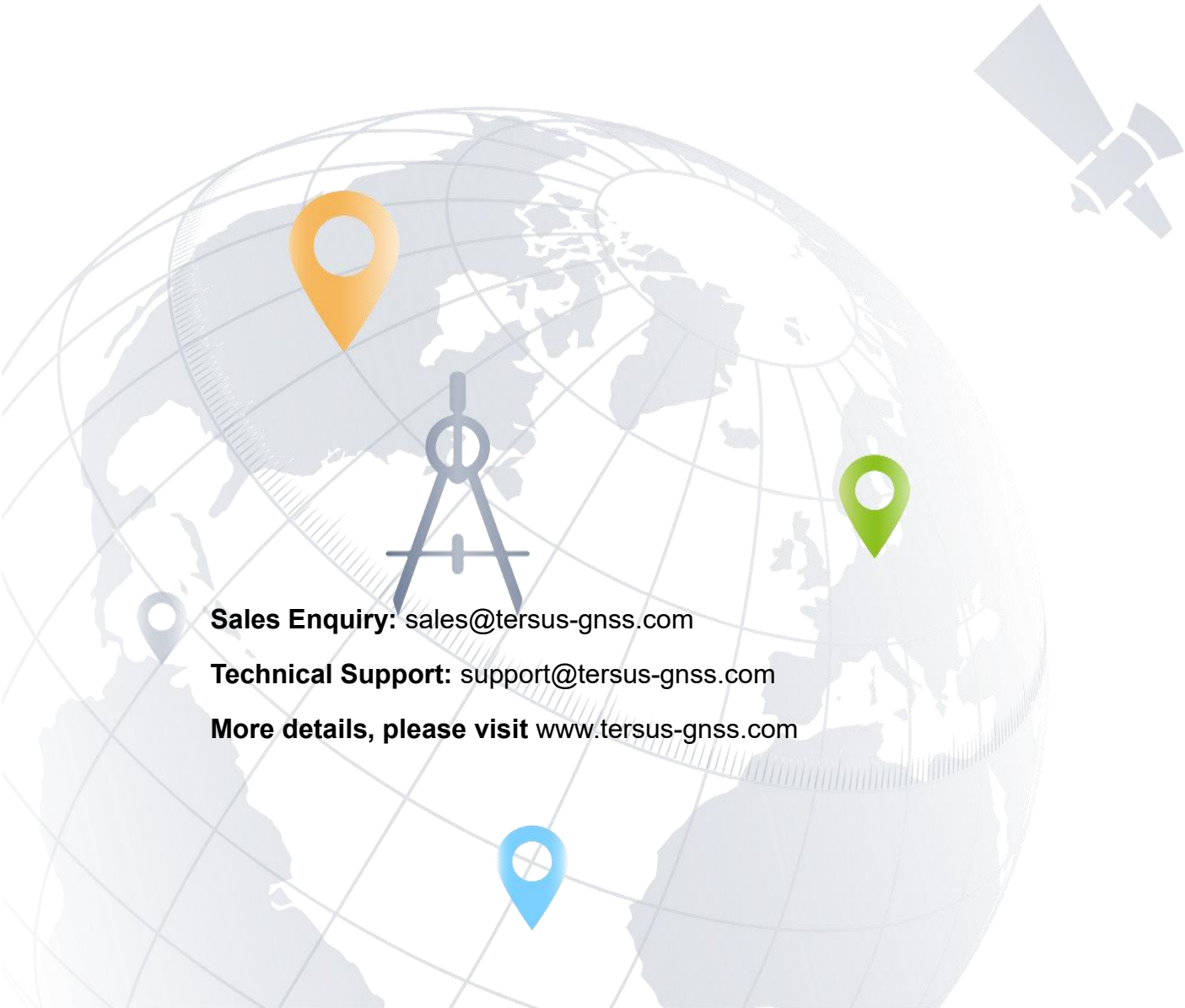
TS21 GNSS Receiver

User Manual



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Revision History

Version	Revision Date	Change Summary
1.0	20251105	Initial Release

TS21 GNSS Receiver User Agreement

CAUTION! Please read this notice carefully before using TS21 GNSS Receiver. Use of TS21 GNSS Receiver indicates acceptance of the terms and conditions of the User Agreement.

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5.Disclaimer

Tersus will try best to make that the function of TS21 GNSS Receiver run normally and the data calculation is correct, but Tersus does not guarantee that all functions of the TS21 GNSS Receiver meets the expectations, the data calculation is correct and the stability of the TS21 GNSS Receiver runs stably. Tersus and distributors will not be liable for any indirect, special, incidental, consequential or exemplary damages caused in any way.

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Tersus TS21 GNSS Receiver and related materials (including, but not limited to, any images, photographs, animations, video, audio, music or text incorporated into the TS21 GNSS Receiver), and all intellectual property rights associated with it, whether exists in a tangible media or in an electronic media is owned by Tersus. You may not remove or alter any trademark, logo, copyright and other proprietary notice in or on the products.

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Tersus has the right to amend all the contents of this agreement and product policy, and the right to interpret them within the scope of law.

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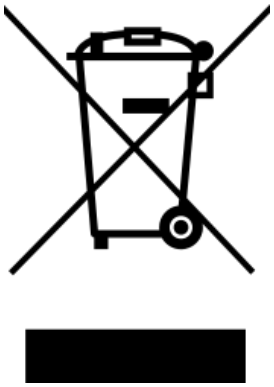
Notices

Restriction of User of Certain Hazardous Substances (RoHS)

Tersus GNSS Inc. declares that TS21 GNSS receiver is in compliance with the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) RoHS Directive 2011/65/EU and its Amendment Directives (EU) 2015/863.

Waste Electrical and Electronic Equipment (WEEE)



This product must not be disposed with household waste.

Dispose of the product appropriately in accordance with the national regulations in force in your country.

Always prevent access to the product by unauthorised personnel.

Product-specific treatment and waste management information can be received from your local Tersus distributor.

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.

The following notices apply to all three versions of TS21 GNSS receivers.

	Operating or storing the receiver outside the specified temperature range can damage it.

	Changes or modifications to this equipment not expressly approved by Tersus could void the user’s authority to operate this equipment or even has risk to damage the receivers.

	DO NOT use the receiver in a thunderstorm as there is increasing risk of being stuck by lightning.

	Install the radio antenna before switching the radio transceiver to

	transmit mode, or the radio transceiver may be damaged due to overheating. The energy to be transmitted cannot be emitted out without the antenna, which may cause the temperature rise and overheat of the radio module.

	Safety: exposure to radio frequency (RF) Exposure to RF energy is an important safety consideration. Although our product is compliance with the safety standard released by various standard organizations, the following precautions are recommended to ensure low exposure to radio frequency radiation. ● DO NOT operate the transmitter when someone is within the following distances of the antenna: ➢ Bluetooth, Wi-Fi, GSM/UTMS – less than 20cm ➢ 450-470MHz UHF radio – less than 47cm ● DO NOT operate the transmitter unless all RF connectors are secured and any open connectors are properly terminated. ● DO NOT operate the equipment near electrical blasting caps or in an explosive atmosphere. ● All equipment must be properly grounded. ● All equipment should be serviced only by a qualified technician.

Related Documentation

Table 0.1 Document and software used in this user manual

Name	Description	Link
Nuwa	Survey application running on Android, David, Oscar, Oscar Trek, TS21 and other NMEA devices can be configured with Nuwa.	https://www.tersus-gnss.com/software/software

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.

Table of Content

1. Introduction

This chapter includes overview, receiver features, and devices in the package.

1.1 Overview

TS21 GNSS receiver is an innovative integration of visual positioning technology, GNSS, IMU and dual cameras. Its front camera enables high-precision, high-efficiency and multi-point measurement, allowing you to measure what you see and generate point clouds on site. Its front and bottom cameras work in tandem to support CAD AR visual stakeout, enabling precise path planning at varying distances. Its built-in IMU ensures accuracy without any limitation on tilt angles.

With an internal high-performance multi-constellation and multi-frequency GNSS board, the TS21 GNSS receiver can provide high accuracy and stable signal detection. The high-performance antenna can speed up the time to first fix (TTFF) and improve anti-jamming performance. The built-in large capacity battery supports up to 9 hours of field work in 4G/3G/2G network and Rover radio mode. The built-in UHF radio module supports long distance communication. The rugged housing protects the equipment from harsh environments.

1.2 Receiver features

The TS21 GNSS receiver has following features:

- Supports multiple constellations & frequencies
  - GPS L1C/A, L2C, L2P, L5
  - GLONASS L1C/A, L2C/A
  - Beidou B1, B2, B3 , support BDS-3
  - Galileo E1, E5a, E5b
  - QZSS L1C/A, L2C, L5
  - SBAS supports WAAS, EGNOS, GAGAN, SDCM, MSAS
- Supports 1792 channels.
- Innovative visual positioning technology for precise measurements.
- Measure what you see, save your time.
- Point clouds generation and export from measurement results.
- Dual professional cameras, visual navigation and stakeout in One step.
- Supports 410-470MHz UHF radio, 4G network, Wi-Fi , Bluetooth, NFC.
- Tilt compensation without calibration, immune to magnetic disturbances .
- 32GB internal storage
- IP68-rated dust- & waterproof enclosure, for reliability in harsh environmental conditions
- Free subscription of Tersus Caster Service (TCS): transmit the correction data from Base to Rover

1.3 Devices 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 TS21 GNSS receiver

The TS21 GNSS receiver is shown as below.

