the staff at OceanTechUSA Inc.

References

For a full list of references used in this article, contact Stephen O'Malley at steve@oceantechusa.com. ■

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Chris McGrath holds a B.S. in electrical engineering and is presently the head of the Chesapeake Instrument Lab for the National Oceanic and Atmospheric Administration's Center for Operational Oceanographic Products and Services. His interests include the evaluation and implementation of emerging technologies related to real-time monitoring of coastal oceanographic and environmental parameters.

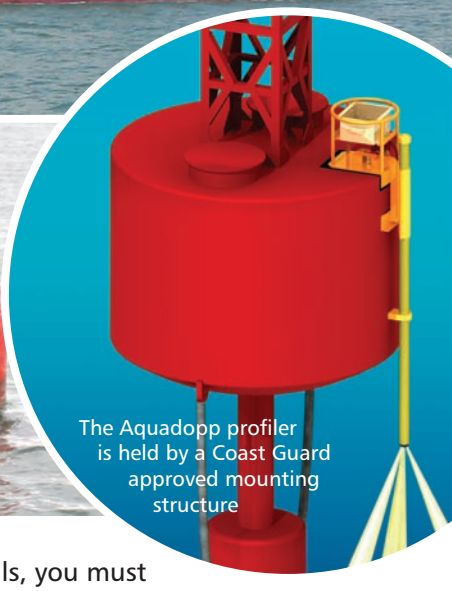
Want to know the currents in the navigation channel?

-Mount your Aquadopp on buoys already out there!

Installation in San Fransisco Bay, marker buoy 6 on South Hampton Shoal

ATON with Aquadopp profiler in New York harbor. Photo courtesy of Steve O'Malley

Preparing installation of Aquadopp profiler



The Aquadopp profiler is held by a Coast Guard approved mounting structure

To advise ships during their harbor approach and efficiently respond to HAZMAT spills, you must measure currents in the navigation channel where vessels come in to port. These places can be hard to reach and cabled instrumentation has proven difficult and expensive to maintain.

The solution? Use the Nortek ATON System to mount your Aquadopp current profiler on the navigation buoy that is already out there and broadcast the real-time currents to ships and to shore!
The ATON System is easy, robust, and fast.

For more information, go to www.nortekusa.com and download "Test, Evaluation, and Implementation of Current Measurement Systems on Aids-to-N avigation". Bosley et al., May 2005. NOAA Technical Report NOS CO-OPS 043.

Current and wave measurements in the ocean, lake and laboratory

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