TheDuck™ USV

User Manual

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Revision History

Version	Revision Date	Change Summary
1.0	20230927	Initial release
2.0	20251201	Add the obstacle avoidance function, update the device in the package, update the software introduction.

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Safety Information

Make sure that you have read and understood all safety requirements before

you start using Tersus product.

Conventions

The following conventions are used in this manual:

!	Information that supplements or clarifies text.

⚠	A caution that actions, operation or configuration may lead to incorrect or improper use of the hardware.

⚠	A warning that actions, operation or configuration may result in regulatory noncompliance, safety issues or equipment damage.

Scope of application

This manual is intended for technicians in the field of high-precision navigation and positioning timing and other related fields.

Manual Use

This manual has a modular structure so that the user can select the designated chapters to read as needed.

Support

If there is any problem and the information needed cannot be found in the product documentation, log a technical support ticket in our tracking system https://tersus.supportsystem.com/ , or mail to support@tersus-gnss.com.

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1. Introduction

This manual provides the product description of the Tersus TheDuck™ USV, introducing product overview, usage scenarios, features and instructions for use.

1.1 Overview

TheDuck™ represents a smart, efficient, and productive unmanned surface vessel equipped with a single-beam echo sounder. It provides a fast, dependable, and portable solution to perform bathymetric surveys in various environments, such as rivers, lakes, reservoirs, and coastal areas. With its advanced capabilities and user-friendly design, TheDuck™ is a powerful tool for professionals in bathymetry, offering unparalleled accuracy and precision in the collection of positioning and depth data. TheDuck™ is sure to meet your needs and exceed your expectations.

1.2 Features

The TheDuck™ has following features:

- **Compact Survey USV**: Designed for bathymetric surveys in lakes, rivers, and coastal areas — efficient and easy to deploy.
- **Durable M-Shaped Hull**: Lightweight PP alloy structure ensures strength, speed, and excellent stability.
- **Anti-Entanglement Propulsion**: Twin ducted propellers reduce risks from fishing nets, weeds, and surface debris.
- **Reliable Long-Range Control:** Dual 2.4 GHz antennas enable up to 2 km transmission`1 with stable signal and auto-return safety.
- **Effortless Operation**: Portable and easy to handle — from transport to setup and full mission execution.
- **Expandable GNSS Capability:** Supports Oscar/LUKA GNSS receivers and PPP function for precise positioning even in weak network areas.
- **Optional high-Performance Echo Sounder**: Available in 100 m/455 kHz or 300 m/200 kHz models to suit different survey depths.

1.3 Device in the package

The devices in the package may vary according to the customer requirement. Here describes the major parts in the package.

1.3.1 TheDuck™ USV

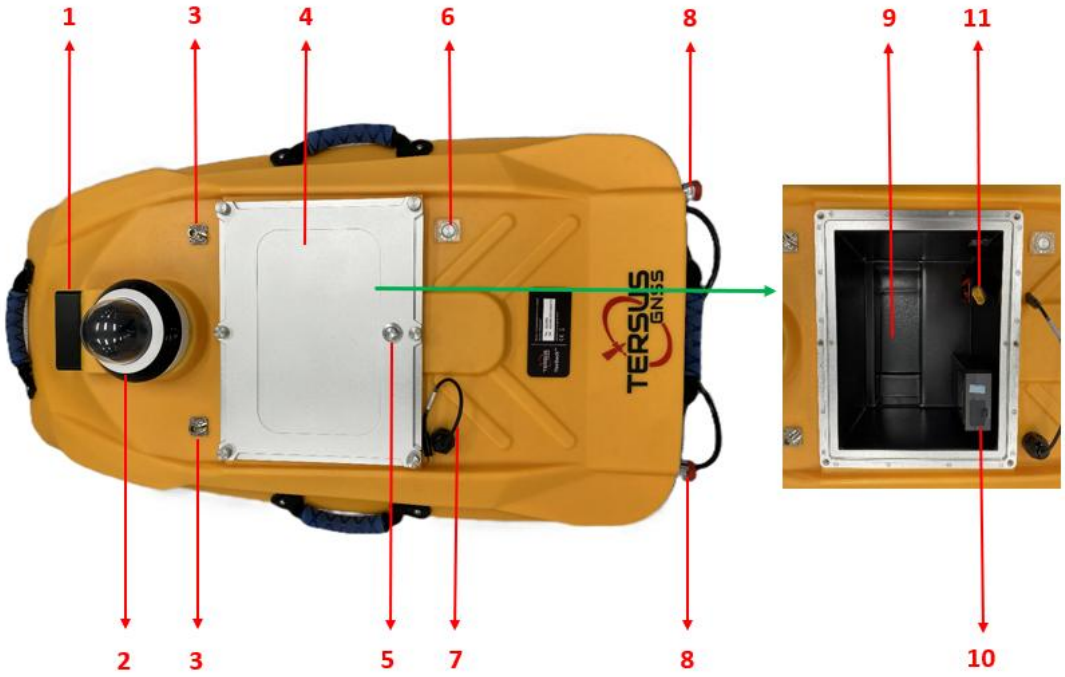


Figure 1.1 TheDuck™

Table 1.1 TheDuck™ Components

No.	Cpmponent	Description
1	Mllimeter Wave Obstacle Avoidance Radar	Range 0.2-40m, 77GHz, Pitch * Azimuth: 15.6 ° * 112 °
2	HD Camera	White light night vision 30m, FOV120°, Resolution 1080P
3	2.4GHz RF Antenna Connector	
4	Battery Compartment Cover	
5	GNSS Receiver Mount	
6	Power Button	
7	Serial Cable	For Oscar/LUKA
8	Propeller Plug	Plug in when working and pull out when transporting
9	Battery Compartment	

10	ES200 Single Beam Echo Sounder (SBES)	Default 0.15m to 100m, 455KHz; Optional 0.15m to 300m, 200KHz; With a 16GB SD Card Inside
11	Battery Connector	Type: XT90S Male

1.3.2 H20 Remote Control

The H20 remote controller provides manual navigation, operational control, and mode management for the USV.

Figure 1.2 H20 Remote Control Multi-view

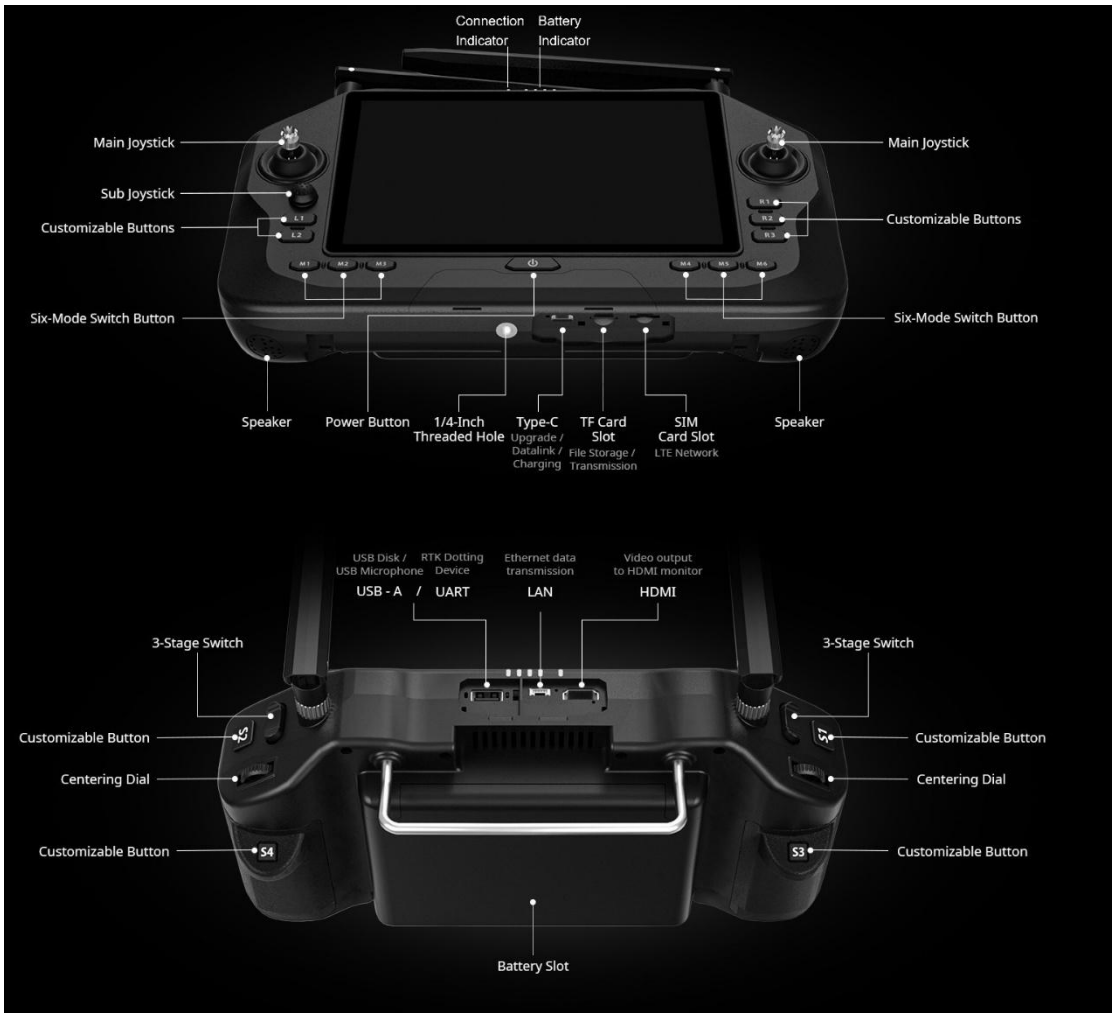


Figure 1.3 H20 Remote Control Interfaces

Table 1.2 Main button/indicator functions

No.	Button	Control/Function	Description
1	**Main Joystick (Left / Right)**	• Left joystick – Forward / backward • Right joystick – Left / right steering • Joystick deflection controls USV speed	Controls propulsion and steering
2	**3-Stage Switch(Left)**	Arm / Disarm Button • Default: Disarm (propellers disabled) • Press once to Arm (propellers active)	Enables or disables the propellers
3	**3-Stage Switch(right)**	Working mode switch • Up – **Fast Return** mode (USV returns to launch point directly) • Middle – **Hold** mode • Down – **Remote** (Manual) mode	Selects the USV operation mode

4	**Power Button**	• **Power on**: First, press the power button for about 1 second until the indicator light turns on. Next, press and hold the button for approximately 2 seconds until the screen lights up to complete the power-on process. • **Power off**: Press and hold the power button for about 2 seconds. A pop-up window will appear on the system interface. Then, simply touch the "Power Off" icon to shut down the device. • **Force Shutdown:** Press and hold the power button for approximately 8 seconds. The device will force shut down.	Controls power and display functions
5	**Connection Indicator**	• On – Remote Control connected to the USV • Off – Not connected	Indicates connection status between the remote control and USV
6	**Battery Indicator**	Displays remaining battery level	

1.3.3 USV Battery

The are two rechargeable lithium batteries in the package. The USV requires only one battery to operate; the other is provided as a backup. The lithium battery features two ports: the MR60-3P is dedicated to charging, and the XT90S is for connection to the USV.

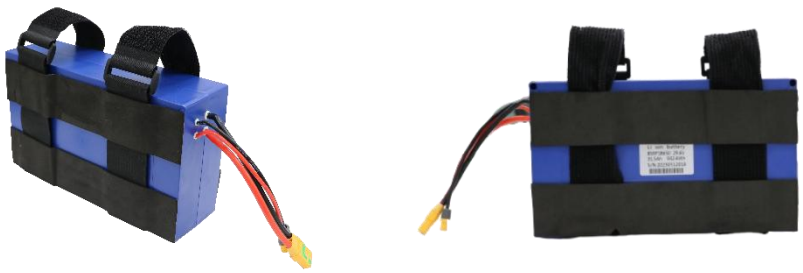


Figure 1.4 USV Battery

1.3.4 2.4G Omnidirectional RF Antenna

The two omnidirectional 2.4 GHz RF antennas must be installed on the USV to facilitate real-time peer-to-peer data transmission between the USV and the remote control.

Figure 1.5 2.4G Omnidirectional RF Antenna

1.3.5 LUKA-TAP GNSS Receiver

The LUKA-TAP GNSS Receiver is a new generation GNSS RTK system, which is small, light, and easy to carry and operate. The LUKA-TAP GNSS Receiver adopts TAP, the satellite-based precise point positioning service developed by Tersus GNSS, which allows users to achieve centimeter-level high-precision positioning worldwide. With TAP, the GNSS rover receiver will not need to work with the local RTK base station or CORS, but directly receives corrections broadcast by the satellites, such as ephemeris error, satellite clock error, etc.

The LUKA-TAP meets the demand of centimeter-level high-precision positioning in areas without or with poor network coverage, such as oceans, deserts, mountains, high altitudes, etc. It can be widely used in autonomous driving precision agriculture, and disaster monitoring and so on.

Figure 1.6 LUKA-TAP GNSS Receiver

1.3.6 TC80 Controller

The TC80 controller is specifically designed for configuring LUKA-TAP GNSS receivers. TC80 is a rugged multi-functional data controller with design of 5.5 inch sunlight readable HD touch screen and an alphanumerical keypad. Equipped with powerful processor and android operating system, it is perfect to adapt with Tersus software. With professional IP68 rating, it is robust and reliable for harsh operating conditions. The large capacity lithium battery guarantees more than 10 hours of field working for a whole day of multiple surveying tasks.

Figure 1.7 TC80 Controller

1.3.7 Quick Release Adapter

The Quick Release Adapter can quickly fix the GNSS receiver on TheDuck™ USV.

Figure 1.8 Quick Release Adapter

2. Technical Specifications

This chapter mainly introduces the technical specifications of TheDuck™ USV, H20 Remote Control, USV Battery, LUKA-TAP GNSS Receiver and TC80

Controller.

2.1 TheDuck™ USV

Table 2.1 TheDuck™ USV Specifitions

Physical	
Hull Dimension:	1000*530*340mm
Weight:	7KG (w/o instrument and battery) 18KG (Maximum Load) 22KG (Normal Weight)
Material:	High Strength PP Alloy
Hull Design:	M-Shaped
Anti-Wave & Wind:	3rd Wind Level and 2nd Wave Level
Water Proof:	IP67
Power	
Rechargeable Lithium Battery:	8S 29.6V 31.5Ah x2
Battery Weight:	4.5kg X2
Battery Endurance:	6 Hours x2（run at 2m/s）
Maximum Speed:	6m/s
Propeller type:	2 x plug-in mental ducted propeller
Type:	Electric
Direction Control:	Differential veering and reverse without steering engine
Positioning (LUKA-TAP GNSS Receiver)	
Satellite System:	GPS, BDS, GLONASS, GALILEO, QZSS
RTK Positioning Accuracy (RMS)	
- Horizontal & Vertical:	±(8mm+1ppm) & ±(15mm+1ppm)
PPP Positioning Accuracy (RMS)	

- Horizontal & Vertical:	±15mm & ±30mm
PPP Convergence Time & Coverage:	3 minutes & Global
PPP Signal Stability:	99.99%
ES200 Single Beam Echo Sounder	
Physical	
Dimension:	155*88*34mm
Display	LCD Screen, Resolution128*64
Weight	480g
Connector	LEMO 0B&1B
Environmental	
Operating temperature	-5°C to +50°C
Relative humidity	95% not condensed
Water & dust proof	IP67
Electrical	
Power consumption	0.85 W
Voltage	12.6V
Internal Battery (Optional)	Standby 10 hours, 4.2 VDC / 0.2A
Sounding Performance	
Working Mode	Auto & Manual
Sounding Range:	0.15m to 100m, 0.15m to 300m (Optional)
TVG:((Time Varied Gain) Mode：	Auto
Beam Angle：	5°(455KHz/200KHz)
Sound velocity Setting:	Automatic & Manual 1350 – 1750m/s
Draft:	0~10m
Sounding Accuracy:	1cm±0.1%*D (D is the depth of water)
Resolution:	1cm
Transducer Frequency	

Standard	455 KHz
Optional	200 KHz
Data Storage	
Internal Storage:	Micor SD Card, 16 GB
Data Format:	*.tsl3, *.csv, *.txt
Data I/O	
GNSS Input	NMEA 0183
Data Output	NMEA0183, ODOM, DESO, etc.
Camera	
Dimensions	Φ130.7×101.7mm
Resolution:	4MP (2560×1440)
Field of View	Horizontal 96.7°–31.6°
IR Distance	Up to 20 meters
Pan/Tilt Range	Pan: 355°; Tilt: 0° - 90°
Video Compression:	H.265+/H.265/H.264+/H.264
Weather Resistance	IP66
Operating Conditions	-20 °C - 60 °C; Humidity less than 90%
Smart Functions:	Area Intrusion Detection, Line Crossing Detection, Moving Detection; Face Detection
Millimeter Wave Obstacle Avoidance Radar	
Modulation:	FMCW
Distance measurement range:	0.20-40m
Distance measurement accuracy:	±0.10m
Angle measurement range:	±56°@6dB
Angle measurement accuracy:	±2°
Speed resolution:	2.06km/h

