Autonomous Discharge Measurement utilising Uncrewed Surface Vehicles: Surfbee ADCP Mode Explained

Application Note

Author: Justin Stockley
Surface Water Business Development Manager
Xylem Analytics Asia-Pacific

The ADCP moving boat method has become the primary way to measure discharge accurately in open channels such as rivers, streams, and irrigation canals. The technique requires moving the ADCP across the channel (single transect), typically for a total of four transects.

A variety of techniques are employed to achieve this including manned boats, tethered boats (from bridges, fixed cableways, or temporary bank-operated cableways) and remote-controlled boats. (***Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat***, USGS Techniques and Methods 3-A22, Version 2.0, December 2013).

During an ADCP measurement, several key criteria need to be met when traversing the ADCP across the river which will influence what technique is best suited for the channel to be measured. ***The importance of how the ADCP is moved across the channel cannot be understated in reference to producing consistent and accurate discharge measurements***.

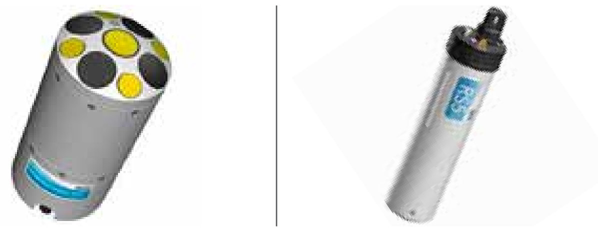
- A good rule of thumb is for the average boat speed during each transect to be approximately equal to or less than the average water speed. Another very important consideration is smooth boat operation (gradual accelerations and decelerations, maintaining a uniform speed, if possible, and slow turns) (USGS, 2013).

- When using a tethered boat, the boat speed should be fast enough to keep the boat moving consistently rather than having the wind or waves move the boat back and forth. Rapid course changes should be avoided; the key element in boat operation during the measurement is to do everything slowly and smoothly (USGS, 2013).

Surfbee Flow Finder

Surfbee Flow Seeker

[Xylem Uncrewed Surface Vehicles Brochure]



[SonTek M9 and RS5 - ADCP Payload Options for USV]

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- In addition to boat speed and consistent course and heading, the start and end edges (where practical) should be in the same location across the required four or more transects. This ensures edge distance measurements are applicable across the entire measurement which facilitates better comparative analysis between transects.

Uncrewed, remote-controlled boats allow the deployment of ADCPs where deployment with a manned boat or tethered boat may not be feasible or ideal (USGS 2013). They provide operators with a key advantage in being able to select the best possible transect to undertake the discharge measurement as they are not a fixed installation and typically are less affected by site access issues.

"With the advent of advanced Uncrewed Surface Vehicles (USV), the challenges in the field of addressing these criteria consistently and reliably are being solved which in turn enables operators to focus more on the data being collected in real-time rather than constantly monitoring ADCP progress across the channel".

This paper looks at the Surfbee ADCP mode, an embedded custom application on the Android OS powered handheld controller. The USV application was designed specifically with making consistent and good quality discharge measurements using ADCPs by addressing the key criteria listed above. Most importantly, by automating the movement of the vessel, human errors in boat control are reduced and the operator is able to focus more on the data being collected.

General USV Advantages	
Safety	No personnel on the water, handling of rope systems
Infrastructure Costs	Avoid installation and maintaining expensive cableway systems
Flexible Site Selection	Ability to measure at the optimal location and easily change transect locations if measurement issues are found
Surfbee ADCP Mode USV Additional Advantages	
Consistency	Consistent edges, boat speed and heading using left and right bank way points and autonomous boat course function
Operator Stress Reduction	Automation of heading and speed and transect completion reduces the stress and fatigue related to completing transects
Enhanced Control	Ability to set boat transect speed on the controller
Improved Discharge Measurement Quality	Ability to focus more on data being collected in real-time to take remedial actions, if necessary, while at site

Table 1: Uncrewed Surface Vehicle Key Advantages Combined with Surfbee ADCP Mode

Surfbee ADCP Mode can be summarised as a semi-autonomous workflow for both moving boat and Stationary discharge measurements. Key steps which can cause operator error and fatigue (such as continuously manually controlling the boat across a channel repeatedly and maintaining stationary edges) are automated, whilst control remains with the operator in ensuring sufficient edge velocity data is collected. A detailed look at the workflow is described for both the moving boat and Stationary measurement methods.