Figure 1.1 TS21 GNSS receiver

Buttons

One buttons is equipped on TS21 GNSS receiver.

[]: Power ON/OFF button. When the device is off, long press it for 2 seconds to power on the receiver. When the receiver is on, long press it for over 3 seconds to power off the receiver.

LED Indicators

Four LED indicators for TS21 GNSS receiver; smart battery with power display on the bottom. The LEDs on the front panel indicate various operating conditions. The detailed LED Descriptions are shown in the tables below.

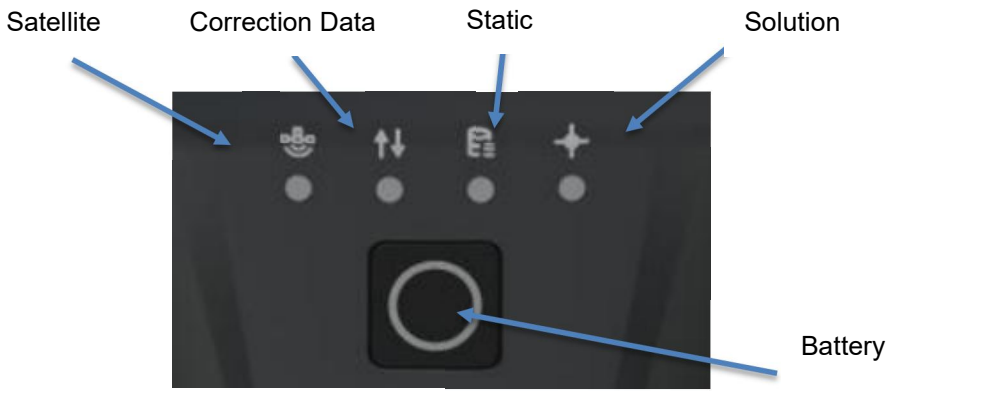


Figure 1.2 Buttons and display on TS21

Table 1.1 LED indicators

LED indicator	Description
Satellite	Blue LED. No flashing indicates no satellites. Flashing indicates that it is searching satellites. If only 1-3 satellites are found, it flashes every 5 seconds. If more than 4 satellites are found, it flashes every 1 second.
Correction data	Blue LED. Flashing indicates correction data.
Static Survey	Blue LED indicates static survey mode.
Solution status	Blue LED. Steady blue indicates fixed solution, flashing 1Hz indicates floating solution, off light for other solutions.
Battery	Blue LED. Steady blue in normal operation. Slow flash indicates the battery level is between 25% and 15%. Fast flash indicates the battery level is below 15% and reminds users to change battery.

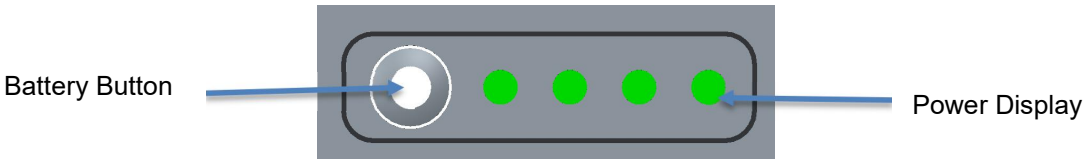


Figure 1.3 Smart battery with power display

Table 1.2 Power display and button

LED indicator	Description
Battery Button	After clicking the battery button, the green light will be on to display the current remaining power.
Power Display	Green LED. Under normal circumstances, one indicator represents 25% of the power. When charging, the green light flashes to display the current charging power.

LED Flash Patterns

The possible flash patterns of various states of receiver operation are listed in the table below.

Table 1.3 Possible LED flash patterns

Receiver mode	Button operation	LED flash patterns
Receiver OFF	Long press the power button for 3s	All LEDs are off.
Receiver ON	Long press the power button for 2s	All LEDs are on, then all off, and each LED especially the power button starts to indicate current status after initialization.
Low power	N/A	Battery LED flashes slow.
Battery exhausting	N/A	Battery LED flashes fast.
Searching satellites	N/A	Satellite LED flashes.
Satellites tracked	N/A	Satellite LED flashes every 5s for 1-3 satellites and flashes every 1s for more than 4 satellites.

Receiving valid data packet	N/A	Correction data LED flashes blue at 1Hz.
Static mode	N/A	Static status LED is steady blue.
Fixed solution	N/A	Solution status LED is steady blue.
Floating solution	N/A	Solution status LED flashes blue at 1Hz.
Firmware upgrade	N/A	For Basic version, all six LEDs are on for 1s thereafter only power LED lights up, then all LEDs light up when upgrading, lights off when restarting. Then all six LEDs light up for 1s thereafter only power LED lights up means it restarts successfully with updated firmware.

Note: N/A means Not Applicable.

Receiver Ports

The bottom of TS21 receiver is shown as below.

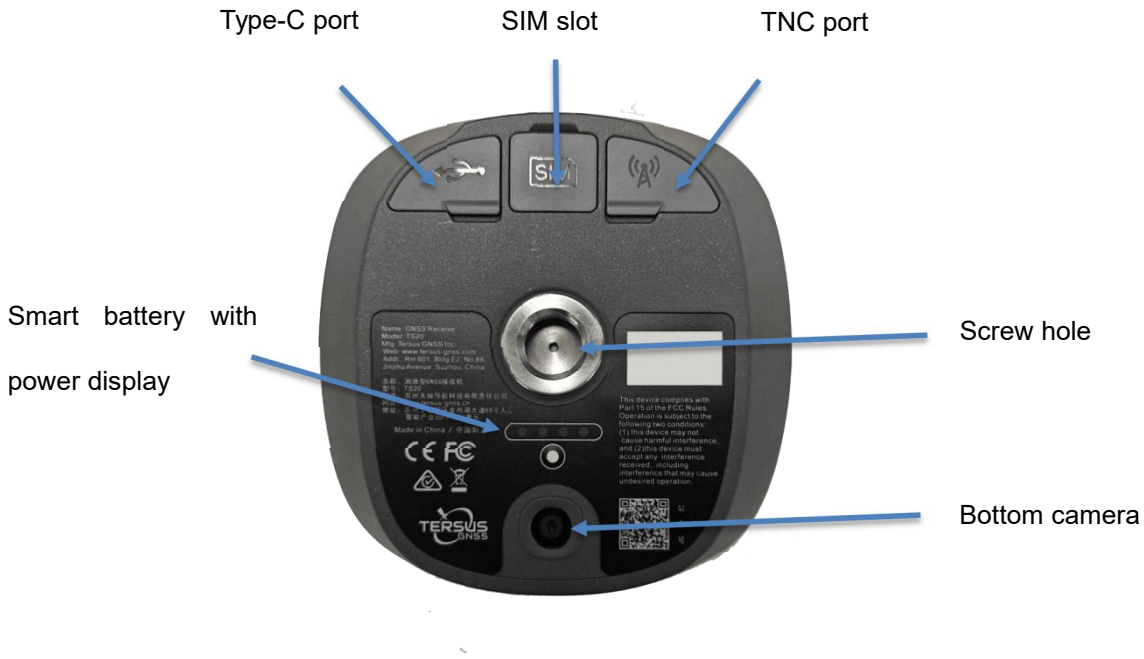
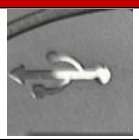


Figure 1.4 Bottom of TS21 GNSS receiver

Table 1.4 Receiver ports on the bottom side

Icon	Name	Connections
	Serial port & external power	Device, computer, USB drive, external power, communication, external radio
	SIM slot	Nano SIM card
	TNC port	Radio antenna
	Screw hole	5/8'' x 11 UNC-2B connector for corresponding connector and pole.

1.3.2 Type-C to USB cable

Functions:

1.Connect to the USB port of computer for data downloading;

2.Firmware upgrade, details refer to section 2.4；

3.Connect to the charger adapter to charge TS21. Charge the battery completely before using TS21 for the first time. The charging takes approximately 3 hours at room temperature. If the battery has been stored for longer than three months, charge it before use.

Figure 1.5 Type-C to USB cable

1.3.3 Adapter

Connect to the Type-C cable to charge TS21. The maximum power can reach 15W(5V 3A), realizing fast charging.

Figure 1.6 Adapter for EU

Figure 1.7 Adapter for US

Figure 1.8 Adapter for UK

Figure 1.9 Adapter for AU

EU: European, US: American, UK: British, AU: Australian

1.3.4 TC80 controller

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.

Features:

- 5.5 inch sunlight readable HD touch screen
- Octa-core 2.0GHz CPU
- Android 12 operating system
- 6GB RAM + 64GB ROM
- 13MP rear camera
- IP68 certified grade, water/shock/dust proof
- 7700mAh battery
- Wi-Fi, Bluetooth, NFC, 4G
- USB Type-C

Note: Although the TC80 controller uses chemical and impact resistant materials, precision instruments require careful use and maintenance and should be kept as dry as possible. In order to improve the stability and life cycle of the TC80 controller, avoid exposing the TC80 controller to extreme environments such as moisture, high temperatures, low temperatures, corrosive liquids or gases.

⚠	TC80 must be in the specified temperature range -20 °C ~ 60 °C when used and stored.

Figure 1.10 TC80 Controller

Power on: Press and hold the power button for 3 seconds

Power off: Press and hold the power button for 3 seconds, select ‘Power Off’ in the menu option.

Reboot: Press and hold the power button for 2 seconds and click "Restart" in the menu option.

Forced restart: Press and hold the power button for 8 seconds to force the controller to restart.

