Sentinel V: *Solid* in Tidal Stream

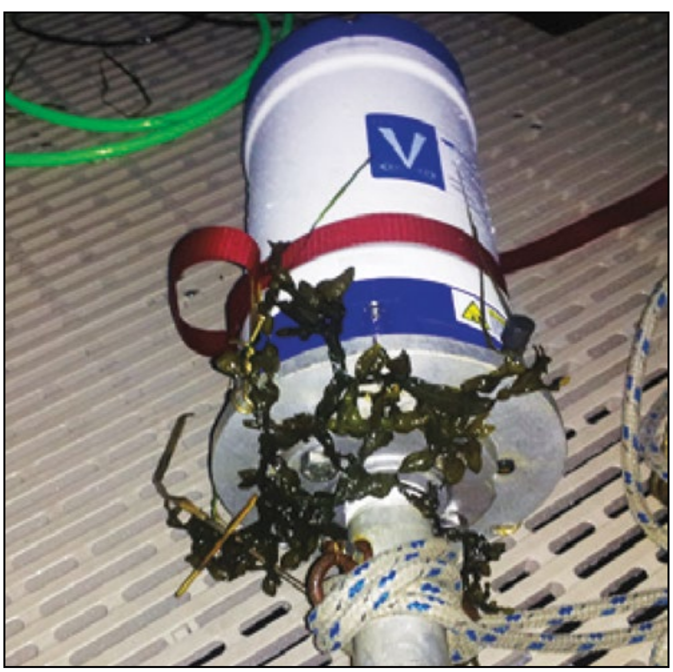
Proceedings of the 2nd Marine Energy Technology Symposium held in Seattle, Washington during April 2014

OVERVIEW

In recent years, the goal of converting kinetic energy within tidal currents to electrical energy for public use has motivated significant marine engineering effort. A challenging problem is to create devices that not only survive but work efficiently in very dynamic environments—across a wide range of energy, space, and time scales. Knowing the ambient conditions in which these devices operate is key to their successful use. To this end, Acoustic Doppler Current Profilers (ADCPs) have been deployed in several stages of these programs to support design and use of renewable energy turbines: from baseline and impact studies to monitoring incident flow fields and confirming turbine efficiency.

THE SOLUTION

A recent study by researchers at University of New Hampshire (UNH addressed questions about ADCP measurements at small space and time scales relevant to the efficient operation of turbine blades. Among their results are data views presented here that demonstrate reliable Sentinel V ADCP profiles in a strong tidal stream.



Images of the site can be seen at:
www.youtube.com/watch?v=tSsjX0Xs0Zw

Products:
Sentinel V Acoustic Doppler Current Profiler (ADCP)

Application:
Renewable Energy

Project:
Spatio-Temporal Resolution of Different Flow Measurement Techniques for Marine Renewal Energy Applications

Client:
Center for Ocean Renewable Energy (CORE) University of New Hampshire, Durham, NH

Data Collection Date:
2012

Location:
UNH-CORE Tidal Energy Test Site in Great Bay Estuary, NH at General Sullivan Bridge

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At the UNH Tidal Energy Test Site, the researchers deployed concurrently a Sentinel V20 along with a device designed specifically for measuring small space and time scales, an ADV (Acoustic Doppler Velocimeter). In the field experiment, inflow upstream of an intermediate-scale turbine was measured from a floating platform. The test site has water depths of nominally 10 m and tidal currents up to 2.6 m/s (5 kn). The ADV was mounted at 1.45 m depth and pinged 100 times over 3 seconds. The Sentinel V ADCP was configured to have 10 cm bins and pinged twice per second.

RESULTS

Positive results in strong flow conditions were confirmed by two intercomparisons of the Sentinel V data: independent sensor (ADV) and theoretical model. Sentinel V data used for intercomparison with the ADV came from the ADCP's 7th bin. The researchers selected a 42-minute period when the current during this particular tidal cycle was near maximum and approximately constant. Considering statistics for this selected period, the researchers confirmed that the Sentinel V measured the same mean velocity as the ADV. Moreover, they found good agreement between the Sentinel V's averaged profile and a theoretical velocity profile for open channel flow over rough surfaces (Figure 1).

Comparing statistics for velocity fluctuations, the researchers observed a sizable difference between the instruments, which is due to the operating principles of each instrument.

