

SparkFun RTK Product Manual

Simple and Cost Effective High-Precision Navigation

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1. Introduction

The SparkFun RTK products are exceptional GNSS receivers out-of-box and can be used with little or no configuration. This RTK Product Manual provides detailed descriptions of all the available features of the RTK products.

The line of RTK products offered by SparkFun all run identical firmware. The [RTK firmware](#) and this guide cover the following products:



[SparkFun RTK Facet L-Band \(GPS-20000\)](#)
[Hookup Guide](#)



[Hookup Guide](#)



[SparkFun RTK Reference Station \(GPS-22429\)](#)
[Hookup Guide](#)



[SparkFun RTK Express Plus \(GPS-18590\)](#)
[Hookup Guide](#)



[Hookup Guide](#)



[Hookup Guide](#)

Depending on the hardware platform different features may or may not be supported. We will denote each product in each section so that you know what is supported.

There are multiple ways to configure an RTK product:

- [Bluetooth](#) - Good for in-field changes
- [WiFi](#) - Good for in-field changes
- [Serial Terminal](#) - Requires a computer but allows for all configuration settings
- [Settings File](#) - Used for configuring multiple RTK devices identically

The Bluetooth or Serial Terminal methods are recommended for most advanced configurations. Most, but not all settings are also available over WiFi but can be tricky to input via mobile phone.

If you have an issue, feature request, bug report, or a general question about the RTK firmware specifically we encourage you to post your comments on the [firmware's repository](#). If you feel like bragging or showing off what you did with your RTK product, we'd be thrilled to hear about it on the issues list as well!

Things like how to attach an antenna or other hardware-specific topics are best read on the Hookup Guides for the individual products.

2. Quick Start

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

This quick start guide will get you started in 10 minutes or less. For the full product manual, please proceed to the **Introduction**.

Are you using [Android](#) or [iOS](#)?

2.1 Android

1. Download [SW Maps](#). This may not be the GIS software you intend to do your data collection, but SW Maps is free and makes sure everything is working correctly out of the box.



Download SW Maps for Android

2. Mount the hardware:

- For RTK Surveyor/Express/Express Plus: Attach the included [antenna](#) to a [monopole](#) using the included [thread adapter](#). [Clamp](#) the RTK device to the monopole. Use the included [cable](#) to connect the antenna to the RTK Surveyor/Express/Express Plus (Figure 1).
- For RTK Facet/Facet L-Band: Attach the Facet to a [monopole](#) using the included [thread adapter](#) (Figure 1).

*Figure 1*

3. Turn on your RTK device by pressing the POWER button until the display shows 'SparkFun RTK' then you can release it (Figure 2).

*Figure 2*

4. Please note the four-digit code in the top left corner of the display (**B022** in the picture below). This is the MAC address you will want to pair with (Figure 3).

*Figure 3*

5. From your cell phone, open Bluetooth settings and pair it with a new device. You will see a list of available Bluetooth devices. Select the 'Facet Rover-3AF1' where 'Facet' is the type of device you have (Surveyor, Express, Facet, etc) and 3AF1 is the MAC address you see on the device's display (Figure 4).

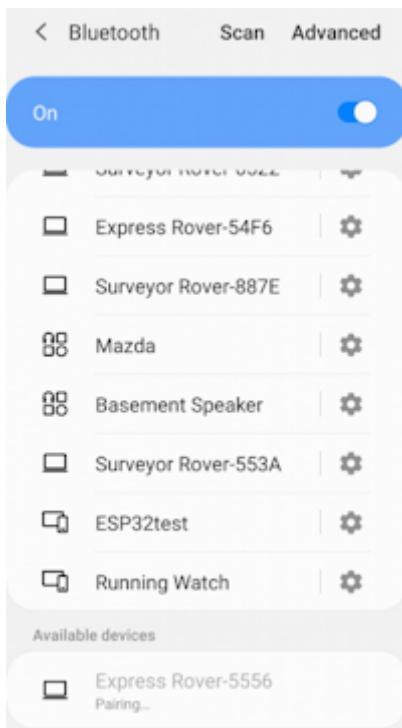


Figure 4

6. Once paired, open SW Maps. Select 'New Project' and give your project a name like 'RTK Project'.
7. Press the SW Maps icon in the top left corner of the home screen and select Bluetooth GNSS. You should see the 'Facet Rover-3AF1' in the list. Select it then press the 'Connect' button in the bottom left corner (Figure 5). SW Maps will show a warning that the instrument height is 0m. That's ok.

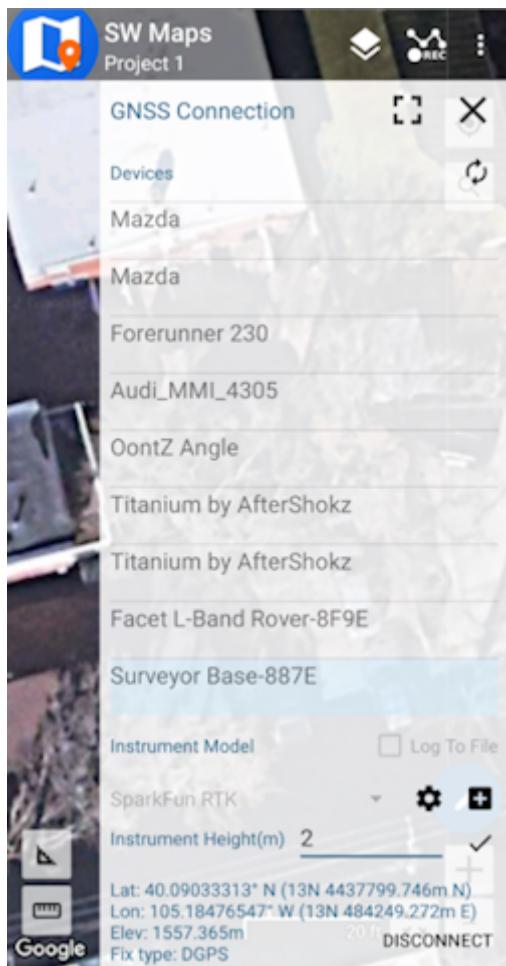


Figure 5

8. Once connected, have a look at the display on the RTK device. You should see the MAC address disappear and be replaced by the Bluetooth icon (Figure 6). You're connected!



Figure 6

9. Now put the device outside with a clear view of the sky. GNSS doesn't work indoors or near windows. Within about 30 seconds you should see 10 or more satellites in view (SIV) (Figure 7). More SIV is better. We regularly see 30 or more SIV. The horizontal positional accuracy (HPA) will start at around 10 meters and begin to decrease. The lower the HPA the more accurate your position. If you wait a few moments, this will drop dramatically to around 0.3 meters (300mm = 1ft) or better.



Figure 7

You can now use your RTK device to measure points with very good (sub-meter) accuracy. If you need extreme accuracy (down to 10mm) continue reading the [RTK Crash Course](#).

2.2 iOS

The software options for Apple iOS are much more limited because Apple products do not support Bluetooth SPP. That's ok! The SparkFun RTK products support Bluetooth Low Energy (BLE) which *does* work with iOS.

1. Download [SW Maps for iOS](#). This may not be the GIS software you intend to do your data collection, but SW Maps is free and makes sure everything is working correctly out of the box.



Download SW Maps for iOS

2. Mount the hardware:

- For RTK Surveyor/Express/Express Plus: Attach the included [antenna](#) to a [monopole](#) using the included [thread adapter](#). Clamp the RTK device to the monopole. Use the included [cable](#) to connect the antenna to the RTK Surveyor/Express/Express Plus (Figure 1).
- For RTK Facet/Facet L-Band: Attach the Facet to a [monopole](#) using the included [thread adapter](#) (Figure 1).



Figure 1

3. Turn on your RTK device by pressing the POWER button until the display shows 'SparkFun RTK' then you can release it (Figure 2).



Figure 2

4. Put the RTK device into configuration mode by tapping the POWER or SETUP button multiple times until the Config menu is highlighted (Figure 3).



Figure 3

5. From your phone, connect to the WiFi network *RTK Config*.
6. Open a browser (Chrome is preferred) and type **rtk.local** into the address bar. Note: Devices with older firmware may still need to enter **192.168.4.1**.
7. Under the *System Configuration* menu, change the **Bluetooth Protocol** to **BLE** (Figure 4). Then click **Save Configuration** and then **Exit and Reset**. The unit will now reboot.

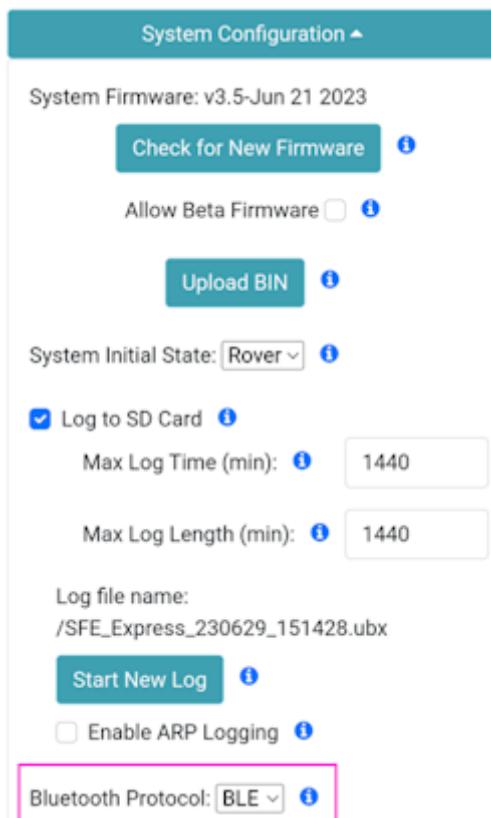


Figure 4

8. You should now be disconnected from the *RTK Config* WiFi network. Make sure Bluetooth is enabled on your iOS device Settings (Figure 5). The RTK device will not appear in the OTHER DEVICES list. That is OK.

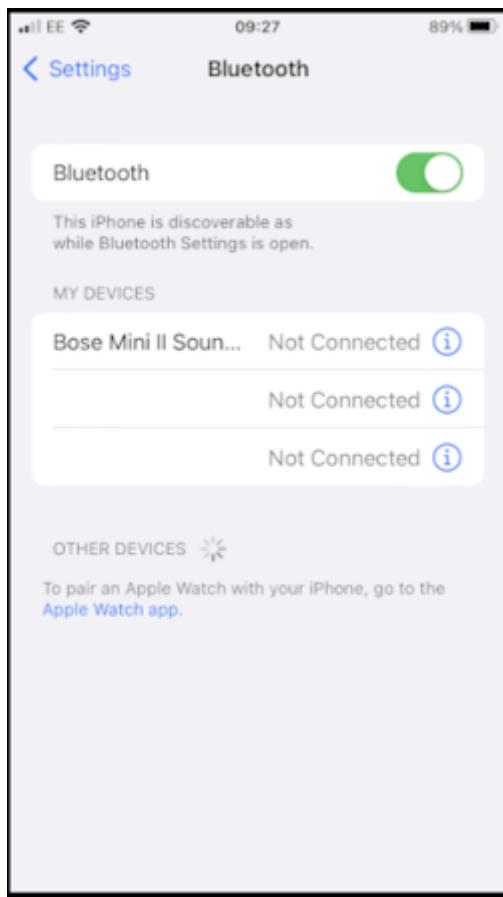


Figure 5

9. Open SW Maps. Select 'New Project' and give your project a name like 'RTK Project'.
10. Press the SW Maps icon in the top left corner of the home screen and select Bluetooth GNSS. You will need to agree to allow a Bluetooth connection. Set the *Instrument Model* to **Generic NMEA (Bluetooth LE)**. Press 'Scan' and your RTK device should appear. Select it then press the 'Connect' button in the bottom left corner.
11. Once connected, have a look at the display on the RTK device. You should see the MAC address disappear and be replaced by the Bluetooth icon (Figure 6). You're connected!

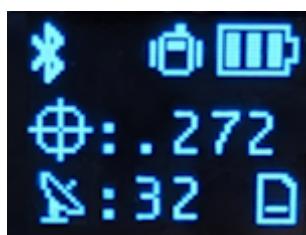


Figure 6

12. Now put the device outside with a clear view of the sky. GNSS doesn't work indoors or near windows. Within about 30 seconds you should see 10 or more satellites in view (SIV) (Figure 7). More SIV is better. We regularly see 30 or more SIV. The horizontal positional accuracy (HPA) will start at around 10 meters and begin to decrease. The lower the HPA the more accurate your position. If you wait a few moments, this will drop dramatically to around 0.3 meters (300mm = 1ft) or better.

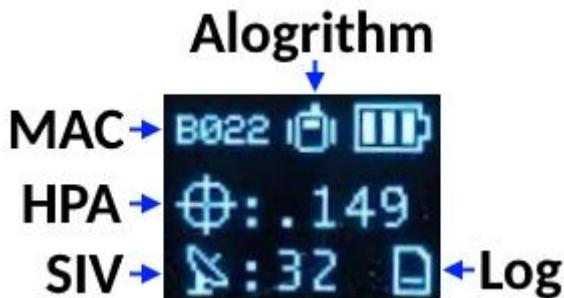


Figure 7

You can now use your RTK device to measure points with very good (sub-meter) accuracy. If you need extreme accuracy (down to 10mm) continue reading the [RTK Crash Course](#).

2.3 RTK Crash Course

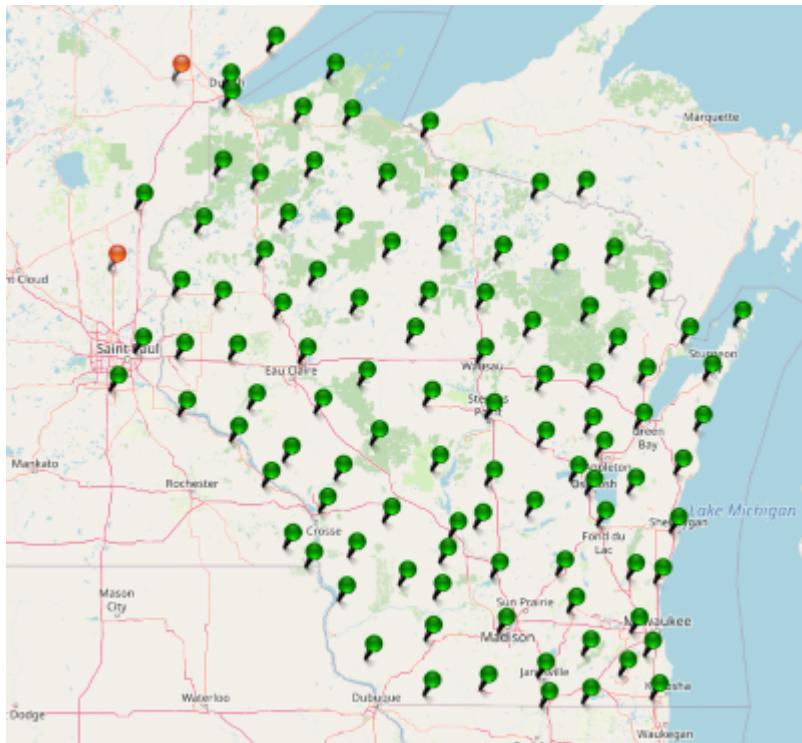
To get millimeter accuracy we need to provide the RTK unit with correction values. Corrections, often called RTCM, help the RTK unit refine its position calculations. RTCM (Radio Technical Commission for Maritime Services) can be obtained from a variety of sources but they fall into three buckets: Commercial, Public, and Civilian Reference Stations.

Commercial Reference Networks

These companies set up a large number of reference stations that cover entire regions and countries, but charge a monthly fee. They are often easy to use but can be expensive.

- [PointOneNav](#) (\$50/month) - US, EU, Australia, South Korea
- [Skylark](#) (\$29 to \$69/month) - US, EU, Japan, Australia
- [SensorCloud RTK](#) (\$100/month) partial US, EU
- [Premium Positioning](#) (~\$315/month) partial EU
- [KeyNetGPS](#) (\$375/month) North Eastern US
- [Hexagon/Leica](#) (\$500/month) - partial US, EU

Public Reference Stations



State Wide Network of Continuously Operating Reference Stations (CORS)

Be sure to check if your state or country provides corrections for free. Many do! Currently, there are 21 states in the USA that provide this for free as a department of transportation service. Search 'Wisconsin CORS' as an example. Similarly, in France, check out [CentipedeRTK](#). There are several public networks across the globe, be sure to google around!

Civilian Reference Stations



The base station at SparkFun

You can set up your own correction source. This is done with a 2nd GNSS receiver that is stationary, often called a Base Station. There is just the one-time upfront cost of the Base Station hardware. See the [Creating a Permanent Base](#) document for more information.

2.4 NTRIP Example

Once you have decided on a correction source we need to feed that data into your SparkFun RTK device. In this example, we will use PointOneNav and SW Maps.

1. Create an account on [PointOneNav](#). **Note:** This service costs \$50 per month at the time of writing.
2. Open SW Maps and connect to the RTK device over Bluetooth.
3. Once connected, open the SW Maps menu again (top left corner) and you will see a new option; click on 'NTRIP Client'.
4. Enter the credentials provided by PointOneNav and click Connect (Figure 1). Verify that *Send NMEA GGA* is checked.

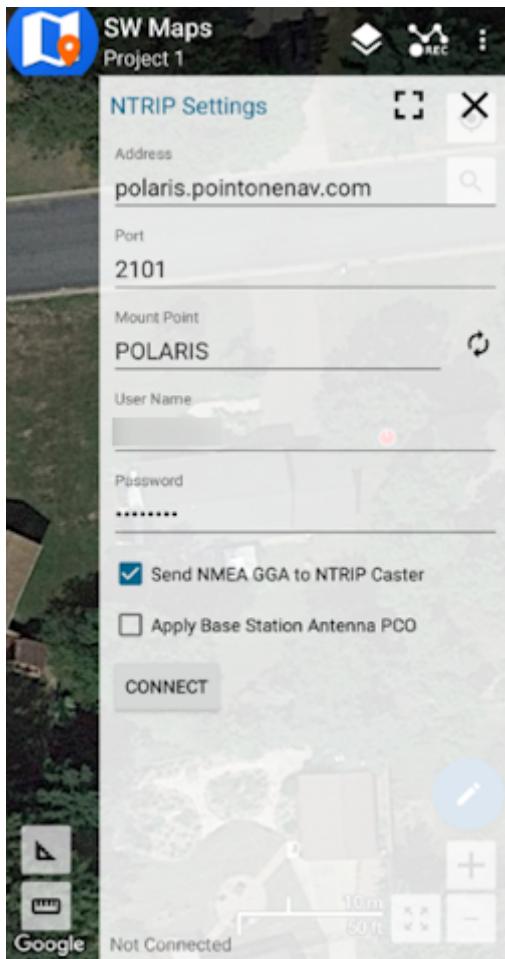


Figure 1

5. Corrections will be downloaded every second from PointOneNav using your phone's cellular connection and then sent down to the RTK device over Bluetooth. You don't need a very fast internet connection or a lot of data; it's only about 530 bytes per second.

Assuming you are outside, as soon as corrections are sent to the device, the Crosshair icon will become double and begin flashing. Once RTK Fix is achieved (usually under 30 seconds) the double crosshairs will become solid and the HPA will be below 20mm (Figure 2). You can now take positional readings with millimeter accuracy!



Figure 2

In SW Maps, the position bubble will turn from Blue (regular GNSS fix), then to Orange (RTK Float), then to Green (RTK Fix) (Figure 3).

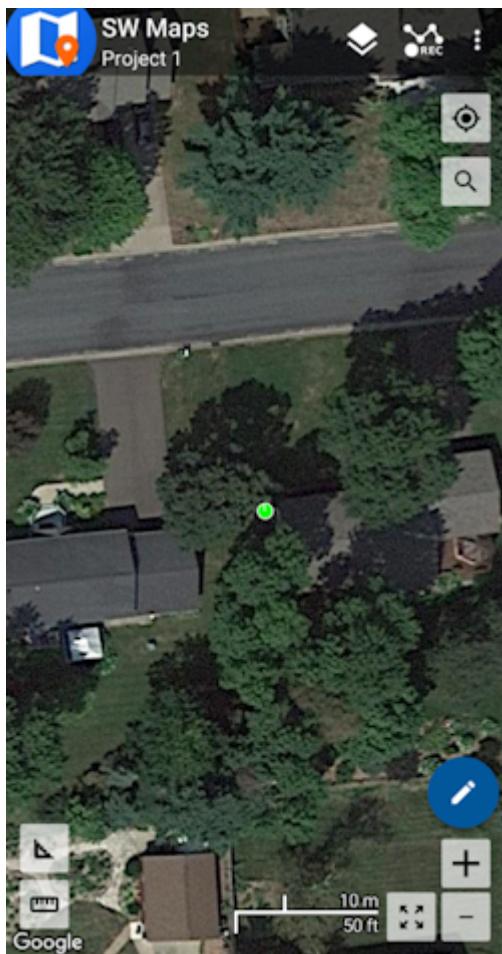


Figure 3

RTK Fix will be maintained as long as there is a clear view of the sky and corrections are delivered to the device every few seconds.

2.5 Common Gotchas

- High-precision GNSS only works with dual frequency L1/L2 antennas. This means that GPS antenna you got in the early 2000s with your TomTom is not going to work. Please use the L1/L2 antennas provided by SparkFun.
- High-precision GNSS works best with a clear view of the sky; it does not work indoors or near a window. GNSS performance is generally *not* affected by clouds or storms. Trees and buildings *can* degrade performance but usually only in very thick canopies or very near tall building walls. GNSS reception is very possible in dense urban centers with skyscrapers but high-precision RTK may be impossible.
- The location reported by the RTK device is the location of the antenna element; it's *not* the location of the pointy end of the stick. Lat and Long are fairly easy to obtain but if you're capturing altitude be sure to do additional reading on ARPs (antenna reference points) and how to account for the antenna height in your data collection software.
- An internet connection is required for most types of RTK. RTCM corrections can be transmitted over other types of connections (such as serial telemetry radios). See [Correction Transport](#) for more details.

2.6 RTK Facet L-Band Keys

The RTK Facet L-Band is unique in that it must obtain keys to decrypt the signal from a geosynchronous satellite. Here are the steps to do so:

1. Turn on your RTK Facet L-Band by pressing the POWER button until the display shows 'SparkFun RTK' then you can release it (Figure 1).



Figure 1

2. Put the RTK device into configuration mode by tapping the POWER button multiple times until the Config menu is highlighted (Figure 2).



Figure 2

3. From your phone or laptop, connect to the WiFi network *RTK Config*.
4. Open a browser (Chrome is preferred) and type **rtk.local** into the address bar. Note: Devices with older firmware may still need to enter **192.168.4.1**.
5. Under the *WiFi Configuration* menu, enter the SSID and password for your local WiFi network (Figure 3). You can enter up to four. This can be a home, office, cellular hotspot, or any other WiFi network. The unit will attempt to connect to the internet periodically to obtain new keys, including this first day. Then click **Save Configuration** and then **Exit and Reset**. The unit will now reboot.

WiFi Configuration ▾

Networks:	i
SSID 1:	TREX
PW 1:	parachutes
SSID 2:	
PW 2:	
SSID 3:	
PW 3:	
SSID 4:	
PW 4:	

TCP Client [i](#)

TCP Server [i](#)

Configure Mode: WiFi [i](#)

Figure 3

- After reboot, the device will connect to WiFi and obtain keys. You should see a series of displays indicating the automatic process (Figure 4).

*Figure 4*

Keys are valid for a minimum of 29 days and a maximum of 60. The device will automatically attempt to connect to WiFi to obtain new keys. If WiFi is not available during that period the keys will expire. The device will continue to operate with expired keys, with ~0.3m accuracy but not be able to obtain RTK Fix mode.

- Now put the device outside with a clear view of the sky. GNSS doesn't work indoors or near windows. Within about 30 seconds you should see 10 or more satellites in view (SIV). More SIV is better. We regularly see 30 or more SIV. The horizontal positional accuracy (HPA) will start at around 10 meters and begin to decrease. The lower the HPA the more accurate your position.



Figure 5

Upon successful reception and decryption of L-Band corrections, the satellite dish icon will increase to a three-pronged icon (Figure 5). As the unit's accuracy increases a normal cross-hair will turn to a double blinking cross-hair indicating a floating RTK solution, and a solid double cross-hair will indicate a fixed RTK solution. The HPA will be below 0.030 (30mm) or better once RTK Fix is achieved.

You can now use your RTK device to measure points with millimeter accuracy. Please see [Android](#) or [iOS](#) for guidance on getting the RTK device connected to GIS software over Bluetooth.

2.7 RTK Reference Station



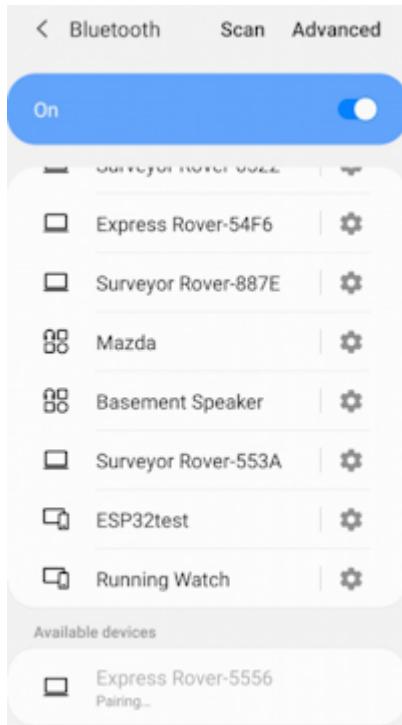
While most of this Quick Start guide can be used with the [RTK Reference Station](#), the [Reference Station Hookup Guide](#) is the best place to get started.

3. Connecting Bluetooth

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

SparkFun RTK products transmit full NMEA sentences over Bluetooth serial port profile (SPP) at 4Hz and 115200bps. This means that nearly any GIS application that can receive NMEA data over a serial port (almost all do) can be used with the RTK Express. As long as your device can open a serial port over Bluetooth (also known as SPP) your device can retrieve industry-standard NMEA positional data. The following steps show how to connect an external tablet, or cell phone to the RTK device so that any serial port-based GIS application can be used.

3.1 Android



Pairing with the 'Express Rover-5556' over Bluetooth

Open Android's system settings and find the 'Bluetooth' or 'Connected devices' options. Scan for devices and pair with the device in the list that matches the Bluetooth MAC address on your RTK device.

When powered on, the RTK product will broadcast itself as either '[Platform] Rover-5556' or '[Platform] Base-5556' depending on which state it is in. [Platform] is Facet, Express, Surveyor, etc. Discover and pair with this device from your phone or tablet. Once paired, open SW Maps.



Bluetooth MAC address B022 is shown in the upper left corner

Note: B022 is the last four digits of your unit's MAC address and will be unique to the device in front of you. This is helpful in case there are multiple RTK devices within Bluetooth range.

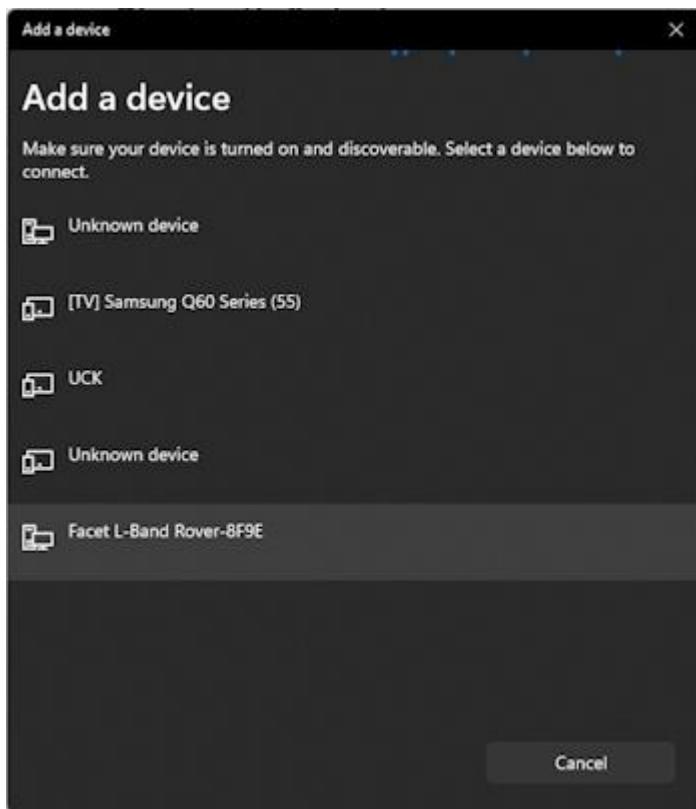
3.2 Windows

Open settings and navigate to Bluetooth. Click **Add device**.



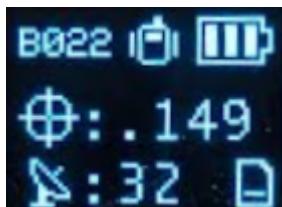
Adding Bluetooth Device

Click Bluetooth 'Mice, Keyboards, ...'



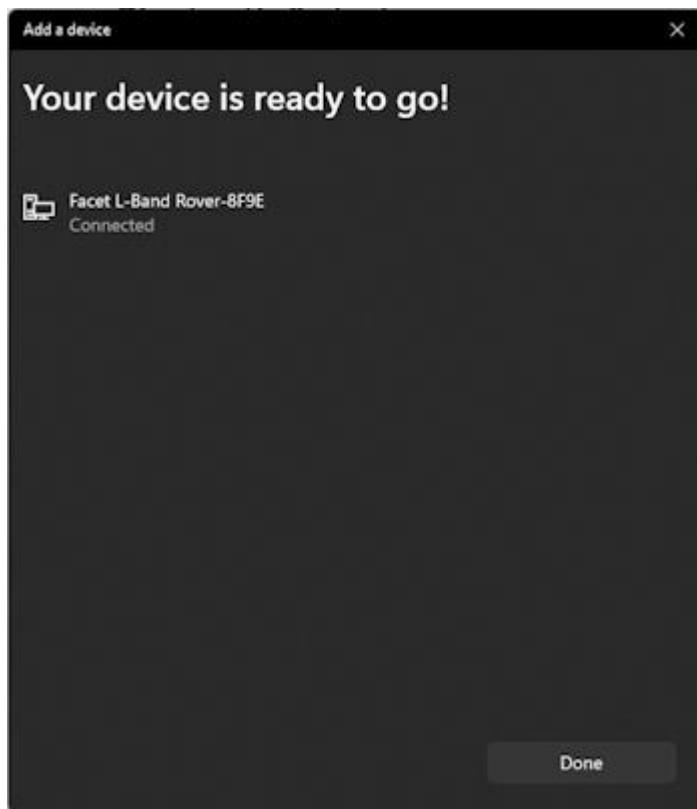
Viewing available Bluetooth Devices

Click on the RTK device. When powered on, the RTK product will broadcast itself as either '[Platform] Rover-5556' or '[Platform] Base-5556' depending on which state it is in. [Platform] is Facet, Express, Surveyor, etc. Discover and pair with this device from your phone or tablet. Once paired, open SW Maps.



Bluetooth MAC address B022 is shown in the upper left corner

Note: B022 is the last four digits of your unit's MAC address and will be unique to the device in front of you. This is helpful in case there are multiple RTK devices within Bluetooth range.



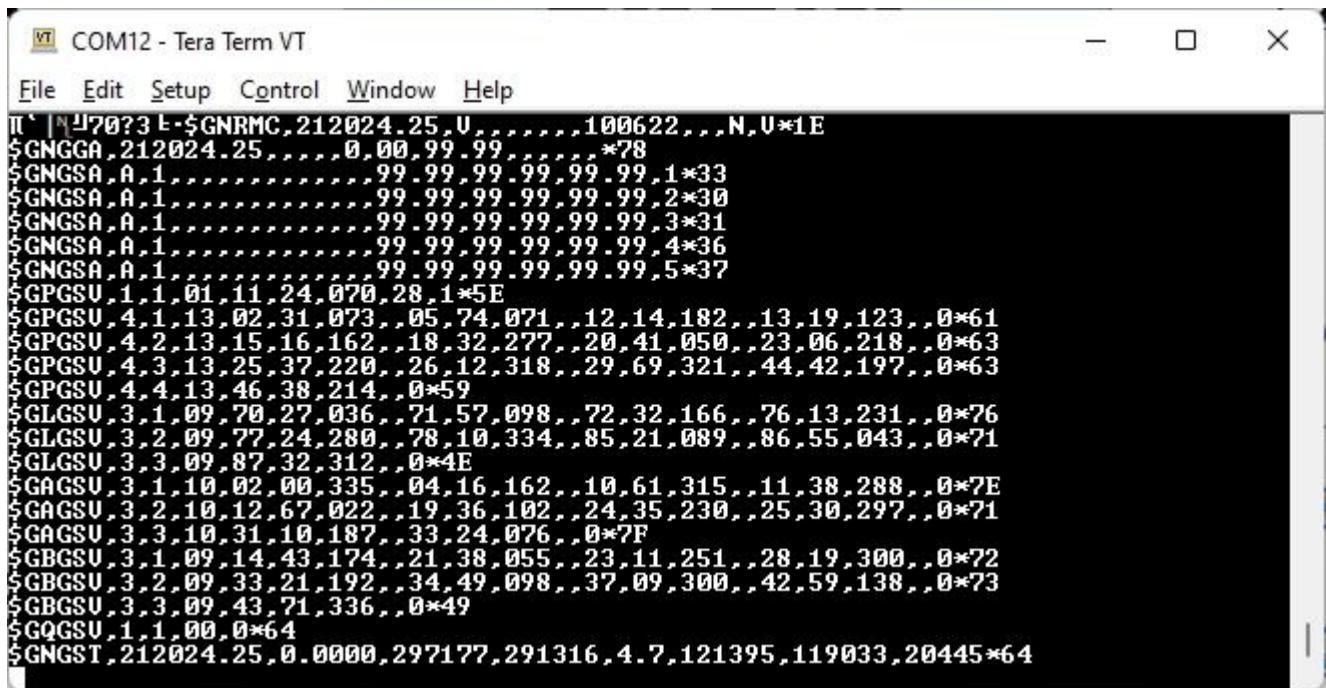
Bluetooth Connection Success

The device will begin pairing. After a few seconds, Windows should report that you are ready to go.

- > MONITORS
- > Network adapters
- ▽ Ports (COM & LPT)
 - Intel(R) Active Management Technology - SOL (COM3)
 - Standard Serial over Bluetooth link (COM11)
 - Standard Serial over Bluetooth link (COM12)
 - Standard Serial over Bluetooth link (COM13)
- > Print queues
- > Printers

Bluetooth COM ports

The device is now paired and a series of COM ports will be added under 'Device Manager'.



The screenshot shows a terminal window titled "COM12 - Tera Term VT". The menu bar includes File, Edit, Setup, Control, Window, and Help. The main window displays a stream of NMEA sentences. Some of the visible sentences include:

```

$GPRMC,212024.25,V,,,100622,,N,0*1E
$GNGGA,212024.25,,,0,00.99,99,*78
$GNGSA,A,1,,,99.99,99.99,99.99,1*33
$GNGSA,A,1,,,99.99,99.99,99.99,2*30
$GNGSA,A,1,,,99.99,99.99,99.99,3*31
$GNGSA,A,1,,,99.99,99.99,99.99,4*36
$GNGSA,A,1,,,99.99,99.99,99.99,5*37
$GPGSV,1,1,24,070,28,1*5E
$GPGSV,4,1,13,02,31,073,,05,74,071,,12,14,182,,13,19,123,,0*61
$GPGSV,4,2,13,15,16,162,,18,32,277,,20,41,050,,23,06,218,,0*63
$GPGSV,4,3,13,25,37,220,,26,12,318,,29,69,321,,44,42,197,,0*63
$GPGSV,4,4,13,46,38,214,,0*59
$GLGSU,3,1,09,70,27,036,,71,57,098,,72,32,166,,76,13,231,,0*76
$GLGSU,3,2,09,77,24,280,,78,10,334,,85,21,089,,86,55,043,,0*71
$GLGSU,3,3,09,87,32,312,,0*4E
$GAGSV,3,1,10,02,00,335,,04,16,162,,10,61,315,,11,38,288,,0*7E
$GAGSV,3,2,10,12,67,022,,19,36,102,,24,35,230,,25,30,297,,0*71
$GAGSV,3,3,10,31,10,187,,33,24,076,,0*7F
$GBGSV,3,1,09,14,43,174,,21,38,055,,23,11,251,,28,19,300,,0*72
$GBGSV,3,2,09,33,21,192,,34,49,098,,37,09,300,,42,59,138,,0*73
$GBGSV,3,3,09,43,71,336,,0*49
$GQGSV,1,1,00,0*64
$GNGST,212024.25,0.0000,297177,291316,4.7,121395,119033,20445*64

```

NMEA received over the Bluetooth COM port

If necessary, you can open a terminal connection to one of the COM ports. Because the Bluetooth driver creates multiple COM ports, it's impossible to tell which is the serial stream so it's easiest to just try each port until you see a stream of NMEA sentences (shown above). You're all set! Be sure to close out the terminal window so that other software can use that COM port.

3.3 Apple iOS

Please see the [Apple iOS](#) example of connecting to SW Maps.

Apple products do not support Bluetooth SPP. That's ok! The SparkFun RTK devices support Bluetooth Low Energy (BLE) which does work with iOS.

More information is available on the [System Menu](#) for switching between Bluetooth SPP and BLE.

4. GIS Software

4.1 Android

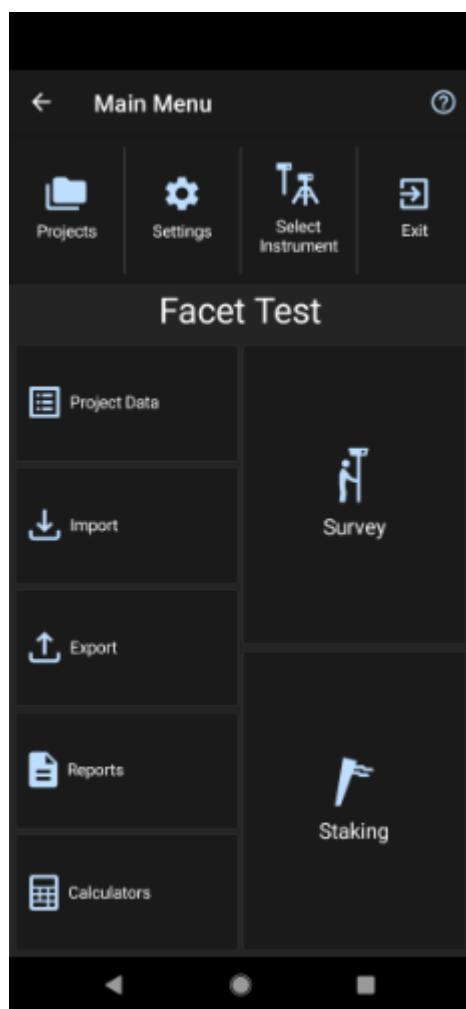
Torch: 

While we recommend [SW Maps for Android](#), there are a variety of 3rd party apps available for GIS and surveying. We will cover a few examples below that should give you an idea of how to get the incoming NMEA data into the software of your choice.

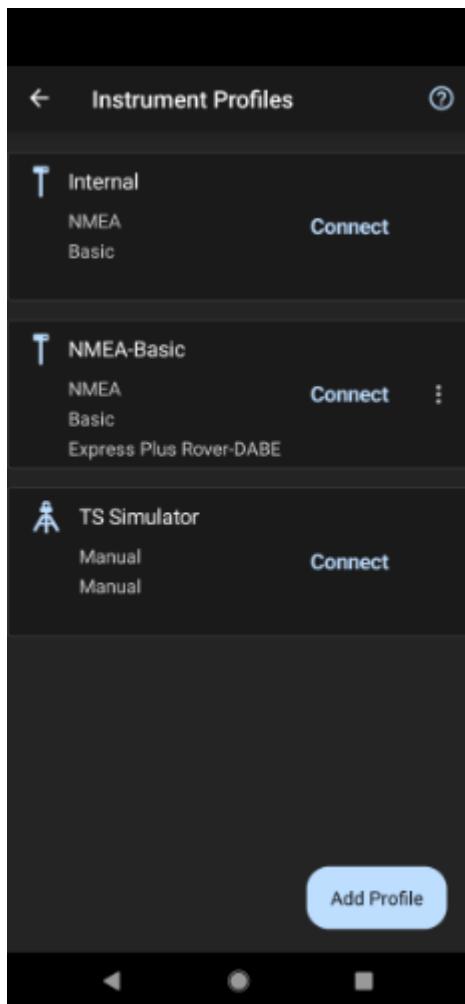
4.1.1 Field Genius

[Field Genius for Android](#) is another good solution, albeit a lot more expensive than free.

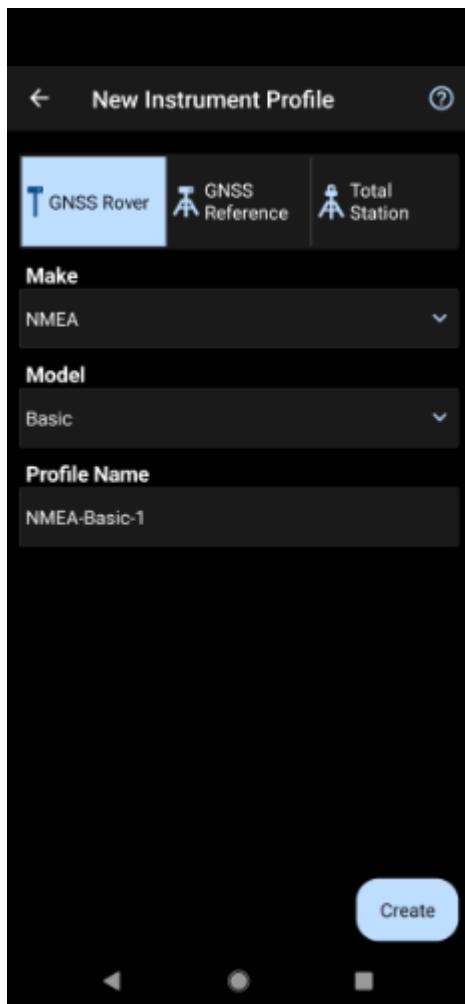
Be sure your device is [paired over Bluetooth](#).



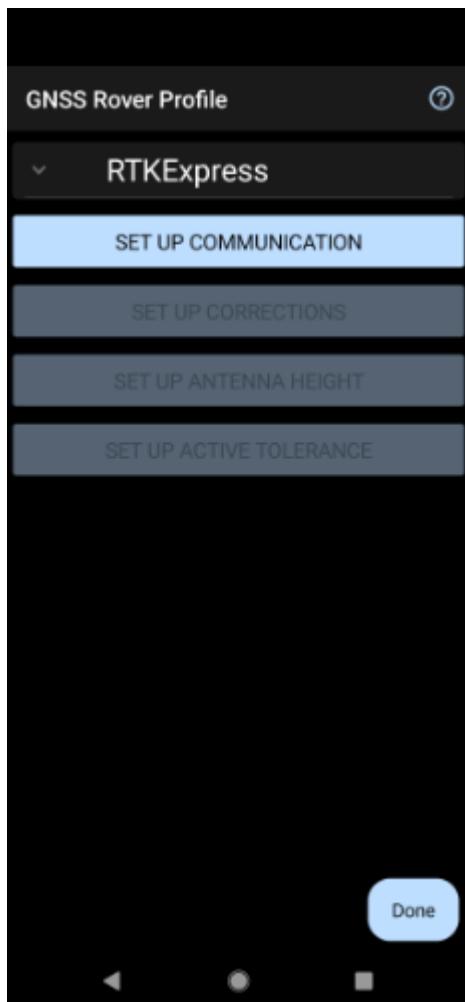
From the Main Menu open `Select Instrument`.



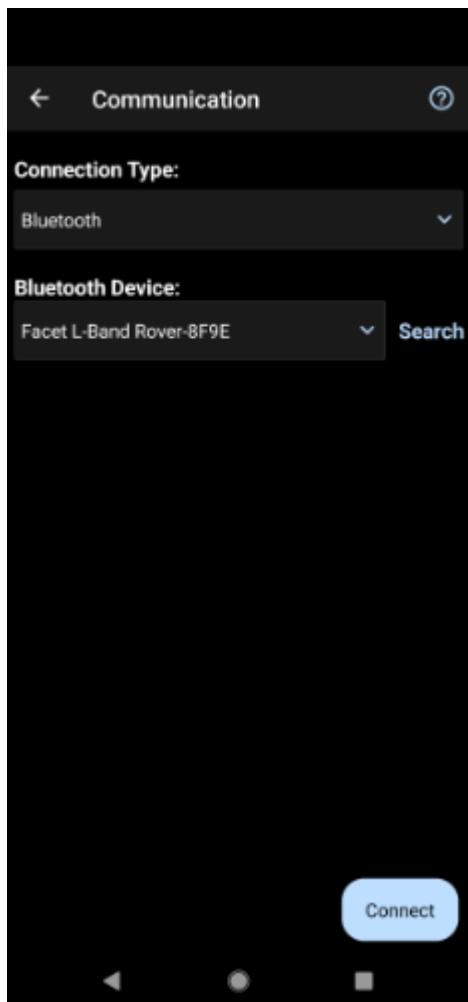
Click the 'Add Profile' button.



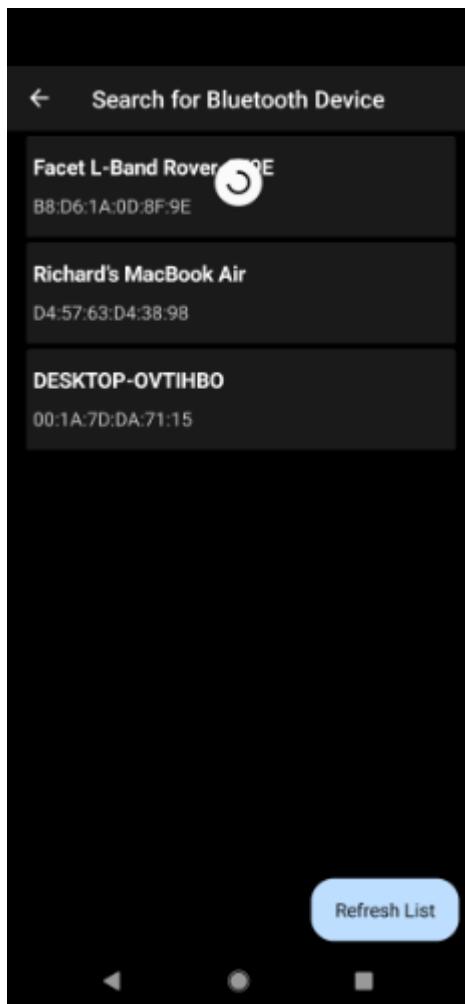
Click **GNSS Rover** and select **NMEA** as the Make. Set your Profile Name to something memorable like '**RTK-Express**' then click the '**Create**' button.



Click on 'SET UP COMMUNICATION'.



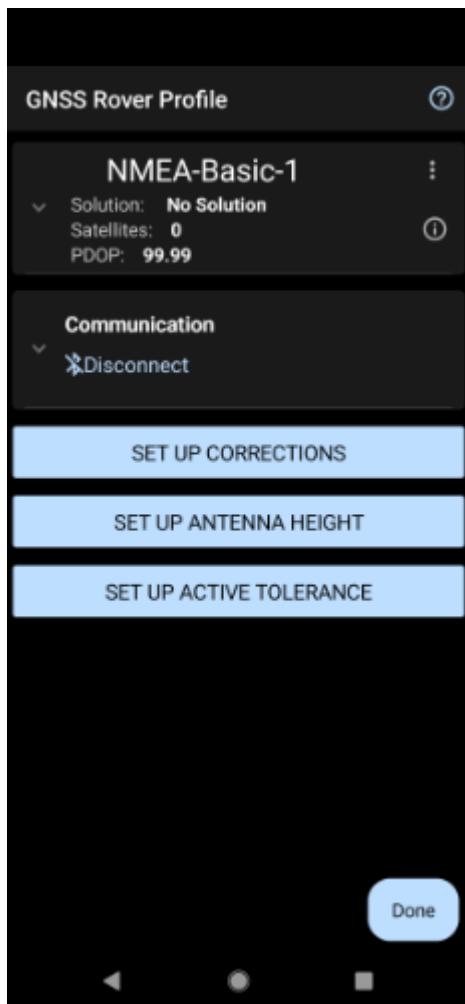
From the Bluetooth communication page, click the 'Search' button.



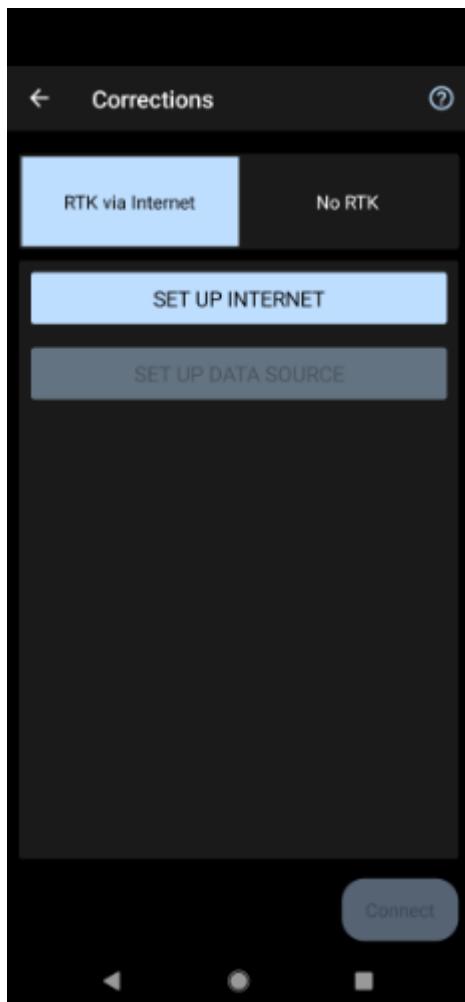
You will be shown a list of paired devices. Select the RTK device you'd like to connect to then click 'Connect'. The RTK device will connect and the MAC address shown on the RTK device OLED will change to the Bluetooth icon indicating a link is open.

NTRIP Client

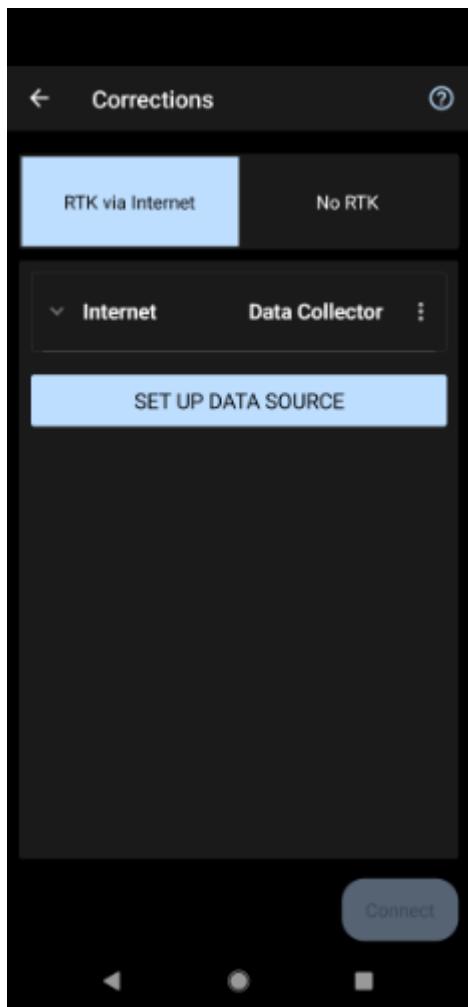
If you're using a serial radio to connect a Base to a Rover for your correction data, or if you're using the RTK Facet L-Band with built-in corrections, you can skip this part.



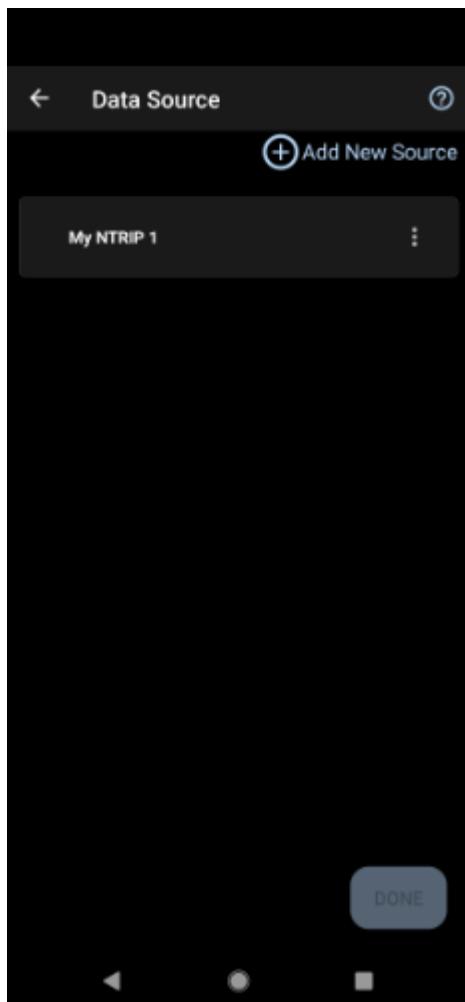
We need to send RTCM correction data from the phone back to the RTK device so that it can improve its fix accuracy. Your phone can be the radio link! Click on 'SET UP CORRECTIONS'.



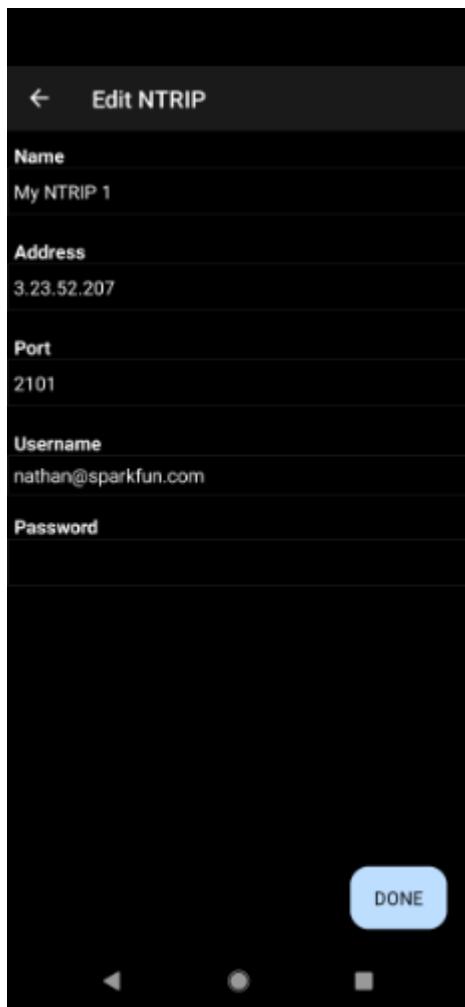
Click on 'RTK via Internet' then 'SET UP INTERNET', then 'Done'.



Click on 'SET UP DATA SOURCE'.



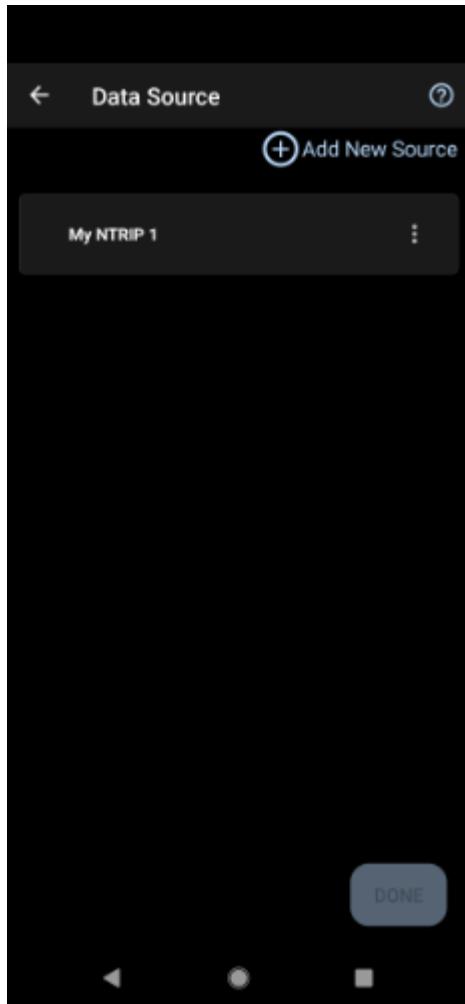
Click 'Add New Source'.



Enter your NTRIP Caster credentials and click 'DONE'.

What's an NTRIP Caster? In a nutshell, it's a server that is sending out correction data every second. There are thousands of sites around the globe that calculate the perturbations in the ionosphere and troposphere that decrease the accuracy of GNSS accuracy. Once the inaccuracies are known, correction values are encoded into data packets in the RTCM format. You, the user, don't need to know how to decode or deal with RTCM, you simply need to get RTCM from a source within 10km of your location into the RTK device. The NTRIP client logs into the server (also known as the NTRIP caster) and grabs that data, every second, and sends it over Bluetooth to the RTK device.

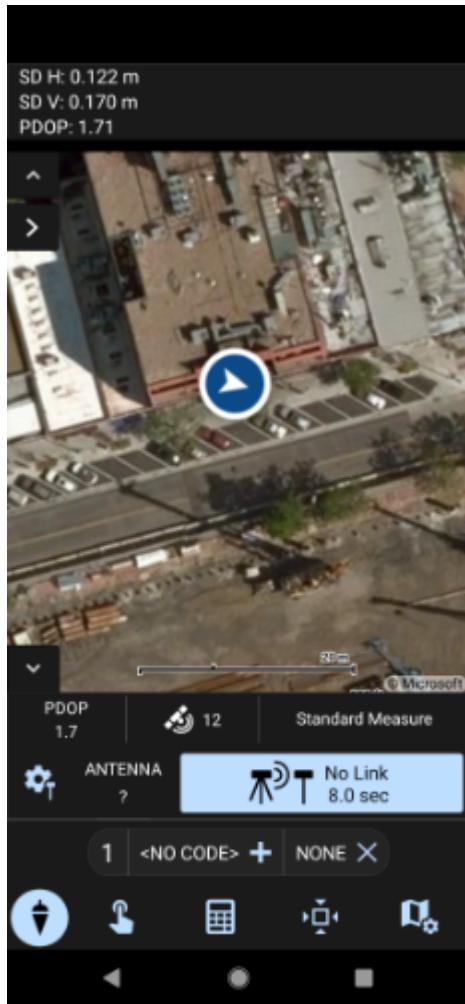
Don't have access to an NTRIP Caster? You can use a 2nd RTK product operating in Base mode to provide the correction data. Check out [Creating a Permanent Base](#). If you're the DIY sort, you can create your own low-cost base station using an ESP32 and a ZED-F9P breakout board. Check out [How to Build a DIY GNSS Reference Station](#). If you'd just like a service, [Syklark](#) provides RTCM coverage for \$49 a month (as of writing) and is extremely easy to set up and use. Remember, you can always use a 2nd RTK device in *Base* mode to provide RTCM correction data but it will be less accurate than a fixed position caster.