1. Vessel moving to left bank waypoint (end edge) autonomously.
2. Hands free vessel movement across transects once edge waypoints are set.
3. Operator can focus on data collection.

Figure 1: Surfbee Flow Seeker Conducting Discharge Measurement using ADCP Mode

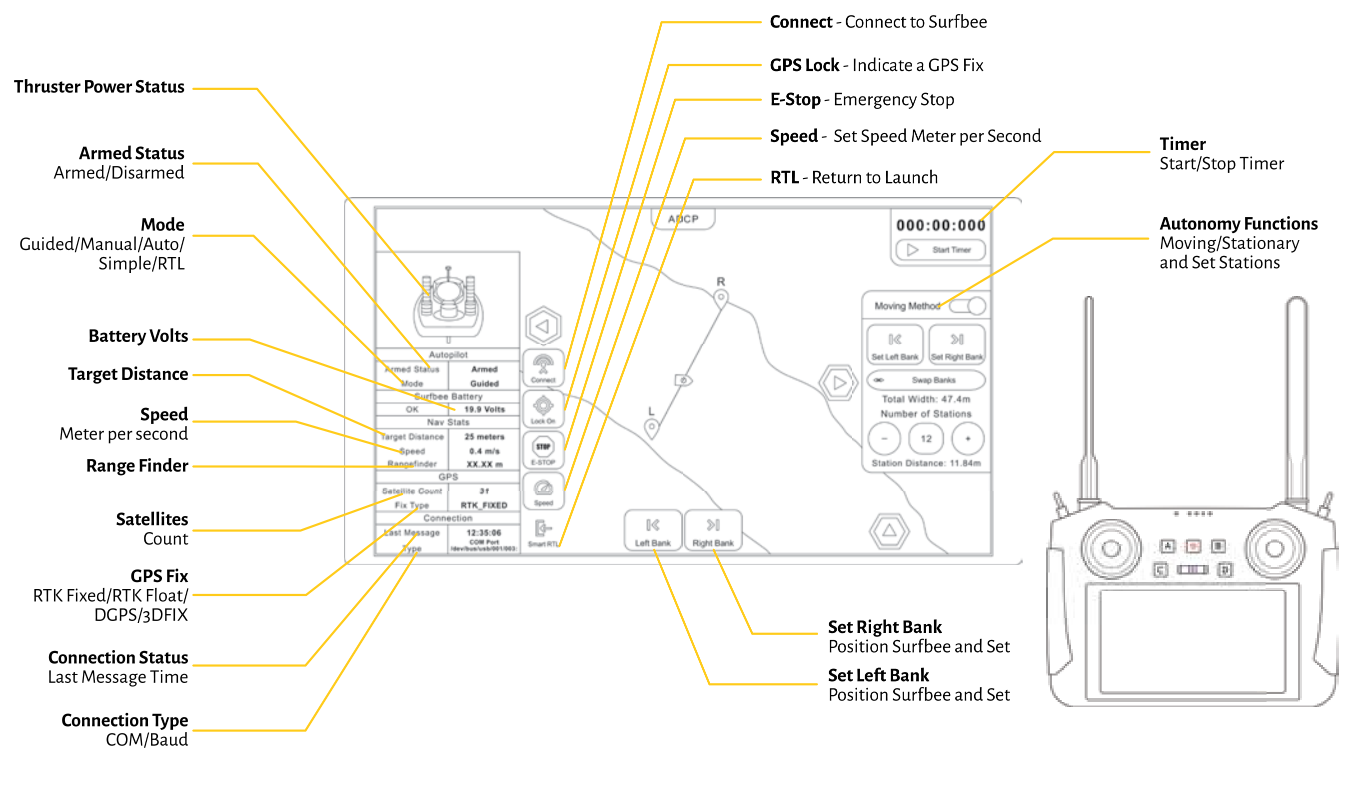


Figure 2: Overview of Surfbee Handheld Controller Touchscreen

Surfbee ADCP Mode: Moving Boat Method Workflow

Whilst the depth of functions available to the user on the Surfbee controller can be overwhelming, the process to undertake a discharge measurement is intuitive and straightforward. Typically, after launching the USV into the water, users will undertake boat operational checks as well as initial ADCP site specific data review. Moving bed tests can be completed easily with the boat whether it is Stationary Moving Bed Assessment (SMBA) using the virtual anchor function or loop test by manually driving across the channel. Once satisfied the site is suitable and the instrument and boat are working correctly, then the user can commence the measurement process.