Speed accuracy:	1.03km/h
Radar transmission frequency:	77GHz
Transmit Power (EIRP):	29.8 dBm (average/peak)
Power consumption:	2.5W
Operating Temperature:	-40℃ ~ +85℃
Storage Temperature:	-55℃ ~ +95℃
Protection level:	IP66

2.2 H20 Remote Control

Table 2.2 H20 Remote Control Specifications

Item	Specification
Operating System	Android 13
Android Hardware	4GB RAM+ 64GB ROM
Screen	7-inch 1080p 1600-nit High Definition and High Brightness LCD Touchscreen
Wi-Fi	Wi-Fi 5
Bluetooth	BT 5.0
GNSS	GPS/GLONASS/BeiDou/Galileo/QZSS
Battery Life	Approx11 hours
Battery Capacity	13400mAh
Charging Protocol	PD 30W
Charging Time	Approx 4.5 hours
Datalink/SDK Port	UART/UDP, Bluetooth, Type-C
Interfaces	Serial Port (for RTK Dotting Module): USB-A Charging: Type-C Firmware Upgrade: Type-C File Transfer: Type-C

	Mobile Network: SIM Card Slot External Storage: TF Card Slot / USB-A Tripod Mount: 1/4-inch Standard Screw Hole
Physical Channels	10 x Custom Buttons 6 x Flight Mode Buttons 2 x Main Joysticks 1 x Sub Joystick 2 x Dials 2 x 3-Stage Switches
Working Frequency	2.400 GHz - 2.476 GHz
Antennas	2 x External (2.4 GHz)
Protection Class	IP54
Dimensions	L274 * W190 * H100 mm
Weight	1.44KG

2.3 USV Battery

Table 2.3 USV Battery Specifications

Item	Specification
Battery Type	18650 Lithium-ion Battery Pack
Configuration	8S9P
Nominal Voltage	29.6 V
Nominal Capacity	31.5 Ah
Charge Limit Voltage	33.6 V
End-of-discharge Voltage	25.6 V
Maximum Continuous Charge Current	10 A
Maximum Continuous Discharge Current	70 A
Internal Resistance	38 mΩ
Dimensions (L*W*H)	250 × 145 × 75 mm
Weight	4.3kg
Operating temperature	-10-55℃
Charge Connector	MR60-3P female

Charge Cable	UL3135 / 14 AWG
Battery Output Connector	XT90S female
Output Cable	UL3135 / 10 AWG, length 150 ±10 mm

2.4 LUKA-TAP GNSS Receiver

The specifications and operations of the LUKA-TAP GNSS Receiver are described in detail in its respective datasheet and user manual. The documents can be downloaded from:

https://www.tersus-gnss.com/product/LUKA_gnss_receiver

2.5 TC80 Controller

The specifications for the TC80 Controller can be downloaded from:

https://www.tersus-gnss.com/product/tc80-controller

The TC80 controller is specifically designed for configuring LUKA-TAP GNSS receivers. The operations and features are also described in detail in the LUKA-TAP GNSS Receiver's user manual. The manual can be downloaded from:

https://www.tersus-gnss.com/product/LUKA_gnss_receiver

3. USV Assembly

This chapter mainly introduces the assembly of TheDuck™ USV.

3.1 Preparation Before Assembly

Verify that all components are present, including TheDuck™ USV, H20 Remote Control, USV Battery, and two 2.4G Omnidirectional RF Antennas. Ensure the work area is safe and avoid assembly and operation during inclement weather or challenging waters.

3.2 Assembly Steps

3.2.1 Installation of 2.4GHz RF Antenna

Install the two 2.4GHz RF antennas to ensure stability of communication with the remote control. When installing the antennas, the antenna shaft is movable. To prevent it from becoming loose or falling, hold the base of the antenna and tighten it securely to the mount.

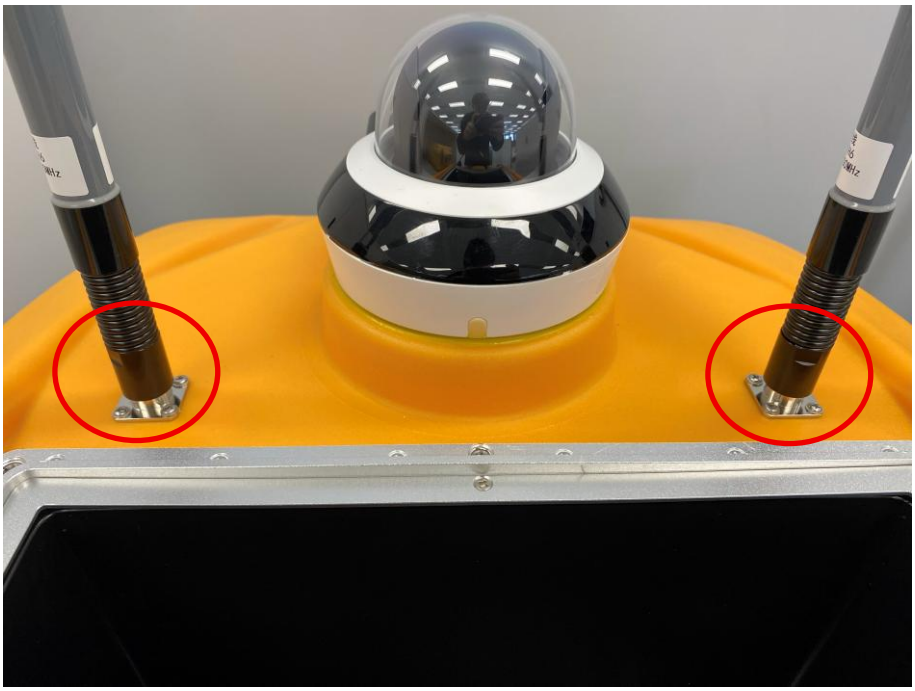


Figure 3.1 2.4G RF Antenna Installation

3.2.2 Installation of the battery

Loosen (no need to unscrew) the six screws on the battery compartment cover and remove the cover. Place the battery vertically into the battery compartment and ensure that the connecting cable is in the same direction as the interface of the battery compartment. Connect the battery correctly. Make sure the positive and negative terminals are connected correctly. The positive terminal is flat and the negative terminal is pointed.

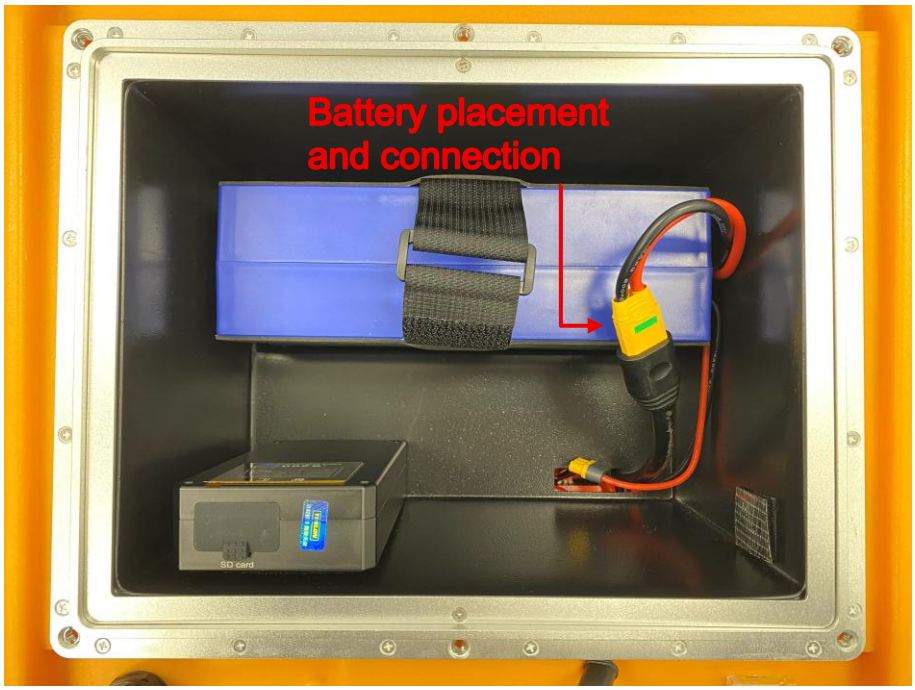


Figure 3.2 Battery placement and connection

Figure 3.3 Battery connector

3.2.3 Installation of the GNSS Receiver

1) Reinstall the battery compartment cover, make sure the GNSS Receiver mount on the battery compartment cover is close to the stern, and then tighten the six screws.

Figure 3.4 GNSS Receiver Mount

2) Take out the Quick Release Adapter from the handbag.
3) Press the button to release the inner part of the adapter.
4) Screw the outer and inner parts onto the GNSS Receiver and GNSS Receiver Mount, respectively.
5) Connect the GNSS serial cable to the GNSS Receiver.
6) Press and hold the button on the outer part, align the red dots on both parts, and insert it into the inner part.
7) The GNSS Receiver is now securely mounted on the hull.

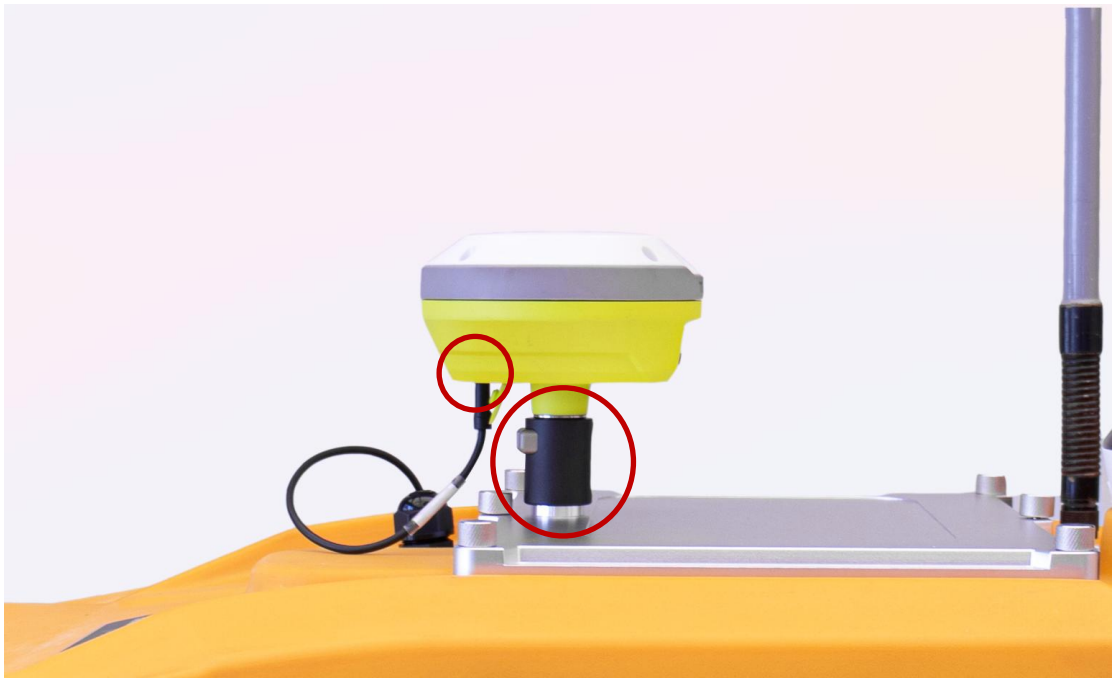


Figure 3.5 GNSS Receiver Installation

Note:

If you want to receive correction data in UHF radio mode to enable LUKA-TAP to obtain a RTK fixed solution, you need to install the radio whip antenna of LUKA-TAP. The antenna should be installed vertically upwards using Bracket and bracket cable in the accessories.

Figure 3.6 Radio Whip Antenna Installation

3.2.4 Installation of the propellers

The Duck™ USV is equipped with two plug-in ducted propellers that offer powerful performance and exceptional resistance to entanglement.

During transportation, it is advisable to remove the propeller socket to prevent any unnecessary force on it. Before beginning operations, always check whether the propeller interface is worn or damaged before plugging or unplugging.

At the interface of the propeller there is a silver button. Press this button and align the propeller interface with the hull interface simultaneously to insert it properly.

You can pull the propeller in and out without releasing the button. The procedure

is the same for both sides.

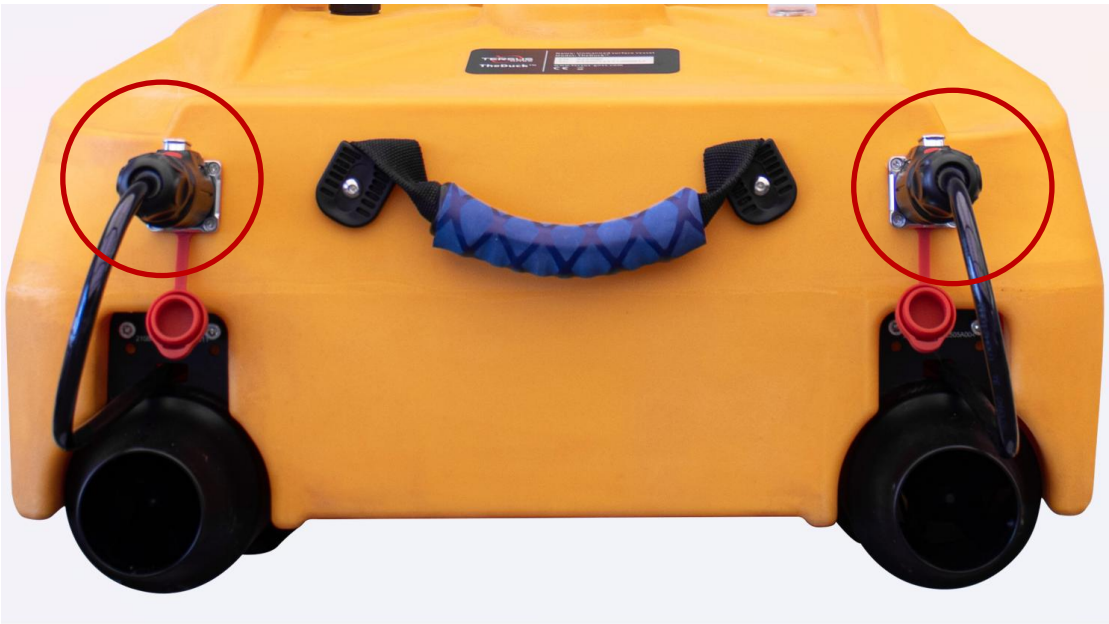


Figure 3.7 Propeller Installation

4. USV Connection

This chapter describes the connection between TheDuck™ USV and the The Tersus Captain software used to remote control the USV in the H20 Remote Control.

4.1 Turn on the H20 Remote Control

1) Attach and securely tighten the two antennas onto the remote control.
2) Adjust both antennas to point upward, ensuring their flat sides are facing outward.

Figure 4.1 Remote Control Antenna Installation

3) Briefly press the power button for 1 second, then immediately press and hold it for 2 seconds until the remote control starts up.

4.2 Turn on the TheDuck™ USV

Flip open the plastic protective cover over the power button. Press the button, and a blue light will illuminate. After waiting a few seconds, you will hear a "beep" startup sound from each of the two propellers, indicating that the USV has successfully powered on.

Note: During the startup process of the USV, do not perform any operation with the remote control.

4.3 Turn on and configure the GNSS Receiver

1) Long-press the power button to turn on the LUKA-TAP.
2) Connect to the LUKA-TAP via the NUWA software on the TC80 Controller.
3) Select either TAP mode (default) or RTK Rover mode.

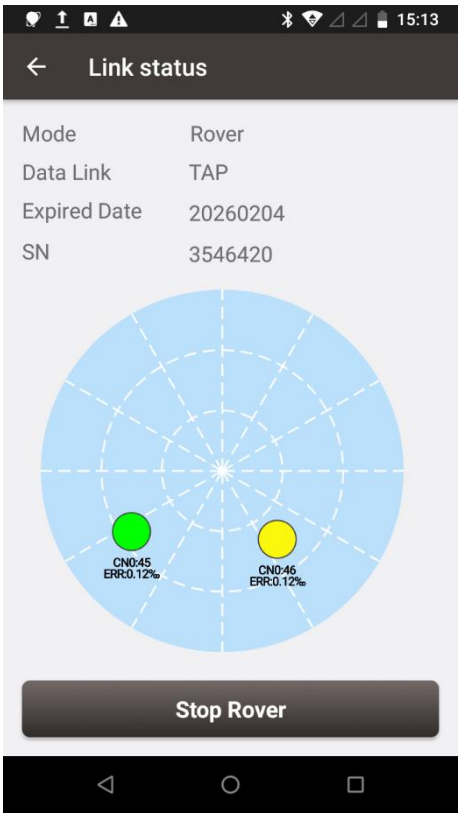


Figure 4.2 TAP Configuration

4) Go to NMEA Output, select the **Serial Config** option.

