RD Instruments: Leading Edge Technology, Age-Old Principle

Celebrating 20 Years of Operations, RDI is Among the Leading Companies in Measuring Water in Motion and Motion in Water

(left) RDI company headquarters.

(below) ADCPs are operated from small boats to obtain accurate profiles in shallow waterways.

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Assistant Editor

RD Instruments Inc. is 20 years old this year. However, the fundamentals that form the basis of the company's products date back to observations made over 150 years ago in Vienna by the physicist Prof. Christian Johann Doppler, who gives his name to the "Doppler effect." This is the change in frequency, Doppler frequency shift, observed when the separation between a wave source and the observer is changing. It is most commonly experienced when the pitch of a siren on a police car seems to change as the car approaches, draws level and passes.

By measuring the rate of the Doppler frequency shift of the siren, an accurate computation of relative speed between the police car and the observer, and thus the speed of the wavelength, can be made. Of course, the police can turn the tables and use a radar gun employing the same Doppler effect to measure the speed of your car approaching a police car.

It was this Doppler principle that Fran Rowe, founder and president of RD Instruments (RDI), applied to measuring water flow. Acoustic Doppler Current Profilers (ADCPs) work by transmitting sound into the water and receiving reflected sound echoes from plankton, detritus and other particles. The Doppler frequency shift between the transmitted sound and echoes is used to compute the velocities of the particles and, thus, those of the water in which they are suspended.

RDI began life in the spare room of the founder's home. Rowe met Kent Deines at Teledyne Ryan when they were working together on Doppler landing radar for lunar modules. The two later moved on to Ametek Straza, where similar Doppler techniques were used for ships' speed sonars. This led to a collaboration with Russ Davis of Scripps Institution of Oceanography to develop a Doppler sonar to measure vertical profiles of current speed from moving ships. Ametek Straza was unconvinced of the product's commercial viability; however, Rowe and Deines were determined, and in 1981 struck out on their own to develop the industry's first ADCP in Rowe's house.

This Rowe and Deines-driven pioneering work laid the foundation for what is today still a family business, but one with sales of $20 million, employing 135 people and having over 3,500 ADCP systems working in 50 nations.

RDI's corporate headquarters, located in San Diego, California, consists of over 40,000 square feet of office, laboratory and manufacturing space. The company has achieved ISO-9001 certification for the development,

Launching a deepwater ADCP from an oceanographic research vessel.

manufacture and worldwide distribution of acoustic instrumentation—ADCPs. Facilities include sonar system and subsystem research and development laboratories; a complete transducer assembly "semi-clean" room; six transducer test tanks; electronics assembly area capable of PC board assembly and rework; and, nearby, two test vessels—one for harbor work, the other for ocean trials. RDI also now maintains an office on the south coast of France which provides local product training, service and support, as well as acting as a resource for the European representative network. More recently, a third corporate office has been established in China. This office is dedicated to research and development projects established to drive and support the local market, as well as general technology advancements.

There is now a wide array of RDI ADCPs to meet every requirement of measuring water in motion, and Doppler Velocity Logs (DVLs) to measure motion in water in every aquatic environment. This array of products benefits from several key technologies developed and patented by RDI.

First is the patented BroadBand processing technique. BroadBand uses a wider acoustic bandwidth and employs pulse-coherent signal processing technology. This technique produces greater accuracy and higher velocity, space and time resolution throughout the water column compared to conventional technology, with improved power efficiency due to the reduced data averaging time. This high precision is a distinguishing aspect of RDI's ADCPs, which provide improved data quality and error detection.

Another is the patented two-dimensional phased array transducer technique. It employs planar array techniques to reduce the ADCP's transducer size by a factor of 10, relative to conventional transducers. This size reduction makes it practical to install ADCPs in many more vessels and decreases the complexity of moored ADCP installations.

These are examples of some of the technologies underpinning RDI's use of Doppler techniques for gathering data on water flow, measuring wave height and direction, and for providing accurate navigation for underwater vehicle operations.

RDI's ADCPs are used extensively in a wide array of coastal applications.