Step 1: Setting Left and Right Bank Edges

Whether conducting a moving boat or stationary discharge measurement, the first step in the process is to set waypoints of the last point where velocity can be profiled close to the waters edge on either side of the river. ***These are the Left and Right Bank waypoints***. The operator moves the boat to the far edge and puts the USV into station hold (virtual anchor). Whilst the boat is holding position, it is important to ensure that the ADCP is profiling with sufficient velocity cells (minimum 2) for the edge measurement at that location. Once satisfied, operator selects "Set Right Bank". The same process is repeated for the Left Bank.

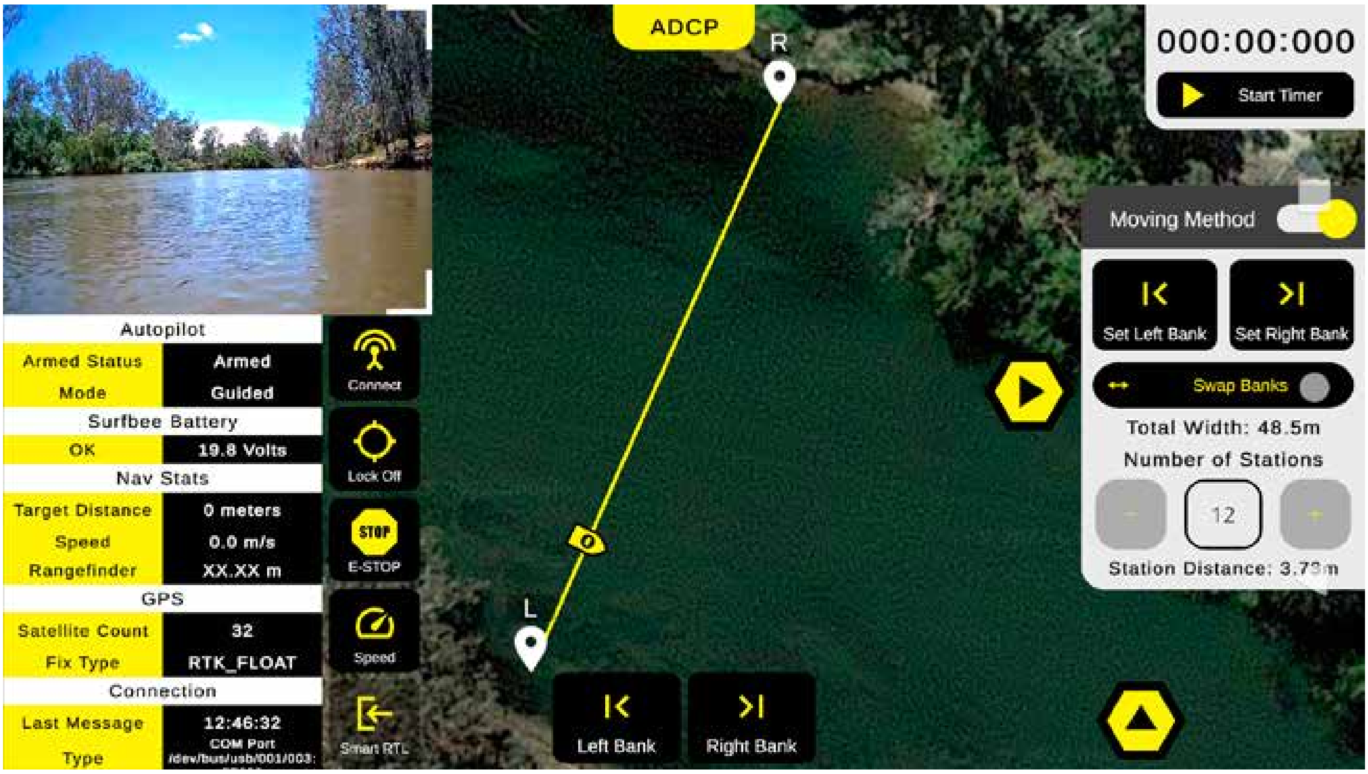
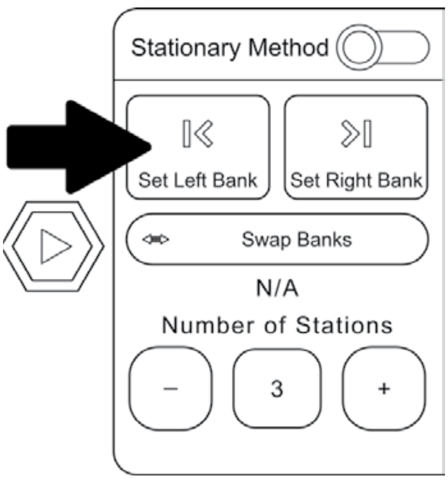
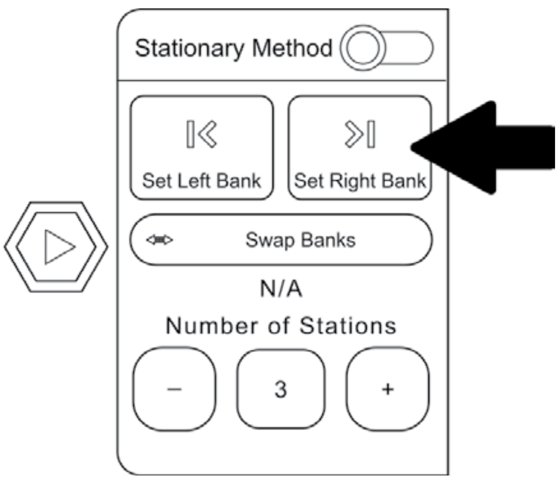