Click 'My NTRIP1' then 'Done' and 'Connect'.

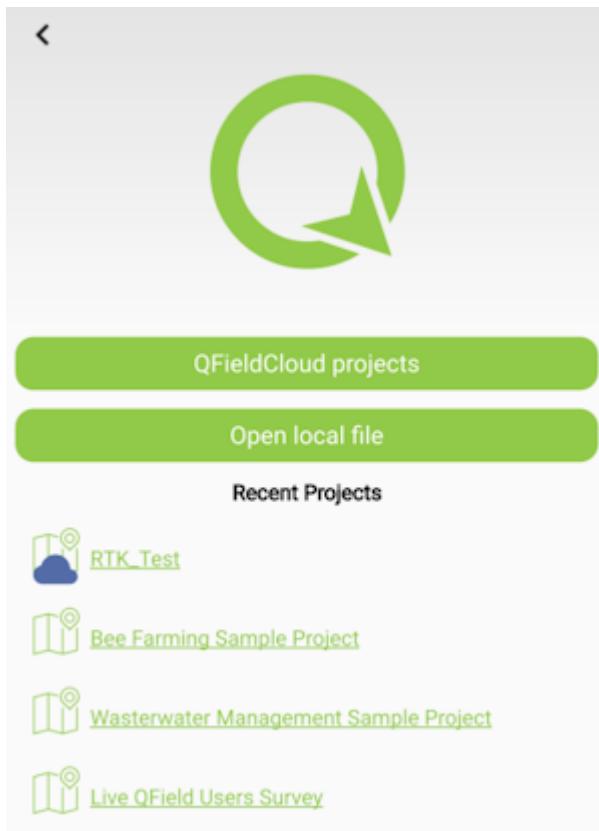
You will then be presented with a list of Mount Points. Select the mount point you'd like to use then click 'Select' then 'Confirm'.

Select 'Done' then from the main menu select 'Survey' to begin using the device.

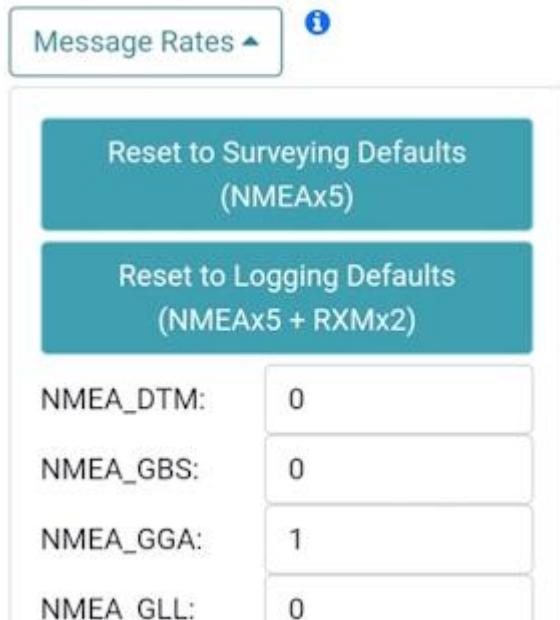


Now you can begin using the SparkFun RTK device with Field Genius.

4.1.2 QField



[QField](#) is a free GIS Android app that runs QGIS.



The 'Reset to Surveying Defaults' button

First, configure the RTK device to output *only* NMEA messages. QField currently does not correctly parse other messages such as RAWX or RTCM so these will interfere with communication if they are enabled.

These RTK device settings can be found under the [Messages menu](#) through the [WiFi config page](#) or through the [Serial Config menu](#).

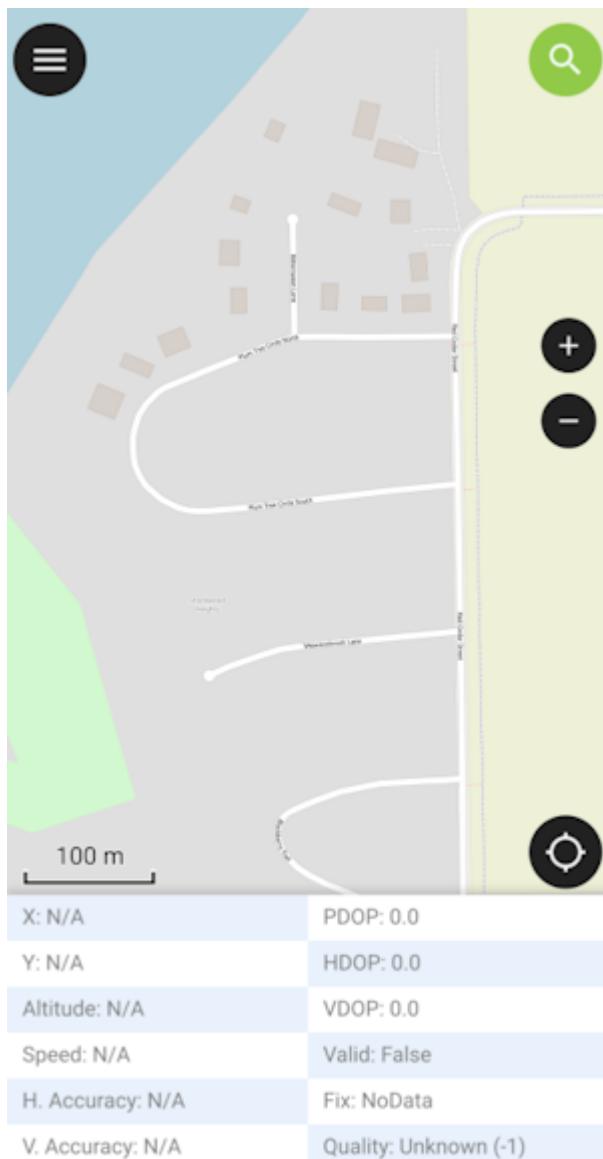


Create an account and project on [QFieldCloud](#). This project will be synchronized and viewable on the QField app.

A screenshot of the QFieldCloud Projects screen. At the top, there's a green header bar with a back arrow and the text "QFieldCloud Projects". Below the header, it says "Greetings loci22." and shows a circular profile picture. There are two tabs: "My Projects" (which is selected) and "Community". Under "My Projects", there's a list item for "loci22" which contains a thumbnail of a project named "RTK_Test" and the note "(Available locally)". A note at the bottom left says "Press and hold over a cloud project for a menu of additional actions." At the bottom right is a green "Refresh projects list" button.

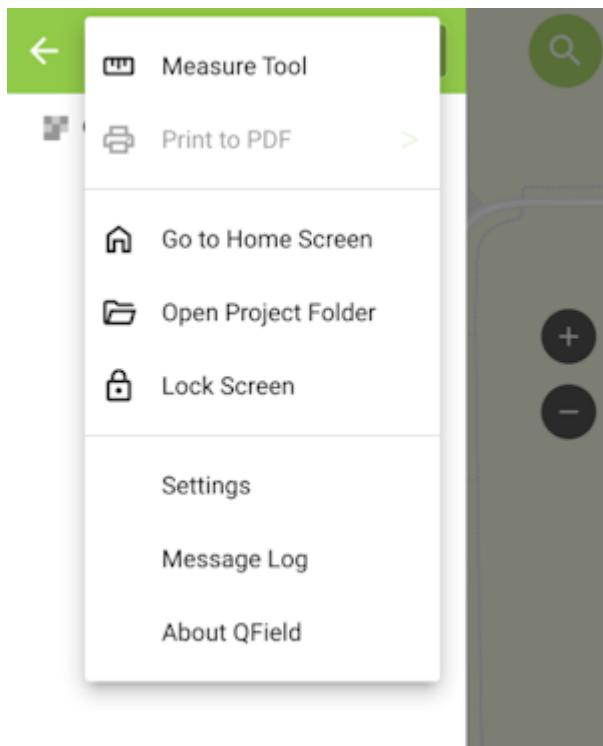
Refresh Projects button

Once the project is created, press the Refresh projects list button to update the list. Then select your project.



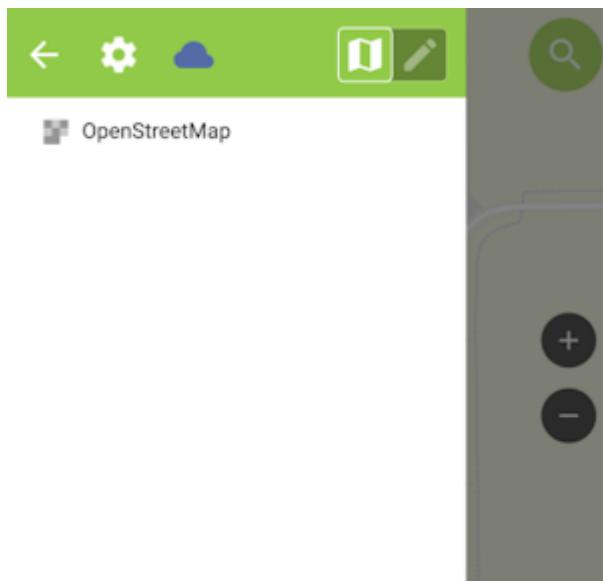
'Hamburger' menu in upper right corner

Press the icon in the top left corner of the app to open the project settings.



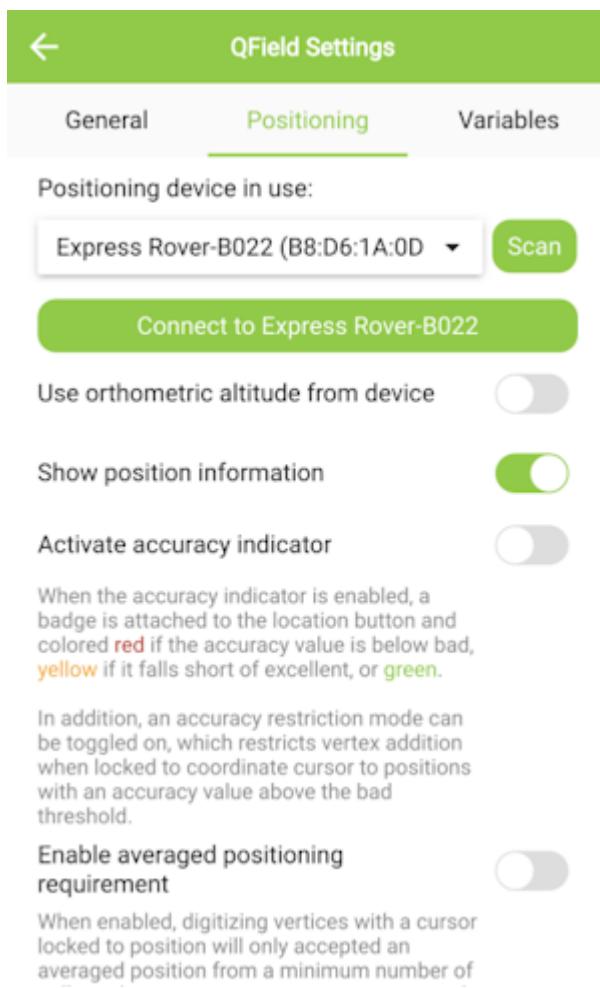
Project settings

From the project settings menu, press the gear icon to open the device settings dropdown menu.



Project settings submenu

From the submenu, select 'Settings'.



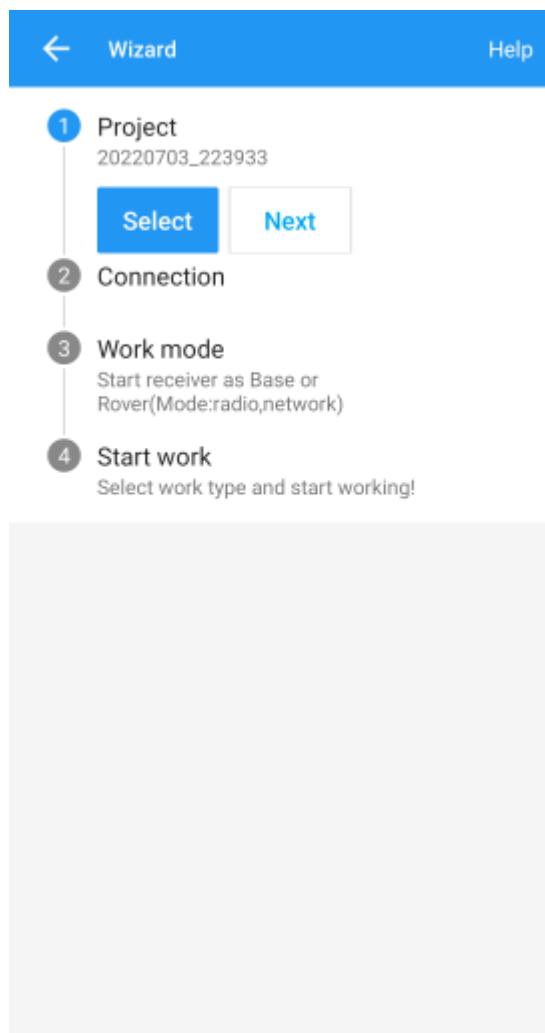
Positioning Menu

Select the Positioning Menu. Then, with your RTK device on and in normal mode (not AP Config) press the Scan button in the QField app to update the dropdown list of available Bluetooth devices. If your device is not detected, be sure you've [paired your cellphone or laptop with Bluetooth](#).

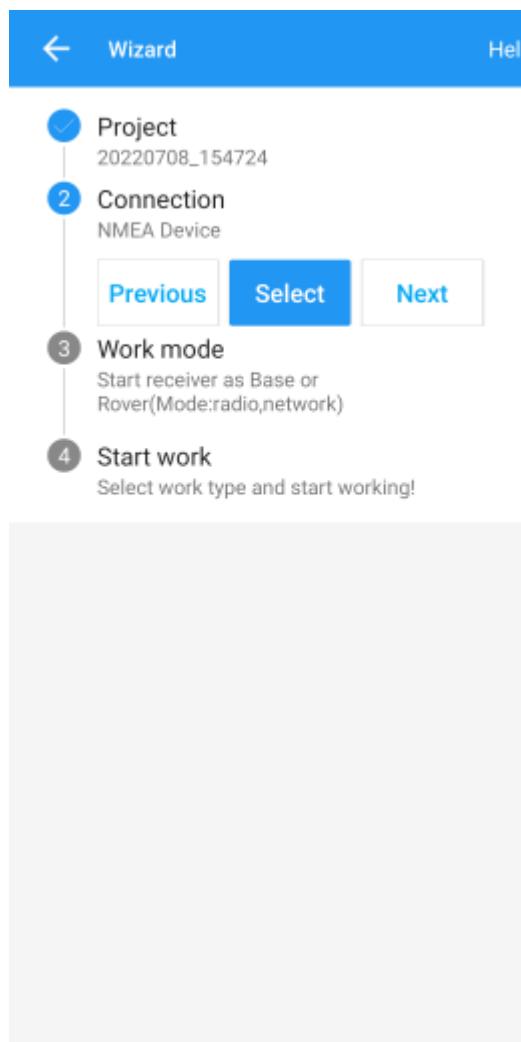
Once connected exit out of the menus and see position information within your project.

4.1.3 Survey Master

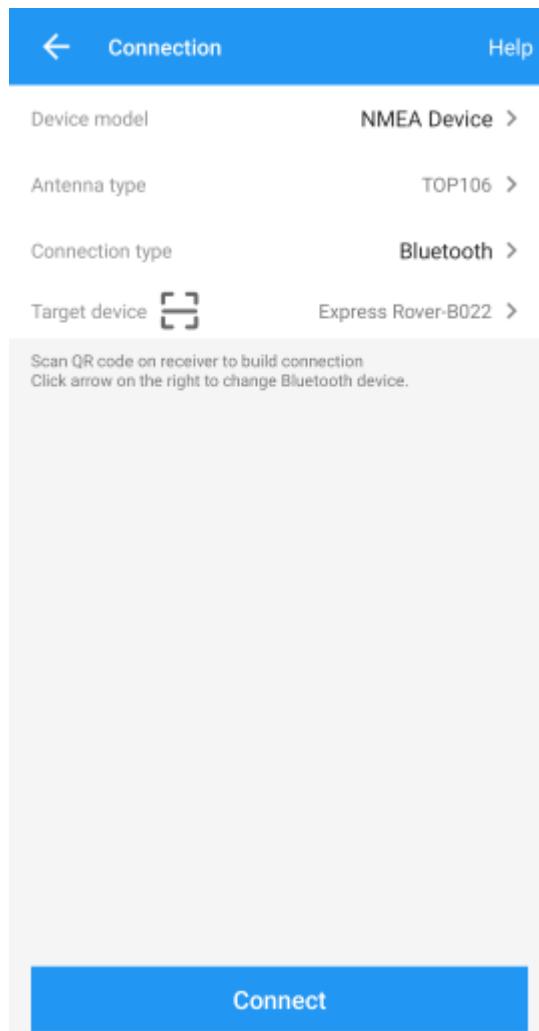
[Survey Master](#) by ComNam / SinoGNSS is an Android-based option. The download location can vary so google 'Survey Master ComNav Download' if the link above fails. Download the zip file, send the APK file to a phone and install the program.



By default, a wizard will guide you through the setup. The Project step will ask you for the name of the project, the datum, etc.



Next select your connection.

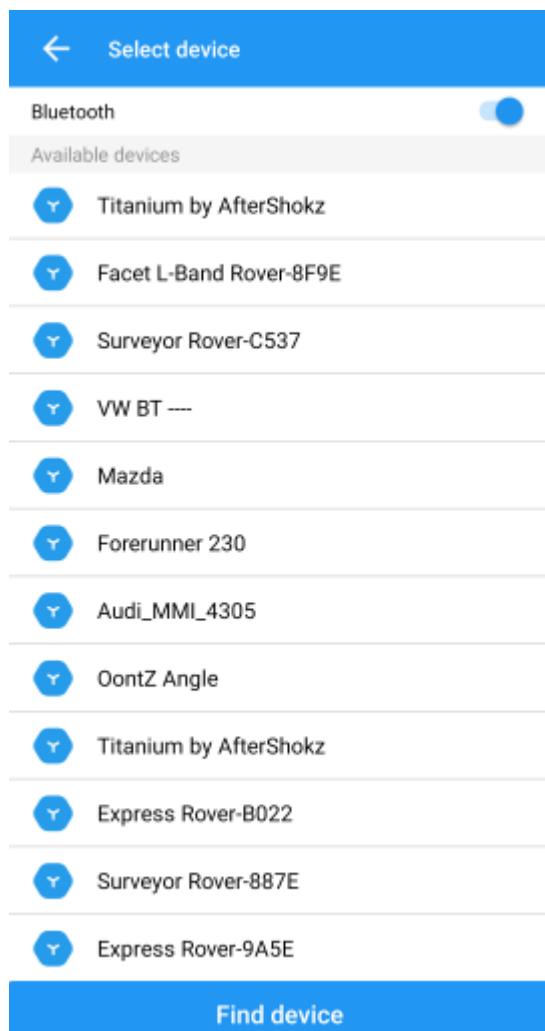


For the Device Model select 'NMEA Device'.

Name	R(R)	Middle(L)	Bottom(V)
T300(NGS)	0.0790	0.0373	0.0753
AT340(NGS)	0.0760	0.0230	0.0530
T300 Plus(NG...)	0.0790	0.0327	0.0707
T30(NGS)	0.0775	0.0287	0.0667
N5(NGS)	0.0775	0.0337	0.0717
AT360(NGS)	0.0765	0.0160	0.0460
N6	0.0615	0.0243	0.0623
N05	0.0380	0.0415	0.1275
LU2	0.0745	0.0135	0.0429
TOP106	0.0740	0.0025	0.0530

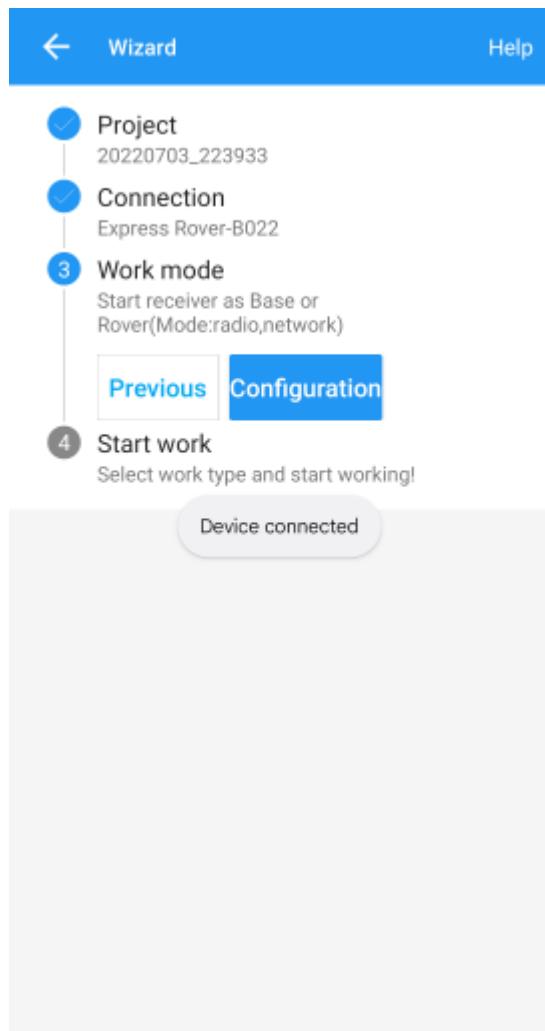
Add

If you are just getting started, use one of the default antenna types. If you are attempting to get sub-centimeter accuracy, enter the parameters of your antenna and add it. Above are the NGS-certified parameters for the [TOP106 antenna](#).

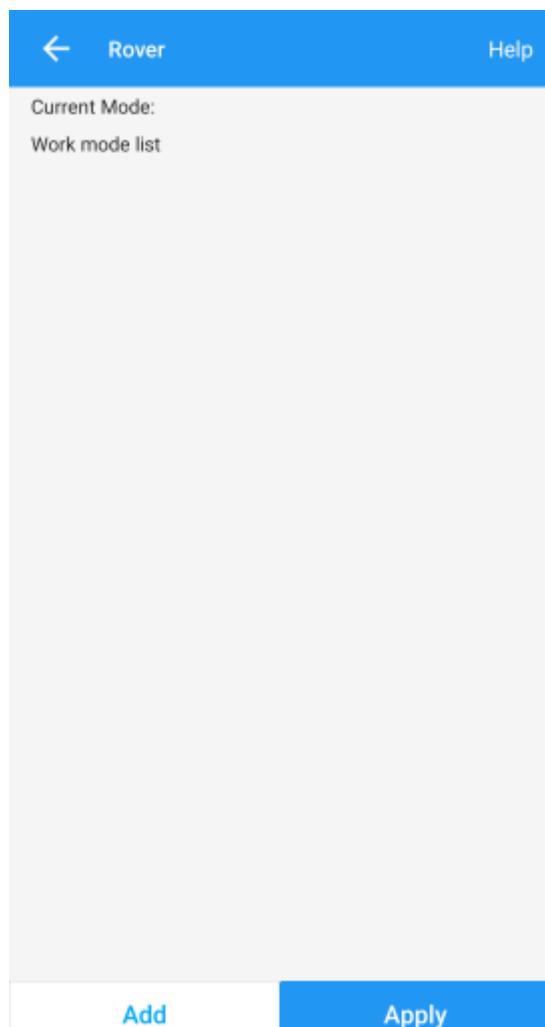


Click the 'Target Device' option to get a list of available Bluetooth devices. Make sure your RTK product is on and you should see the device. In this example 'Express Rover-B022' was chosen.

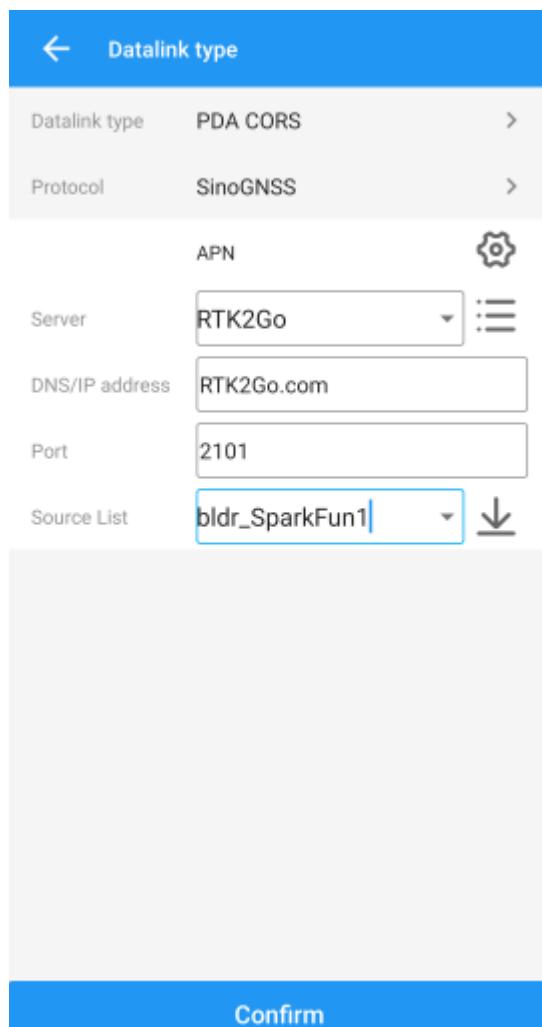
To finish, click 'Connect'. You should see the Bluetooth MAC address on your RTK product change to the Bluetooth icon indicating a connection is established.



Next is configuring the 'Work mode' of the device. The step is where we set up our NTRIP correction source.



Click 'Add' to create a new work mode.

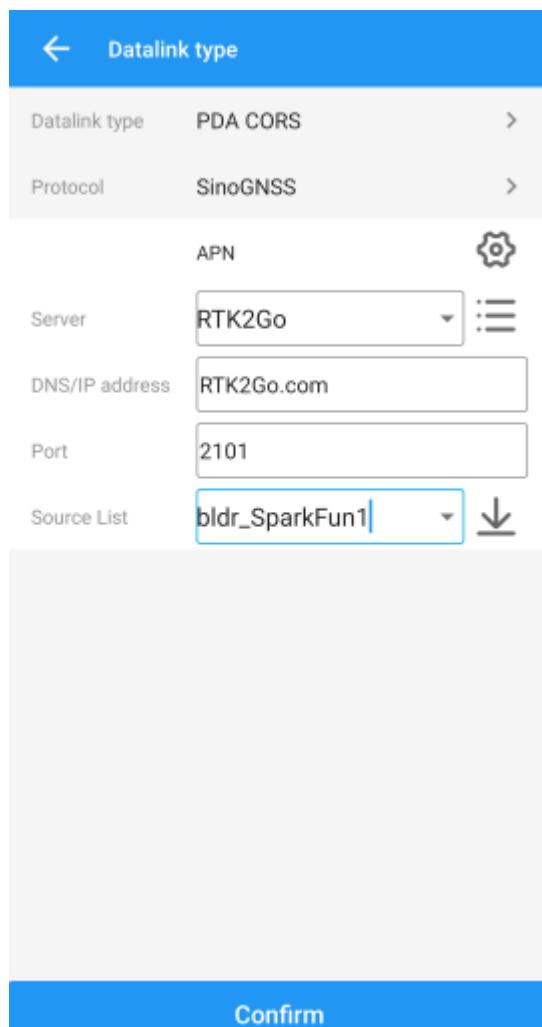


Shown above, we configure the NTRIP Client. Survey Master calls this the 'SinoGNSS' Protocol. Click on the three bars to the right of 'Server' to enter a new NTRIP connection.

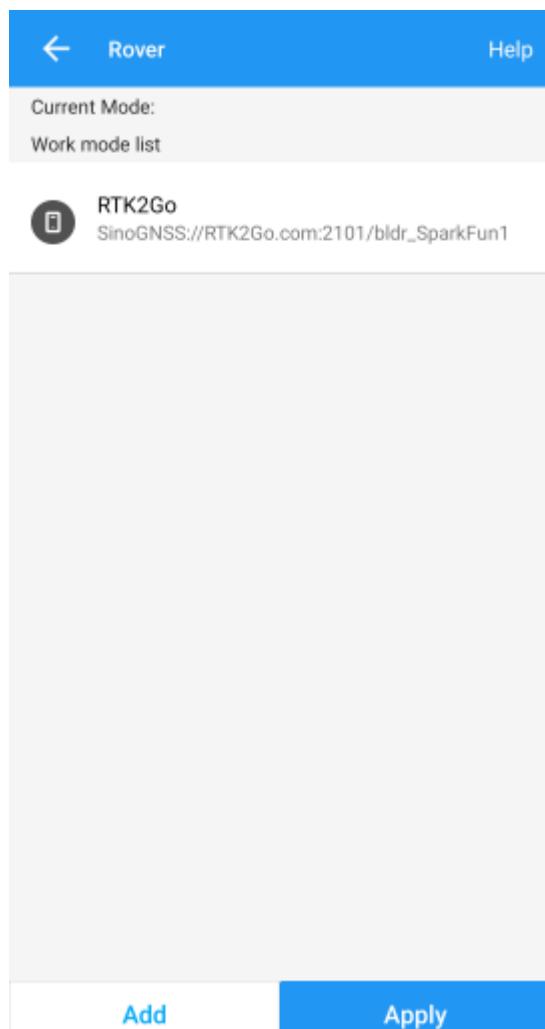
Service account manager		
Name	Address	User
QXWZ	rtk.ntrip.qxwz.com:8003	
CMCC	sdk.pnt.10086.cn:8001	
RTK2Go	rtk2go.com:2101	work@w...

Add

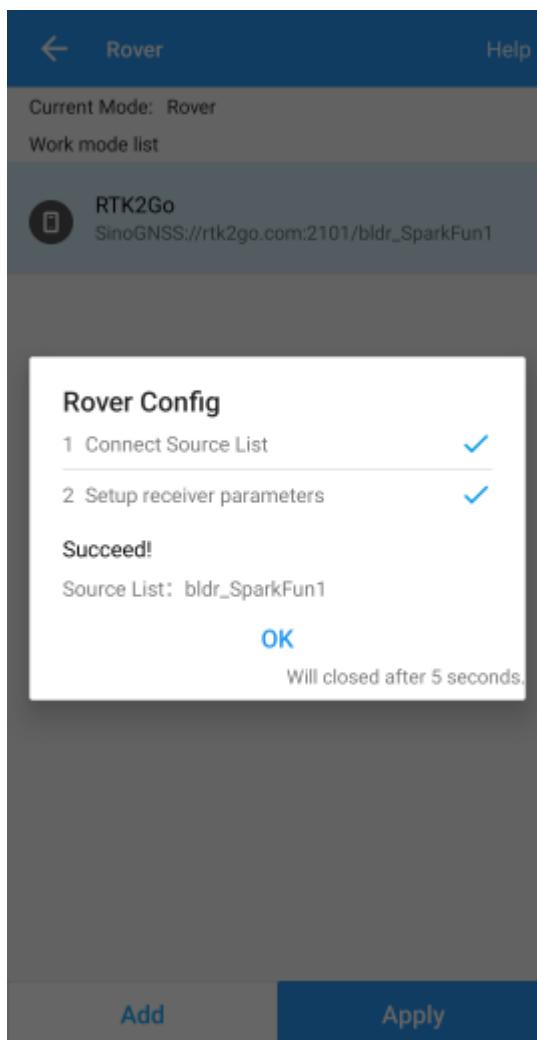
Here you can add different NTRIP Caster providers. If you're using RTK2Go be sure to enter your contact email into the user name.



Return to the 'Datalink type' window and select the Server you just entered. Re-enter the server address and port for your NTRIP Caster. Once complete, click on the down-pointing arrow. This will ping the Caster and obtain the mount point table. Select your mount point.



Select the newly created work mode and press the 'Apply' button.



Survey Master will attempt to connect to your specified RTK corrections source (NTRIP Caster). Upon success, you will be located on the Project menu.

Survey Master expects many more NMEA sentences than most GIS software. We must enable some additional messages on the RTK device to correctly communicate with Survey Master.

```

SparkFun RTK Express v2.3-Jul 8 2022
** Bluetooth broadcasting as: Express Rover-B022 **
Menu: Main Menu
1> Configure GNSS Receiver
2> Configure GNSS Messages
3> Configure Base
4> Configure Ports
5> Configure Logging
p> Configure Profiles
s> System Status
f> Firmware upgrade
x> Exit

Menu: Messages Menu
Active messages: 9
1> Set NMEA Messages
2> Set RTCM Messages
3> Set RXM Messages
4> Set NAV Messages
5> Set MON Messages
6> Set TLM Messages
7> Reset to Surveying Defaults <NMEAx5>
8> Reset to PPP Logging Defaults <NMEAx5 + RXMx2>
9> Turn off all messages
10> Turn on all messages
x> Exit
1

Menu: Message NMEA Menu
1> Message UBX_NMEA_DTM: 0
2> Message UBX_NMEA_GBS: 0
3> Message UBX_NMEA_GGA: 1
4> Message UBX_NMEA_GLL: 1
5> Message UBX_NMEA_GNS: 0
6> Message UBX_NMEA_GRS: 1
7> Message UBX_NMEA_GSA: 1
8> Message UBX_NMEA_GST: 1
9> Message UBX_NMEA_GSV: 1
10> Message UBX_NMEA_RMC: 1
11> Message UBX_NMEA_VLW: 0
12> Message UBX_NMEA_VTG: 1
13> Message UBX_NMEA_ZDA: 1
x> Exit

```

Note above: There are 9 enabled messages and GSV is set to '1'.

Connect to the RTK device either over [WiFi AP config](#) or via [Serial](#). Above is shown the serial method.

Open a terminal at 115200bps and press a key to open the serial configuration menu. Press '2' for GNSS Messages, press '1' for NMEA messages, now be sure to enable 9 messages to a rate of 1:

- GGA
- GLL
- GRS
- GSA
- GST
- GSV
- RMC
- VTG
- ZDA

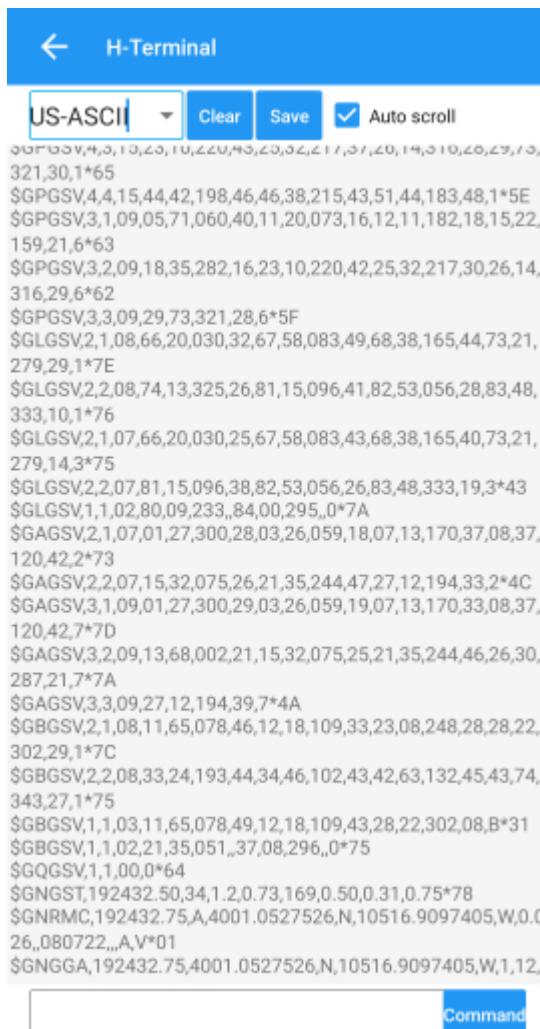
Once complete, press x until you exit the serial menus. Now we may return to Survey Master.



Click on the 'Survey' menu and then 'Topo Survey'. Above we can see a device with RTK float, and 117mm horizontal positional accuracy.

Known Issues:

- Survey Master parses the GxGSV sentence improperly and will only indicate GPS satellites even though the fix solution is using all satellites.



To verify the NMEA sentences are being delivered correctly, Survey Master has a built-in tool. Select the Device->Rover->More->'H-Terminal'.

4.1.4 SurvPC

Be sure your device is [paired over Bluetooth](#).

JOB:NEWJOB

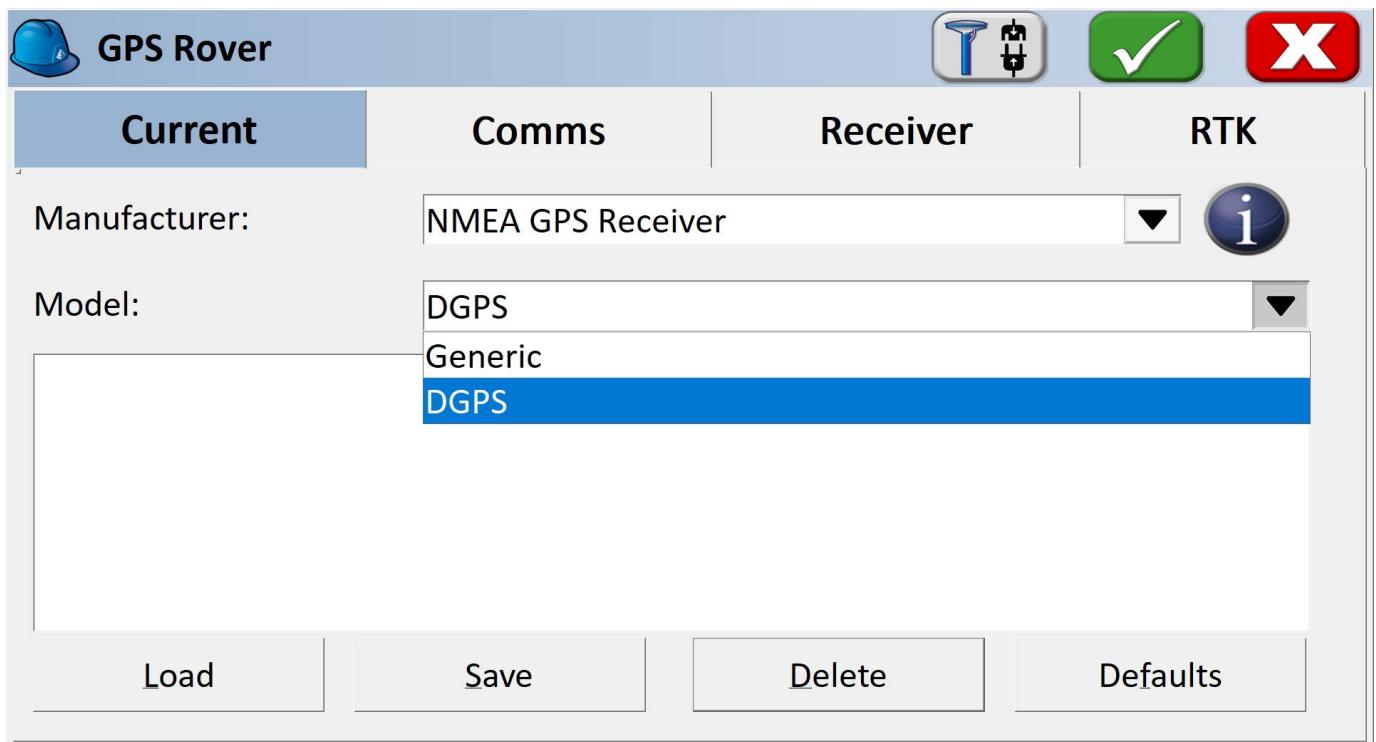
File	Equip	Survey	COGO	Road
1 Total Station	*	6 Localization		
2 GPS Base	*	7 Monitor/Skyplot		
3 GPS Rover	*	8 Tolerances		
4 GPS Raw Only		9 Peripherals		
5 Configure		0 GPS Utilities		

*Equip Sub Menu*Select the *Equip* sub menu then *GPS Rover*

GPS Rover

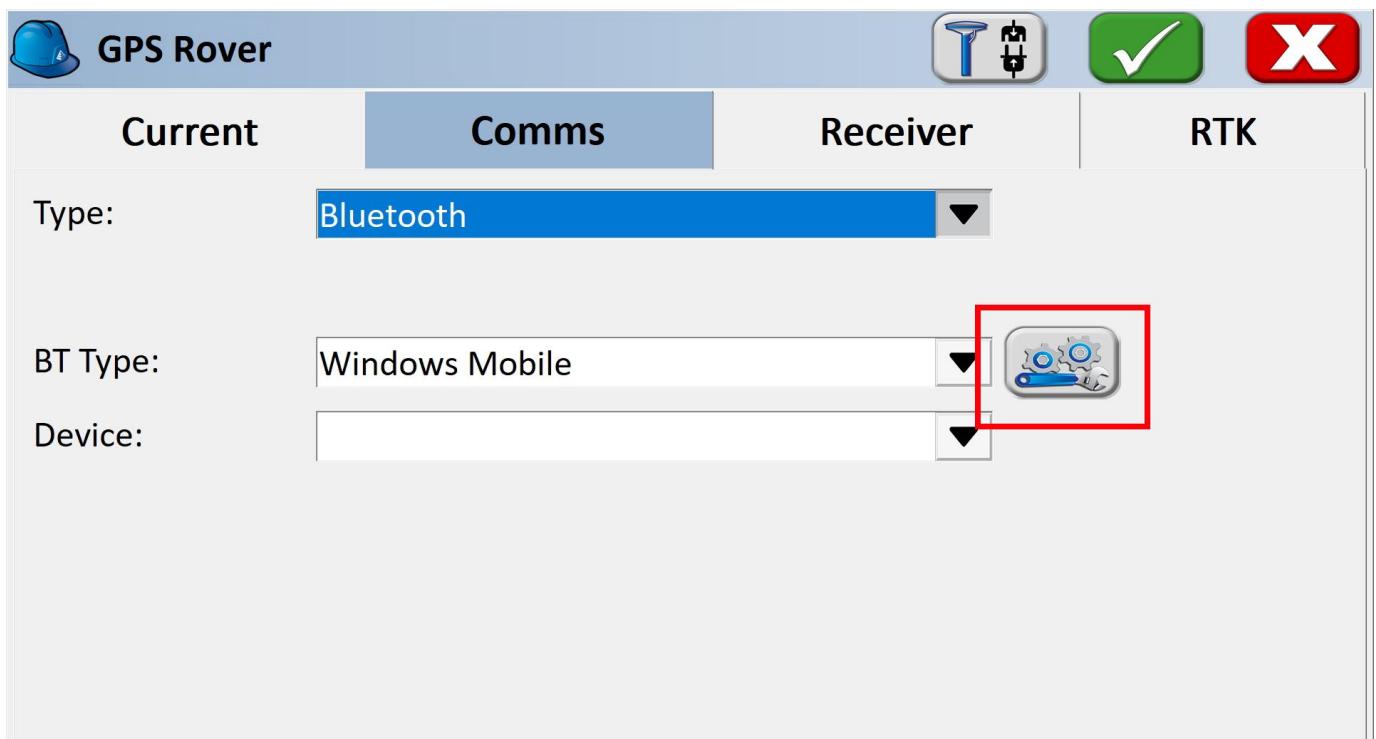
Current	Comms	Receiver
Manufacturer:	NMEA GPS Receiver	
Model:	NMEA GPS Receiver	
	NovAtel	
	North	
	NVS	
	Pentax	
	Prexiso	
	Ruide	
	Sanding	
	SatLab	
	Septentrio	
	Sokkia	
Load		

*Select NMEA GPS Receiver*From the drop down, select *NMEA GPS Receiver*.



Select Model: DGPS

Select DGPS if you'd like to connect to an NTRIP Caster. If you are using the RTK Facet L-Band, or do not need RTK fix type precision, leave the model as Generic.



Bluetooth Settings Button

From the `Comms` submenu, click the Bluetooth settings button.

Bluetooth Devices

Receiver Name	Receiver ID	Address	PIN

[Find Device](#)

[Delete Device](#)

[Set Device PIN](#)

[Set Device Name](#)

*SurvPC Bluetooth Devices*Click [Find Device](#).

Bluetooth Devices

Please select from these available devices:

- Express Rover-DA76
- [TV] Samsung Q60 Series (55)
- Facet L-Band Rover-8F9E

List of Paired Bluetooth Devices

You will be shown a list of devices that have been paired. Select the RTK device you want to connect to.

Bluetooth Devices

Select Rover BT Device

Receiver Name	Receiver ID	Address	PIN
Facet L-Band Rover-8F9E	Facet L-Band Rover-8F9E	b8:d6:1a:0d:8f:9e	

[Find Device](#) [Delete Device](#)

[Set Device PIN](#) [Set Device Name](#)

Connect to Device

Click the `Connect Bluetooth` button, shown in red in the top right corner. The software will begin a connection to the RTK device. You'll see the MAC address on the RTK device changes to the Bluetooth icon indicating it's connected.

If SurvPC detects NMEA, it will report a successful connection.

GPS Rover

[Connect](#) [Checkmark](#) [X](#)

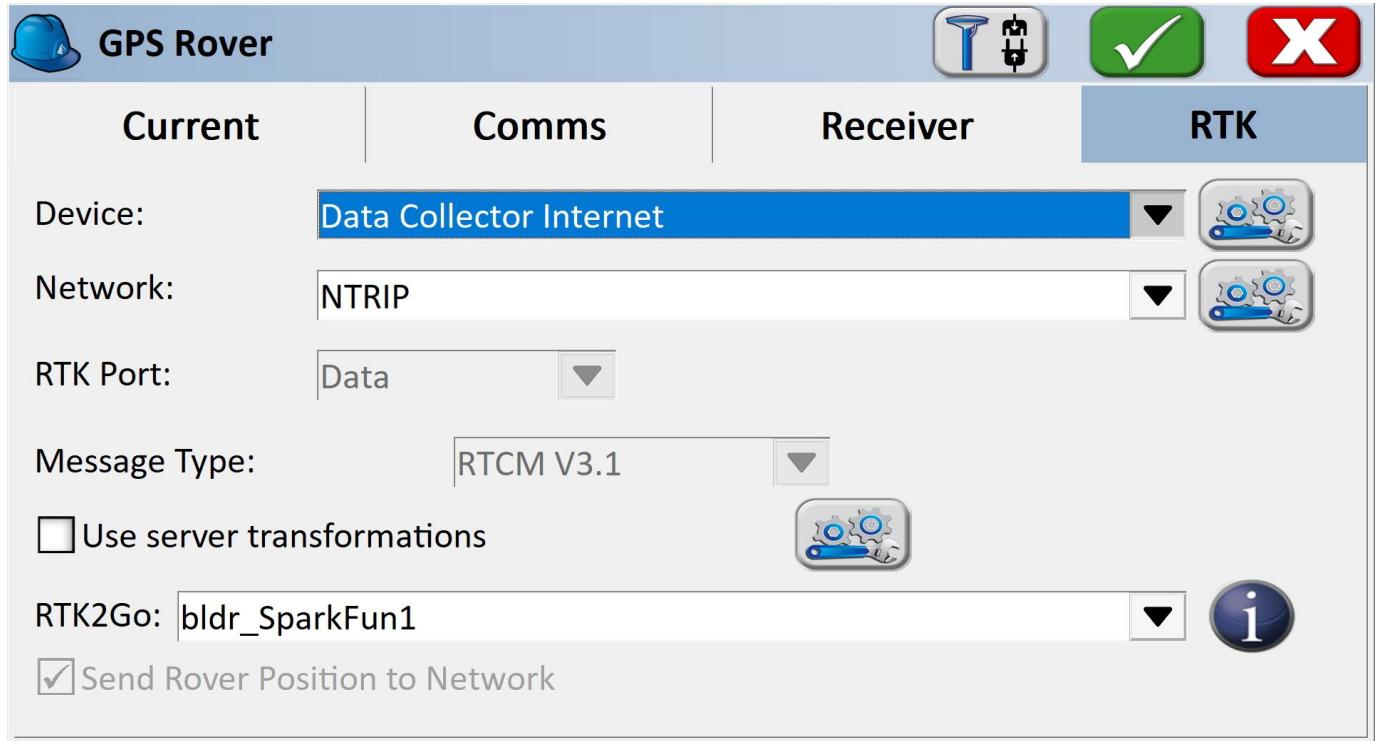
Current	Comms	Receiver	RTK
Antenna Type:	[NONE] NONE	Vert Slant	
Antenna Height:	0 ft	Abs. 0.0mm	
Advanced			

Receiver Submenu

You are welcome to enter the ARP (antenna reference point) and surveying stick length for your particular setup.

NTRIP Client

Note: If you are using a radio to connect Base to Rover, or if you are using the RTK Facet L-Band you do not need to set up NTRIP; the device will achieve RTK fixes and output extremely accurate location data by itself. But if L-Band corrections are not available, or you are not using a radio link, the NTRIP Client can provide corrections to this Rover.



RTK Submenu

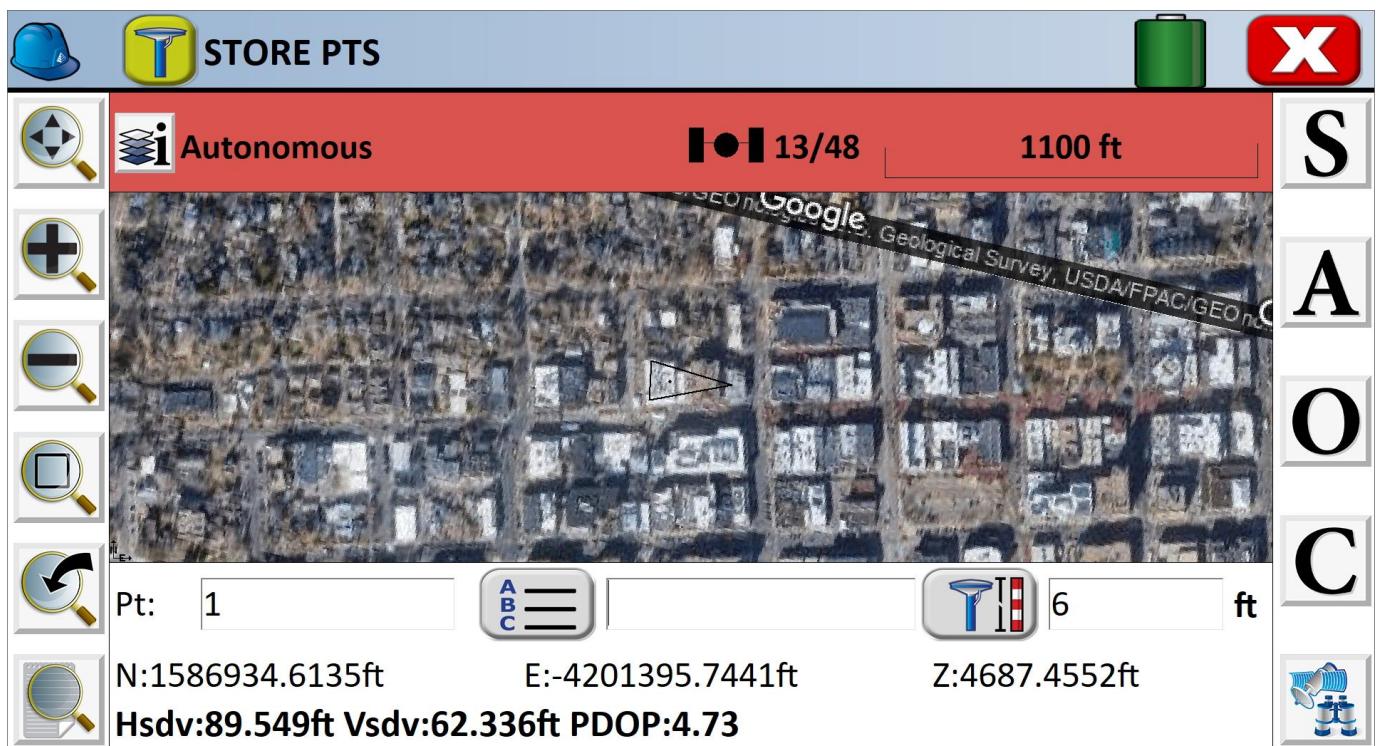
If you selected 'DGPS' as the Model type, the RTK submenu will be shown. This is where you give the details about your NTRIP Caster such as your mount point, user name/pw, etc. For more information about creating your own NTRIP mount point please see [Creating a Permanent Base](#)

Enter your NTRIP Caster credentials and click connect. You will see bytes begin to transfer from your phone to the RTK device. Within a few seconds, the RTK device will go from ~300mm accuracy to 14mm. Pretty nifty, no?

What's an NTRIP Caster? In a nutshell, it's a server that is sending out correction data every second. There are thousands of sites around the globe that calculate the perturbations in the ionosphere and troposphere that decrease the accuracy of GNSS accuracy. Once the inaccuracies are known, correction values are encoded into data packets in the RTCM format. You, the user, don't need to know how to decode or deal with RTCM, you simply need to get RTCM from a source within 10km of your location into the RTK device. The NTRIP client logs into the server (also known as the NTRIP caster) and grabs that data, every second, and sends it over Bluetooth to the RTK device.

Don't have access to an NTRIP Caster? You can use a 2nd RTK product operating in Base mode to provide the correction data. Checkout [Creating a Permanent Base](#). If you're the DIY sort, you can create your own low-cost base station using an ESP32 and a ZED-F9P breakout board. Check out [How to Build a DIY GNSS Reference Station](#) (<https://learn.sparkfun.com/tutorials/how-to-build-a-diy-gnss-reference-station>). If you'd just like a service, [Syklark](#) provides RTCM coverage for \$49 a month (as of writing) and is extremely easy to set up and use. Remember, you can always use a 2nd RTK device in *Base* mode to provide RTCM correction data but it will be less accurate than a fixed position caster.

Once everything is connected up, click the Green check in the top right corner.



Storing Points

Now that we have a connection, you can use the device, as usual, storing points and calculating distances.

Monitor/Skyplot				
Quality	Position	SATView	SATInfo	Ref
Status:	AUTONOMOUS	Satellites:	12/47	
Latency:	N/A	Local Elev:	5280.9218ft	
Local Northing:	1587134.3031ft		06/10/2022	
Local Easting:	-4201260.5881ft		14:37:13.7	
HDOP:	1.78	VDOP:	2.84	
TDOP:	N/A	PDOP:	3.35	
GDOP:	N/A			
Hsdv:	69.751ft			
Vsdv:	52.493ft			

SurvPC Skyplot

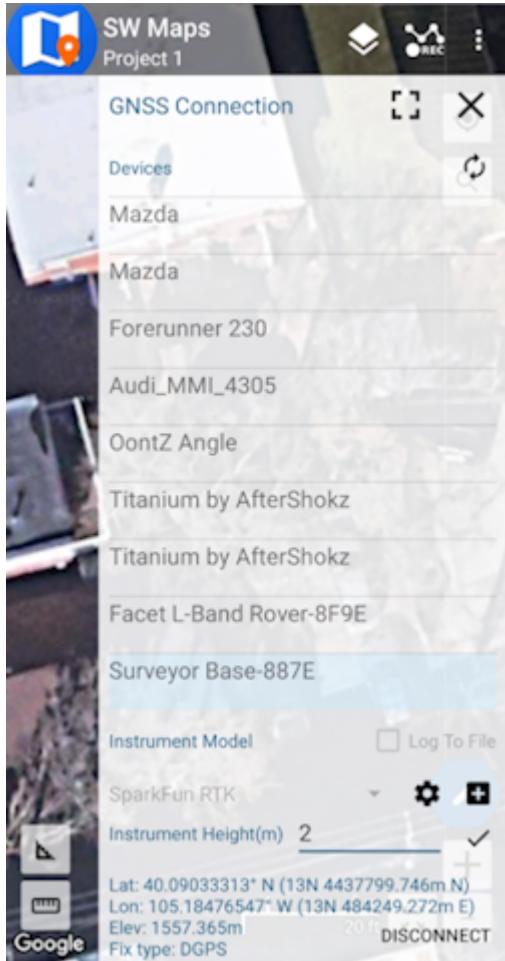
Opening the Skyplot will allow you to see your GNSS details in real-time.

If you are a big fan of SurvPC please contact your sales rep and ask them to include SparkFun products in their Manufacturer drop-down list.

4.1.5 SW Maps

The best mobile app that we've found is the powerful, free, and easy-to-use [SW Maps](#) by Softwel. It is compatible with Android and iOS, either phone or tablet with Bluetooth. What makes SW Maps truly powerful is its built-in NTRIP client. This is a fancy way of saying that we'll be showing you how to get RTCM correction data over the cellular network.

Be sure your device is [paired over Bluetooth](#).



List of available Bluetooth devices

From SW Map's main menu, select *Bluetooth GNSS*. This will display a list of available Bluetooth devices. Select the Rover or Base you just paired with. If you are taking height measurements (altitude) in addition to position (lat/long) be sure to enter the height of your antenna off the ground including any [ARP offsets](#) of your antenna (this should be printed on the side).

Click on 'CONNECT' to open a Bluetooth connection. Assuming this process takes a few seconds, you should immediately have a location fix.



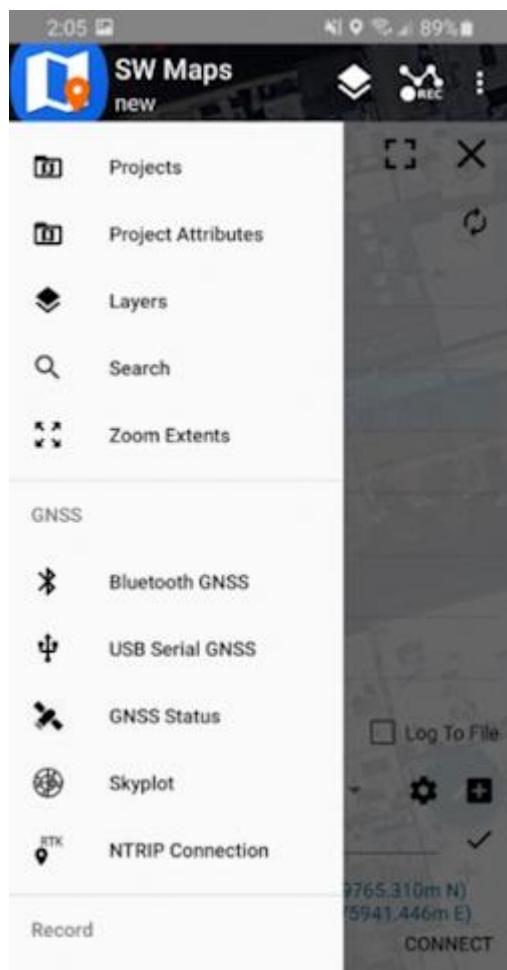
SW Maps with RTK Fix

You can open the GNSS Status sub-menu to view the current data.