The company is divided into three business units: Coastal and Inland, headed by Earl Childress; Blue Water, the open ocean current profiling section with Darryl Symonds at the helm; and Navigation, headed by John Romeo. These business units operate under the guiding hands of Rowe as president and CEO, Harry Maxfield as vice president sales and marketing, K-C Tran as chief operating officer and John Yiannakakis as chief financial officer.

Coastal and Inland

Rivers of all sizes need constant monitoring to provide data on flow rates and depth. Of particular interest is measuring the river discharge, or the net volume of water transported downstream. This is necessary for safe navigation, planning dredging programs, flood defense design, support of civil engineering works and monitoring abstraction rates.

For many years, the methods for directly measuring river discharge changed little. Methods using mechanical devices ranged from hanging the relevant sensors from a bridge to setting up cross-river cableways, from which equipment was deployed to make spot measurements. Acoustic devices measured time-of-flight differences along reciprocal paths between two or more receivers.

These methods have inherent limitations such as inflexibility, unavoidable under-sampling of flow and delayed data processing. ADCPs overcame these problems, and so today there are some 400 RDI ADCPs in use in waterway survey operations measuring not just flow rates, but also a number of other key parameters. The ADCP is accurate and samples rapidly. It is operated safely from a moving boat, and it enables the user to see discharge results as soon as the boat travels across the river. High-density sampling through the water column and along the boat path reveals intricate details of the flow both in quite shallow streams and in deep, high-speed rivers and estuaries.

The latest RDI ADCP to find wide use in shallow-water applications is the ZedHed™, which makes real-time flow measurements in water depths as shallow as 0.3 meters. Operating at 1,200 kHz, ZedHed combines shallow-water bottom tracking and high resolution profiling to measure flow rates in estuaries, rivers and streams over ranges of 0.3 meters to 20 meters, with a minimum resolution of 0.01 meters. The ZedHed complements the RDI Rio Grande range of river survey ADCPs that work in river depths from 20 meters to 75 meters, depending on frequency.

Another recent RDI innovation is the use of a coastal seabed-mounted ADCP to measure wave height, wave period, water depth and, simultaneously, ocean currents. Because the ADCP is seabed-mounted, it is safer than surface-floating, buoy-mounted wave measuring systems. The instrument is typically used in near-shore studies of hydrodynamic and ecological conditions to support design studies for ports, harbors and shipping terminals.

Also finding wide use in ports and harbors is the RDI Horizontal ADCP (HADCP), which "looks" horizontally through the water to distances of up to 200 meters to measure currents at up to 128 individual points. HADCPs

mounted on piers monitor shipping channels to aid navigation and safety; they are also used in estuaries to define complex circulation patterns and lateral mixing and to provide data to support oil spill response programs.

Oil and Gas

Further out to sea, RDI ADCPs are playing a key role at every stage of the search for hydrocarbon reserves. Even at the earliest stages of exploration—shooting seismic—multi-streamer vessels use hull-mounted ADCPs to measure speed and direction of cross-track currents in order to gauge the precise position of the streamers.

But it is in support of offshore exploration drilling that ADCPs have their widest use in oil and gas activity. Even before the drilling rig moves in, preliminary studies are made in order for mooring systems to be designed and to predict the ocean forces that will act upon the rig.

RDI's new Cobra-Tac diver navigation system incorporates the company's Doppler technology.

A typical preliminary study will employ perhaps two oceanographic moorings in water depths up to 3,000 meters. Each mooring is typically comprised of an anchor weight on the seabed, an acoustic release just above and then up to a dozen instruments at various points through the water column—some conventional recording current meters and RDI ADCPs. Deployments can last for up to a year with regular service visits to recover data.

When the rig moves in, a hull-mounted ADCP provides data to support a wide range of operational decision-making processes. They include rig orientation; riser and tubular deployment and recovery; ROV operations; and support vessel station-keeping.

In the Gulf of Mexico, for example, large eddies break off of the Loop Current. These eddies can spawn currents of more than three knots and extend hundreds of meters below the surface. Current profile data have proven particularly useful in warning of these high currents.