Figure 3: Surfbee App Controller View – Left bank and Right Bank Waypoints Setup



Set Left Bank Waypoint



Set Right Bank Waypoint

Step 2: Moving Boat Measurement Transects

Once the waypoints are completed, the measurement process becomes straight forward. Select on the controller which bank the measurement is to start at. In the example below, the right bank is selected, and the boat will move to the right bank way point after confirming the selection.

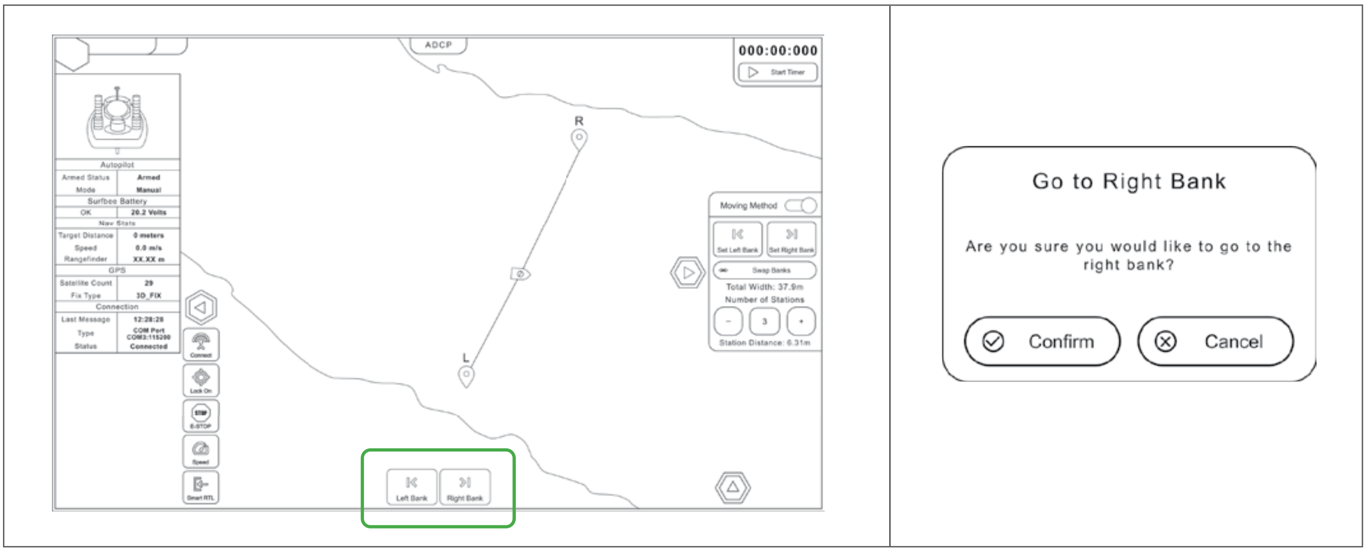


Table 2: Surfbee App Controller View – Moving the USV between Right and Left Banks

As the USV is holding position, the ADCP measurement is commenced with edge velocity data collection. Once sufficient samples have been recorded, then the operator simply selects (Left Bank) on the bottom of the handheld screen, confirms the selection, and the boat will then automatically move to the Left Bank waypoint with a consistent speed and heading.
At any time during a measurement, the user can adjust the vessel speed using the handheld controller shown below.

Figure 4: Surfbee App Controller View – Changing Vessel Speed for Autonomous Transect

The key advantages of this process as compared to conventional methods are:

1. The operator remains in control of the key aspects of ADCP measurement. Namely, edge velocity data collection and setting vessel speed for each transect.
2. The movement of the boat and holding position at edges is removed from the operator and automated using the USV navigation and positioning system. The result is vessel tracks that are extremely consistent even across wide rivers which produces more reliable ADCP measurements.

Figure 5: Straight line ADCP Tracks Over 115m Wide River

Surfbee ADCP Mode: Stationary Method Workflow