5) Configure the settings as follows:

   Baud Rate: 115200

   GPGGA, GPRMC, GPVTG: 0.2

   All other NMEA messages: OFF

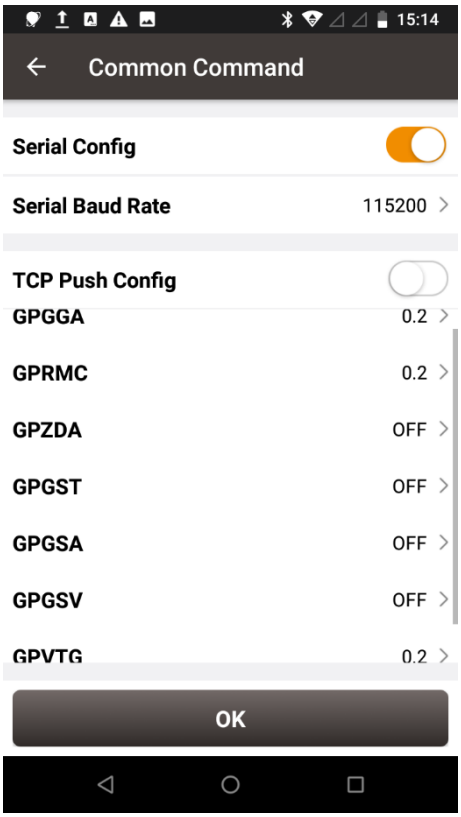


Figure 4.3 Serial NMEA Output Configuration

4.4 Software Connection

Launch the **[Tersus Captain]** software from the main interface of the remote control. The status in the upper-left corner will initially show **[Disconnected]**. Wait for approximately ten seconds. The remote control will automatically match and connect to the USV and load parameters, and it will pop up **[Initializing···]**. After the parameters are loaded, the **[Disconnected]** status will change to **[Ready To Fly]**, and the real-time image from the camera will be displayed.

At this point:

1) Switch the option in the upper-left corner of the remote control to the **[Armed]** position to unlock the USV.
2) Press the **[Fast Return/ Hold/Remote]** option in the upper-right corner of the remote control to switch to the **[Remote]** mode for manual control.

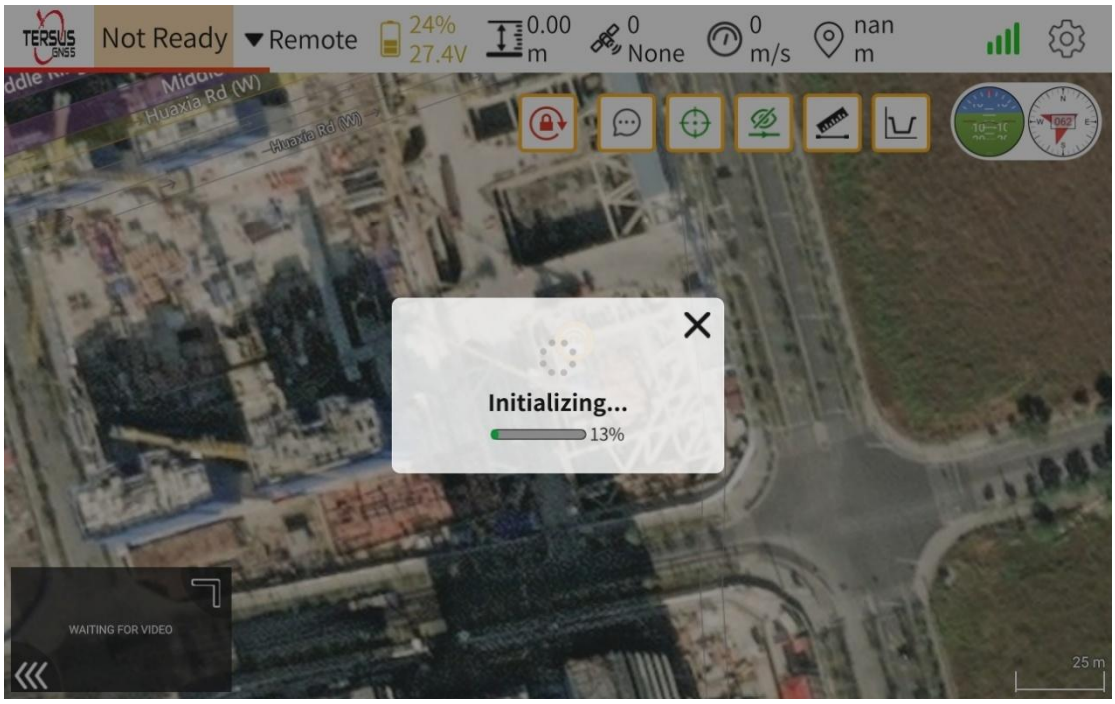


Figure 4.4 Tersus Captain Software Connection

⚠	When the remote control is charging or connecting to a computer to copy data, it may not be able to connect to the USV normally. If the remote control is not in the above state, but still does not automatically connect to the USV, please manually establish a connection via the settings: 1) Tap Settings > Link Settings. 2) Select **Default** and then tap **Link**. Wait for approximately 10 seconds for the connection to establish. 3) If the connection is unsuccessful, tap **Close** and repeat the steps above. 4) If the connection still fails after several attempts, please contact the technical support engineer for help.

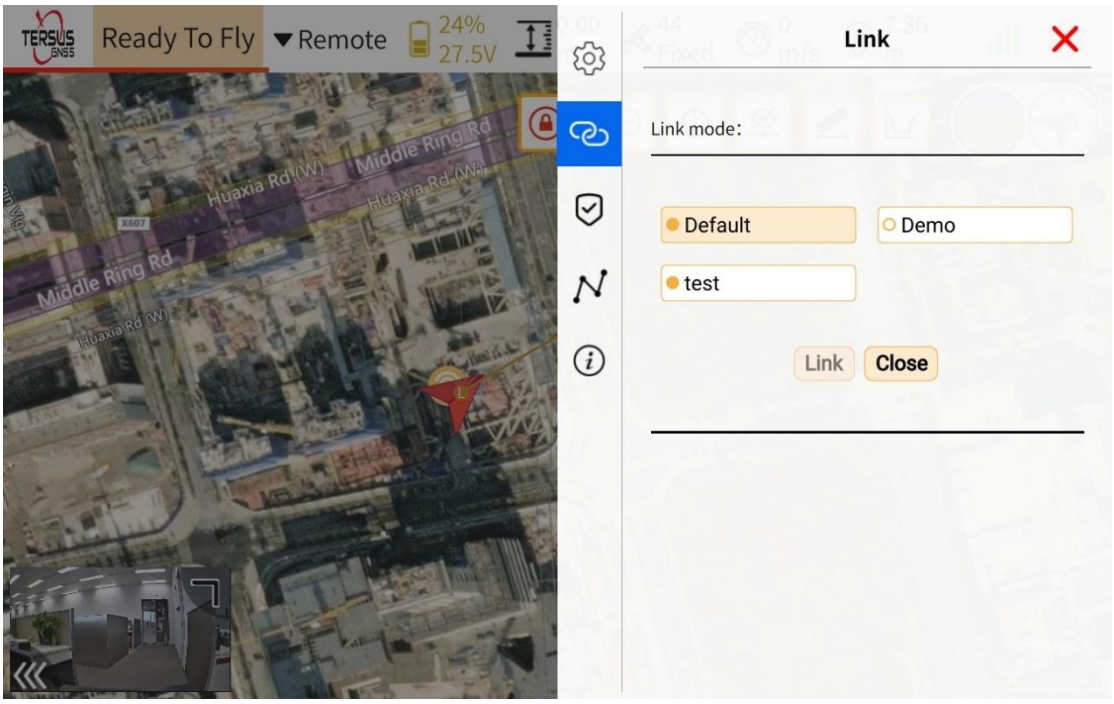


Figure 4.5 Link Settings

5. USV Deployment

This chapter describes the detailed operation methods for USV deployment.

5.1 Pre-deployment Inspection

After the USV Assembly and USV Connection, the USV needs to undergo a status check before it can enter the water.

1) Installation inspection of SD card

   The SD card is by default installed in the ES200 Single Beam Echo Sounder (SBES) unit inside the USV battery compartment. The depth measurement data is automatically recorded in this SD card. Before each task, it is necessary to check whether the SD card has been installed properly. If the ES200 SBES is not equipped with an SD card, a "beep beep" alarm will be triggered after the ship is turned on.

Figure 5.1 Installation inspection of SD card

2) Camera Status Check

After a normal connection, the camera image will appear automatically.

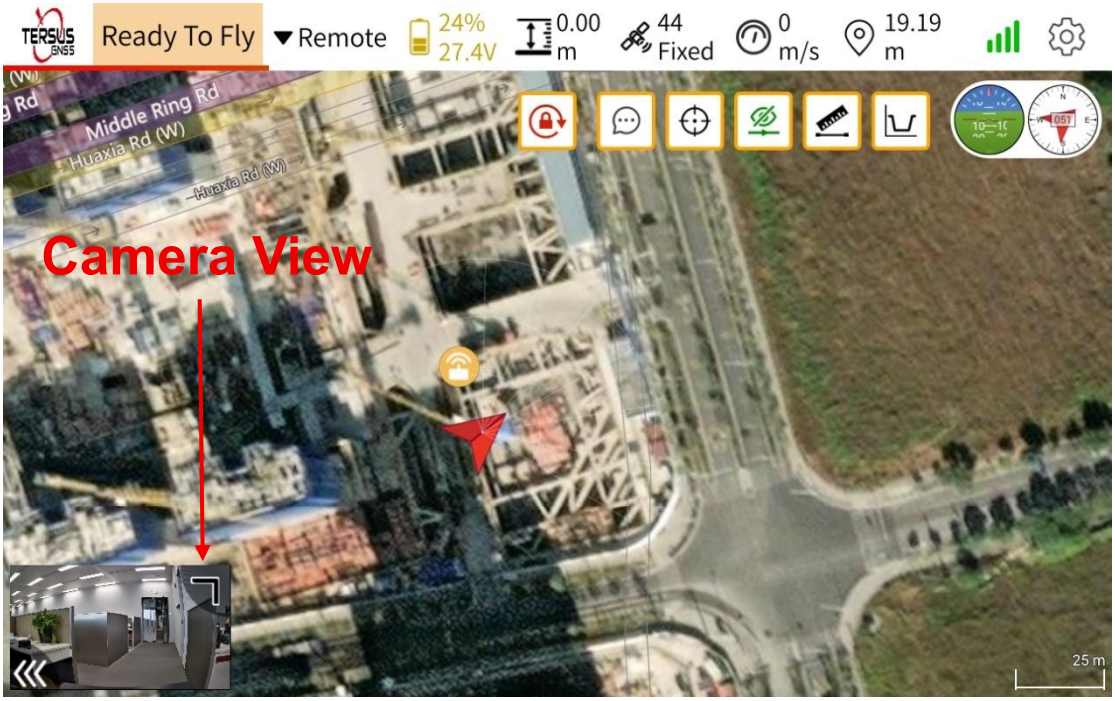


Figure 5.2 Camera Status Check

3) Propeller Control Check

After the USV is powered on and connected to the remote controller, gently push the control sticks and carefully place your hand near the **propellers** to feel the airflow. The observed state must match the following requirements:

- **Push the stick forward:** The propellers should blow air outward (away from the hull).

- **Pull the stick backward:** The propellers should suck air inward (toward the hull).
- **Push the stick left:** The left propeller sucks air inward, and the right propeller blows air outward.
- **Push the stick right:** The left propeller blows air outward, and the right propeller sucks air inward.

WARNING: Keep your hands clear of the propeller internals. Do not place your hands inside the duct, as contact with the spinning propeller blades can cause serious injury.

4) Antenna Assembly Verification

- **Check:** Ensure all antennas are installed and positioned correctly on the remote controller.
- **Note:** The two 2.4G antennas must be installed on the USV. Otherwise, you will experience a significantly shortened control range and may lose control of the USV.

5) Power Level Check

- **Check:** Verify that the USV battery and remote controller battery have sufficient charge.
- **Note:** If either the USV or the remote controller has a low battery, a connection dropout is likely to occur.

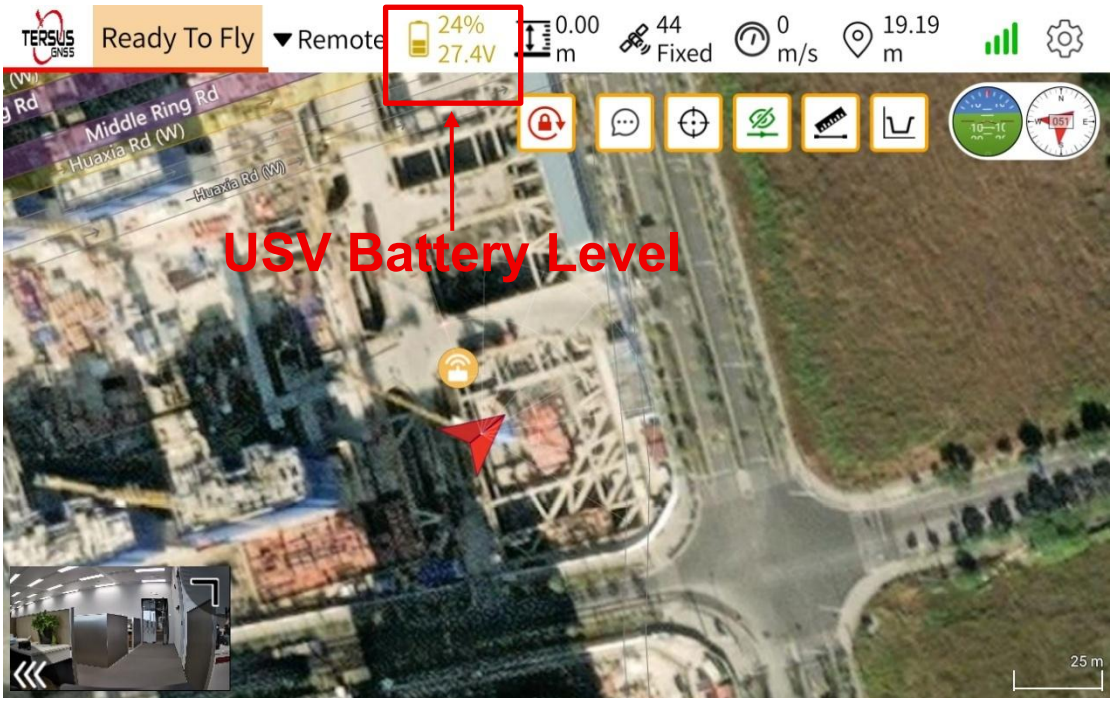


Figure 5.3 USV Battery Level

5.2 USV Water Entry

1) Select a relatively flat area at the water's edge for launch.
2) Place the hull in the water, holding onto the stern while the bow floats freely.
3) Have the remote operator gently push the **Forward Stick**.
4) Once you feel the USV generating forward thrust, release the stern to complete the launch.

Figure 5.4 USV Successfully Entered the Water

5.3 Manual Operation

1) After the USV is safely in the water, you may begin manual operation.
2) Use the **Left Stick** to control forward and backward movement.
3) Use the **Right Stick** to control left and right turns.
4) **Note:** As the propellers can accelerate rapidly, avoid pushing the sticks too forcefully to prevent sudden surges that could damage the hull or equipment.

Figure 5.5 Push the Stick Slowly

5.4 Situational Awareness

1) While operating the USV, continuously monitor its position and heading to avoid running aground or collisions.
2) If your direct line of sight is obstructed, use the onboard camera to check for obstacles ahead.
3) The red arrow on the map interface on the remote controller also shows the USV's real-time position.

Figure 5.6 The Operator Follows the USV for Operation

5.5 Map Loading

1) When using the remote controller for the first time in a new area, an internet connection (e.g., a mobile hotspot) is required to load the base map.
2) After the initial load for a specific area, the map is cached and an internet connection is no longer required for subsequent operations in the same region.

6. Tersus Captain software

This chapter describes the Tersus Captain software in detail.

Tersus Captain, developed by Tersus GNSS, is the central platform for managing your USV operations. It provides a real-time overview of all critical metrics—from positioning and bathymetry to battery status—all displayed over a detailed satellite map with camera support.

The software enables full mission control, allowing you to plan routes, activate autonomous obstacle avoidance, and define safety boundaries with electronic geofencing, ensuring precise and protected unmanned missions.

6.1 Main Interface Introduction

Figure 6.1 Main Interface Introduction

1) Mission Planning： For comprehensive instructions, please see the **[Mission Planning]** section.
2) USV Status: Indicator for the USV's State, includes “Disconnected”, “Not Ready”, “Ready To Fly” and “Armed”.
3) USV Working Mode: Further information is available in the **[Switch the USV Working Mode]** section.
4) Battery Level: Display the current battery percentage and voltage.
5) Depth: The current water depth, which has three display states: it shows "nan" if no device is connected, displays "0" if connected but in excessively shallow water or on land, and provides normal depth readings when properly connected and operating in sufficient water.
6) Position Status: Shows the USV's real-time positioning status and satellite number. "**3D**" for Single, "**Float**" for Float, "**Fixed**" for Fixed solution (as shown above), and "**None**" for no positioning data received.
7) Speed (SOG): Indicates the USV's Current Speed Over Ground.