However, the practical depth to which a hull-mounted ADCP can "see" through the water column to measure currents is around 1,000 meters, and today's exploration work has extended to 2,000 meters and beyond. In order to obtain current profiles throughout the water column in depths greater than 1,000 meters, Shell Global Solutions (U.S.) Inc., RDI and other manufacturers developed a real-time system, which has a rig-mounted ADCP "looking" down through the water column and a bottom-mounted ADCP "looking" up. The rig-mounted ADCP feeds data directly to a computer aboard the rig. The bottom-mounted system collects ADCP data and transmits it to the surface in real time via an acoustic modem.

A validation test for this configuration was performed in the Gulf of Mexico, where Shell Oil Co. was drilling from the Transocean Sedco Forex *Deepwater Nautilus* semi-submersible in a 1,574-meter water depth.

The trials were successful. The rig-mounted, downward-looking ADCP achieved a current profiling range of 633 meters, slightly over what had been predicted. The more interesting results came with the seafloor-mounted, upward-looking Long Ranger instrument. Here, the expected current profiling range was 614 meters, but the Long Ranger consistently provided data in far longer ranges—an average of 700 meters, with a maximum range of 969 meters. These profiling ranges provided data returns from the two instruments, which were overlapping by about 50 meters at the end of each of their two ranges, thus making it possible to create a profile of the entire water column. Shell Global Solutions (U.S.) Inc. has since purchased a complete system configuration rated for 3,000-meter operations.

Another approach to obtaining ADCP profiles throughout the water column in 2,680 meters in the Gulf of Mexico was adopted by the U.K.'s Fugro GEOS Ltd., which is the largest single user of RDI ADCPs. The client required real-time current measurements from the drilling rig over the full ocean depth, so Fugro GEOS mounted an RDI 300 kHz ADCP on an Oceaneering Magnum 51 ROV. Current profile data was recorded as the vehicle descended to the seabed. Individual data points to the correct depth were mapped and an average current velocity for each of the selected depths was built up as the ADCP descended. Results were displayed in real time onboard the rig.

The most recent development for the offshore industry is a 300-kHz horizontal long range ADCP. This looks out horizontally from the rig or other offshore structure to measure near-surface currents in a single plane outside the platform's field of influence to ranges of 300 meters.

Research Vessels

The scientific community, too, is a wide user of RDI ADCPs, in particular the deep ocean research fleet, with more than 350 vessel-mounted instruments in use. The Ocean Surveyor ADCP employs RDI's 2D phased array transducer technology to measure current profiles in the ranges of 375-1,000 meters and is used in applications such as Gulf Stream climate studies, mid-ocean frontal mapping, fisheries research and deepwater cable laying activity.

Precise Positioning

A departure from making flow measurements is the development of RDI's DVL, which on its own or combined with other navigation systems such as INS, gyros, depth sensors and long and short baseline acoustic systems, provides highly accurate speed-over-the-ground information for a wide variety of surface and subsurface platforms.

The DVL draws heavily on existing ADCP technology. These technologies are the BroadBand signal processing for precise vessel velocity measurement, four beams for robust operation and improved data quality, and a patented bottom algorithm to allow reliable tracking in changing seabed conditions and uneven terrain.

The DVL has found particular use in precisely positioning underwater vehicles where over 100 ROVs and the entire world AUV fleet (commercial and military) have RDI DVLs installed (*Sea Technology*, December 2001, p. 24). There are also DVL systems for military and commercial divers. The base technology was developed through a contract with the U.S. Naval Research Laboratory for a Clandestine Littoral Acoustic Mapper (CLAM) and has evolved into RDI's Cobra-Tac diver-held navigation system, which is now marketed world-

wide by RJE International, located in Irvine, California.

The Future

"For the future, we will remain a people-oriented company doing all things with high personal and professional standards, with a clear commitment to meeting our employees' and customers' needs," said Rowe, "We'll continue to develop high quality, innovative products to pioneer new markets and continually expand the ADCP's applications."

RDI is also actively involved in the development of several new Doppler products to address the ever growing and changing needs of the inland water market.

With the impact that RDI's ADCP technology has made on the oceanographic industry, and the role that this data has played in better understanding our planets oceans, rivers and streams, RDI believes that Christian Doppler would be proud to know just how far his basic founding principles have travelled. /st/