Introduction of functional keys：

- **Menu Key:** Select to show applications that was used recently.
- **Home Key:** Return to home screen. To view recent application, press and hold the home key.
- **Back Key:** Return to previous screen.
- **APP Key:** Quick start Nuwa application.
- **Positioning Key:** Perform the function of starting measurement in the Survey and Stakeout interface of Nuwa application.

- **Short Press on Power Key：** Control the screen on and off.
- **Enter Key:** Execute the function of confirming in Nuwa application.

The accessories of TC80 Controller are listed below.

TC80 Charger

Figure 1.11 TC80 Charger

Type-C Cable

Figure 1.12 Type-C Cable

Functions:

1. Connect to the USB port of computer for data downloading;
2. Connect to the charger to charge TC80 controller.

1.3.5 Other accessories

Other accessories may be packed according to customer requirements.

The GNSS antenna connector is used to install TS21 to a tripod.

Figure 1.13 GNSS antenna connector

The height measure accessory is used to determine the height of TS21 with higher accuracy.

Figure 1.14 Height measure accessory

The 450-470MHz radio whip antenna is to be installed on the TNC port to transmit or receive signal for the internal radio. And 430-450MHz radio antenna, 410-430MHz radio antenna, 410-470MHz radio antenna are optional.

Figure 1.15 450-470MHz radio whip antenna

When using TS21 as a rover, you need a ranging pole.

Figure 1.16 Ranging Pole

The bracket for TC80 controller is to fix the TC80 controller on a ranging pole.

Figure 1.17 Bracket for TC80

A yellow carrying case is to store all the devices and accessories except ranging pole, high gain radio antenna and telescopic pole.

Figure 1.18 Carrying Case

2. General Operations

This chapter includes setting up, configuration and other related operations.

2.1 Setting up TS21

2.1.1 Insert the SIM card

When 4G/3G/2G network is chosen for survey operation, you need to insert a nano SIM card into TS21 GNSS receiver. Insert the nano SIM card with the contacts facing outside which is shown as below.

Figure 2.1 Insert the SIM card

To eject the nano SIM card, slightly push it in to trigger the spring-loaded release mechanism.

Note: The SIM card is provided by your cellular network service provider.

2.1.2 Fix TS21 on a ranging pole

Figure 2.2 TS21 as a rover without radio antenna

Table 2.2 Devices to set TS21 as a rover without radio antenna

Device Name	Quantity	Items in the figure
TS21 GNSS receiver	1	1, details refer to section 1.3.1
Ranging pole	1	2, details refer to section 1.3.5
Bracket for TC80	1	3, details refer to section 1.3.5
TC80 Controller	1	4, details refer to section 1.3.4

2.2 TS21 configuration

You can configure TS21 GNSS receiver via TC80 controller or other android devices with Tersus Nuwa application.

The detailed introduction of TC80 controller refers to section 1.3.4 and technical specification refers section 3.2. Here in this section describes how to configure TS21 via Nuwa app which is installed in TC80 controller.

2.2.1 Connect TS21 in Nuwa

The general operations of Nuwa app refer to *User Manual for Nuwa App* which can be downloaded on Tersus official website.

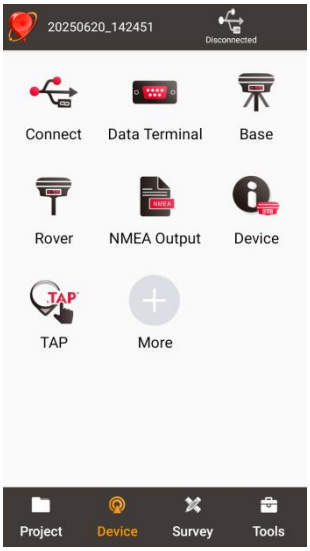


Figure 2.3 Device functional group

When TS21 GNSS receiver is powered on, to connect TS21, put TC80 controller near the NFC logo on TS21, the TC80 controller pair WiFi with TS21 automatically; or click [Device] -> [Connect] under an opened project, and select [TS21] for the Device Type which is shown as below.

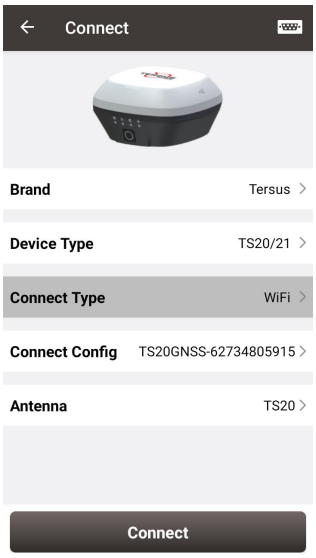


Figure 2.4 Connect TS21 via WiFi

Click [Connect Config] to search and connect WiFi of TS21. The antenna is selected as [TS21] by default. Then click [Connect] to enable the communication between TC80 controller and TS21.

2.2.2 Registration

When the registration is not effective, follow below steps to complete the registration by using QR code.

Click the scan button at the top right of the device information interface and directly scan the QR code provided by kinematic to complete the registration.

2.2.3 Configure rover

To configure TS21 as a rover, back to Device interface which is shown in Figure 2.6 Device functional group, click [Rover], then create a work mode of detailed configurations for base or rover which are shown as below.

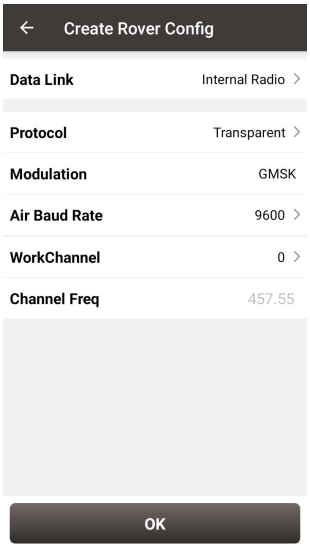


Figure 2.5 Rover configuration

Fill in the detailed information of base configuration or rover configuration, then click [OK] and back to the work mode list, select this configuration to start data transmission for rover which are shown as below.

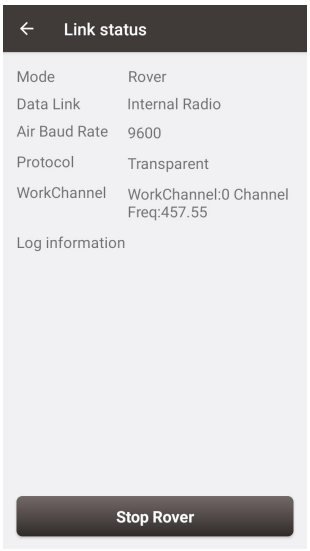


Figure 2.6 Link status of Rover

2.3 Data download

2.3.1 Connection

TS21 can be used as an USB storage device when connecting with a computer. Before connecting TS21 to a computer, ensure TS21 is powered on. Use the Mini USB cable in the package to connect TS21 to the USB port of a computer which is shown as below.

Figure 2.7 Connect TS21 to a computer

After completing the connection, a USB device is listed in the file browser of the computer. Find the data file needed to download, copy and paste it to a designated folder in your computer.

2.3.2 Download static data

If you want to download the recorded static data for post processing, find F:\record folder in the USB drive shown as below, and then copy the specific file you need to your computer.

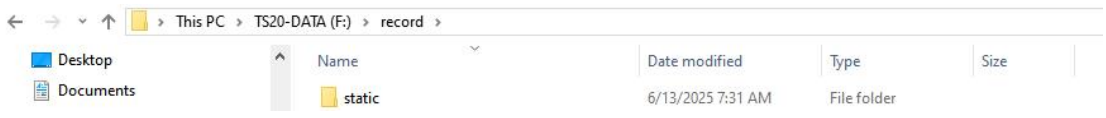


Figure 2.8 Static record folder

Each folder named after the date contains rinex format and tersus binary data, which can be downloaded and processed as you need.

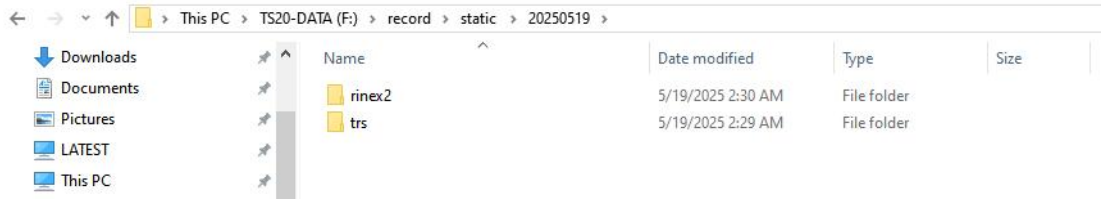


Figure 2.9 Static data for one day

2.3.3 Download debug data

When you don't turn on the debug mode, find F:\debug\LOG folder and you can see rtkmain.log file which includes all the operation information of the receiver.

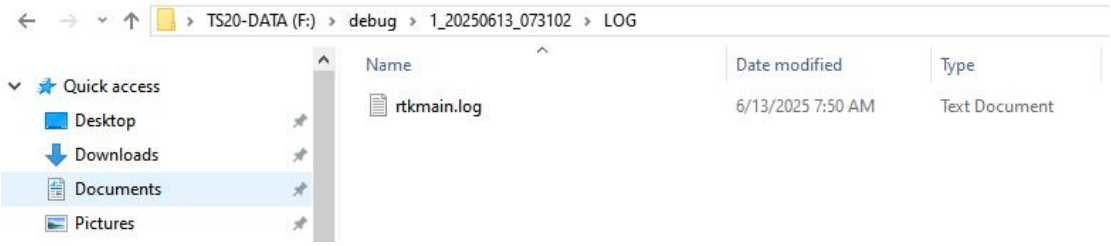


Figure 2.10 rtkmain.log file location

To turn on the debug mode, you can click [Device] -> [Device Debug] -> [Set] in Nuwa app. The debug information includes GNSS, tilt, internal radio and NTRIP information. Select the debug info you want to record and turn on the debug mode. After you select some debug info to turn on and confirm, TS21 will record them when you are doing survey work.