8) Distance to USV: Shows the Straight-line Distance between the Remote Controller and the USV.
9) Link Status: Displays the state of the communication link between the USV and the remote control.
10) Settings: Access to Software Settings , refer to Section 6.6 **[Settings]** for more information.
11) Arm/Disarm: Arm and Disarm shortcut.
12) Log: Log messages of the USV.
13) Center: Center on USV shortcut.
14) Hide Route: Hide Planned Route Shortcut.
15) Measure: Quickly measures the approximate distance between any two points on the base map.
16) Hydrographic Cross-Section Mode: For details, refer to the Section 6.7 **[Hydrographic Cross-Section Mode]**.
17) Camera View: For details, refer to the Section 6.8 **[Camera].**

6.2 Mission Planning

Tap the  icon in the upper-left corner of the remote controller screen to enter the Mission Planning interface. And there are two mission planning methods, Manual Waypoint Planning and Area Coverage Planning.

6.2.1 Manual Waypoint Planning

1) Tap the Manual Waypoint Planning button  .
2) Manually place waypoints on the satellite map. They will be automatically numbered in sequence: 1, 2, 3... After placing a waypoint, you can adjust its position by holding it down on the map and dragging.

3) On the right side, various parameters for the defined area can be configured. Key settings include:

- Hold time: the hold time after the USV reaches the waypoint.
- Lat and Lon: The longitude and latitude coordinates of this waypoint.
- : Delete this waypoint.

4) Tap **[Upload]** in the top toolbar. The system will display the distance between each waypoint and the total route distance. Once tapped, a green progress bar will appear. Completion of this bar indicates a successful upload.

5) Tap the **[MainPage]** button in the upper-left corner to return to the main interface. The planned waypoints will be saved.

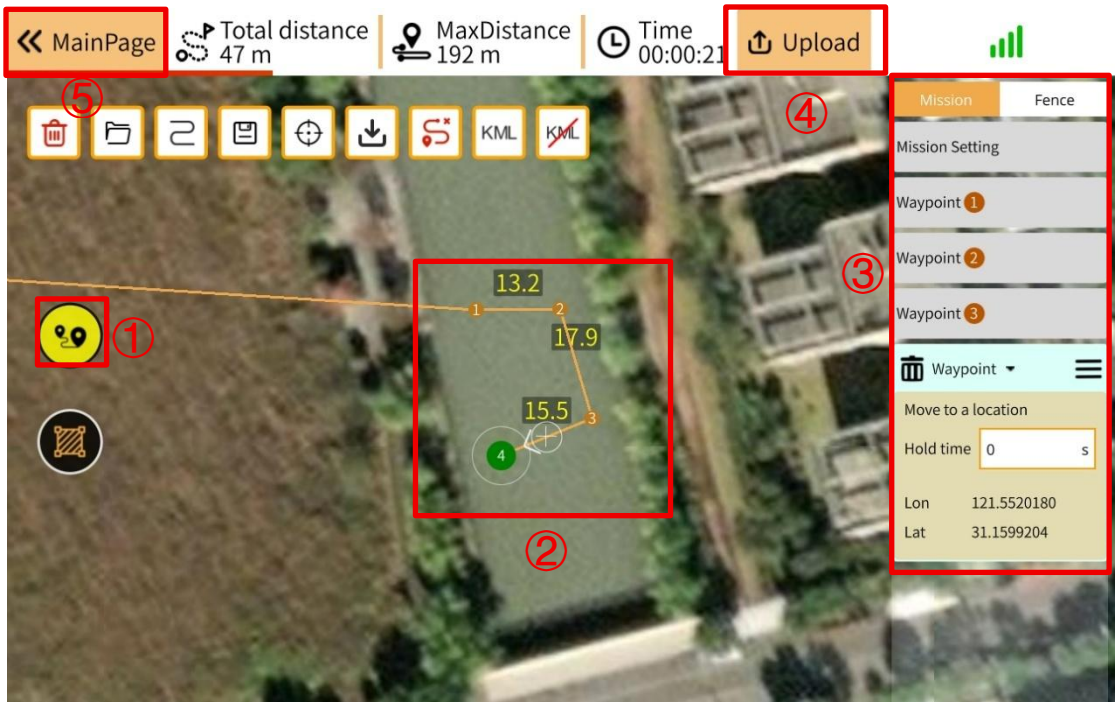


Figure 6.2 Operation Steps for Manual Waypoint Planning

6.2.2 Area Coverage Planning

1) Tap the Area Coverage Planning icon .

2) Tap the **[Start]** button to begin adding boundary points on the map. After you add three or more boundary points to create a polygon area, the route will be generated automatically.
3) After placing a boundary point, you can adjust its position by holding it down on the map and dragging.
4) Once the planning is completed, tap **[Done]**.
5) On the right side, various parameters for the defined area can be configured. Key settings include:

- Spacing: Adjusts the density of the survey lines within the planned area, based on the required scale.
- Angle: Sets the overall angle/orientation of the survey lines, adjustable via the slider below.
- Rotate Entry Point: Tap this button repeatedly to cycle the starting point of the survey pattern to a suitable location for the operation.

6) Tap **[Upload]** in the top toolbar. The system will display the distance between waypoints and the total mission distance. Once tapped, a green progress bar will appear. Its completion indicates a successful upload.
7) Tap the **[MainPage]** button in the upper-left corner to return to the main interface. The planned route will be saved.

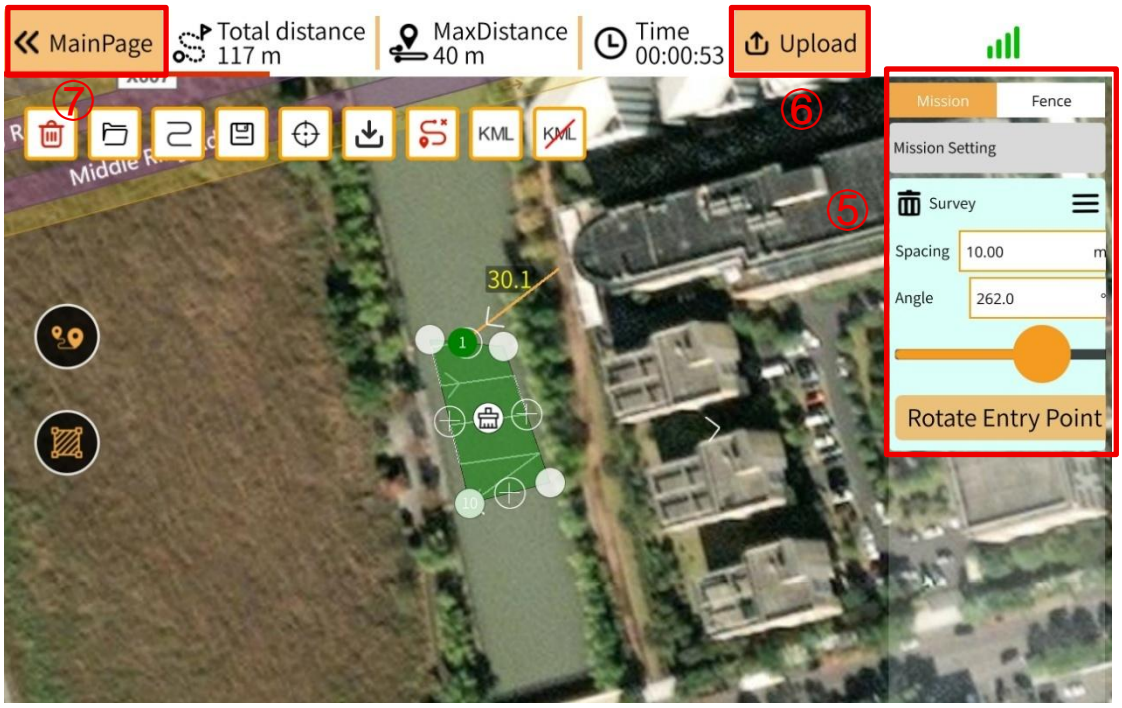


Figure 6.3 Operation Steps for Area Coverage Planning

⚠	1) Due to inherent inaccuracies in satellite maps, during both **Manual Waypoint Planning** and **Area Coverage Planning**, carefully avoid plotting courses too close to the shore to prevent the USV from running aground or colliding with the bank. 2) If data collection near the shoreline is required during a mission, manually operate the USV to survey along the edge. A new route can then be planned based on the resulting track line. 3) Waypoints can also be modified in real-time during a mission, as needed.

6.2.3 Other functions

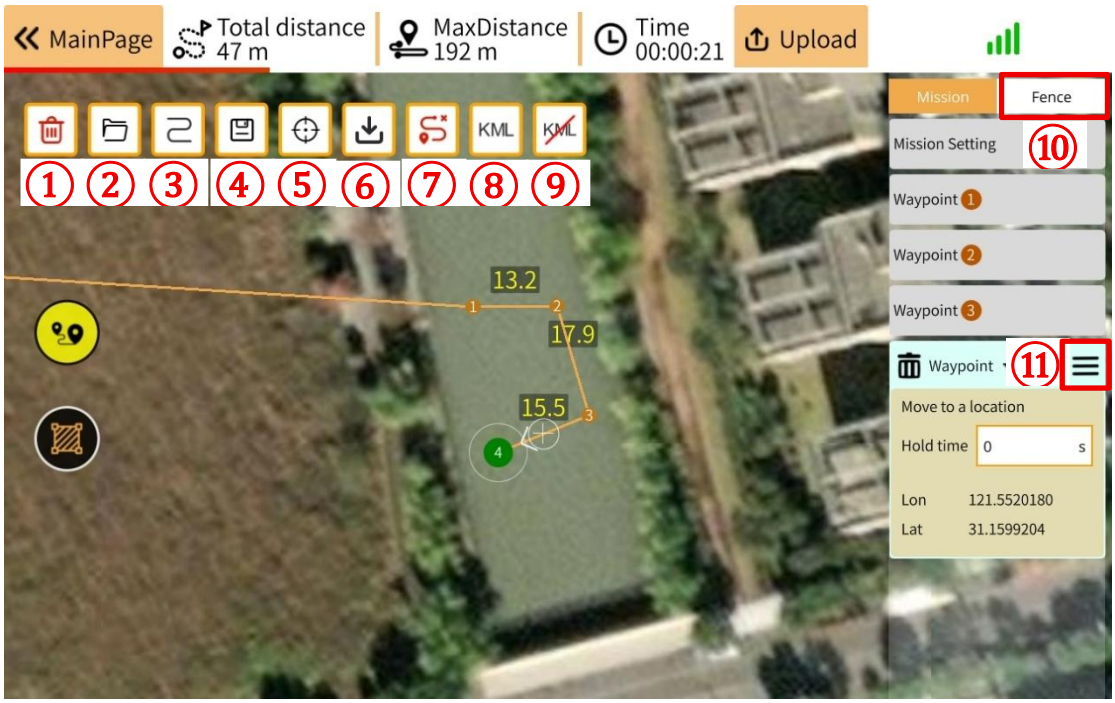


Figure 6.4 Other functions on the Mission Planning interface

1) **Clear All:** Deletes all planned routes.
2) **Import Route:** Loads externally imported .kml or .plan route files.
3) **Toggle KML Load Mode:** Switches the loading method for .kml format routes.
4) **Save Route:** Saves the currently planned route.
5) **Center on USV:** Re-centers the map view on the USV's current position.
6) **Load Last Route:** Loads the most recently used route.
7) **Clear Track:** Deletes the red track line showing the USV's past path
8) **Load KML Overlay:** Loads a base map/image contained within a .kml file (does not connect it as a route).
9) **Clear KML Overlay:** Removes the base map/image loaded from a .kml file.
10) **Fence:** Set up electronic fences in the operation waters.