HIGHLIGHTS:

- Researchers at University of New Hampshire (UNJ) addressed questions about ADCP measurements at small space and time scales relevant to the efficient operation of turbine blades

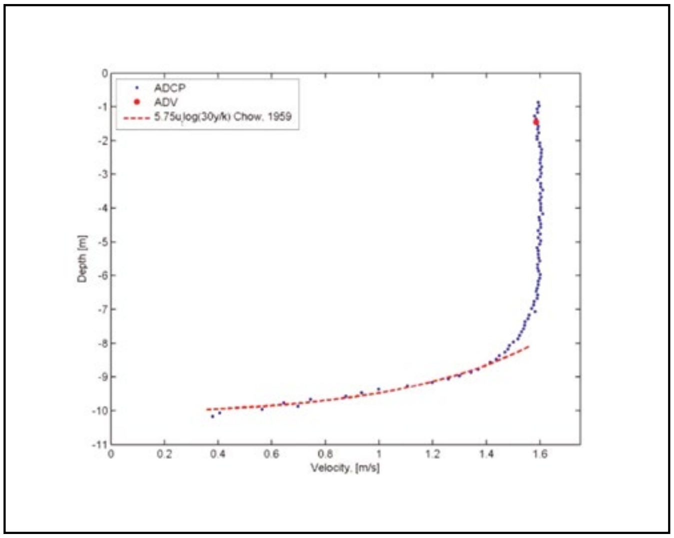


Figure 1

Sentinel V ADCP's Mean Velocity Profile compared with ADV (red dot) and Logarithmic profile for open channel flow (red dashed).

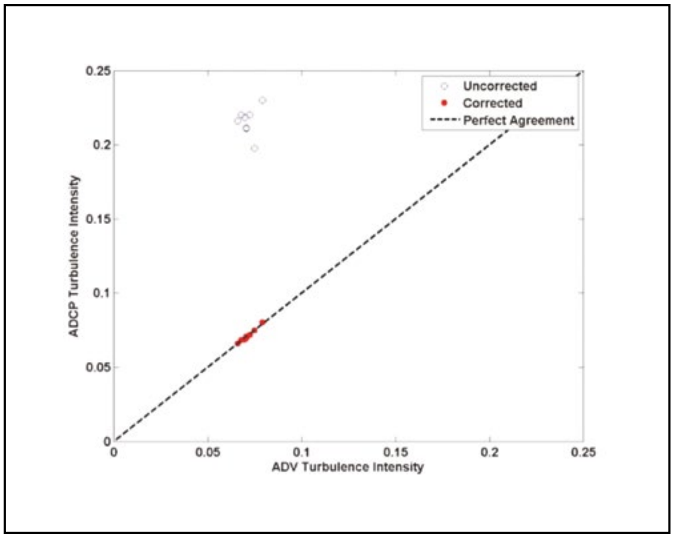
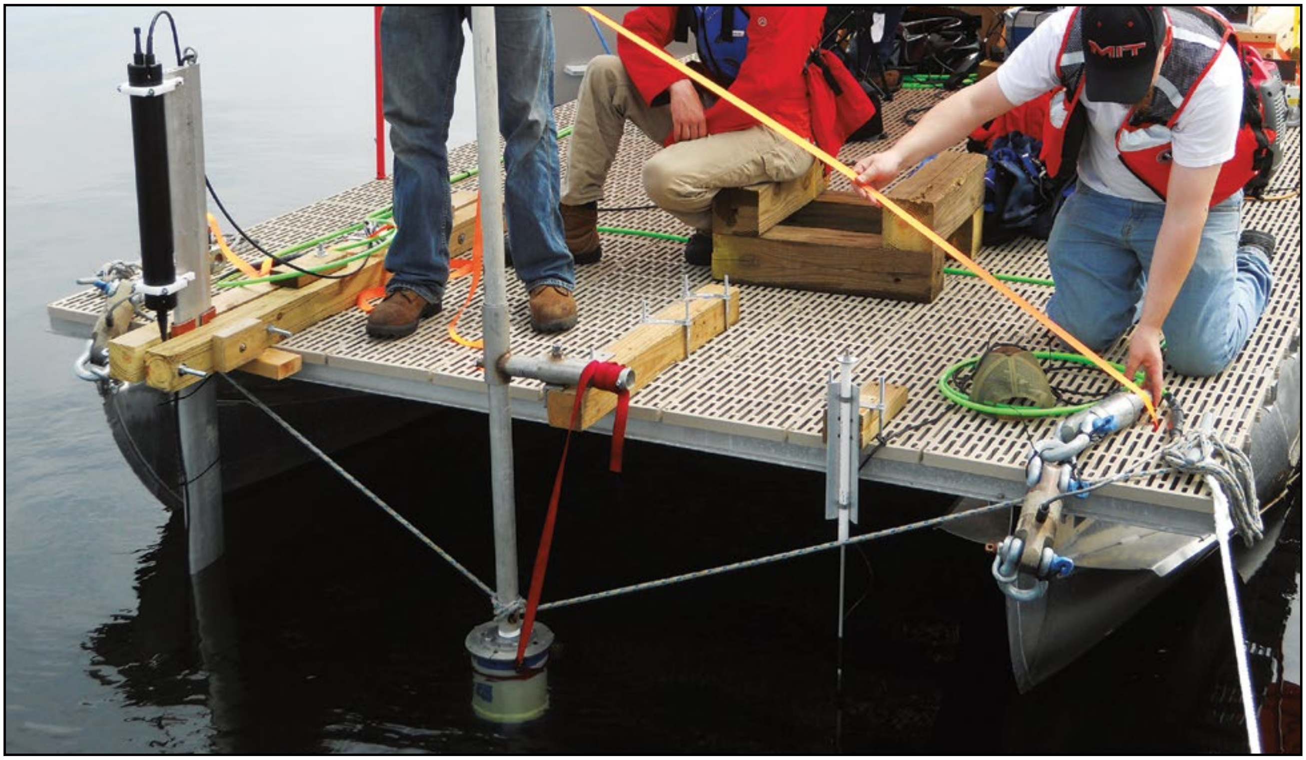