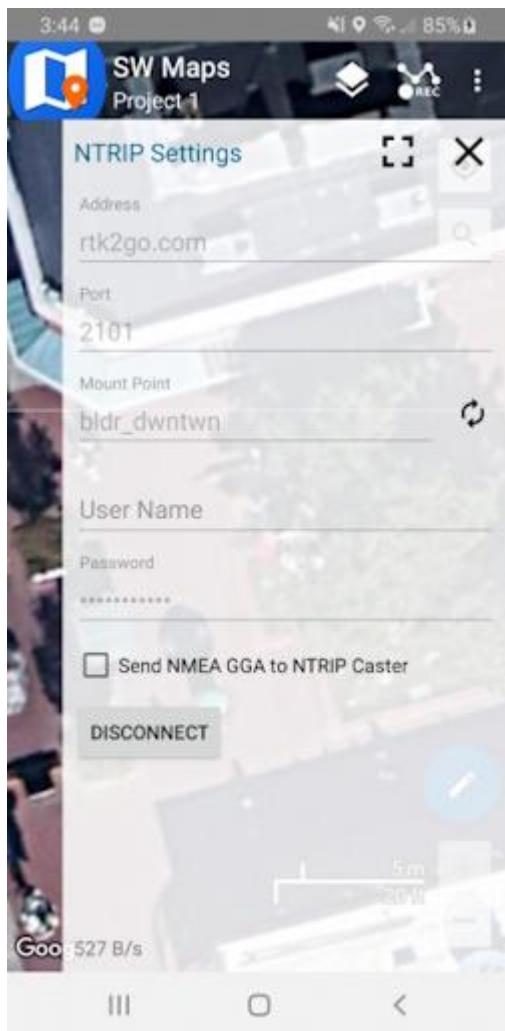
NTRIP Client

If you're using a serial radio to connect a Base to a Rover for your correction data, or if you're using the RTK Facet L-Band with built-in corrections, you can skip this part.

We need to send RTCM correction data from the phone back to the RTK device so that it can improve its fix accuracy. This is the amazing power of the SparkFun RTK products and SW Maps. Your phone can be the radio link! From the main SW Maps menu select NTRIP Client. Not there? Be sure the 'SparkFun RTK' instrument was automatically selected connecting. Disconnect and change the instrument to 'SparkFun RTK' to enable the NTRIP Connection option.



NTRIP Connection - Not there? Be sure to select 'SparkFun RTK' was selected as the instrument



Connecting to an NTRIP Caster

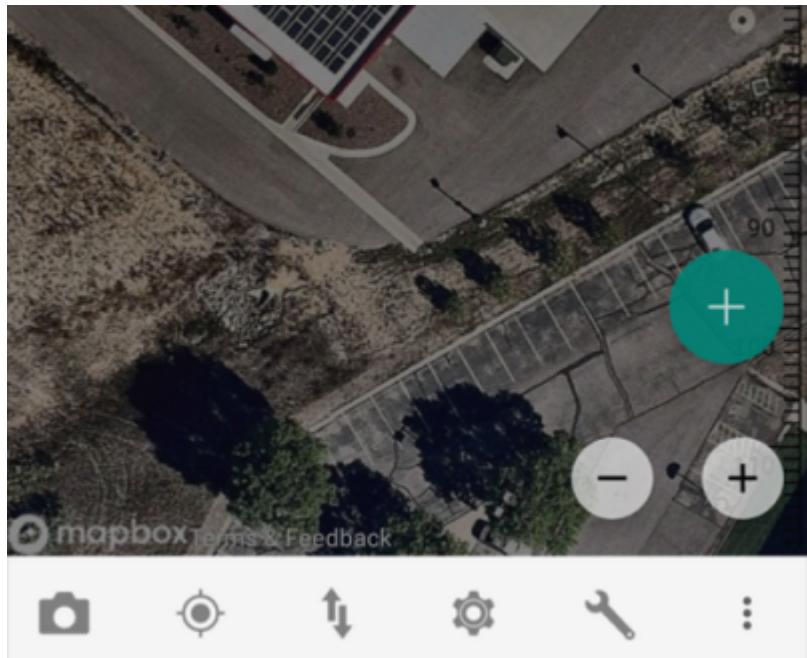
Enter your NTRIP Caster credentials and click connect. You will see bytes begin to transfer from your phone to the RTK device. Within a few seconds, the RTK device will go from ~300mm accuracy to 14mm. Pretty nifty, no?

Once you have a full RTK fix you'll notice the location bubble in SW Maps turns green. Just for fun, rock your rover monopole back and forth on a fixed point. You'll see your location accurately reflected in SW Maps. Millimeter location precision is a truly staggering thing.

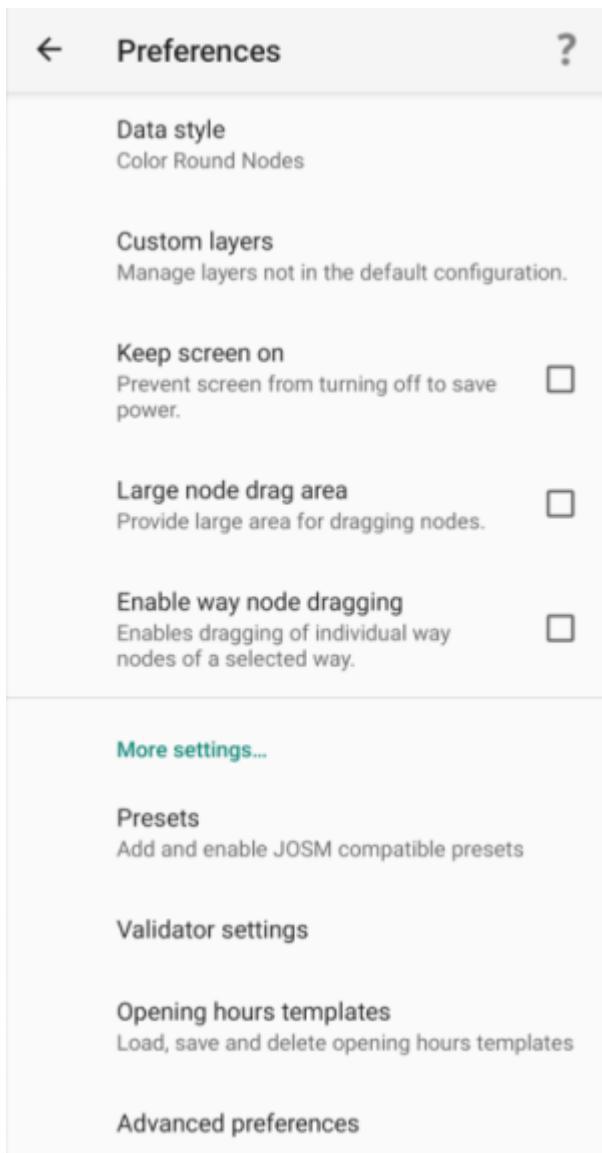
4.1.6 Vespucci

[Vespucci](#) is an Open Street Map editor for Android.

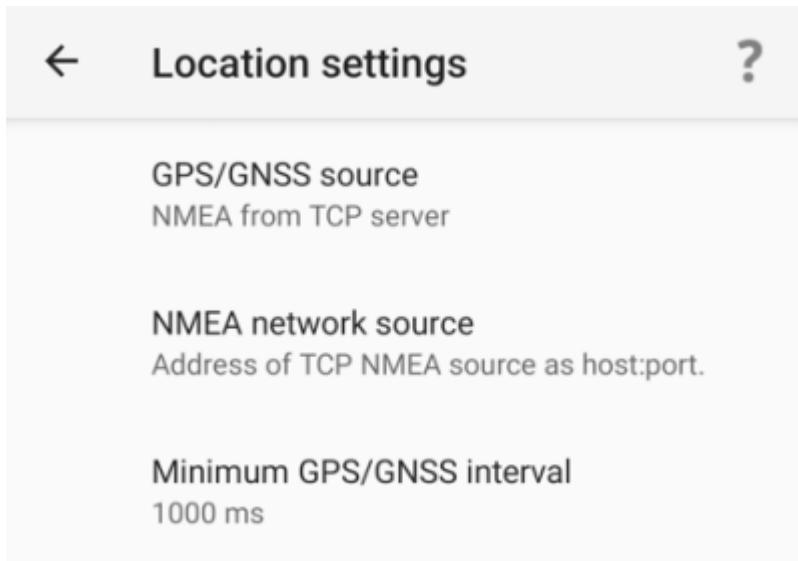
This software requires the RTK device to connect over TCP. Be sure you have a local WiFi network entered into the [WiFi Config menu](#), have a TCP Client or Server enabled, and have noted the TCP port (it's 2947 by default).



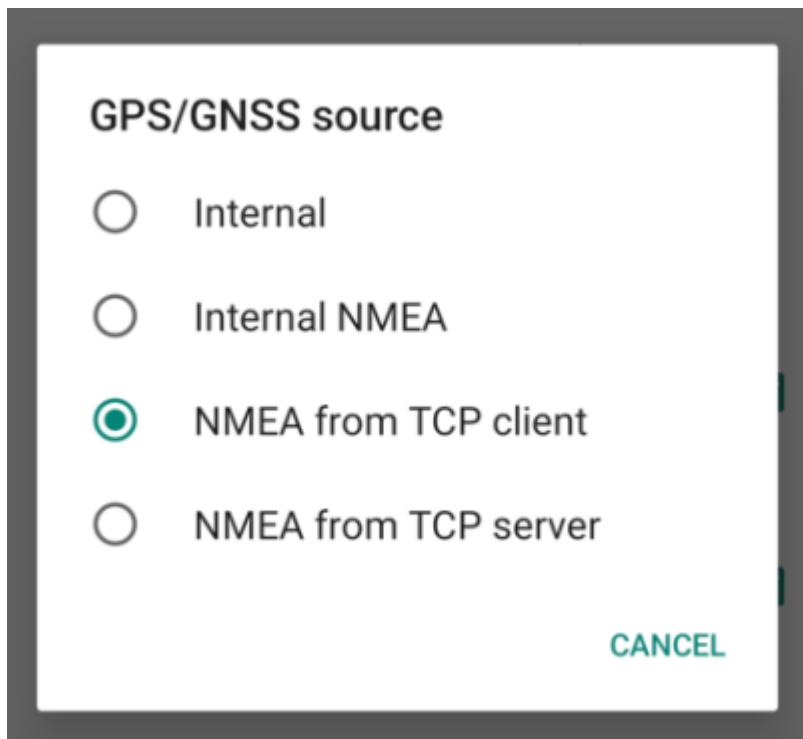
With a map open, select the gear icon on the bottom bar.



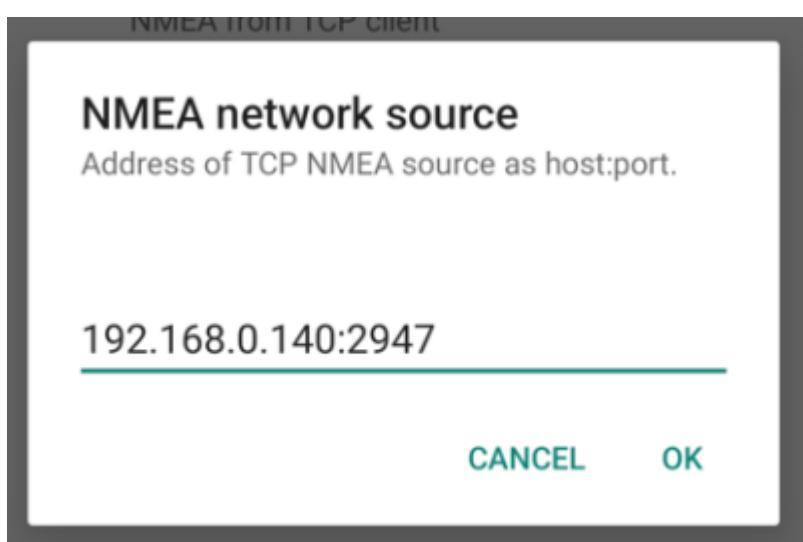
From the Preferences menu, scroll to the bottom and select 'Advanced Preferences'.



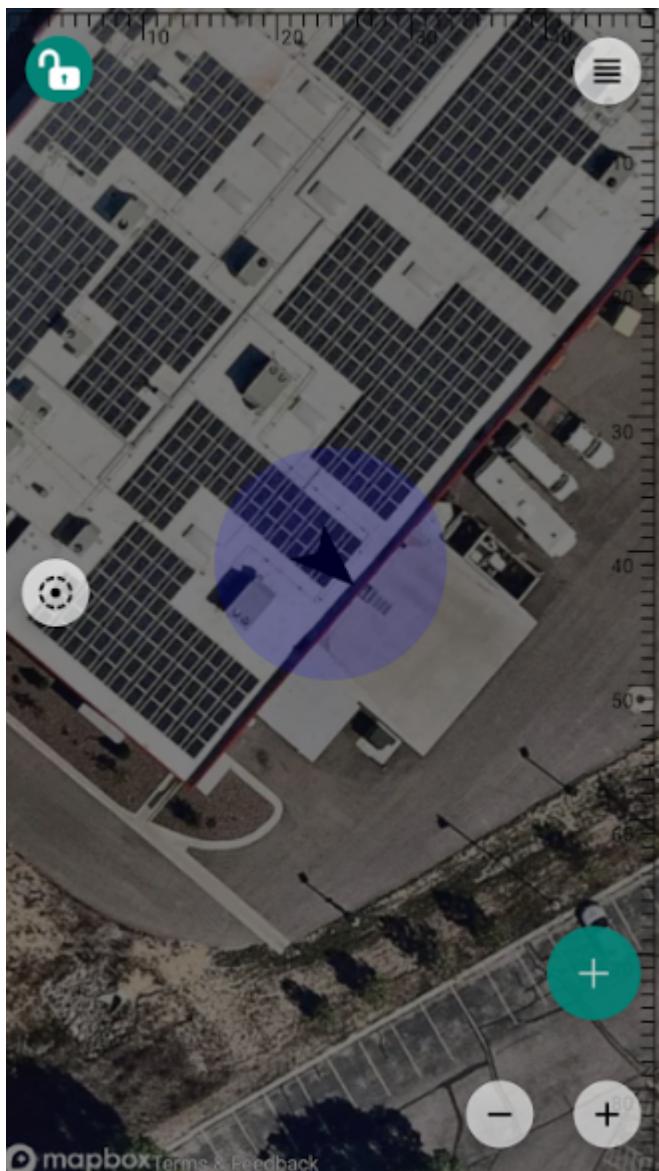
Select **Location settings**.



Select **GPS/GNSS source**. Select **NMEA from TCP client**. TCP server is also supported.



Select **NMEA network source**. Enter the IP address and TCP port of the RTK device. The IP address can be found by opening a serial terminal while connected to WiFi (it is reported every few seconds). The TCP port is entered into the [WiFi Config menu](#).



Close all menus and you should see your location within Vespucci.

4.1.7 Other GIS Packages

Hopefully, these examples give you an idea of how to connect the RTK product line to most any GIS software. If there is other GIS software that you'd like to see configuration information about, please open an issue on the [RTK Firmware repo](#) and we'll add it.

4.1.8 What's an NTRIP Caster?

In a nutshell, it's a server that is sending out correction data every second. There are thousands of sites around the globe that calculate the perturbations in the ionosphere and troposphere that decrease the accuracy of GNSS accuracy. Once the inaccuracies are known, correction values are encoded into data packets in the RTCM format. You, the user, don't need to know how to decode or deal with RTCM, you simply need to get RTCM from a source within 10km of your location into the RTK device. The NTRIP client logs into the server (also known as the NTRIP caster) and grabs that data, every second, and sends it over Bluetooth to the RTK device.

4.1.9 Where do I get RTK Corrections?

Be sure to see [Correction Sources](#).

Don't have access to an NTRIP Caster or other RTCM correction source? There are a few options.

The [SparkFun RTK Facet L-Band](#) gets corrections via an encrypted signal from geosynchronous satellites. This device gets RTK Fix without the need for a WiFi or cellular connection.

Also, you can use a 2nd RTK product operating in Base mode to provide the correction data. Check out [Creating a Permanent Base](#).

If you're the DIY sort, you can create your own low-cost base station using an ESP32 and a ZED-F9P breakout board. Check out [How to Build a DIY GNSS Reference Station](#).

There are services available as well. [Syklark](#) provides RTCM coverage for \$49 a month (as of writing) and is extremely easy to set up and use. [Point One](#) also offers RTK NTRIP service with a free 14 day trial and easy to use front end.

4.2 iOS

Torch: 

There are a variety of 3rd party apps available for GIS and surveying. We will cover a few examples below that should give you an idea of how to get the incoming NMEA data into the software of your choice.

The software options for Apple iOS are much more limited because Apple products do not support Bluetooth SPP. That's ok! The SparkFun RTK products support additional connection options including TCP and Bluetooth Low Energy (BLE).

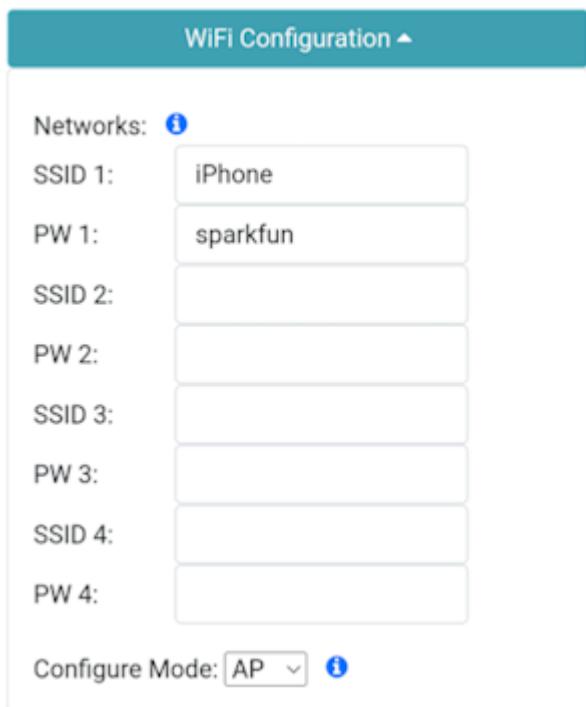
4.2.1 ArcGIS Survey123



ArcGIS Survey123 Home Screen

[ArcGIS Survey123](#) is a popular offering from Esri that works well with SparkFun RTK products.

ArcGIS Survey123 connects to the RTK device over TCP. In other words, the RTK device needs to be connected to the same WiFi network as the device running ArcGIS. Generally, this is an iPhone or iPad.



```
Menu: WiFi Networks
1) SSID 1: iPhone
2) Password 1: sparkfun
3) SSID 2:
4) Password 2:
5) SSID 3:
6) Password 3:
7) SSID 4:
8) Password 4:
a) Configure device via WiFi Access Point or connect to WiFi: AP
c) Captive Portal: Enabled
m) MDNS: Enabled
x) Exit
```

Adding WiFi network to settings

The RTK device must use WiFi to connect to the data collector. Using a cellular hotspot or cellphone is recommended. In the above image, the device will attempt to connect to *iPhone* (a cell phone hotspot) when WiFi is needed.

```
Menu: TCP/UDP

1) TCP Client: Disabled
4) TCP Server: Enabled
5) TCP Server Port: 2948
6) UDP Server: Disabled
x) Exit
```

TCP Server Enabled on port 2948

Next, the RTK device must be configured as a *TCP Server*. The default port of 2948 works well. See [TCP/UDP Menu](#) for more information.

```

System Status
2024-06-07 20:44:29.759
GNSS: Online - UM980 firmware: 7923
Module ID: ff3b68963b35b28c
SIV: 35, HPA (m): 0.008, Lat: 40.09032494, Lon: -105.184
Fuel Gauge: Online - Batt (100%) / Voltage: 8.16V
Bluetooth Low Energy (FDAE): Online
WiFi MAC Address: 64:B7:00:SD-FD-48
WiFi 'iPhone' IP address: 172.20.10.2 RSSI: -18
System Uptime: 0 00:00:30.065 (Resets: 0)
NTRIP Client Connected - rtk2go.com/bldr SparkFun1:2101
Filtered by parser: 0 NMEA / 0 RTCM / 0 UBX

```

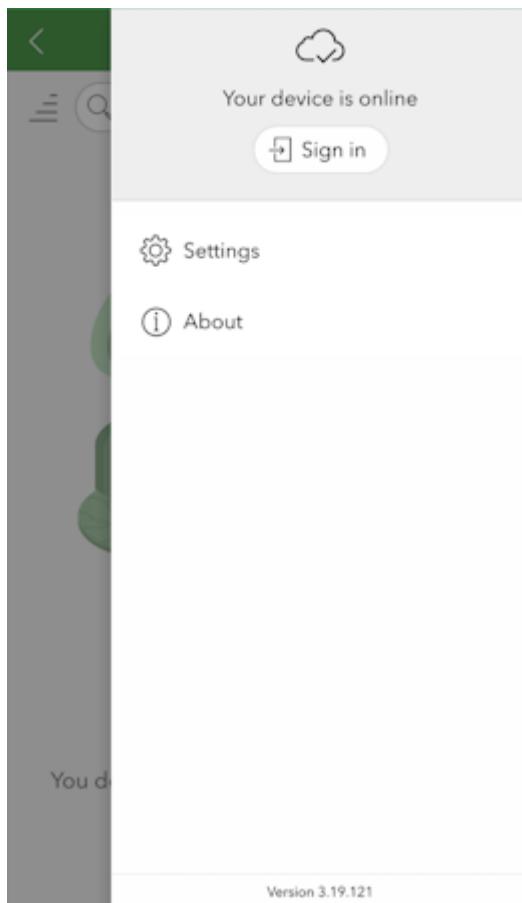
RTK device showing IP address

Once the RTK device connects to the WiFi hotspot, its IP address can be found in the [System Menu](#). This is the number that needs to be entered into ArcGIS Survey123. You can now proceed to the ArcGIS Survey123 app to set up the software connection.



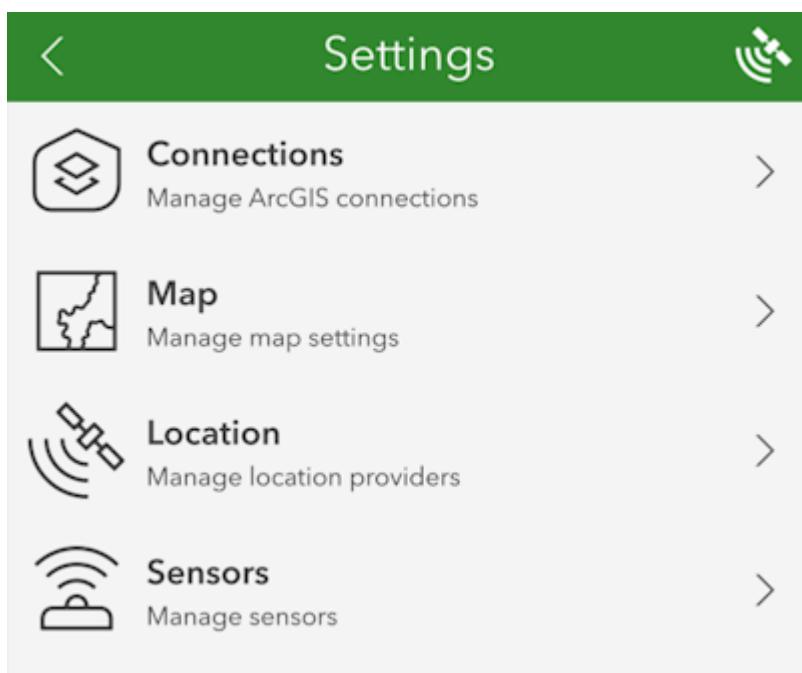
ArcGIS Survey123 Home Screen

From the home screen, click on the 'hamburger' icon in the upper right corner.



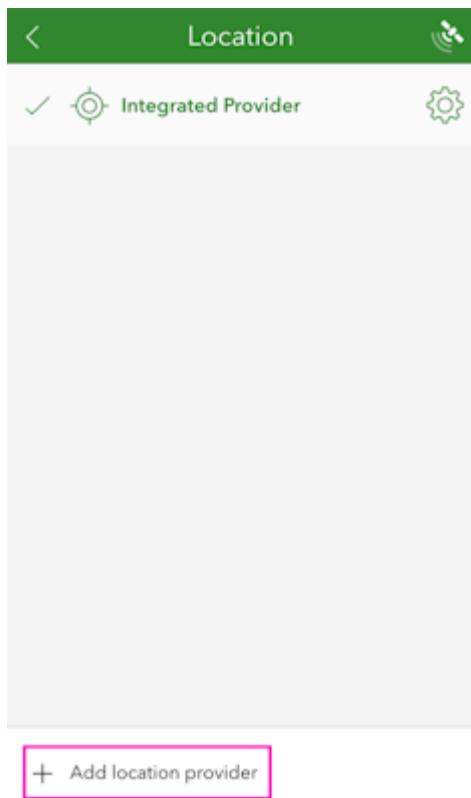
ArcGIS Survey123 Settings Menu

From the settings menu, click on the *Settings* gear.



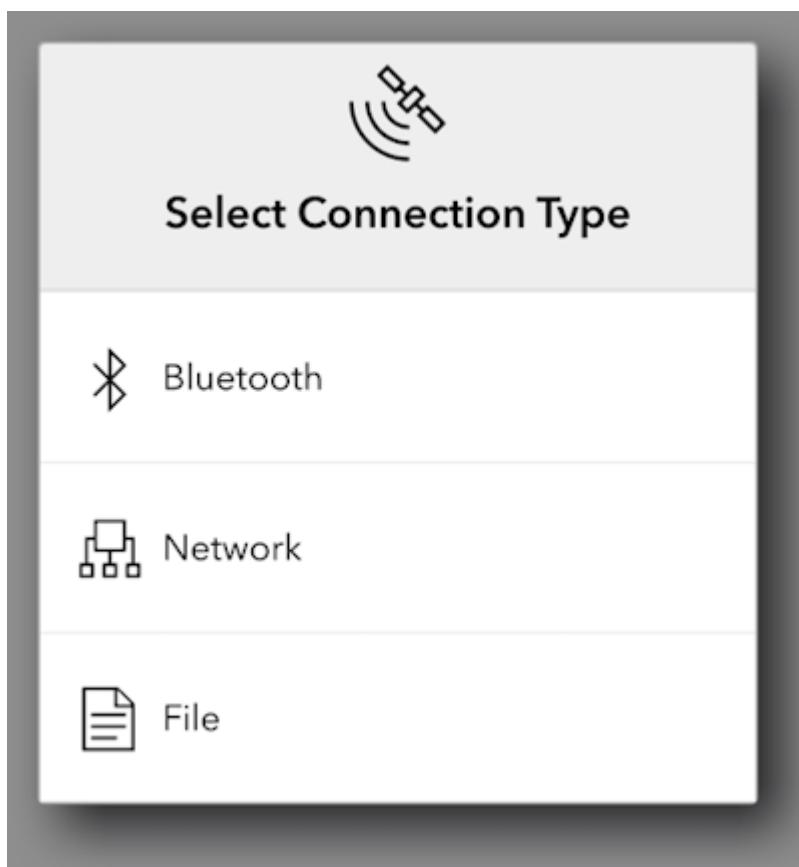
ArcGIS Survey123 Settings List

From the settings list, click on *Location*.



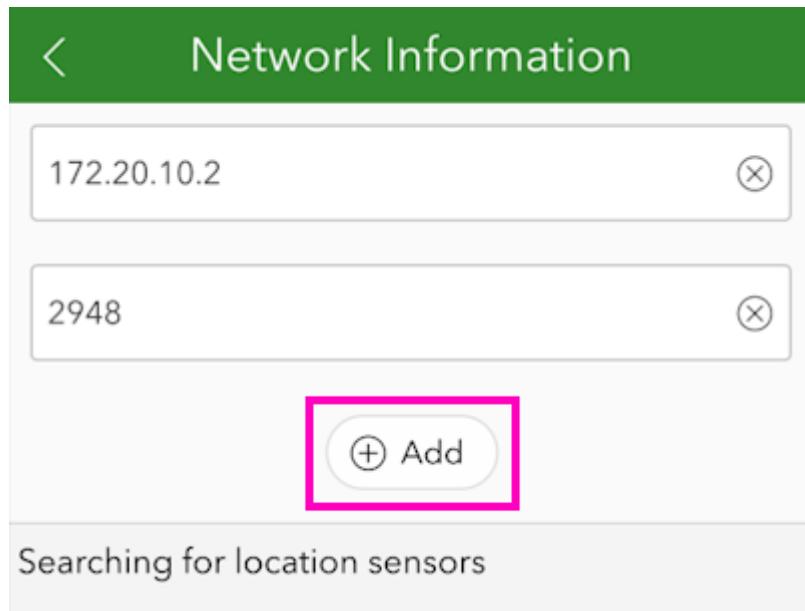
ArcGIS Survey123 List of Location Providers

Click on the *Add location provider*.



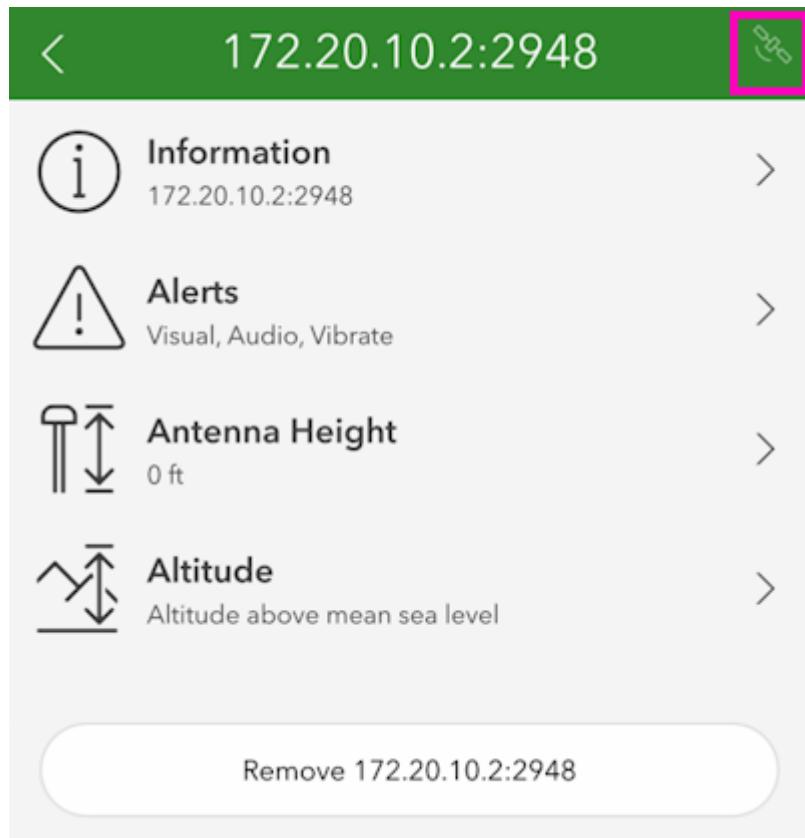
ArcGIS Survey123 Network Connection Type

Select Network.



ArcGIS Survey123 TCP Connection Information

Enter the IP address previously found along with the TCP port. Once complete, click *Add*.



ArcGIS Survey123 Sensor Settings

You may enter various sensor-specific settings including antenna height, if desired. To view real-time sensor information, click on the satellite icon in the upper right corner.

< Location Status

Source **172.20.10.2:2948**

Mode **RTK Fixed**

Time since last update **0.8 s**

Latitude **40°5'25.170"N**

Longitude **105°11'5.195"W**

Altitude **5175.49 ft**

USNG **13T DE 8424 3779**

Speed *No data*

Vertical speed *No data*

Direction *No data*

Magnetic variation *No data*

Accuracy mode **Error RMS**

Confidence level **68%**

Horizontal accuracy **0.044 ft**

Vertical accuracy **0.072 ft**

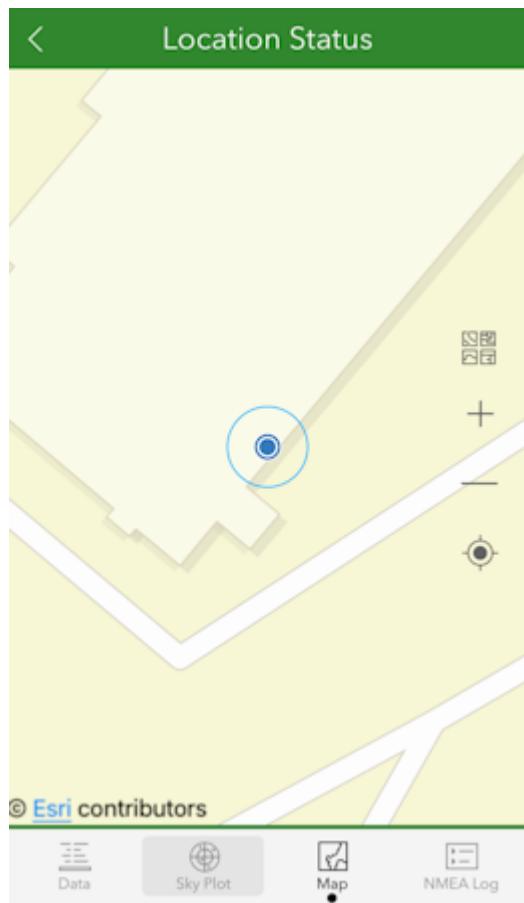
Position accuracy **0.085 ft**

Elevation: 5175.49 ft

 Data Sky Plot Map NMEA Log

ArcGIS Survey123 Sensor Data

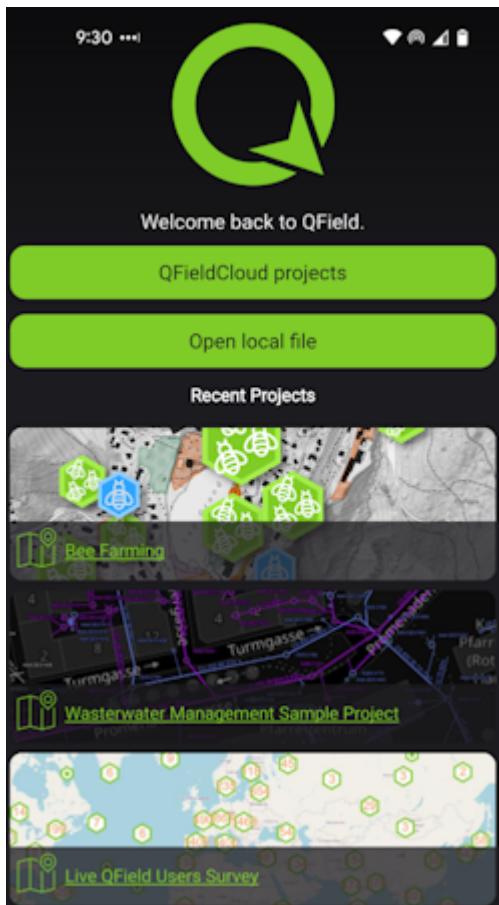
The SparkFun RTK device's data should now be seen. Click on the *Map* icon to return to the mapping interface.



ArcGIS Survey123 Map Interface

Returning to the map view, we can now begin gathering point information with millimeter accuracy.

4.2.2 QField



[QField](#) is a free iOS app that runs QGIS.

```
Menu: Message NMEA
1) Message GPDTM: 0
2) Message GPGBS: 0
3) Message GPGGA: 0.5
4) Message GPGLL: 0
5) Message GPGNS: 0
6) Message GPGRS: 0
7) Message GPGSA: 0.5
8) Message GPGST: 0.5
9) Message GPGSV: 1
10) Message GPRMC: 0
11) Message GPROT: 0
12) Message GPTHGS: 0
13) Message GPVTG: 0
14) Message GPZDA: 0
x) Exit
```

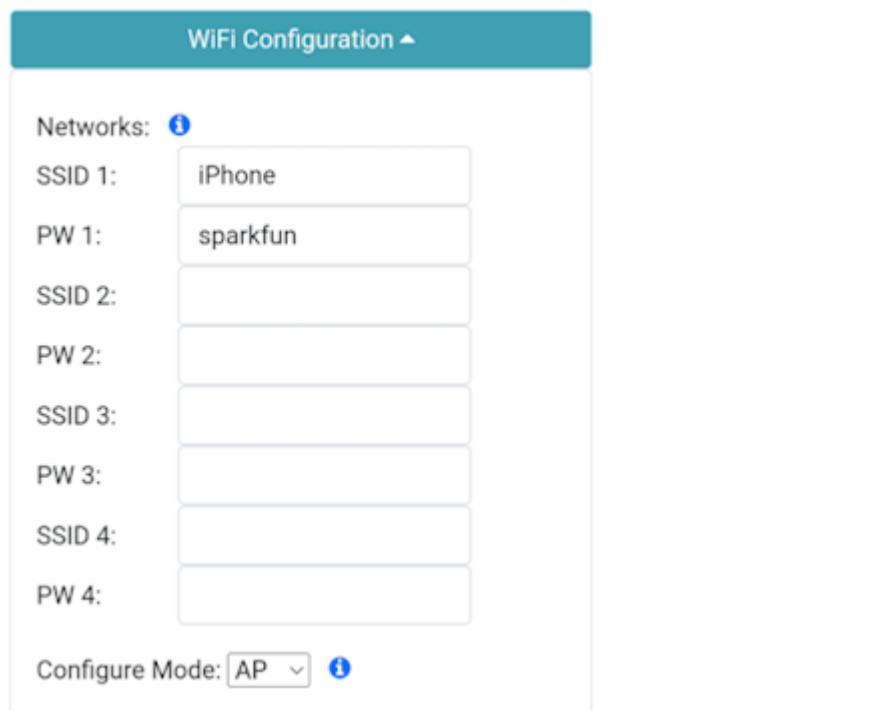
Modified NMEA messages on RTK Torch

First, configure the RTK device to output *only* the following NMEA messages:

- GPGGA
- GPGSA
- GPGST
- GPGSV

QField currently does not correctly parse other messages such as **GPRMC**, or **RTCM**. These messages will prevent communication if they are enabled.

These NMEA message settings can be found under the [Messages menu](#), using the [web config page](#) or the [serial config interface](#).



```
Menu: WiFi Networks
1) SSID 1: iPhone
2) Password 1: sparkfun
3) SSID 2:
4) Password 2:
5) SSID 3:
6) Password 3:
7) SSID 4:
8) Password 4:
a) Configure device via WiFi Access Point or connect to WiFi: AP
c) Captive Portal: Enabled
m) MDNS: Enabled
x) Exit
```

Adding WiFi network to settings

Next, the RTK device must use WiFi to connect to the data collector. Using a cellular hotspot or cellphone is recommended. In the above image, the device will attempt to connect to *iPhone* (a cell phone hotspot) when WiFi is needed.

```
Menu: TCP/UDP
1) TCP Client: Disabled
4) TCP Server: Enabled
5) TCP Server Port: 9000
6) UDP Server: Disabled
x) Exit
```

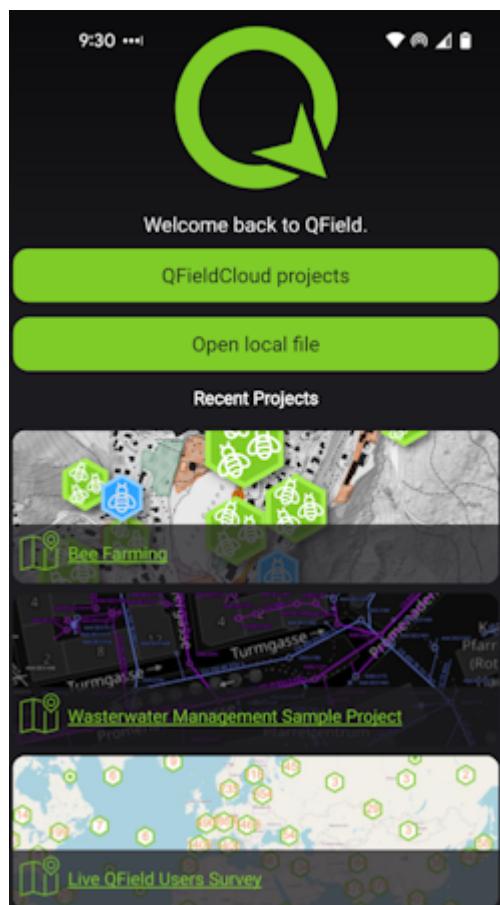
TCP Server Enabled on port 9000

Next, the RTK device must be configured as a *TCP Server*. QField uses a default port of 9000 so that is what we recommend using. See [TCP/UDP Menu](#) for more information.

```
System Status
2024-06-07 20:44:29.759
GNSS: Online - UM980 firmware: 7923
Module ID: ff3b68963b35b28c
SIV: 35, HPA (m): 0.008, Lat: 40.09032494, Lon: -105.184
Fuel Gauge: Online - Batt (100%) / Voltage: 8.16V
Bluetooth Low Energy (FDAE): Online
WiFi MAC Address: 64:B7:00:SD:FD:AC
WiFi 'iPhone' IP address: 172.20.10.2 RSSI: -18
System Uptime: 0 00:00:30.065 (Resets: 0)
NTRIP Client Connected - rtk2go.com/bldr SparkFun1:2101
Filtered by parser: 0 NMEA / 0 RTCM / 0 UBX
```

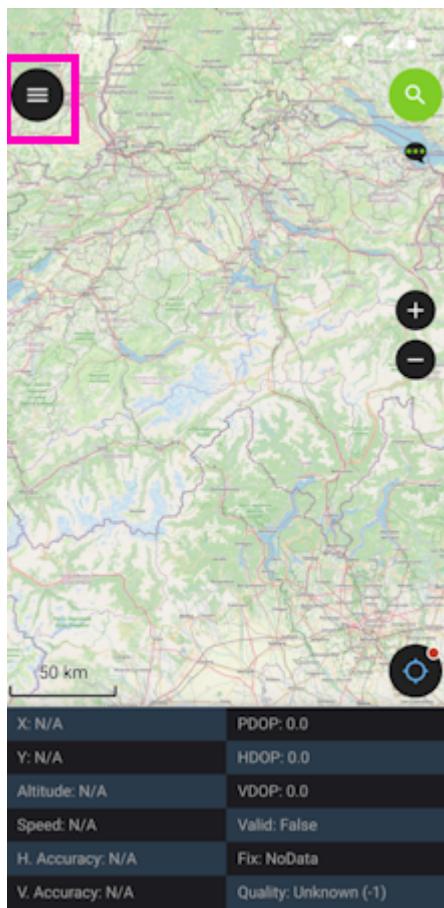
RTK device showing IP address

Once the RTK device connects to the WiFi hotspot, its IP address can be found in the [System Menu](#). This is the number that needs to be entered into QField. You can now proceed to the QField app to set up the software connection.



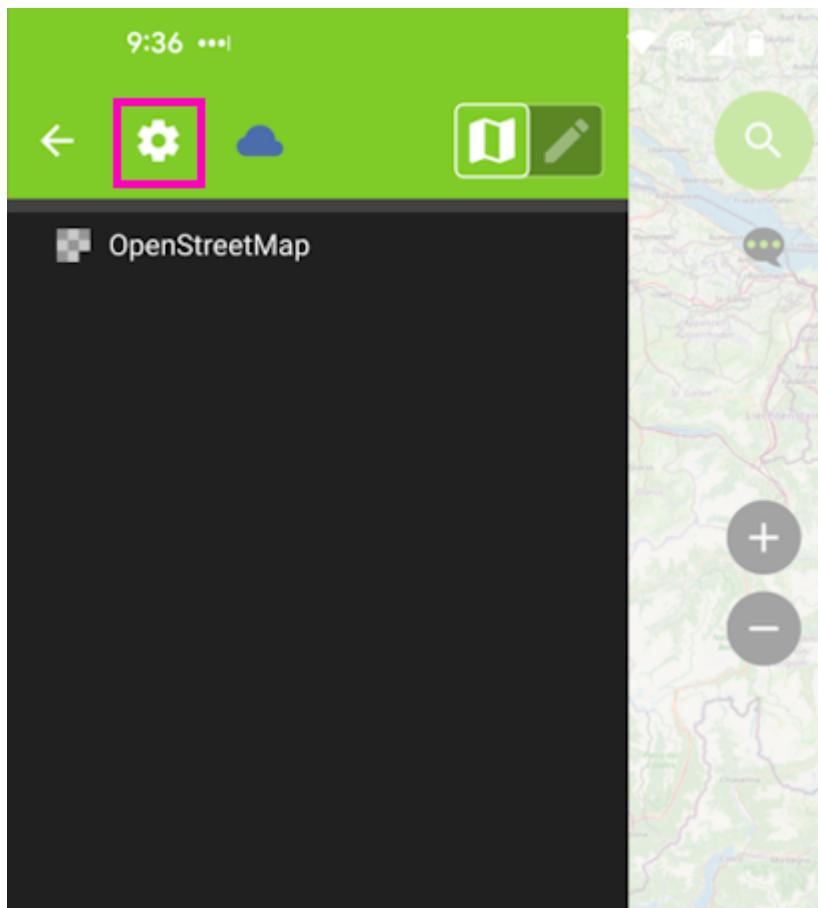
QField Opening Screen

Click on *QFieldCloud projects* to open your project that was previously created on the [QField Cloud](#) or skip this step by using one of the default projects (*Bee Farming*, *Wastewater*, etc).



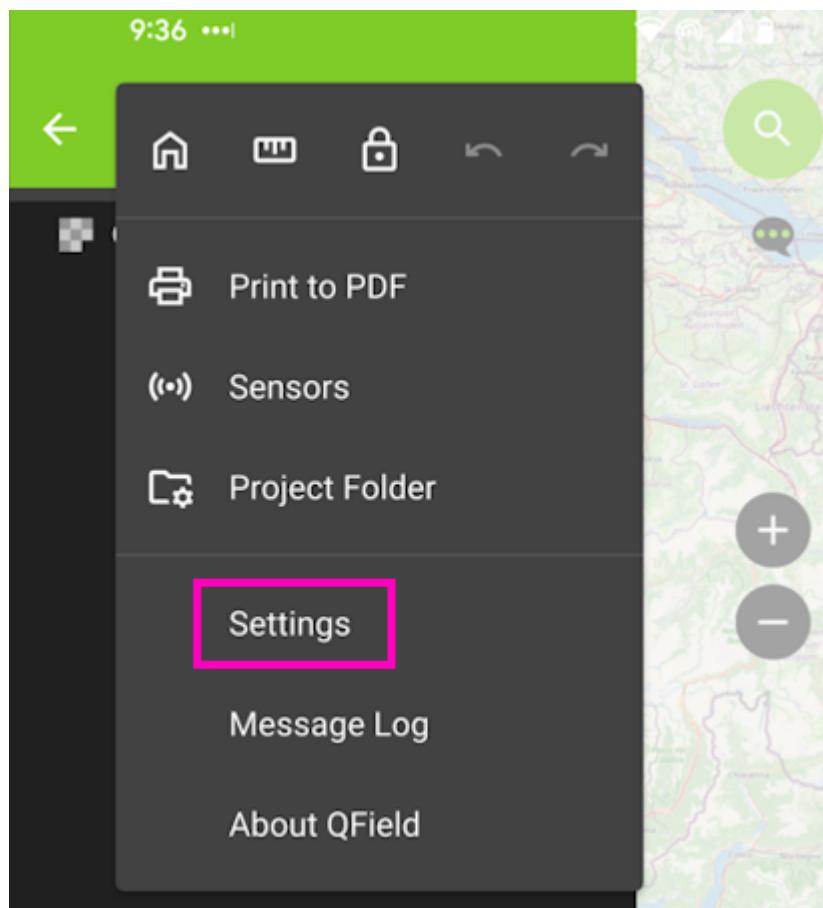
QField Main Map

From the main map, click on the 'hamburger' icon in the upper left corner.

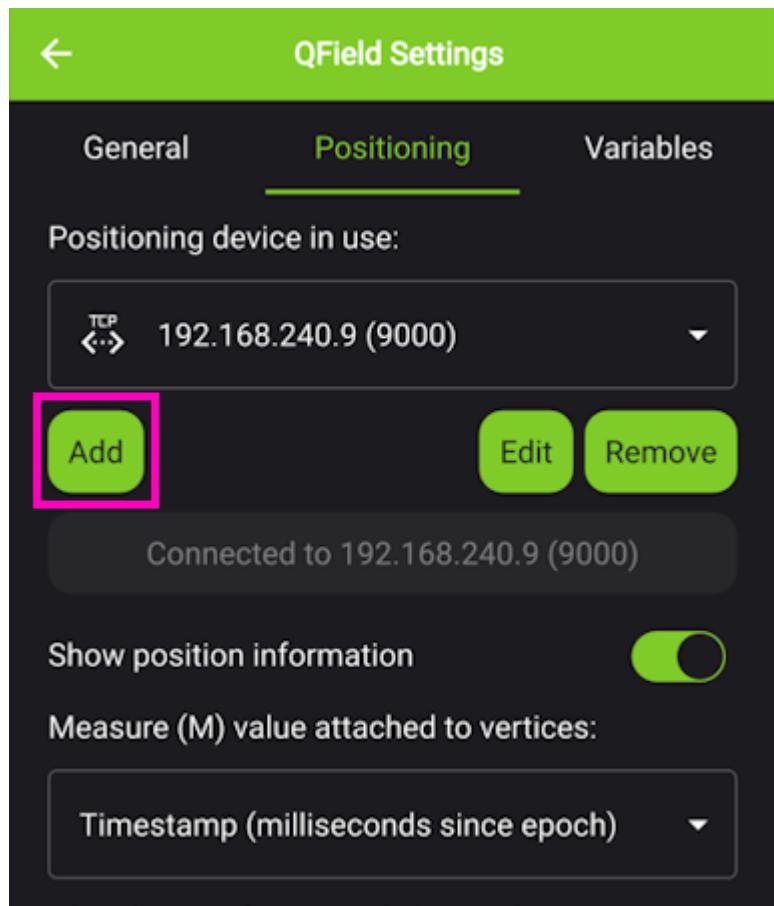


QField Settings Gear

Click on the gear to open settings.

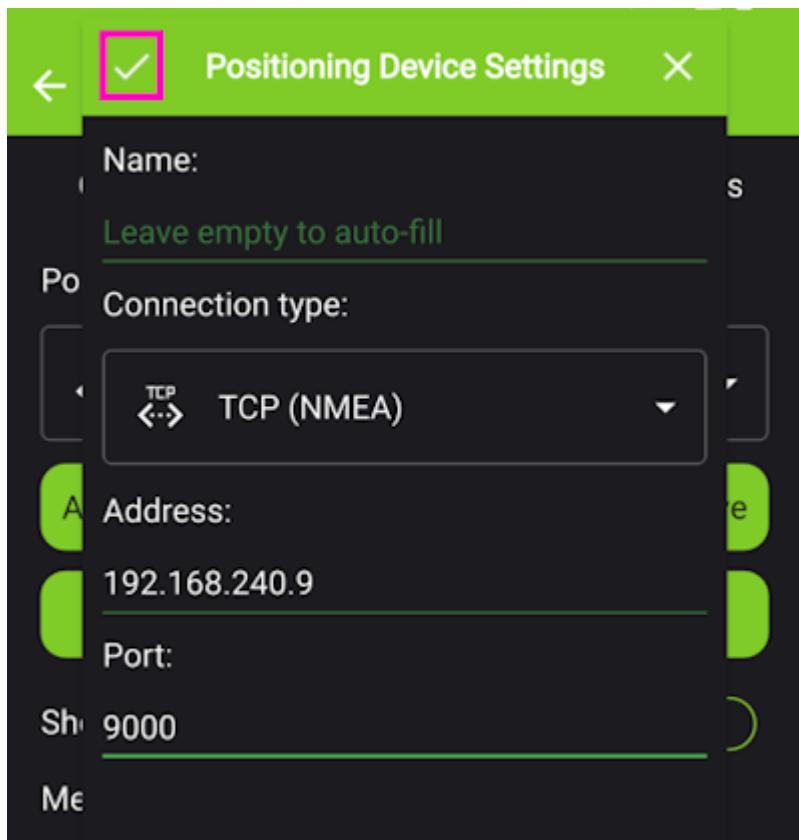


Click on the *Settings* menu.



QField Positioning Menu

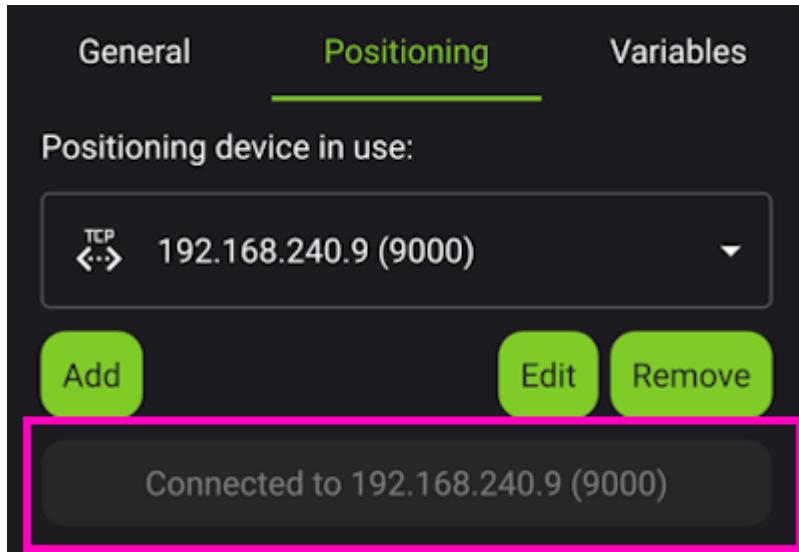
From the *Positioning* menu, click Add.



QField Entering TCP Information

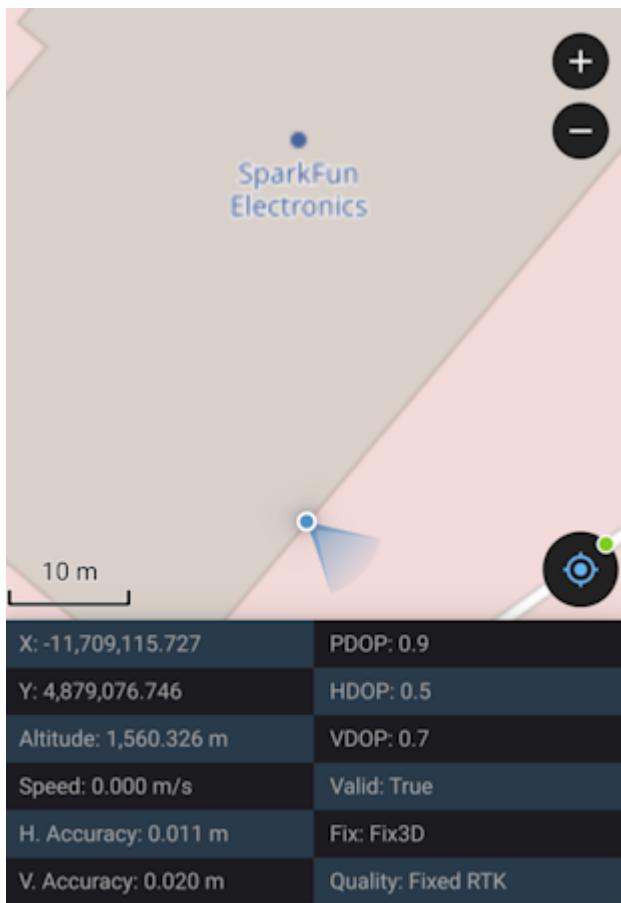
Select TCP as the connection type. Enter the IP address of the RTK device and the port number. Finally, hit the small check box in the upper left corner (shown in pink above) to close the window.

Once this information is entered, QField will automatically attempt to connect to that IP and port.



QField TCP Connected

Above, we see the port is successfully connected. Exit out of all menus.



QField Connected via TCP with RTK Fix

Returning to the map view, we see an RTK Fix with 11mm positional accuracy.

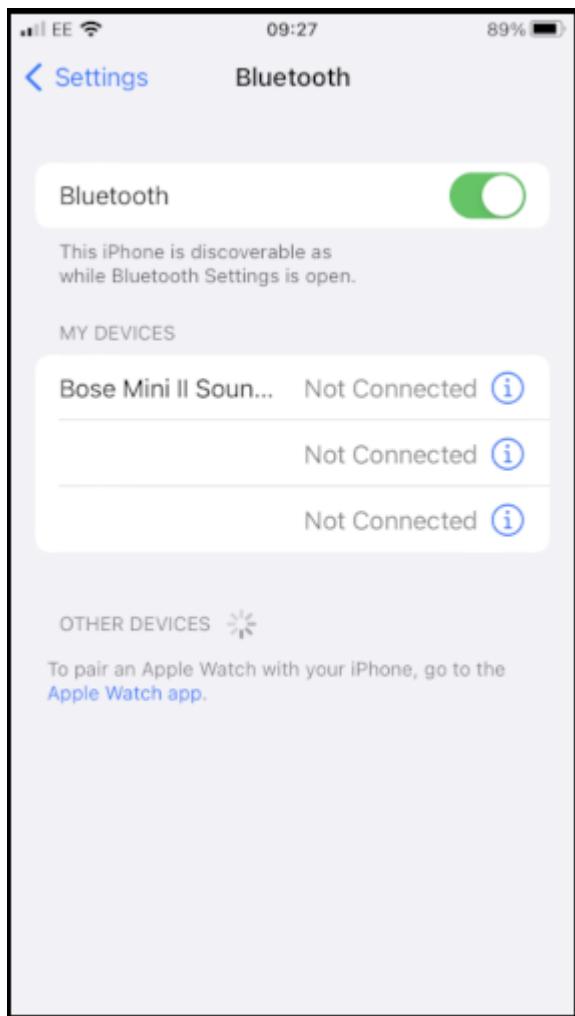
4.2.3 SW Maps

SWMaps is available for iOS [here](#).

Make sure your RTK device is switched on and operating in Rover mode.

Make sure Bluetooth is enabled on your iOS device Settings.

The RTK device will not appear in the *OTHER DEVICES* list. That is OK.

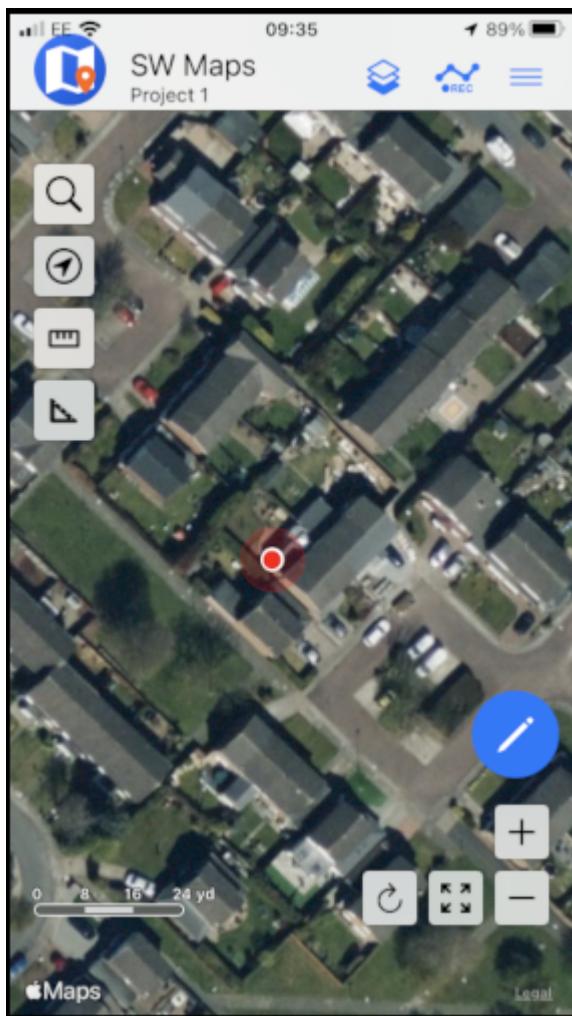


iOS Settings Bluetooth

Open SWMaps.