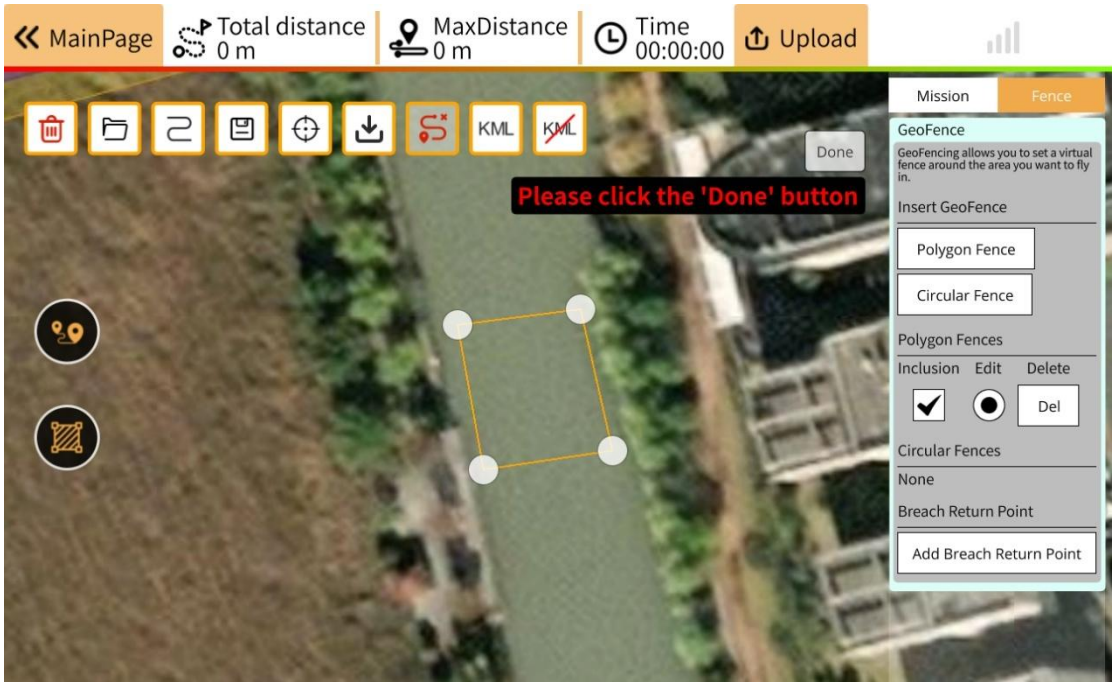


Figure 6.5 Polygon Fence Settings

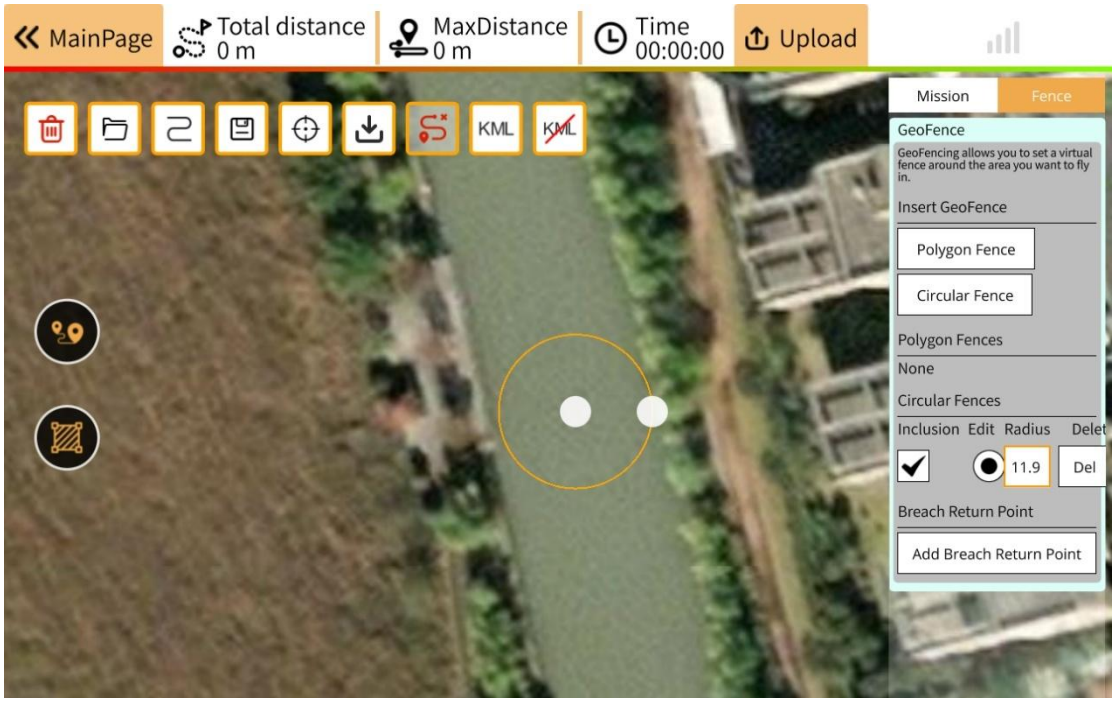


Figure 6.6 Circular Fence Settings

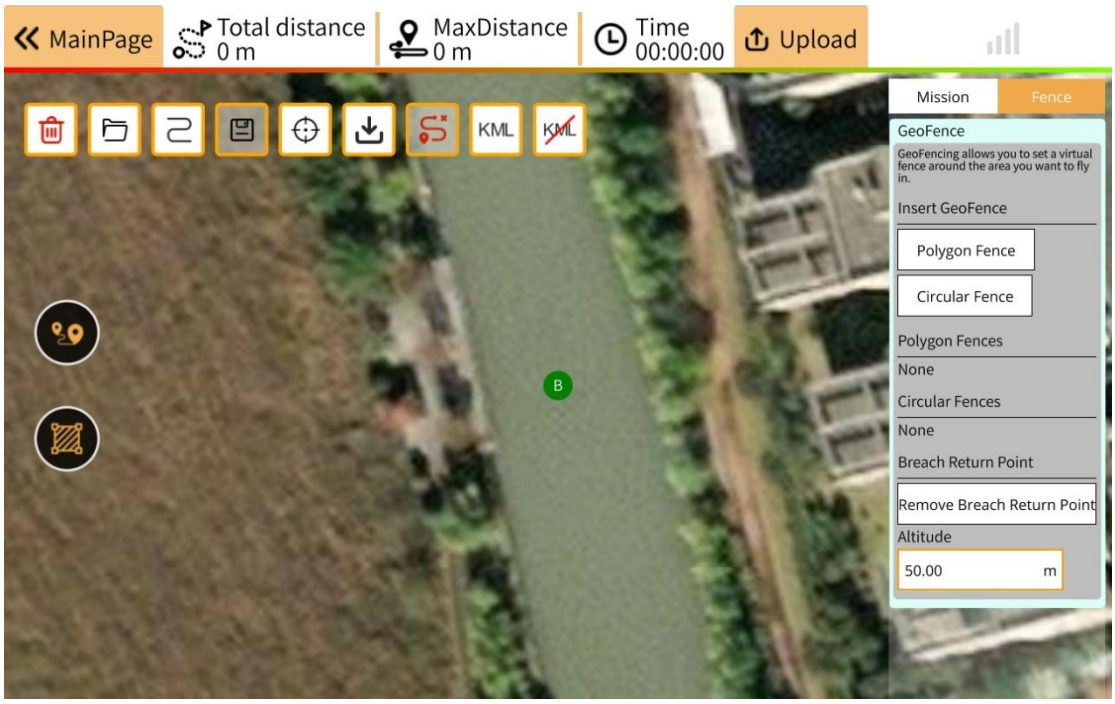
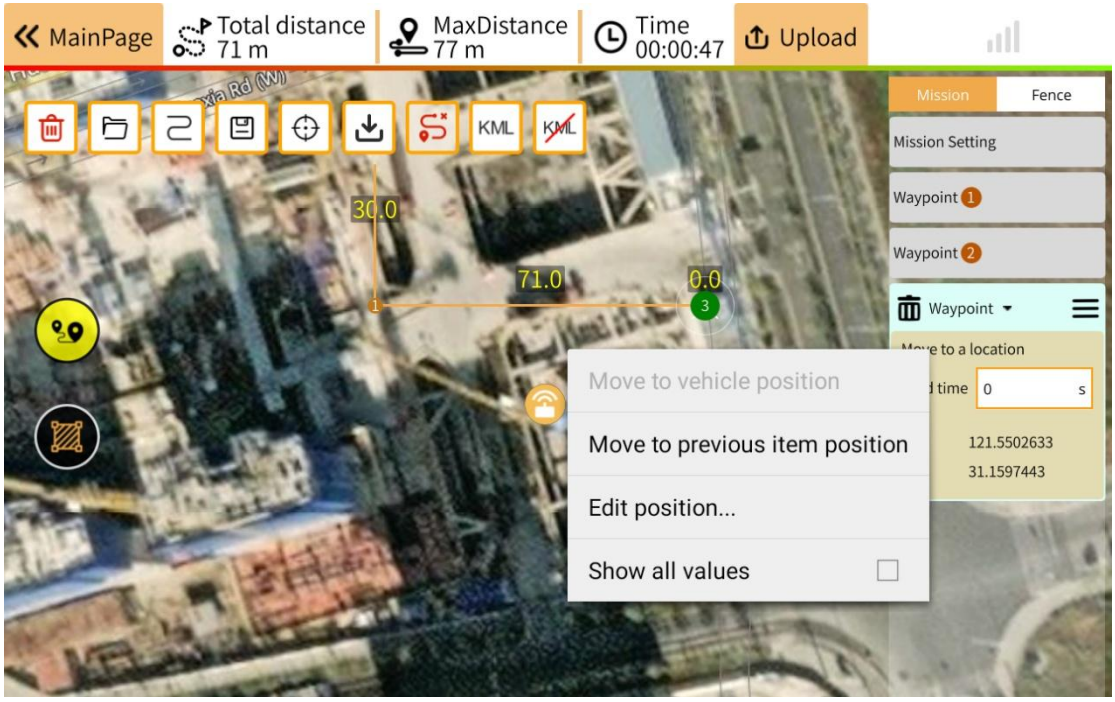


Figure 6.7 Breach Return Point Setting

11) **Advanced settings:** Include “Move to vehicle position”, “Move to previous item position”, “Edit position” and “Show all values”. “Edit position” can be used to modify the longitude and latitude coordinates, UMT Zone, and the local UTM projected coordinates.



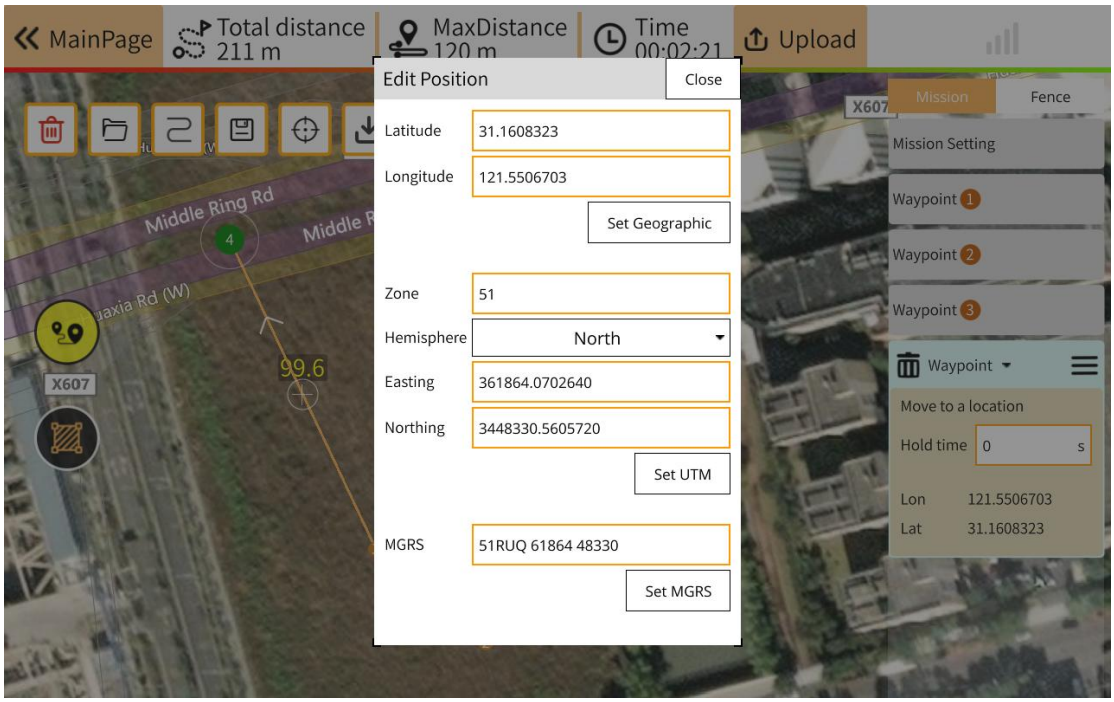


Figure 6.8 Advanced Settings

6.3 Start Mission

1) After finishing the mission planning and returning to the main interface, you can manually select any waypoint on the map as the mission's start point. Swipe the bottom progress bar to confirm the selection. Note: If no point is selected, the USV will default to starting from Waypoint 1.
2) Tap the **[Remote]** function key in the upper-left corner. From the dropdown menu, select **[Auto]** mode. The control sticks can now be released, and the USV will sail automatically along the planned route.

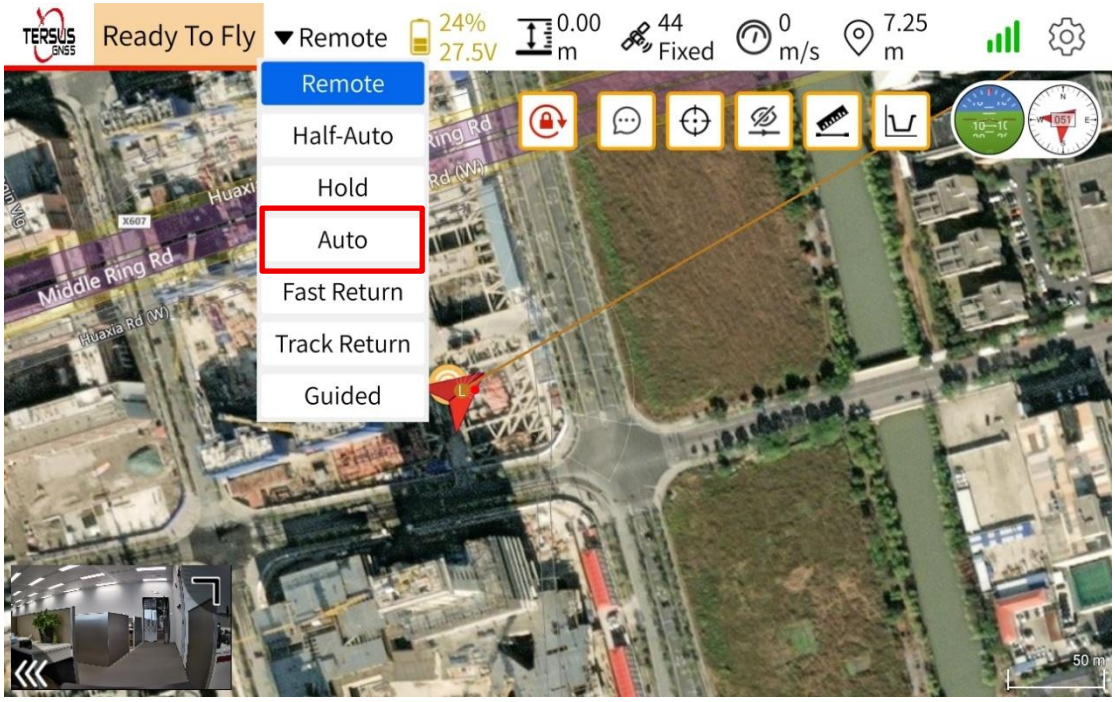


Figure 6.9 Switch to Auto Mode to Start the Mission

6.4 Mission Operation

1) If the USV needs to be urgently switched to manual control mode during the mission, move the **[Fast Return/ Hold/ Remote]** switch first to "Hold", and then immediately to "Remote".
2) Upon reaching the final waypoint, the USV will automatically enter **[Hold]** mode. At this point, you can:

- Move the **[Fast Return/ Hold/ Remote]** switch to "Fast Return". The USV will automatically return at a constant speed to its starting point for easy recovery.
- Move the **[Fast Return/ Hold/ Remote]** switch to "Remote" to regain manual control and ensure the hull's safety.

3) To resume an interrupted route, first select the next desired waypoint from which to continue, then swipe the bottom progress bar to confirm the selection, and tap the upper-left **[Remote]** function key, from the dropdown

menu select "Auto". The USV will proceed to complete the remaining planned route.

6.5 Switch the USV Working Mode

Tap the **[Remote]** function key in the upper-left corner to reveal a dropdown menu where you can change the USV's working mode. For certain specific modes, quick shortcuts are available on the screen for faster switching.

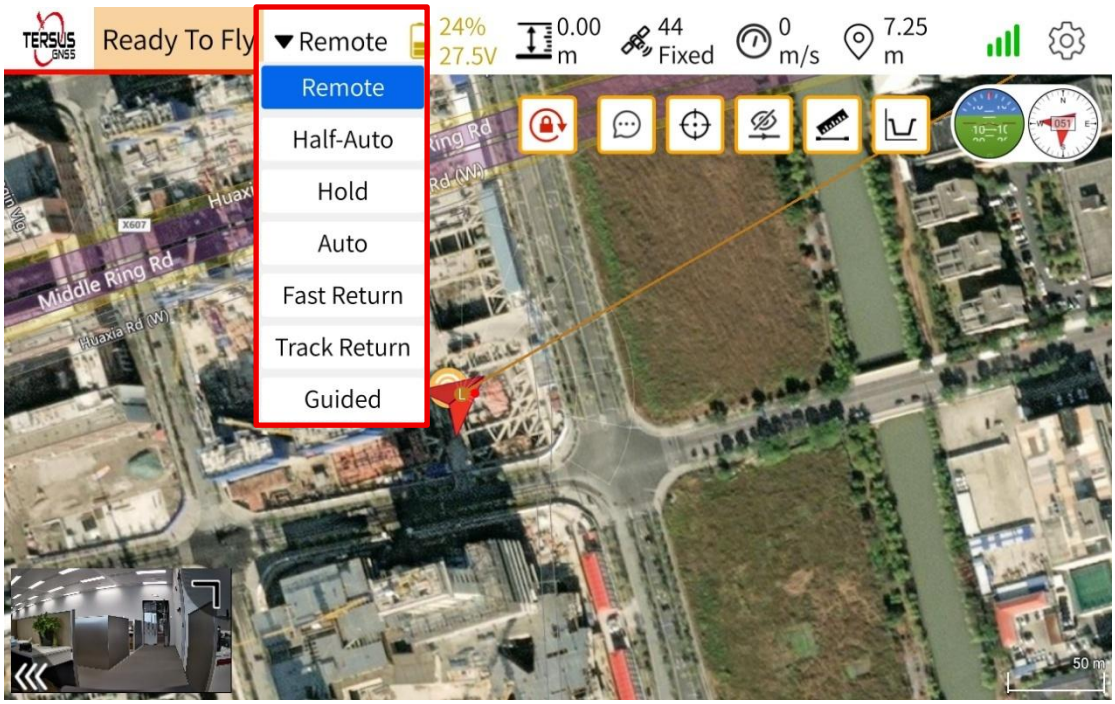


Figure 6.10 USV Working Mode

1) **Remote Mode**: Directly control the USV's movement via the remote controller.
2) **Half-Auto Mode**: The USV maintains the initial heading as its course direction. Simply push the forward throttle on the remote controller, and the USV will automatically correct its heading to counteract the effects of current in rivers.
3) **Hold Mode**: When activated, the USV will maintain its current position against water currents.

4) **Auto Mode**: Tap the Auto button and swipe to confirm. The USV will begin executing the uploaded planned mission from its current location, following the waypoints in sequence.
5) **Fast Return Mode**: After engaging Return mode, the USV will navigate in a straight line back to the set Home Point.
6) **Track Return Mode**: The USV will return to the Home Point by retracing the original path it traveled.
7) **Guide Mode**: Long press the map to set a target point. After swiping the progress bar to confirm, the USV will automatically navigate to that guided target point.

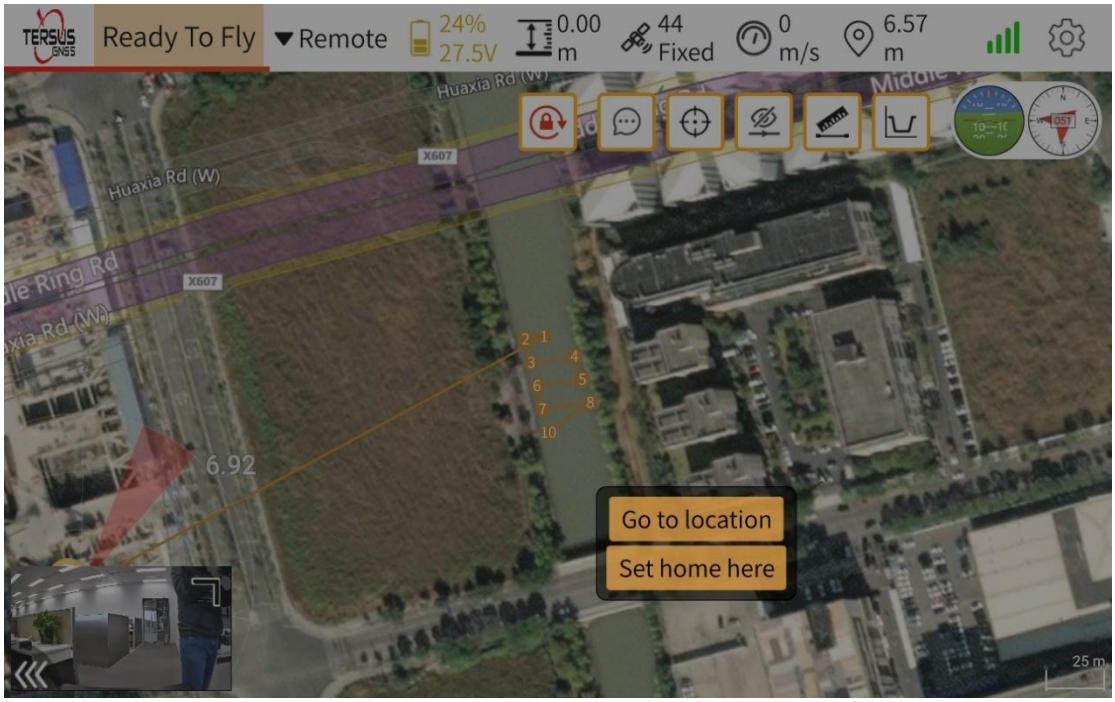


Figure 6.11 Long Press to Set a Target Point

6.6 Settings

Tap the icon in the upper-right corner of the software to access the settings menu.

