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GNSS Differential or RTK:

How Relative Errors Can Make a **BIG** Difference

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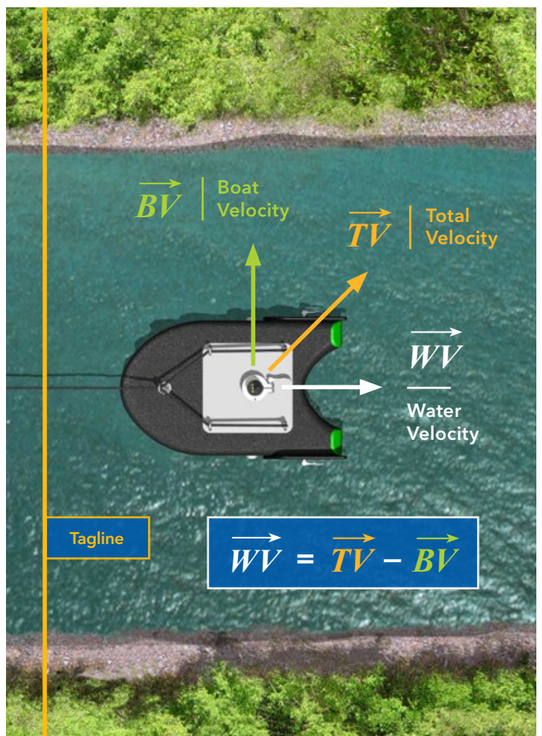
Acoustic Doppler Current Profilers (ADCPs) equipped with bottom tracking have been used for discharge measurements from a moving boat for decades. Water speed and direction are calculated by subtracting the **boat motion** from the total measured **boat velocity**.

Accounting for boat motion is essential for water velocity measurements from a moving boat. **Bottom track** measures the speed of the boat relative to the bottom of the channel and is a great tool to account for this; however, it does not work at every site.

Fortunately, there is another option: **Global Navigation Satellite Systems (GNSS)**, a general term for any satellite constellation that provides position, navigation, and time. In the US, this is the **Global Positioning System (GPS)**. In this article, we'll refer to the generic term, GNSS.

The challenges below are limitations of bottom track and will likely require using a GNSS alternative:

- **Profiling Range** – Each ADCP has physical limits to the maximum depth at which it can velocity profile and bottom track. This is based on the acoustic frequency and environmental conditions.
- **Boat Navigation** – Erratic boat course and speed can impact bottom track performance and thus the boat velocity vectors.
- **Moving Bed** – Significant amounts of sediment migrating downstream along the riverbed will result in calculated discharge that is lower than actual discharge. This happens because bottom track will calculate boat speed relative to the moving bed instead of the actual riverbed.



Water velocity calculated from a moving Acoustic Doppler Current Profiler (ADCP)

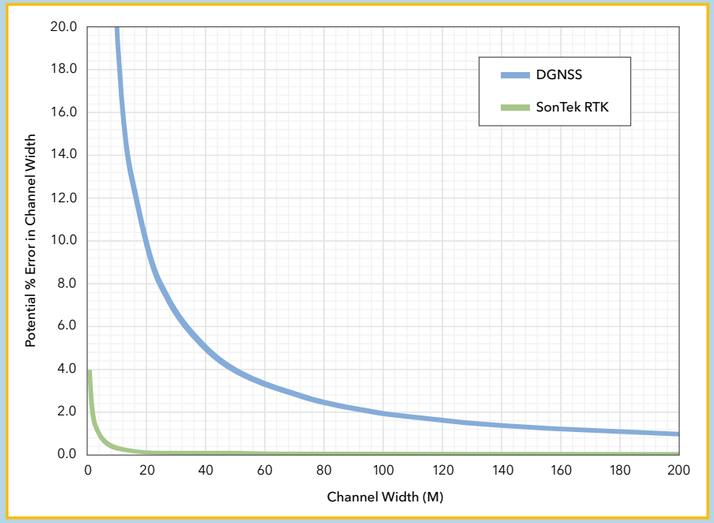
You Have Options:

When using a GNSS track, the software computes boat velocity from GNSS data. The ADCP measures the total sum vector of water velocity and boat velocity.

The software then subtracts the GNSS-based boat velocity from the total sum vector to resolve the water velocity. Both RiverSurveyor Live and RSQ software programs enable either bottom track or GNSS track reference to be chosen.

If a GNSS receiver was used and connected to the software during data collection, you can easily toggle between references in post-processing.

If you plan to collect GNSS data, there are two correction types to choose from: **Differential (DGNSS)** or **Real-time Kinematic (RTK)**. SonTek offers both solutions for our M9 and RS5 ADCPs.



Relative error of different GNSS solutions, calculated with the assumption of ideal GNSS performance, using the horizontal accuracies noted previously.

A Tale of Two Systems

Differential Global Navigation Satellite System (DGNSS)

A **DGNSS** will consist of a single receiver, which will be connected to the ADCP on the boat. DGNSS utilizes Space Based Augmentation System (SBAS) correction signals to correct its own real-time position signals. SBAS is derived from geostationary satellites, which can broadcast positional errors in the current area based on a network of base stations on the ground.

There are free and paid SBAS services around the world, but not everywhere. Therefore, in some regions SBAS corrections are not available. Typical horizontal positioning accuracy for a DGNSS solution is about 1 m (3 ft).

Real-Time Kinematic (RTK) System

An **RTK** system consists of a rover and base station; the rover will be deployed with the ADCP on its boat, while the base station will remain stationary onshore and is typically mounted on a tripod. The base station will continuously send correction information to the rover.

Since the rover and base station are relatively close in position, the SonTek RTK system can gain precise measurements of the rover and thus ADCP position. This allows for position accuracy down to 2 cm (0.8 in).

Which Option is Best?

The answer is dependent on the site characteristics, geographical location, and accuracy requirements. The main limitations with DGNSS are regional availability and channel width. If SBAS corrections for DGNSS are available, channel width and accuracy requirements should be considered first.

A basic calculation of the relative error is illustrated in the **graph above**. Using this, a channel width of just 20 m (65 ft) will carry an error of up to 10% when referencing a differential solution, compared to a 0.2% error with the SonTek RTK solution. This relative error becomes critically important in narrow streams.

The DGNSS solution will impart larger errors due to the meter-scale accuracy; therefore, RTK is the best solution when channel widths are 30 m (98 ft) or less. When the channel width is 100 m (328 ft) or more, the relative error of the two GNSS options approach similar values.

Some regions have better SBAS coverage than others, so it's important to know if your measurement site will have this correction type available. SBAS coverage maps can be easily found on GNSS manufacturers' websites. If there's limited to no SBAS coverage, the SonTek RTK will be the best GNSS option.

The final consideration is reporting requirements. If your work requires accurate georeferenced data, RTK is the best solution.

Regardless of which option you choose, it's important to review your data thoroughly and make sure that the selected track reference, along with other system configuration settings, are appropriate for your site and data quality needs. For additional guidance, contact us at SonTek@Xylem.com!