The stationary method of measurement is also catered for in the Surfbee USV Handheld and makes for a powerful solution when combined with the SonTek M9 and RS5 integrated tagline free stationary measurement solution (***Technical Paper: Gps Positioning For Riversurveyor Live Measurements***, Daniel Wagenaar, Xue Fan, 2017).

The workflow is similar to the moving boat method in that left and right bank waypoints are set (Step 1 Moving Boat Work Flow). Once the two waypoints are set, the operator can then select the number of stations required on the handheld and the application will auto matically fill equally spaced stations across the section. In the example below, the number of stations added was 4 between the two left and right bank stations.

Figure 6: Setting the Number of Stations for a Stationary Measurement

Once the number of stations is set, the measurement can commence, with the operator only having to direct the boat to which station to go to and hold position. The boat will remain at that position until the measurement is completed and the operator directs it to move to the next station.

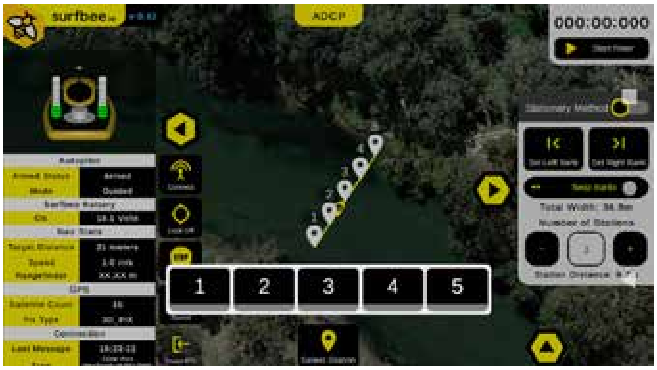


Figure 7: Directing Boat to a Station to Hold Position

Uncrewed Surface Vehicles offer a wide range of advantages for operators to conduct hydrometric operations efficiently and safely. ***With advances in navigation systems and custom operational abilities, the next generation of USV are implementing advanced functionality that is enhancing the ADCP data collection process.***

References

Technical Paper: Gps Positioning For RiverSurveyor Live Measurements, Daniel Wagenaar, Xue Fan, 2017

Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat, USGS Techniques and Methods 3-A22, Version 2.0, USGS, December 2013.

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