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Nortek Introduces New Techniques for Offshore Wave Measurements

New Methods for Subsurface Wave Measurements at Offshore Locations

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Requirements are increasing for real-time directional wave and current measurements at offshore sites in support of oil exploration, wind, wave and tidal energy production, as well as commercial and research ocean observing systems. There are many challenges to operational systems that provide real-time data and here we report on new hardware products and measurement techniques that have been developed to provide robust solutions for these demanding offshore requirements.

Background

In shallow, coastal environments (less than 50 m depth) a common solution for directional wave and current measurements is to deploy an acoustic Doppler current profiler on the sea floor. Keeping the equipment away from the ocean surface provides several advantages such as reduced exposure to harsh storms, security from theft or vandalism, and protection from ships, ice, or drifting debris.

Historically, surface buoys and fixed mounted equipment such as wave staffs and wave RADAR have been used for making wave measurements in offshore regions (deeper than 50 m). At this depth, bottom mounted acoustic Doppler current profilers do not provide the directional resolution necessary for research and commercial wave measurement requirements.

The ability to mount an acoustic system, such as the Nortek Acoustic Wave and Current profiler (AWAC), on a subsurface buoy, or underwater directly to an offshore platform, would permit the instrument to be close enough to the surface for high quality wave measurements, yet be removed from the dangers of exposure at the surface. Until now, there have been no clear commercial off-the-shelf solutions to meet this requirement.

Platform Mounted AWAC

In 2004 Nortek was approached by the oil industry to develop a modified AWAC wave system that could be mounted directly to a subsurface structure on an offshore platform. The resulting design, commonly known as the "Platform Mount AWAC", employs four acoustic transducers asymmetrically arranged on one hemisphere of the system to point away from the offshore platform. The three slanted beams are used for current profile and wave directional estimates, and the fourth (almost vertical) beam is used to measure wave height. This permits the Platform Mount AWAC to be deployed underwater directly to an offshore structure while at the same time measuring the waves and currents away from the structure (Figure 1).

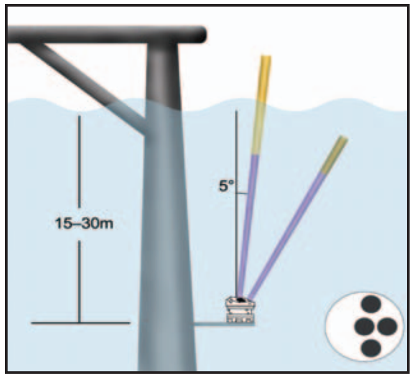


Figure 1. Platform Mount AWAC with asymmetric transducer head for deployment on offshore structure.

The upward looking Platform Mount AWAC is typically deployed 15-30 m below the surface. A downward looking current profiler can be placed below the AWAC to extend the current measurement range into deeper water (Figure 2). A cable running to the Platform Mount AWAC provides power to the system and transmits data from the AWAC to a computer or telemetry node on the platform.

Figure 2. Platform Mount AWAC being lowered into place on oil platform. Downward looking AWAC is used for current profile measurements into deeper water. *Photo: B. Magnell, Woods Hole Group*

The Platform Mount AWAC is being tested by NOAA's National Data Buoy Center (NDBC) on their Coastal-Marine Automated Network (C-MAN) stations. The first unit was deployed in 2006 on the Ambrose Light C-MAN Station, offshore New York harbor (Station ALSN6), and transmits processed data to shore by satellite. NOAA has developed QA/QC protocols for these data. Real-time wave data from this AWAC are available on the NDBC website.

Real-time wave and current measurements from offshore structures may provide critical decision-making data points for safe personnel and vessel operations, as well as long term wave loading information for facility design, maintenance, and repair planning. Future applications could include real-time dynamic feed-back loops for optimizing wave energy harvesting systems, such as real-time modifications of the harvest system based on parameters such as wave height or peak period.

Subsurface Buoy Mounted AWAC

Offshore wave measurements are often needed for site surveys during the planning stages of petroleum and renewable energy projects, as well as boundary conditions for wave models. Surface wave buoys have been a common solution to meet these requirements; however, surface buoys may be damaged by storms, ice and ships. Also, there are many places in the world that surface buoys would be vandalized or stolen.

The ability to mount an acoustic Doppler current profiler for wave measurements on a subsurface buoy would permit the instrument to be close enough to the surface for high quality wave measurements yet be removed from the dangers of exposure at the surface (Figure 3). However, a subsurface buoy will both rotate and translate during a wave sampling period of 10-30 minutes. For this reason, it is not possible to measure waves with a typical acoustic Doppler current profiler deployed on

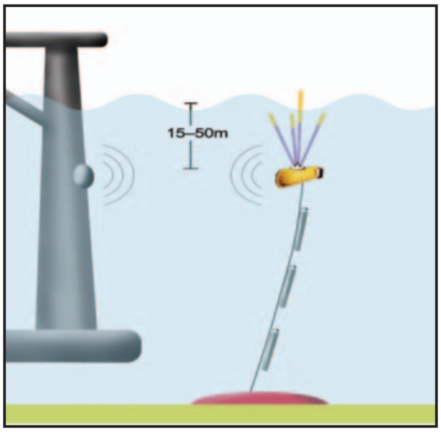


Figure 3. AWAC mounted on subsurface buoy. Real-time data telemetry provided to offshore structure via underwater acoustic modems.

a subsurface buoy without modifying the wave processing algorithms developed for stationary systems.