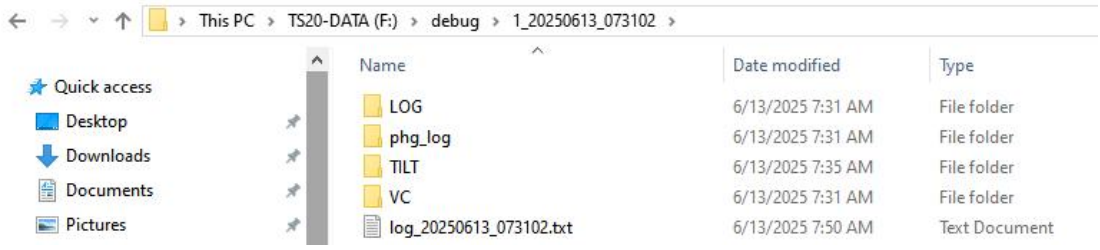


Figure 2.11 Debug info folders

Send these debug info to Tersus technical support team to help solve the problems you encountered.

2.4 Firmware upgrade

View TS21 firmware version. When TS21 GNSS receiver is powered on, to connect TS21, put controller near the NFC logo on TS21, the controller will connect to TS21 automatically via WiFi; or click [Device] -> [Connect] under an opened project, and select [TS21] for the Device Type, select [WiFi] for the Connect Type. Click [Connect Config] to search and select the WiFi of TS21. The antenna is selected as [TS21] by default. Then click [Connect] to enable the communication between controller and TS21.

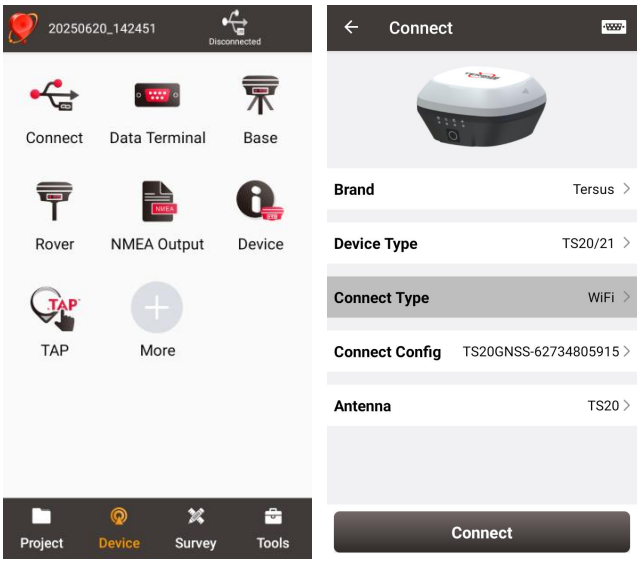


Figure 2.12 Connect to TS21 via WiFi

Click [Device] in the Device screen, the TS21 info is shown as below. You can view TS21 firmware version.

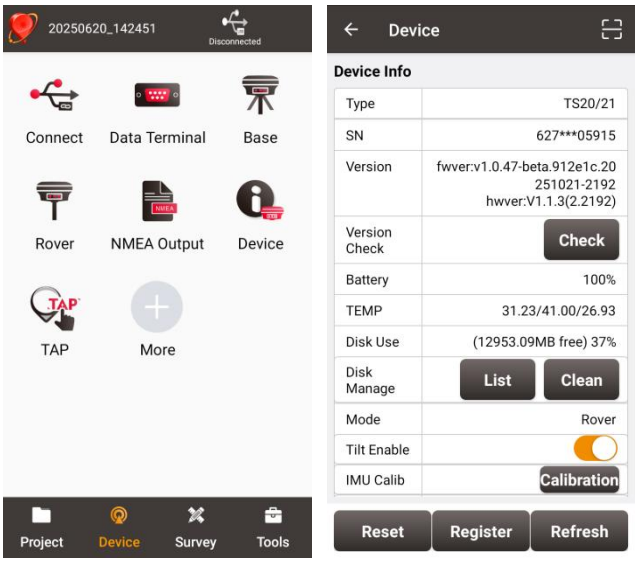


Figure 2.13 View TS21 firmware version

The detailed steps are as follows.

1) Download the latest firmware file from kinematic website

Please be noted that the downloaded file is a .zip file, unzip this file to find the firmware file of .BIN format.

2) Prepare a Type-C to USB cable, when TS21 is turned on, connect the

Type-C port of TS21 to the computer with a Type-C to USB cable.

Figure 2.14 connect the computer and TS21

3) The computer interface will automatically pop up two removable disks. As shown in the figure below.

Figure 2.15 Two Removable Disks

4) Choose the Update removable disk and put the firmware file in the .BIN format on this removable disk. As shown in the figure below.

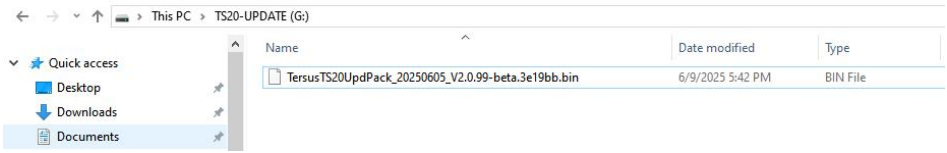


Figure 2.16 The FW is placed in the Update removable disk

5) Unplug the Type-C to USB cable, press and hold the power button for 3 seconds to shut down TS21 .

6) Make sure that TS21 is turned off, then press and hold the power button to

turn on TS21.

When the indicators on the LED panel are all on, the boot is successful, release the power button. TS21 enters the upgrade mode when the indicators on the LED panel start blinking, and waits for the upgrade to complete.

After the firmware upgrade is completed, the power LED light is on and the satellite light flashes. At this time, you can check the TS21 firmware version. If it is consistent with the latest firmware version in the removable disk, the firmware upgrade is successful.

Note: Please make sure the battery has enough power for the firmware upgrade. The GNSS board inside TS21 will upgrade when the firmware is upgrading, any forced power failure will cause the system crash.

2.5 Operations of TC80 controller

2.5.1 Insert SIM card and SD card

Please note the direction of the card notch when inserting the card, inserting a non-standard card may cause damage to the SIM card slot of the controller.

To install the card you need to pull out the SIM card slot on the side.

Figure 2.17 SIM card slot

2.5.2 Using of touch screen

Single Click: To select an icon. For example, click dial to open the keypad which will be displayed on the screen.

Double Click: To zoom-in or zoom-out. For example, to zoom-in or out of a photo, click twice when viewing a photo or browsing on the internet.

Hold: press and hold the screen, icon or input box to get more operation options.

a) Long-Time Click a picture in the gallery list interface, the status bar prompts to select a picture, you select to share or delete it.

b) Long-Time Click the blanks of home screen to add home screen widgets.

c) Long-Time Click the blanks of home screen wallpaper sources can be selected.

d) Long-Time Click the blanks of home screen to home settings.

Slide Upward: Slide up on the main screen (or click the upward arrow icon) to view more applications.

Slide Downward: Slide down on any interface to open the status bar and message board.

Slide Left and Right: Slide left and right on the main screen to switch the desktop interface.

3. Technical Specifications

This chapter mainly introduces the technical specifications of TS21 GNSS receiver, TC80 Controller , external radio and internal radio whip antenna.

3.1 TS21 GNSS receiver

Table 3.1 TS21 GNSS receiver performance

GNSS Performance		
Position accuracy(RMS)	Single Point Positioning	1.5m (Horizontal)
		3.0m (Vertical)
	DGPS Positioning	0.25m (Horizontal)
		0.5m (Vertical)
	High Precision Static	2.5mm+0.1ppm (Horizontal)
		3.5mm+0.4ppm (Vertical)
	Static & Fast Static	2.5mm+0.5ppm (Horizontal)
		5mm+0.5ppm (Vertical)
	Post Processed Kinematic	2.5mm+1ppm (Horizontal)
		5mm+1ppm (Vertical)
	Real Time Kinematic	8mm+1ppm (Horizontal)
		15mm+1ppm (Vertical)
	Network Real Time Kinematic	8mm+0.5ppm (Horizontal)
		15mm+0.5ppm (Vertical)
Observation accuracy (zenith direction)	C/A code	10cm
	P code	10cm
	Carrier phase	1mm
Time To First Fix (TTFF)	Cold start	<35s
	Warm start	<10s
Reacquisition	<1s	
Tilt compensation accuracy (within 60°)	≤2cm	
Timing accuracy (RMS)	20ns	
Velocity accuracy (RMS)	0.03m/s	
Initialization (typical)	4s	
Initialization reliability	>99.99%	
System & Data		
Operating system	Linux	
Storage	built-in 32GB	