6.6.1 General Settings

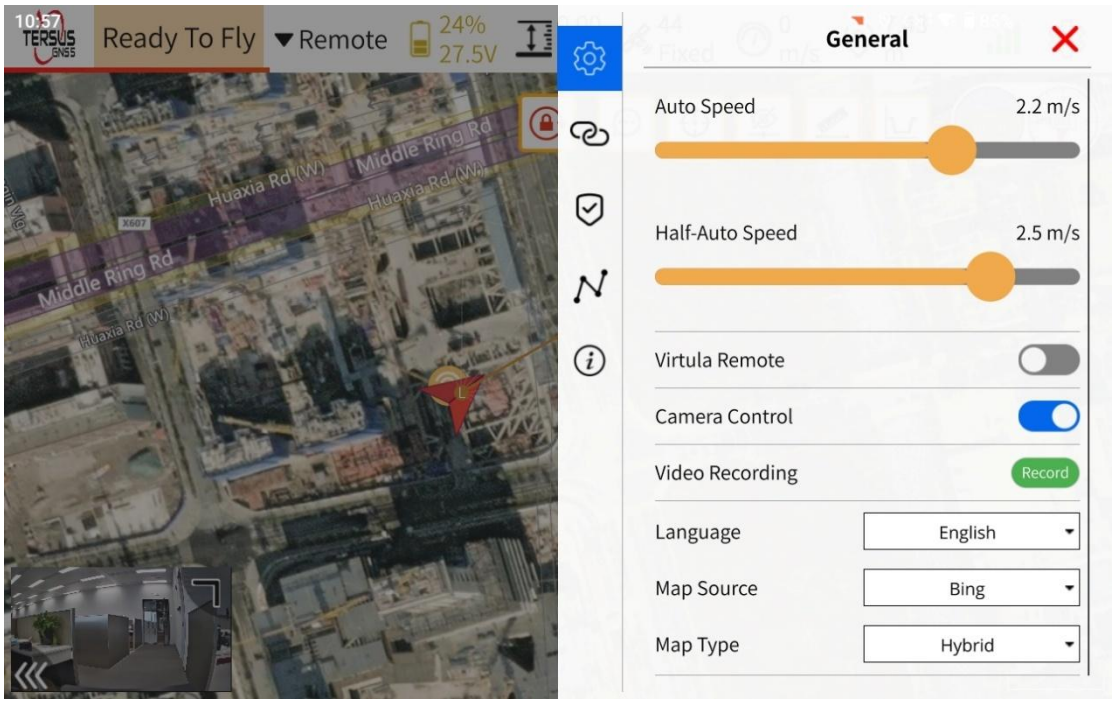


Figure 6.12 General Settings

1) Auto Speed: Adjusts the USV's speed in Auto mode.
2) Half-Auto Speed: Sets the maximum speed for the USV when operating in Half-Auto Mode.
3) Virtual Remote: Enable this function to control the USV via an on-screen interface if the physical control sticks are malfunctioning.
4) Camera Control: When enabled, allows for fine-tuning of the camera gimbal angle.
5) Video Recording: Display the video recording status.
6) Language: Switch the software language.
7) Map Source: The default map source is Bing.
8) Map Type: The default map source is Satellite.

6.6.2 Link Settings

After turning on the USV and then launching the **[Tersus Captain]** software, the remote control will automatically match and connect to the USV and load

parameters, and it will pop up **[Initializing···]**. So users don't have to connect manually in the **[Link]** interface.

Manual connection is only required when some abnormal situations occur or when the Demo mode needs to be used.

For the detailed operations, refer to Section 4.4 **[Software Connection]**

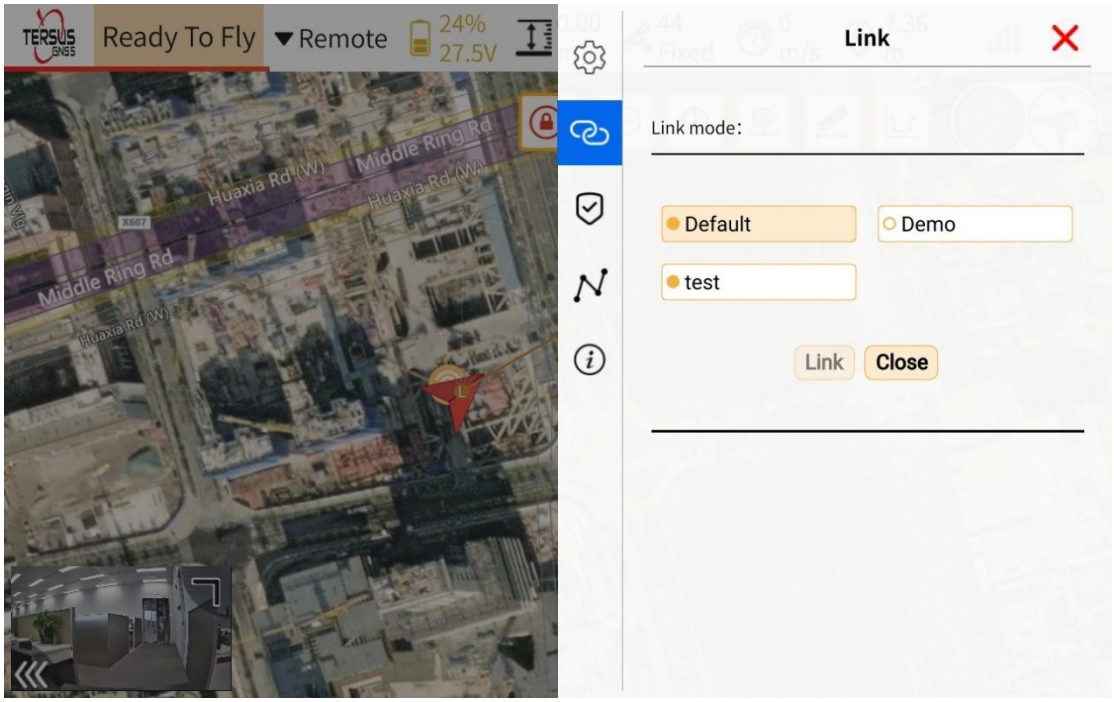


Figure 6.13 Link Settings

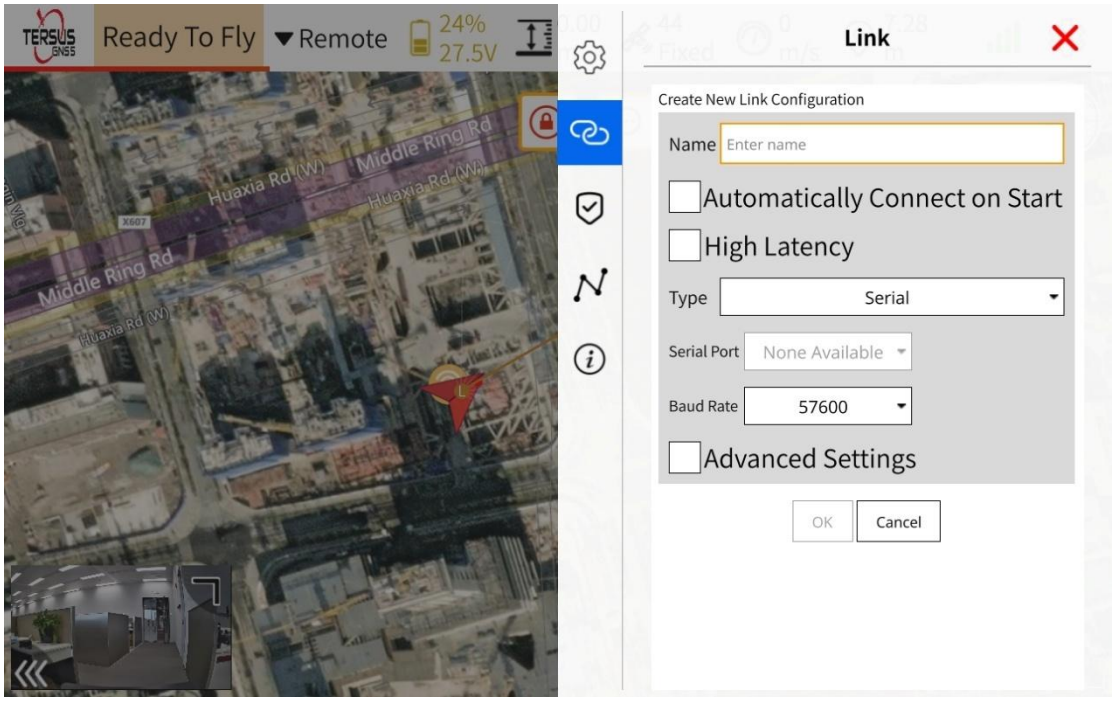


Figure 6.14 Create New Link

6.6.3 Safety Settings

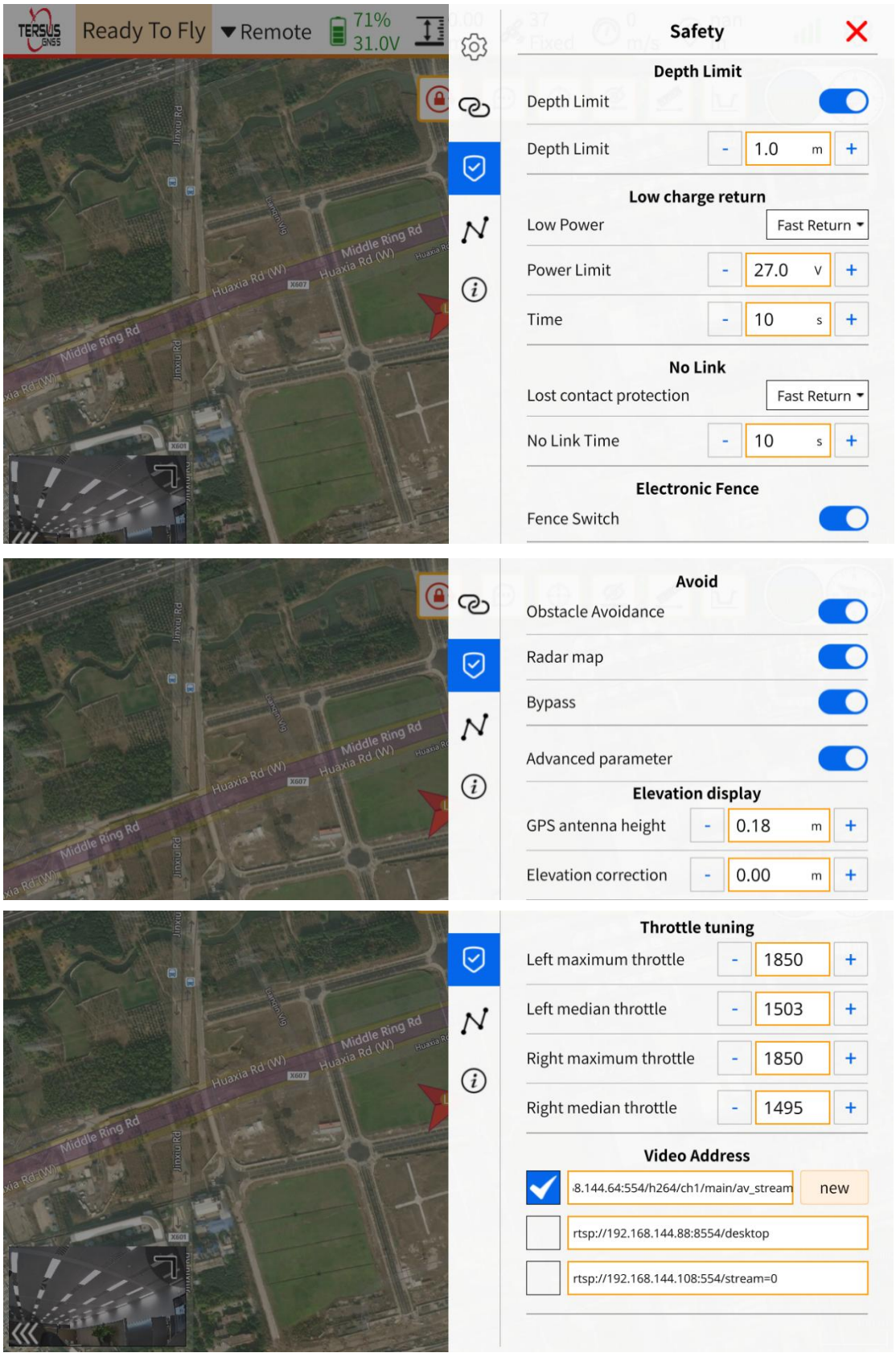


Figure 6.15 Safety Settings

1) Depth Limit: The USV will trigger an alarm when entering waters shallower than the set depth to prevent grounding. The set depth should be determined based on actual conditions.
2) Low charge return: When the USV's battery voltage drops below the set threshold for a predetermined duration, the Low charge return function is triggered. This can be configured to: **Disabled / Fast Return / Hold / Track Return**.
3) No Link: Triggered when the USV loses connection for the set duration. This can be configured to: Return to **Fast Return / Hold / Track Return**.
4) Electronic Fence: When enabled, a boundary can be drawn on the mission planning interface (Refer to Section 6.2.3 **[Other Functions]**). The USV will trigger the **"No Link"** procedure if it moves outside the Geofence.
5) Avoid

   - **Obstacle Avoidance:** Enables or disables the automatic obstacle avoidance function. When an obstacle is detected within 2 meters, the USV will stop and hover for 30 seconds.
   - **Radar map:** When enabled, a 150° sector scan area is displayed in front of the USV. Obstacles detected by the LiDAR avoidance radar will be shown as red dots.
   - **Bypass:** When enabled, the system will determine if a bypass is feasible. If so, the USV will automatically re-plan its route to the next waypoint to avoid this obstacle.

6) Advanced parameter: Pre-configured for factory settings
7) Elevation Display

- GPS antenna height: The height of the USV's antenna above the water surface. Once set, this value is used in elevation calculations (can be reset during post-processing of single-beam data).
- Elevation Correction: Within a localized area, this allows for vertical adjustment (bulk shift) of single-beam data based on the water level datum measured by the RTK system.

8) Throttle tuning: Allows fine-tuning of propeller thrust by adjusting the throttle parameter values.
9) Video Adress: Can be used to switch the video stream address to accommodate different types of cameras.

6.6.4 Track Color Settings

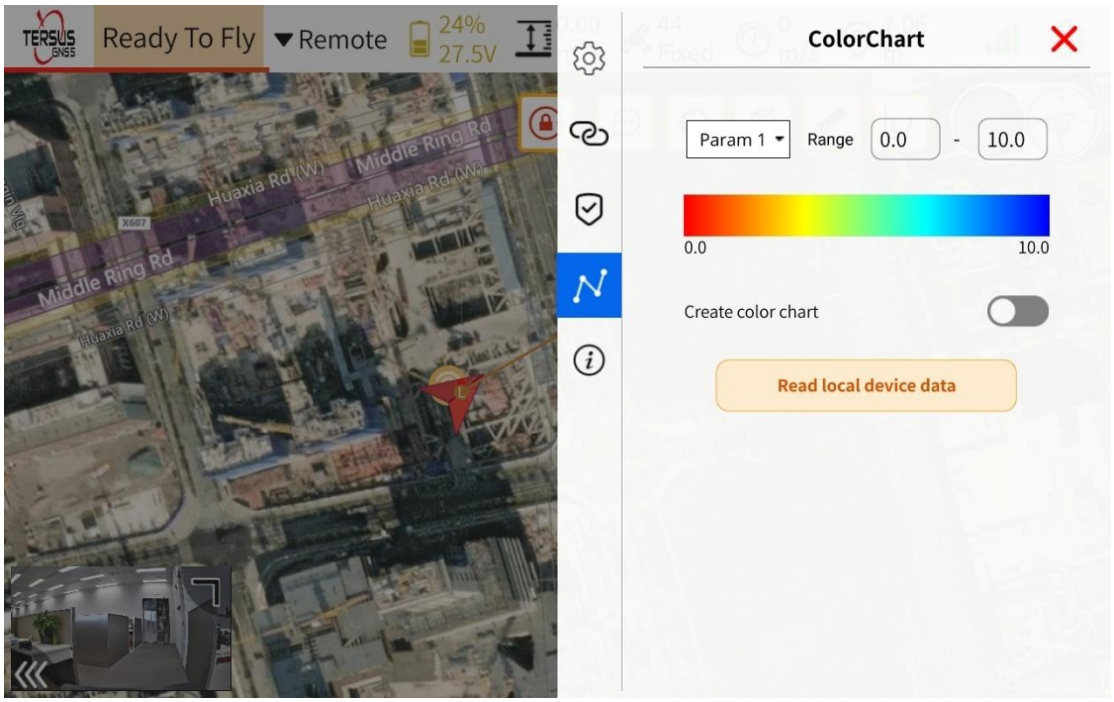


Figure 6.16 Color Chart Settings

Select a parameter, such as water depth or other water quality metrics, as the data reference. The system can then read a local CSV file to visualize the track line. Instead of a single red color, the track will be dynamically color-coded to represent different values from the data.