Figure 2

Intercomparision of Measured Velocity Variance (Turbulence Intensity): Sentinel V ADCP and ADV. Circles ("uncorrected") represent recorded ADCP variance (due to setup + water motions) whereas red dots ("corrected") are ADCP estimates of variance due to water motions only.



This difference is not unexpected and has been reported and explained previously. Whereas the velocity variability recorded by the ADV is solely due to water motions, the higher value reported by the ADCP is due to two sources:

1. “natural” velocity variance caused by turbulent eddies in the water (reported by the ADV).
2. “impressed” velocity variance stemming from the ADCP’s setup: acoustic signal and profile. In fact, this second contribution is an output parameter, titled “standard deviation” of the ADCP Plan program.

For each 5-minute segment in their time series, the researchers then combined statistics for each instrument to remove empirically the contribution of (2) in the ADCP data. The comparison between the ADV variance and the “natural” variance observed by the Sentinel V shows impressive agreement (Figure 2).

Paul Devine of TRDI observed that the ADV data set provided a field confirmation of (2) for the Sentinel V ADCP. The turbulent intensities reported for the 42-minute time series were 19.5% and 7.2% for the ADCP and ADV respectively. These percentages are computed relative to the mean flow speed, which is about 1.6 m/s. After the r.m.s. difference is computed, the variance contribution due to (2) is seen to be 18.1%. This result equates to an r.m.s. value of 29 cm/s that matches well with the standard deviation of 27.4 cm/s output by the Sentinel V’s Planning program.

HIGHLIGHTS:

- Researchers deployed concurrently a Sentinel V20 along with a device designed specifically for measuring small space and time scales, an ADV (Acoustic Doppler Velocimeter)

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SUMMARY

In summary, field data collected by researchers at the University of New Hampshire demonstrate the Sentinel V ADCP's performance in demanding conditions by comparison with an independent current sensor and a theoretical model. A bonus from this work was confirmation in a high-current regime of predictions by the Sentinel V planning model regarding velocity noise due to profile configuration.

HIGHLIGHTS:

- Comparing statistics for velocity fluctuations, the researchers observed a sizable difference between the instruments, which is due to the operating principles of each instrument

REFERENCE:

Lyon V; Wosnik M (2014) *Spatio-temporal resolution of different flow measurement techniques for marine renewable energy applications.* Proceedings of the 2nd Marine Energy Technology Symposium, METS2014, April 15-18, 2014, Seattle, WA

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www.teledynemarine.com/rdi

14020 Stowe Drive, Poway, CA 92064 USA
Tel. +1-858-842-2600 • Email: rdisales@teledyne.com

Les Nertieres 5 Avenue Hector Pintus 06610 La Gaude France
Tel. +33-49-211-0930 • Email: rdie@teledyne.com