Data format	CMR, CMR+ (GPS only), RTCM 2.3, RTCM3.0, RTCM3.1, RTCM3.2	
Data output	RINEX, NMEA-0183, Tersus Binary	
Software Support		
Tersus Nuwa		
Communication		
Cellular	4G LTE/WCDMA/GSM/EDG	
Cellular bands	LTE FDD B1,B3,B7,B8,B20,B28A LTE TDD B38,B40,B41 WCDMA B1,B8 GSM/EDGE B3,B8	
Network protocols	Ntrip Client, Ntrip Server, Tersus Caster Service (TCS)	
Wi-Fi	802.11b/g	
Bluetooth	4.1	
Internal radio	RF transmit power	0.5W/1W/2W
	Frequency	410MHz ~ 470MHz
	Operating mode	Half-duplex
	Channel spacing	12.5KHz / 25KHz
	Modulation type	GMSK, 4FSK
	Air baud rate	4800/9600/19200 bps
	Radio protocols	TrimTalk450, TrimMark 3, South, Transparent, Satel
USB OTG	Type-C, OTG x1	
Electrical		
External power supply	Support USB (5~20V)	
Fast charging	Support, 15W max(5V 3A)	
Lithium battery	7000mAh/7.4V	
Charing time	3 hours (20%~90%)	
Battery charging temperature:	+10°C ~ +45°C	
Battery working time	Up to 9 hours	
Physical		
Dimension	ф132x68mm	
Weight	≈850g	
Screw hole for assembly	5/8"x11UNC-2B	
Vibration	MIL-STD-810G,FIG.514.6C-1	
Environmental		
Operating temperature	-40°C to +70°C	
Storage temperature	-55°C to +85°C	
Relative humidity	100% not condensed	
Water & dust proof	IP68	
Pole drop onto concrete	2m	

The pin definition of the TNC connector is as below:

Table 3.2 Pin definition of the TNC connector

Connector Pin No.	Pin Definition
Inside	Signal
Outside	Ground

Table 3.3 Default factory configuration for internal radio

Channel	Frequency
00	457.550MHz
01	458.050MHz
02	458.550MHz
03	459.050MHz
04	459.550MHz
05	460.550MHz
06	461.550MHz
07	462.550MHz
08	463.550MHz
09	464.550MHz
Customized frequency	410~470MHz

Table 3.4 Detailed configuration information for internal radio

Protocol	Modulation type	Channel band	Air baud rate	COM baud rate
TrimTalk450	GMSK	12.5 KHz	4800 bps	9600/19200/38400/115200bps
	GMSK	25 KHz	9600 bps	9600/19200/38400/115200bps
TrimMark3	GMSK	50 KHz	19200 bps	9600/19200/38400/115200bps
Transparent	GMSK	12.5 KHz	4800 bps	9600/19200/38400/115200bps
	GMSK	25 KHz	9600 bps	9600/19200/38400/115200bps
Satel	4FSK	12.5 KHz	9600 bps	9600/19200/38400/115200bps
	4FSK	25 KHz	19200 bps	9600/19200/38400/115200bps
South	GMSK	12.5 KHz	4800 bps	9600/19200/38400/115200bps
	GMSK	25 KHz	9600 bps	9600/19200/38400/115200bps

	GMSK	50 KHz	19200 bps	9600/19200/38400/115200bps

3.2 TC80 controller

Table 3.5 TC80 technical specification

System	
Operating System	Android 12
CPU	Octa-Core 2.0GHz
Memory	6GB RAM + 64GB ROM
External storage	Micro SD, up to 256GB
Display	5.5″ sunlight-readable capacitive touch screen
Resolution	720x1440
Camera	13MP Auto Focus Camera
Flash Light	High light Flash LED
Electrical	
Battery	7700mAh 3.8V
Battery Life	10 hours
Charging Time	<4 hours (fast charge)
Communication	
Wi-Fi	IEEE 802.11a/b/g/n 2.4G&5G
Cellular Mode	Dual SIM Dual Standby
SIM1 & SIM2	FDD-LTE B1/B3/B5/B7/B8 TDD-LTE B38/B39/B40/B41 WCDMA B1/B2/B5/B8 GSM B2/B3/B5/B8 CDMA/EVDO BC0/BC1
Bluetooth	BT5.0 (BLE)

USB	USB Type-C (supports OTG)
NFC	Protocol of ISO14443A/B, and ISO15693 Readable Distance 0~5cm
GNSS	GPS/GLONASS/BeiDou
Sensors:	G-Sensor, Compass, Light-Sensor, Gyro
Physical	
Dimension	221.3mmx77.7mmx19.6mm
Weight	320g (include battery)
Reliability	
Operating Temperature	-20°C ~ +60°C
Storage Temperature	-30°C ~ +70°C
Humidity	5% ~ 95%
Dustproof & Waterproof	IP68
Shock	1.5m drop onto concrete

3.3 Radio whip antenna

The 450-470MHz radio whip antenna is to be installed on the TNC port to transmit or receive signal for the internal radio. This antenna is elastic whip structure, resistant to bending.

Figure 3.1 Radio Antenna

Table 3.6 Radio whip antenna technical specification

Technical Specification	
Frequency Range	450~470MHz
Bandwidth	20MHz
Polarization Mode	Vertical
Gain	4dBi

Input Impedance	50Ω
VSWR	≤2.1
Maximum Power	20W
Connector	TNC Male
Antenna Length	303mm
Antenna Weight	About 45g
Extreme Wind Speed	90 Km/h

4. Typical Applications

This chapter introduces typical applications of TS21 receiver, and solutions for some possible issues.

⚠	Install the radio antenna before switching the radio transceiver to transmit mode, or the radio transceiver may be damaged due to overheating. The energy to be transmitted cannot be emitted out without the antenna, which may cause the temperature rise and overheat of the radio module.

4.1 Rover operation

Figure 4.10 TS21 as a Rover - Network Mode

Table 4.1 Devices of TS21 as a rover network mode

NO.	Device Name
1	TS21 GNSS receiver
2	Ranging pole
3	Bracket for TC80
4	TC80 Controller

Figure 4.2 TS21 as a Rover - Internal Radio

Table 4.2 Devices of TS21 as a rover internal radio mode

NO.	Device Name
1	TS21 GNSS receiver
2	450–470MHz radio whip antenna
3	Bracket for TC80
4	Ranging pole
5	TC80 Controller

Detailed steps of software operation:

1. Set up TS21 according section 2.1 Setting up TS21 after all the components above are ready, ensure one battery and one SIM card are installed in TS21;
2. Long press the power button to power on TS21;
3. Use NFC function to launch Nuwa app. While the screen of TC80 Controller is unlocked, put TC80 Controller close to the TS21 NFC logo. The WiFi connects automatically after a beep and Nuwa is launched requesting to open the latest project. Click [OK] and start configuring TS21 from step 7. Also you can click [Cancel] to create a new project or open an existing project, and then start configuring TS21 from step 7.

4. If using an android device without NFC function, ensure TS21 is powered on, and launch Nuwa application on the android device. Click [Project] in the main interface to create a new project or open an existing project and connect TS21 manually.
5. Back to the main interface of Nuwa app, click [Device] -> [Connect] under an opened project;
6. Select [TS21] for the Device Type, select [WiFi] for the Connect Type, click [Connect Config] to search and connect the WiFi SSID of TS21, select [TS21] for the Antenna and click [Connect] to enable communication between the android controller and TS21.
7. Back to [Device] - > [Rover], click [New] to create a new configuration for rover.

Figure 4.3 Rover setting interface

8. Edit rover configuration for TS21 GNSS receiver under different data link selections. The Receiver Network and PDA Network have three protocol options respectively: Ntrip, TCP and Tersus Caster Service (TCS).

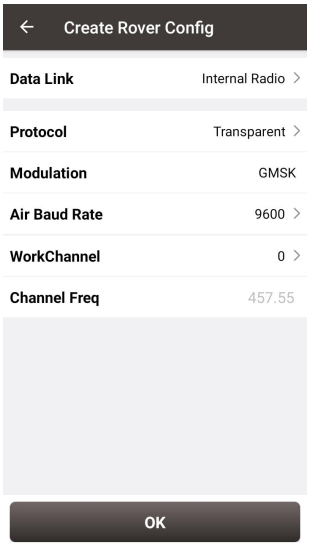


Figure 4.4 Rover configuration - Internal Radio

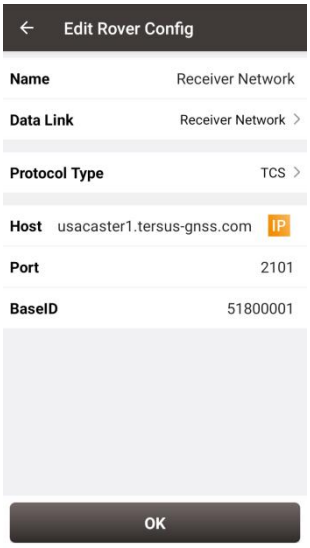


Figure 4.5 Rover configuration - Receiver Network (TCS)

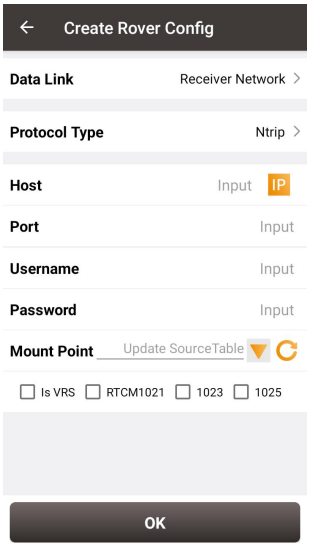


Figure 4.6 Rover configuration - Receiver Network (Ntrip)

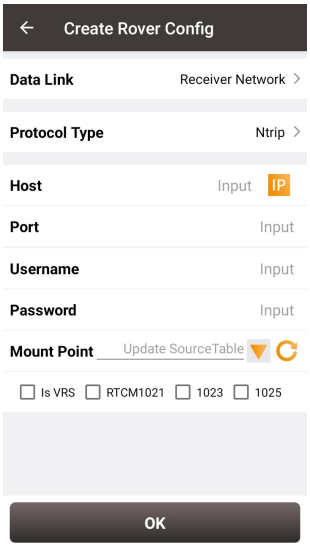


Figure 4.7 Rover configuration - PDA Network (Ntrip)

Note: Select PDANetwork when using cellular network of a PDA such as TC80 Controller.