6.6.4 Version

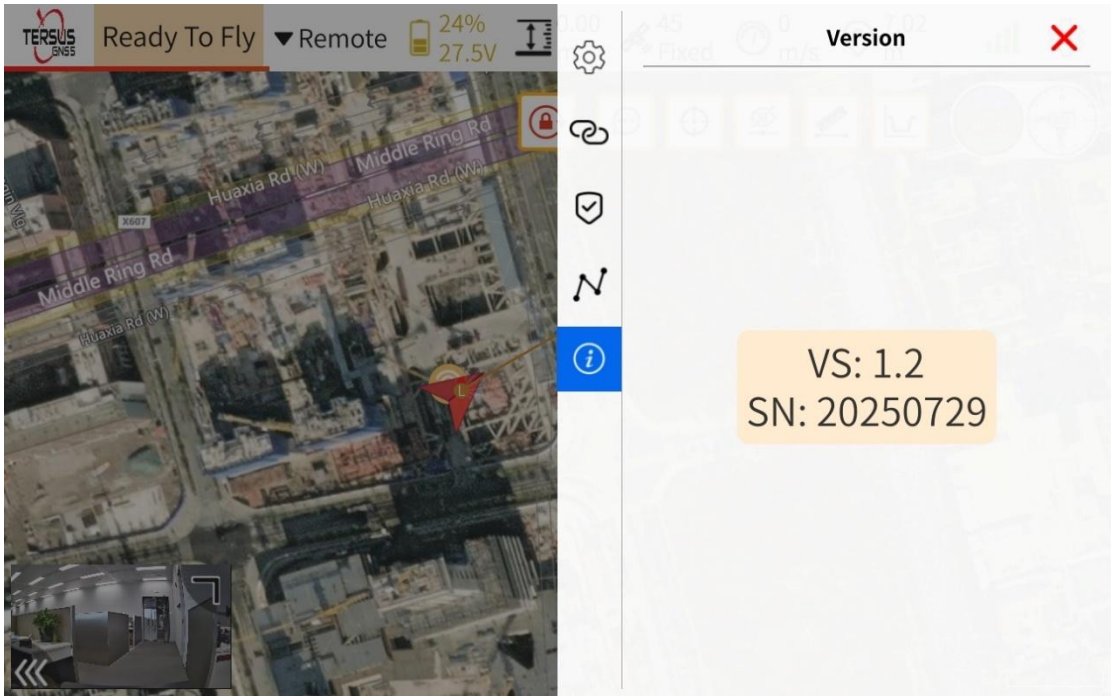


Figure 6.17 Color Chart Settings

Display the current software version.

6.7 Hydrographic Cross-Section Mode

1) On the main interface, tap the icon  to turn on the Hydrographic Cross-Section Mode. A floating window will appear in the lower-right corner, used for recording depth data to generate a riverbed cross-sectional profile.

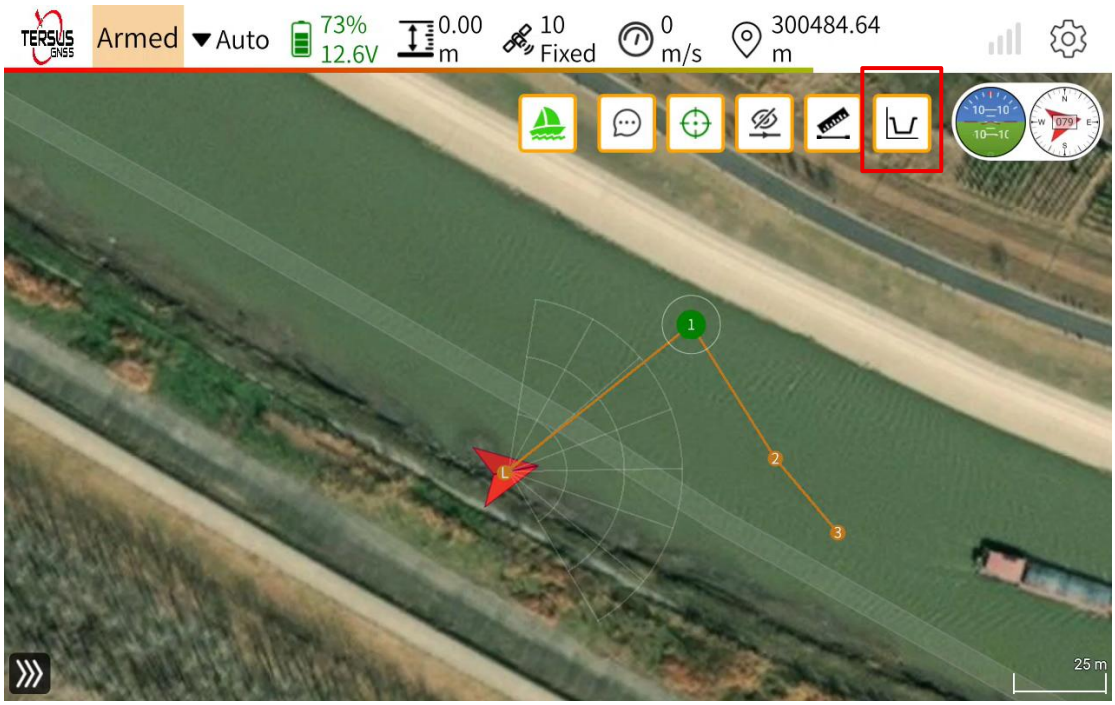


Figure 6.18 Turn on the Hydrographic Cross-Section Mode

2) After aligning the USV's bow direction and turning on the Hydrographic Cross-Section mode, you can start the measurement. Tap **[First]** to set the Start Point.

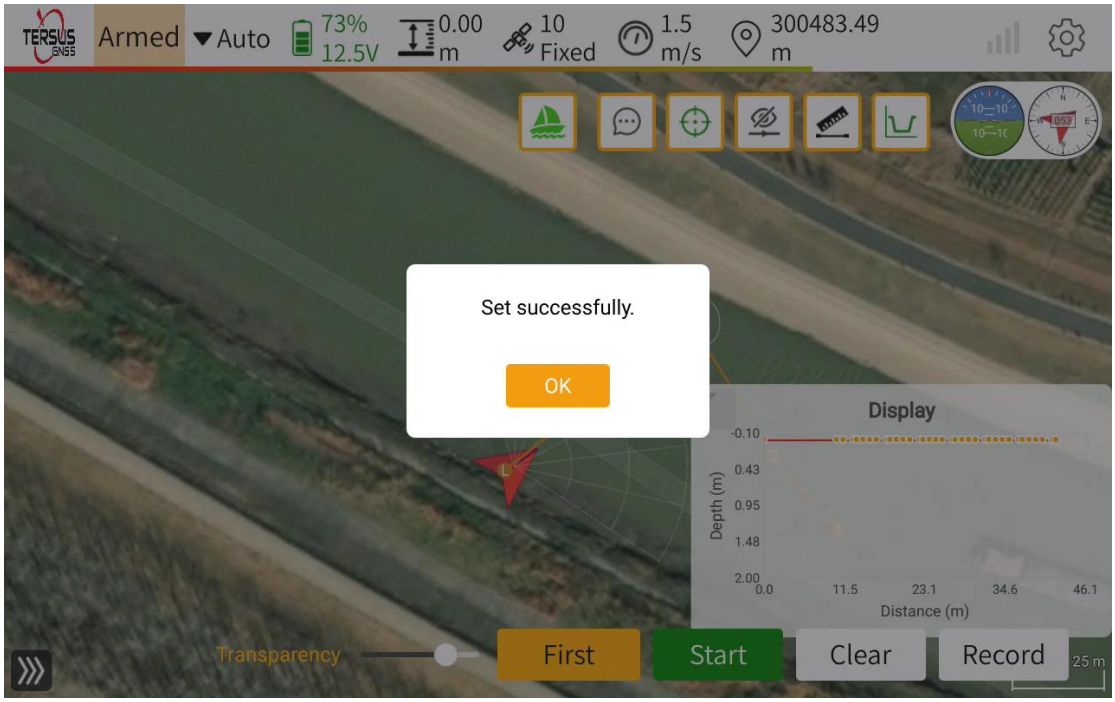


Figure 6.19 Set Start Point

3) Tap **Start**. Simultaneously, manually operate the USV towards the other end of the cross-section, trying to maintain a straight line. You will see the cross-section window in the lower-right corner recording the profile data.

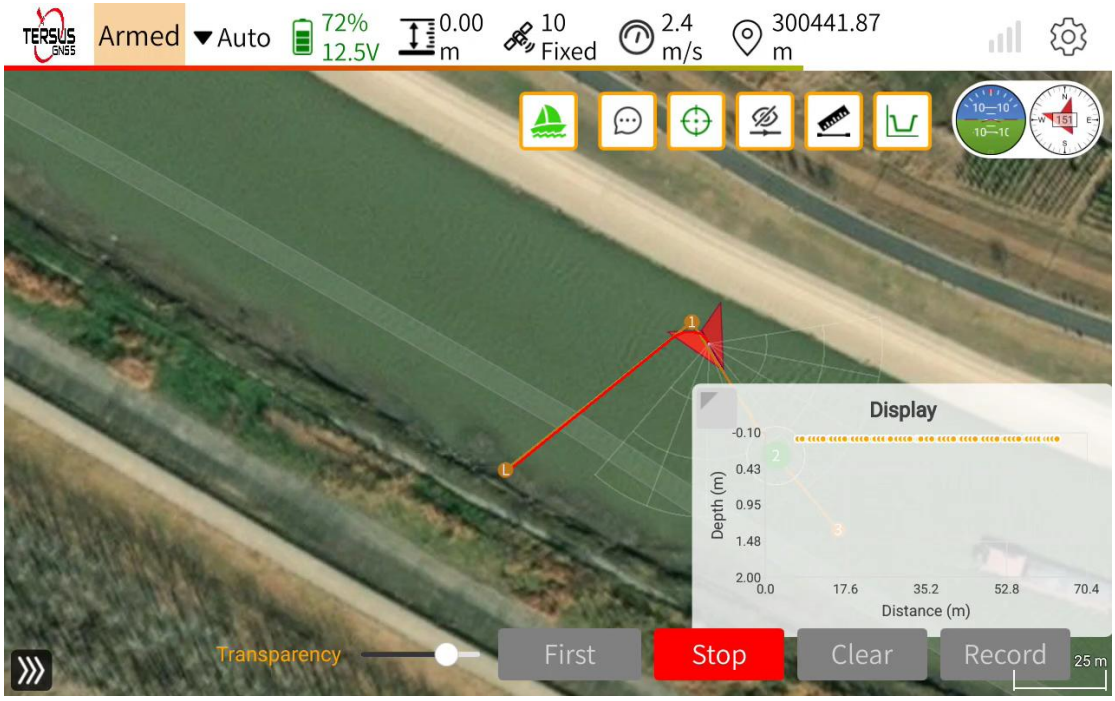


Figure 6.20 Start the Collection

4) Once the USV reaches the opposite bank, tap **[Stop]**. The cross-section data will be saved in the Download folder on the remote controller.

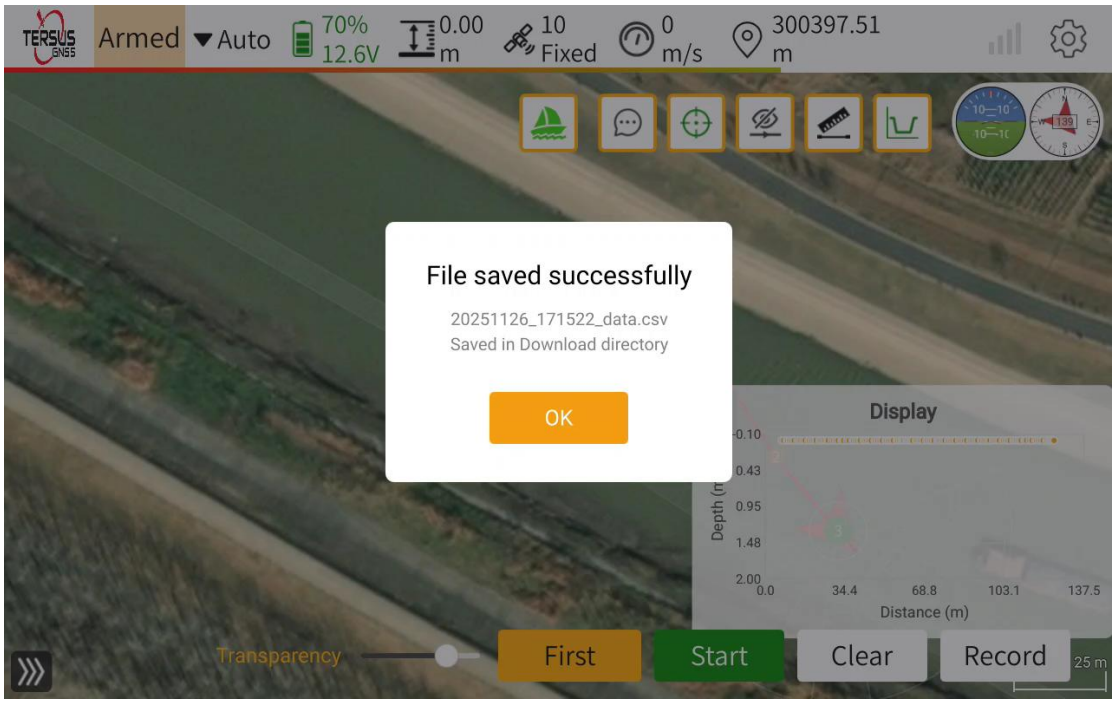


Figure 6.21 Finish the Collection

5) After manually or automatically completing the cross-section run and the file is successfully saved, you can tap **[Record]** in the cross-section window to play back the data. Navigate to the remote controller's storage space under Standard_94/Download, and select the newly saved file according to its date.

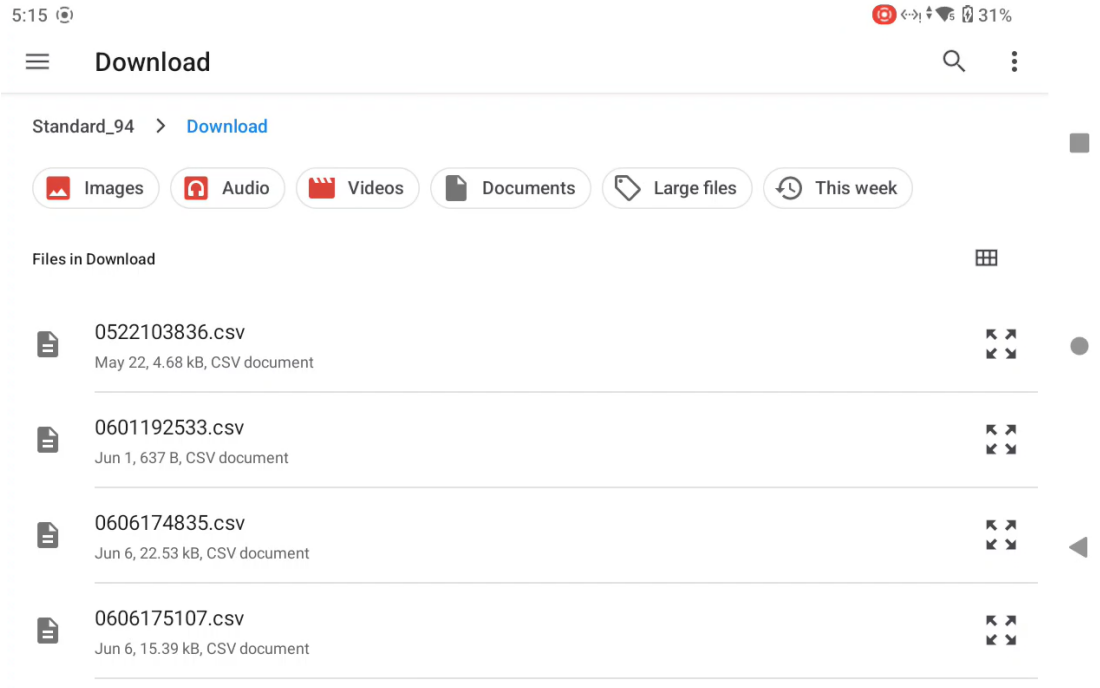


Figure 6.22 Select the Data File to Play Back

6) After opening the data playback, you can review the recorded data in the floating window. The cross-section track will also be marked by a thick red line on the base map. At the bottom of the floating window, you can configure the following on-site environmental parameters:

- Shore: The distance from the starting point to the bank, the unit is meter.
- Elevation: The water surface elevation, the unit is meter. If the USV's positioning status is Fixed, this input is optional, and the exported data will use the default seabed elevation. If the positioning status is Single Point or lower, input this value to improve the accuracy of the seabed elevation data.
- Interval: The sampling distance interval for the output data, the unit is meter.