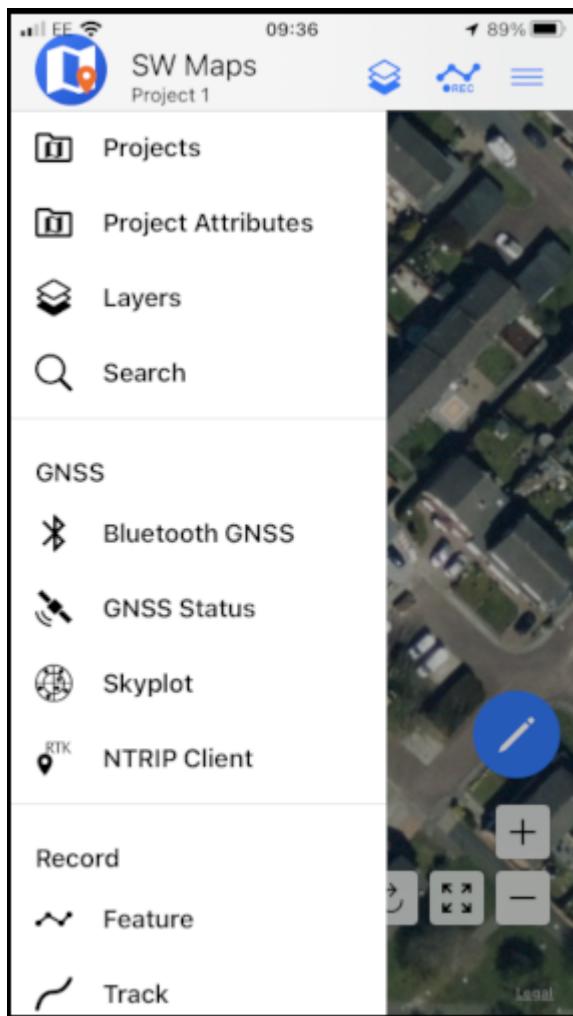
Open or continue a Project if desired.

SWMaps will show your approximate location based on your iOS device's location.



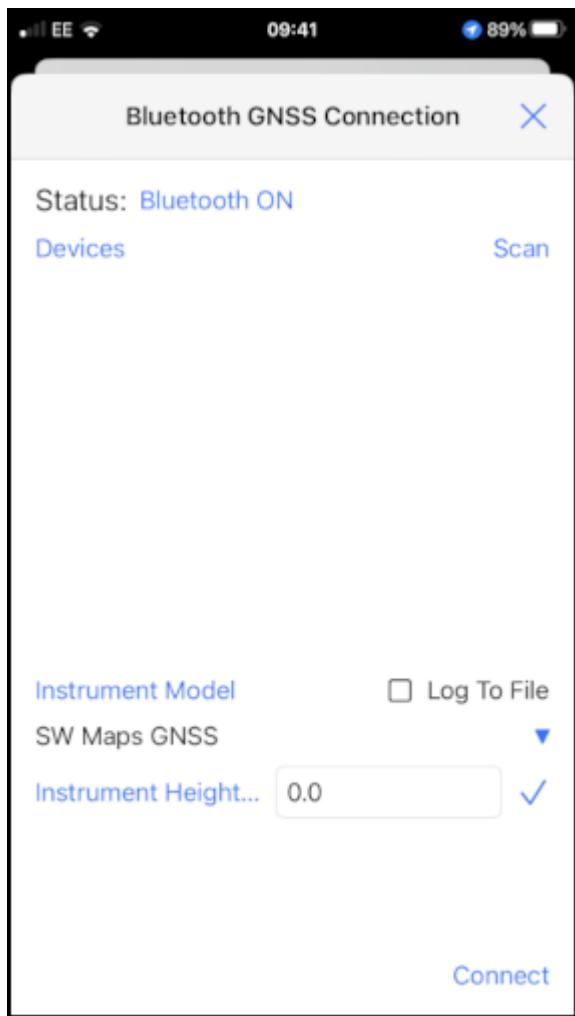
iOS SWMaps Initial Location

Press the 'SWMaps' icon at the top left of the screen to open the menu.

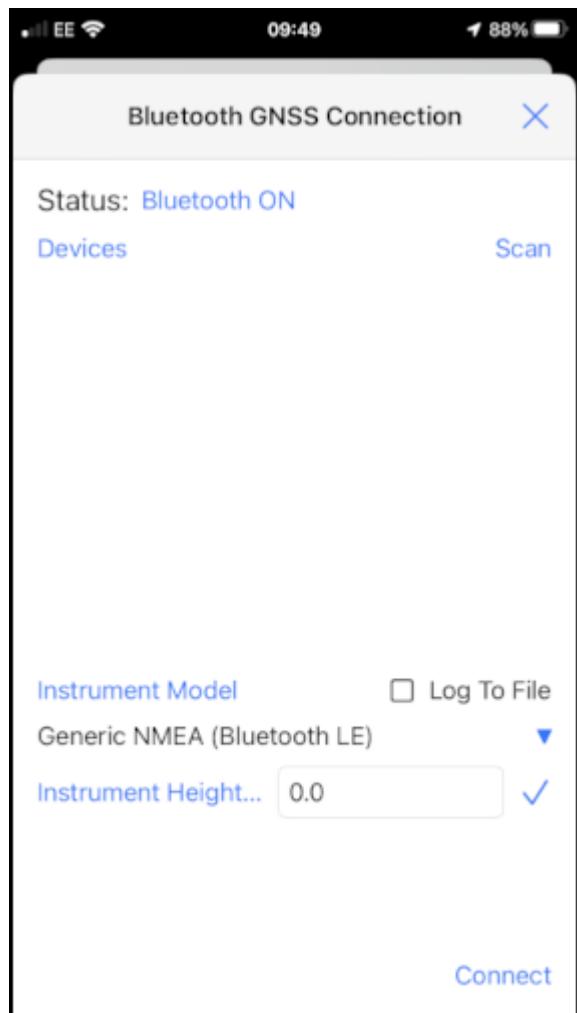


iOS SWMaps Menu

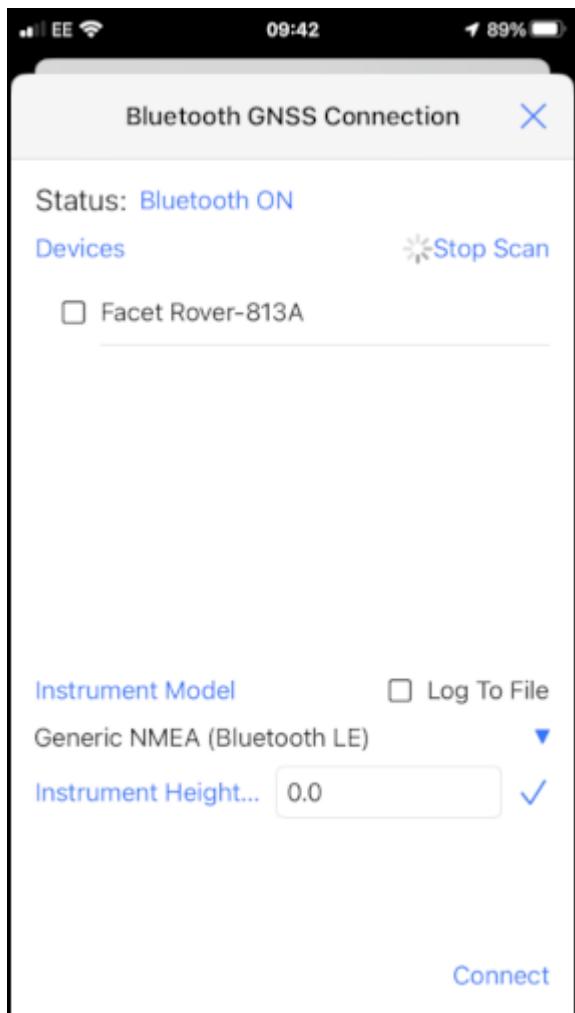
Select Bluetooth GNSS.

*iOS SWMaps Bluetooth Connection*

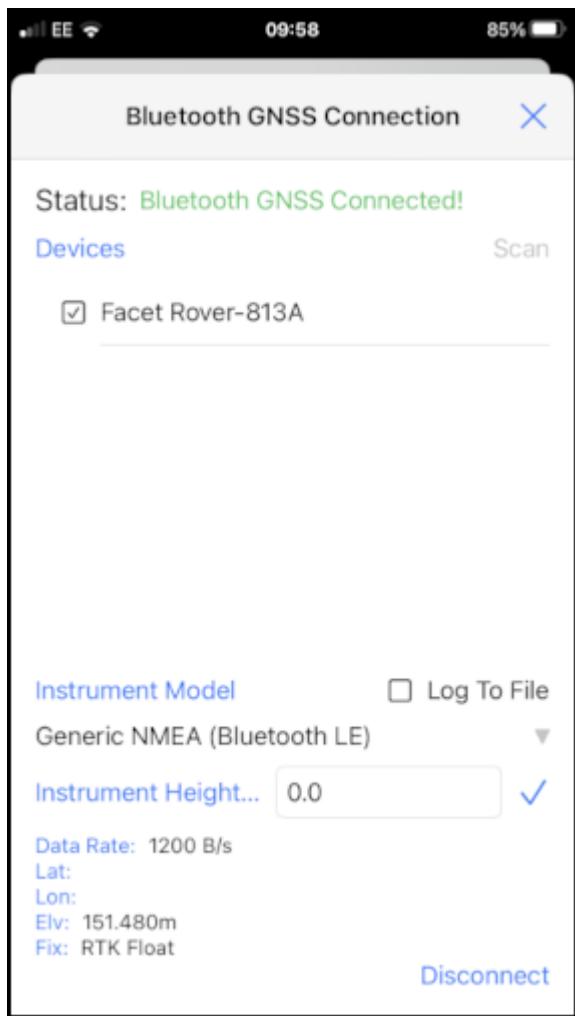
Set the **Instrument Model** to **Generic NMEA (Bluetooth LE)**.

*iOS SWMaps Instrument Model*

Press 'Scan' and your RTK device should appear.

*iOS SWMaps Bluetooth Scan*

Select (tick) the RTK device and press 'Connect'.



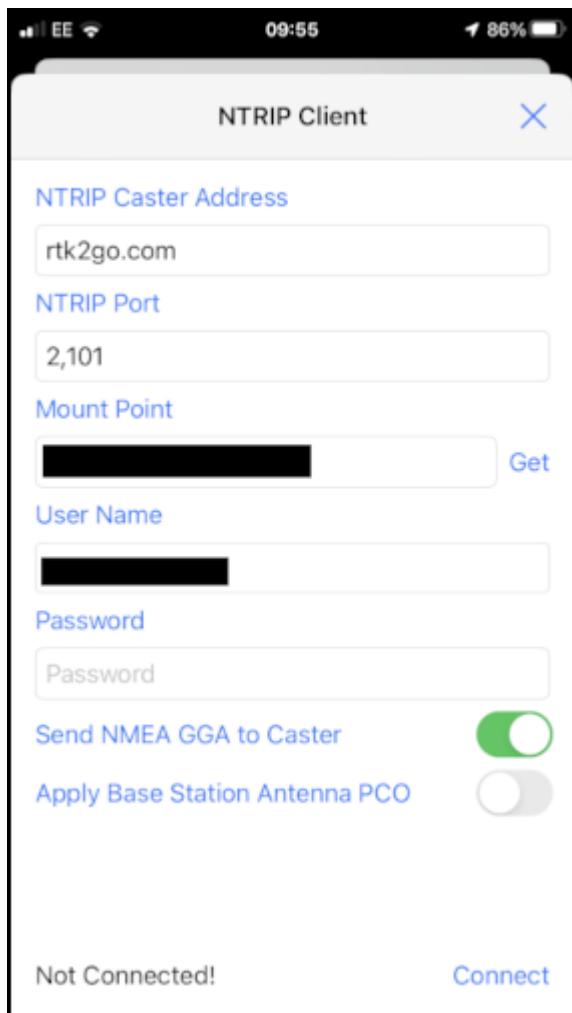
iOS SWMaps Bluetooth Connected

Close the menu and your RTK location will be displayed on the map.

You can now use the other features of SWMaps, including the built-in NTRIP Client.

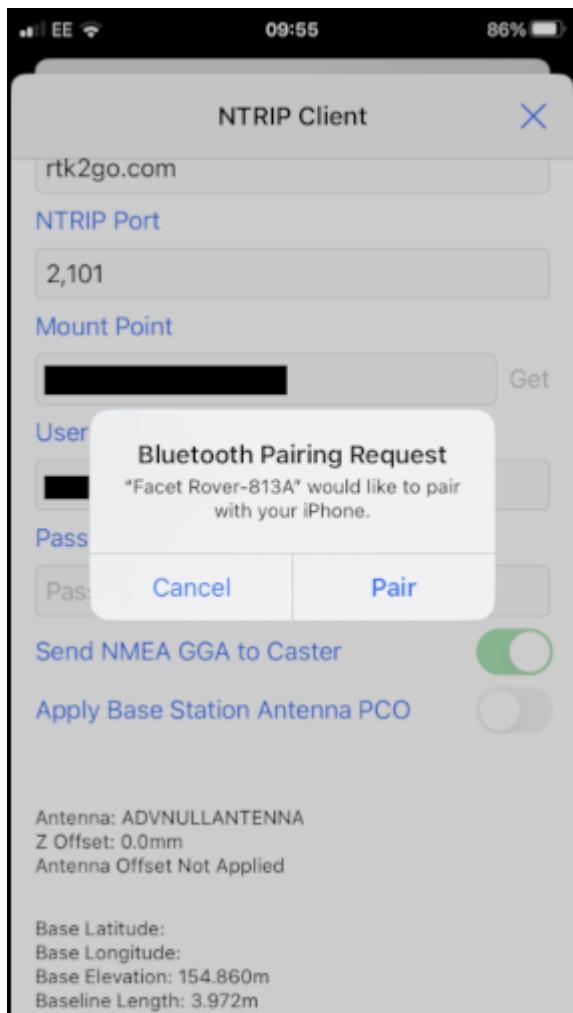
Re-open the menu and select 'NTRIP Client'.

Enter the details for your NTRIP Caster - as shown in the [SWMaps section above](#).

*iOS SWMaps NTRIP Client*

Click 'Connect'

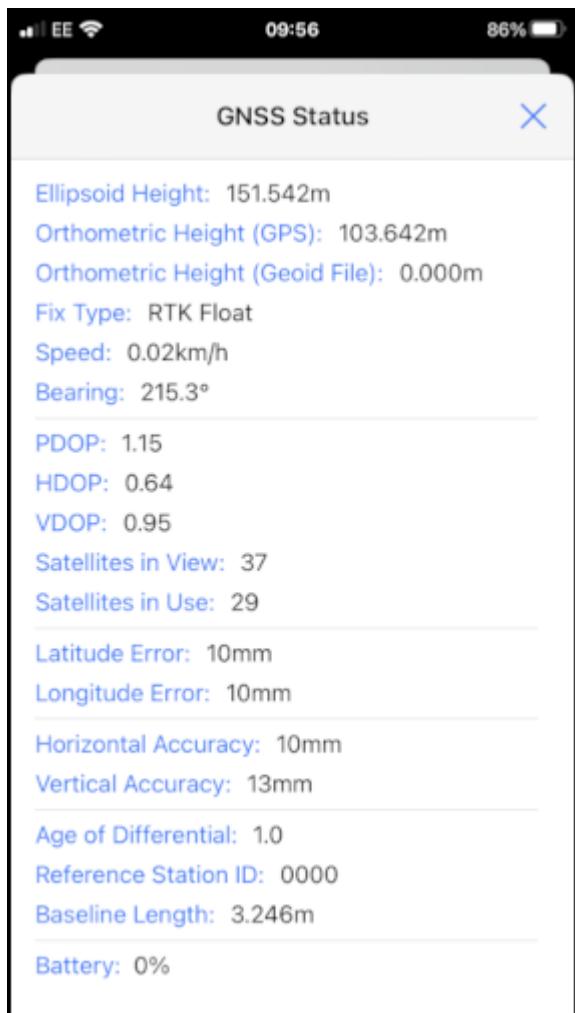
At this point, you should see a Bluetooth Pairing Request. Select 'Pair' to pair your RTK with your iOS device.



iOS Bluetooth Pairing

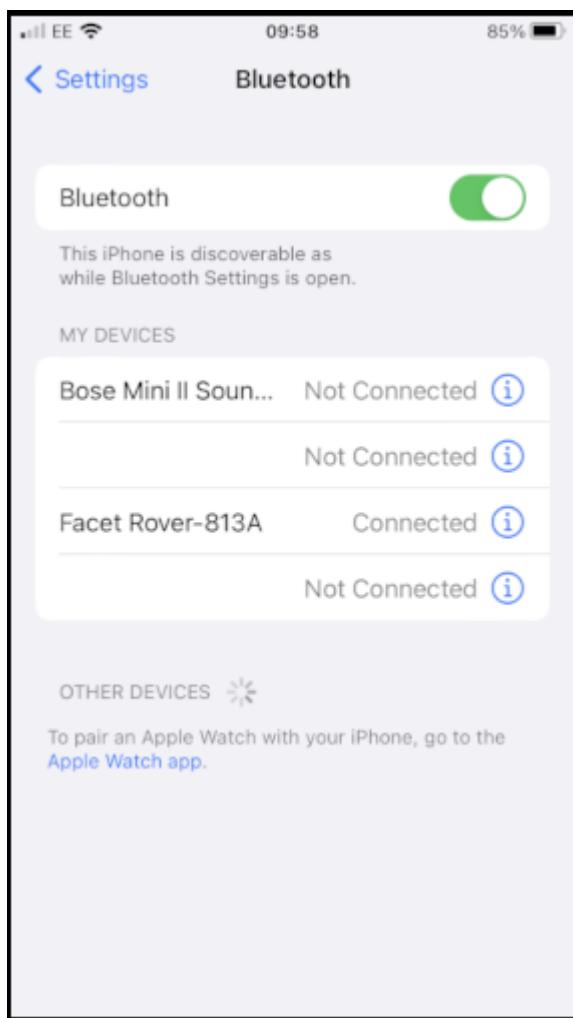
SWMaps will now receive NTRIP correction data from the caster and push it to your RTK over Bluetooth BLE.

From the SWMaps menu, open 'GNSS Status' to see your position, fix type and accuracy.



iOS SWMaps GNSS Status

If you return to the iOS Bluetooth Settings, you will see that your iOS and RTK devices are now paired.



iOS Settings Bluetooth - Paired

4.2.4 Other GIS Packages

Hopefully, these examples give you an idea of how to connect the RTK product line to most any GIS software. If there is other GIS software that you'd like to see configuration information about, please open an issue on the [RTK Firmware repo](#) and we'll add it.

4.2.5 What's an NTRIP Caster?

In a nutshell, it's a server that is sending out correction data every second. There are thousands of sites around the globe that calculate the perturbations in the ionosphere and troposphere that decrease the accuracy of GNSS accuracy. Once the inaccuracies are known, correction values are encoded into data packets in the RTCM format. You, the user, don't need to know how to decode or deal with RTCM, you simply need to get RTCM from a source within 10km of your location into the RTK device. The NTRIP client logs into the server (also known as the NTRIP caster) and grabs that data, every second, and sends it over Bluetooth to the RTK device.

4.2.6 Where do I get RTK Corrections?

Be sure to see [Correction Sources](#).

Don't have access to an NTRIP Caster or other RTCM correction source? There are a few options.

The [SparkFun RTK Facet L-Band](#) gets corrections via an encrypted signal from geosynchronous satellites. This device gets RTK Fix without the need for a WiFi or cellular connection.

Also, you can use a 2nd RTK product operating in Base mode to provide the correction data. Check out [Creating a Permanent Base](#).

If you're the DIY sort, you can create your own low-cost base station using an ESP32 and a ZED-F9P breakout board. Check out [How to Build a DIY GNSS Reference Station](#).

There are services available as well. [Syklark](#) provides RTCM coverage for \$49 a month (as of writing) and is extremely easy to set up and use. [Point One](#) also offers RTK NTRIP service with a free 14 day trial and easy to use front end.

4.3 Windows

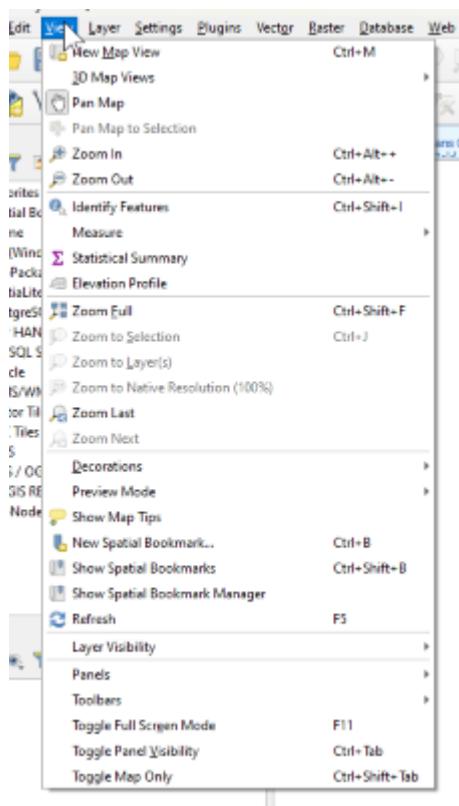
Torch: 

There are a variety of 3rd party apps available for GIS and surveying. We will cover a few examples below that should give you an idea of how to get the incoming NMEA data into the software of your choice.

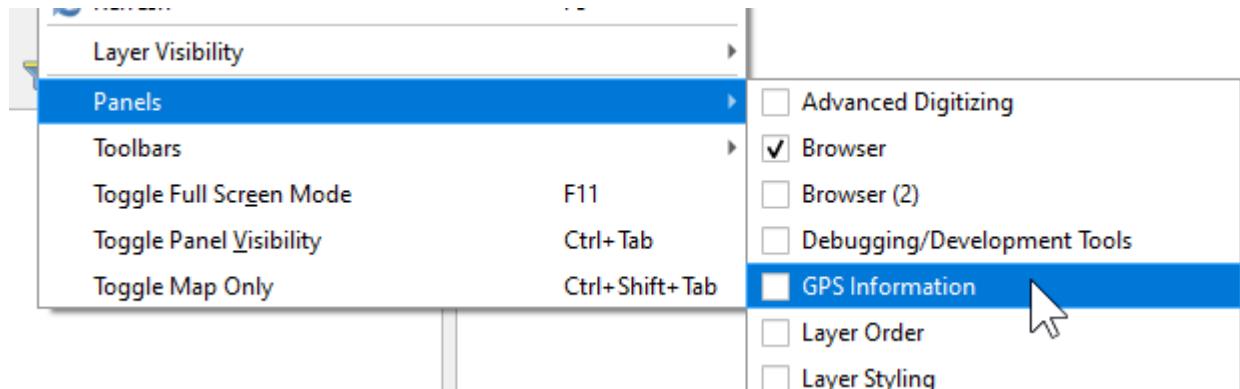
4.3.1 QGIS

QGIS is a free and open-source geographic information system software for desktops. It's available [here](#).

Once the software is installed open QGIS Desktop.

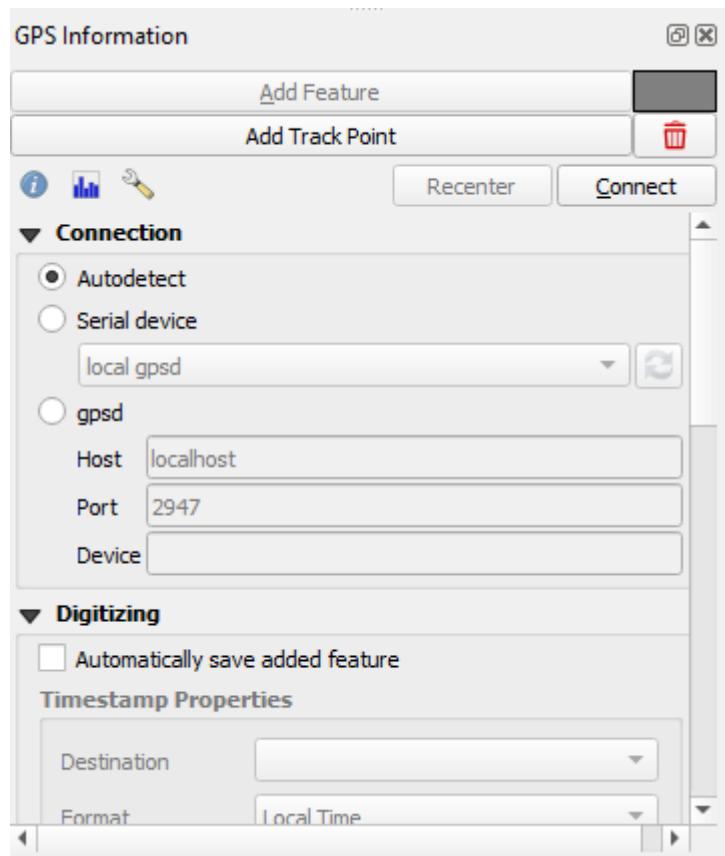


Open the View Menu, then look for the 'Panels' submenu.

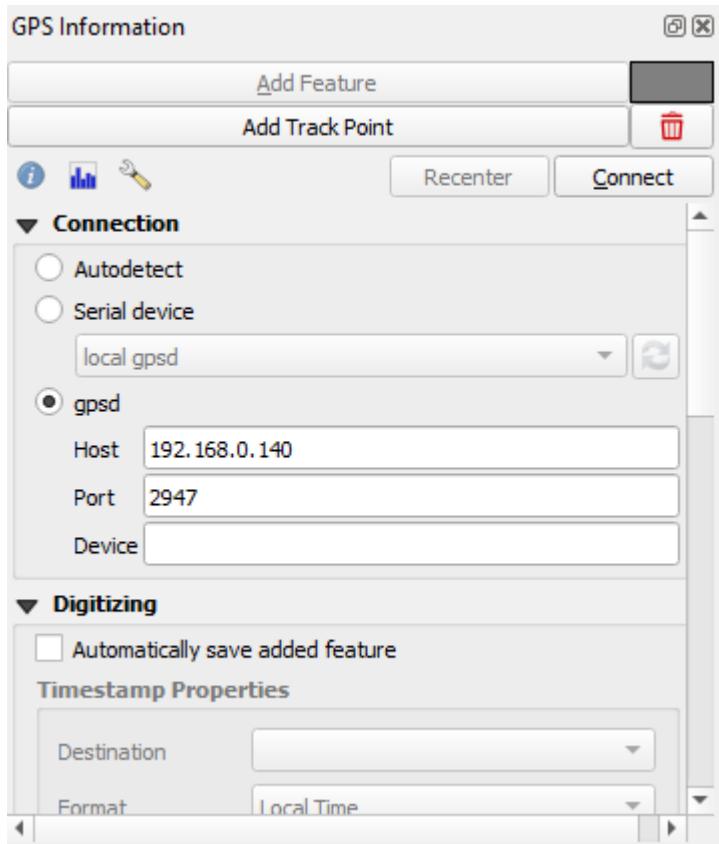


From the Panels submenu, enable 'GPS Information'. This will show a new panel on the left side.

At this point, you will need to enable *TCP Server* mode on your RTK device from the [WiFi Config menu](#). Once the RTK device is connected to local WiFi QGIS will be able to connect to the given IP address and TCP port.

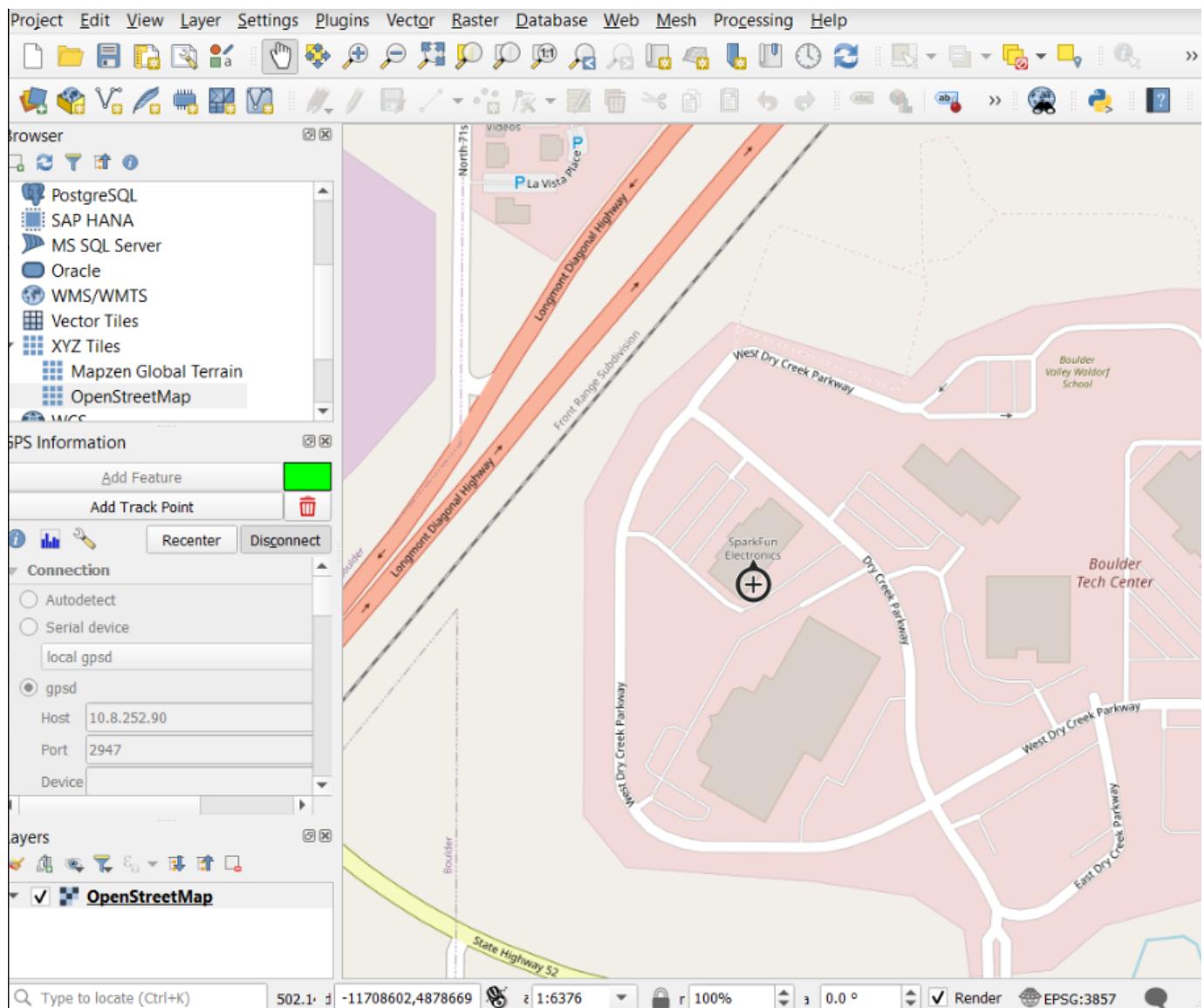


Above: From the subpanel, select 'gpson'.

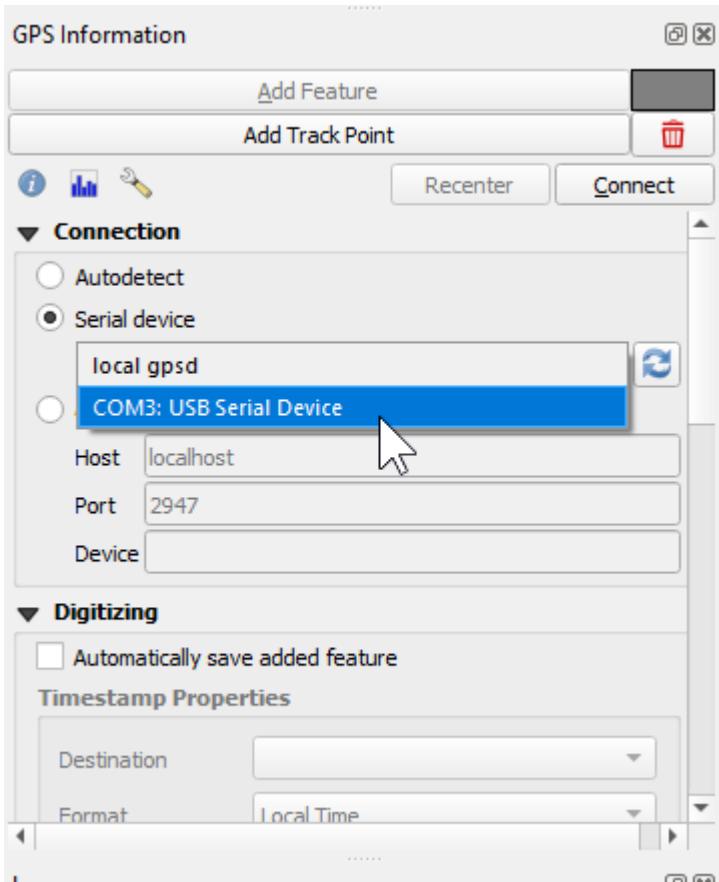


Enter the IP address of your RTK device. This can be found by opening a serial connection to the device. The IP address will be displayed every few seconds. Enter the TCP port to use. By default an RTK device uses 2947.

Press 'Connect'.



The device location will be shown on the map. To see a map, be sure to enable OpenStreetMap under the XYZ Tiles on the Browser.



Alternatively, a direct serial connection to the RTK device can be obtained. Use a USB cable to connect to the 'CONFIG UBLOX' port on RTK Surveyor/Express/Plus and the single USB C port on the RTK Facet/L-Band. Be sure you have the u-blox driver installed. Then select the appropriate COM port for the u-blox module. See [Configure with Serial](#) for more information.

4.3.2 Other GIS Packages

Hopefully, these examples give you an idea of how to connect the RTK product line to most any GIS software. If there is other GIS software that you'd like to see configuration information about, please open an issue on the [RTK Firmware repo](#) and we'll add it.

4.3.3 What's an NTRIP Caster?

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4.3.4 Where do I get RTK Corrections?

Be sure to see [Correction Sources](#).

Don't have access to an NTRIP Caster or other RTCM correction source? There are a few options.

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Also, you can use a 2nd RTK product operating in Base mode to provide the correction data. Check out [Creating a Permanent Base](#).

If you're the DIY sort, you can create your own low-cost base station using an ESP32 and a ZED-F9P breakout board. Check out [How to Build a DIY GNSS Reference Station](#).

There are services available as well. [Syklark](#) provides RTCM coverage for \$49 a month (as of writing) and is extremely easy to set up and use. [Point One](#) also offers RTK NTRIP service with a free 14 day trial and easy to use front end.

5. Configuration Methods

5.1 Configure with WiFi

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 



RTK Express Firmware: v2.7-Dec 23 2022

ZED-F9P Firmware: HPG 1.32

Device Bluetooth ID: B022

LLh: 14.89112977, -98.89585371, 240.546 (APC)

ECEF: -143128.185, -4773831.175, 4478954.892

Profile Configuration ▾

GNSS Configuration ▲

Base Configuration ▾

Ports Configuration ▾

Radio Configuration ▾

System Configuration ▾

File Manager ▾

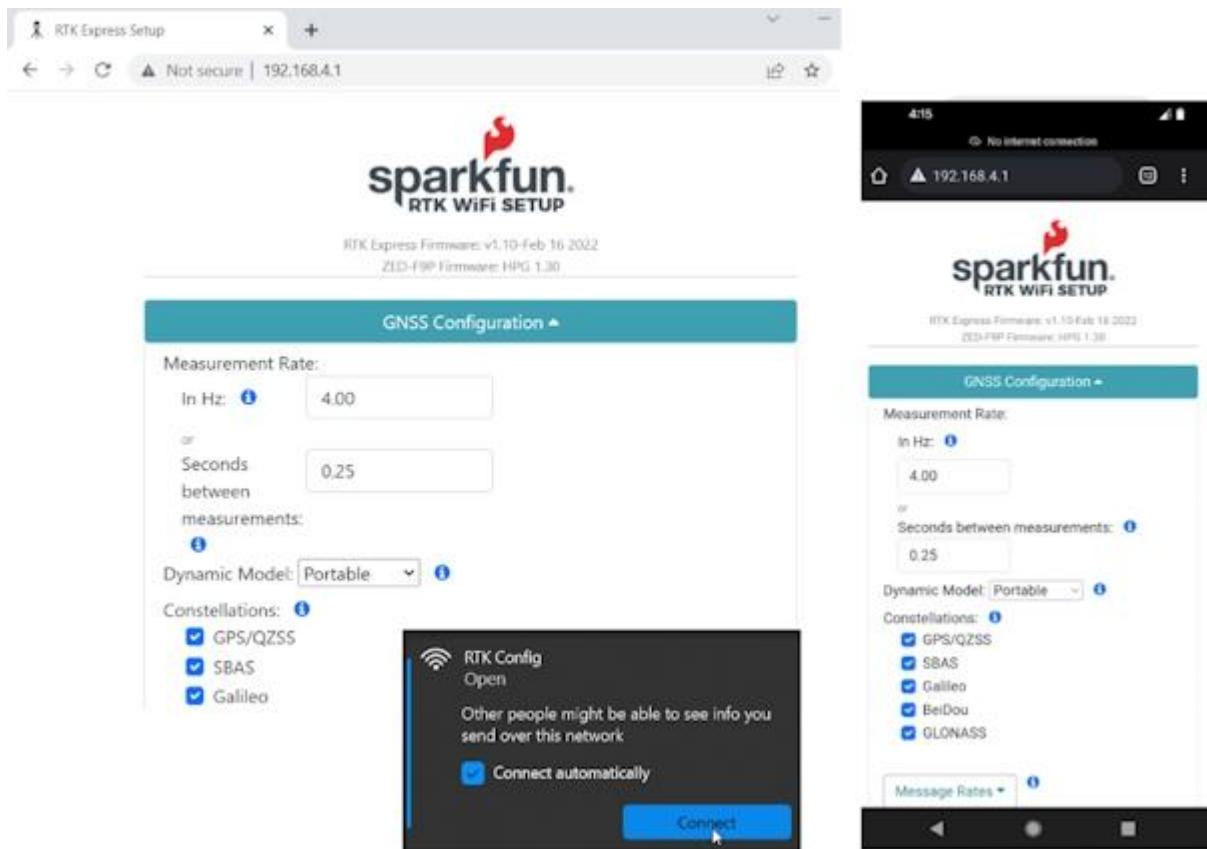
Save Configuration 

Exit and Reset 

Configuration page via WiFi

Starting with firmware v1.7, WiFi-based configuration is supported. For more information about updating the firmware on your device, please see [Updating RTK Firmware](#).

The RTK device will present a webpage that is viewable from either a desktop/laptop with WiFi or a cell phone. For advanced configurations, a desktop is recommended. For quick in-field changes, a cell phone works great.

*Desktop vs Phone display size configuration*

5.1.1 RTK Express / Express Plus / Facet

To get into WiFi configuration follow these steps:

1. Power on the RTK Express, Express Plus, or Facet.
2. Once the device has started press the Setup button repeatedly until the *Config* menu is highlighted.
3. The display will blink a WiFi icon indicating it is waiting for incoming connections.
4. Connect to WiFi network named 'RTK Config'.
5. Open a browser (Chrome is preferred) and type **192.168.4.1** into the address bar.



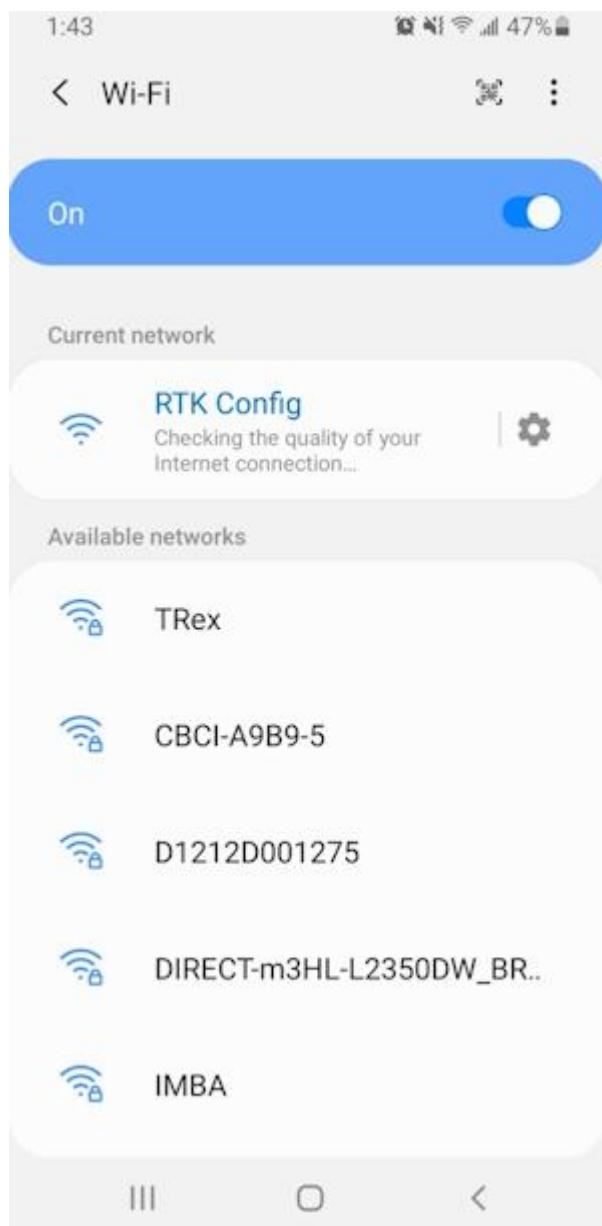
Device ready for cellphone configuration

5.1.2 RTK Surveyor

To get into WiFi configuration follow these steps:

1. Power the RTK Surveyor on in Rover mode.
2. Once the device has started the Bluetooth status LED should be blinking at 1Hz. Now toggle the **SETUP** switch from Base and back to Rover within 1 second. If successful, the Bluetooth status LED will begin fading in/out. The device is now broadcasting as a WiFi access point.
3. Connect to WiFi network named 'RTK Config'.
4. Open a browser (Chrome is preferred) and type **192.168.4.1** into the address bar.

5.1.3 Connecting to WiFi Network



The WiFi network RTK Config as seen from a cellphone

Note: Upon connecting, your phone may warn you that this WiFi network has no internet. That's ok. Stay connected to the network and open a browser. If you still have problems turn off Mobile Data so that the phone does not default to cellular for internet connectivity and instead connects to the RTK Device.

The screenshot shows a mobile browser interface with the address bar displaying "192.168.4.1". The main content area features the SparkFun logo and "RTK WiFi SETUP" text. Below this, it displays "RTK Facet Firmware: v1.8-Oct 7 2021" and "ZED-F9P Firmware: HPG 1.13". A teal header bar contains the text "GNSS Configuration ▾". Underneath, the "Measurement Rate:" section is visible, showing "In Hz: 4.00" with an information icon (i) next to it. The entire screenshot is framed by a light gray border.

Connected to the RTK WiFi Setup Page

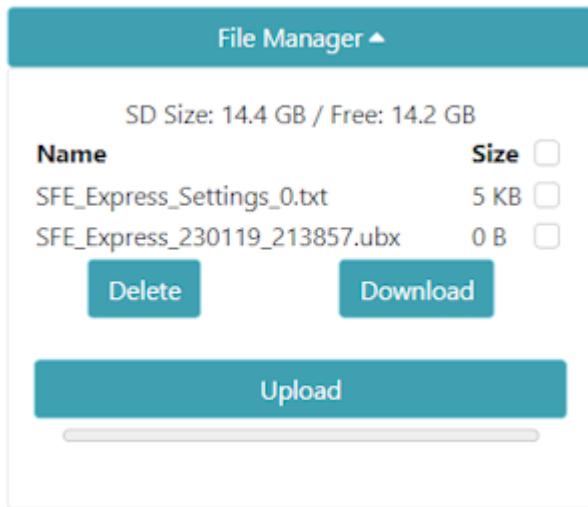
Clicking on the category 'carrot' will open or close that section. Clicking on an 'i' will give you a brief description of the options within that section.

The screenshot shows a mobile browser interface with the address bar displaying "192.168.4.1". The main content area features the SparkFun logo and "RTK WiFi SETUP" text. Below this, it displays "RTK Facet Firmware: v1.8-Oct 7 2021" and "ZED-F9P Firmware: HPG 1.13". A teal header bar contains the text "GNSS Configuration ▾". Underneath, the "Measurement Rate:" section is visible, showing "In Hz: 4.00" with an information icon (i) next to it. The entire screenshot is framed by a light gray border.

This unit has firmware version 1.8 and a ZED-F9P receiver

Please note that the firmware for the RTK device and the firmware for the ZED receiver is shown at the top of the page. This can be helpful when troubleshooting or requesting new features.

5.1.4 File Manager



Added in v3.0 firmware, a file manager is shown if an SD card is detected. This is a handy way to download files to a local device (cell phone or laptop) as well as delete any unneeded files. The SD size and free space are shown. And files may be uploaded to the SD card if needed.

Additionally, clicking on the top checkbox will select all files for easy removal of a large number of files.

5.1.5 Saving and Exit

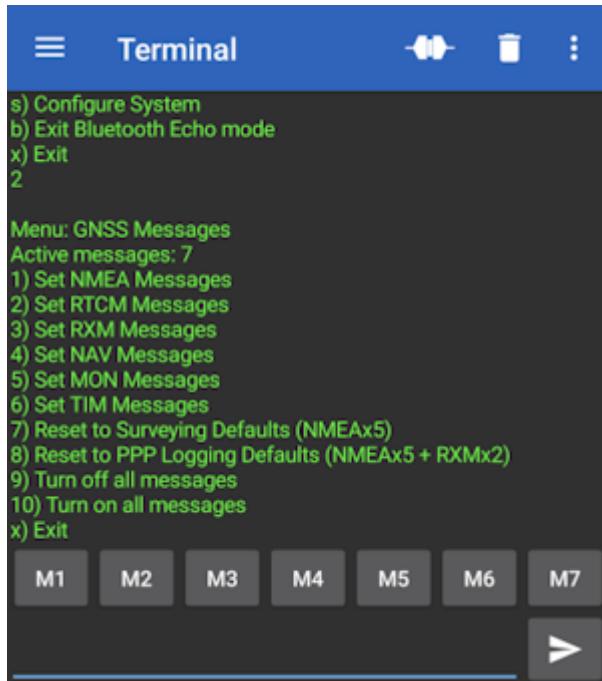
Save Configuration

Exit to Rover Mode

Once settings are input, please press 'Save Configuration'. This will validate any settings, show any errors that need adjustment, and send the settings to the unit. The page will remain active until the user presses 'Exit to Rover Mode' at which point the unit will exit WiFi configuration and return to standard Rover mode.

5.2 Configure with Bluetooth

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

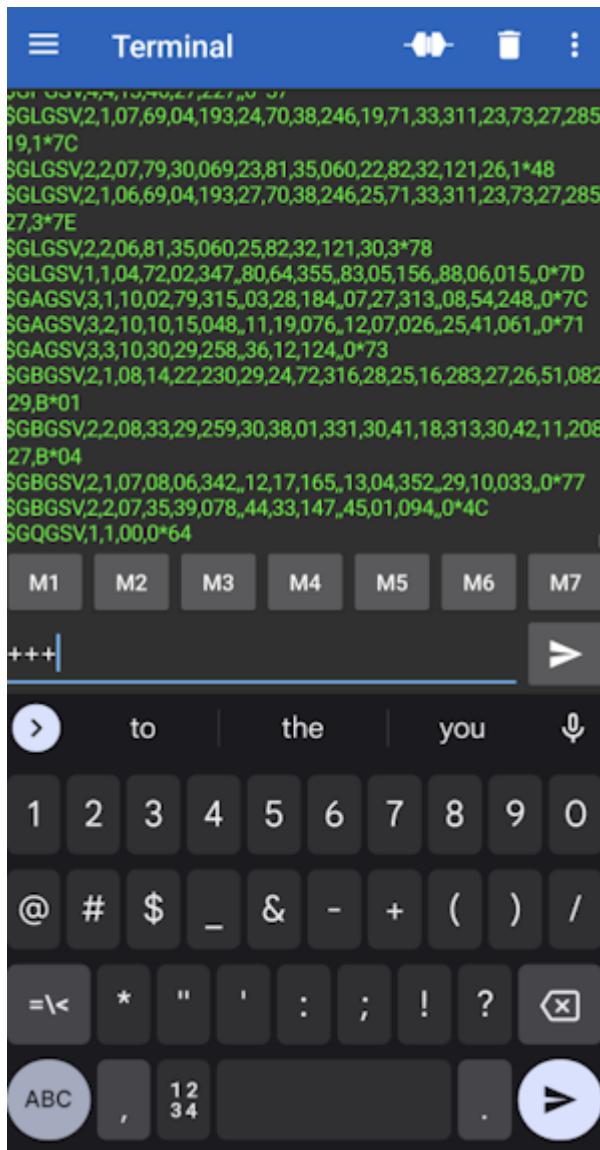


Configuration menu via Bluetooth

Starting with firmware v3.0, Bluetooth-based configuration is supported. For more information about updating the firmware on your device, please see [Updating RTK Firmware](#).

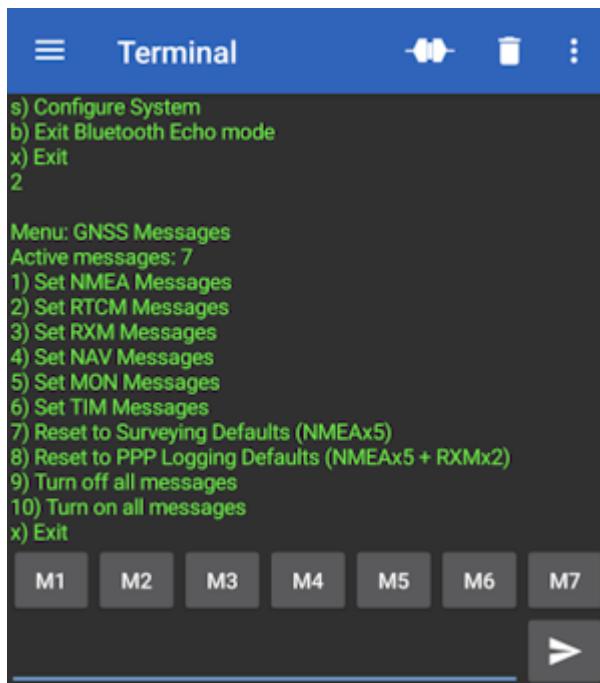
The RTK device will be a discoverable Bluetooth device (both BT SPP and BLE are supported). For information about Bluetooth pairing, please see [Connecting Bluetooth](#).

5.2.1 Entering Bluetooth Echo Mode



Once connected, the RTK device will report a large amount of NMEA data over the link. To enter Bluetooth Echo Mode send the characters +++.

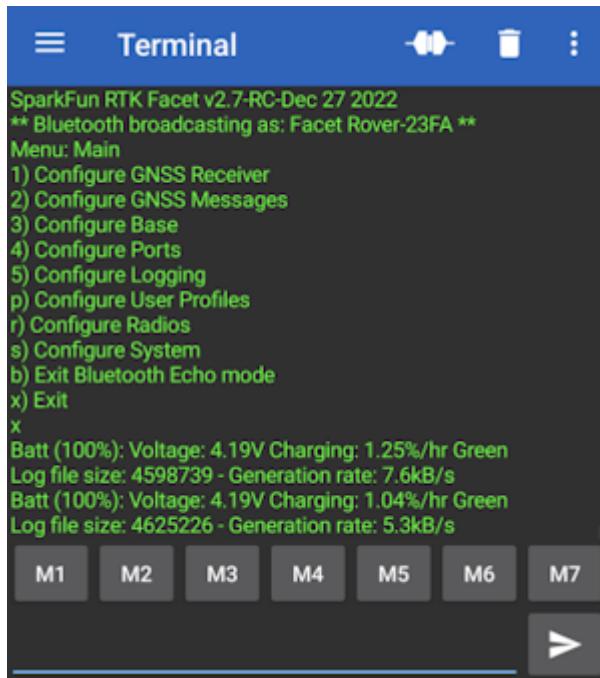
Note: There must be a 2 second gap between any serial sent from a phone to the RTK device, and any escape characters. In almost all cases this is not a problem. Just be sure it's been 2 seconds since an NTRIP source has been turned off and attempting to enter Bluetooth Echo Mode.



The GNSS Messages menu shown over Bluetooth Echo Mode

Once in Bluetooth Echo Mode, any character sent from the RTK unit will be shown in the Bluetooth app, and any character sent from the connected device (cell phone, laptop, etc) will be received by the RTK device. This allows the opening of the config menu as well as the viewing of all regular system output.

For more information about the Serial Config menu please see [Configure with Serial](#).

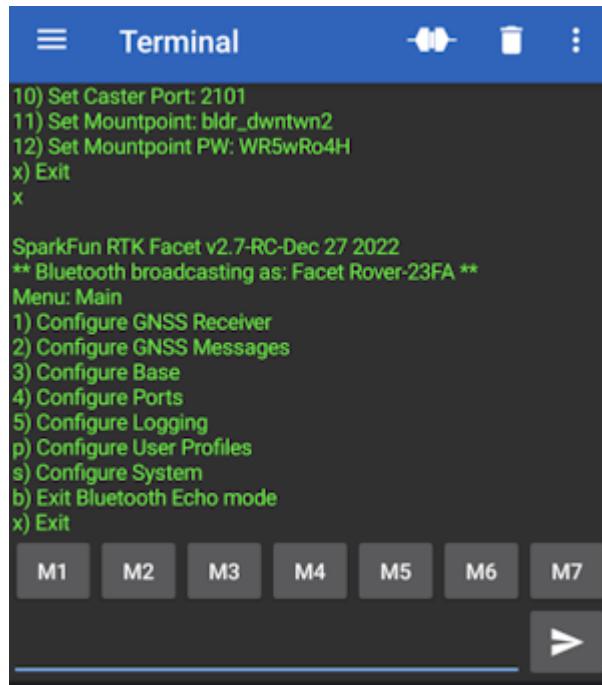


Exit from the Serial Config Menu

Bluetooth can also be used to view system status and output. Simply exit the config menu using option 'x' and the system output can be seen.

5.2.2 Exit Bluetooth Echo Mode

To exit Bluetooth Echo Mode simply disconnect Bluetooth. In the Bluetooth Serial Terminal app, this is done by pressing the 'two plugs' icon in the upper right corner.

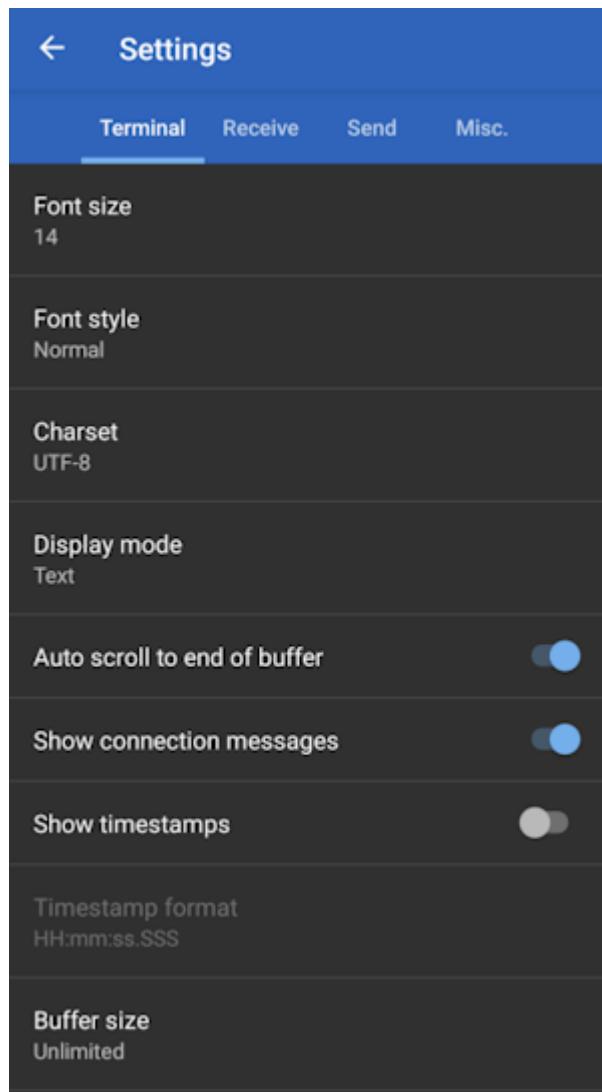


Menu option 'b' for exiting Bluetooth Echo Mode

Alternatively, if you wish to stay connected over Bluetooth but need to exit Bluetooth Echo Mode, use the 'b' menu option from the main menu.

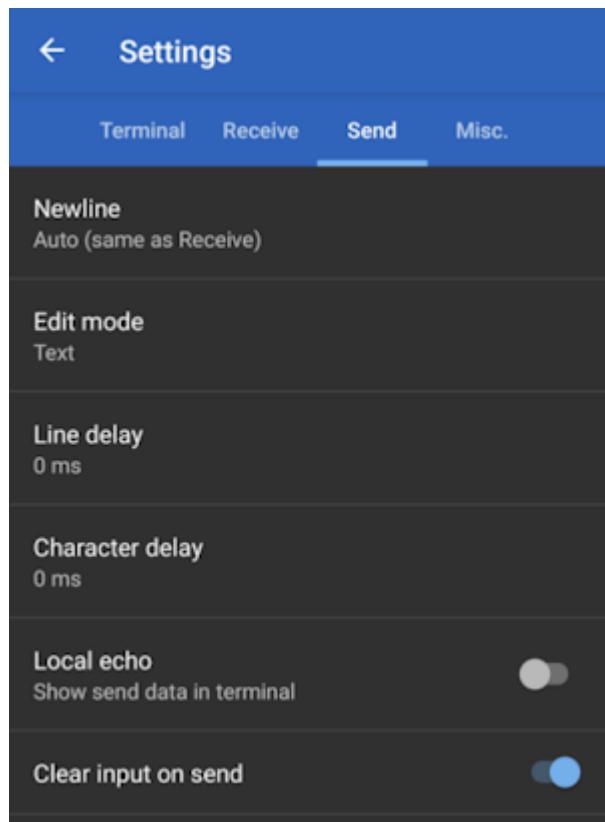
5.2.3 Serial Bluetooth Terminal Settings

Here we provide some settings recommendations to make the terminal navigation of the RTK device a bit easier.