9. After filling the information for the above configuration, click [OK]. Select this configuration in the work mode list and click [Start] to start data transmission for rover which is shown as below.

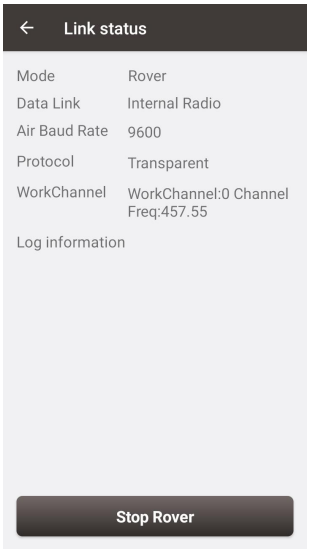


Figure 4.8 Link status of Rover using internal radio

4.2 Static survey

Detailed steps of software operation:

1. Long press the power button to power on TS21;
2. Use NFC function to launch Nuwa app. While the screen of Controller is unlocked, put Controller close to the TS21 NFC logo. The WiFi connects automatically after a beep and Nuwa is launched requesting to open the latest project. Click [OK] and start configuring TS21 from step 6. Also you can click [Cancel] to create a new project or open an existing project, and then start configuring TS21 from step 6.
3. If using an android device without NFC function, ensure TS21 is powered on, and launch Nuwa application on the android device. Click [Project] in the main interface to create a new project or open an existing project and connect TS21 manually.
4. Back to the main interface of Nuwa app, click [Device] -> [Connect] under

an opened project;

5. Select [TS21] for the Device Type, select [WiFi] for the Connect Type, click [Connect Config] to search and connect the WiFi SSID of TS21, select [TS21] for the Antenna and click [Connect] to enable communication between the android controller and TS21.
6. Click [Survey] -> [Static Survey], fill in the parameters of interval, cutoff angle, and etc. Then click [Start] to start static survey.

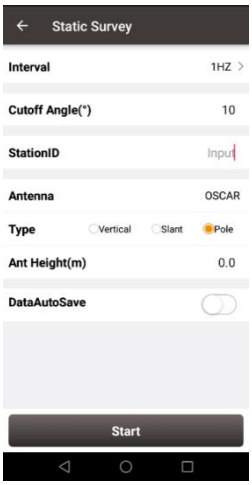


Figure 4.9 Static Survey configuration

7. If the DataAutoSave function is turned on, the static data is recorded automatically in the internal storage when power up TS21 next time. You can download data file refer to section 2.3.

4.3 Tilt survey

Tilt function is only applicable for TS21 GNSS receiver Ultimate version under rover mode.

4.3.1 Tilt initialization

The tilt compensation of TS21 GNSS receiver Ultimate version is free of

complex calibration. The tilt compensation will be initialized when the surveyor walks forward naturally for several meters after turning on the tilt compensation function. You can start tilt survey right after you walk to the survey point.

After the TS21 GNSS receiver Ultimate version is connect in Nuwa app, and we configure it working as a Rover. Click [Device] under the device functional group to enter the device information interface. Turn on the [Tilt Enable] on the device interface.

When tilt function is turned on, walk a few steps ahead, tilt the pole at any direction, then the tilt icon in the Survey screen turns green which indicates tilt compensation is valid. Now you can start tilt survey.

When the tilt compensation is valid, click the Satellite info icon to view the detailed information of tilt compensation including tilt status, tilt direction, tilt angle, heading and their quality index. Among them, the tilt direct indicates which direction is tilted, that is, the angle between the projection of the ranging pole on the ground and the north direction after tilting; the tilt angle indicates the degree of tilt, that is, the angle between the tilted pole and the vertical direction; Heading indicates the surveyor's orientation (the facing of TS21's back, we consider TS21's panel is always facing the surveyor).

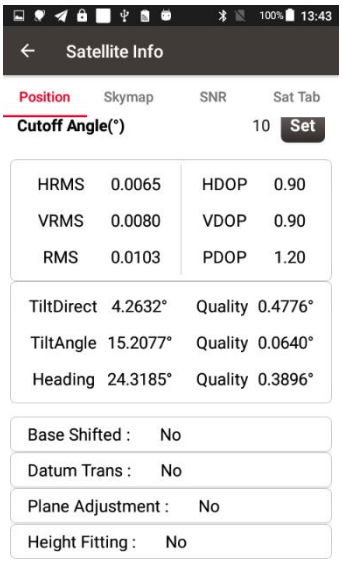


Figure 4.10 Detailed information of tilt compensation

4.3.2 Tilt survey

After turning on [Tilt Enable] and tilt initialization is finished, enter Survey interface and start tilt survey.

The tilt status is displayed at the top of the survey interface. When the tilt status is ON, it is considered that the tilt compensation accuracy is high and it is in a usable state. You can start survey using the tilted ranging pole. Please ensure that the antenna height setting is correct which will affect the tilt measurement results.

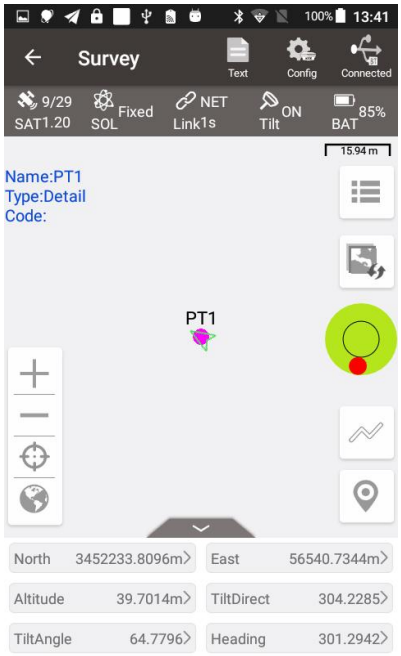


Figure 4.11 Tilt status is ON

When the status is displayed as N/A and blinking, it is considered that the accuracy of tilt compensation is reduced and it is in a state that is not recommended. At this time, the tilt indicator of the TS21 Ultimate OLED display turns flashing red. This may be caused by the surveyor standing for too long, rotating the ranging pole, or hitting the ranging pole to the ground. When the status is N/A, you need to redo the initialization. Generally, you do not need to stand still, just hold the ranging pole and walk forward to the next point, the initialization is complete automatically.

Note: during the tilt survey, please keep the TS21 OLED display facing the surveyor as much as possible. Please do not rotate the pole or hit the pole to the ground, which will invalidate the initialization or affect the accuracy of the tilt compensation. In addition, during the tilt point survey, if it does not continue at the third epoch reached when it is set smoothing 5 epochs for surveying points, please check whether the tilt compensation is invalid. It is not allowed to continue to complete the survey in the case where the tilt initialization

accuracy is low.

4.4 Issues and solutions

This section lists possible issues and effective solutions to solve them. Please read this section before contacting Tersus technical support.

1. TS21 GNSS receiver cannot receive satellite signals.

Solution:

(1) Change the survey environment, and restart TS21 in an open space.

(2) Reset the GNSS module by Reset button in Device interface.

2. The communication between Nuwa and TS21 fails.

Solution:

(1) Check whether the TS21 is powered on;

(2) Re-search and connect the WiFi;

(3) Upgrade Nuwa to the latest version.

3. There is no correction data for rover when using receiver network Ntrip work mode.

Solutions:

(1) Check whether the IP address, port, user name, password is correct.

(2) Try to connect to CORS via controller network and receive correction data to ensure there is no issue on CORS service, then switch back to receiver network mode.

(3) Check whether the 4G SIM card is properly installed, and whether it can be used normally.

(4) Go to [Device] - [Cellular], check the registration status of the network. Try

entering APN name and restarting cellular module.

(5) Try to log in with the same configuration and get a compared result if there is an extra receiver.

4. How to export static observation data from TS21?

Solutions:

(1) Connect TS21 receiver with a computer through a USB Type-C cable.

(2) The computer detects the TS21 receiver as an external disk.

(3) Open the \Data\record folder, find the trs file and rinex file in its storage according to recording date.

(4) Copy the static observation data and paste them to the designated folder in your computer.

5. How to apply Geoid model file correctly?

Solutions:

(1) Prepare the Geoid file at first and placed in the path of Internal storage\TersusSurvey\Geoid.

(2) Next step, launch Nuwa and go to select Project - Current Project and edit Coordinate System. Find the Height Fitting - Geoid and select Geoid, or directly download Geoid files from Tersus server after clicking More.

6. How to configure TS21 serial port output NMEA log?

Solutions:

Nuwa can configure to output NMEA by the NMEA option. It can be specified the Baud Rate, the kind of sentence.

7. A base receiver is working well, the rover receiver cannot get correction data via UHF, how to fix this?

Solutions:

(1) Check whether the radio antenna connects well with receiver. Carefully check whether the interface is tightened.

(2) Check whether the air baud rate, Protocol, Bandwidth, Frequency match right with that of the base receiver.