To address this particular problem, Nortek introduced the "SUV" method for measuring ocean waves with an AWAC mounted on a subsurface buoy. The SUV method differs from the traditional maximum likelihood method (MLM) array approach of measuring waves from a Doppler profiler and allows directional wave estimates to be made even when the instrument is rotating on a subsurface buoy.

The SUV method for measuring waves works in a similar way to the PUV method. Both methods use a triplet of wave-related measurements to estimate wave energy and the first four Fourier coefficients. The Fourier coefficients are used to estimate the standard parameters of direction. The SUV method is composed of the acoustic surface tracking (AST) and two horizontal and orthogonal velocities, U and V. The U and V are special in the sense that the quantities are generated from spatially separated cells near the surface. These estimates of U and V come from conversion of the Beam to Earth referenced coordinate system. Converting to an Earth referenced system is necessary if the buoy is expected to freely rotate. The conversion is possible since the AWAC compass and tilt sensors are sampled at the same rate as the velocity measurements (1 Hz). Mathematically, the phase relationship of the AST, U, and V is preserved which permits the directional wave processing.

In 2006 NortekUSA initiated a collaborative experiment with Bedford Institute of Oceanography, Dalhousie University, Open Seas Instrumentation, and Mooring Systems, Inc to validate directional wave measurements from a subsurface buoy. Two Nortek AWAC's were deployed on two subsurface buoys (spherical and asymmetric shapes) next to a Datawell wave buoy for independent reference (Figure 4).

Results from this experiment indicate that the SUV method works well for making directional wave measurements with the Nortek AWAC mounted on a subsurface buoy. The experiment also suggests that the lateral motion of the buoy must either be measured or kept outside the wave energy bands of interest. Depending on the local conditions, this challenge can be approached with a well conceived subsurface mooring that takes into account appropriate mooring line length and buoy buoyancy to keep the natural period of the mooring system above the typical wave period (5-20 sec).

Figure 4. AWAC being deployed on subsurface buoy at offshore location for site survey. *Photo: J. Barthelotte, Bedford Institute of Oceanography.*

Communication Solutions

Real-time wave and current data are critical for safe operations at sea, assimilation with nowcast and forecast models, and may be advantageous for dynamic feed-back loops for optimizing wave and current energy harvesting systems. The two most common methods of underwater data telemetry are cables and wireless underwater acoustic modems.

Rugged cables may be used to transfer data from a Platform Mount AWAC up to a data collection station on the platform. This cable may also provide power to the AWAC for long-term measurements without the need to change batteries.

Wireless underwater data telemetry solutions are required for instruments mounted in areas where cables are not suitable (Figure 5). This includes areas where bottom trawling is common, on subsurface buoys, and in other situations where cables are impractical because of time or cost constraints. Nortek uses a modified version of the Benthos modem to transmit data from the AWAC to a receiving station such as an offshore platform or surface buoy. The horizontal distance between the acoustic modems can range up to 1-3 km, depending on several

Figure 5. AWAC being deployed on a bottom frame in the Gulf of Mexico. Real-time wave data are processed by NIP and sent to the surface buoy via underwater acoustic modems.

environmental factors such as local bathymetry, hydrography, and environmental noise.

Underwater acoustic modems operate at low data transfer rates (typically 300 – 9600 baud). To address the increasing need for wave data passing through low-bandwidth channels, Nortek developed the Nortek Internal Processor (NIP). The NIP is a scaled down PC running a Windows CE Operating System. It is small enough to fit within the AWAC and it processes the raw AWAC data into a user selectable set of wave parameters, energy spectra, and velocity profiles. These processed data are considerably reduced in size (0.1 – 1.0 kilobytes) as compared with the raw wave data (25 – 50 kilobytes) and can be easily transmitted through the Nortek underwater acoustic modems. Data formats can be adapted to the user requirements and can be scaled for satellite transmissions.

