Optimizing the Choice of DVLs for Noisy Environments

The Wide Range of Teledyne RDI DVLs Offers a Variety of Solutions

Teledyne RD Instruments

Instruments

Products:
Navigator, Pioneer DVLs

Application:
Navigation and positioning of underwater vehicles

Organizations:
Subsea vehicle producers
Research groups
Service companies

Product Line:
Teledyne RDI Navigation

Sales Team:
Grant Jennings
John Roscoe-Hudson
Cindy Weems

Location:
San Diego, CA, USA

Overview

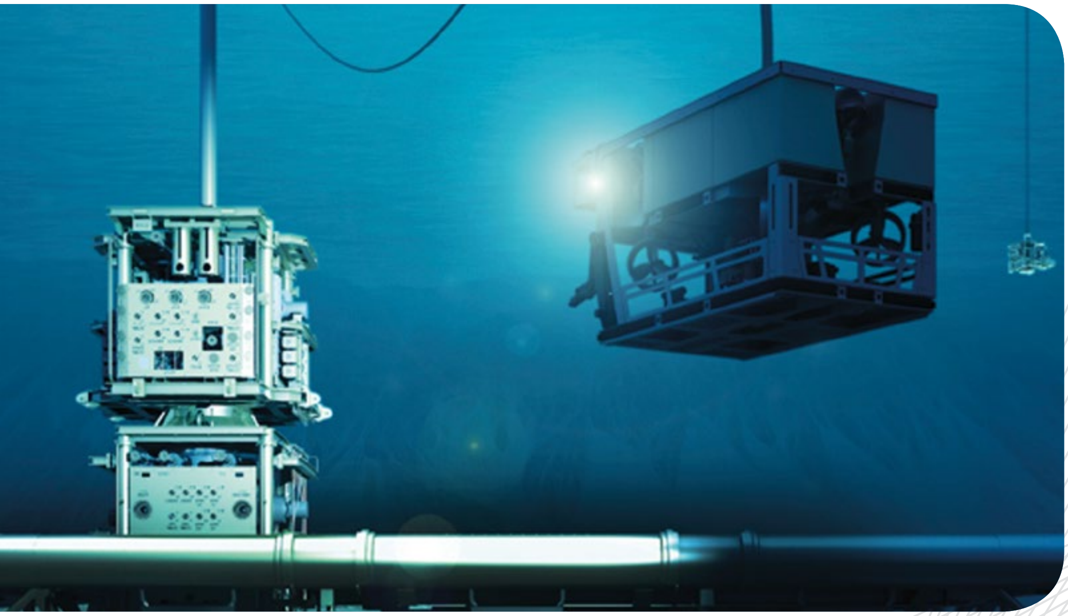
Reliable navigation and positioning underpin productive use of submerged vehicles, leading to optimized operations, expanded capabilities, and greater cost-effectiveness.

For 25 years, Teledyne RDI Doppler Velocity Logs (DVLs) have been an industry-leading solution for this need. DVLs are sonar systems that accurately measure a vehicle's speed over ground and altitude above the seabed.

The high precision and fast update rates of Teledyne RDI's data have enhanced subsea operations, from high-resolution spatial surveys to low-altitude stationkeeping. Moreover, Teledyne RDI DVLs have delivered robust navigation over highly demanding terrain, such as rugged hydrothermal vent fields on mid-ocean ridges.

To operate reliably, a DVL must hear its signals returning from the seabed. Sometimes, an unusually noisy environment can mask otherwise workable signal strengths, causing the DVL's bottom tracking (BT) range to be unexpectedly low.

During field trials of a remotely operated vehicle (ROV), the BT range of an onboard Navigator 600 kHz DVL was about 60 m—less than the expected 90-100 m. Troubleshooting showed problematic noise and interference were heard by the DVL when the ROV was in operation. In fact, the principal culprit was narrowband noise due to the ROV's electrical system.



ROV at work in an offshore energy field

Credit: TechnipFMC website
http://bit.ly/30F5wM2

Changing to the Pioneer 600 kHz phased array DVL reduced the contamination and achieved the desired 100 m BT range. Furthermore, adding the recently released XRT upgrade to the Pioneer DVL saw BT ranges reach 150 m, despite the operational noise.