Terminal Settings with Timestamps disabled

Disable timestamps to make the window a bit wider, allowing the display of longer menu items without wrapping.



Clear on send and echo off

Clearing the input box when sending is very handy as well as turning off local echo.

5.3 Configure with Serial

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

Note: Starting with v3.0 of the firmware any serial menu that is shown can also be accessed over Bluetooth. This makes any configuration of a device much easier in the field. Please see [Configure With Bluetooth](#) for more information.

To configure an RTK device using serial attach a [USB C cable](#) to the device. The device can be on or off.

5.3.1 RTK Surveyor / Express / Express+



The SparkFun RTK Surveyor has a variety of connectors

Connect the USB cable to the connector labeled **Config ESP32**.

Once connected a COM port will enumerate. Open the Device Manager in Windows and look under the Ports branch to see what COM port the device is assigned to.

5.3.2 RTK Facet



Connect the USB cable to the USB connector.

There is a USB hub built into the RTK Facet. When you attach the device to your computer it will enumerate two COM ports.

- > Network adapters
- > Portable Devices
- ▽ Ports (COM & LPT)
 - Communications Port (COM1)
 - USB Serial Device (COM41)
 - USB-SERIAL CH340 (COM39)
- > Print queues
- > Printers
- ▽ Processors

In the image above, the `USB Serial Device` is the ZED-F9P and the `USB-SERIAL CH340` is the ESP32.

Don't See 'USB-Serial CH340'? If you've never connected a CH340 device to your computer before, you may need to install drivers for the USB-to-serial converter. Check out our section on "[How to Install CH340 Drivers](#)" for help with the installation.

Don't See 'USB Serial Device'? The first time a u-blox module is connected to a computer you may need to adjust the COM driver. Check out our section on "[How to Install u-blox Drivers](#)" for help with the installation.

Configuring the RTK device is done over the `USB-Serial CH340` COM port via the serial text menu. Various debug messages are printed to this port at 115200bps and a serial menu can be opened to configure advanced settings.

Configuring the ZED-F9P is done over the `USB Serial Device` port using [u-center](#). It's not necessary for normal operation but is handy for tailoring the receiver to specific applications. As an added perk, the ZED-F9P can be detected automatically by some mobile phones and tablets. If desired, the receiver can be directly connected to a compatible phone or tablet removing the need for a Bluetooth connection.

5.3.3 Terminal Window

Open a terminal window at 115200bps; you should see various status messages every second. Press any key to open the configuration menu. Not sure how to use a terminal? Check out our [Serial Terminal Basics](#) tutorial.

Note that some Windows terminal programs (e.g. Tera Term) may reboot the Facet when the terminal connection is closed. You can disconnect the USB cable first to prevent this from happening.

```
Batt <96%>: Voltage: 4.16V Discharging: 0.00%/hr Green
Batt <96%>: Voltage: 4.16V Discharging: 0.00%/hr Green

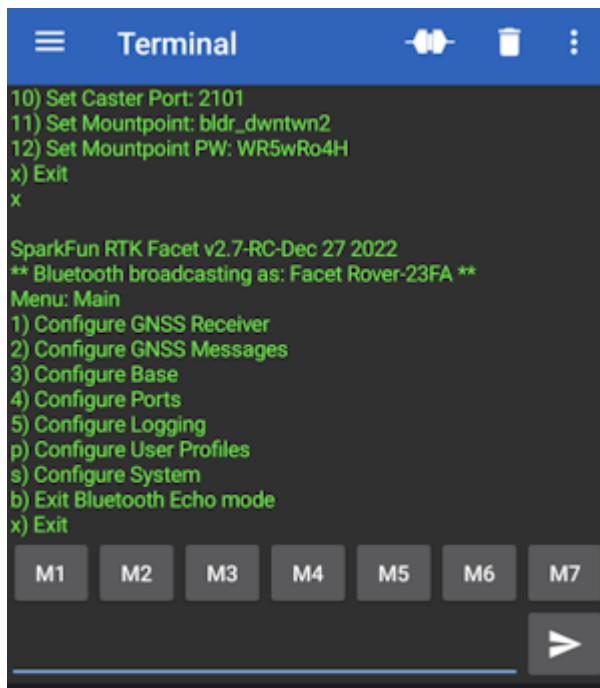
SparkFun RTK Express Plus v1.11-Apr 12 2022
** Bluetooth broadcasting as: Express Plus Rover-DABE **
Menu: Main Menu
1> Configure GNSS Receiver
2> Configure GNSS Messages
3> Configure Sensor Fusion
4> Configure Ports
5> Configure Logging
p> Configure Profiles
s> System Status
x> Exit
```

Main Menu

Pressing any button will display the Main menu. The Main menu will display the current firmware version and the Bluetooth broadcast name. Note: When powered on, the RTK device will broadcast itself as either *[Platform] Rover-XXXX* or *[Platform] Base-XXXX* depending on which state it is in. The Platform is 'Facet', 'Express', 'Surveyor', etc.

Pressing '1' or 's' for example, will open those submenus.

The menus will timeout after 10 minutes of inactivity, so if you do not press a key the device will exit the menu and return to reporting status messages.

*Configuration menu via Bluetooth*

Note: Starting with firmware v3.0, Bluetooth-based configuration is supported. Please see [Configure With Bluetooth](#) for more information.

5.3.4 System Report

Sending the ~ character to the device over the serial port will trigger a system status report. This is a custom NMEA-style sentence, complete with CRC.

```
Rover Accuracy <m>: 0.5119
Batt <111%>: Voltage: 4.19U Charging: 8.53%/hr Green
Rover Accuracy <m>: 0.4951
Rover Accuracy <m>: 0.4800
Rover Accuracy <m>: 0.4665
Batt <111%>: Voltage: 4.19U Charging: 4.37%/hr Green
Rover Accuracy <m>: 0.4542
Rover Accuracy <m>: 0.4418
Batt <111%>: Voltage: 4.19U Charging: 4.37%/hr Green
Rover Accuracy <m>: 0.4318
Rover Accuracy <m>: 0.4228
Rover Accuracy <m>: 0.4145
Batt <111%>: Voltage: 4.19U Charging: 0.21%/hr Green
Rover Accuracy <m>: 0.4070
Rover Accuracy <m>: 0.4002
Batt <111%>: Voltage: 4.19U Charging: 0.21%/hr Green
Rover Accuracy <m>: 0.3939
Rover Accuracy <m>: 0.3881
Rover Accuracy <m>: 0.3822
Batt <111%>: Voltage: 4.15U Charging: 0.21%/hr Green
~$GNGPS,01,01,05,202447.00,270522,0.380,29,40.090355193,-105.184764700,1560.56,3,0,111*71
Rover Accuracy <m>: 0.3773
```

Terminal showing System Status

Below is an example system status report sentence:

```
$GNTXT,01,01,05,202447.00,270522,0.380,29,40.090355193,-105.184764700,1560.56,3,0,86*71
```

- \$GNTXT : Start of custom NMEA sentence
- 01 : Number of sentences
- 01 : Sentence number
- 05 : Sentence type ID (5 is for System Status messages)
- 202447.00 : Current hour, minute, second, milliseconds
- 270522 : Current day, month, year
- 0.380 : Current horizontal positional accuracy (m)
- 29 : Satellites in view
- 40.090355193 : Latitude
- -105.184764700 : Longitude
- 1560.56 : Altitude
- 3 : Fix type (0 = no fix, 2 = 2D fix, 3 = 3D fix, 4 = 3D + Dead Reckoning, 5 = Time)
- 0 : Carrier solution (0 = No RTK, 1 = RTK Float, 2 = RTK Fix)
- 86 : Battery level (% remaining)
- *71 : The completion of the sentence and a [CRC](#)

Note: This is a custom NMEA sentence, can vary in length, and may exceed the [maximum permitted sentence length](#) of 61 characters.

5.3.5 L-Band Performance During Serial Configuration

Because of the way corrections are provided between the sub modules (NEO-D9S and ZED-F9P), the corrections will be interrupted while the configuration menu is open. RTK Fix may be lost if the menu is open for more than ~30s. RTK Fix will return once the configuration is complete and the menu is closed.

Note: This only affects the RTK Facet L-Band model.

5.4 Configure with Settings File

Surveyor: / Express: / Express Plus: / Facet: / Facet L-Band: / Reference Station:

```
SFE_Express_Settings.txt - Notepad
File Edit Format View Help
sizeOfSettings=3056
rtkIdentifier=19
rtkFirmwareVersion=v1.4-Jun 17 2021
zedFirmwareVersion=FWVER=HPG 1.13
printDebugMessages=0
enableSD=1
enableDisplay=1
maxLogTime_minutes=600
observationSeconds=60
observationPositionAccuracy=5.00
fixedBase=0
fixedBaseCoordinateType=0
fixedEcefX=0.00
Ln 1, Col 1 100% Windows (CRLF) UTF-8
```

SparkFun RTK Settings File

All device settings are stored both in internal memory and an SD card if one is detected. The device will load the latest settings at each power on. If there is a discrepancy between the internal settings and a settings file then the settings file will be used. This allows a collection of RTK products to be identically configured using one 'golden' settings file loaded onto an SD card.

All system configuration can be done by editing the *SFE_[Platform]_Settings_0.txt* file (example shown above) where [Platform] is Facet, Express, Surveyor, etc and 0 is the profile number (0, 1, 2, 3). This file is created when a microSD card is installed. The settings are clear text but there are no safety guards against setting illegal states. It is not recommended to use this method unless You Know What You're Doing®.

Keep in mind:

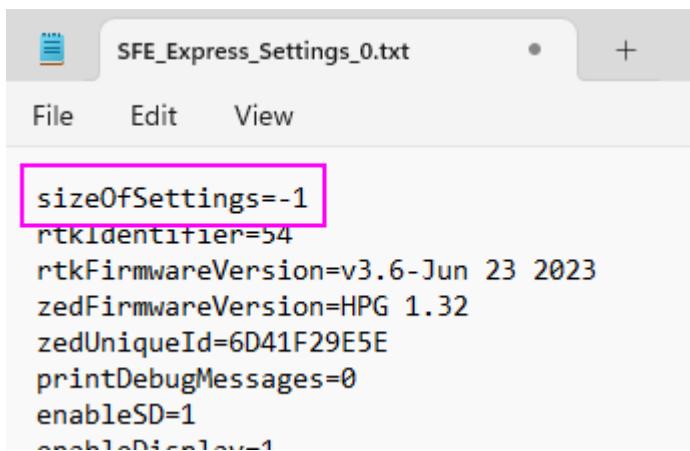
- The settings file contains hundreds of settings.
- The SD card file "SFE_Express_Settings_0.txt" is used for Profile 1, SD card file "SFE_Express_Settings_1.txt" is used for Profile 2, etc. (note that setting 0 is for profile 1, ...)
- When switching to a new profile, the settings file on the SD card with all settings will be created or updated. The internal settings will not be updated until you switch to the profile. Additionally, the file for a particular profile will not be created on the SD card until you switch to that profile.
- It is not necessary that the settings file on the SD card have all of the settings.

For example, if you only wanted to set up two wireless networks for profile 2, you could create a file named "SFE_Express_Settings_1.txt" that only contained the following settings:

```
profileName=a name you choose
enablePvtServer=1
wifiNetwork0SSID=your SSID name 1
wifiNetwork0Password=your SSID password 1
wifiNetwork1SSID=your SSID name 2
wifiNetwork1Password=your SSID password 2
wifiConfigOverAP=0
```

These settings on the SD card will overwrite the settings in the RTK Express internal memory. Once you select this profile on your RTK Express, the SD card file will be overwritten with all of the merged settings.

5.4.1 Forcing a Factory Reset



```
SFE_Express_Settings_0.txt
File Edit View
sizeOfSettings=-1
rtkIdentifier=54
rtkFirmwareVersion=v3.6-Jun 23 2023
zedFirmwareVersion=HPG 1.32
zedUniqueId=6D41F29E5E
printDebugMessages=0
enableSD=1

```

If the device has been configured into an unknown state the device can be reset to factory defaults. Power down the RTK device and remove the SD card. Using a computer and an SD card reader, open the SFE_[Platform]_Settings_0.txt file where [Platform] is Facet, Express, Surveyor, etc and 0 is the profile number (0, 1, 2, 3). Modify the **sizeOfSettings** value to -1 and save the file to the SD card. Reinsert the SD card into the RTK unit and power up the device. Upon power up, the device will display 'Factory Reset' while it clears the settings.

Note: A device may have multiple profiles, ie multiple settings files (SFE_Express_Settings_0.txt, SFE_Express_Settings_1.txt, etc). All settings files found on the SD card must be modified to guarantee the factory reset.

5.5 Configure with u-center

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

The ZED-F9P module can be configured independently using the u-center software from u-blox by connecting a USB cable to the *Config u-blox* USB connector. Settings can be saved to the module between power cycles. For more information please see SparkFun's [Getting Started with u-center by u-blox](#).

However, because the ESP32 does considerable configuration of the ZED-F9P at power on it is not recommended to modify the settings of the ZED-F9P using u-center. Nothing will break but your changes will likely be overwritten at the next power cycle.

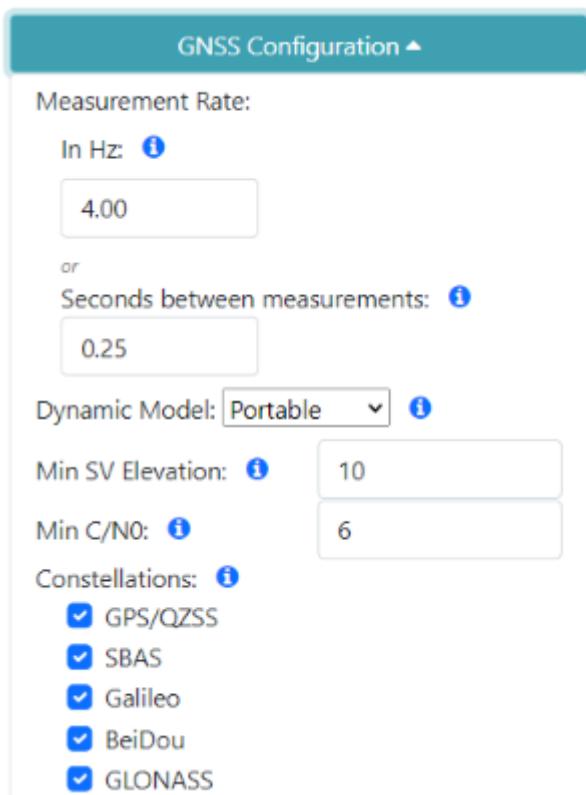
6. Configuration Menus

6.1 GNSS Menu

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

The ZED-F9P is immensely configurable. The RTK device will, by default, put the ZED-F9P into the most common configuration for rover/base RTK for use with *SW Maps* and other GIS applications.

The GNSS Configuration menu allows a user to change the report rate, dynamic model, and select which constellations should be used for fix calculations.



The most common settings on the RTK Device WiFi AP Config

From the main menu, pressing 1 will bring up the GNSS configuration menu.

```

COM20 - Tera Term VT
File Edit Setup Control Window Help
2) Set measurement rate in seconds between measurements: 0.25
3) Set dynamic model: Portable
4) Set Constellations
5) Toggle NTRIP Client: Disabled
x) Exit
5

Menu: GNSS Menu
1) Set measurement rate in Hz: 4.0000
2) Set measurement rate in seconds between measurements: 0.25
3) Set dynamic model: Portable
4) Set Constellations
5) Toggle NTRIP Client: Enabled
6) Set WiFi SSID: TRex
7) Set WiFi PW: parachutes
8) Set Caster Address: rtk2go.com
9) Set Caster Port: 2101
10) Set Caster User Name: test@test.com
11) Set Caster User Password:
12) Set Mountpoint: bldr_SparkFun1
13) Set Mountpoint PW:
14) Toggle sending GGA Location to Caster: Enabled
x) Exit

```

GNSS menu showing measurement rates and dynamic model

6.1.1 Measurement Frequency

Measurement Frequency can be set by either Hz or by seconds between measurements. Some users need many measurements per second; RTK devices support up to 20Hz with RTK enabled. Some users are doing very long static surveys that require many seconds between measurements; the ZED-F9P supports up to 8255 seconds (137 minutes) between readings.

GNSS ⁴		GPS+GLO+GAL+BDS	GPS+GLO+GAL	GPS+GAL	GPS+GLO	GPS+BDS	GPS
Acquisition ⁵	Cold start	25 s	25 s	30 s	25 s	30 s	30 s
	Hot start	2 s	2 s	2 s	2 s	2 s	2 s
	Aided start ⁶	2 s	2 s	2 s	2 s	2 s	2 s
Nav. update rate ⁷	RTK	7 Hz	10 Hz	15 Hz	14 Hz	13 Hz	20 Hz
	PVT	9 Hz	10 Hz	20 Hz	20 Hz	16 Hz	25 Hz
	RAW	15 Hz	18 Hz	25 Hz	25 Hz	25 Hz	25 Hz

Note: When in **Base** mode, the measurement frequency is set to 1Hz. This is because RTK transmission does not benefit from faster updates, nor does logging of RAWX for PPP.

6.1.2 Dynamic Model

The Dynamic Model can be changed but it is recommended to leave it as *Portable*. For more information, please refer to the [ZED-F9P Integration Manual](#).

6.1.3 Min SV Elevation and C/N0

GNSS Configuration ▾

Measurement Rate:

In Hz: ⓘ

or

Seconds between measurements: ⓘ

Dynamic Model: ⓘ

Min SV Elevation: ⓘ

Min C/N0: ⓘ

Constellations: ⓘ

GPS/QZSS

SBAS

Galileo

BeiDou

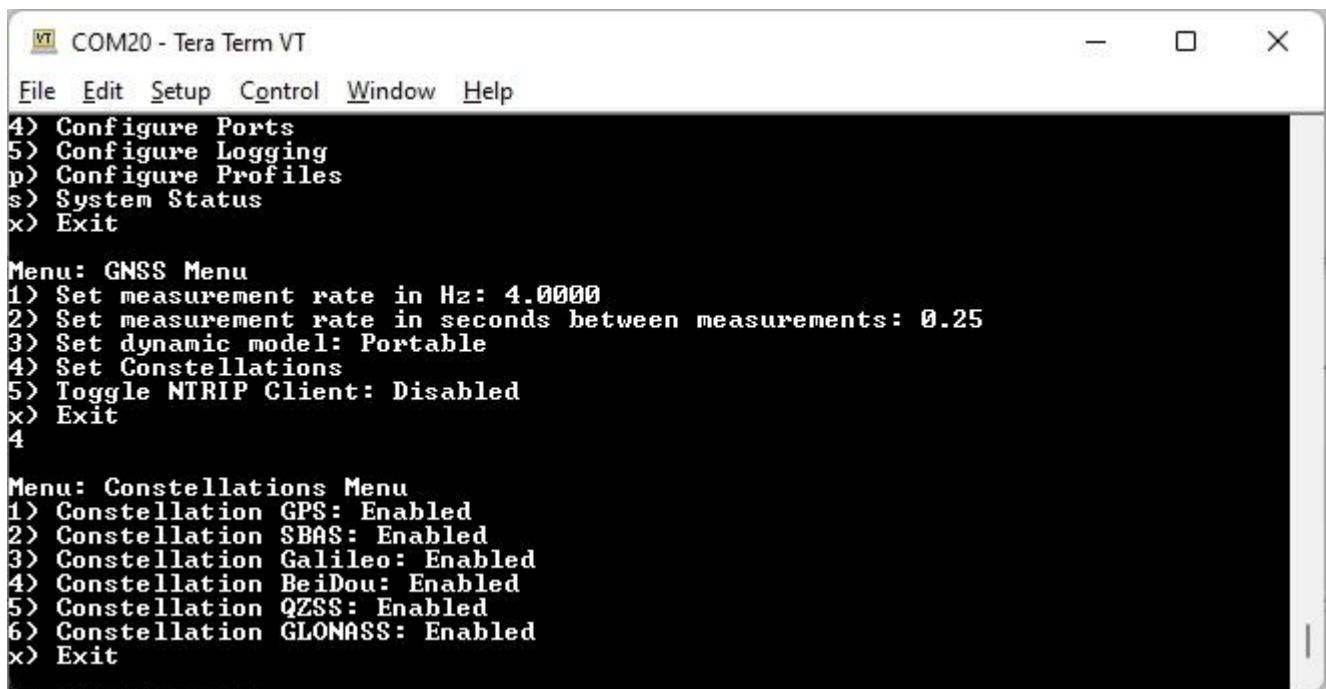
GLONASS

GNSS menu showing Minimum SV Elevation and C/N0

A minimum elevation is set in degrees. If a satellite is detected that is below this elevation, it will be *excluded* from any GNSS position calculation.

A minimum C/N0 is set in dB. If a satellite is detected that is below this signal strength, it will be *excluded* from any GNSS position calculation.

6.1.4 Constellations Menu



VT COM20 - Tera Term VT

File Edit Setup Control Window Help

```

4> Configure Ports
5> Configure Logging
p> Configure Profiles
s> System Status
x> Exit

Menu: GNSS Menu
1> Set measurement rate in Hz: 4.0000
2> Set measurement rate in seconds between measurements: 0.25
3> Set dynamic model: Portable
4> Set Constellations
5> Toggle NTRIP Client: Disabled
x> Exit
4

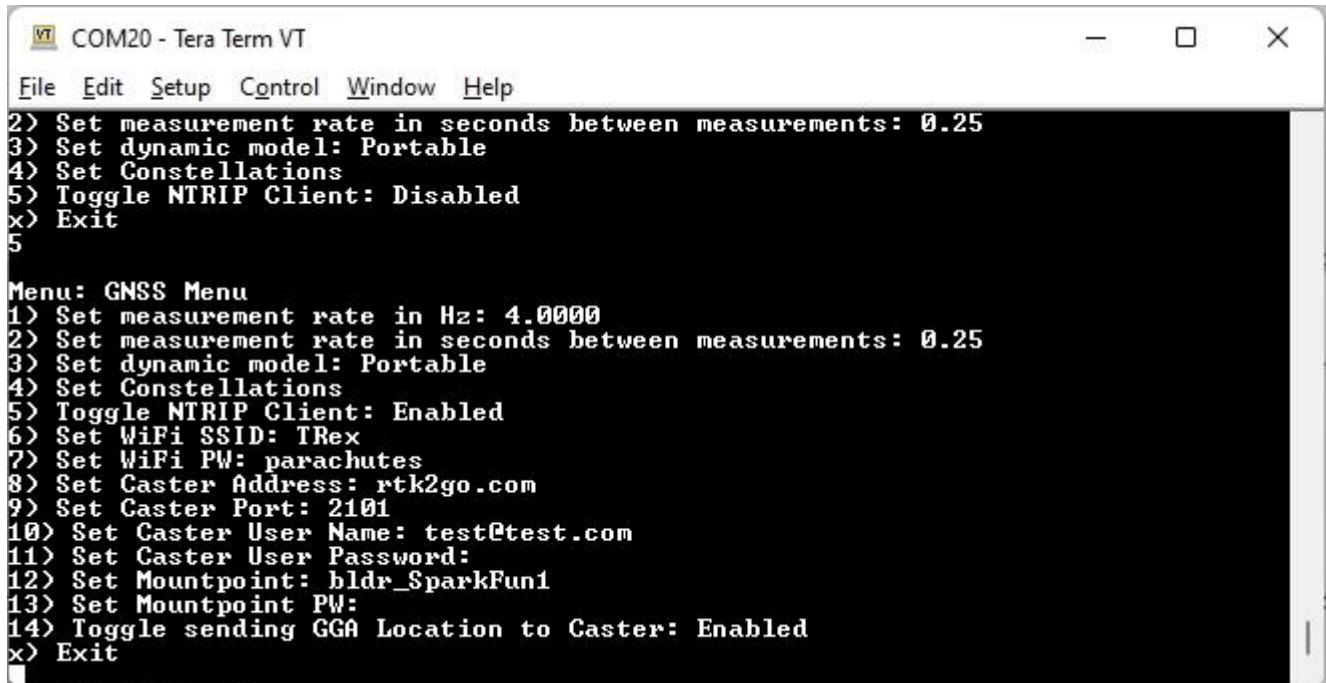
Menu: Constellations Menu
1> Constellation GPS: Enabled
2> Constellation SBAS: Enabled
3> Constellation Galileo: Enabled
4> Constellation BeiDou: Enabled
5> Constellation QZSS: Enabled
6> Constellation GLONASS: Enabled
x> Exit

```

Enable or disable the constellations used for fixes

The ZED-F9P is capable of tracking 184 channels across four constellations and two bands (L1/L2) including GPS (USA), Galileo (EU), BeiDou (China), and GLONASS (Russia). SBAS (satellite-based augmentation system) is also supported. By default, all constellations are used. Some users may want to study, log, or monitor a subset. Disabling a constellation will cause the ZED to ignore those signals when calculating a location fix.

6.1.5 NTRIP Client



VT COM20 - Tera Term VT

File Edit Setup Control Window Help

```

2> Set measurement rate in seconds between measurements: 0.25
3> Set dynamic model: Portable
4> Set Constellations
5> Toggle NTRIP Client: Disabled
x> Exit
5

Menu: GNSS Menu
1> Set measurement rate in Hz: 4.0000
2> Set measurement rate in seconds between measurements: 0.25
3> Set dynamic model: Portable
4> Set Constellations
5> Toggle NTRIP Client: Enabled
6> Set WiFi SSID: TRex
7> Set WiFi PW: parachutes
8> Set Caster Address: rtk2go.com
9> Set Caster Port: 2101
10> Set Caster User Name: test@test.com
11> Set Caster User Password:
12> Set Mountpoint: bldr_SparkFun1
13> Set Mountpoint PW:
14> Toggle sending GGA Location to Caster: Enabled
x> Exit

```

NTRIP Client enabled showing settings

The SparkFun RTK devices can obtain their correction data over a few different methods. For detailed information see [Correction Sources](#).

- Bluetooth - This is the most common. An app running on a tablet or phone has an NTRIP client built into it. Once the phone is connected over Bluetooth SPP, the RTCM is sent from the phone to the RTK device.
- WiFi - The rover uses WiFi to be an NTRIP Client and connect to an NTRIP Caster. WiFi and Bluetooth can run simultaneously. This is helpful in situations where a GIS software does not have an NTRIP Client; a cellular hotspot can be used to provide WiFi to the RTK device setup to use NTRIP Client and obtain RTK Fix, while Bluetooth is used to connect to the GIS software for data mapping and collection.
- Radio - A base RTK unit and a rover have serial radios plugged into the **RADIO** port. RTCM data generated by the base station is set over the radio to the rover.

Once the NTRIP Client is enabled you will need a handful of credentials:

- Local WiFi SSID and password (WPA2)
- A casting service and port such as [RTK2Go](#) or [Emlid](#) (the port is almost always 2101)
- A mount point and password

With these credentials set, the RTK device will attempt to connect to WiFi, then connect to your caster of choice, and then begin downloading the RTCM data over WiFi. We tried to make it as easy as possible. Every second a few hundred bytes, up to ~2k, will be downloaded from the mount point you've entered. Remember, the rover must be in WiFi range to connect in this mode.

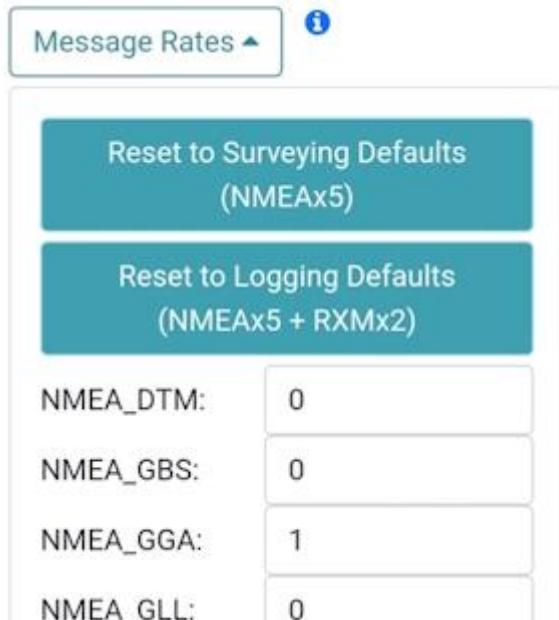


Rover with Active NTRIP Client Connection

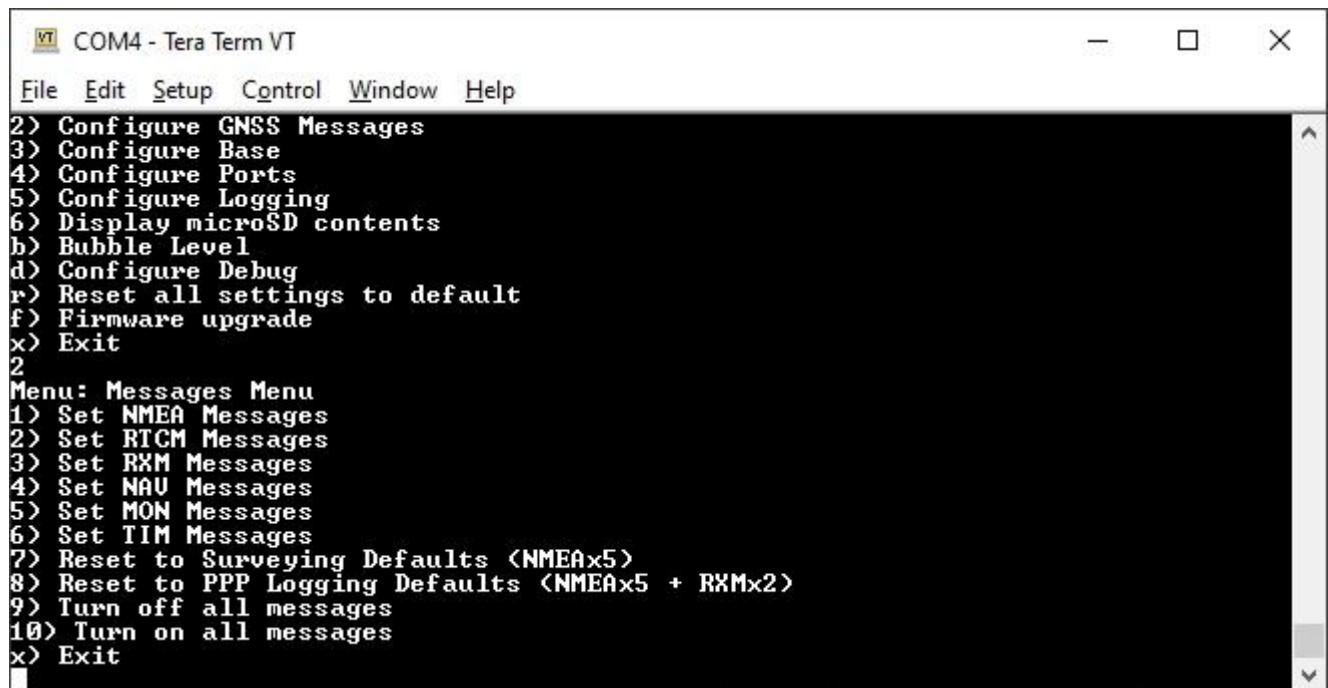
Once the device connects to WiFi, it will attempt to connect to the user's chosen NTRIP Caster. If WiFi or the NTRIP connection fails, the rover will return to normal operation.

6.2 Messages Menu

Surveyor: / Express: / Express Plus: / Facet: / Facet L-Band: / Reference Station:



Message rate configuration from WiFi AP Config



The messages configuration menu

From this menu, a user can control the output of various NMEA, RTCM, RXM, and other messages. Any enabled message will be broadcast over Bluetooth and recorded to SD (if available).

Because of the large number of configurations possible, we provide a few common settings:

- Reset to Surveying Defaults (NMEAx5)
- Reset to PPP Logging Defaults (NMEAx5 + RXMx2)
- Turn off all messages (serial command only)
- Turn on all messages (serial command only)

6.2.1 Reset to Surveying Defaults (NMEAx5)

This will turn off all messages and enable the following messages:

- NMEA-GGA, NMEA-GSA, NMEA-GST, NMEA-GSV, NMEA-RMC

These five NMEA sentences are commonly used with SW Maps for general surveying.

6.2.2 Reset to PPP Logging Defaults (NMEAx5 + RXMx2)

This will turn off all messages and enable the following messages:

- NMEA-GGA, NMEA-GSA, NMEA-GST, NMEA-GSV, NMEA-RMC, RXM-RAWX, RXM-SFRBX

These seven sentences are commonly used when logging and doing Precise Point Positioning (PPP) or Post Processed Kinematics (PPK). You can read more about PPP [here](#).

6.2.3 Individual Messages

```

VT COM4 - Tera Term VT
File Edit Setup Control Window Help
?> Reset to Surveying Defaults <NMEAx5>
8> Reset to PPP Logging Defaults <NMEAx5 + RXMx2>
9> Turn off all messages
10> Turn on all messages
x> Exit
1

Menu: Message NMEA Menu
1> Message NMEA DTM: 1
2> Message NMEA GBS: 0
3> Message NMEA GGA: 1
4> Message NMEA GLL: 0
5> Message NMEA GNS: 0
6> Message NMEA GRS: 0
7> Message NMEA GSA: 1
8> Message NMEA GST: 1
9> Message NMEA GSV: 1
10> Message NMEA RMC: 1
11> Message NMEA ULW: 0
12> Message NMEA UTG: 1
13> Message NMEA ZDA: 0
x> Exit
9
Enter UBX_NMEA_GSV message rate <0 to disable>: 4

```

Configuring the NMEA messages

There are a large number of messages supported (listed below). Each message sub-menu will present the user with the ability to set the message report rate.

Each message rate input controls which messages are disabled (0) and how often the message is reported (1 = one message reported per 1 fix, 5 = one report every 5 fixes). The message rate range is 0 to 20.

Note: The message report rate is the *number of fixes* between message reports. In the image above, with GSV set to 4, the NMEA GSV message will be produced once every 4 fixes. Because the device defaults to a 4Hz fix rate, the GSV message will appear once per second.

The following 120 messages are supported for Bluetooth output and logging:

• NMEA-DTM	• NMEA-GBS	• NMEA-GGA
• NMEA-GLL	• NMEA-GNS	• NMEA-GRS
• NMEA-GSA	• NMEA-GST	• NMEA-GSV
• NMEA-RLM	• NMEA-RMC	• NMEA-THS
• NMEA-VLW	• NMEA-VTG	• NMEA-ZDA
• NMEA-NAV2-GGA	• NMEA-NAV2-GLL	• NMEA-NAV2-GNS
• NMEA-NAV2-GSA	• NMEA-NAV2-RMC	• NMEA-NAV2-VTG
• NMEA-NAV2-ZDA	• PUBX-POLYP	• PUBX-POLYS
• PUBX-POLYT	• RTCM3x-1005	• RTCM3x-1074
• RTCM3x-1077	• RTCM3x-1084	• RTCM3x-1087
• RTCM3x-1094	• RTCM3x-1097	• RTCM3x-1124
• RTCM3x-1127	• RTCM3x-1230	• RTCM3x-4072-0
• RTCM3x-4072-1	• ESF-ALG	• ESF-INS
• ESF-MEAS	• ESF-RAW	• ESF-STATUS
• MON-COMMS	• MON-HW2	• MON-HW3
• MON-HW	• MON-IO	• MON-MSGPP
• MON-RF	• MON-RXBUF	• MON-RXR
• MON-SPAN	• MON-SYS	• MON-TXBUF
• NAV2-CLOCK	• NAV2-COV	• NAV2-DOP
• NAV2-EELL	• NAV2-EOE	• NAV2-POSECEF
• NAV2-POSLH	• NAV2-PVAT	• NAV2-PVT
• NAV2-SAT	• NAV2-SBAS	• NAV2-SIG
• NAV2-STATUS	• NAV2-TIMEBDS	• NAV2-TIMEGAL
• NAV2-TIMEGLO	• NAV2-TIMEGPS	• NAV2-TIMELS
• NAV2-TIMEQZSS	• NAV2-TIMEUTC	• NAV2-VELECEF
• NAV2-VELNED	• NAV-ATT	• NAV-CLOCK
• NAV-COV	• NAV-DOP	• NAV-EELL
• NAV-EOE	• NAV-GEOFENCE	• NAV-HPOSECEF
• NAV-HPOSLH	• NAV-ODO	• NAV-ORB
• NAV-PL	• NAV-POSECEF	• NAV-POSLH
• NAV-PVAT	• NAV-PVT	• NAV-RELPOSNED
• NAV-SAT	• NAV-SBAS	• NAV-SIG
• NAV-SLAS	• NAV-STATUS	• NAV-SVIN
• NAV-TIMEBDS	• NAV-TIMEGAL	• NAV-TIMEGLO
• NAV-TIMEGPS	• NAV-TIMELS	• NAV-TIMEQZSS

• NAV-TIMEUTC	• NAV-VELECEF	• NAV-VELNED
• RXM-COR	• RXM-MEASX	• RXM-RAWX
• RXM-RLM	• RXM-RTCM	• RXM-SFRBX
• RXM-SPARTN	• TIM-TM2	• TIM-TP
• TIM-VRFY		

6.2.4 Turn off all messages

This will turn off all messages. This is handy for advanced users who need to start from a blank slate. This setting is only available over serial configuration.

6.2.5 Turn on all messages

This will turn on all messages. This is a setting used for firmware testing and should not be needed in normal use. This setting is only available over serial configuration.

6.2.6 ESF Messages

The ZED-F9R module, found only on the Express Plus, supports additional External Sensor Fusion messages. These messages show the raw accelerometer and gyroscope values of the internal IMU. These messages can consume up to 34,000 bytes of bandwidth. Please see [here](#) for more information.

6.3 Base Menu

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

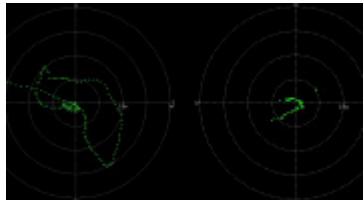
In addition to providing accurate local location fixes, the SparkFun RTK devices can also serve as a correction source, also called a *Base*. The Base doesn't move and 'knows' where it is so it can calculate the discrepancies between the signals it is receiving and what it should be receiving. Said differently, the 'Base' is told where it is, and that it's not moving. If the GPS signals say otherwise, the Base knows there was a disturbance in the F₀ce ionosphere. These differences are the correction values passed to the Rover so that the Rover can have millimeter-level accuracy.

There are two types of bases: *Surveyed* and *Fixed*. A surveyed base is often a temporary base set up in the field. Called a 'Survey-In', this is less accurate but requires only 60 seconds to complete. The 'Fixed' base is much more accurate but the precise location at which the antenna is located must be known. A fixed base is often a structure with an antenna bolted to the side. Raw satellite signals are gathered for a few hours and then processed using Precision Point Position. We have a variety of tutorials that go into depth on these subjects but all you need to know is that the RTK Facet supports both Survey-In and Fixed Base techniques.

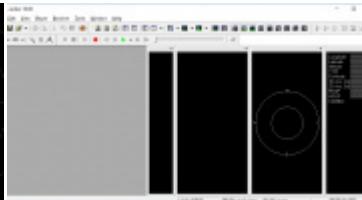
Note: The RTK Express Plus does not support Base mode. The Express Press contains an internal IMU and additional algorithms to support high-precision location fixes using dead reckoning.

Note: The RTK Facet is designed to use corrections provided via u-blox's PointPerfect system therefore, a Base/Rover setup is not needed. However, if the service is not available the RTK Facet L-Band can still be used in a traditional Base/Rover setup. Here we'll describe how to assemble a Rover and Base.

Please see the following tutorials for more information:



[What is GPS RTK?](#)



[Getting Started with u-center for u-blox](#)



[Setting up a Rover Base RTK System](#)



[How to build a DIY GNSS reference station](#)

The Base Menu allows the user to select between Survey-In or Fixed Base setups.

Base Configuration ▲

Survey-In 

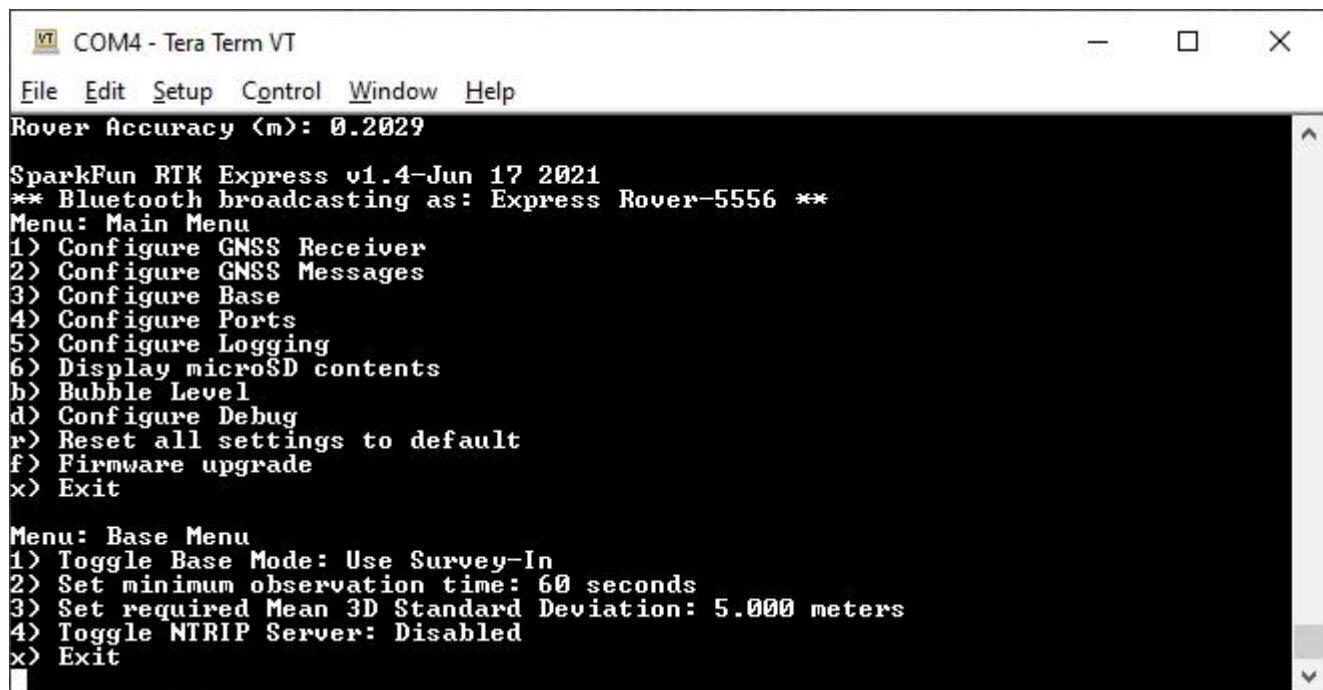
Minimum observation time(s):

Required Mean 3D Standard Deviation (m):

Fixed (Choose ECEF or Geodetic) 

Enable NTRIP Server 

[RTCM Rates ▾](#) 

Controlling the type of Base from WiFi AP Config

VT COM4 - Tera Term VT

File Edit Setup Control Window Help

Rover Accuracy <m>: 0.2029

SparkFun RTK Express v1.4-Jun 17 2021
** Bluetooth broadcasting as: Express Rover-5556 **

Menu: Main Menu

1> Configure GNSS Receiver
2> Configure GNSS Messages
3> Configure Base
4> Configure Ports
5> Configure Logging
6> Display microSD contents
b> Bubble Level
d> Configure Debug
r> Reset all settings to default
f> Firmware upgrade
x> Exit

Menu: Base Menu

1> Toggle Base Mode: Use Survey-In
2> Set minimum observation time: 60 seconds
3> Set required Mean 3D Standard Deviation: 5.000 meters
4> Toggle NTRIP Server: Disabled
x> Exit

Base Menu Options

6.3.1 Mode

In **Survey-In** mode, the minimum observation time and Mean 3D Standard Deviation can be set. The defaults are 60 seconds and 5 meters as directed by u-blox. The device will wait for the position accuracy to be better than 1 meter before a Survey-In is started. Don't be fooled; setting the observation time to 4 hours or an initial positional accuracy of 0.3m is not going to significantly improve the accuracy of the survey - use [PPP](#) instead.

Base Configuration ▾

Survey-In [i](#)

Fixed (Choose ECEF or Geodetic) [i](#)

ECEF Coordinates

Paste Current XYZ [i](#)

X:	-1280322.233
Y:	-4716532.488
Z:	4086116.922
Name:	Monument1

Commonly Used Coordinates [i](#)

Nickname: X/Y/Z

SparkFunHQ: -1280206.568 -4716804.403 408666
Monument1: -1280322.233 -4716532.488 408611

Add [i](#) **Load [i](#)** **Delete [i](#)**

Geodetic

Enable NTRIP Server [i](#)

Fixed base coordinate input

In **Fixed** mode, the coordinates of the antenna need to be set. These can be entered in ECEF or Geographic coordinates. Whenever a user enters Base mode by pressing the SETUP button the GNSS receiver will immediately go into Base mode with these coordinates and immediately begin outputting RTCM correction data.

Note: The 'Paste Current XYZ' button will copy the current base coordinates and paste them into the X/Y/Z boxes. This shortcut allows the user to skip writing down coordinates just to re-enter them. However, taking a snap-shot of the unit's position in time is a very inaccurate way to assign the unit's base position.



RTK Facet in Survey-In Mode

Once the device has been configured, pressing the Setup button will change the device to Base mode. If the device is configured for *Survey-In* base mode, a flag icon will be shown and the survey will begin. The mean standard deviation will be shown as well as the time elapsed. For most Survey-In setups, the survey will complete when both 60 seconds have elapsed *and* a mean of 5m or less is obtained.



RTK Facet in Fixed Transmit Mode

Once the *survey-in* is complete the device enters RTCM Transmit mode. The number of RTCM transmissions is displayed. By default, this is one per second. During this phase, the ZED-F9P is outputting the RTCM corrections out of the **RADIO** port. Attaching an external serial radio to this port will allow the Base to send corrections to any Rover.

The *Fixed Base* mode is similar but uses a structure icon (shown above) to indicate a fixed base.

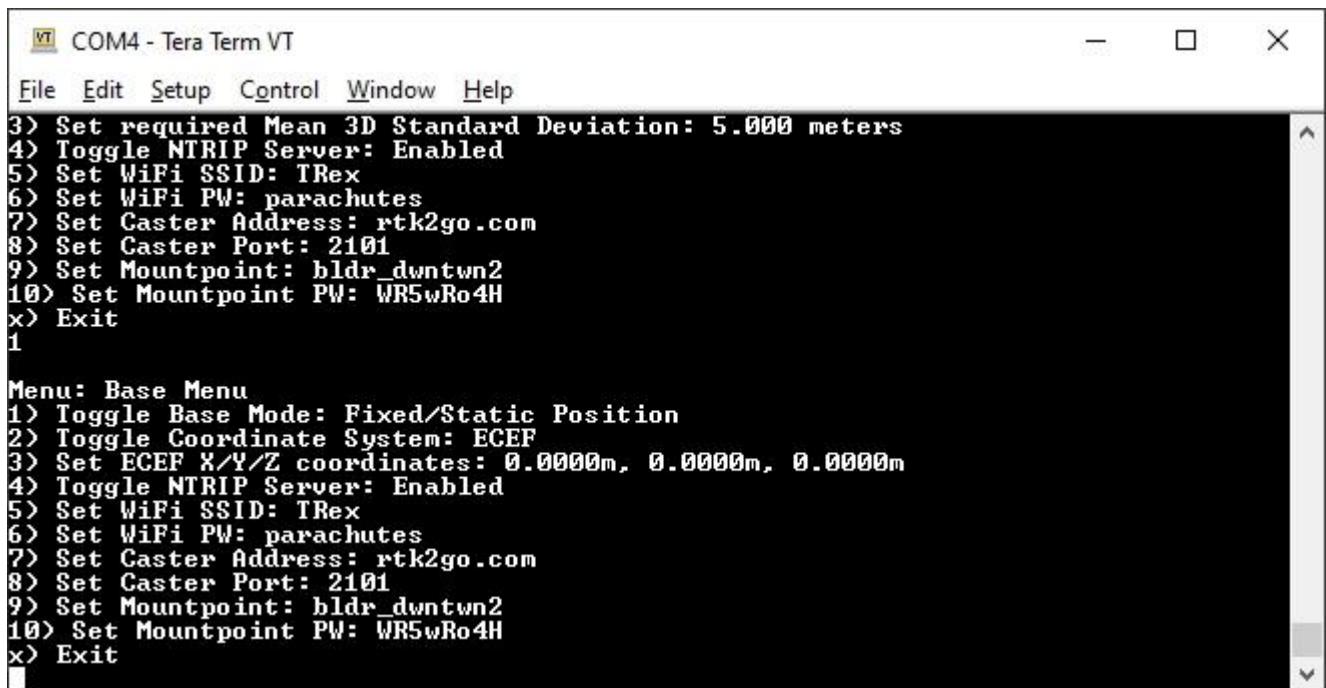
6.3.2 NTRIP Server

NTRIP is where the real fun begins. The Base needs a method for getting the correction data to the Rover. This can be done using radios but that's limited to a few kilometers at best. If you've got WiFi reception, use the internet!

Enabling NTRIP will present a handful of new options seen below:

<input type="checkbox"/> Enable NTRIP Server	i
WiFi SSID:	TRex
WiFi PW:	parachutes
Caster Host:	rtk2go.com
Caster Port:	2101
Mount Point:	bldr_dwntwn2
Mount Point PW:	WR5wRo4H

Configuring NTRIP Server settings via WiFi Config AP



COM4 - Tera Term VT

File Edit Setup Control Window Help

```
3> Set required Mean 3D Standard Deviation: 5.000 meters
4> Toggle NTRIP Server: Enabled
5> Set WiFi SSID: TRex
6> Set WiFi PW: parachutes
7> Set Caster Address: rtk2go.com
8> Set Caster Port: 2101
9> Set Mountpoint: bldr_dwntwn2
10> Set Mountpoint PW: WR5wRo4H
x> Exit
1

Menu: Base Menu
1> Toggle Base Mode: Fixed/Static Position
2> Toggle Coordinate System: ECEF
3> Set ECEF X/Y/Z coordinates: 0.0000m, 0.0000m, 0.0000m
4> Toggle NTRIP Server: Enabled
5> Set WiFi SSID: TRex
6> Set WiFi PW: parachutes
7> Set Caster Address: rtk2go.com
8> Set Caster Port: 2101
9> Set Mountpoint: bldr_dwntwn2
10> Set Mountpoint PW: WR5wRo4H
x> Exit
```

Settings for the NTRIP Server

This is a powerful feature of the RTK line of products. The RTK device can be configured to transmit its RTCM directly over WiFi to the user's mount point. This eliminates the need for a radio link.

Once the NTRIP server is enabled you will need a handful of credentials:

- Local WiFi SSID and password
- A casting service such as [RTK2Go](#) or [Emlid](#) (the port is almost always 2101)
- A mount point and password



RTK Facet in Transmit Mode with NTRIP Enabled

VT COM4 - Tera Term VT

File Edit Setup Control Window Help

```

Bluetooth broadcasting as: Surveyor Base-0D6E
Static Base Started Successfully
Bluetooth turned off
Connecting to local WiFi: sparkfun-guest.....
Opening socket to rtk2go.com
Connected to rtk2go.com:2101
Sending credentials:
SOURCE WR5wRo4H /bldr_dwntwn2
Source-Agent: NTRIP SparkFun RTK Surveyor/App Version 1.0

Caster responded with: ICY 200 OK

Connected to caster
Batt <62%>: Voltage: 3.90V Charging: 3.54%/hr Green all good
Total bytes sent to caster: 0

```

NTRIP Server Connected!

If the NTRIP server is enabled the device will first attempt to connect over WiFi. The WiFi icon will blink until a WiFi connection is obtained. If the WiFi icon continually blinks be sure to check your SSID and PW for the local WiFi.

Once WiFi connects the device will attempt to connect to the NTRIP mount point. Once successful the display will show 'Casting' along with a solid WiFi icon. The number of successful RTCM transmissions will increase every second.

VT COM4 - Tera Term VT

File Edit Setup Control Window Help

```

Total bytes sent to caster: 8662
Total bytes sent to caster: 8662
Total bytes sent to caster: 9147
Total bytes sent to caster: 9147
Total bytes sent to caster: 9147
Total bytes sent to caster: 9488
Total bytes sent to caster: 9488
Total bytes sent to caster: 9488
Total bytes sent to caster: 9973
Total bytes sent to caster: 9973
Total bytes sent to caster: 9973
Total bytes sent to caster: 10458
Total bytes sent to caster: 10458
Total bytes sent to caster: 10458
Total bytes sent to caster: 10943

```

Every second a few hundred bytes, up to ~2k, will be transmitted to your mount point.

Note: During NTRIP transmission WiFi is turned on and Bluetooth is turned off. You should not need to know the location information of the base so Bluetooth should not be needed. If necessary, USB can be connected to view detailed location information using the [System Report](#) command.

6.3.3 Commonly Use Coordinates

Base Configuration ▾

Survey-In ⓘ

Fixed (Choose ECEF or Geodetic) ⓘ

ECEF Coordinates

Paste Current XYZ ⓘ

X:	-1280322.233
Y:	-4716532.488
Z:	4086116.922
Name:	Monument1

Commonly Used Coordinates ⓘ

Nickname: X/Y/Z

SparkFunHQ: -1280206.568 -4716804.403 408666
Monument1: -1280322.233 -4716532.488 408611

Add Load Delete ⓘ

Geodetic

Enable NTRIP Server ⓘ

A list of common coordinates

For users who return to the same base position or monument, the coordinates can be saved to a 'Commonly Used Coordinates' list. A nickname and the X/Y/Z positions are saved to the list. Any record on the list can be loaded from the list into the X/Y/Z fields allowing quick switching without the need to hand record or re-enter coordinates from day-to-day repositioning of the base.

6.3.4 RTCM Message Rates

Base Configuration ▾

Survey-In i

Minimum observation time(s):
60

Required Mean 3D Standard Deviation (m):
5.00

Fixed (Choose ECEF or Geodetic) i

Enable NTRIP Server i

RTCM Rates ▾ i

When the device is in Base mode, the fix rate is set to 1Hz. This will override any Rover setting.

RTCM Rates ▾ i

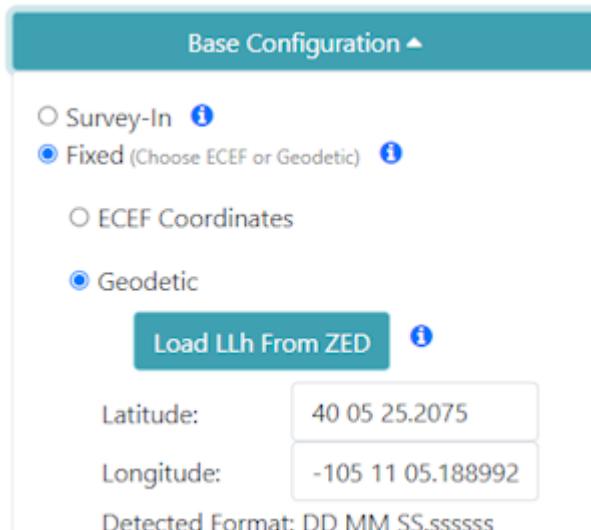
Reset to Defaults

Reset to Low Bandwidth Link

RTCM_1005:	<input type="text" value="1"/>
RTCM_1074:	<input type="text" value="1"/>
RTCM_1077:	<input type="text" value="0"/>
RTCM_1084:	<input type="text" value="1"/>
RTCM_1087:	<input type="text" value="0"/>
RTCM_1094:	<input type="text" value="1"/>
RTCM_1097:	<input type="text" value="0"/>
RTCM_1124:	<input type="text" value="1"/>
RTCM_1127:	<input type="text" value="0"/>
RTCM_1230:	<input type="text" value="10"/>
RTCM_4072_0:	<input type="text" value="0"/>
RTCM_4072_1:	<input type="text" value="0"/>

Additionally, RTCM messages are generated at a rate of 1Hz. If lower RTCM rates are desired the RTCM Rates menu can be used to modify the rates of any supported RTCM message. This can be helpful when using longer-range radios that have lower bandwidth.

6.3.5 Supported Lat/Long Coordinate Formats



When entering coordinates for a fixed Base in Geodetic format, the following formats are supported:

- DD.dddddddd (ie -105.184774720, 40.090335429)
- DDMM.mmmmmmmm (ie -10511.0864832)
- DD MM.mmmmmmmm (ie 40 05.42013)
- DD-MM.mmmmmmmm (40-05.42013)
- DDMMSS.ssssss (-1051105.188992)
- DD MM SS.ssssss (-105 11 05.188992)
- DD-MM-SS.ssssss (40-05-25.2075)

```

Menu: Base
Total Height Above Ellipsoid - Antenna Phase Center (HAE APC): 1560.089mm
1> Toggle Base Mode: Fixed/Static Position
2> Toggle Coordinate System: Geodetic
3> Set Lat/Long/Altitude coordinates: 40 05 25.207501, -105 11 05.188992, 1560.0890m
4> Set coordinate display format: DD MM SS.ssssss
5> Set Antenna Height: 0mm
6> Set Antenna Reference Point: 0.0mm
7> Toggle NTRIP Server: Disabled
8> Set RTCM Message Rates
x> Exit
  
```

These coordinate formats are automatically detected and converted as needed. The coordinates are displayed in the format they are entered. If a different format is desired, the coordinate display format can be changed via the serial Base menu.

For more information about coordinate formats, check out this [online converter](#).

6.3.6 Assisted Base

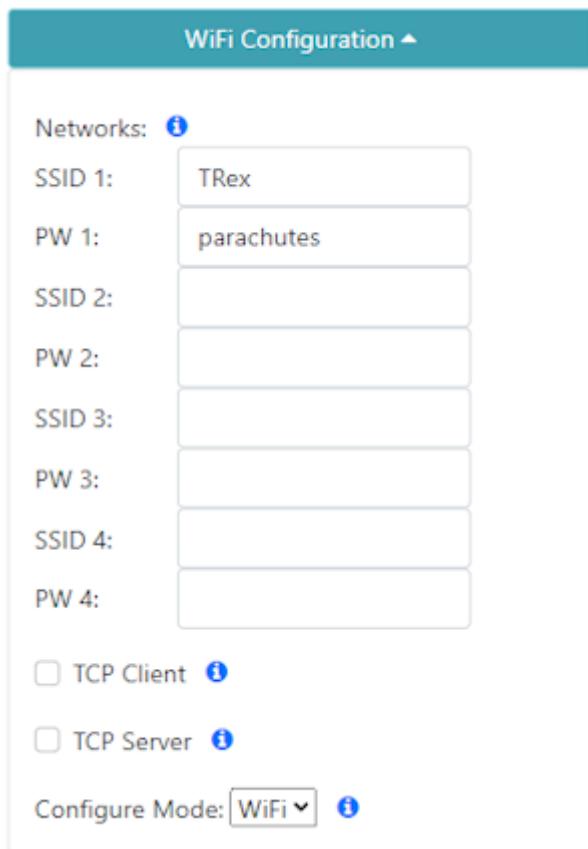
An Assisted Base is where a temporary base is set up to Survey-In its location but is simultaneously provided RTCM corrections so that its Survey-In is done with very precise readings. An assisted base running a Survey-In removes much of the relative inaccuracies from a Rover-Base system. We've found an Assisted Base varies as little as 50mm RMS between intra-day tests, with accuracy within 65mm of a PPP of the same location, same day.