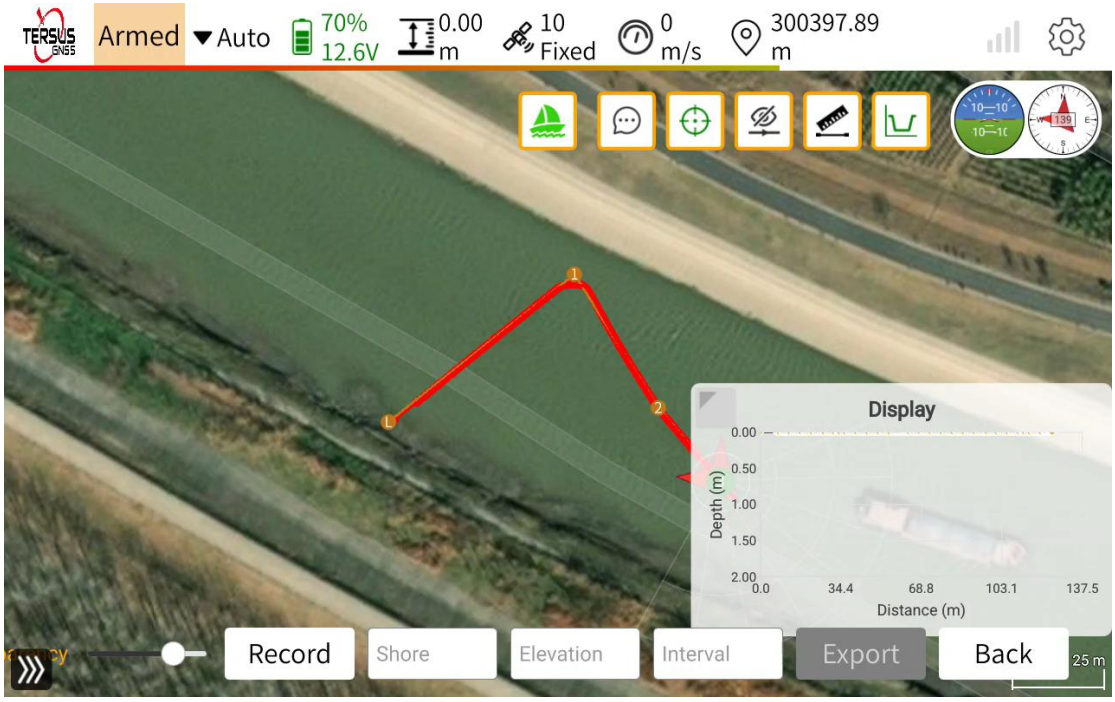


Figure 6.23 Data Play Back

7) After entering the values, tap **[Export]** The file will be saved in the Download folder named with **[Date_filtered].csv**.

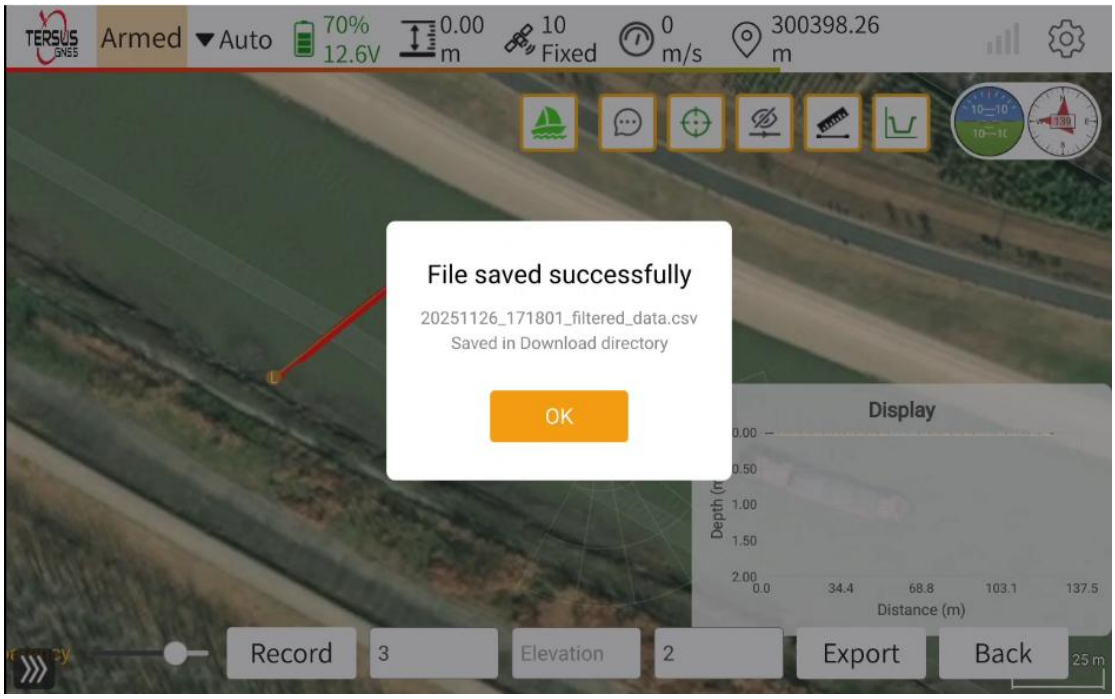


Figure 6.24 Save the file

8) Connect the remote control to a computer using the provided data cable. Navigate to **Remote Control / Settings / Storage / Internal Shared Storage / Other / Download** to locate and view the **[Date_filtered].csv** file.

6.8 Camera

The live camera feed is located in the lower-left corner of the software interface. You can drag its borders to resize the video window or tap on it to switch places with the map display. During navigation, this camera provides a real-time view to check for obstacles ahead, ensuring the safety of the USV and the smooth progress of waterborne operations.

Detailed Functions:

- Resize the Video Window: Drag the borders of the camera window to change its size.

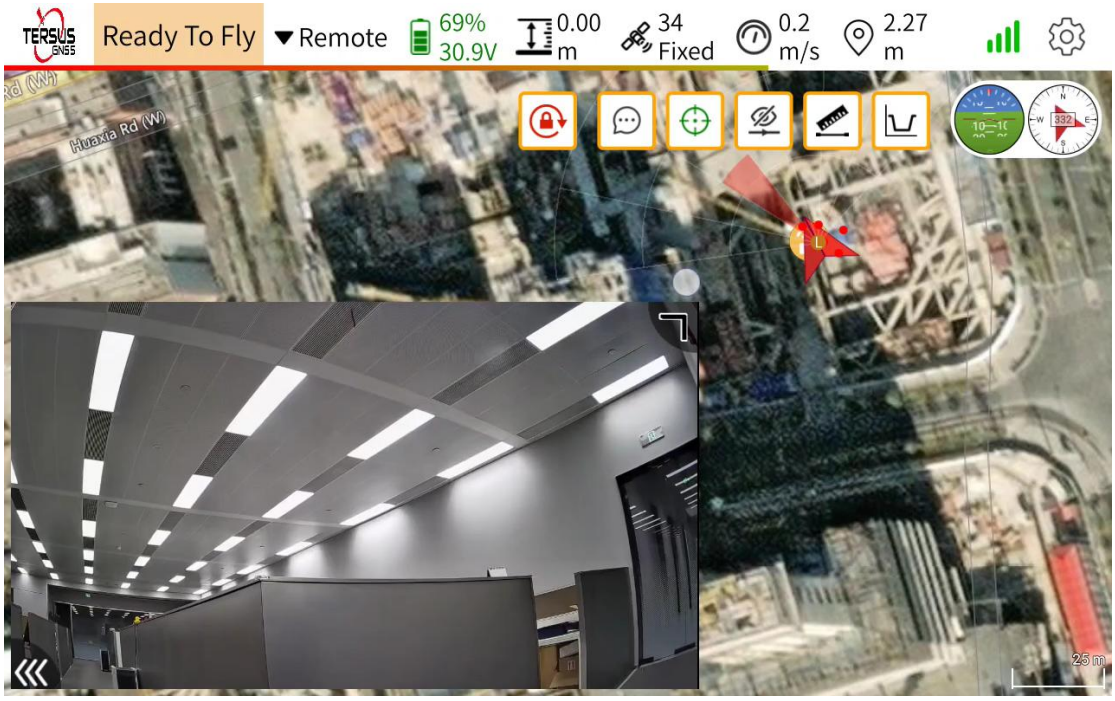


Figure 6.25 Camera Window

- Hide/Show the Camera Panel: Click the arrow on the left side of the panel to hide the camera window, maximizing the map view. Click it again to restore the camera panel.

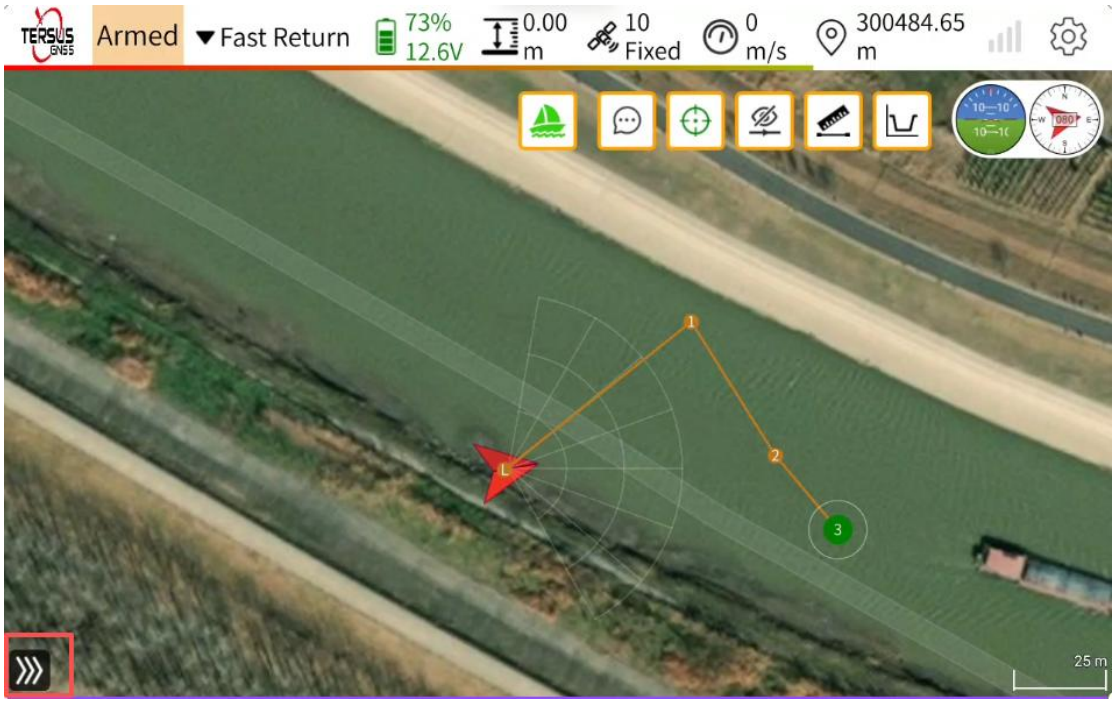


Figure 6.26 Hide the Camera Window

- Toggle Full-Screen View: Tap on the camera window to switch it with the map on the main display, maximizing the camera feed for a better view.
- Upon tapping the window to expand the camera view to full screen, Record and Photo toggle buttons will appear on the right side of the screen, allowing you to start video recording or capture photos at any time during operations. A virtual joystick for directional adjustment is located in the lower-right corner, which can be used to control the camera's orientation.

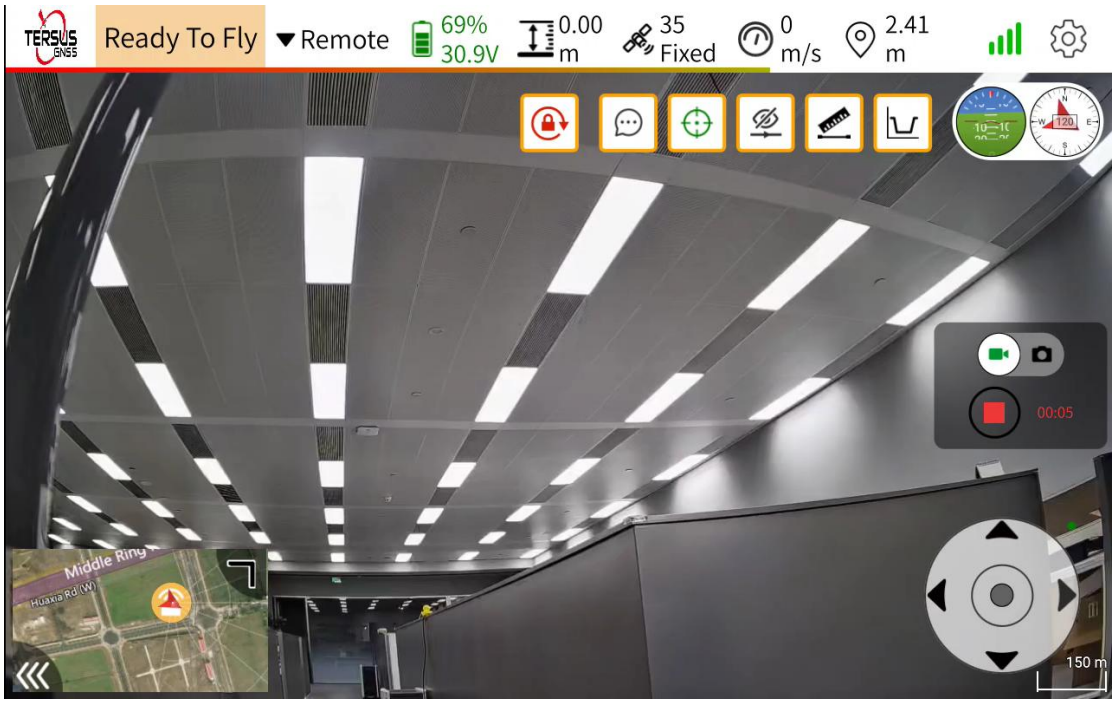


Figure 6.27 Full-Screen Camera View

7. USV Recovery

This chapter describes the detailed operation methods for TheDuck™ USV recovery.

7.1 Power Down

After mission completion, manually navigate the USV back to shore at low speed and retrieve it from the water. Power off the USV first, then turn off the remote control. Open the front compartment and disconnect the battery to complete the full power-down.

7.2 Hull Inspection

Conduct a thorough inspection of the hull. Remove any debris entangled in the propellers promptly to prevent performance issues. Check the hull for impacts and any signs of water leakage. If leakage is found, contact our technical support immediately for repair.

7.3 Equipment Unloading

Unload all mission equipment (e.g., the GNSS receiver) from the USV. To access depth data, remove the SD card from the echo sounder unit, use a SD card reader to transfer the data to a computer, and then reinsert the card into the echo sounder promptly after copying to prevent loss.

7.4 Post-Operation Maintenance

1) Thoroughly rinse the USV hull with fresh water after each use to ensure cleanliness.
2) Inspect the propellers for any entangled debris and remove if present.
3) Check the hull for damage. Pay special attention to the bottom surface:

- If excessive scratching is observed, maintenance is required.
- Minor damage can be sealed using waterproof sealant.
- Significant damage requires the unit to be returned for professional maintenance.

4) Check the hull for water leakage. If any is found, please contact our support personnel immediately to prevent potential instrument damage or impact on future operations.

8. Terminology

Table 8.1 Terminology

Abbreviation	Description
USV	Unmanned Surface Vessel
SBES	Single Beam Echo Sounder
RTK	Real-Time Kinematic
TAP	Tersus Advanced Positioning
PP	Polypropylene
HD	High Definition
RF	Radio Frequency
GNSS	Global Navigation Satellite System
CORS	Continuously Operating Reference Stations
NMEA	National Marine Electronics Association

TF	TransFlash
USB	Universal Serial Bus
UHF	Ultra-high Frequency

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