Remotely Operated Vehicle set for work

Credit: TechnipFMC website
http://bit.ly/2xPQ2IV

Situation

An ROV working offshore in an oil and gas field can have assorted roles. Some activities require the vehicle to hold position—stationkeep—for a long time, such as during the opening and closing of valves on a pipeline.

One design goal for an ROV developed by Schilling Robotics, a business unit of TechnipFMC, was stationkeeping at an altitude of 100 m. Based on their success with Teledyne RDI's Navigator 1200 kHz DVL, these operators included a 600 kHz Navigator on the ROV. During field trials, BT range of the Navigator DVL was less than expected, owing to operational noise and interference when the ROV was working.

A Teledyne RDI DVL's cutoff for BT range is set by an internal processing threshold for signal-to-noise power (SNR) that specifies when received echoes (signals) can no longer be distinguished from noise. Sometimes, the cutoff is reached due to an unusually noisy environment masking otherwise workable signal strengths, curtailing BT range.

Navigator DVLs operate with 25% bandwidth, whereas Pioneer DVLs use 6.25% bandwidth. Filtering across narrower bandwidths lowers noise power, which raises SNR for returning signals, thereby boosting BT range. Yet there is a tradeoff for using reduced bandwidth: increased standard deviation of the DVL's velocity measurements.

Interfering signals that lie outside a receiver's nominal bandwidth can also degrade BT range. The receiver in a Pioneer DVL admits less noise energy from these out-of-band frequencies, providing another reason why they are a better choice for noisy environments.

Solution: Bottom Tracking

Bottom tracking is a method of measuring a vehicle's speed over ground and altitude. In marine applications, a sonar emits long acoustic pulses that propagate through the water column to be scattered by the seabed. The pulse's round trip travel time reveals the vehicle's altitude while Doppler shift in the returned echo's frequency shows the vehicle's velocity.

Signal and Noise:

- Acoustic signal strength fades with distance traveled due to absorption and spreading of energy
- For a given situation, BT range varies with factors such as transmit frequency and operational noise
- Noise has two main categories—receiver electronics and environment
- Environmental noise varies with installation and operating environment, such as flow noise and interfering signals

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In 1990, Teledyne RDI was granted a patent for its broadband signaling technology, supplying BT data with unmatched single-ping precision and accuracy—typically a few mm/s. As well, Teledyne RDI DVLs' single-ping bottom-location algorithm has been proven and improved over time, mitigating false detections (e.g., strong scattering layers) and returning reliable results—even over changing seabed conditions and uneven terrain. Accurate bottom detection on each ping means that altitude and vehicle velocity data are immediately available.

Teledyne RDI bottom tracking can inform vehicle control and integrated navigation systems (INS). Less noise and less drift mean fewer adjustments in vehicle control, resulting in rock-solid stationkeeping. Plus, a combined INS can supply a tenfold increase in accuracy compared with its component parts.

BT pulses provide other advantages too. They complement an onboard ADCP by identifying water velocity offsets, arising because the observing platform is moving. For profiling, a second, shorter acoustic pulse reveals how currents change with depth. In this case, the two types of pulses are interleaved, with BT reaching twice as far.

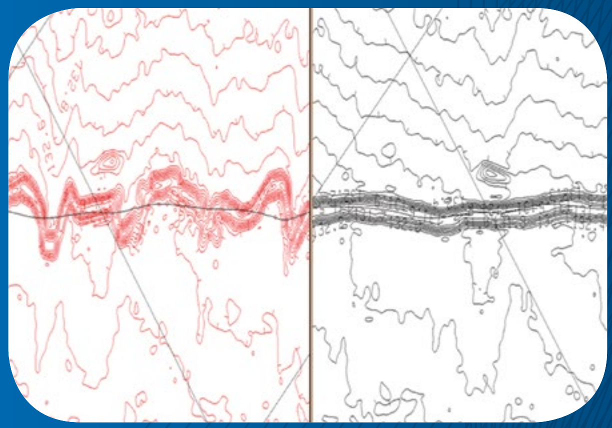
At the other extreme, Teledyne RDI DVLs automatically switch to more precise BT when altitude diminishes. At just 15 cm off the seabed, a Teledyne RDI 600 kHz phased array DVL can track the bottom, maintaining positional accuracy. This advantage expands the range of operating sites and applications.