To set up an assisted base the RTK device should be located in a good reception area and provided with RTCM corrections. Let it obtain RTK Fix from a fixed position (on a tripod, for example) in *Rover* mode. Once an RTK fix is achieved, change the device to temporary *Base* mode (also called Survey-In). The device will take 60 seconds of positional readings, at which point the fixed position of the base will be set using RTK augmented coordinates. At this point, corrections provided to the base can be discontinued. The Base will begin outputting very accurate RTCM corrections that can be relayed to a rover that is in a less optimal reception setting.

Similarly, the RTK Facet L-Band can be set up as a relay: the L-Band device can be located in a good reception area, and then transmit very accurate corrections to a rover via Radio or internet link. Because the RTK Facet L-Band can generate its own corrections, you do not need to provide them during Survey-In. To set up an assisted base, set up an RTK Facet L-Band unit with a clear view of the sky, and let it obtain RTK Fix from a fixed position in *Rover* mode. Once an RTK fix is achieved, change the device to temporary *Base* mode. The device will take 60 seconds of positional readings, at which point the fixed position will be set using RTK fixed coordinates. The RTK Facet L-Band will then output very accurate RTCM corrections that can be relayed to a rover that is in a less optimal reception setting.

6.4 WiFi Menu

Surveyor: / Express: / Express Plus: / Facet: / Facet L-Band: / Reference Station:



WiFi Menu in the WiFi config page

```

COM29 - Tera Term VT
File Edit Setup Control Window Help
p> Configure User Profiles
r> Configure Radios
s> Configure System
f> Firmware upgrade
x> Exit
6

Menu: WiFi Networks
1> SSID 1: Trex
2> Password 1: parachutes
3> SSID 2:
4> Password 2:
5> SSID 3:
6> Password 3:
7> SSID 4:
8> Password 4:
a> Configure device via WiFi Access Point or connect to WiFi: WiFi
c> WiFi TCP Client <connect to phone>: Disabled
s> WiFi TCP Server: Disabled
m> MDNS: Disabled
x> Exit

```

WiFi Menu containing one network

Beginning in firmware version 3.0, the WiFi menu allows a user to input credentials of up to four WiFi networks. WiFi is used for a variety of features on the RTK device. When WiFi is needed, the RTK device will attempt to connect to any network on the list of WiFi networks. For example, if you enter your home WiFi, work WiFi, and the WiFi for a mobile hotspot, the RTK device will automatically detect and connect to the network with the strongest signal.

Additionally, the device will continue to try to connect to WiFi if a connection is not made. The connection timeout starts at 15 seconds and increases by 15 seconds with each failed attempt. For example, 15, 30, 45, etc seconds are delayed between each new WiFi connection attempt. Once a successful connection is made, the timeout is reset.

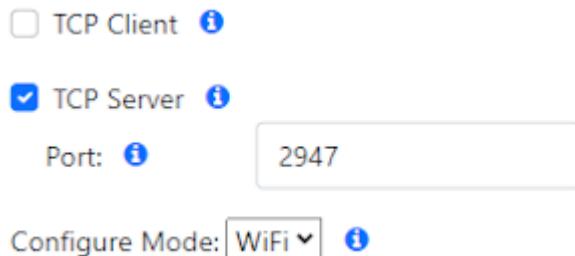
WiFi is used for the following features:

- NTRIP Client or Server
- TCP Client or Server
- Firmware Updates
- Device Configuration (WiFi mode only)
- PointPerfect Key renewal (RTK Facet L-Band only)

6.4.1 TCP Client and Server

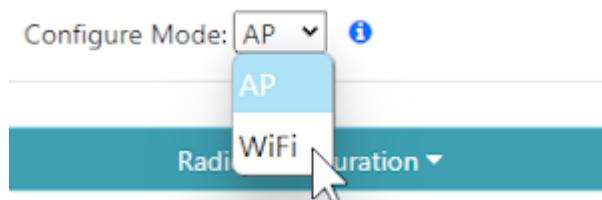
The RTK device supports connection over TCP. Some Data Collector software (such as [Vespucci](#)) requires that the SparkFun RTK device connect as a TCP Client. Other software (such as [QGIS](#)) requires that the SparkFun RTK device acts as a TCP Server. Both are supported.

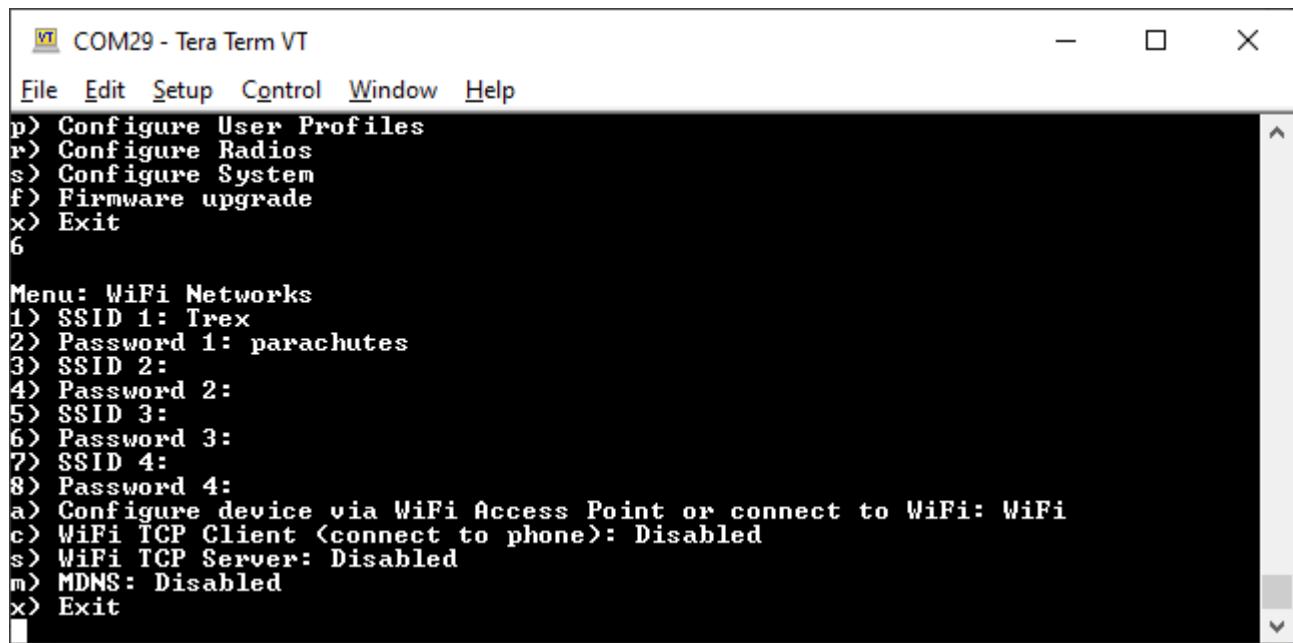
Note: Currently TCP is only supported while connected to local WiFi, not AP mode. This means the device will need to be connected to a WiFi network, such as a mobile hotspot, before TCP connections can occur.



If either Client or Server is enabled, a port can be designated. By default, the port is 2947 (registered as [GPS Daemon request/response](#)) but any port 0 to 65535 is supported.

6.4.2 Configure Mode: AP vs WiFi





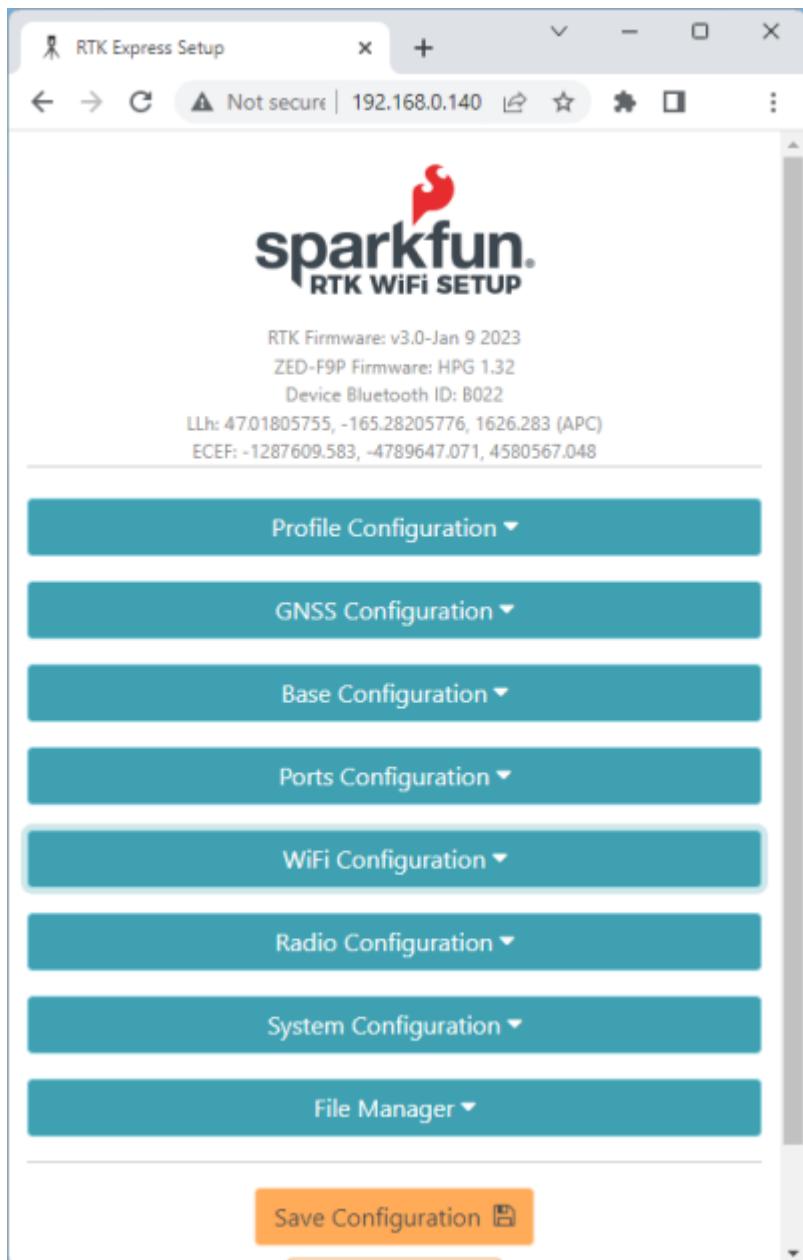
VT COM29 - Tera Term VT

File Edit Setup Control Window Help

```
p> Configure User Profiles
r> Configure Radios
s> Configure System
f> Firmware upgrade
x> Exit
6

Menu: WiFi Networks
1> SSID 1: Trex
2> Password 1: parachutes
3> SSID 2:
4> Password 2:
5> SSID 3:
6> Password 3:
7> SSID 4:
8> Password 4:
a> Configure device via WiFi Access Point or connect to WiFi: WiFi
c> WiFi TCP Client (connect to phone): Disabled
s> WiFi TCP Server: Disabled
m> MDNS: Disabled
x> Exit
```

By default, the device will become an Access Point when the user selects 'Config' from the front panel controls. This is handy for in-field device configuration. Alternatively, changing this setting to 'WiFi' will cause the device to connect to local WiFi.

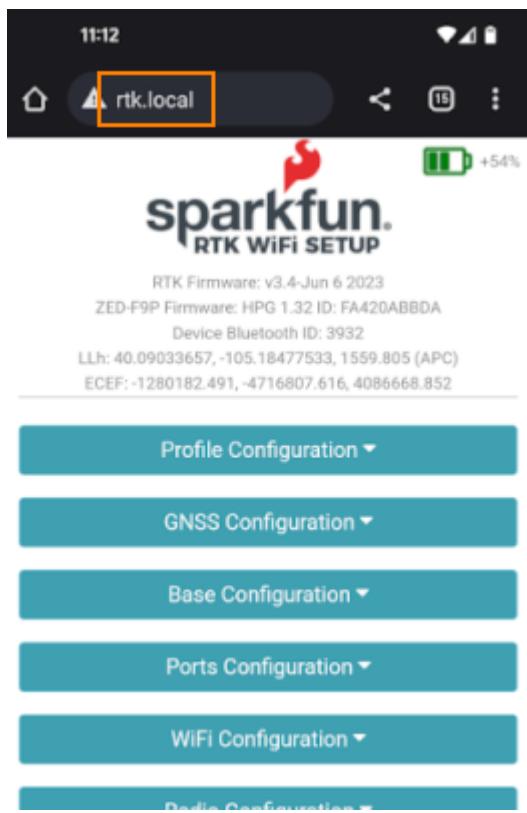


Configuring over WiFi allows the device to be configured from any desktop computer that has access to the same WiFi network. This method allows for greater control from a full size keyboard and mouse.



When the device enters WiFi config mode it will display the WiFi network it is connected to as well as its assigned IP address.

6.4.3 MDNS



Multicast DNS or MDNS allows the RTK device to be discovered over wireless networks without needing to know the IP. For example, when MDNS is enabled, simply type 'rtk.local' into a browser to connect to the RTK Config page. This feature works both for 'WiFi Access Point' or direct WiFi config. Note: When using WiFi config, you must be on the same subdomain (in other words, the same WiFi or Ethernet network) as the RTK device.

6.5 Ports Menu

Surveyor: / Express: / Express Plus: / Facet: / Facet L-Band: / Reference Station:



Setting the baud rates of the two available external ports

```

COM4 - Tera Term VT
File Edit Setup Control Window Help
UBX file size: 5825013 - Generation rate: 3.1kB/s - Write speed: 4577.7kB/s
Rover Accuracy <m>: 0.3002

SparkFun RTK Express v1.4-Jun 17 2021
** Bluetooth broadcasting as: Express Rover-5556 **
Menu: Main Menu
1> Configure GNSS Receiver
2> Configure GNSS Messages
3> Configure Base
4> Configure Ports
5> Configure Logging
6> Display microSD contents
b> Bubble Level
d> Configure Debug
r> Reset all settings to default
f> Firmware upgrade
x> Exit

Menu: Port Menu
1> Set Radio port serial baud rate: 57600 bps
2> Set Data port connections: NMEA TX Out/RX In
3> Set Data port serial baud rate: 460800 bps
x> Exit

```

Baud rate configuration of Radio and Data ports

6.5.1 Radio Port

By default, the **Radio** port is set to 57600bps to match the [Serial Telemetry Radios](#) that are recommended to be used with the RTK Facet (it is a plug-and-play solution). This can be set from 4800bps to 921600bps.

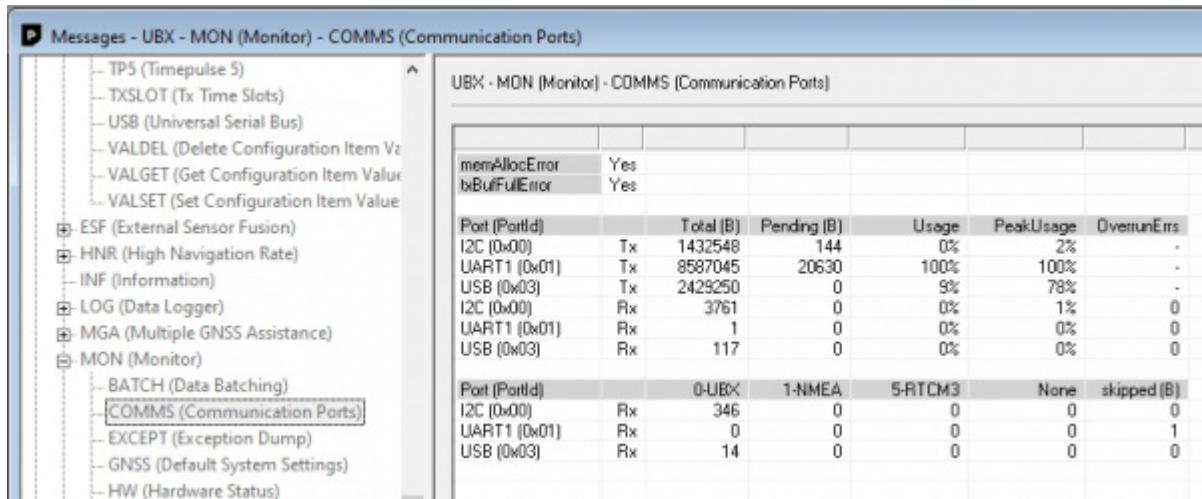
6.5.2 Mux Channel

The **Data** port on the RTK Facet, Express, and Express Plus is very flexible. Internally the **Data** connector is connected to a digital mux allowing one of four software-selectable setups. By default, the Data port will be connected to the UART1 of the ZED-F9P and output any messages via serial.

- **NMEA** - The TX pin outputs any enabled messages (NMEA, UBX, and RTCM) at a default of 460,800bps (configurable 9600 to 921600bps). The RX pin can receive RTCM for RTK and can also receive UBX configuration commands if desired.
- **PPS/Trigger** - The TX pin outputs the pulse-per-second signal that is accurate to 30ns RMS. This pin can be configured as an extremely accurate time base. The pulse length and time between pulses are configurable down to 1us. The RX pin is connected to the EXTINT pin on the ZED-F9P allowing for events to be measured with incredibly accurate nano-second resolution. Useful for things like audio triangulation. See the [External Event Logging](#) section below and the Timemark section of the [ZED-F9P Integration Manual](#) for more information.
- **I2C** - (On Express, Facet, and Facet L-Band) The TX pin operates as SCL, RX pin as SDA on the I2C bus. This allows additional sensors to be connected to the I2C bus.
- **Wheel/Dir Encoder** - (On Express Plus) Connect the DATA port to the wheel tick inputs on the ZED-F9R. This aids the Sensor Fusion engine for IMU based location fixes when installed in an automobile. Signals must be limited to 3.3V.
- **GPIO** - The TX pin operates as a DAC-capable GPIO on the ESP32. The RX pin operates as an ADC-capable input on the ESP32. This is useful for custom applications.

6.5.3 Data Port

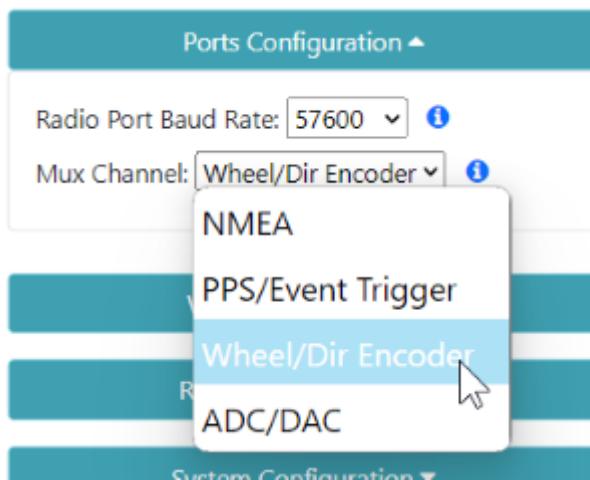
By default, the **Data** port is set to 460800bps and can be configured from 4800bps to 921600bps. The 460800bps baud rate was chosen to support applications where a large number of messages are enabled and a large amount of data is sent. If you need to decrease the baud rate to 115200bps or other, be sure to monitor the MON-COMM message within u-center for buffer overruns. A baud rate of 115200bps and the NMEA+RXM default configuration at 4Hz *will* cause buffer overruns.



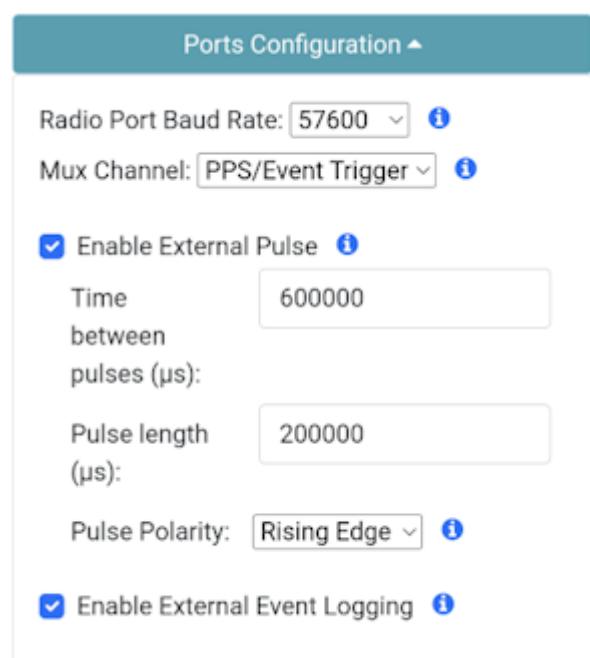
Monitoring the COM ports on the ZED-F9P

If you must run the data port at lower than 460800bps, and you need to enable a large number of messages and/or increase the fix frequency beyond 4Hz, be sure to verify that UART1 usage stays below 99%. The image above shows the UART1 becoming overwhelmed because the ZED cannot transmit at 115200bps fast enough.

Most applications do not need to plug anything into the **Data** port. Most users will get their NMEA position data over Bluetooth. However, this port can be useful for sending position data to an embedded microcontroller or single-board computer. The pinout is 3.3V / TX / RX / GND. **3.3V** is provided by this connector to power a remote device if needed. While the port is capable of sourcing up to 600mA, we do not recommend more than 300mA. This port should not be connected to a power source.

Wheel Ticks

On the RTK Express Plus only. This dropdown is made available if users wish to connect wheel ticks and a direction encoder as inputs to the ZED-F9R. This aids the Sensor Fusion engine for IMU based location fixes when installed in an automobile. Signals must be limited to 3.3V.

Pulse Per Second

Configuring the External Pulse and External Events over WiFi

```
VT COM4 - Tera Term VT
File Edit Setup Control Window Help
1> Configure GNSS Receiver
2> Configure GNSS Messages
3> Configure Base
4> Configure Ports
5> Configure Logging
6> Display microSD contents
b> Bubble Level
d> Configure Debug
r> Reset all settings to default
f> Firmware upgrade
x> Exit

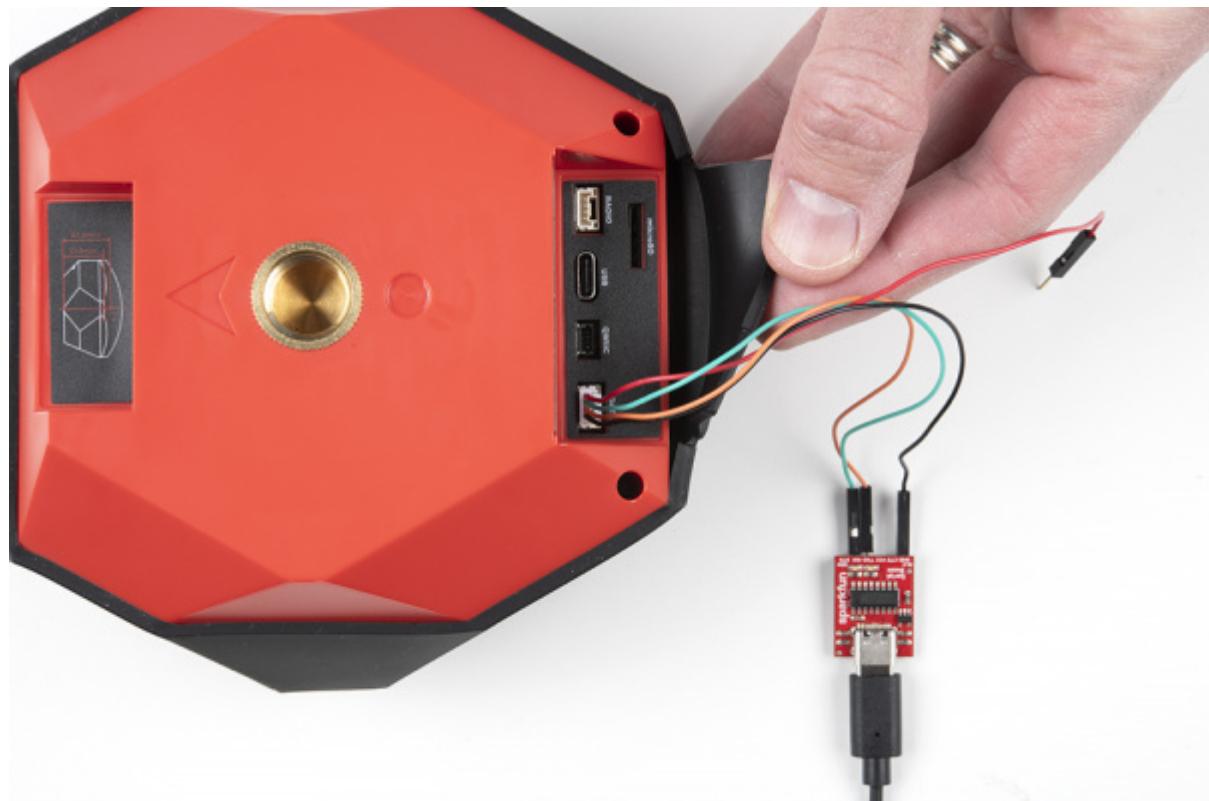
Menu: Port Menu
1> Set Radio port serial baud rate: 57600 bps
2> Set Data port connections: NMEA TX Out/RX In
3> Set Data port serial baud rate: 460800 bps
x> Exit

Enter the pin connection to use <1 to 4> for Data Port:
1> NMEA TX Out/RX In
2> PPS OUT/Event Trigger In
3> I2C SDA/SCL
4> ESP32 DAC Out/ADC In
```

Port menu showing mux data port connections

When PPS/Event Trigger is selected, the Pulse-Per-Second output from the ZED-F9x is sent out of the TX pin of the DATA port. Once the RTK device has GNSS reception, this can be used as a *very* accurate time base.

The time between pulses can be configured down to 100ns (10MHz) with an accuracy of 30ns RMS and 60ns 99%. The pulse width and polarity are also configurable.



For PPS, only the Black and Green wires are needed. If you need to provide 3.3V to your system, the red wire can supply up to 600mA but we do not recommend sourcing more than 300mA.

- **Red** - 3.3V
- **Green** - TX (output from the RTK device)
- **Orange** - RX (input into the RTK device)
- **Black** - GND

Similarly, the RX pin of the DATA port can be used for event logging. See [External Event Logging](#) for more information.

External Event Logging

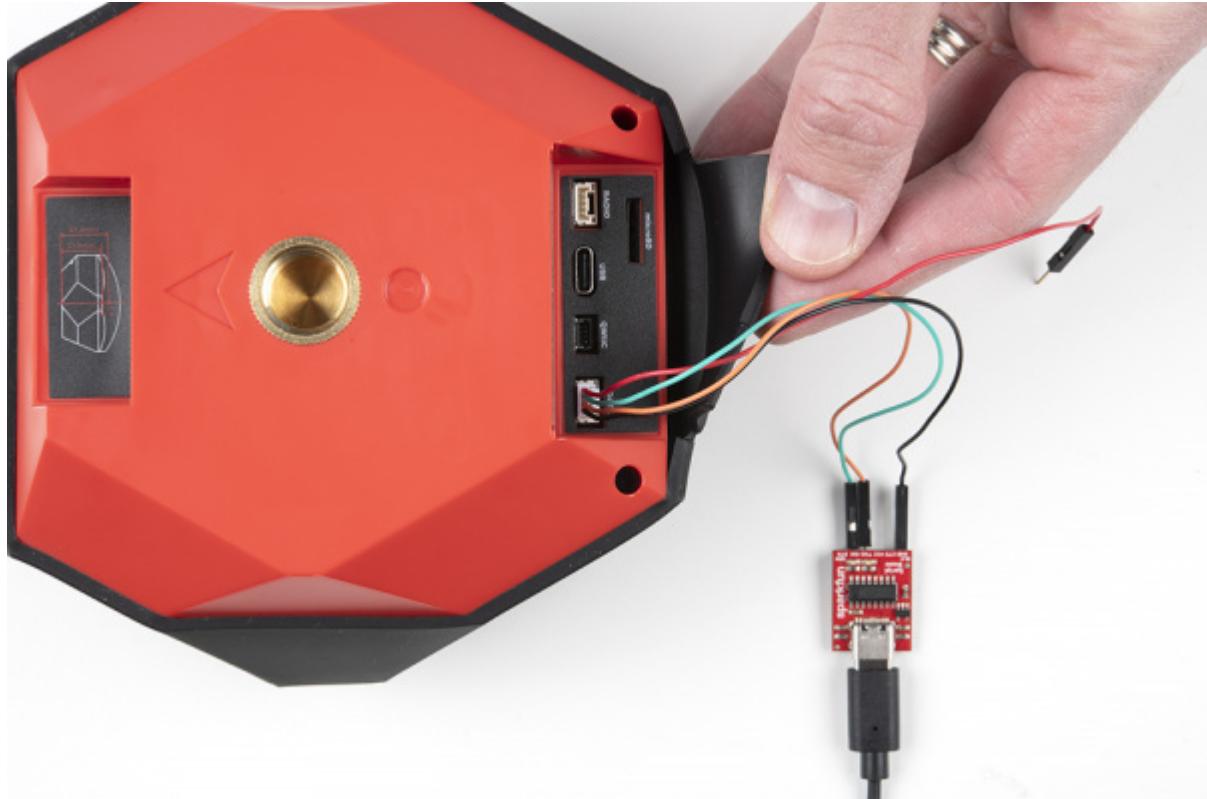


Three RTK Expresses wired with external microphones

The external triggering system is a powerful feature enabling a variety of scientific applications. Above is three RTK Expresses wired with external microphones used in a 'popped balloon' audio triangulation experiment.

The ZED-F9P has the ability to mark a detected event with *+/-30 nanosecond accuracy*. When enabled, an event on the RX pin (a low-to-high or high-to-low transition) on the DATA port, will trigger a message in the log with a very accurate timestamp.

- **Red** - 3.3V
- **Green** - TX (output from the RTK device)
- **Orange** - RX (input into the RTK device)
- **Black** - GND



For event logging, only the Black and Orange wires are needed. If you need to provide 3.3V to your system, the red wire can supply up to 600mA but we do not recommend sourcing more than 300mA.

Ports Configuration ▾

Radio Port Baud Rate:	57600	<input type="button" value="i"/>
Mux Channel:	PPS/Event Trigger	<input type="button" value="i"/>
<input checked="" type="checkbox"/> Enable External Pulse <input type="button" value="i"/>		
Time between pulses (μs):	600000	
Pulse length (μs):	200000	
Pulse Polarity:	Rising Edge	<input type="button" value="i"/>
<input checked="" type="checkbox"/> Enable External Event Logging <input type="button" value="i"/>		

Configuring the External Pulse and External Events over WiFi

Be sure to select 'Enable External Event Logging' through the ports menu.

Events within the log have the following format:

```
$GNTXT,numberOfSentences,sentenceNumber,CUSTOM_NMEA_TYPE_EVENT,triggerCount,towMsR,towSubMsR,accEst*CRC
```

For example:

```
$GNTXT,01,01,02,5,494326906,136292,31*74
```

Where

- \$GNTXT: Custom NMEA text message
- 01: numberOfSentences in this report
- 01: sentenceNumber
- 02: sentenceType - Externally triggered events are type 0x02
- 5: triggerCount
- 494326906: towMsR - Time Of Week of rising edge (ms)
- 136292: towSubMsR - Millisecond fraction of Time Of Week of rising edge (ns)
- 31: accEst - Accuracy estimate (ns)
- 74: NMEA CRC

The event timestamps can be analyzed to precisely coordinate or triangulate a past event. In the case of the three RTK Expresses with microphones, the three units' locations were known with RTK 14mm accuracy. The air temperature was taken to obtain the speed of sound. From these data points, we can solve for the location of a sound such as a popped balloon.

6.5.4 Surveyor Data Port

By default, the Data port is set to 460800bps and can be configured from 4800bps to 921600bps.

Note: The Data port does not output NMEA by default. The unit must be opened and the *Serial NMEA Connection* switch must be moved to 'Ext Connector'. See [Hardware Overview - Advanced Features](#) for the location of the switch.

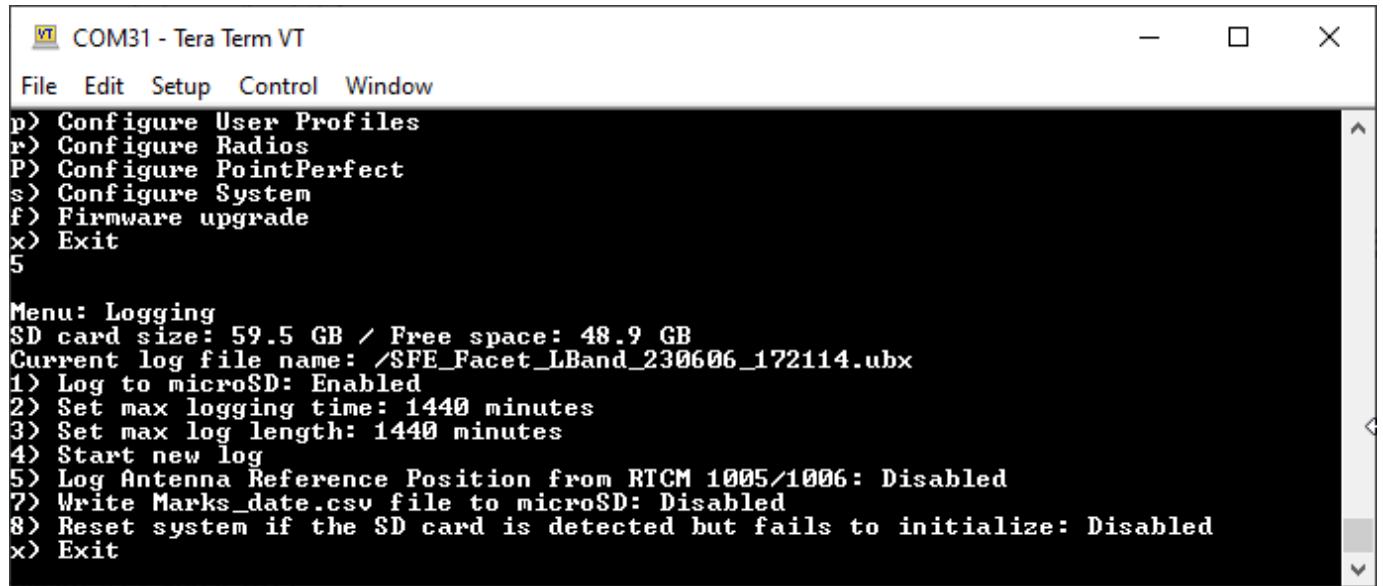
6.6 Data Logging Menu

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

6.6.1 WiFi Interface

Please see the System Menu [WiFi Interface](#).

6.6.2 Serial Interface



The screenshot shows a terminal window titled "COM31 - Tera Term VT". The menu structure is as follows:

- File Edit Setup Control Window
- p> Configure User Profiles
- r> Configure Radios
- P> Configure PointPerfect
- s> Configure System
- f> Firmware upgrade
- x> Exit

After selecting "Configure System" (option 5), the following sub-menu is displayed:

- SD card size: 59.5 GB / Free space: 48.9 GB
- Current log file name: /SFE_Facet_LBand_230606_172114.ubx
- 1> Log to microSD: Enabled
- 2> Set max logging time: 1440 minutes
- 3> Set max log length: 1440 minutes
- 4> Start new log
- 5> Log Antenna Reference Position from RTCM 1005/1006: Disabled
- 7> Write Marks_date.csv file to microSD: Disabled
- 8> Reset system if the SD card is detected but fails to initialize: Disabled
- x> Exit

RTK Data Logging Configuration Menu

From the Main Menu, pressing 5 will enter the Logging Menu. This menu will report the status of the microSD card. While you can enable logging, you cannot begin logging until a microSD card is inserted. Any FAT16 or FAT32 formatted microSD card up

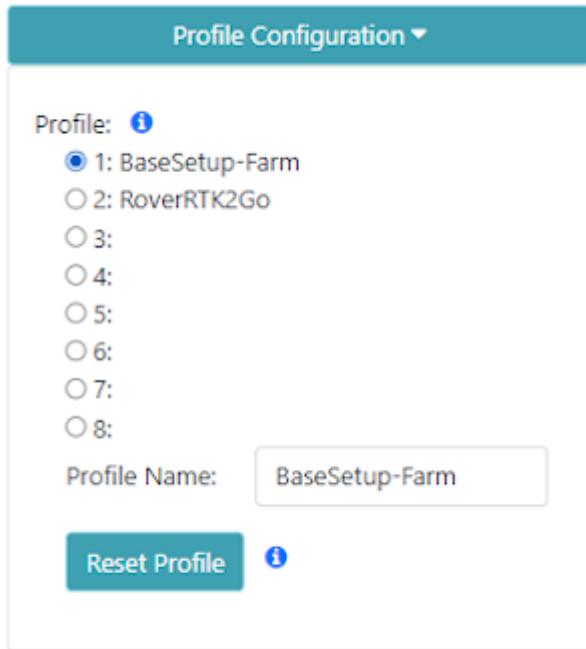
to 128GB will work. We regularly use the [SparkX brand 1GB cards](#) but note that these log files can get very large (>500MB) so plan accordingly.

- Option 1 will enable/disable logging. If logging is enabled, all messages from the ZED-F9P will be recorded to microSD. A log file is created at power on with the format *SFE [DeviceName] YYMMDD HHMMSS.txt* based on current GPS data/time. The [DeviceName] is Surveyor, Express, etc.
- Option 2 allows a user to set the max logging time. This is convenient to determine the location of a fixed antenna or a receiver on a repeatable landmark. Set the RTK Facet to log RAWX data for 10 hours, convert to RINEX, run through an observation processing station and you'll get the corrected position with <10mm accuracy. Please see the [How to Build a DIY GNSS Reference Station](#) tutorial for more information.
- Option 3 allows a user to set the max logging length in minutes. Every 'max long length' amount of time the current log will be closed and a new log will be started. This is known as cyclic logging and is convenient on *very* long surveys (ie, months or years) to prevent logs from getting too unwieldy and helps limit the risk of log corruption. This will continue until the unit is powered down or the *max logging time* is reached.
- Option 4 will close the current log and start a new log.
- Option 5 will record the coordinates of the base antenna to a custom NMEA message within the log if the RTCM1005 or RTCM1006 message is received. This can be helpful when doing field work and the location of the base is needed; the log on the roving device will contain the location of the base preventing the user from needing to record the base location separately. The ARP is logged in a custom GNTXT,01,01,10 message as ECEF-X, ECEF-Y, ECEF-Z, Antenna Height. The Antenna Height will be zero if the data was extracted from RTCM1005.
- Option 7 will enable/disable creating a comma separated file (Marks_date.csv) that is written each time the mark state is selected with the setup button on the RTK Surveyor, RTK Express or RTK Express Plus, or the power button on the RTK Facet.
- Option 8 will enable/disable the resetting of the system if an SD card is detected but fails to initialize. This can be helpful to harden a system that may be deployed for long periods of time. Without intervention, if an SD card is detected but fails to respond, the system will reset in an attempt to re-mount the faulty SD card interface.

Note: If you are wanting to log RAWX sentences to create RINEX files useful for post-processing the position of the receiver please see the GNSS Configuration Menu. For more information on how to use a RAWX GNSS log to get a higher accuracy base location please see the [How to Build a DIY GNSS Reference Station](#) tutorial.

6.7 Profiles Menu

Surveyor: / Express: / Express Plus: / Facet: / Facet L-Band: / Reference Station:



Profiles Menu on the WiFi config page

```
VT COM20 - Tera Term VT
File Edit Setup Control Window Help
2> Set measurement rate in seconds between measurements: 0.25
3> Set dynamic model: Portable
4> Set Constellations
5> Toggle NTRIP Client: Disabled
x> Exit

SparkFun RTK Express Plus v1.11-Apr 12 2022
** Bluetooth broadcasting as: Express Plus Rover-DABE **
Menu: Main Menu
1> Configure GNSS Receiver
2> Configure GNSS Messages
3> Configure Sensor Fusion
4> Configure Ports
5> Configure Logging
p> Configure Profiles
s> System Status
x> Exit

Menu: User Profiles Menu
Current profile: 1-Profile1
1> Change profile
2> Edit profile name: Profile1
x> Exit
```

User Profiles Menu

Profiles are a very powerful feature. A profile is a complete copy of all the settings on the RTK product. Switching profiles changes all the settings in one step. This is handy for creating a complex setup for surveying, and a different setup for an NTRIP-enabled base station. Rather than changing the variety of parameters, a user can simply switch profiles.



Multiple Profiles on Menu

If more than one profile is defined, the profiles will be displayed and selectable by using the **Power/Setup** on the Facet or **Setup** on the Express and Express Plus. Profiles can be named up to 50 characters; only the first 7 characters will be shown on the menu.

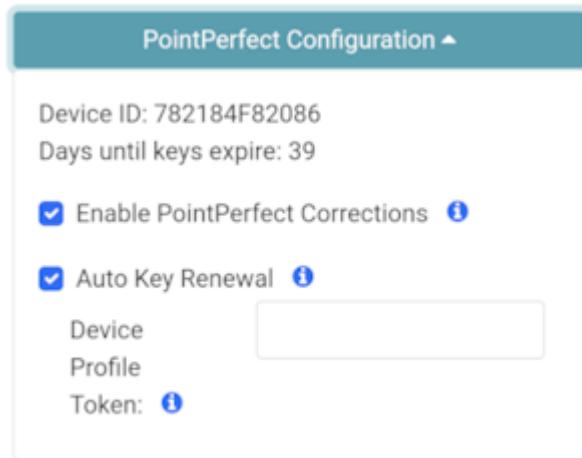
6.7.1 Surveyor Profiles

Because the Surveyor does not have a display, profiles are not available. The Base/Rover switch allows simple pre-set configurations to be toggled.

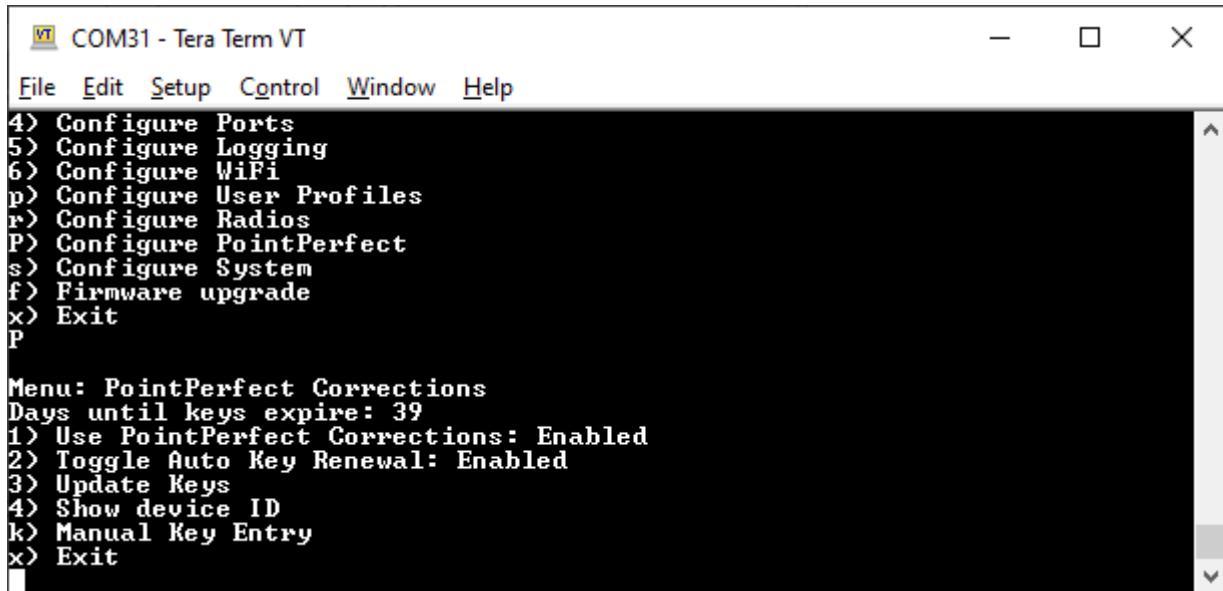
6.8 PointPerfect Menu

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

Note: This section only applies to RTK Facet *L-Band* products. Regular RTK Facet, Surveyor, Express, and Express Plus products do not have L-Band antennas or receivers built-in.



Configuring PointPerfect settings over WiFi



Configuring PointPerfect settings over serial

RTK Facet *L-Band* products are equipped with a special antenna and extra receiver to decrypt the L-Band corrections using the PointPerfect service from u-blox. The PointPerfect sub-menu allows a user to enter their 'Home' WiFi settings. This WiFi SSID and password are used to regularly obtain the needed decryption keys from u-blox. This is normally your home WiFi or other accessible WiFi.

PointPerfect L-Band decryption keys are valid for a maximum of 56 days. During that time, the RTK Facet L-Band can operate normally without the need for WiFi access. However, when the keys are set to expire in 28 days or less, the RTK Facet L-Band will attempt to log in to WiFi at each power on. If WiFi is not available, it will continue normal operation. If the keys fully expire, the device will continue to receive the L-Band signal but will be unable to decrypt the signal, disabling high-precision GNSS. The RTK Facet L-Band will continue to have extraordinary accuracy (we've seen better than 0.15m HPA) but not the centimeter-level accuracy that comes with RTK.

Note: The RTK Facet L-Band is capable of receiving RTCM corrections over traditional means including NTRIP data over Bluetooth or a serial radio. But the real point of L-Band and PointPerfect is that you can be *anywhere*, without cellular or radio cover, and still enjoy millimeter accuracy.



Display showing 14 days until keys expire

The unit will display various messages to aid the user in obtaining keys as needed.



Three pronged satellite dish indicating L-Band reception

Upon successful reception and decryption of PointPerfect corrections, the satellite dish icon will increase to a three-pronged icon. As the unit's fix increases the cross-hair will indicate a basic 3D solution, a double blinking cross-hair will indicate a floating RTK solution, and a solid double cross-hair will indicate a fixed RTK solution.

```
COM31 - Tera Term VT
File Edit Setup Control Window Help
4> Configure Ports
5> Configure Logging
6> Configure WiFi
p> Configure User Profiles
r> Configure Radios
P> Configure PointPerfect
s> Configure System
f> Firmware upgrade
x> Exit
P

Menu: PointPerfect Corrections
Days until keys expire: 39
1> Use PointPerfect Corrections: Enabled
2> Toggle Auto Key Renewal: Enabled
3> Update Keys
4> Show device ID
k> Manual Key Entry
x> Exit
```

PointPerfect Menu

The *Days until keys expire* inform the user how many days the unit has until it needs to connect to WiFi to obtain new keys.

- Option '1' disables the use of PointPerfect corrections.
- Option '2' disables the automatic attempts at WiFi connections when key expiry is less than 28 days.
- Option '3' will trigger an immediate attempt to connect over WiFi and update the keys.
- Option '4' will display the Device ID. This is needed when a SparkFun RTK Facet L-Band product needs to be added to the PointPerfect system. This is normally taken care of when you purchase the L-Band unit with PointPerfect service added, but for customers who wish to extend their subscription beyond the initial year, or did not purchase the service and want to add it at a later date, this Device ID is what customer service needs.
- Option 'k' will bring up the Manual Key Entry menu.

```

COM10 - Tera Term VT
File Edit Setup Control Window Help
5> Configure Logging
p> Configure Profiles
l> Configure LBand
s> System Status
x> Exit

Menu: PointPerfect Corrections
Device ID: 3945000CDFC
Days until keys expire: 49
1> Use LBand Corrections: Enabled
2> Set Home WiFi SSID: TReX
3> Set Home WiFi PW: parachutes
4> Toggle Auto Key Renewal: Enabled
5> Update Keys
k> Manual Key Entry
x> Exit

Menu: PointPerfect Keys
1> Set ThingStream Device Profile Token: Use SparkFun Token
2> Set Current Key: 74EDD9DB20CCDFC6833358EACDC7BD6F
3> Set Current Key Expiration Date <DD/MM/YYYY>: 03/06/2022
4> Set Next Key: ACCDFC689578CCDFC6860017BADD9DB2
5> Set Next Key Expiration Date <DD/MM/YYYY>: 01/07/2022
x> Exit

```

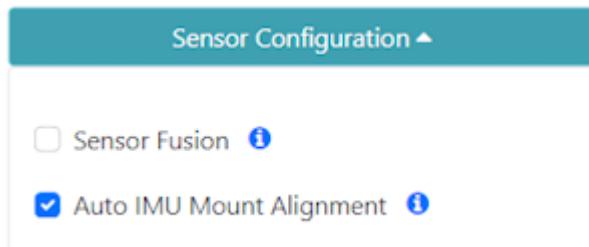
Manual Key Entry Menu

Because of the length and complexity of the keys, we do not recommend you manually enter them. This menu is most helpful for displaying the current keys.

Option '1' will allow a user to enter their Device Profile Token. This is the token that is used to provision a device on a PointPerfect account. By default, users may use the SparkFun token but must pay SparkFun for the annual service fee. If an organization would like to administer its own devices, the token can be changed here.

6.9 Sensor Menu

Surveyor: / Express: / Express Plus: / Facet: / Facet L-Band: / Reference Station:



```

VT COM10 - Tera Term VT
File Edit Setup Control Window Help
Log file size: 342 - Generation rate: 0.1kB/s

SparkFun RTK Express Plus v3.0-Jan 19 2023
** Bluetooth broadcasting as: Express Plus Rover-DABE **
Menu: Main
1> Configure GNSS Receiver
2> Configure GNSS Messages
3> Configure Sensor Fusion
4> Configure Ports
5> Configure Logging
6> Configure WiFi
p> Configure User Profiles
r> Configure Radios
s> Configure System
f> Firmware upgrade
x> Exit
3

Menu: Sensor Fusion
Fusion Mode: 3 - Disabled
1> Toggle Sensor Fusion: Disabled
2> Toggle Automatic IMU-mount Alignment: Enabled
x> Exit

```

Setting the Sensor options over WiFi config and serial connections

The [RTK Express Plus](#) utilizes the ZED-F9R GNSS receiver with built-in IMU. This allows the RTK device to continue to output high-precision location information even if GNSS reception goes down or becomes unavailable. This was designed for and is especially helpful in automotive environments, such as tunnels or parking garages, where GNSS reception can be sparse.

Enable 'Sensor Fusion' to begin using the onboard IMU when GNSS is available. Sensor Fusion will only aid position information when used with an automobile and may lead to degraded position fixes when used in other situations (ie, surveying, pedestrian, etc.).

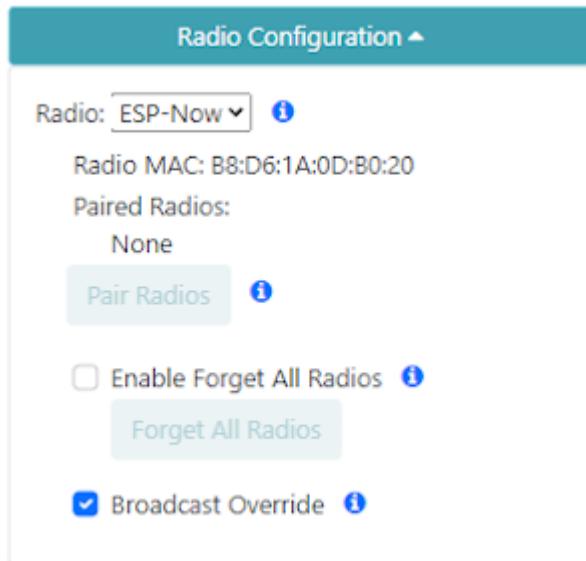
'Automatic IMU-Mount Alignment' will allow the device to automatically determine how the product is mounted within the vehicle's frame of reference.

Additionally, wheel ticks should be provided to the unit to enhance the positional fixes. Please see [Mux Channel](#) of the Ports Menu for more information.

6.10 Radios Menu

6.10.1 ESP-Now

Surveyor: / Express: / Express Plus: / Facet: / Facet L-Band: / Reference Station:



Radio configuration through WiFi

```

COM21 - Tera Term VT
File Edit Setup Control Window Help
Rover Accuracy (m): 0.2391
Batt (66%): Voltage: 3.98V Charging: 11.86%/hr Green

SparkFun RTK Surveyor v2.4-Aug 18 2022
** Bluetooth broadcasting as: Surveyor Base-887E **
Menu: Main Menu
1> Configure GNSS Receiver
2> Configure GNSS Messages
3> Configure Base
4> Configure Ports
5> Configure Logging
p> Configure Profiles
r> Configure Radios
s> System Status
x> Exit

Menu: Radio Menu
1> Select Radio Type: Internal ESP NOW
    Radio MAC: FC:F5:C4:2C:88:7C
    No Paired Radios
2> Pair radios
3> Forget all radios
x> Exit

```

Radio menu showing ESP-Now

Pressing 'r' from the main menu will open the Configure Radios menu. This allows a user to enable or disable the use of the internal ESP-Now radio.

ESP-Now is a 2.4GHz protocol that is built into the internal ESP32 microcontroller; the same microcontroller that provides Bluetooth and WiFi. ESP-Now does not require WiFi or an Access Point. This is most useful for connecting a Base to Rover

without the need for an external radio. Simply turn two SparkFun RTK products on, enable their radios, pair them, and data will be passed between units.

Additionally, ESP-Now supports point-to-multipoint transmissions. This means a Base can transmit to multiple Rovers simultaneously.

The ESP-Now radio feature was added in firmware release v2.4. If the **Configure Radio** menu is not visible, consider upgrading your firmware.

ESP-Now is a free radio included in every RTK product, and works well, but it has a few limitations:

1. Limited use with Bluetooth SPP. The ESP32 is capable of [simultaneously transmitting](#) ESP-Now and Bluetooth LE, but not classic Bluetooth SPP. Unfortunately SPP (Serial Port Profile) is the most common method for moving data between a GNSS receiver and the GIS software. Because of this, using ESP-Now while connecting to the RTK product using Bluetooth SPP is not stable. SparkFun RTK products support Bluetooth LE and ESP-Now works flawlessly with Bluetooth LE. There are a few GIS applications that support Bluetooth LE including SW Maps.

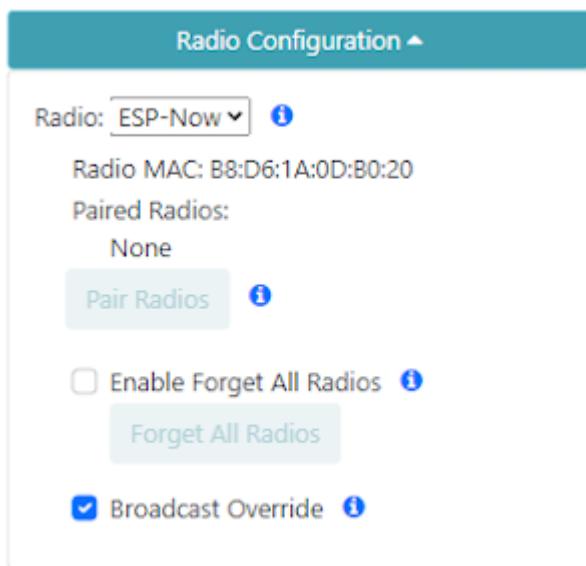


2. Limited range. You can expect two RTK devices to be able to communicate approximately 250m (845 ft) line of sight but any trees, buildings, or objects between the Base and Rover will degrade reception. This range is useful for many applications but may not be acceptable for some applications. We recommend using ESP-Now as a quick, free, and easy way to get started with Base/Rover setups. If your application needs longer RF distances consider cellular NTRIP, WiFi NTRIP, or an external serial telemetry radio plugged into the **RADIO** port.
3. Bug limited to Point to Point. There is a known bug in the ESP32 Arduino core that prevents a base from [transmitting to multiple rovers](#). This will be fixed in future releases of the RTK firmware once the ESP32 core is updated. For now, a base can be paired successfully with a single rover.

6.10.2 Pairing

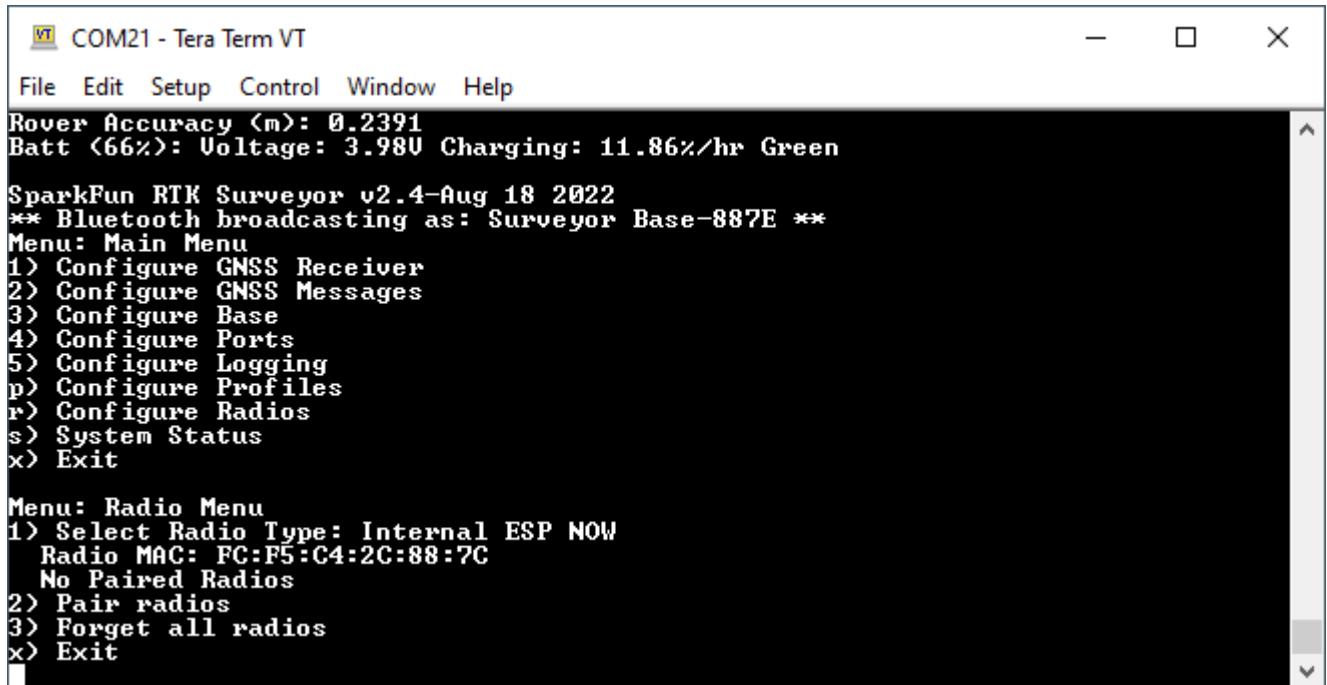


Pressing the Setup button (Express or Express Plus) or the Power/Setup button (Facet or Facet L-Band) will display the various submenus. Pausing on E-Pair will put the unit into ESP-Now pairing mode. If another RTK device is detected nearby in pairing mode, they will exchange MAC addresses and pair with each other. Multiple Rover units can be paired to a Base in the same fashion.