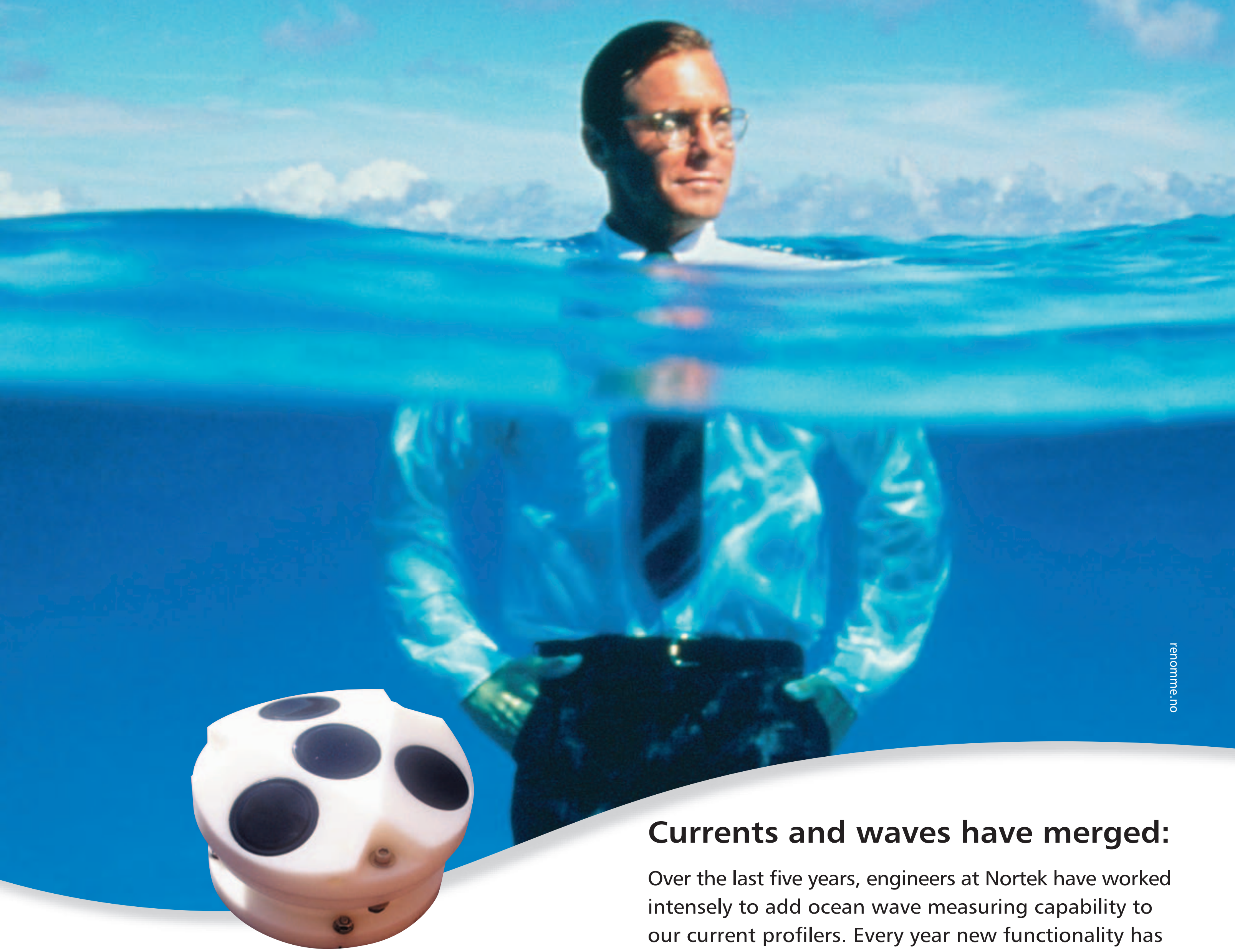
The Complete Solution

Nortek has acknowledged the increased need for operational, real-time wave and current measurements in deepwater, offshore environments. Nortek has responded to this requirement with innovative hardware products and measurement techniques to provide the complete solution including data collection, processing, and real-time telemetry.

The Platform Mount AWAC allows the installation of an acoustic Doppler current profiler and wave gauge on the side of an offshore structure. The SUV wave measurement technique allows the AWAC to be installed on a subsurface buoy for current and wave measurements. The NIP provides real-time data processing and facilities processed wave parameters to be sent wirelessly via underwater acoustic modems.

Contact NortekUSA for further information: www.nortekusa.com

Nortek gives you full control over your wave and current measurements



The AWAC
(Acoustic Waves And Currents)
uses the center beam to measure wave height and the slanted beams to measure the current profile and the wave direction.

Mounting options:	Online systems:
- On the bottom	- Cables to shore (max 5 km)
- On offshore platforms	- Acoustic modems
- On subsurface buoys	- Radio, GSM or CDMA

Currents and waves have merged:

Over the last five years, engineers at Nortek have worked intensely to add ocean wave measuring capability to our current profilers. Every year new functionality has been added and full scale intercomparisons have been completed with impressive results. The result is a powerful system that allows you to collect and publish realtime current profiles and waves in a variety of mounting configurations.

Curious about what the AWAC can do for you?
To find out more, check the extensive documentation on our WEB site www.nortekusa.com

Water velocity measurements in the ocean, lake, river and laboratory

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