(3) Switchover the radio frequency to avoid the possible interference from nearby devices.

(4) Get a compared result when an extra receiver is configured as rover with the same settings.

8. The TS21 rover works at a short distance (not normal distance) at the radio mode?

Solutions:

(1) Check whether the rover connects a radio antenna.

(2) Adjust the radio of base at the high power gear.

(3) Check the environment if there exists radio interference along the propagation line.

5. AR Stakeout

5.1 Introduction

AR stakeout for Tersus TS21 is an innovative integration of GNSS, IMU and dual cameras. Front and bottom cameras work together to precisely mark the targets on the live view at different distances. Guided by a clear, eye-catching directional arrow and real-time distance display, it achieves up to a 70% improvement in efficiency.

5.2 Start AR Stakeout

1) Connect TS21 via WiFi and start rover mode to get a fixed solution.

2) Turn on Tilt, input the correct pole height and finish the tilt initialization.

3) Enter Point Stakeout interface. Click  to show the Staking Point list and click [Import] to import targets from file, from other point lists or directly manually add.

Figure 5.1 Staking Point List

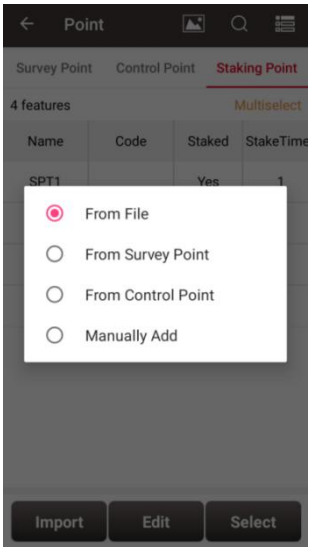


Figure 5.2 Import Targets

6) Select one of the point as the target, back to the Point Stakeout interface. Click AR to open the bottom camera and enter AR staking interface.

5.3 Go to the Target

The target point will be calculated and displayed in the real scene as shown below. When the current position is several meters away from targets, it will display the live view from the front camera and mark targets on it. As moving closer, it will automatically switch to the bottom camera view and even zooms in when very close to the targets.

It also indicates the direction and distance from the current position to the target on both front camera view and bottom camera view. Move toward the target until the pole tip aligns with the target to complete the AR stakeout.

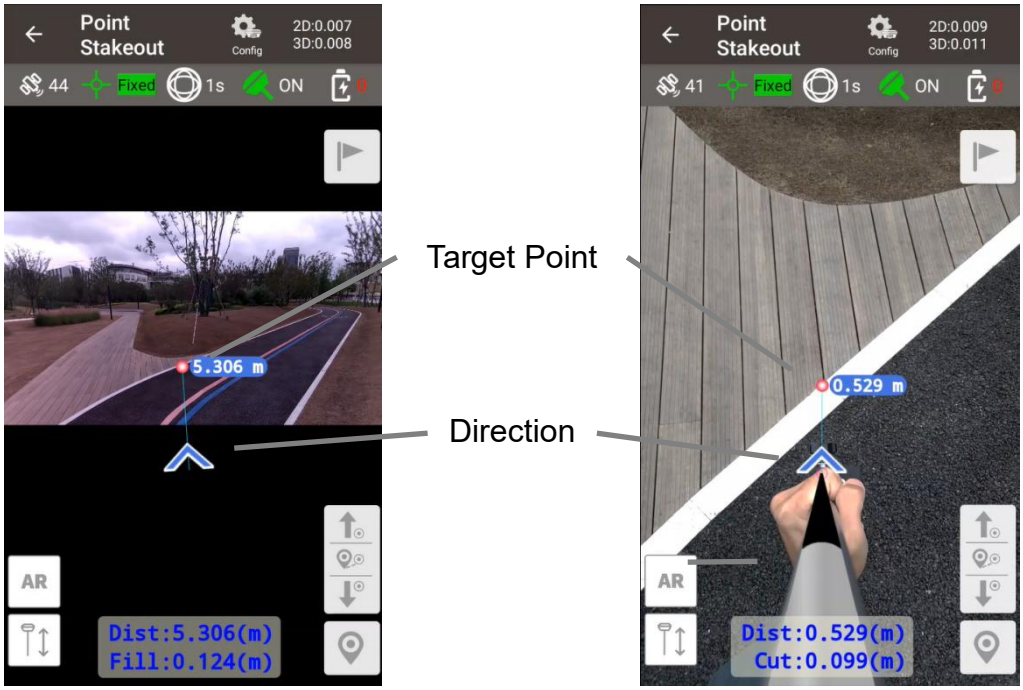


Figure 5.3 AR Stakeout with Front and Bottom Cameras

6. Visual Positioning

6.1 Introduction

Visual Positioning for Tersus TS21 is an innovative integration of GNSS, IMU and visual positioning technology. Equipped with a global shutter front camera, the TS21 not only captures the coordinates of points of interest from recorded video but also generates point cloud data on-site in real time.

6.2 Connect and Take Video

1) Connect TS21 via WiFi and start rover mode to get a fixed solution.

2) Turn on Tilt, input the correct pole height and finish the tilt initialization.

3) Go to [Survey] - [Visual Positioning]. The main interface shows TS21 front camera shooting screen. When the upper-right precision estimate is too large and the icon shows red, shake the pole or move TS21 according to the animation shown to take tilt initialization and visual positioning initialization until the upper-right precision estimate meets the requirements, the icon shows green and the animation disappears.

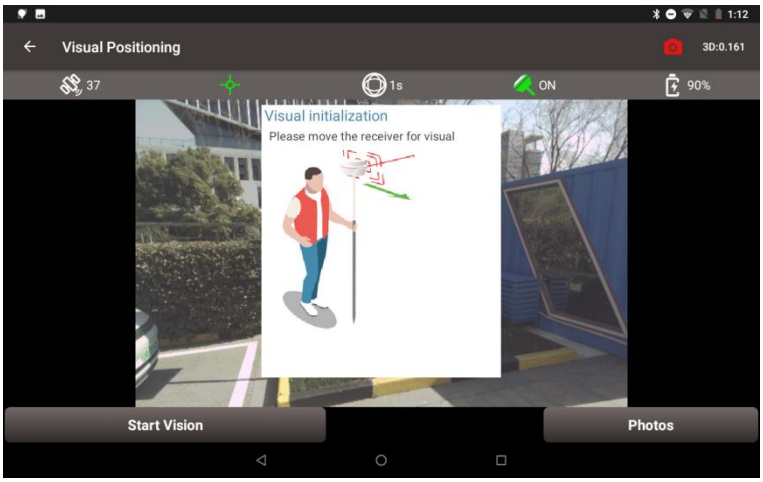


Figure 6.1 Visual Positioning Initialization

4) Click [Start Vision], keep the front camera on TS21 facing the target points, move TS21 to take photos of the target points from different directions.

5) Click [Stop] to end recording. Check the quality and the number of pictures for this visual positioning and enter the group name..

Figure 6.2 Start Vision

Note:

- ✧ **Ensure that the TS21 is located in an open sky environment, without any obstruction to the GNSS antenna, throughout the initialization process.**
- ✧ **Remember not to rotate the receiver violently during the initialization process. To improve visual measurement performance, focus on ensuring sufficient moving, as rotation does not enhance it.**
- ✧ **During the initialization phase, the camera should be turned back toward the surveyor to avoid obstruction of the view by their body.**
- ✧ **In the moving stage, the camera should not be pointed at non-textured objects, such as the sky and white walls.**
- ✧ **3D values in the upper right corner indicates the predicted 3D measuring error at 10 meter distance.**

6.3 Photo Groups

Click [Photos] to view all groups of photos taken for further measurement. Click on the mode button on the upper right corner in photos screen, there are four modes to take measurement for visual positioning.

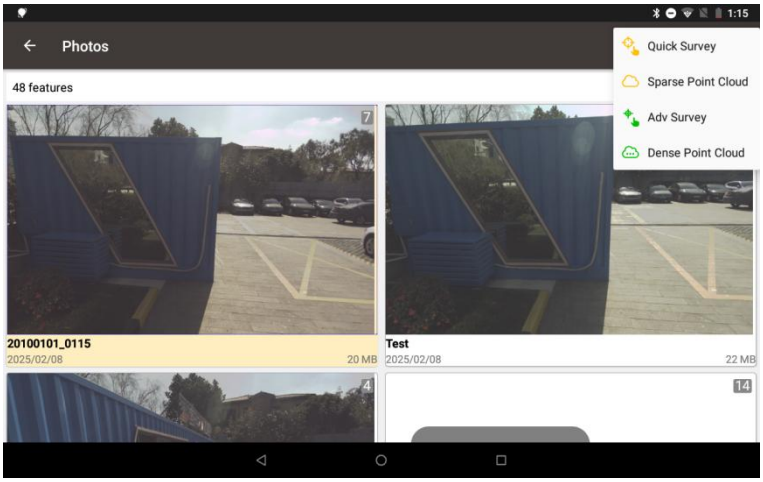


Figure 6.3 Four Measurement Modes

If needed, click the [Multi-select] button and choose the photo group to export. Then connect the TS21 to a computer and locate the exported image group in the directory for 3D modeling post-processing.

6.4 Quick Survey

This section introduces Quick Survey mode. Quick Survey use the traditional Pick point - Calculate - Adjust process. Calculations are performed at the receiver side. The advantage of quick survey is that there are no controller performance requirements and calculations are faster.

1) Click on a photo group to slide through all the photos in the group.