Built on almost four decades of BT experience—from scientific submersibles to deep-sea trenching machines—Teledyne RDI bottom tracking provides accurate, precise, and proven results.

Results

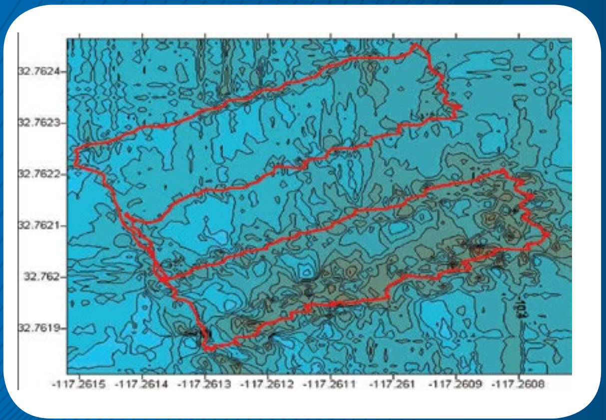
Teledyne RDI and Schilling Robotics worked together in several tests to identify the noise and interference that were degrading the BT range of the Navigator DVL.

First, the Navigator DVL was installed on a Teledyne RDI boat and tested off San Diego. The DVL's BT ranges matched specifications—retaining bottom lock in water depths of 100 m. A second DVL—a Pioneer 600 kHz phased array—held bottom lock in 110 m depth.



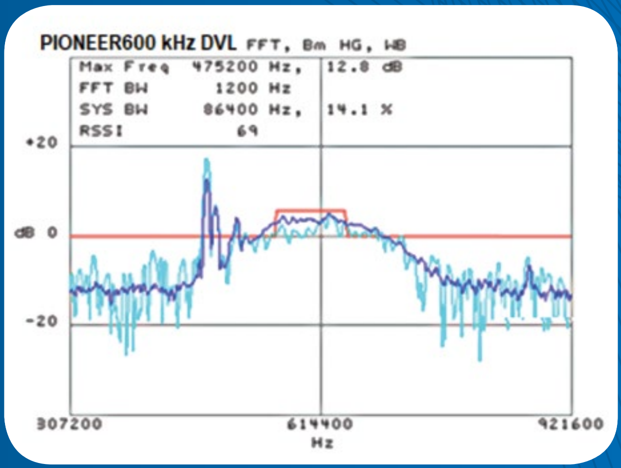
Map of a seabed pipeline's location. The images, scanned from a subsea vehicle, show how Teledyne RDI bottom tracking (black image) improves positioning data

Credit: N. Vase, EIVA



Track of a diver carrying a Teledyne RDI DVL, overlaid on map of bottom topography

Pioneer family of DVLs



Power spectrum of signals heard by Pioneer DVL when ROV was operating

During a second test at the Schilling Robotics factory (Davis, CA), the Pioneer DVL was installed on an ROV. The noise floor heard by the Pioneer was 12 db higher when the ROV was operating.

An audio recording taken aboard the working ROV was analyzed with power spectra. A significant interfering signal, near 480 kHz, came from the ROV's electrical system. See graph on this page.

Clearly, the Navigator's broadband receiver was not well-suited to work near a loud signal at an adjacent frequency. A Pioneer DVL, with its narrower bandwidth, should be less susceptible to this noisy environment.

A second round of sea trials proved this to be true. During the tests, the operating ROV was raised from 10 m to 200 m altitude. The Pioneer 600 kHz DVL satisfied the BT need at 100 m. Moreover, using the Teledyne RDI new BT upgrade—XRT, extended range tracking—the Pioneer DVL successfully maintained bottom lock to 150 m altitude, despite the noisy environment.

XRT is a hybrid technology, transmitting a new style of coded signal and using new signal processing to boost received SNR. This upgrade continues a Teledyne RDI tradition in innovative subsea signaling, first patented almost three decades ago.

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