Radio configuration through WiFi

The radio system can be configured over WiFi. The radios subsystem is disabled by default. Enabling the radio to ESP-Now will expose the above options. The unit's radio MAC can be seen as well as a button to forget all paired radios. This button is disabled until the 'Enable Forget All Radios' checkbox is checked. The 'Broadcast Override' function changes all data transmitted by this radio to be sent to all radios in the vicinity, instead of only the radios it is paired with. This override feature is helpful if using a base that has not been paired: a base can transmit to multiple rovers regardless if they are paired or not.



VT COM21 - Tera Term VT

File Edit Setup Control Window Help

```
Rover Accuracy <m>: 0.2391
Batt <66%>: Voltage: 3.98V Charging: 11.86%/hr Green

SparkFun RTK Surveyor v2.4-Aug 18 2022
** Bluetooth broadcasting as: Surveyor Base-887E **
Menu: Main Menu
1> Configure GNSS Receiver
2> Configure GNSS Messages
3> Configure Base
4> Configure Ports
5> Configure Logging
p> Configure Profiles
r> Configure Radios
s> System Status
x> Exit

Menu: Radio Menu
1> Select Radio Type: Internal ESP NOW
  Radio MAC: FC:F5:C4:2C:88:7C
  No Paired Radios
2> Pair radios
3> Forget all radios
x> Exit
```

A serial menu is also available. This menu allows users to enter pairing mode, view the unit's current Radio MAC, the MAC addresses of any paired radios, as well as the ability to remove all paired radios from memory.

6.10.3 Reference Station

There is not enough RAM available on the Reference Station to run ESP-Now and Bluetooth simultaneously. ESP-Now does work on the Reference Station but you need to disable Bluetooth in order to use it.

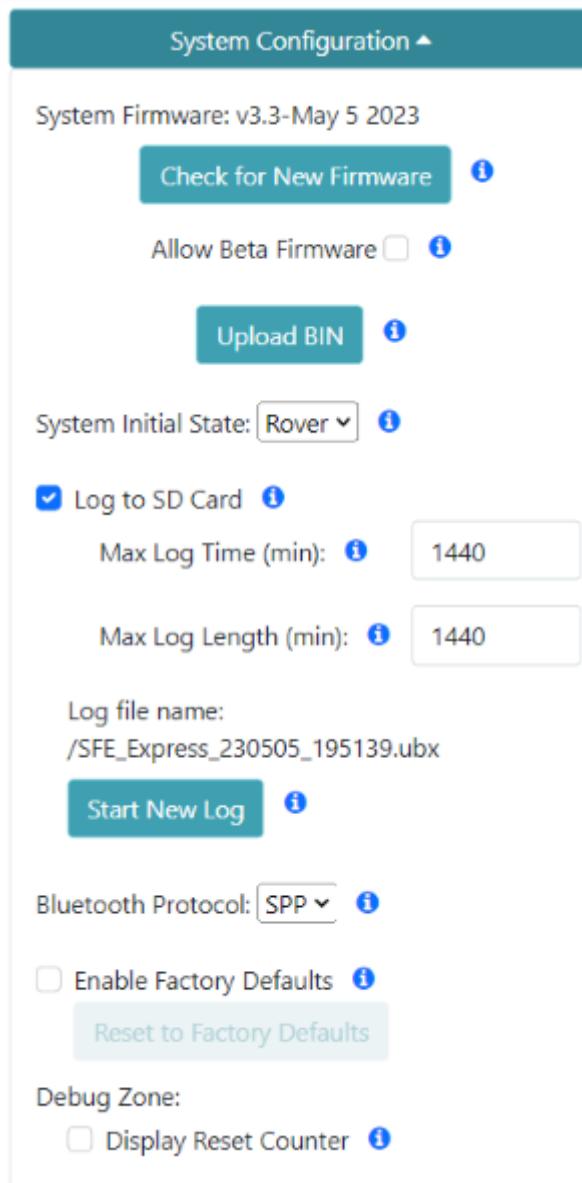
- Disable Bluetooth via the System Menu. Select "b" twice to: first select BLE mode; and then to disable Bluetooth completely
- Restart the system using the System Menu Debug Menu: enter "s" followed by "d" followed by "r" to restart the Reference Station. This ensures the RAM used by Bluetooth is released
- Select the E-Pair option by pressing the MODE button until "E-Pair" is displayed
- Pair the Reference Station Base with an RTK Rover and the Rover will achieve RTK-Fix

6.11 System Menu

Surveyor: / Express: / Express Plus: / Facet: / Facet L-Band: / Reference Station:

6.11.1 WiFi Interface

Because of the nature of these controls, the AP config page is different than the terminal menu.



System Config Menu on WiFi Config Page

Check for New Firmware

This feature allows over-the-air updates of the RTK device's firmware. Please see [Updating RTK Firmware](#) for more information.

System Initial State

At power on, the device will enter either Rover or Base state.

Log to SD

If a microSD card is detected, all messages will be logged.

Max Log Time

Once the max log time is achieved, logging will cease. This is useful for limiting long-term, overnight, static surveys to a certain length of time. Default: 1440 minutes (24 hours). Limit: 1 to 2880 minutes.

Max Log Length

Every 'max long length' amount of time the current log will be closed and a new log will be started. This is known as cyclic logging and is convenient on *very* long surveys (ie, months or years) to prevent logs from getting too unwieldy and helps limit the risk of log corruption. This will continue until the unit is powered down or the *max logging time* is reached.

Start New Log

Pressing the 'Start New Log' button will close the current log. A new log will be opened immediately and the file name will be shown. This can be helpful in the field when a certain set of coordinates or feature marks need to be recorded in close proximity to one another. By dividing up the logs, the work can be more easily identified.

Bluetooth Protocol

By default, the RTK products use Bluetooth v2.0 SPP (Serial Port Profile) to connect to data collectors. Nearly all data collectors support this protocol. The RTK product line also supports BLE (Bluetooth Low Energy). The BLE protocol has a variety of improvements but very few data collectors support it.

Note: Bluetooth SPP cannot operate concurrently with ESP-Now radio transmissions. Therefore, if you plan to use the ESP-Now radio system to connect RTK products, the BLE protocol must be used to communicate over Bluetooth to data collectors. Alternatively, ESP-Now works concurrently with WiFi so connecting to a data collector over WiFi can be used.

Enable Factory Defaults

See [Factory Reset](#).

SD Card

Various stats for the SD card are shown.

Update Firmware

New firmware may be uploaded via WiFi to the unit. See [Updating Firmware from WiFi](#) for more information.

Reset Counter

A counter is displayed indicating the number of non-power-on-resets since the last power-on.

6.11.2 Serial Interface

```

VT COM10 - Tera Term VT
File Edit Setup Control Window Help
s
Menu: System
GNSS: Online - ZED-F9P firmware: HPG 1.13
SIU: 32, HPA (m): 0.238, Lat: 40.09032438, Lon: -105.18477424, Altitude (m): 1561.4
Display: Online
Accelerometer: Online
Fuel Gauge: Online - Batt <37%> / Voltage: 3.79V
microSD: Online
Bluetooth <9CEE>: Online
WiFi MAC Address: 40:F5:20:57:9C:EC
System Uptime: 0 01:39:54.035 (Resets: 0)
f> Display microSD Files
e> Echo User Input: On
d> Configure Debug
z> Set time zone offset: 00:00:00
b> Set Bluetooth Mode: Classic
r> Reset all settings to default
B> Switch to Base mode
R> Switch to Rover mode
W> Switch to WiFi Config mode
S> Shut down
x> Exit

```

Menu showing various attributes of the system

The System Status menu will show a large number of system parameters including a full system check to verify what is and what is not online. For example, if an SD card is detected it will be shown as online. Not all systems have all hardware. For example, the RTK Surveyor does not have an accelerometer so it will always be shown offline.

This menu is helpful when reporting technical issues or requesting support as it displays helpful information about the current ZED-F9x firmware version, and which parts of the unit are online.

- **z** - A local timezone in hours, minutes and seconds may be set by pressing 'z'. The timezone values change the RTC clock setting and the file system's timestamps for new files.
- **d** - Enters the [debug menu](#) that is for advanced users.
- **f** - Show any files on the microSD card (if present).
- **b** - Change the Bluetooth protocol. By default, Serial Port Profile (SPP) for Bluetooth v2.0 is used. This can be changed to BLE if desired at which time serial is sent over BLESerial. Additionally, Bluetooth can be turned off. This state is normally used for debugging.
- **r** - Reset all settings to default including a factory reset of the ZED-F9x receiver. This can be helpful if the unit has been configured into an unknown or problematic state.
- **B, R, W, or S** - Change the mode the device is in without needing to press the external SETUP or POWER buttons.

System Configuration ▾

System Firmware: v3.3-May 5 2023

Check for New Firmware 

Allow Beta Firmware 

Upload BIN 

System Initial State: **Rover** 

Log to SD Card 

Max Log Time (min):  1440

Max Log Length (min):  1440

Log file name:
/SFE_Express_230505_195139.ubx

Start New Log 

Bluetooth Protocol: **SPP** 

Enable Factory Defaults 

Reset to Factory Defaults

Debug Zone:

Display Reset Counter 

System Config over WiFi Config

The WiFi Config page also allows various aspects of the system to be configured but it is limited by design.

6.11.3 Factory Reset

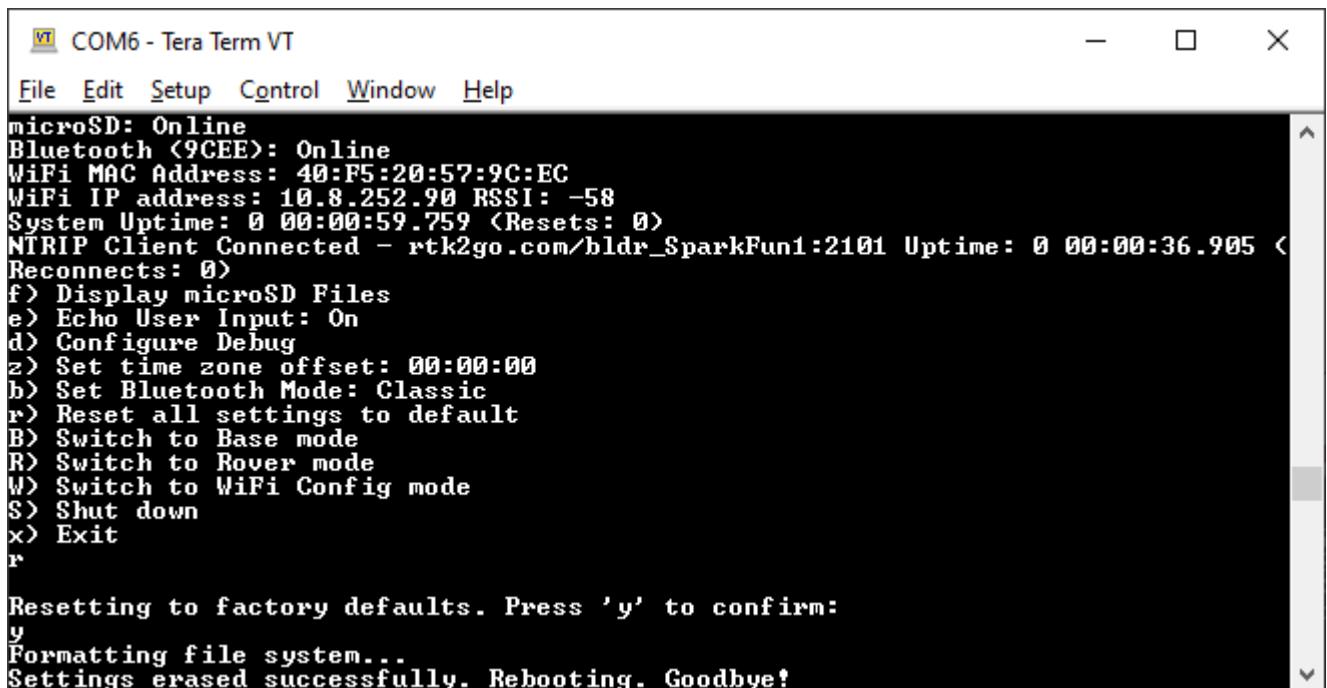
If a device gets into an unknown state it can be returned to default settings using the WiFi or Serial interfaces.

Enable Factory Defaults 

Reset to Factory Defaults

Enabling and Starting a Factory Reset

Factory Defaults will erase any user settings and reset the internal receiver to stock settings. To prevent accidental reset the checkbox must first be checked before the button is pressed. Any logs on SD are maintained. Any settings file and commonly used coordinate files on the SD card associated with the current profile will be removed.



VT COM6 - Tera Term VT

File Edit Setup Control Window Help

```
microSD: Online
Bluetooth <9CEE>: Online
WiFi MAC Address: 40:F5:20:57:9C:EC
WiFi IP address: 10.8.252.90 RSSI: -58
System Uptime: 0 00:00:59.759 <Resets: 0>
NTRIP Client Connected - rtk2go.com/bldr_SparkFun1:2101 Uptime: 0 00:00:36.905 <Reconnects: 0>
f) Display microSD Files
e) Echo User Input: On
d) Configure Debug
z) Set time zone offset: 00:00:00
b) Set Bluetooth Mode: Classic
r) Reset all settings to default
B) Switch to Base mode
R) Switch to Rover mode
W) Switch to WiFi Config mode
S) Shut down
x) Exit
r

Resetting to factory defaults. Press 'y' to confirm:
y
Formatting file system...
Settings erased successfully. Rebooting. Goodbye!
```

Issuing and confirming a Factory Reset

If a device gets into an unknown state it can be returned to default settings. Press 'r' then 'y' to confirm. Factory Default will erase any user settings and reset the internal receiver to stock settings. Any settings file and commonly used coordinate files on the SD card associated with the current profile will be removed.

Note: Log files and any other files on the SD card are *not* removed or modified.

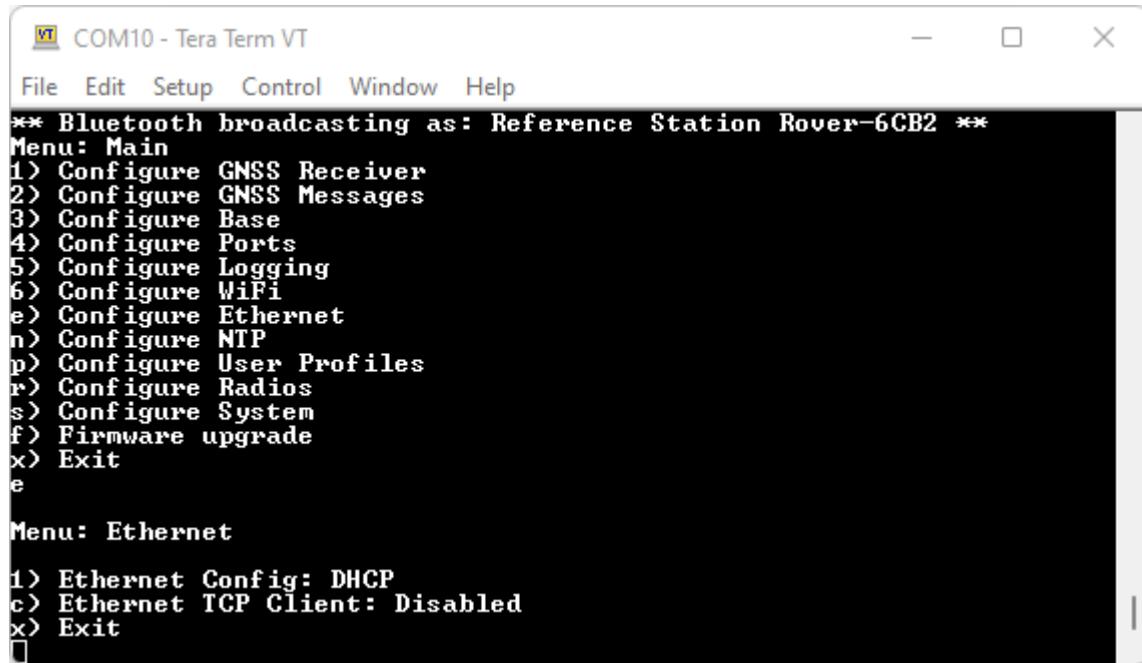
Note: A factory reset can also be accomplished by editing the settings files. See Force a [Factory Reset](#) for more information.

6.12 Ethernet Menu

Surveyor: / Express: / Express Plus: / Facet: / Facet L-Band: / Reference Station:

The Reference Station sends and receives NTRIP correction data via Ethernet. It can also send NMEA and RTCM navigation messages to an external TCP Server via Ethernet. It also has a dedicated Configure-Via-Ethernet (*Cfg Eth*) mode which is accessed via the MODE button and OLED display.

By default, the Reference Station will use DHCP to request an IP Address from the network Gateway. But you can optionally configure it with a fixed IP Address.



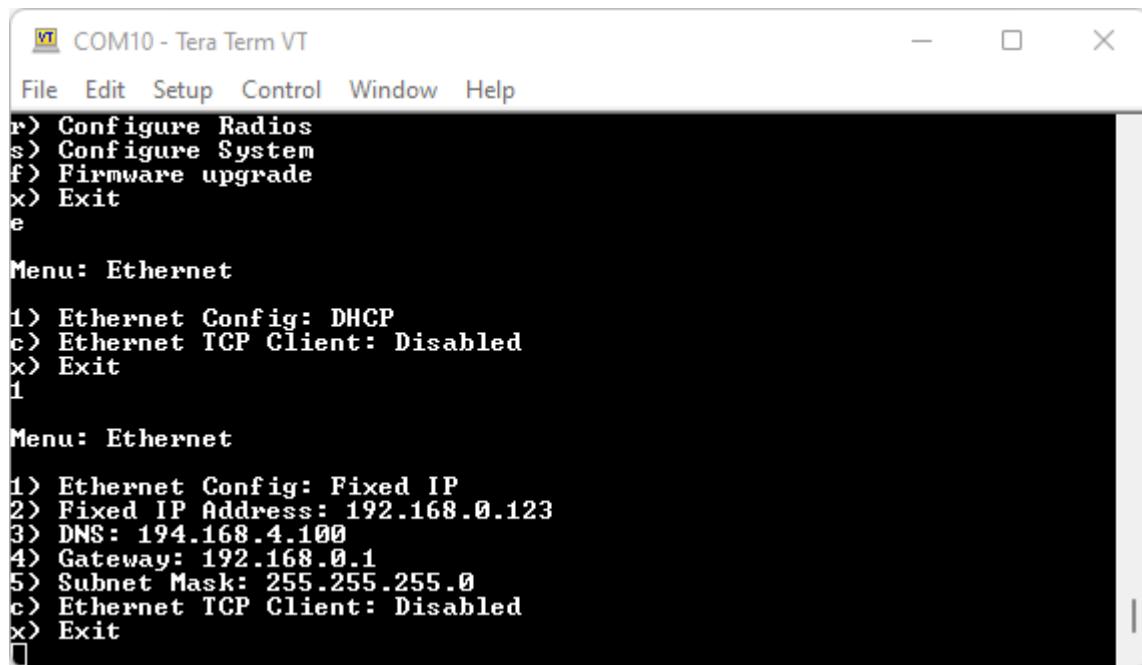
```

COM10 - Tera Term VT
File Edit Setup Control Window Help
** Bluetooth broadcasting as: Reference Station Rover-6CB2 **
Menu: Main
1> Configure GNSS Receiver
2> Configure GNSS Messages
3> Configure Base
4> Configure Ports
5> Configure Logging
6> Configure WiFi
e> Configure Ethernet
n> Configure NTP
p> Configure User Profiles
r> Configure Radios
s> Configure System
f> Firmware upgrade
x> Exit
e

Menu: Ethernet
1> Ethernet Config: DHCP
c> Ethernet TCP Client: Disabled
x> Exit

```

The Reference Station Ethernet menu - with DHCP selected



```

COM10 - Tera Term VT
File Edit Setup Control Window Help
r> Configure Radios
s> Configure System
f> Firmware upgrade
x> Exit
e

Menu: Ethernet
1> Ethernet Config: Fixed IP
2> Fixed IP Address: 192.168.0.123
3> DNS: 194.168.4.100
4> Gateway: 192.168.0.1
5> Subnet Mask: 255.255.255.0
c> Ethernet TCP Client: Disabled
x> Exit

```

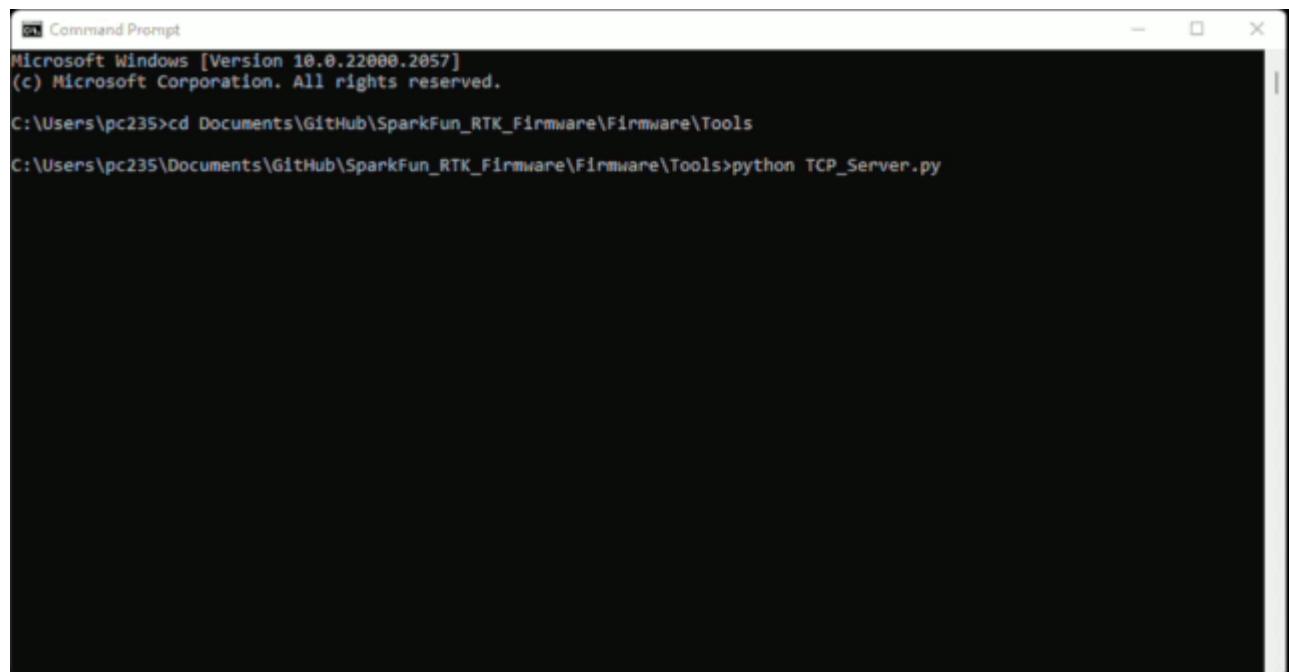
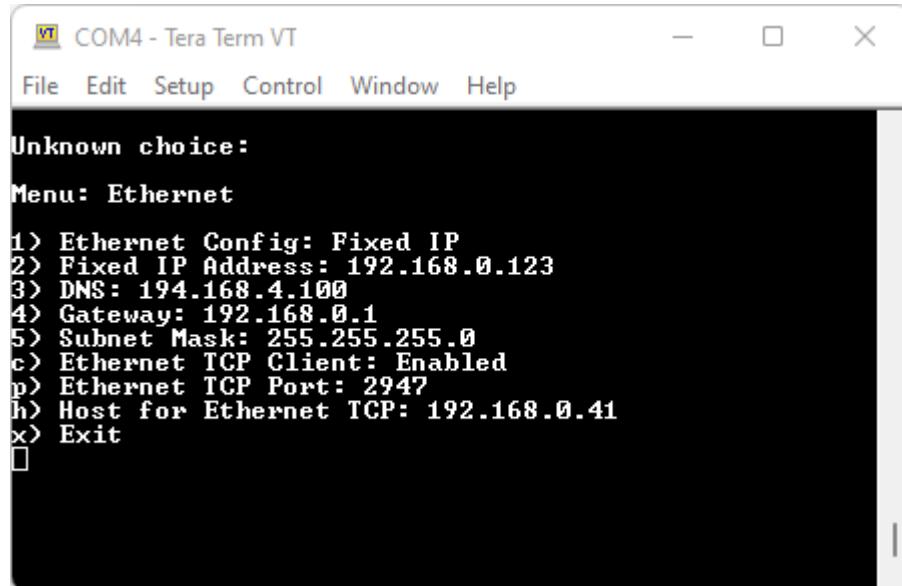
The Reference Station Ethernet menu - with a fixed IP address selected

Ethernet TCP Client

The Reference Station can act as an Ethernet TCP Client, sending NMEA and / or UBX data to a remote TCP Server.

This is similar to the WiFi TCP Client mode on our other RTK products, but the data can be sent to any server based on its IP Address or URL.

E.g. to connect to a local machine via its IP Address, select option "c" and then enter the IP Address using option "h"



The above animation was generated using [TCP_Server.py](#).

6.13 Network Time Protocol Menu

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

The Reference Station can act as an Ethernet Network Time Protocol (NTP) server.

Network Time Protocol has been around since 1985. It is a simple way for computers to synchronize their clocks with each other, allowing the network latency (delay) to be subtracted:

- A client sends a NTP request (packet) to the chosen or designated server
- The request contains the client's current clock time - for identification
- The server logs the time the client's request arrived and then sends a reply containing:
 - The client's clock time - for identification
 - The server's clock time - when the request arrived at the server
 - The server's clock time - when the reply is sent
 - The time the server's clock was last synchronized - providing the age of the synchronization
 - The client logs the time the reply is received - using its own clock

When the client receives the reply, it can deduce the total round-trip delay which is the sum of:

- How long the request took to reach the server
- How long the server took to construct the reply
- How long the reply took to reach the client

This exchange is repeated typically five times, before the client synchronizes its clock to the server's clock, subtracting the latency (delay) introduced by the network.

Having your own NTP server on your network allows tighter clock synchronization as the network latency is minimized.

The Reference Station can be placed into its dedicated NTP mode, by pressing the **MODE** button until NTP is highlighted in the display and pausing there.



Selecting NTP mode

The Reference Station will first synchronize its Real Time Clock (RTC) using the very accurate time provided by the u-blox GNSS module. The module's Time Pulse (Pulse-Per-Second) signal is connected to the ESP32 as an interrupt. The ESP32's RTC is synchronized to Universal Time Coordinate (UTC) on the rising edge of the TP signal using the time contained in the UBX-TIM-TP message.

The WIZnet W5500 interrupt signal is also connected to the ESP32, allowing the ESP32 to accurately log when each NTP request arrives.

The Reference Station will respond to each NTP request within a few 10s of milliseconds.

If desired, you can log all NTP requests to a file on the microSD card, and/or print them as diagnostic messages. The log and messages contain the NTP timing information and the IP Address and port of the Client.

```

Menu: System
[206020511(Wire.cpp:2041 begin()): Bus already started in Master Mode.
GNSS: Online - ZED-F9P firmware: HPG 1.32
S10: 22. HPA (m): 0.452, Lat: 54. , Lon: -1. , Altitude (m): 154.7
Display: Online
Fuel Gauge: Offline
microSD: Online
Bluetooth (<4DPA>: OFF
WiFi MAC Address: BB:B2:1C:9D:4D:P8
Ethernet cable: connected
Ethernet MAC Address: BB:B2:1C:9D:4D:P8
Ethernet IP Address: 192.168.0.123
Ethernet DNS: 194.168.4.100
Ethernet Gateway: 192.168.0.1
Ethernet Subnet Mask: 255.255.255.0
System Uptime: 0 05:43:22.095 <Resets: 0>
f) Display microSD Files
e) Echo User Input: On
d) Configure Debug
z) Set time zone offset: 00:00:00
b) Set Bluetooth Mode: Off
r) Reset all settings to default
B) Switch to Base mode
R) Switch to Rover mode
W) Switch to WiFi Config mode
S) Shut down
x) Exit
M

Menu: Debug
Filtered by parser: 0 NMEA / 0 RTCM / 0 UBX
1) u-blox I2C Debugging Output: Disabled
2) Heap Reporting: Enabled
3) Task Highwater Reporting: Disabled
4) Set SPI/SD Interface Frequency: 16 MHz
5) Set SPP RX Buffer Size: 2048
6) Set SPP TX Buffer Size: 512
8) Display Reset Counter: 0 - Disabled
9) GNSS Serial Timeout: 1
10) Periodically print WiFi IP Address: Enabled
11) Periodically print state: Enabled
12) Periodically print WiFi state: Enabled
13) Periodically print NTRIP client state: Enabled
14) Periodically print NTRIP server state: Enabled
15) Periodically print position: Disabled
16) Periodically print CPU idle time: Disabled
17) Mirror ZED-F9x's UART1 settings to USB
18) Print battery status messages: Disabled
19) Print Rover accuracy messages: Enabled
20) Print messages with bad checksums or CRCs: Disabled
21) Print log file messages: Disabled
22) Print log file status: Enabled
23) Print ring buffer offsets: Disabled
24) Print GNSS —> NTRIP caster messages: Disabled
25) Print NTRIP caster —> GNSS messages: Disabled
26) Print states: Enabled
27) Print duplicate states: Disabled
28) RTCM message checking: Disabled
29) Run Logging Test: Disabled
30) Run Bluetooth Test
31) Print TCP status: Enabled
32) ESP-Nuv Broadcast Override: Enabled
33) Print buffer overruns: Disabled
34) Set UART Receive Buffer Size: 2048
35) Set GNSS Handler Buffer Size: 4096
26) Print SD and UART buffer sizes: Disabled
37) Print RTC resyncs: Enabled
38) Print NTP Request diagnostics: Enabled
39) Print Ethernet diagnostics: Enabled
    Press 'q' to quit, 'x' to exit, 'esc' to cancel, 'ctrl-c' to interrupt
t) Enter Test Screen
e) Erase LittleFS
r) Force system reset
x) Exit

```

System Debug Menu - NTP Diagnostics (Click for a closer look)

```

COM14 - Tera Term VT
File Edit Setup Control Window Help

SparkFun RTK Reference Station v99.99-RC-May 18 2023
** Bluetooth broadcasting as: **

Menu: Main
1) Configure GNSS Receiver
2) Configure GNSS Messages
3) Configure Base
4) Configure Ports
5) Configure Logging
6) Configure WiFi
e) Configure Ethernet
n) Configure NTP
p) Configure User Profiles
r) Configure Radios
s) Configure System
f) Firmware upgrade
x) Exit
5

Menu: Logging
SD card size: 14.8 GB / Free space: 13.8 GB
Current log file name: /SFE_Reference_Station_230531_192128.ubx
1) Log to microSD: Enabled
2) Set max logging time: 1440 minutes
3) Set max log length: 1440 minutes
4) Start new log
5) Log Antenna Reference Position from RTCM 1005/1006: Enabled
6) Set ARP logging interval: 20 seconds
7) Write Marks_date.csv file to microSD: Disabled
8) Reset counter if the SD card is detected but fails to initialize: Disabled
9) Write NTP requests to microSD: Enabled
x) EXIT

```

Logging Menu - Log NTP Requests

Logged NTP Requests

```

COM14 - Tera Term VT
File Edit Setup Control Window Help

Reference Timestamp <Last Sync>: 3894543933.000000
Transmit Timestamp: 3894543954.130227
RTC resync took place at: 2023-05-31 17:46:33.000
NTP request from: Remote IP: 192.168.0.50 Remote Port: 123
Originate Timestamp <Client Transmit>: 3894544021.120645
Received Timestamp: 3894544021.121519
Reference Timestamp <Last Sync>: 3894543993.000000
Transmit Timestamp: 3894544021.142448
RTC resync took place at: 2023-05-31 17:47:33.000
NTP request from: Remote IP: 192.168.0.50 Remote Port: 123
Originate Timestamp <Client Transmit>: 3894544088.120594
Received Timestamp: 3894544088.121392
Reference Timestamp <Last Sync>: 3894544053.000000
Transmit Timestamp: 3894544088.131267
RTC resync took place at: 2023-05-31 17:48:33.000
NTP request from: Remote IP: 192.168.0.50 Remote Port: 123
Originate Timestamp <Client Transmit>: 3894544155.120642
Received Timestamp: 3894544155.121350
Reference Timestamp <Last Sync>: 3894544113.000000
Transmit Timestamp: 3894544155.131638
RTC resync took place at: 2023-05-31 17:49:33.000
NTP request from: Remote IP: 192.168.0.50 Remote Port: 123
Originate Timestamp <Client Transmit>: 3894544220.120631
Received Timestamp: 3894544220.121270
Reference Timestamp <Last Sync>: 3894544173.000000
Transmit Timestamp: 3894544220.129209
RTC resync took place at: 2023-05-31 17:50:33.000

```

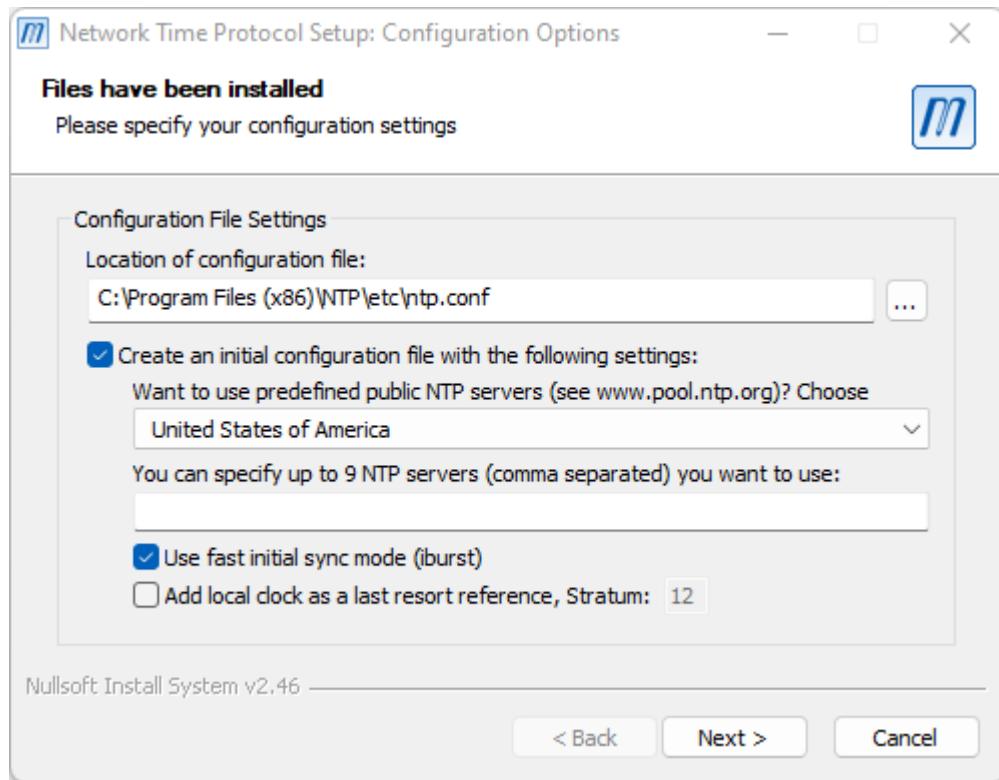
NTP uses its own epoch - midnight January 1st, 1900. This is different than the standard Unix epoch - midnight January 1st, 1970 - and the GPS epoch - midnight January 6th, 1980. The times shown in the log and diagnostic messages use the NTP epoch. You can use online calculators to convert between the different epochs:

- <https://weirdo.cloud/>
- <https://www.unixtimestamp.com/>
- <https://www.labsat.co.uk/index.php/en/gps-time-calculator>

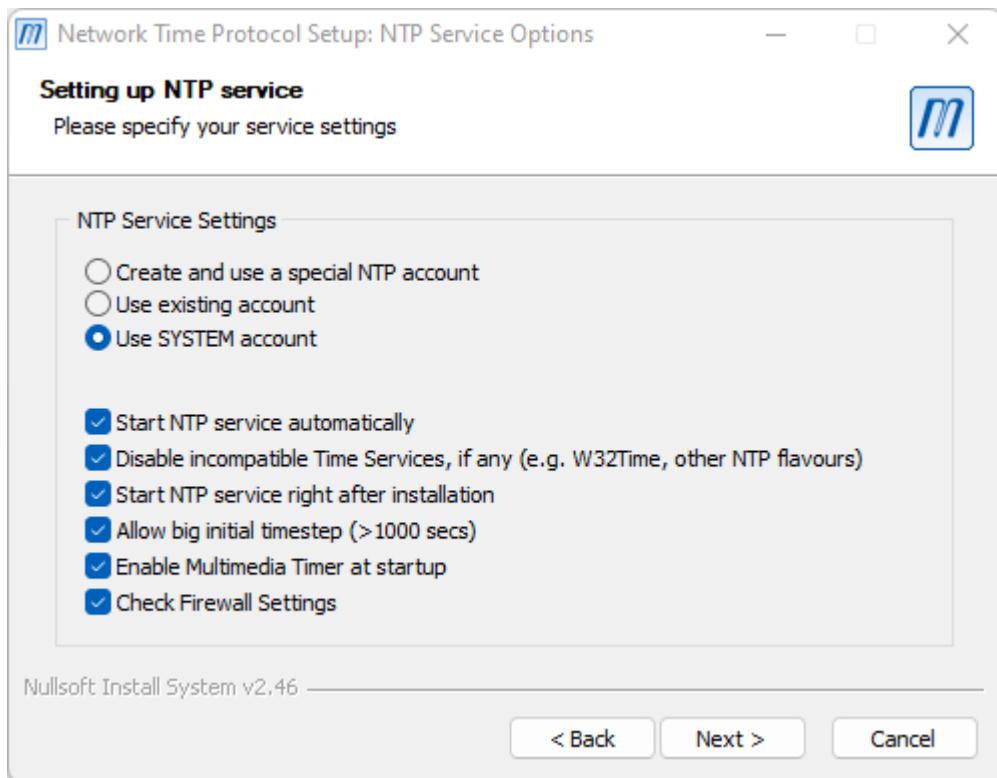
NTP on Windows

If you want to synchronize your Windows PC to a Reference Station NTP Server, here's how to do it:

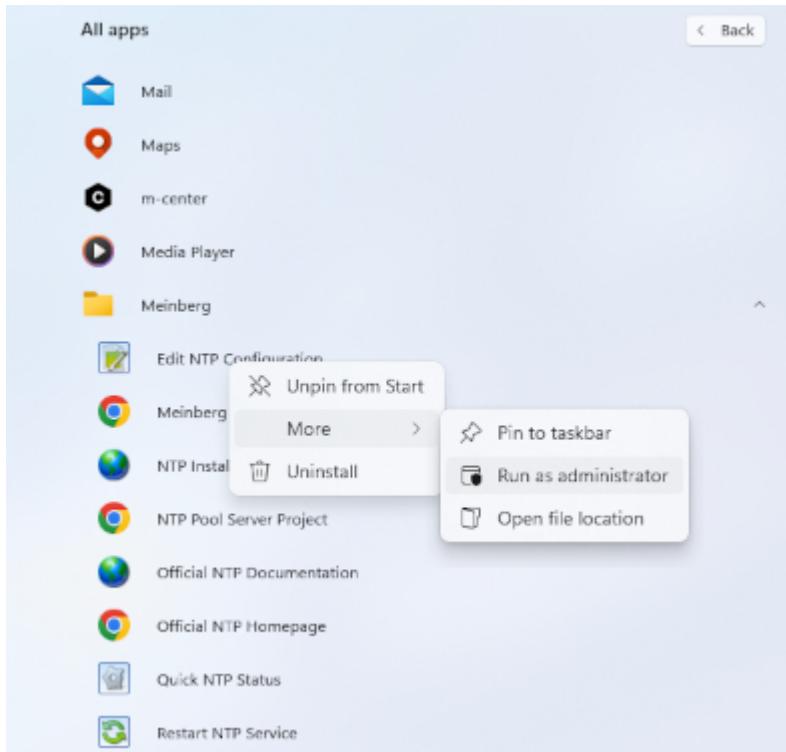
- Install [Meinberg NTP](#) - this replaces the Windows built-in Time Service



- During the installation, select "Create an initial configuration file" and select the NTP Pool server for your location
- Select "Use fast initial sync mode" for faster first synchronization



- The next step is to edit the NTP Configuration File
- Editing the file requires Administrator privileges
- Open the *Start* menu, navigate to *Meinberg*, right-click on *Edit NTP Configuration* and select *Run as administrator*



- Comment the lines in *ntp.conf* which name the pool.ntp servers
- Add an extra *server* line and include the IP Address for your Reference Station. It helps to give your Reference Station a fixed IP Address first - see [Menu Ethernet](#)
- Save the file

```

ntp.conf - Notepad

File Edit View

# NTP Network Time Protocol
# **** ATTENTION ****: You have to restart the NTP service when you change this file to activate the changes
# PLEASE CHECK THIS FILE CAREFULLY AND MODIFY IT IF REQUIRED
# Configuration File created by Windows Binary Distribution Installer Rev.: 1.27 mbg
# please check http://www.ntp.org for additional documentation and background information
# restrict access to avoid abuse of NTP for traffic amplification attacks
# see http://news.meinberg.de/244 for details
restrict default noquery nopeer nomodify notrap
restrict -6 default noquery nopeer nomodify notrap

# allow status queries and everything else from localhost
restrict 127.0.0.1
restrict -6 ::1

# If you need to allow access from a remote host, you can add lines like this:
# restrict <IP OF REMOTE HOST>

# Use drift file
driftfile "C:\Program Files (x86)\NTP\etc\ntp.drift"

# your local system clock, could be used as a backup
# (this is only useful if you need to distribute time no matter how good or bad it is)
#server 127.127.1.8
server 192.168.0.123 iburst
# But it should operate at a high stratum level to let the clients know and force them to
# use any other timesource they may have.
#fudge 127.127.1.8 stratum 12

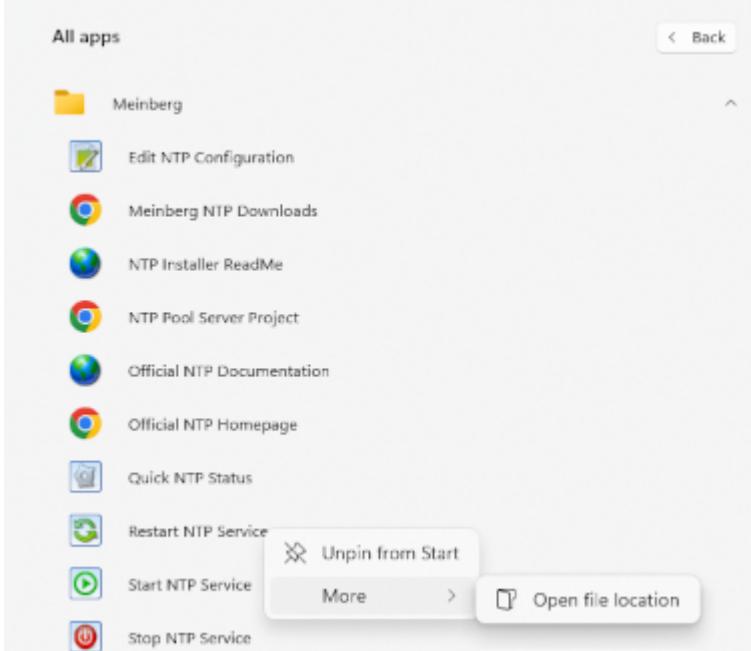
# Use a NTP server from the ntp pool project (see http://www.pool.ntp.org)
# Please note that you need at least four different servers to be at least protected against
# one falsicker. If you only rely on internet time, it is highly recommended to add
# additional servers here.
# The 'iburst' keyword speeds up initial synchronization, please check the documentation for more details!
#server 0.uk.pool.ntp.org iburst minpoll 6 maxpoll 7
#server 1.uk.pool.ntp.org iburst minpoll 6 maxpoll 7
#server 2.uk.pool.ntp.org iburst minpoll 6 maxpoll 7
#server 0.nl.pool.ntp.org iburst minpoll 6 maxpoll 7
#server 1.nl.pool.ntp.org iburst minpoll 6 maxpoll 7

# End of generated ntp.conf --- Please edit this to suite your needs

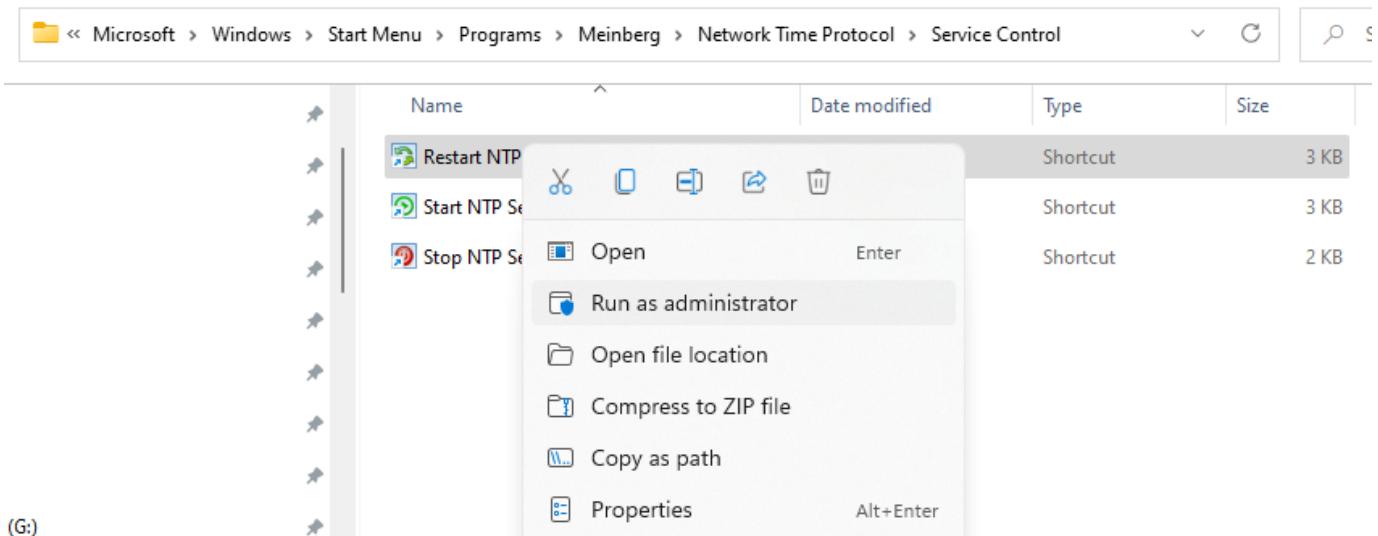
```

Ln 38, Col 2 | 100% | Windows (CRLF) | UTF-8

- Finally, restart the NTP Service
- Again this needs to be performed with Administrator privileges
- Open the *Start* menu, navigate to *Meinberg*, right-click on *Restart NTP Service* and select *Open file location*



- Right-click on the *Restart NTP Service* and select *Run as administrator*



- You can check if your PC clock synchronized successfully by opening a *Command Prompt* (*cmd*) and running *ntpq -pd*

```

Command Prompt
Microsoft Windows [Version 10.0.22000.2057]
(c) Microsoft Corporation. All rights reserved.

C:\Users\pc235>ntpq -pd
1 packets reassembled into response
[56105]
1 associations total
::1 reversed to Core_i5
Core_i5 forward check lookup fail: The operation completed successfully.
    remote          refid      st t when poll reach   delay   offset  jitter
=====
2 packets reassembled into response
*192.168.0.123    .GPS.        1 u      2   64     3    4.043   -0.347   7.051

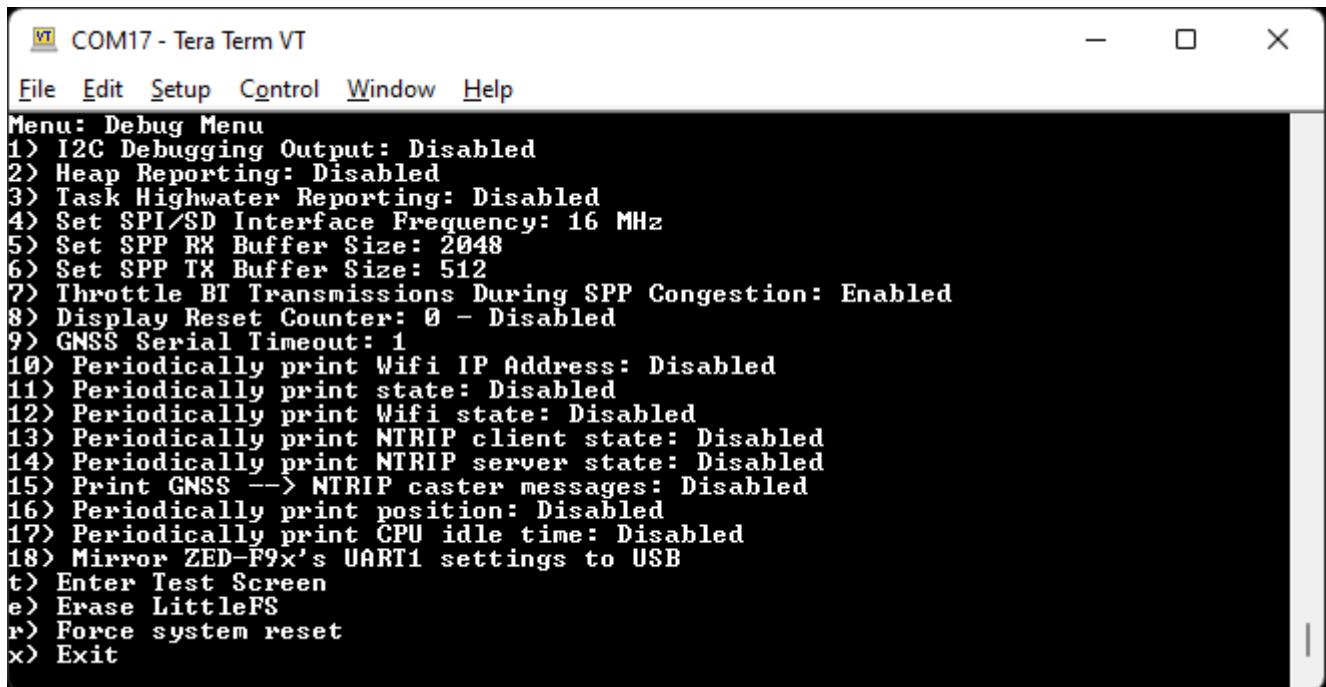
C:\Users\pc235>

```

If enabled, your Windows PC NTP requests will be printed and logged by the reference station. See [above](#).

6.14 Debug Menu

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 



The screenshot shows a terminal window titled "COM17 - Tera Term VT". The menu bar includes File, Edit, Setup, Control, Window, and Help. The main window displays a numbered list of debug menu options:

```

Menu: Debug Menu
1> I2C Debugging Output: Disabled
2> Heap Reporting: Disabled
3> Task Highwater Reporting: Disabled
4> Set SPI/SD Interface Frequency: 16 MHz
5> Set SPP RX Buffer Size: 2048
6> Set SPP TX Buffer Size: 512
7> Throttle BT Transmissions During SPP Congestion: Enabled
8> Display Reset Counter: 0 - Disabled
9> GNSS Serial Timeout: 1
10> Periodically print WiFi IP Address: Disabled
11> Periodically print state: Disabled
12> Periodically print WiFi state: Disabled
13> Periodically print NTRIP client state: Disabled
14> Periodically print NTRIP server state: Disabled
15> Print GNSS --> NTRIP caster messages: Disabled
16> Periodically print position: Disabled
17> Periodically print CPU idle time: Disabled
18> Mirror ZED-F9x's UART1 settings to USB
t> Enter Test Screen
e> Erase LittleFS
r> Force system reset
x> Exit

```

Showing the debug menu

The Debug menu enables the user to enable and disable various debug features. None of these options are needed for normal users or daily use. These are provided for faster software development and troubleshooting.

1. **I2C Debugging Output** - Enable additional ZED-F9P interface debug messages
2. **Heap Reporting** - Display currently available bytes, lowest value and the largest block
3. **Task Highwater Reporting** - Shows stack usage of select tasks
4. **Set the SPI / microSD card frequency** - SD card interface speed. Default is 16MHz.
5. **Set SPP RX buffer size** - Default 128 bytes
6. **Set SPP TX buffer size** - Controls how large the buffer used to communicate over Bluetooth
7. **Throttle Bluetooth transmissions during SPP congestion** - Reduce bytes transmitted if Bluetooth link becomes busy
8. **Display reset counter** - Enable to display a small number indicating non-power on reset count
9. **Set GNSS serial timeout in seconds** - Sets the number of milliseconds before reporting serial available
10. Periodically display WiFi IP Address
11. Periodically display system states
12. Periodically display WiFi states
13. Periodically display NTRIP Client states
14. Periodically display NTRIP Server states
15. **t** - Display the test screen
16. **e** - Erase LittleFS: Clear settings and profiles saved internally (not on microSD card)
17. **r** - Reset the system
18. **x** - Exit the debug menu

7. Hardware

7.1 Updating RTK Firmware

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

The device has two primary firmwares:

- Firmware on the ESP32 microcontroller. Keep reading.
- Firmware on the u-blox ZED-F9P, ZED-F9P, or NEO-D9S Receiver. [See below](#).

The device firmware is displayed in a variety of places:

- Power On
- Serial Config Menu
- WiFi Config



RTK Express with firmware v3.0

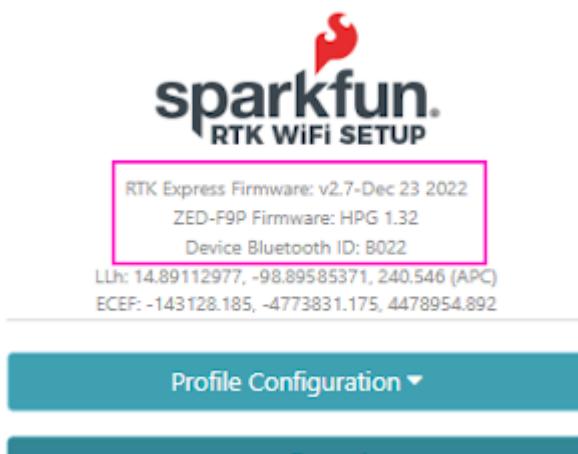
During power-on, the display will show the current device Firmware.

```
VT COM10 - Tera Term VT
File Edit Setup Control Window Help
x
Rover Accuracy (m): 0.0141
Batt <86%>: Voltage: 4.06V Discharging: -6.66%/hr Green
Log file size: 12234809 - Generation rate: 6.6kB/s
FreeHeap: 47900 / HeapLowestPoint: 24808 / LargestBlock: 30196

SparkFun RTK Express Plus v3.0-Jan 19 2023
** Bluetooth broadcasting as: Express Plus Rover-DABE **
Menu: Main
1> Configure GNSS Receiver
2> Configure GNSS Messages
3> Configure Sensor Fusion
4> Configure Ports
5> Configure Logging
6> Configure WiFi
p> Configure User Profiles
r> Configure Radios
s> Configure System
f> Firmware upgrade
x> Exit
```

Main Menu showing RTK Firmware v3.0-Jan 19 2023

The firmware is displayed when the main menu is opened over a serial connection.



WiFi Config page showing device firmware v2.7 and ZED-F9P firmware HPG 1.32

The firmware is shown at the top of the WiFi config page.

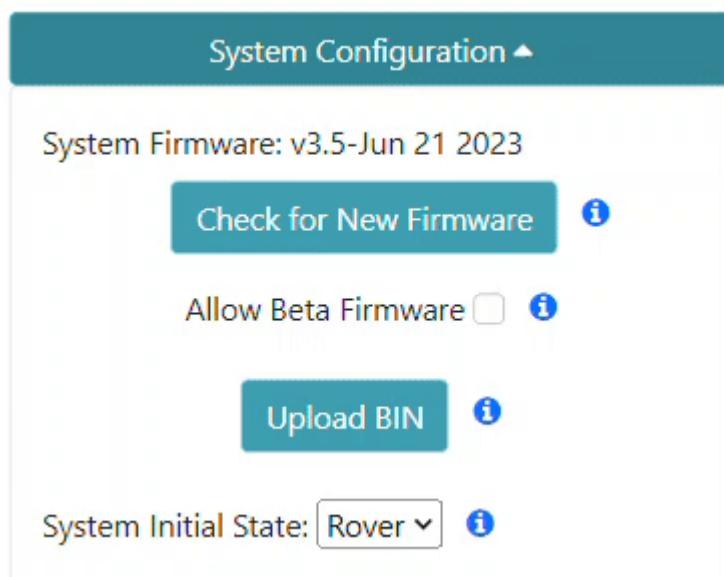
From time to time SparkFun will release new firmware for the RTK product line to add and improve functionality. For most users, firmware can be upgraded over WiFi using the OTA method.

- **OTA Method:** Connect over WiFi to SparkFun to download the latest firmware *over-the-air*. This can be done using the serial menu or while in WiFi AP Config Mode. Requires a local WiFi network.
- **GUI Method:** Use the [Windows](#), [Linux](#), [MacOS](#) or [Python GUI](#) and a USB cable. (The Python package has been tested on Raspberry Pi)
- **SD Method:** Load the firmware on an SD card, then use a serial terminal with the *Firmware Upgrade* menu
- **WiFi Method:** Load the firmware over WiFi when the device is in WiFi AP Config Mode
- **CLI Method:** Use the command line *batch_program.bat*

The OTA method is generally recommended. For more information see [here](#).

Remember, all SparkFun RTK devices are open source hardware meaning you have total access to the [firmware](#) and [hardware](#). Be sure to check out each repo for the latest firmware and hardware information.