2) Click on one of the photos that contains target points to enter the photo measurement interface. Click the target point directly on the picture, then the clicked position will show a blue cross, and you can change the position of the blue cross by dragging. You can also zoom in and out of the picture to make it

easier to align the blue cross to the target point.

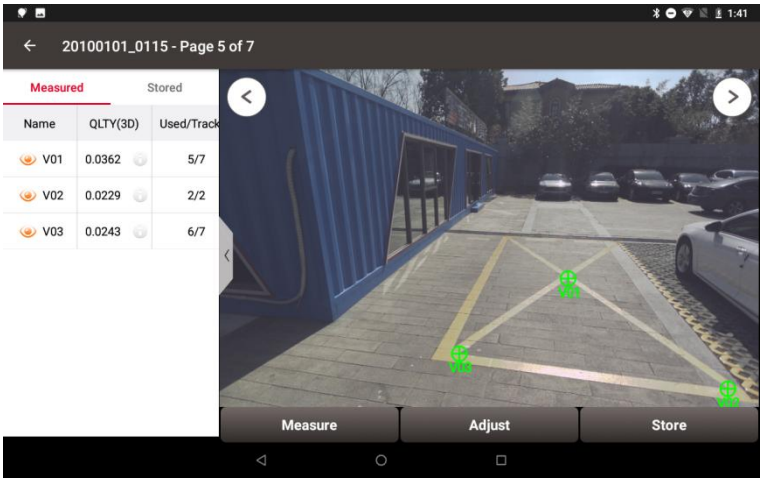


Figure 6.4 Quick Survey

3) Click [Measure], the blue cross will turn green, and the measured point list will show 3D quality and the number of used photos. Continue to select other target points in this way.

4) Switch to other photos, check whether the green cross is aligned with the target point. If failed to match on some photos, it will be shown as a red circle.

5) Click [Adjust], select the point and drag to align target manually. It will be recalculated and generally the quality will become higher and the used photos will increase.

6) Confirm that all points are measured correctly. Click the white icon to check the detailed information and edit point name. Then click [Store] and enter points information to store visual positioning points into the point database.

Note:

- ✧ **Hold the receiver steady and keep a normal walking speed while capturing images.**
- ✧ **For optimal accuracy and performance, capture the object of interest from a distance between 2m and 10m.**

- **Avoid using it in dark conditions or when directly facing the sun, as it may lead to difficulty in recognizing enough features in the captured images to make a match.**
- **Try to select feature points on an image directly in front of the target object. For example, choose an image in the middle of the captured images.**
- **Multiple feature points can be selected at a time.**

6.5 Sparse Point Cloud

This section introduces Sparse Point Cloud mode. In this mode, you need to circle the position around the target point first, then after the sparse point cloud being generated, select the nearest point in the sparse point cloud to obtain coordinates directly.

Calculations are performed at the receiver side. The advantage of this mode is that there are no controller performance requirements and calculations are faster, while at the same time the operations are simpler without adjustments.

1) Click on a photo group and click on one of the photos that contains target points. Click the circle button  and draw a circle containing the target point.

2) After the calculation, the sparse point cloud of the circled position will be displayed on the picture. If the points in the sparse point cloud are too far away from the target, draw another circle near the target position to generate more point clouds.

3) Click the select button  and click one of the point in sparse point cloud to select. If a wrong point is selected, use the button  to cancel the selection.

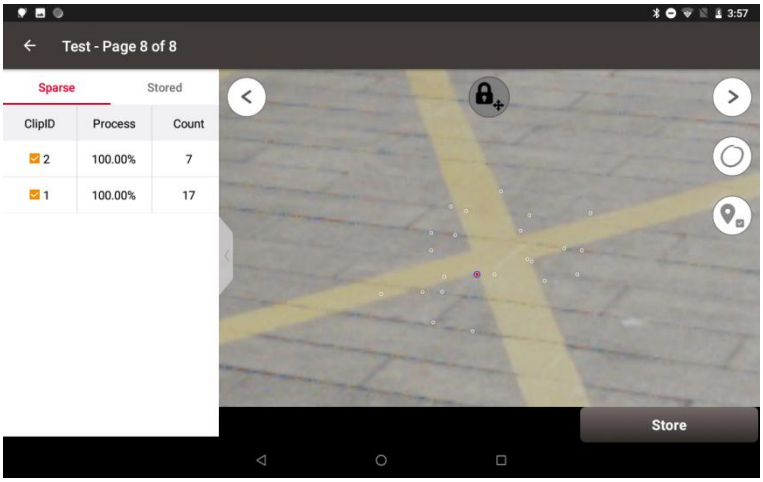


Figure 6.5 Sparse Point Cloud

4) Continue to select other target points in the way above. Then click [Store] and enter points information to store visual positioning points into the point database

6.6 Adv Survey

This section introduces Adv Survey mode. In Advanced Survey mode, the software will prepare the dense point cloud automatically first. The user only need to pick the point on the picture and the software will automatically generate the dense point cloud around the target, select the corresponding point in point cloud and give the results directly.

Calculations are performed at the controller side and therefore has performance requirements for the controller. The advantage of this mode is that the point cloud is dense and accurate, simplest for the user to operate and very accurate in measurement.

1) Click on a photo group and click on one of the photos that contains target points. It may take some time to prepare dense point cloud.

2) Click the target point directly on the picture, then the clicked position will

show a blue cross, and you can change the position of the blue cross by dragging. You can also zoom in and out of the picture to make it easier to align the blue cross to the target point.

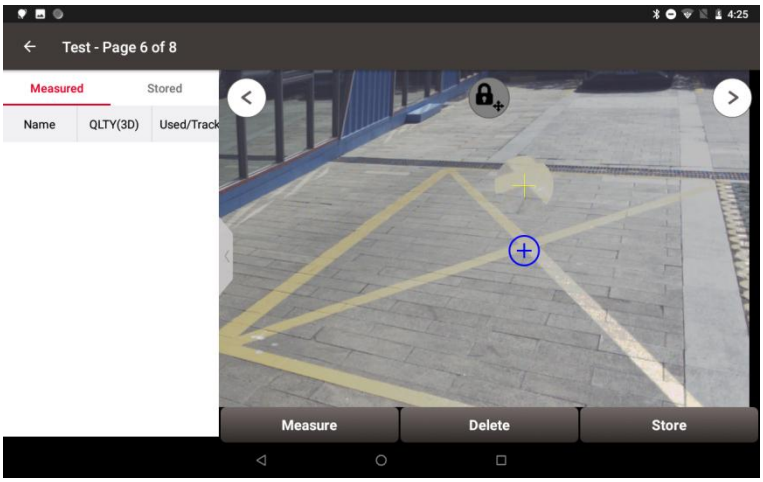


Figure 6.6 Advanced Survey

3) Click [Measure], and it may take some time to calculate the dense point cloud. The blue cross will turn green after the calculation. Select other target points in the same way.

4) Click the white icon to check the detailed information and edit point name. Click [Store] to store visual positioning points into the point database.

6.7 Dense Point Cloud

This section introduces Dense Point Cloud mode. The measurement process in this mode is similar to that of the sparse point cloud. More importantly, we can export the dense point cloud.

Calculations are performed at the controller side and therefore has performance requirements for the controller.

1) Click on a photo group and click on one of the photos that contains target points. It may take some time to prepare dense point cloud.

2) Click the button  and wait for global 3D point cloud reconstruction results the dense point cloud of the circled position will be displayed on the picture.

3) Click [Export] and select the path to the las file. Then open las file to check the dense point cloud generated by TS21 visual positioning on site.

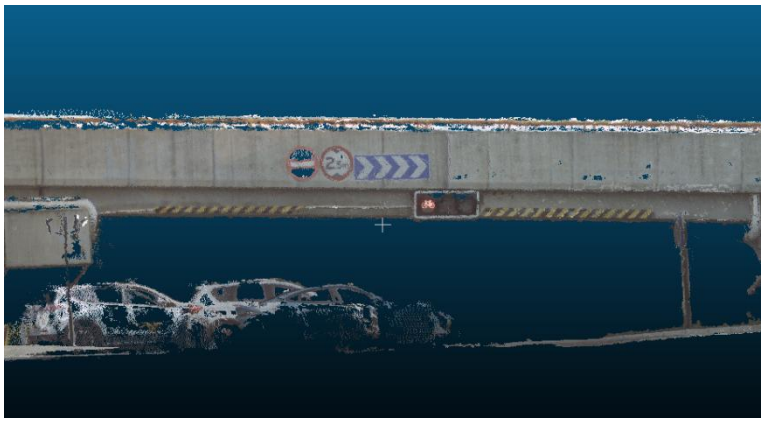


Figure 6.7 Export Dense Point Clouds

7. Terminology

Abbreviation	Description
AC	Alternating Current
BDS	BeiDou Navigation Satellite System
CMR	Compact Measurement Record
DC	Direct Current
eMMC	Embedded Multi Media Card
GLONASS	GLObal NAvigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
LED	Light Emitting Diode
OLED	Organic Light-Emitting Diode
PDA	Personal Digital Assistant
PPK	Post-Processing Kinematic
PPS	Pulse Per Second
QZSS	Quasi-Zenith Satellite System
RINEX	Receiver Independent Exchange format
RMS	Root Mean Squares
RTK	Real-Time Kinematic
RTCM	Radio Technical Commission for Maritime Services
SIM	Subscriber Identification Module
TCP	Transmission Control Protocol
UAV	Unmanned Aerial Vehicle, drone
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial BUS
UTC	Universal Time Coordinated