7.1.1 Updating Firmware Over-The-Air



Updating the firmware via WiFi config page

The screenshot shows a terminal window titled "COM13 - Tera Term VT". The menu displays the following options:

```
Unknown choice: d
SparkFun RTK Express v3.0-Jan 9 2023
** Bluetooth broadcasting as: **

Menu: Main
1> Configure GNSS Receiver
2> Configure GNSS Messages
3> Configure Base
4> Configure Ports
5> Configure Logging
6> Configure WiFi
p> Configure User Profiles
r> Configure Radios
s> Configure System
f> Firmware upgrade
x> Exit
f

Menu: Update Firmware
Current firmware: v3.0
c> Check SparkFun for device firmware
e> Allow Beta Firmware: Disabled
x> Exit
```

Updating the firmware via Firmware serial menu

Introduced with version 3.0, firmware can be updated by pressing a button in the System Configuration section of the WiFi Config page, or over the Firmware menu of the serial interface. This makes checking and upgrading a unit very easy.

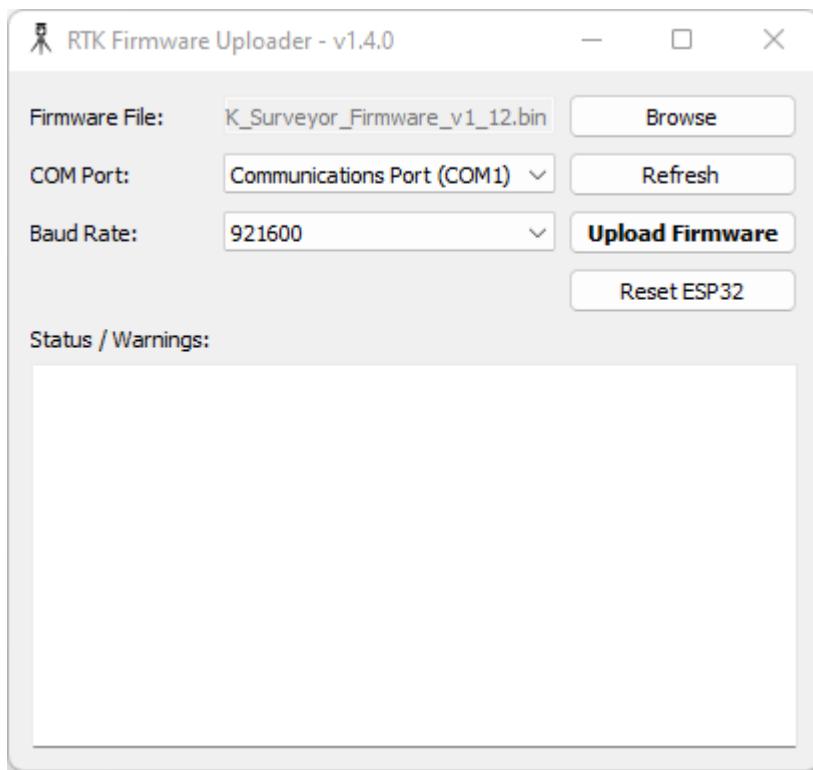
Additionally, users may opt into checking for Beta firmware. This is the latest firmware that may have new features and is meant for testing. Beta firmware is not recommended for units deployed into the field as it may not be stable.

If you have a device with firmware lower than v3.0, you will need to use the [GUI](#) or a method listed below to get to v3.x.

With version 3.10 automatic release firmware update is supported over WiFi. Enabling this feature is done using the serial firmware menu. The polling period is specified in minutes and defaults to once a day. The automatic firmware update only checks for and installs the current SparkFun released firmware versions over top of any:

- Older released versions (continual upgrade)
- Beta firmware versions (newer or older, restore to released version)
- Locally built versions (newer or older, restore to released version)

7.1.2 Updating Firmware Using The Uploader GUI



RTK Firmware GUI

This GUI makes it easy to point and click your way through a firmware update. There are versions for Windows, Linux, MacOS and a Python package installer.

The latest GUI release can be downloaded [here](#).

Download the latest RTK firmware binary file located on the [releases page](#) or from the [binaries repo](#).

To Use

- Attach the RTK device to your computer using a USB cable.
- Turn the RTK device on.
- On Windows, open the Device Manager to confirm which COM port the device is operating on. On other platforms, check `/dev`.



Device Manager showing 'USB-Serial CH340' port on COM27

- Get the latest binary file located on the [releases page](#) or from the [binaries repo](#).
- Run `RTKUploader.exe` (it takes a few seconds to start)
- Click `Browse` and select the binary file to upload
- Select the COM port previously seen in the Device Manager
- Click `Upload Firmware`

Once complete, the device will reset and power down.

If your RTK 'freezes' after the update, press `Reset ESP32` to get it going again.

7.1.3 Updating Firmware From the SD Card

```

VT COM13 - Tera Term VT
File Edit Setup Control Window Help
d> Configure Debug
r> Reset all settings to default
f> Firmware upgrade
x> Exit
f
Menu: Update Firmware Menu
1> Load RTK_Surveyor_Firmware_v11.bin
2> Load RTK_Surveyor_Firmware_v12.bin
3> Load RTK_Surveyor_Firmware_v13.bin
x> Exit
33

WiFi Stopped
Bluetooth turned off
Loading RTK_Surveyor_Firmware_v13.bin
[D][Updater.cpp:132] begin(): OTA Partition: app1
Moving file to OTA section
Bytes to write: 1492176
[=0%
[==5%
[==10%
[==15%
[==20%
[==25%

```

Firmware update taking place

Download the latest binary file located on the [releases page](#) or from the [binaries repo](#).

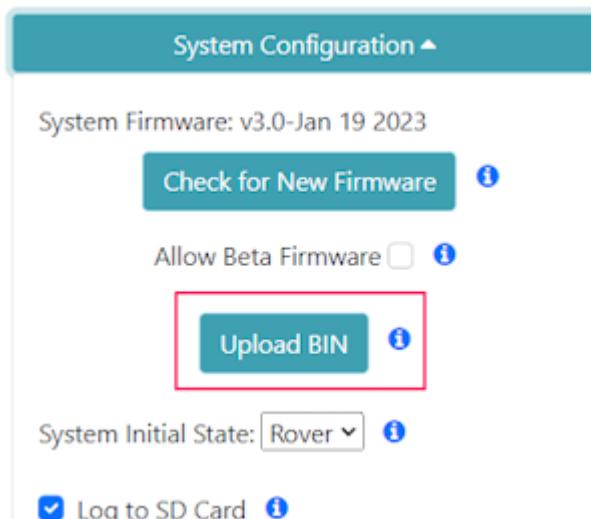
The firmware upgrade menu will only display files that have the "RTK_Surveyor_Firmware*.bin" file name format so don't change the file names once loaded onto the SD card. Select the firmware you'd like to load and the system will proceed to load the new firmware, then reboot.

Note: The firmware is called `RTK_Surveyor_Firmware_vxx.bin` even though there are various RTK products (Facet, Express, Surveyor, etc). We united the different platforms into one. The [RTK Firmware](#) runs on all our RTK products.

Force Firmware Loading

In the rare event that a unit is not staying on long enough for new firmware to be loaded into a COM port, the RTK Firmware (as of version 1.2) has an override function. If a file named `RTK_Surveyor_Firmware_Force.bin` is detected on the SD card at boot that file will be used to overwrite the current firmware, and then be deleted. This update path is generally not recommended. Use the [GUI](#) or [WiFi OTA](#) methods as the first resort.

7.1.4 Updating Firmware From WiFi



Note: Firmware versions 1.1 to 1.9 have an issue that severely limits firmware upload over WiFi and is not recommended; use the [GUI](#) method instead. Firmware versions v1.10 and beyond support direct firmware updates via WiFi.

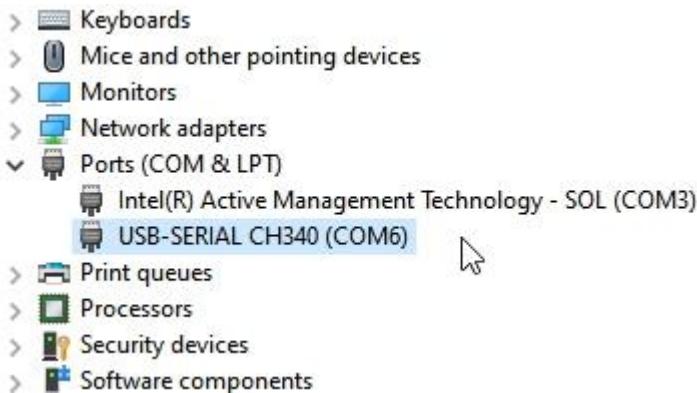
Firmware may be uploaded to the unit by clicking on 'Upload BIN', selecting the binary such as 'RTK_Surveyor_Firmware_v3_x.bin' and pressing upload. The unit will automatically reset once the firmware upload is complete.

7.1.5 Updating Firmware From CLI

The command-line interface is also available. You'll need to download the [RTK Firmware Binaries](#) repo. This repo contains the binaries but also various supporting tools including esptool.exe and the three binaries required along with the firmware (bootloader, partitions, and app0).

Windows

Connect a USB A to C cable from your computer to the ESP32 port on the RTK device. Turn the unit on. Now identify the COM port the RTK enumerated at. The easiest way to do this is to open the Device Manager:



CH340 is on COM6 as shown in Device Manager

If the COM port is not showing be sure the unit is turned **On**. If an unknown device is appearing, you'll need to [install drivers for the CH340](#). Once you know the COM port, open a command prompt (Windows button + r then type 'cmd').

```

C:\WINDOWS\system32\cmd.exe - batch_program.bat RTK_Surveyor_Firmware_v2_1.bin COM26
esptool.py v3.1
Serial port COM26
Connecting....
Chip is ESP32-D0WD-V3 (revision 3)
Features: WiFi, BT, Dual Core, 240MHz, VRef calibration in efuse, Coding Scheme None
Crystal is 40MHz
MAC: 34:ab:95:5c:da:bc
Uploading stub...
Running stub...
Stub running...
Changing baud rate to 921600
Changed.
Configuring flash size...
Auto-detected Flash size: 16MB
Flash will be erased from 0x00001000 to 0x00005fff...
Flash will be erased from 0x00008000 to 0x00008fff...
Flash will be erased from 0x0000e000 to 0x0000ffff...
Flash will be erased from 0x00010000 to 0x001f1fff...
Flash params set to 0x024f
Compressed 17984 bytes to 12318...
Wrote 17984 bytes (12318 compressed) at 0x00001000 in 0.5 seconds (effective 313.4 kbit/s)...
Hash of data verified.
Compressed 3072 bytes to 129...
Wrote 3072 bytes (129 compressed) at 0x00008000 in 0.1 seconds (effective 439.6 kbit/s)...
Hash of data verified.
Compressed 8192 bytes to 47...
Wrote 8192 bytes (47 compressed) at 0x0000e000 in 0.1 seconds (effective 543.3 kbit/s)...
Hash of data verified.
Compressed 1971968 bytes to 1244398...
Writing at 0x00098deb... (21 %)

```

batch_program.bat running *esptool*

Once the correct COM is identified, run '*batch_program.bat*' along with the binary file name and COM port. For example *batch_program.bat RTK_Surveyor_Firmware_v2_0.bin COM6*. COM6 should be replaced by the COM port you identified earlier.

The batch file runs the following commands:

```

esptool.exe --chip esp32 --port COM6 --baud 921600 --before default_reset --after hard_reset write_flash -z --flash_mode dio --flash_freq 80m --flash_size detect 0x1000 ./bin/RTK_Surveyor.ino.bootloader.bin 0x8000 ./bin/RTK_Surveyor_Partitions_16MB.bin 0xe000 ./bin/boot_app0.bin 0x10000 ./RTK_Surveyor_Firmware_vxx.bin

```

Where *COM6* is replaced with the COM port that the RTK product enumerated at and *RTK_Surveyor_Firmware_vxx.bin* is the firmware you would like to load.

Note: Some users have reported the 921600bps baud rate does not work. Decrease this to 115200 as needed.

Upon completion, your RTK device will reset and power down.

macOS / Linux

Get [esptool.py](#). Connect a USB A to C cable from your computer to the ESP32 port on the RTK device. Turn the unit on. Now identify the COM port the RTK enumerated at.

If the COM port is not showing be sure the unit is turned **On**. If an unknown device is appearing, you'll need to [install drivers for the CH340](#). Once you know the COM port, run the following command:

```

py esptool.py --chip esp32 --port /dev/ttyUSB0 --baud 921600 --before default_reset --after hard_reset write_flash -z --flash_mode dio --flash_freq 80m --flash_size detect 0x1000 ./bin/RTK_Surveyor.ino.bootloader.bin 0x8000 ./bin/RTK_Surveyor_Partitions_16MB.bin 0xe000 ./bin/boot_app0.bin 0x10000 ./RTK_Surveyor_Firmware_vxx.bin

```

Where */dev/ttyUSB0* is replaced with the port that the RTK product enumerated at and *RTK_Surveyor_Firmware_vxx.bin* is the firmware you would like to load.

Note: Some users have reported the 921600bps baud rate does not work. Decrease this to 115200 as needed.

Upon completion, your RTK device will reset and power down.

7.1.6 Updating 4MB Surveyors

RTK Surveyors sold before September 2021 may have an ESP32 WROOM module with 4MB flash instead of 16MB flash. These units still support all the functionality of other RTK products with the following limitations:

- There is not enough flash space for OTA. Upgrading the firmware must be done via [CLI](#) or [GUI](#). OTA, WiFi, or SD update paths are not possible.

The GUI (as of v1.3) will autodetect the ESP32's flash size and load the appropriate partition file. No user interaction is required.

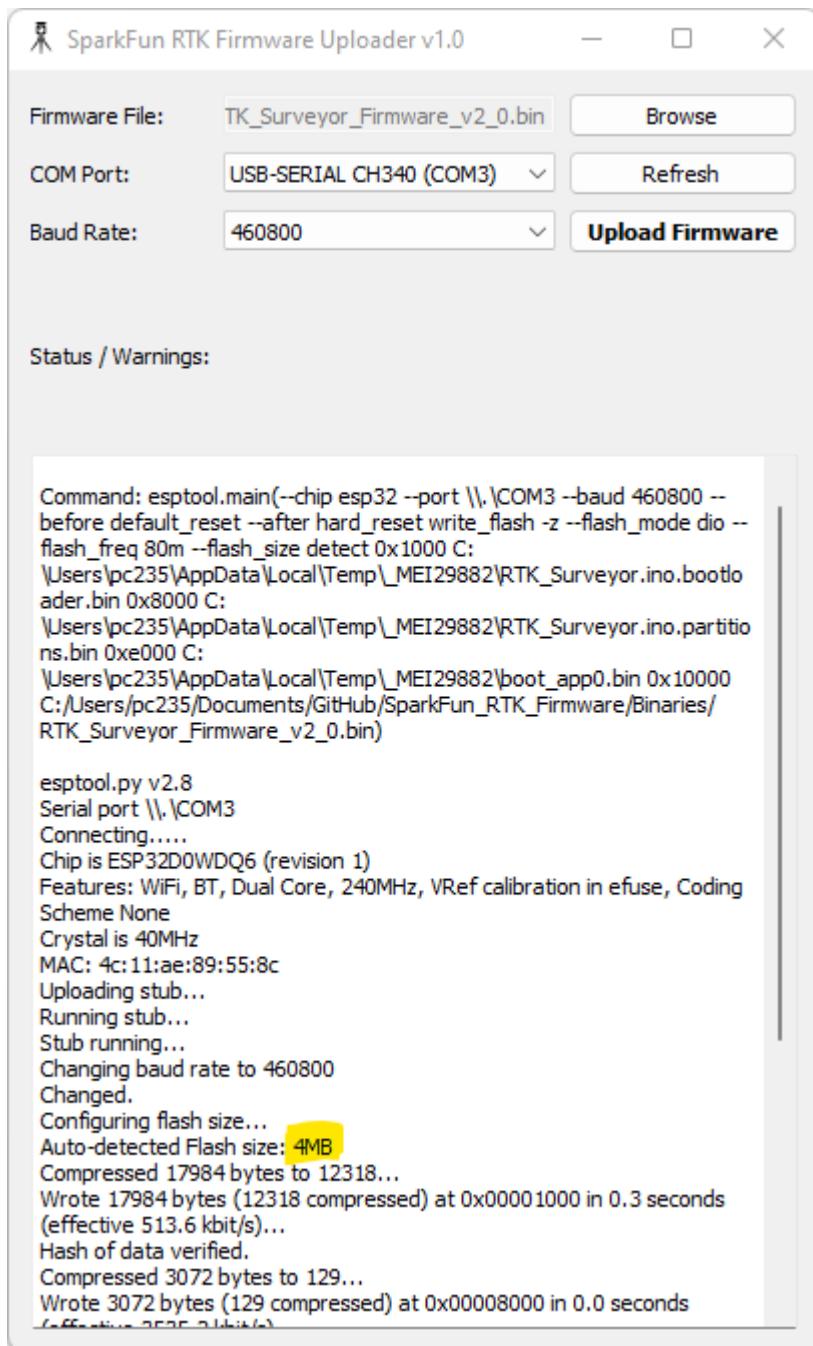
If you are using the CLI method, be sure to point to the [4MB partition file](#). For example:

```
esptool.exe --chip esp32 --port COM6 --baud 921600 --before default_reset --after hard_reset write_flash -z --flash_mode dio --flash_freq 80m --flash_size detect 0x1000 ./bin/RTK_Surveyor.ino.bootloader.bin 0x8000 ./bin/**RTK_Surveyor_Partitions_4MB**.bin 0xe000 ./bin/boot_app0.bin 0x10000 ./RTK_Surveyor_Firmware_vxx.bin
```

Determining The Size of Flash

To determine if the device has a 4MB module:

- Use the esptool via CLI. Please see the [flash_id](#) command for usage.
- Use the GUI and attempt a firmware update. The output will auto-detect and show the flash size, as shown below:



7.1.7 Updating u-blox Firmware

The following products contain the following u-blox receivers:

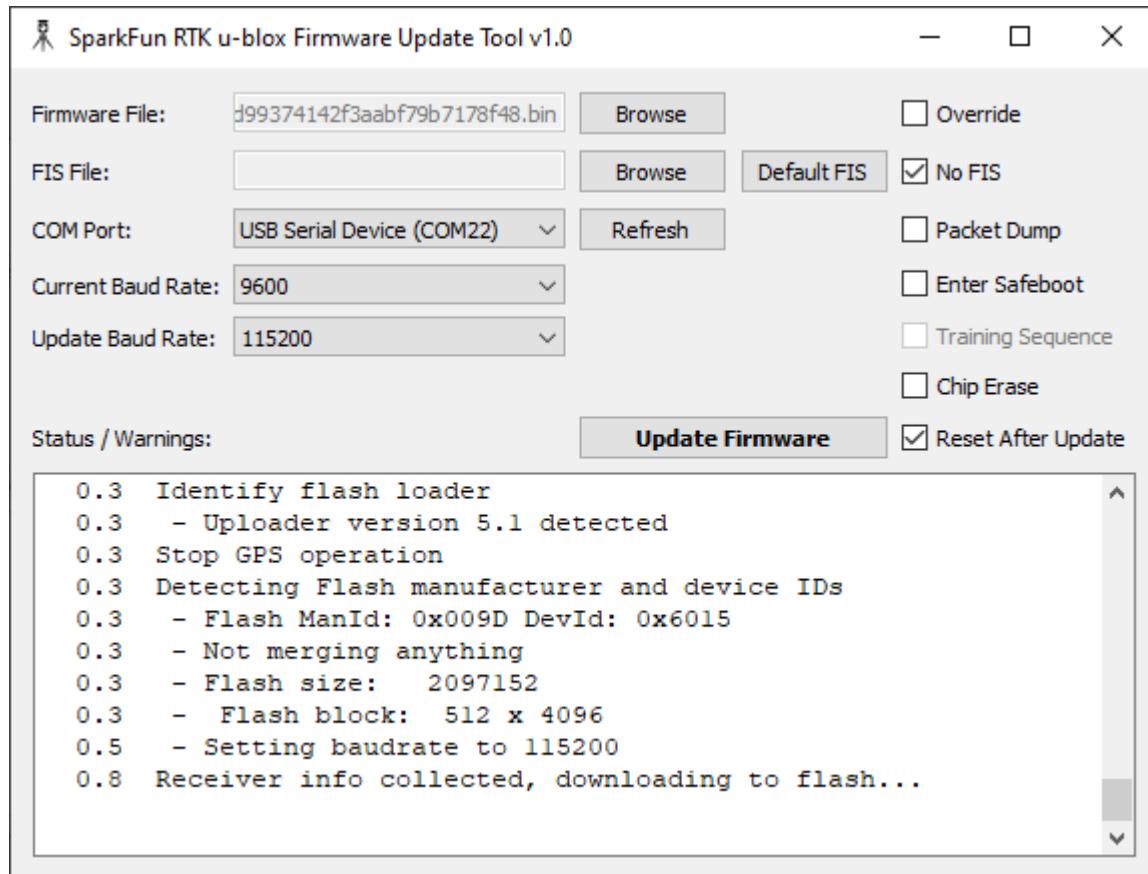
- RTK Surveyor: ZED-F9P
- RTK Express: ZED-F9P
- RTK Express Plus: ZED-F9R
- RTK Facet: ZED-F9P
- RTK Facet L-Band: ZED-F9P and NEO-D9S

The firmware loaded onto the ZED-F9P, ZED-F9R, and NEO-D9S receivers is written by u-blox and can vary depending on the manufacture date. The RTK Firmware (that runs on the ESP32) is designed to flexibly work with any u-blox firmware. Upgrading the ZED-F9x/NEO-D9S is a good thing to consider but is not crucial to the use of RTK products.

Not sure what firmware is loaded onto your RTK product? Open the [System Menu](#) to display the module's current firmware version.

The firmware on u-blox devices can be updated using a [Windows-based GUI](#) or [u-center](#). A CLI method is also possible using the `ubxfwupdate.exe` tool provided with u-center. Additionally, u-blox offers the source for the `ubxfwupdate` tool that is written in C. It is currently released only under an NDA so contact your local u-blox Field Applications Engineer if you need a different method.

7.1.8 Updating Using Windows GUI

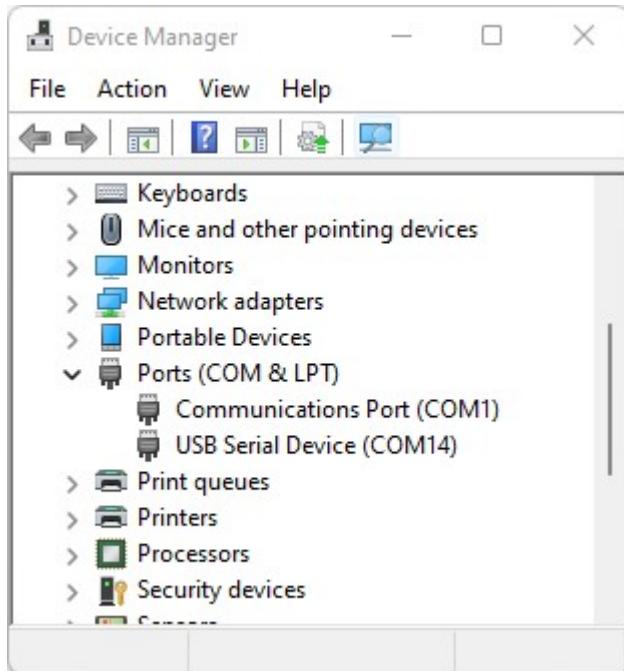


SparkFun RTK u-blox Firmware Update Tool

The [SparkFun RTK u-blox Firmware Update Tool](#) is a simple Windows GUI and python script that runs the `ubxfwupdate.exe` tool. This allows users to directly update module firmware without the need for u-center. Additionally, this tool queries the module to verify that the firmware type matches the module. Because the RTK Facet L-Band contains two u-blox modules that both appear as identical serial ports, it can be difficult and perilous to know which port to load firmware. This tool prevents ZED-F9P firmware from being accidentally loaded onto a NEO-D9S receiver and vice versa.

The SparkFun RTK u-blox Firmware Update Tool will only run on Windows as it relies upon u-blox's `ubxfwupdate.exe`. The full, integrated executable for Windows is available [here](#).

- Attach the RTK device's USB port to your computer using a USB cable
- Turn the RTK device on
- Open Device Manager to confirm which COM port the device is operating on



Device Manager showing USB Serial port on COM14

- Get the latest binary firmware file from the [ZED Firmware](#), [NEO Firmware](#) folder, or the [u-blox](#) website
- Run [RTK_u-blox_Update_GUI.exe](#) (it takes a few seconds to start)
- Click the Firmware File Browse and select the binary file for the update
- Select the COM port previously seen in the Device Manager
- Click *Update Firmware*

Once complete, the u-blox module will restart.

Updating Using u-center

If you're familiar with u-center a tutorial with step-by-step instructions for locating the firmware version as well as changing the firmware can be found in [How to Upgrade Firmware of a u-blox Receiver](#).

ZED-F9P Firmware Changes

This module is used in the Surveyor, Express, and Facet. It is capable of both Rover *and* base modes.

Most of these binaries can be found in the [ZED Firmware/ZED-F9P](#) folder.

All field testing and device-specific performance parameters were obtained with ZED-F9P v1.30.

- v1.12 has the benefit of working with SBAS and an operational RTK status signal (the LED illuminates correctly). See [release notes](#).
- v1.13 has a few RTK and receiver performance improvements but introduces a bug that causes the RTK Status LED to fail when SBAS is enabled. See [release notes](#).
- v1.30 has a few RTK and receiver performance improvements, I²C communication improvements, and most importantly support for SPARTN PMP packets. See [release notes](#).
- v1.32 has a few SPARTN protocol-specific improvements. See [release notes](#). This firmware is required for use with the NEO-D9S and the decryption of PMP messages.

ZED-F9R Firmware Changes

This module is used in the Express Plus. It contains an internal IMU and additional algorithms to support high-precision location fixes using dead reckoning. The ZED-F9R is not capable of operating in base mode.

Most of these binaries can be found in the [ZED Firmware/ZED-F9R](#) folder.

- v1.00 Initial release.
- v1.21 SPARTN support as well as adding E-scooter and robotic lawnmower dynamic models. See [release notes](#).

NEO-D9S Firmware Changes

This module is used in the Facet L-Band to receive encrypted PMP messages over ~1.55GHz broadcast via a geosynchronous Inmarsat.

This binary file can be found in the [NEO Firmware](#) folder.

- v1.04 Initial release.

As of writing, no additional releases of the NEO-D9S firmware have been made.

7.1.9 Compiling Source

Windows

The SparkFun RTK firmware is compiled using Arduino (currently v1.8.15). To compile:

1. Install [Arduino](#).
2. Install ESP32 for Arduino. [Here](#) are some good instructions for installing it via the Arduino Boards Manager. **Note:** Use v2.0.2 of the core. **Note:** We use the 'ESP32 Dev Module' for pin numbering. Select the correct board under Tools->Board->ESP32 Arduino->ESP32 Dev Module.
3. Change the Partition table. Replace

C:\Users\\[user name]\AppData\Local\Arduino15\packages\esp32\hardware\esp32\2.0.2\tools\partitions\app3M_fat9M_16MB.csv
with the app3M_fat9M_16MB.csv file found in the [Firmware folder](#). This will increase the program partition from a maximum of 1.9MB to 3MB.
4. From the Arduino IDE, set the core settings from the **Tools** menu:
 - A. Set the 'Partition Scheme' to *16M Flash (3MB APP/9MB FATFS)*. This will use the 'app3M_fat9M_16MB.csv' updated partition table.
 - B. Set the 'Flash Size' to 16MB (128mbit)
5. Obtain all the [required libraries](#).

Once compiled, firmware can be uploaded directly to a unit when the RTK unit is on and the correct COM port is selected under the Arduino IDE Tools->Port menu.

If you are seeing the error:

text section exceeds available space ...

You have not replaced the partition file correctly. See the 'Change Partition table' step inside the [Windows instructions](#).

Note: There are a variety of compile guards (COMPILE_WIFI, COMPILE_AP, etc) at the top of RTK_Surveyor.ino that can be commented out to remove them from compilation. This will greatly reduce the firmware size and allow for faster development of functions that do not rely on these features (serial menus, system configuration, logging, etc).

REQUIRED LIBRARIES

Note: You should click on the link next to each of the #includes at the top of RTK_Surveyor.ino within the Arduino IDE to open the library manager and download them. Getting them directly from Github also works but may not be 'official' releases.

Using the library manager in the Arduino IDE, for each of the libraries below:

1. Locate the library by typing the library name into the search box
2. Click on the library
3. Select the version listed in the `compile-rtk-firmware.yml` file for the [main](https://github.com/sparkfun/SparkFun_RTK_Firmware/blob/main/.github/workflows/compile-rtk-firmware.yml) or the [release_candidate](https://github.com/sparkfun/SparkFun_RTK_Firmware/blob/release_candidate/.github/workflows/compile-rtk-firmware.yml) branch
4. Click on the Install button in the lower right

The RTK firmware requires the following libraries:

- * [Arduino JSON](<https://github.com/bblanchon/ArduinoJson>)
- * [ESP32Time](<https://github.com/fbiego/ESP32Time>)
- * [ESP32 BleSerial](https://github.com/avinabmalla/ESP32_BleSerial)
- * [ESP32-OTA-Pull](<https://github.com/mikalhart/ESP32-OTA-Pull>)
- * Ethernet
- * [JC_Button](https://github.com/JChristensen/JC_Button)
- * [PubSub Client for MQTT](<https://github.com/knolleary/pubsubclient>)
- * [SdFat](<https://github.com/greiman/SdFat>)
- * [SparkFun LIS2DH12 Arduino Library](https://github.com/sparkfun/SparkFun_LIS2DH12_Arduino_Library)
- * [SparkFun MAX1704x Fuel Gauge Arduino Library](https://github.com/sparkfun/SparkFun_MAX1704x_Fuel_Gauge_Arduino_Library)
- * [SparkFun u-blox GNSS v3](https://github.com/sparkfun/SparkFun_u-blox_GNSS_v3)
- * [SparkFun WebServer_ESP32_W5500](https://github.com/SparkFun/SparkFun_WebServer_ESP32_W5500)

The following libraries are only available via GitHub:

- * [AsyncTCP](<https://github.com/me-no-dev/AsyncTCP>) (not available via library manager)
- * [ESPAsyncWebServer](<https://github.com/me-no-dev/ESPAsyncWebServer>) (not available via library manager)
- * [SparkFun Micro OLED Breakout](https://github.com/sparkfun/SparkFun_Micro_OLED_Arduino_Library)

Ubuntu 20.04

VIRTUAL MACHINE

Execute the following commands to create the Linux virtual machine:

1. Using a browser, download the Ubuntu 20.04 Desktop image
2. virtualbox
 - a. Click on the new button
 - b. Specify the machine Name, e.g.: Sparkfun_RTK_20.04
 - c. Select Type: Linux
 - d. Select Version: Ubuntu (64-bit)
 - e. Click the Next> button
 - f. Select the memory size: 7168
 - g. Click the Next> button
 - h. Click on Create a virtual hard disk now
 - i. Click the Create button
 - j. Select VDI (VirtualBox Disk Image)
 - k. Click the Next> button
 - l. Select Dynamically allocated
 - m. Click the Next> button
 - n. Select the disk size: 128 GB
 - o. Click the Create button
 - p. Click on Storage
 - q. Click the empty CD icon
 - r. On the right-hand side, click the CD icon
 - s. Click on Choose a disk file...
 - t. Choose the ubuntu-20.04... iso file
 - u. Click the Open button
 - v. Click on Network
 - w. Under 'Attached to:' select Bridged Adapter
 - x. Click the OK button
 - y. Click the Start button
3. Install Ubuntu 20.04
4. Log into Ubuntu
5. Click on Activities
6. Type terminal into the search box
7. Optionally install the SSH server
 - a. In the terminal window
 - i. sudo apt install -y net-tools openssh-server
 - ii. ifconfig

Write down the IP address
 - b. On the PC
 - i. ssh-keygen -t rsa -f ~/.ssh/Sparkfun_RTK_20.04
 - ii. ssh-copy-id -o IdentitiesOnly=yes -i ~/.ssh/Sparkfun_RTK_20.04 <username>@<IP address>
 - iii. ssh -Y <username>@<IP address>

BUILD ENVIRONMENT

Execute the following commands to create the build environment for the SparkFun RTK Firmware:

1. sudo adduser \$USER dialout
2. sudo shutdown -r 0

Reboot to ensure that the dialout privilege is available to the user
3. sudo apt update
4. sudo apt install -y git gitk git-cola minicom python3-pip
5. sudo pip3 install pyserial
6. mkdir ~/SparkFun
7. mkdir ~/SparkFun/esptool
8. cd ~/SparkFun/esptool
9. git clone https://github.com/espressif/esptool .
10. cd ~/SparkFun
11. nano serial-port.sh

Insert the following text into the file:

```
#!/bin/bash
#   serial-port.sh
#
#   Shell script to read the serial data from the RTK Express ESP32 port
#
#   Parameters:
#       1:  ttyUSBn
#
sudo minicom -b 115200 -8 -D /dev/$1 < /dev/tty
```

12. chmod +x serial-port.sh

13. nano new-firmware.sh

Insert the following text into the file:

```
#!/bin/bash
#   new-firmware.sh
#
#   Shell script to load firmware into the RTK Express via the ESP32 port
#
#   Parameters:
#       1:  ttyUSBn
#       2: Firmware file
#
sudo python3 ~/SparkFun/RTK_Binaries/Uploader_GUI/esptool.py --chip esp32 --port /dev/$1 --baud 921600 --before default_reset --after hard_reset write_flash -z
--flash_mode dio --flash_freq 80m --flash_size detect \
0x1000  ~/SparkFun/RTK_Binaries/bin/RTK_Surveyor.ino.bootloader.bin \
0x8000  ~/SparkFun/RTK_Binaries/bin/RTK_Surveyor_Partitions_16MB.bin \
0xe000  ~/SparkFun/RTK_Binaries/bin/boot_app0.bin \
0x10000 $2
```

14. chmod +x new-firmware.sh

15. nano new-firmware-4mb.sh

Insert the following text into the file:

```
#!/bin/bash
#   new-firmware-4mb.sh
#
#   Shell script to load firmware into the 4MB RTK Express via the ESP32 port
#
#   Parameters:
#       1:  ttyUSBn
#       2: Firmware file
#
sudo python3 ~/SparkFun/RTK_Binaries/Uploader_GUI/esptool.py --chip esp32 --port /dev/$1 --baud 921600 --before default_reset --after hard_reset write_flash -z
--flash_mode dio --flash_freq 80m --flash_size detect \
0x1000  ~/SparkFun/RTK_Binaries/bin/RTK_Surveyor.ino.bootloader.bin \
0x8000  ~/SparkFun/RTK_Binaries/bin/RTK_Surveyor_Partitions_4MB.bin \
0xe000  ~/SparkFun/RTK_Binaries/bin/boot_app0.bin \
0x10000 $2
```

16. chmod +x new-firmware-4mb.sh

Get the SparkFun RTK Firmware sources

17. mkdir ~/SparkFun/RTK

18. cd ~/SparkFun/RTK
19. git clone https://github.com/sparkfun/SparkFun_RTK_Firmware .
 Get the SparkFun RTK binaries
20. mkdir ~/SparkFun/RTK_Binaries
21. cd ~/SparkFun/RTK_Binaries
22. git clone https://github.com/sparkfun/SparkFun_RTK_Firmware_Binaries.git .
 Install the Arduino IDE
23. mkdir ~/SparkFun/arduino
24. cd ~/SparkFun/arduino
25. wget <https://downloads.arduino.cc/arduino-1.8.15-linux64.tar.xz>
26. tar -xvf ./arduino-1.8.15-linux64.tar.xz
27. cd arduino-1.8.15/
28. sudo ./install.sh
 Add the ESP32 support
29. Arduino
 - a. Click on File in the menu bar
 - b. Click on Preferences
 - c. Go down to the Additional Boards Manager URLs text box
 - d. Only if the textbox already has a value, go to the end of the value or values and add a comma
 - e. Add the link: https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json
 - f. Note the value in Sketchbook location
 - g. Click the OK button
 - h. Click on File in the menu bar
 - i. Click on Quit Get the required external libraries, then add to the Sketchbook location from above
30. cd ~/Arduino/libraries
31. mkdir AsyncTCP
32. cd AsyncTCP/
33. git clone <https://github.com/me-no-dev/AsyncTCP.git> .
34. cd ..
35. mkdir ESPAsyncWebServer
36. cd ESPAsyncWebServer
37. git clone <https://github.com/me-no-dev/ESPAsyncWebServer> .
 Connect the Config ESP32 port of the RTK to a USB port on the computer
38. ls /dev/ttyUSB*
 Enable the libraries in the Arduino IDE
39. Arduino
 - a. From the menu, click on File
 - b. Click on Open...
 - c. Select the ~/SparkFun/RTK/Firmware/RTK_Surveyor/RTK_Surveyor.ino file
 - d. Click on the Open button

Select the ESP32 development module

- a. From the menu, click on Tools
- b. Click on Board
- c. Click on Board Manager...
- d. Click on esp32
- e. Select version 2.0.2
- f. Click on the Install button in the lower right

g. Close the Board Manager...

h. From the menu, click on Tools

- i. Click on Board

j. Click on ESP32 Arduino

k. Click on ESP32 Dev Module

Load the required libraries

a. From the menu, click on Tools

b. Click on Manage Libraries...

c. For each of the following libraries:

i. Locate the library

ii. Click on the library

iii. Select the version listed in the compile-rtk-firmware.yml file for the [main](#) or the [release_candidate](#) branch

iv. Click on the Install button in the lower right

Library List:

- ArduinoJson
- ESP32Time
- ESP32-OTA-Pull
- ESP32_BleSerial
- Ethernet
- JC_Button
- MAX17048 - Used for "Test Sketch/Batt_Monitor"
- PubSubClient
- SdFat
- SparkFun LIS2DH12 Arduino Library
- SparkFun MAX1704x Fuel Gauge Arduino Library
- SparkFun Qwiic OLED Graphics Library
- SparkFun u-blox GNSS v3
- SparkFun_WebServer_ESP32_W5500

d. Click on the Close button

Select the terminal port

- a. From the menu, click on Tools
- b. Click on Port, Select the port that was displayed in step 38 above
- c. Select /dev/ttyUSB0
- d. Click on Upload Speed
- e. Select 230400

Setup the partitions for the 16 MB flash

- a. From the menu, click on Tools
 - b. Click on Flash Size
 - c. Select 16MB
 - d. From the menu, click on Tools
 - e. Click on Partition Scheme
 - f. Click on 16M Flash (3MB APP/9MB FATFS)
 - g. From the menu click on File
 - h. Click on Quit
40. cd ~/SparkFun/RTK/
41. cp Firmware/app3M_fat9M_16MB.csv ~/.arduino15/packages/esp32/hardware/esp32/2.0.2/tools/partitions/app3M_fat9M_16MB.csv

Arduino CLI

The firmware can be compiled using [Arduino CLI](#). This makes compilation fairly platform independent and flexible. All release candidates and firmware releases are compiled using Arduino CLI using a github action. You can see the source of the action [here](#), and use it as a starting point for Arduino CLI compilation.

7.2 Displays

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

The RTK Facet, Facet L-Band, Express, and Express Plus utilize a 0.96" high-contrast OLED display. While small, it packs various situational data that can be helpful in the field. We will walk you through each display.

7.2.1 Power On/Off



RTK Facet Startup and Shutdown Screens

Press and hold the power button until the display illuminates to turn on the device. Similarly, press and hold the power button to turn off the device.

The device's firmware version is shown during the Power On display.

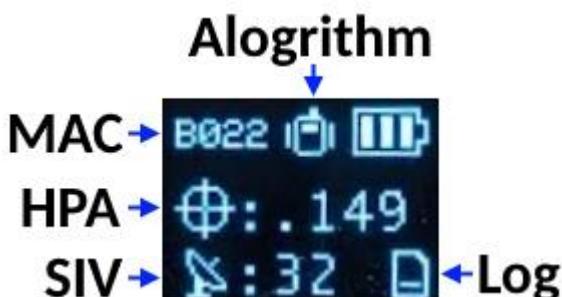
Force Power Off

In the event that a device becomes unresponsive, the device can be completely powered off by holding the power button for 10 seconds or more. The force-power-off method is hardware-based and will therefore work regardless of what firmware the device may be running.

- >  Network adapters
- >  Portable Devices
- ▼  Ports (COM & LPT)
 -  Communications Port (COM1)
 -  USB Serial Device (COM41)
 -  USB-SERIAL CH340 (COM39)
- >  Print queues
- >  Printers
- ✓  Processors

If the power state of a device is not known (for example, because a display may be malfunctioning) the device can be connected to USB. If one or more COM ports enumerate, the device is on (shown above). If no COM ports are seen, the device is fully powered off.

7.2.2 Rover Fix



Rover with location fix

Upon power up the device will enter either Rover mode or Base mode. Above, the Rover mode is displayed.

- **MAC:** The MAC address of the internal Bluetooth module. This is helpful knowledge when attempting to connect to the device from your phone. This will change to a Bluetooth symbol once connected.
- **HPA:** Horizontal positional accuracy is an estimate of how accurate the current positional readings are. This number will decrease rapidly after the first power-up and settle around 0.3m depending on your antenna and view of the sky. When RTK fix is achieved this icon will change to a double circle and the HPA number will decrease even further to as low as 0.014m.
- **SIV:** Satellites in view is the number of satellites used for the fix calculation. This symbol will blink before a location fix is generated and become solid when the device has a good location fix. SIV is a good indicator of how good of a view the antenna has. This number will vary but anything above 10 is adequate. We've seen as high as 31.
- **Model:** This icon will change depending on the selected dynamic model: Portable (default) Pedestrian, Sea, Bike, Stationary, etc.
- **Log:** This icon will remain animated while the log file is increasing. This is a good visual indication that you have an SD card inserted and RTK Facet can successfully record to it. There are three logging icons  inserted and RTK Facet can successfully record to it. There are three logging icons

7.2.3 Rover RTK Fix



Rover with RTK Fix and Bluetooth connected

Once NTRIP is enabled on your phone or RTCM data is being streamed into the **Radio** port the device will gain an RTK Fix. You should see the HPA drop to 14mm with a double circle bulls-eye as shown above.

7.2.4 Base Survey-In



RTK device in Survey-In Mode

Pressing the Setup button will change the device to Base mode. If the device is configured for *Survey-In* base mode, a flag icon will be shown and the survey will begin. The mean standard deviation will be shown as well as the time elapsed. For most Survey-In setups, the survey will complete when both 60 seconds have elapsed *and* a mean of 5m or less is obtained.

7.2.5 Base Transmitting



RTK Facet in Fixed Transmit Mode

Once the *survey-in* is complete the device enters RTCM Transmit mode. The number of RTCM transmissions is displayed. By default, this is one per second.

The *Fixed Base* mode is similar but uses a structure icon (shown above) to indicate a fixed base.

7.2.6 Base Transmitting NTRIP

If the NTRIP server is enabled the device will first attempt to connect over WiFi. The WiFi icon will blink until a WiFi connection is obtained. If the WiFi icon continually blinks be sure to check your SSID and PW for the local WiFi.



RTK Facet in Transmit Mode with NTRIP

Once WiFi connects the device will attempt to connect to the NTRIP mount point. Once successful the display will show 'Casting' along with a solid WiFi icon. The number of successful RTCM transmissions will increase every second.

Note: During NTRIP transmission WiFi is turned on and Bluetooth is turned off. You should not need to know the location information of the base so Bluetooth should not be needed. If necessary, USB can be connected to the USB port to view detailed location and ZED-F9P configuration information.

7.2.7 L-Band

L-Band decryption keys are valid for a maximum of 56 days. During that time, the RTK Facet L-Band can operate normally without the need for WiFi access. However, when the keys are set to expire in 28 days or less, the RTK Facet L-Band will attempt to log in to the 'Home' WiFi at each power on. If WiFi is not available, it will continue normal operation.



Display showing 14 days until L-Band Keys Expire

The unit will display various messages to aid the user in obtaining keys as needed.



Three-pronged satellite dish indicating L-Band reception

Upon successful reception and decryption of L-Band corrections, the satellite dish icon will increase to a three-pronged icon. As the unit's fix increases the cross-hair will indicate a basic 3D solution, a double blinking cross-hair will indicate a floating RTK solution, and a solid double cross-hair will indicate a fixed RTK solution.

7.2.8 Reference Station

The Reference Station is able to detect an open circuit or a short circuit on the GNSS antenna connection.



Reference Station with the GNSS antenna disconnected (open circuit)



Reference Station with a GNSS antenna cable fault (short circuit)

When the Reference Station is in Network Time Protocol (NTP) mode, the display also shows a clock symbol - as shown above. The value next to the clock symbol is the Time Accuracy Estimate (tAcc) from the UBX-NAV-PVT message.

Note: tAcc is the time accuracy estimate for the navigation position solution. The timing accuracy of the TP pulse is significantly better than this. We show the tAcc as we believe it is more meaningful than the TIM-TP time pulse quantization error (qErr) - which is generally zero.

7.2.9 Adding a Display to the RTK Surveyor

While the RTK Surveyor works very well using only LEDs, it is possible to add an external display. The [SparkFun Micro OLED Breakout \(Qwiic\)](#) can be attached to the Qwiic connector on the end of the Surveyor. At power on, the display will be automatically detected and used.

7.3 Output to an Embedded System

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

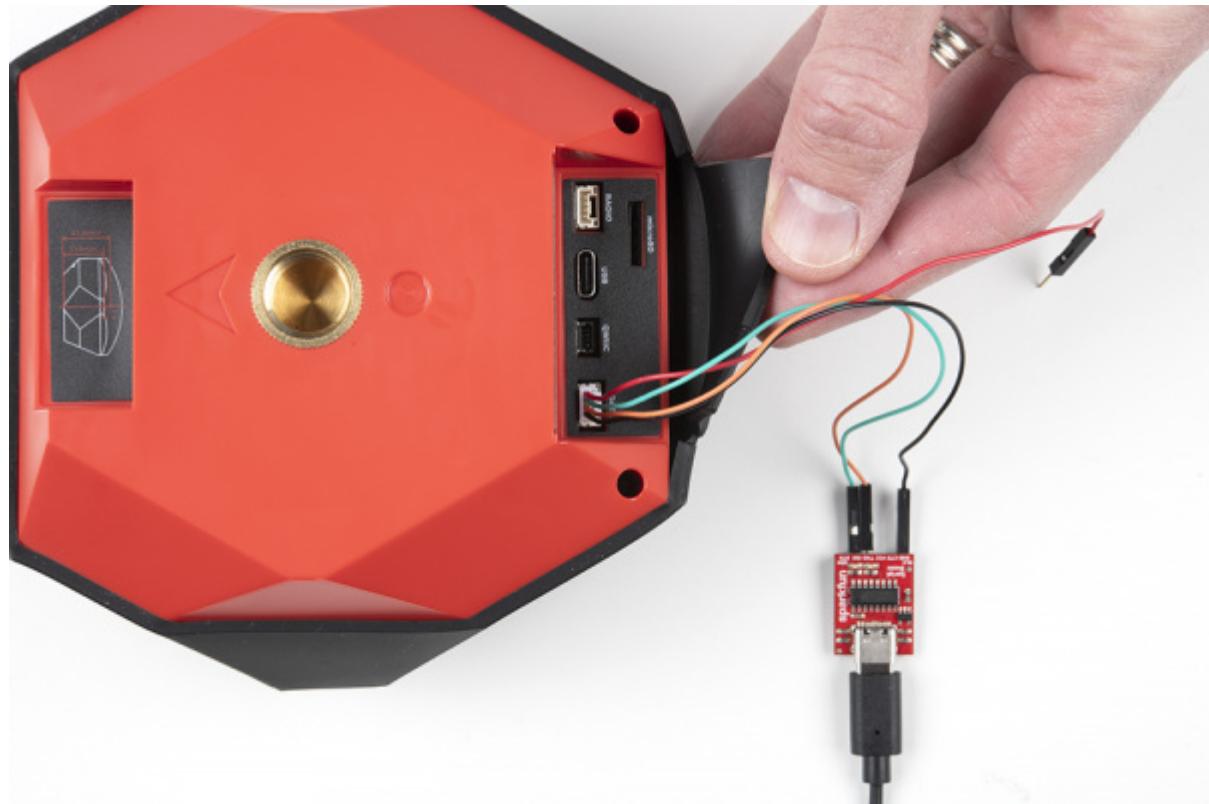
Many applications using the RTK products will use a 3rd party GIS application or mobile app like SW Maps and receive the data over Bluetooth. Alternatively, for embedded applications, a user can obtain the NMEA data over serial directly.

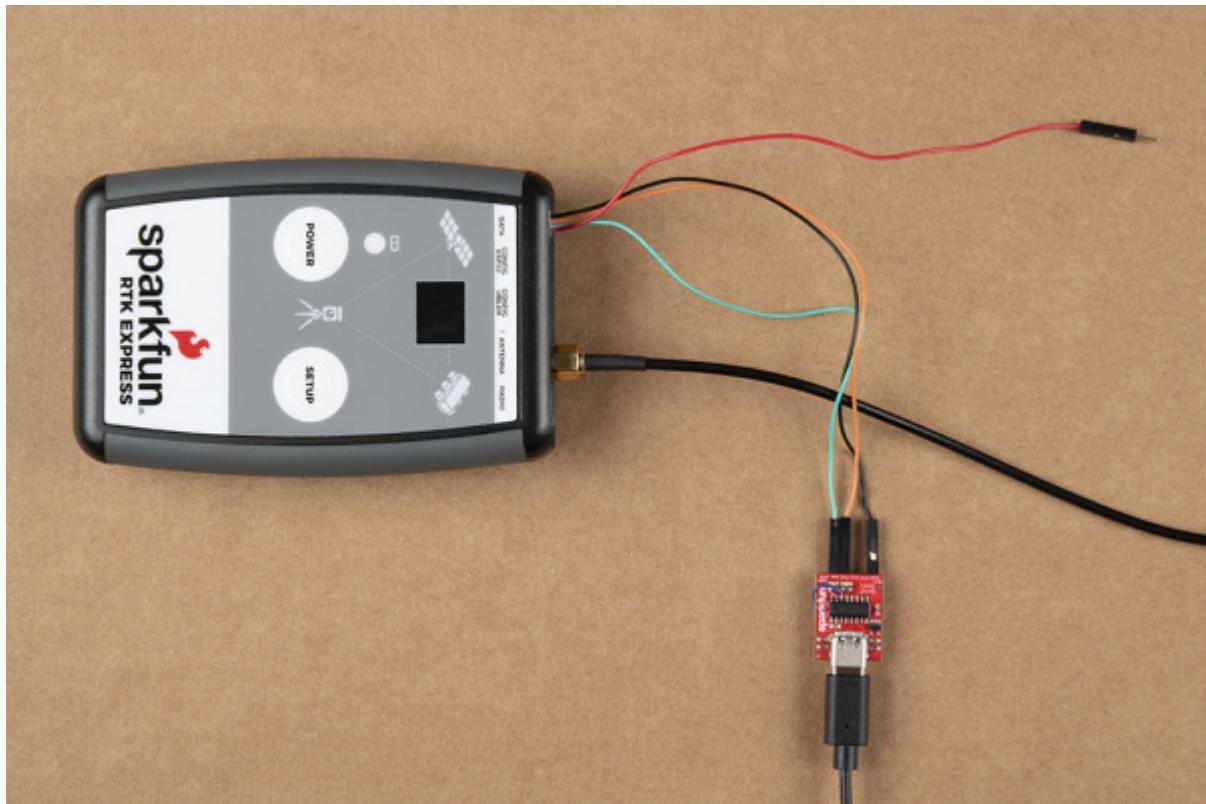
For this example, we will connect the output from the **Data** port to a [USB to Serial adapter](#) so that we can view the serial data over a terminal connection.

The **Data** port on the RTK Facet, Express, and Express Plus can be configured to output a variety of different signals including NMEA Serial data. Be sure to check out the [Ports Menu](#) section to be sure your device is configured to output NMEA.

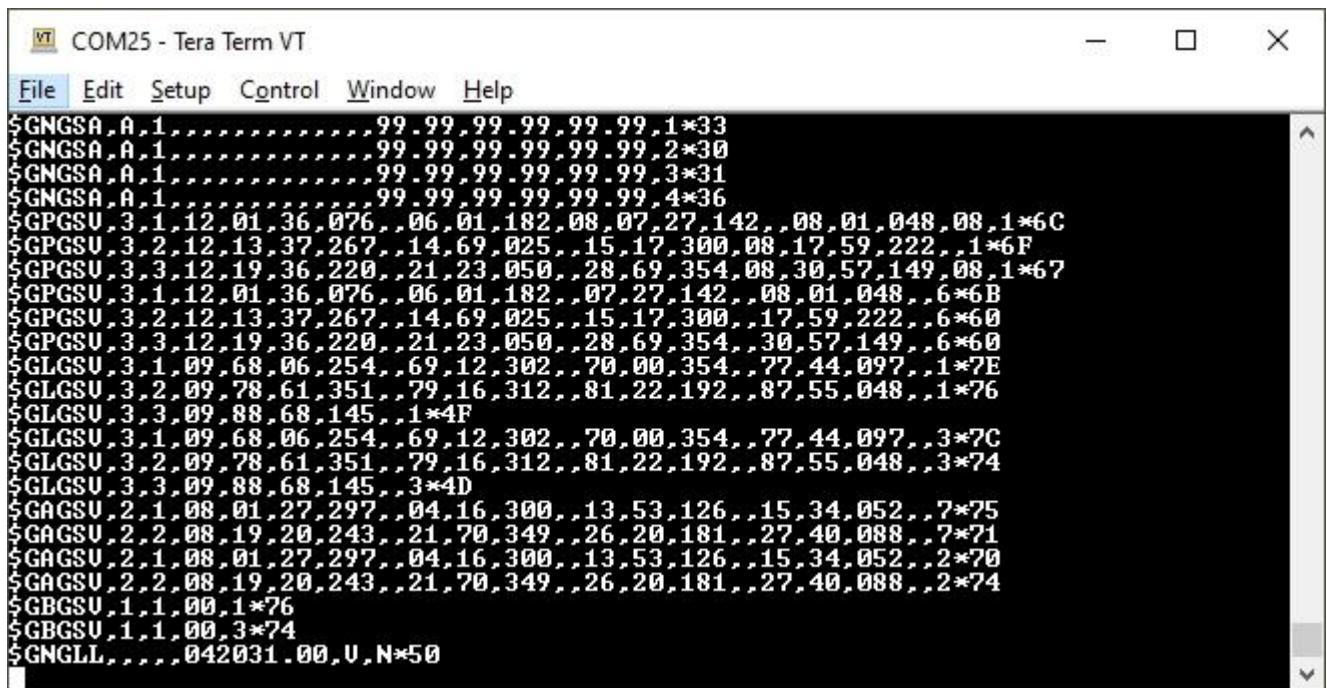
Connect the included [4-pin JST to breadboard cable](#) to the **Data** port. The cable has the following pinout:

- **Red** - 3.3V
- **Green** - TX (output from the RTK device)
- **Orange** - RX (input into the RTK device)
- **Black** - GND





Open a terminal at 115200bps and you should see NMEA sentences:



```

$GNGSA,A,1,,00000000,99.99,99.99,99.99,1*33
$GNGSA,A,1,,00000000,99.99,99.99,99.99,2*30
$GNGSA,A,1,,00000000,99.99,99.99,99.99,3*31
$GNGSA,A,1,,00000000,99.99,99.99,99.99,4*36
$GPGSU,3,1,12,01,36,076,,06,01,182,08,07,27,142,,08,01,048,08,1*6C
$GPGSU,3,2,12,13,37,267,,14,69,025,,15,17,300,08,17,59,222,,1*6F
$GPGSU,3,3,12,19,36,220,,21,23,050,,28,69,354,08,30,57,149,08,1*67
$GPGSU,3,1,12,01,36,076,,06,01,182,,07,27,142,,08,01,048,,6*6B
$GPGSU,3,2,12,13,37,267,,14,69,025,,15,17,300,,17,59,222,,6*60
$GPGSU,3,3,12,19,36,220,,21,23,050,,28,69,354,,30,57,149,,6*60
$GLGSU,3,1,09,68,06,254,,69,12,302,,70,00,354,,77,44,097,,1*7E
$GLGSU,3,2,09,78,61,351,,79,16,312,,81,22,192,,87,55,048,,1*76
$GLGSU,3,3,09,88,68,145,,3*4D
$GLGSU,3,1,09,68,06,254,,69,12,302,,70,00,354,,77,44,097,,3*7C
$GLGSU,3,2,09,78,61,351,,79,16,312,,81,22,192,,87,55,048,,3*74
$GAGSU,2,1,08,01,27,297,,04,16,300,,13,53,126,,15,34,052,,7*75
$GAGSU,2,2,08,19,20,243,,21,70,349,,26,20,181,,27,40,088,,7*71
$GAGSU,2,1,08,01,27,297,,04,16,300,,13,53,126,,15,34,052,,2*70
$GAGSU,2,2,08,19,20,243,,21,70,349,,26,20,181,,27,40,088,,2*74
$GBGSU,1,1,00,1*76
$GBGSU,1,1,00,3*74
$GNGLL,,,042031.00,U,N*50

```

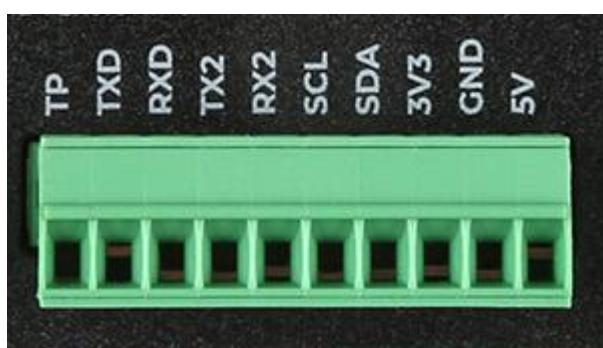
The Data connector on all RTK products is a 4-pin locking 1.25mm JST SMD connector (part#: SM04B-GHS-TB, mating connector part#: GHR-04V-S). **3.3V** is provided by this connector to power a remote device if needed. While the port is capable of sourcing up to 600mA, we do not recommend more than 300mA. This port should not be connected to a power source, so if your embedded device has its own power do not connect the red wire.

Warning! All data in and out of RTK products is **3.3V**. Exposing these pins to **5V** or higher voltage logic will damage the device.

The parsing of NMEA sentences is straightforward and left to the reader. There are ample NMEA parsing libraries available in C++, Arduino, Python, and many more languages.

7.3.1 Reference Station

The Reference Station provides direct access to the u-blox GNSS TX and RX signals via the 3.5mm screw terminal I/O header:



- TX2 : u-blox ZED-F9P UART2 transmit: 3.3V OUTPUT
- RX2 : u-blox ZED-F9P UART2 receive: 3.3V INPUT

Please see the [Reference Station Hookup Guide](#) for more details.

7.4 Disassembly / Repair

Surveyor:  / Express:  / Express Plus:  / Facet:  / Facet L-Band:  / Reference Station: 

The RTK product line is fully open-source hardware. This allows users to view schematics, code, and repair manuals. This section documents how to safely disassemble the RTK Facet and [Reference Station](#).

Repair Parts:

