SparkFun RTK Everywhere Product Manual

Simple and Cost Effective High-Precision Navigation

This PDF is automatically generated. See https://docs.sparkfun.com/SparkFun_RTK_Everywhere_Firmware/ for the latest version.

SparkFun Electronics - 2023

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1. Introduction

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

The line of RTK Everywhere products offered by SparkFun all run identical firmware. The RTK Everywhere firmware and this guide cover the following products:

SparkFun RTK Torch (GPS-26250)
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

2.1 Quick Start - RTK Torch

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?

2.1.1 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 Torch: Attach the Torch to a 5/8" 11-TPI standard surveying pole or to a monopole using the included thread adapter (Figure 1).

Figure 1

3. Turn on the RTK Torch device by pressing the Power button for 3 to 4 seconds until a beep is heard and the two front LEDs illuminate (Figure 2).

Figure 2

4. 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 ‘Torch Rover-3AF1’. The '3AF1' is the last four digits of the device's MAC address and will vary depending on the device (Figure 4).

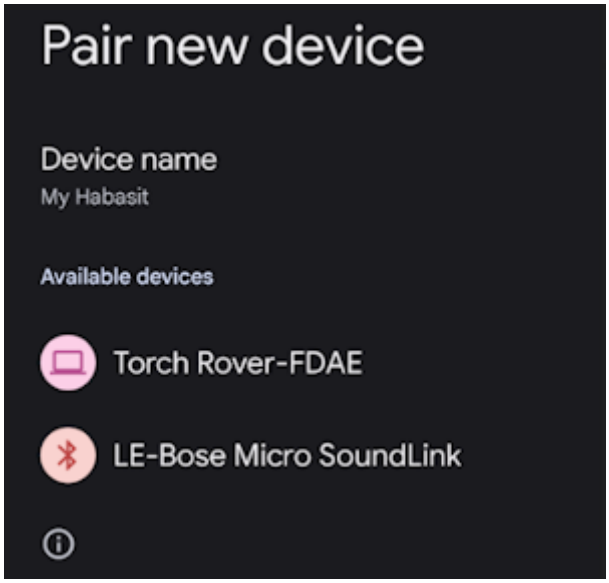


Figure 4

5. Once paired, open SW Maps. Select ‘New Project’ and give your project a name like ‘RTK Project’.
6. Press the SW Maps icon in the top left corner of the home screen and select **Bluetooth GNSS**. You should see the Torch Rover-3AF1’ in the list. Select it. Confirm that the *Instrument Model* is **SparkFun RTK**, 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.

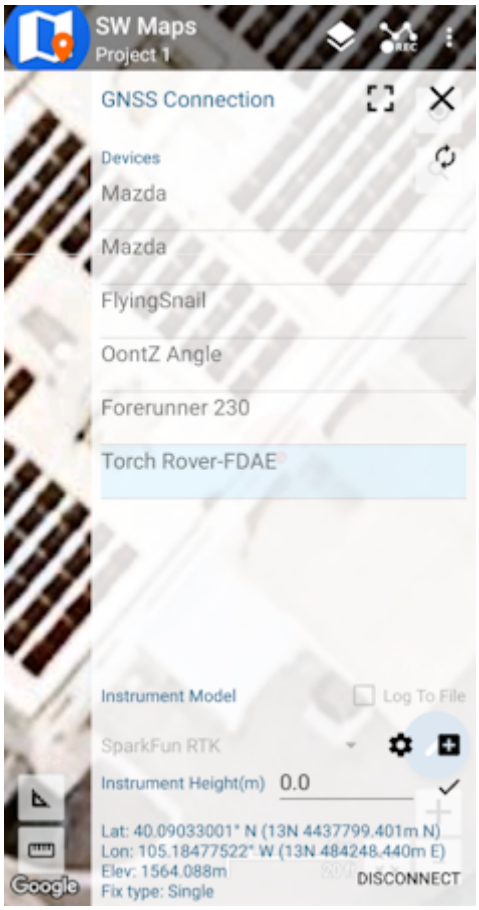


Figure 5

7. Once connected, have a look at the Bluetooth LED on the RTK device. You should see the LED turn solid. You're connected!
8. Now put the device outside with a clear view of the sky. GNSS doesn't work indoors or near windows. Press the SW Maps icon in the top left corner of the home screen and select **GNSS Status**. Within about 30 seconds you should see 10 or more satellites in view (SIV) (Figure 6). 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. This accuracy is around 2m in normal mode.

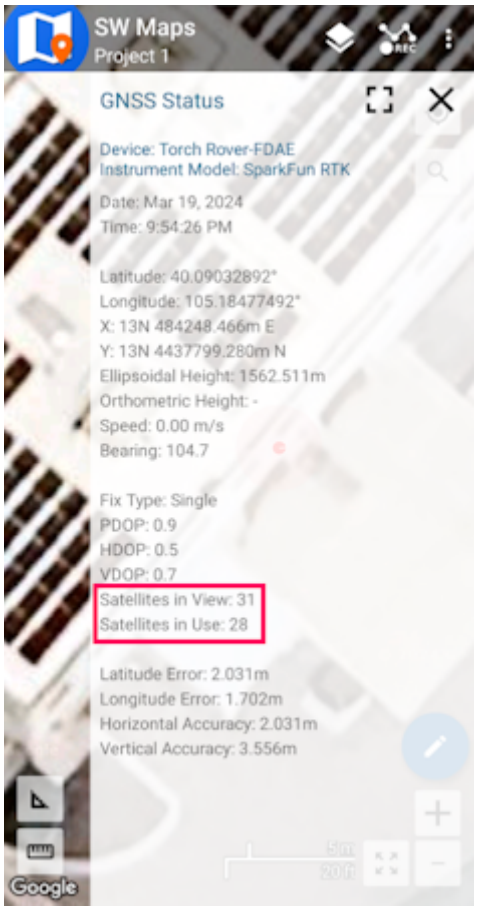


Figure 6

You can now use your RTK device to measure points with good (meter) accuracy. If you need extreme accuracy (down to 8mm) continue reading the RTK Crash Course.

2.1.2 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 Torch: Attach the Torch to a 5/8" 11-TPI standard surveying pole or to a monopole using the included thread adapter (Figure 1).

Figure 1

3. Turn on the RTK Torch device by pressing the Power button for 3 to 4 seconds until a beep is heard and the two front LEDs illuminate (Figure 2).

Figure 2

4. Open SW Maps. Select ‘New Project’ and give your project a name like ‘RTK Project’.
5. 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.
6. Once connected, have a look at the Bluetooth LED on the RTK device. You should see the LED turn solid. You’re connected!
7. Now put the device outside with a clear view of the sky. GNSS doesn’t work indoors or near windows. Press the SW Maps icon in the top left corner of the home screen and select **GNSS Status**. Within about 30 seconds you should see 10 or more satellites in view (SIV) (Figure 3). 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. This accuracy is around 2m in normal mode.

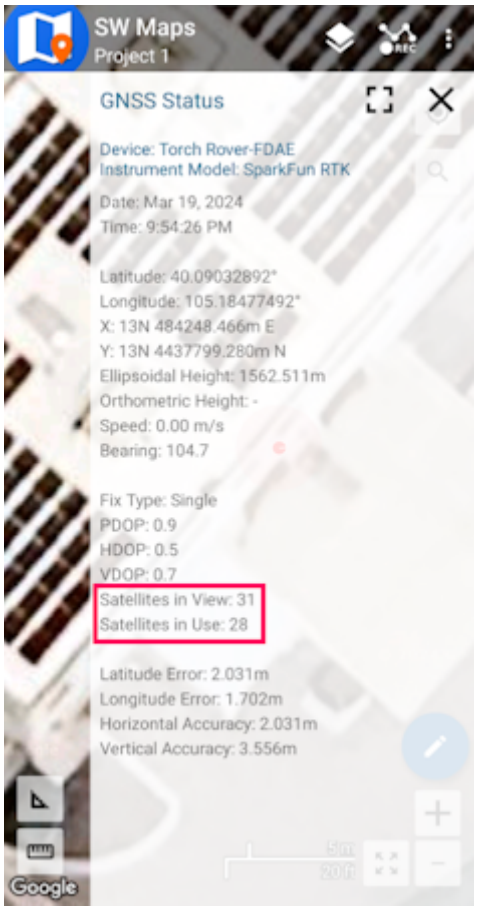


Figure 3

You can now use your RTK device to measure points with good (meter) accuracy. If you need extreme accuracy (down to 8mm) continue reading the RTK Crash Course.

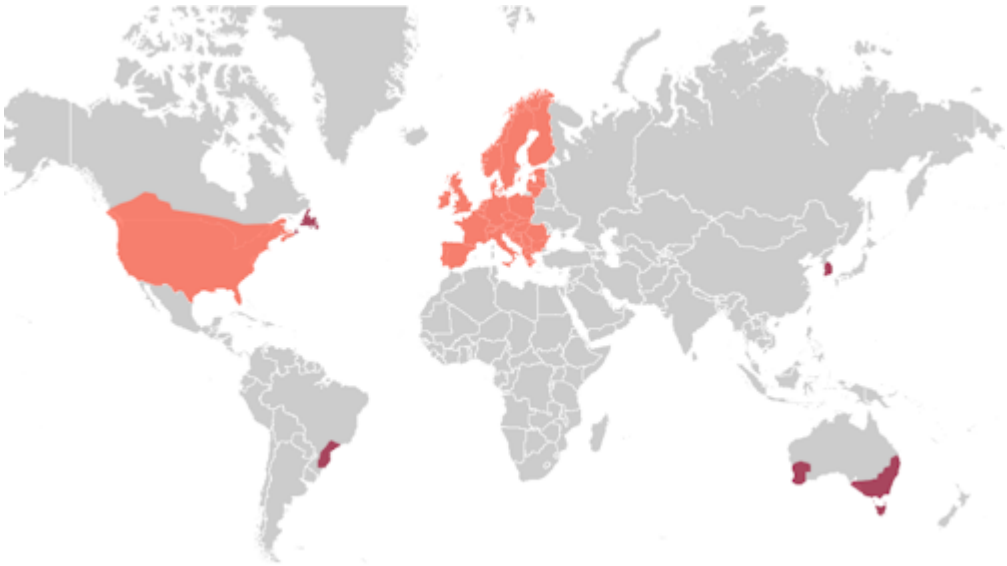
2.1.3 RTK Crash Course

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.

See Corrections Sources for a breakdown of the options and the pros and cons of each. For this quickstart, we'll be showing two examples: using PointPerfect for $8 a month (a little less accurate but nation-wide coverage) and PointOne Nav for $50 a month (maximum accuracy, gaps in the coverage area).

2.1.4 PointPerfect Corrections

One of the great features of the RTK Torch is that it has the ability to get corrections from PointPerfect over WiFi. No need for NTRIP credentials! Contact SparkFun with your device ID, pay a small monthly fee of $8 per month (as of this writing) and your device will obtain credentials and start receiving corrections anywhere there is coverage.



PointPerfect Coverage map including L-Band and IP delivery methods

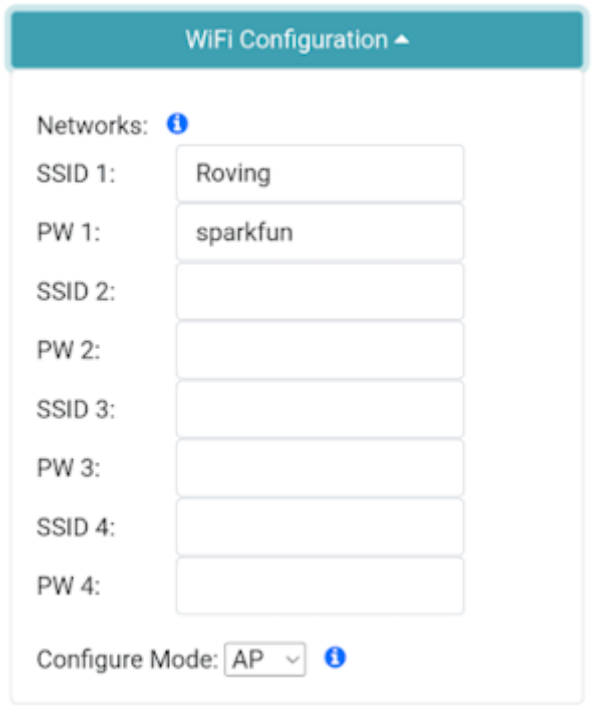
The PointPerfect IP service is available for various areas of the globe including the contiguous US, EU, South Korea, as well as parts of Brazil, Australia, and Canada. See the coverage map for specifics; the RTK Torch is compatible with any area that has *IP Coverage* (it is not compatible with L-Band coverage).

Steps to use PointPerfect:

1. Register the device with SparkFun by entering the device ID (this is the ID seen on the printed stickers included in the kit). It can take up to two business days for registration to complete.
2. Power on the RTK Torch by pressing and holding the power button for around 4 seconds. The device will emit a short beep and illuminate the LEDs.
3. Put the RTK Torch into WiFi config mode by double-tapping the power button. You will hear two beeps indicating it is ready to connect to.

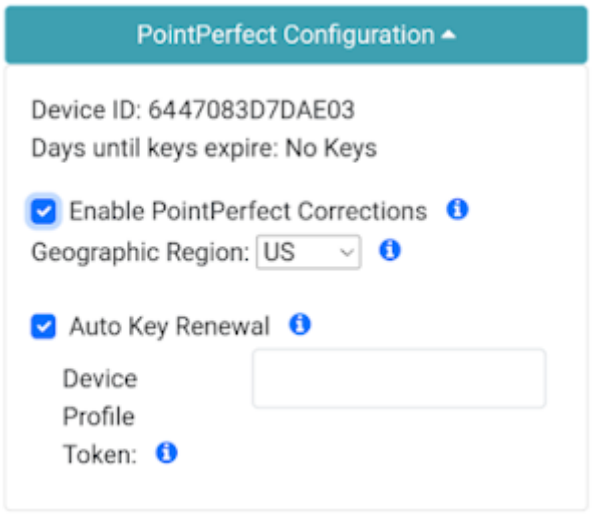
SparkFun RTK WiFi Configuration Interface

4. From your phone, connect to the WiFi network *RTK Config*. You should be redirected to the WiFi Config page. If you are not, open a browser (Chrome is preferred) and type **rtk.local** into the address bar.



WiFi Menu containing one network

5. Under the *WiFi Configuration* menu, give the device WiFi credentials for your local WiFi. This can be the cellphone hotspot if local WiFi is not available.

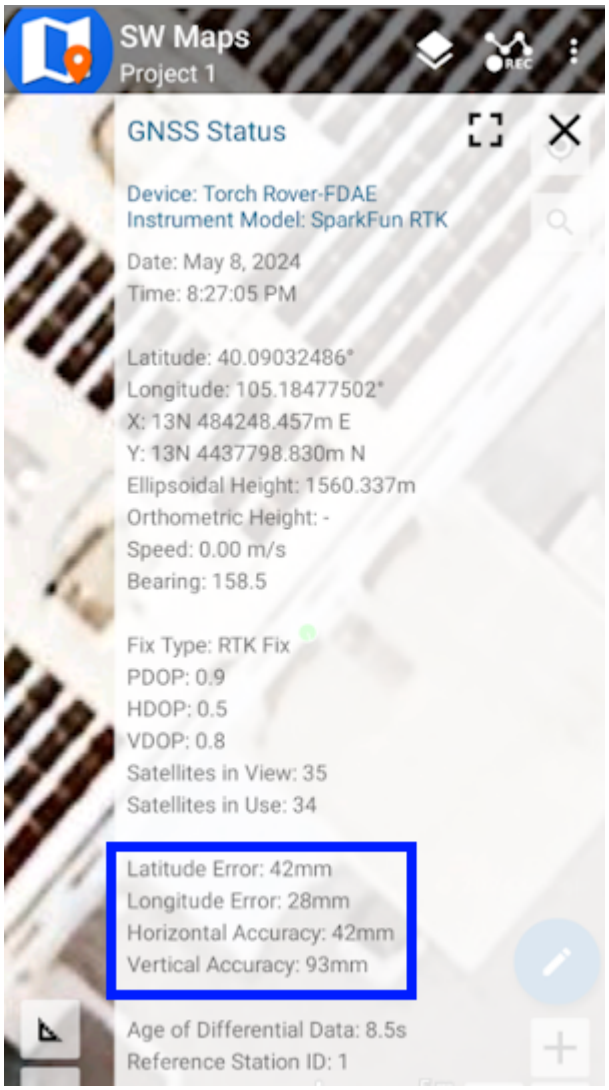


PointPerfect Configuration Menu

6. Under the *PointPerfect Configuration* menu, **Enable PointPefect Corrections**.

Saving... then All Saved

7. Click **Save Configuration**. The device will record all settings in a few seconds. Then press **Exit and Reset**. The unit will now reboot.



SW Maps showing positional accuracy

After the reboot, the device will connect to WiFi, obtain keys, and begin applying corrections. Assuming you are outside, after a few minutes of receiving PointPerfect corrections to the device, connect to the RTK Torch over SW Maps (or other) and the device will enter RTK Float, then RTK Fix (usually under 3 minutes). You can now take positional readings with millimeter accuracy!

2.1.5 NTRIP Example

If you decide to use a service that provides NTRIP (as opposed to PointPerfect) 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.

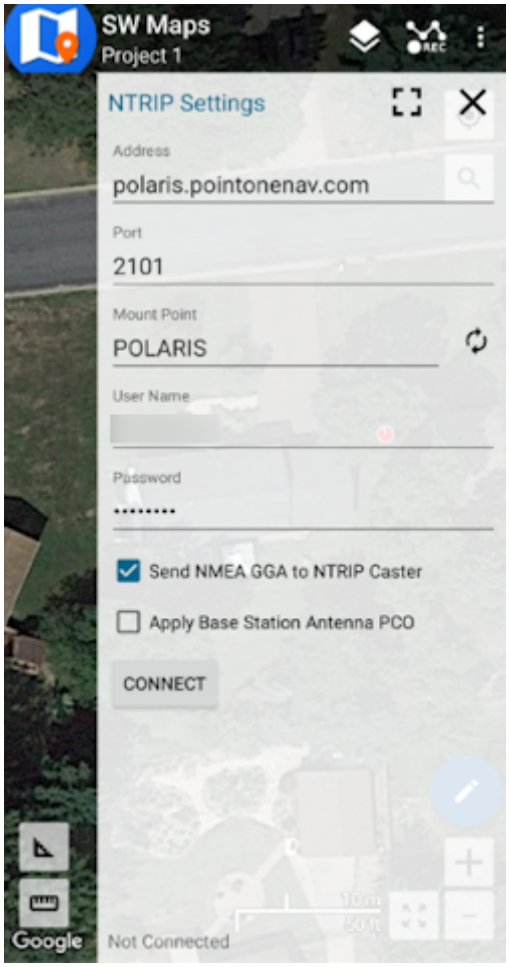


Figure 1

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 bubble in SW Maps will turn Orange (RTK Float). Once RTK Fix is achieved (usually under 30 seconds) the bubble will turn Green and the HPA will be below 20mm (Figure 2). You can now take positional readings with millimeter accuracy!

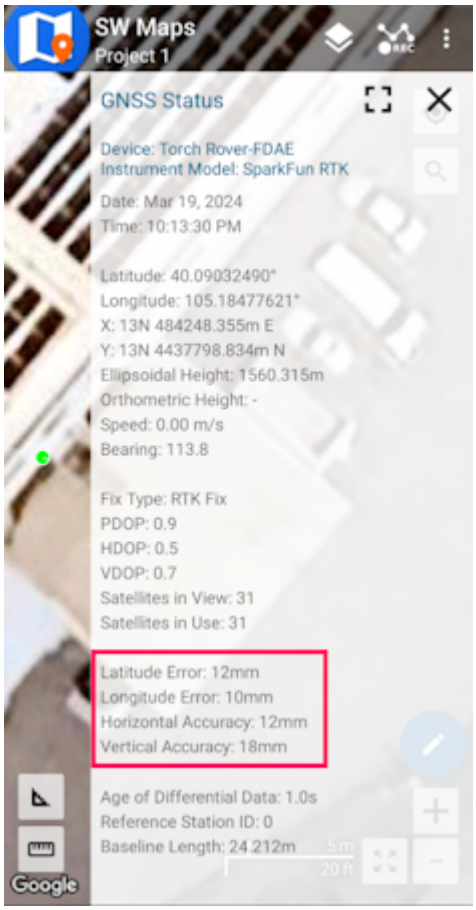


Figure 2

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).

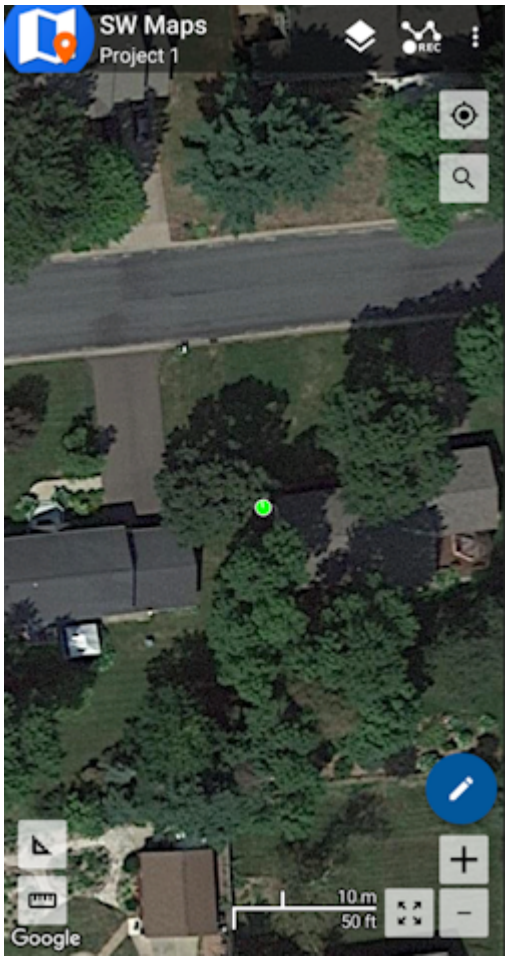


Figure 3

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.

2.1.6 Common Gotchas

- 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. The Torch ARP is here. Note: This rule does not apply when tilt compensation is activated. See the Tilt Compensation Menu for more information.
- 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.

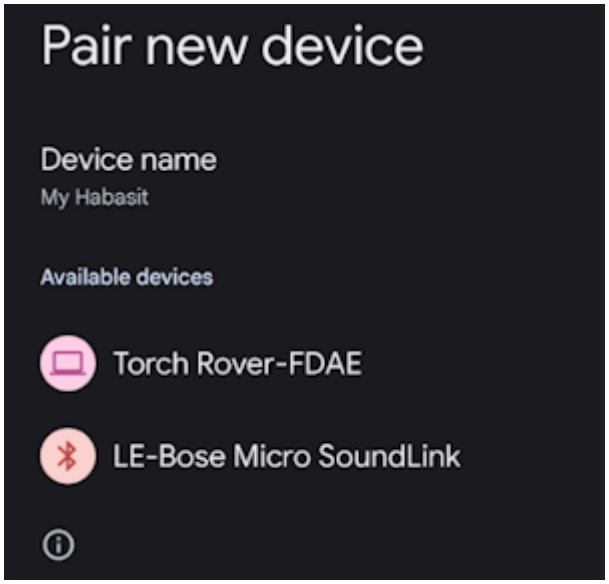
3. Connecting Bluetooth

Torch:

SparkFun RTK devices transmit full NMEA sentences over Bluetooth serial port profile (SPP) at 2Hz 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 SparkFun RTK devices. As long as your end system can open a serial port over Bluetooth (also known as SPP) your system 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.

Note: BLE is also supported and can be used in place of Bluetooth SPP. See Bluetooth Protocols for more information.

3.1 Android



Pairing with the 'Torch Rover-DFAE' 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 Torch, Facet, 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

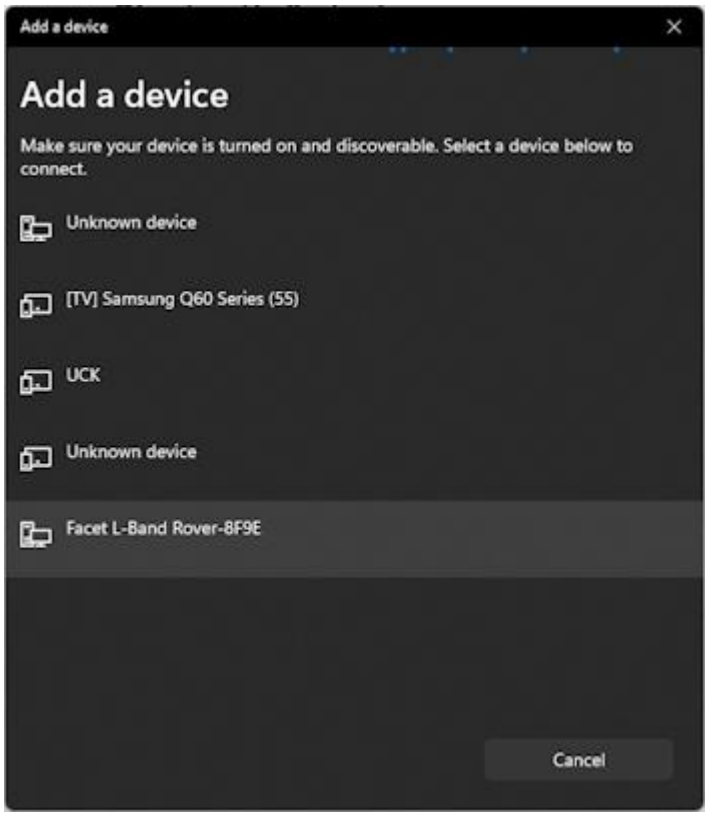
Note: For devices with a built-in display, *B022* is the last four digits of your unit's MAC address and will be unique to the device in front of you. This is helpful in case there are multiple RTK devices within Bluetooth range.

3.2 Windows

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

Adding Bluetooth Device

Click Bluetooth 'Mice, Keyboards, ...'



Viewing available Bluetooth Devices

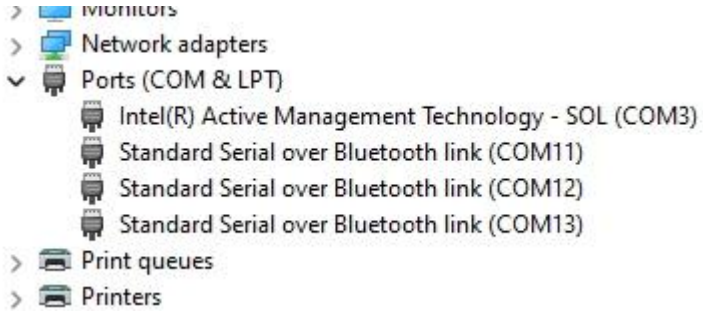
Click on the RTK device. When powered on, the RTK product will broadcast itself as either '[Platform] Rover-5556' or '[Platform] Base-5556' depending on which state it is in. [Platform] is Facet, Express, Surveyor, etc. Discover and pair with this device from your phone or tablet. Once paired, open SW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

Bluetooth MAC address B022 is shown in the upper left corner

Note: For devices with a built-in display, *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.

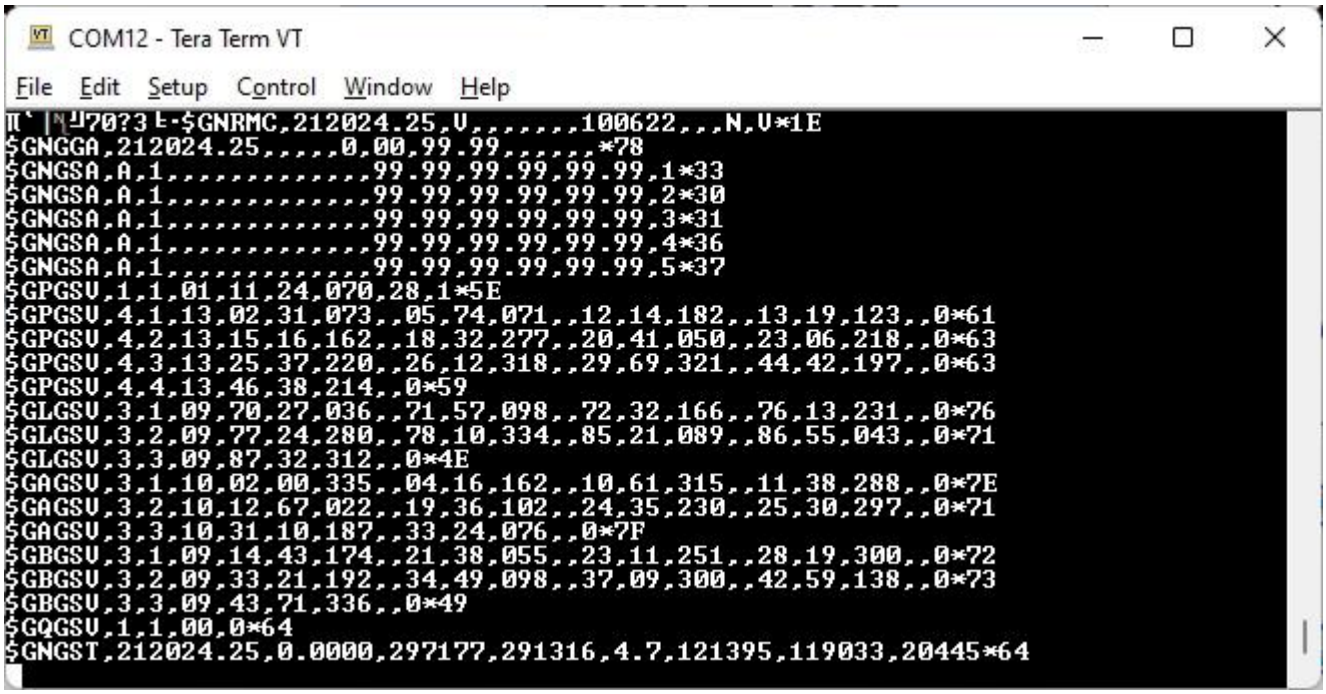
Bluetooth Connection Success

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



Bluetooth COM ports

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



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

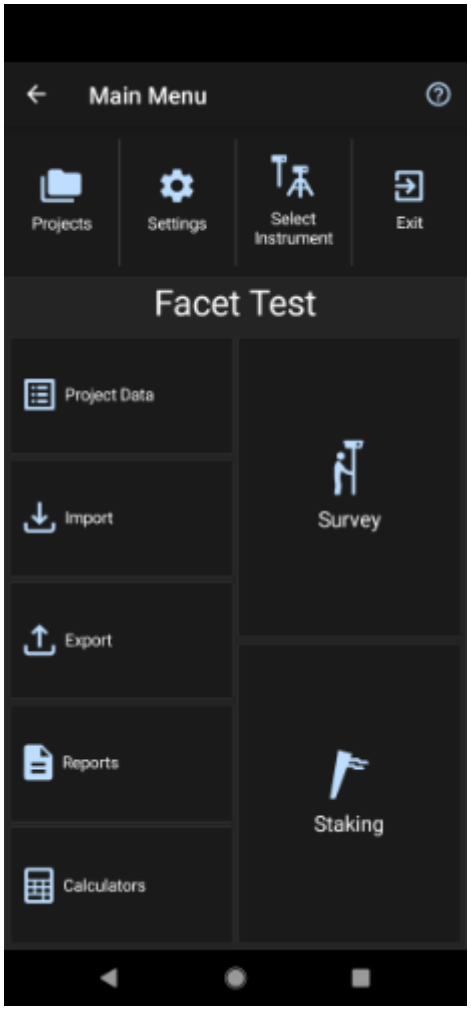
Torch:

While we recommend SW Maps for Android, there are a variety of 3rd party apps available for GIS and surveying for Android, iOS, and Windows. 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.

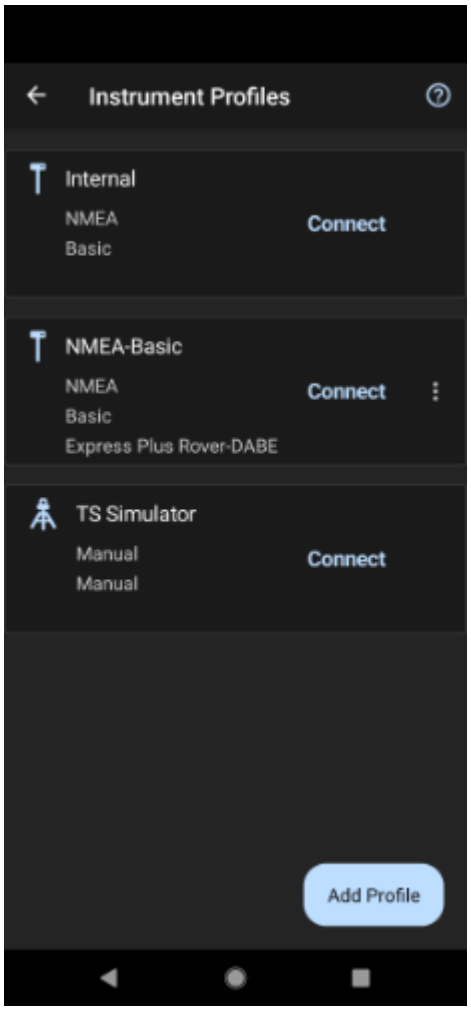
4.1.1 Field Genius

Field Genius for Android is another good solution, albeit a lot more expensive than free.

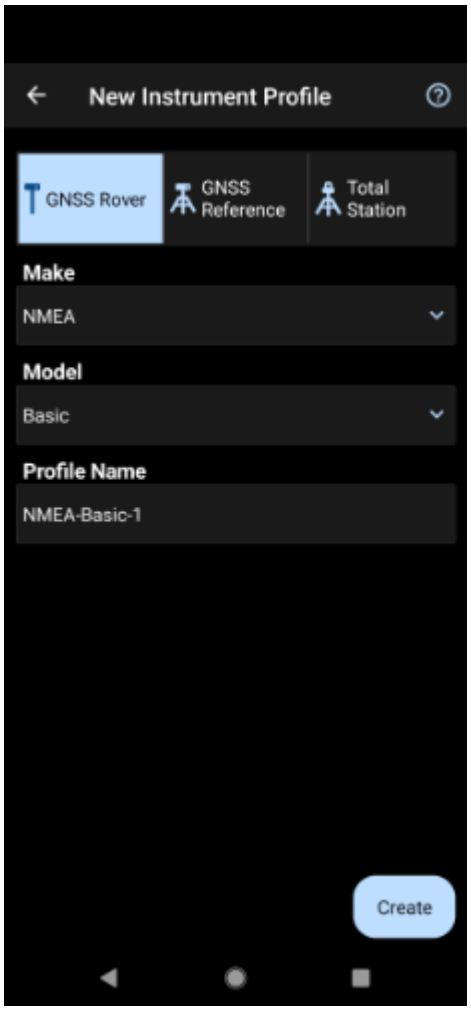
Be sure your device is paired over Bluetooth.



From the Main Menu open `Select Instrument`.

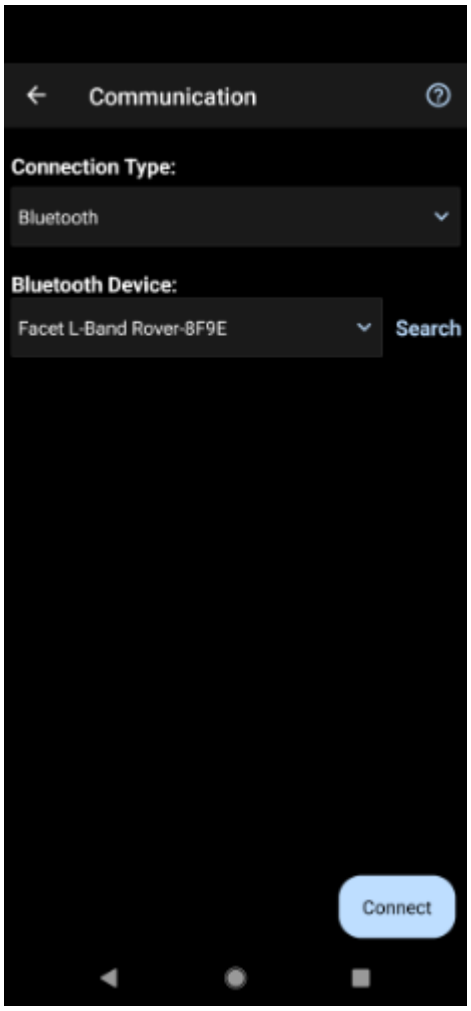


Click the 'Add Profile' button.

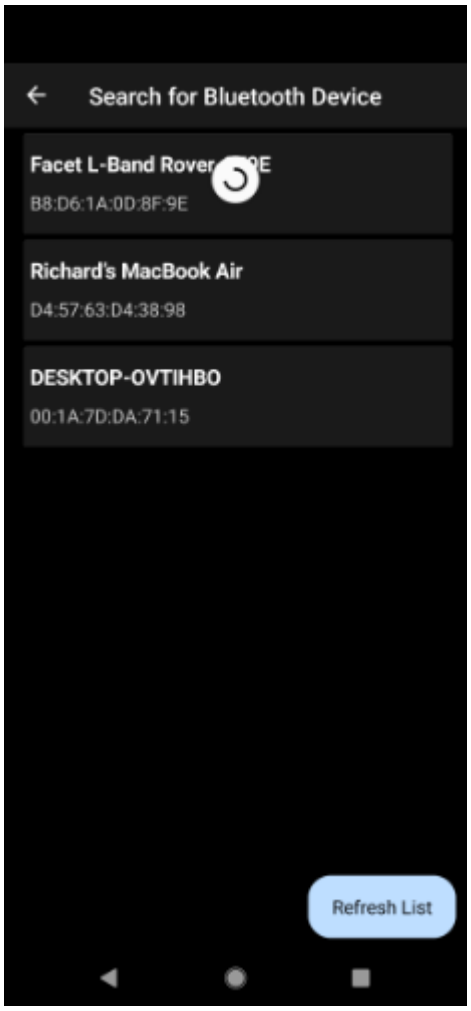


Click `GNSS Rover` and select *NMEA* as the Make. Set your Profile Name to something memorable like 'SparkFun RTK' then click the 'Create' button.

Click on 'SET UP COMMUNICATION'.



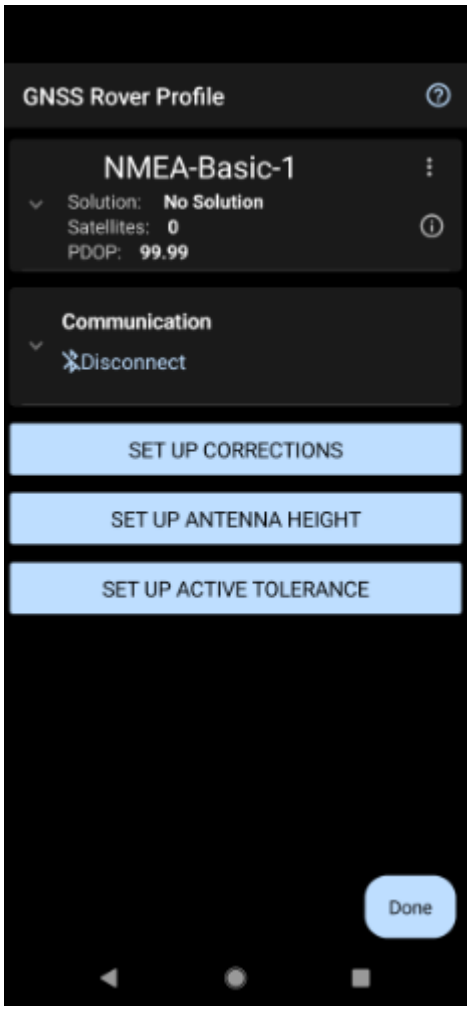
From the Bluetooth communication page, click the 'Search' button.



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.

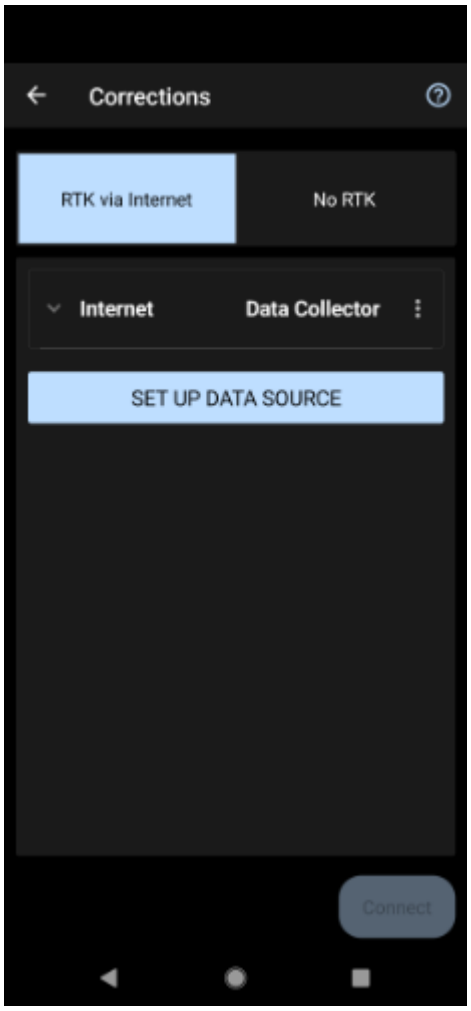
NTRIP Client

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.

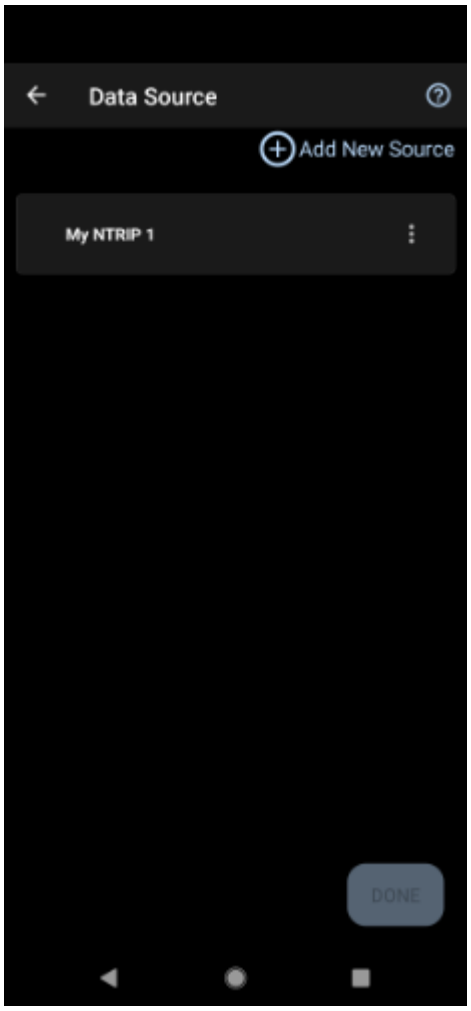


We need to send RTCM correction data from the phone back to the RTK device so that it can improve its fix accuracy. Your phone can be the radio link! Click on 'SET UP CORRECTIONS'.

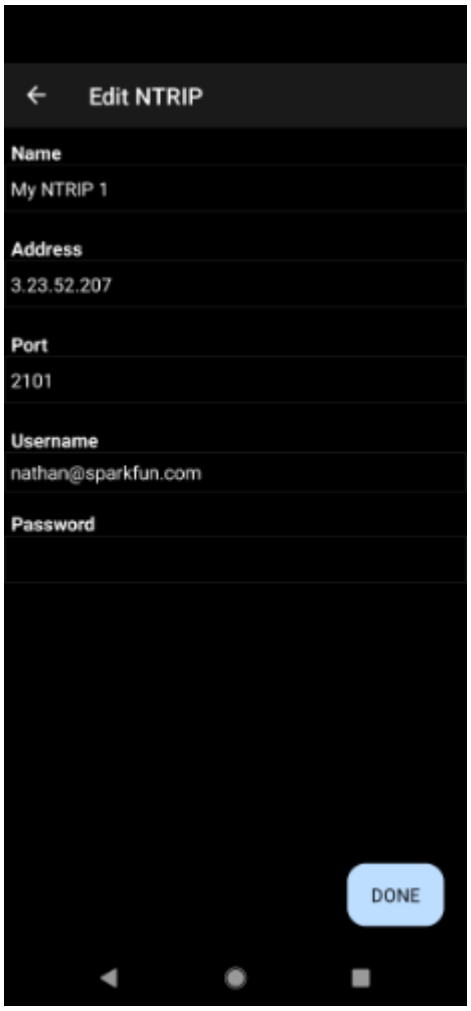
Click on 'RTK via Internet' then 'SET UP INTERNET', then 'Done'.



Click on 'SET UP DATA SOURCE'.



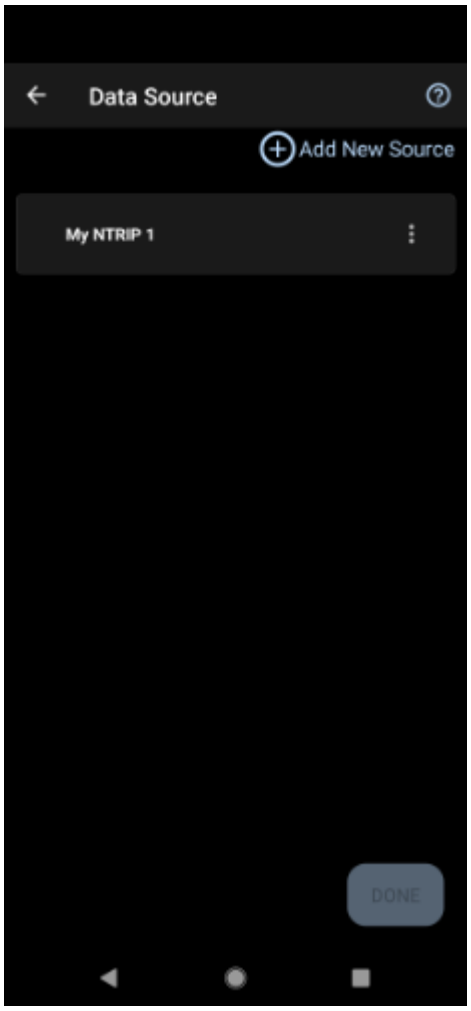
Click 'Add New Source'.



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.

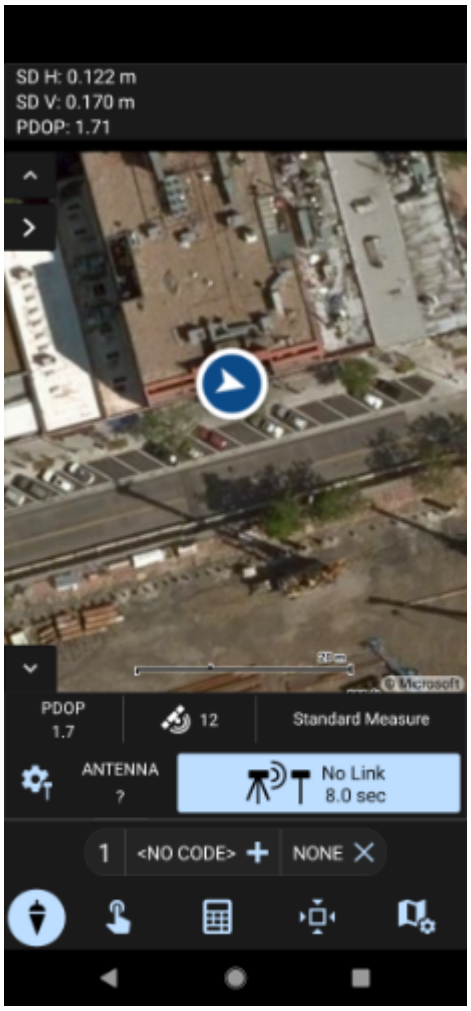
Don't have access to an NTRIP Caster? You can use a 2nd RTK product operating in Base mode to provide the correction data. Checkout Creating a Permanent Base. If you're the DIY sort, you can create your own low-cost base station using an ESP32 and a ZED-F9P breakout board. Check out How to Build a DIY 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.



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'.

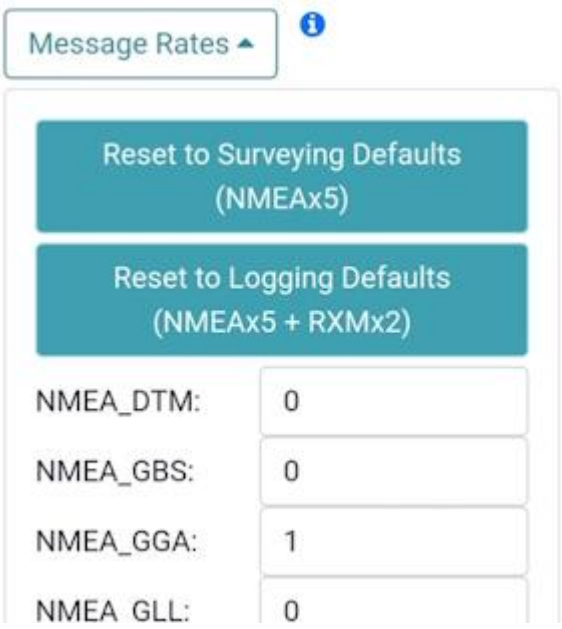
Select 'Done' then from the main menu select 'Survey' to begin using the device.



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.

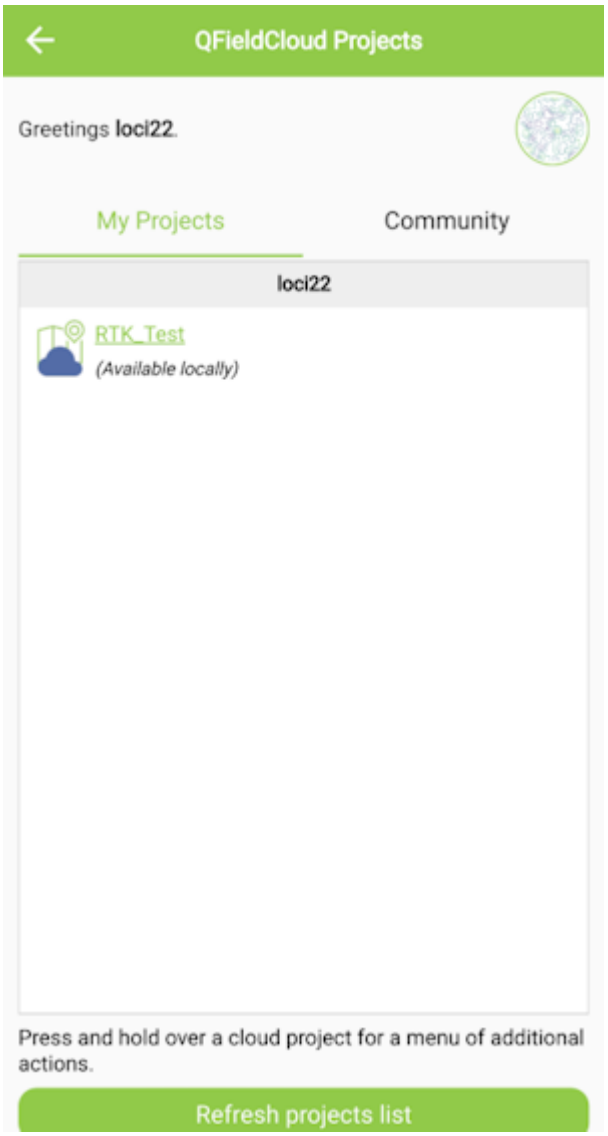


The 'Reset to Surveying Defaults' button

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.

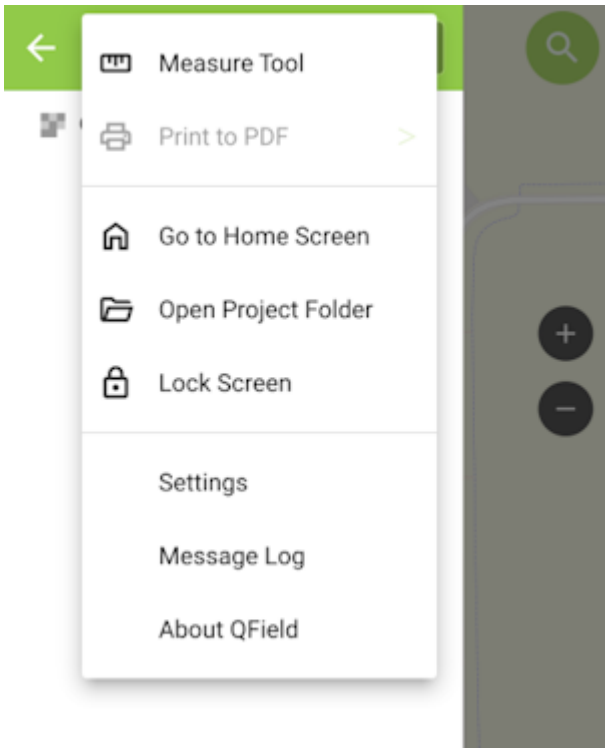


Refresh Projects button

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

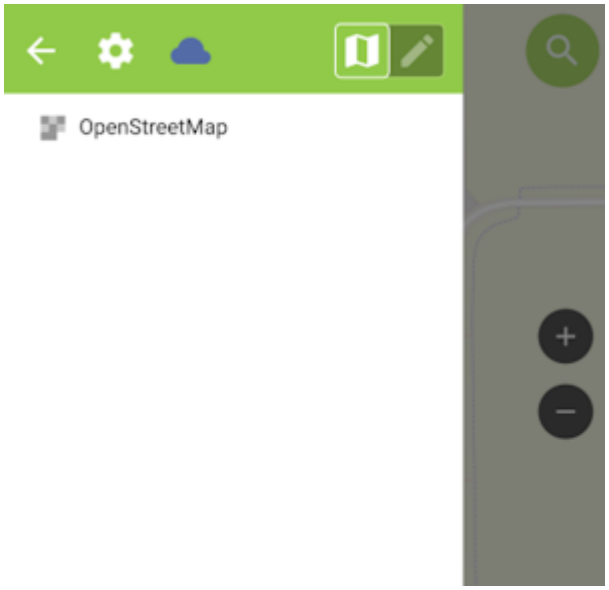
'Hamburger' menu in upper right corner

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



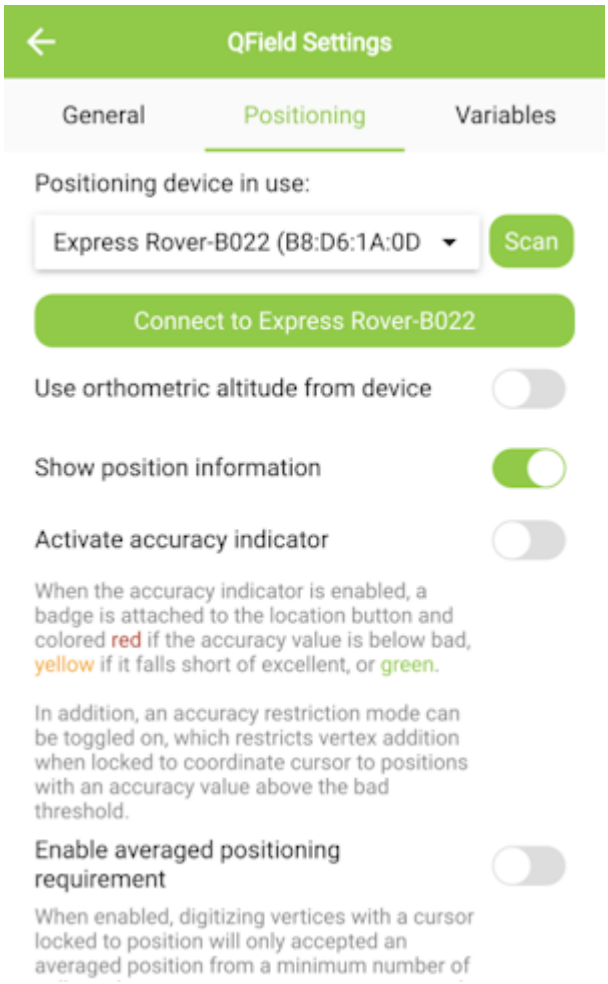
Project settings

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



Project settings submenu

From the submenu, select 'Settings'.



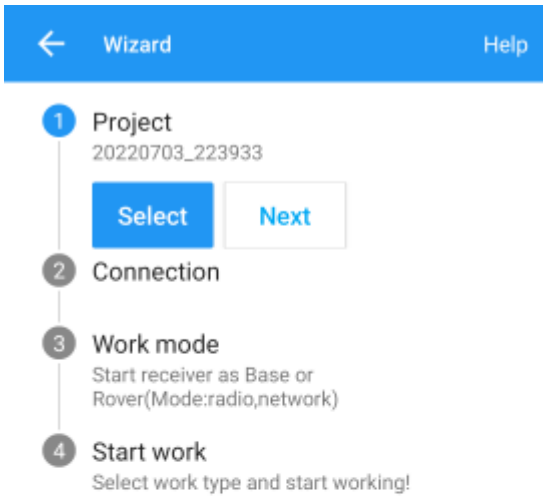
Positioning Menu

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.

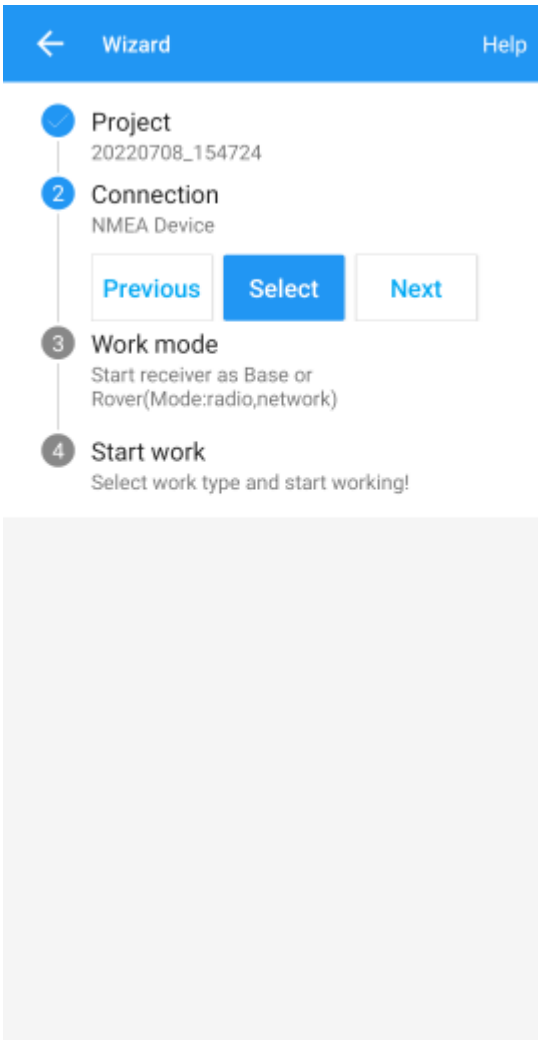
Once connected exit out of the menus and see position information within your project.

4.1.3 Survey Master

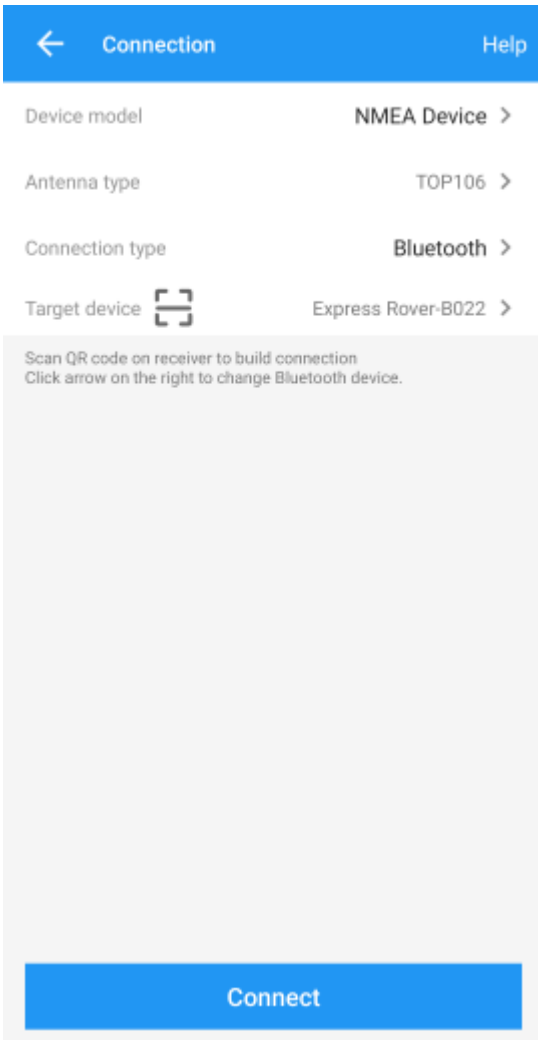
Survey Master by ComNam / SinoGNSS is an Android-based option. The download location can vary so google 'Survey Master ComNav Download' if the link above fails. Download the zip file, send the APK file to a phone and install the program.



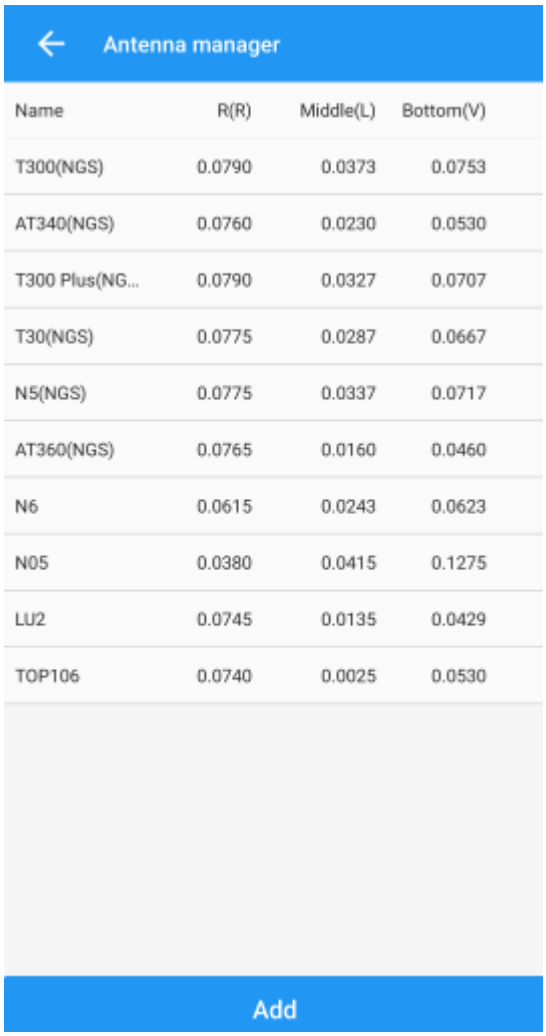
By default, a wizard will guide you through the setup. The Project step will ask you for the name of the project, the datum, etc.



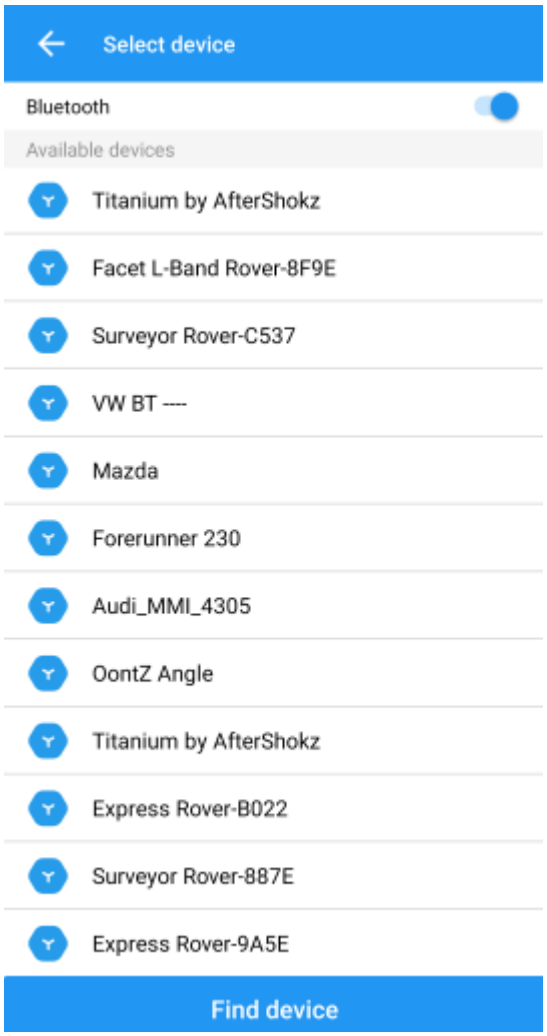
Next select your connection.



For the Device Model select 'NMEA Device'.

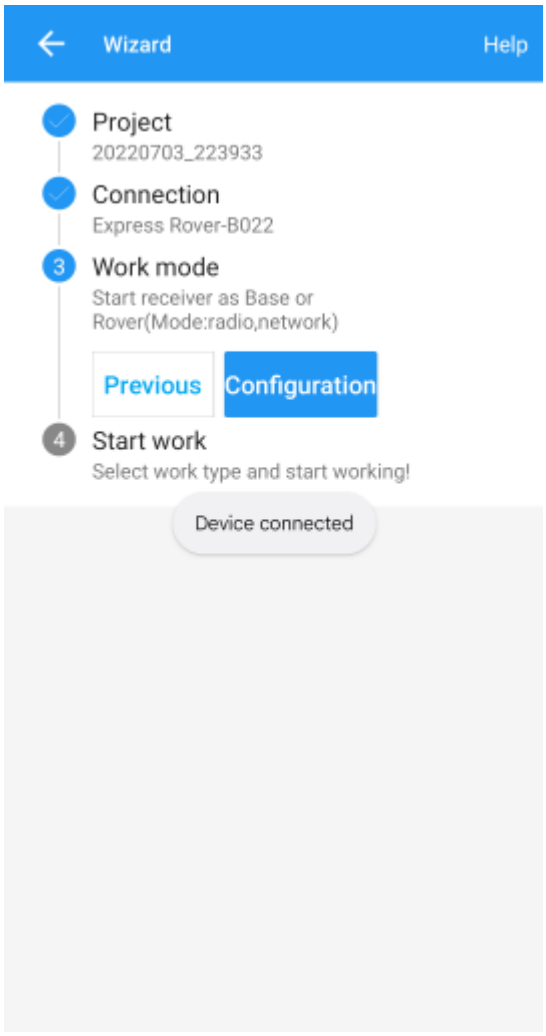


If you are just getting started, use one of the default antenna types. If you are attempting to get sub-centimeter accuracy, enter the parameters of your antenna and add it. Above are the NGS-certified parameters for the TOP106 antenna.

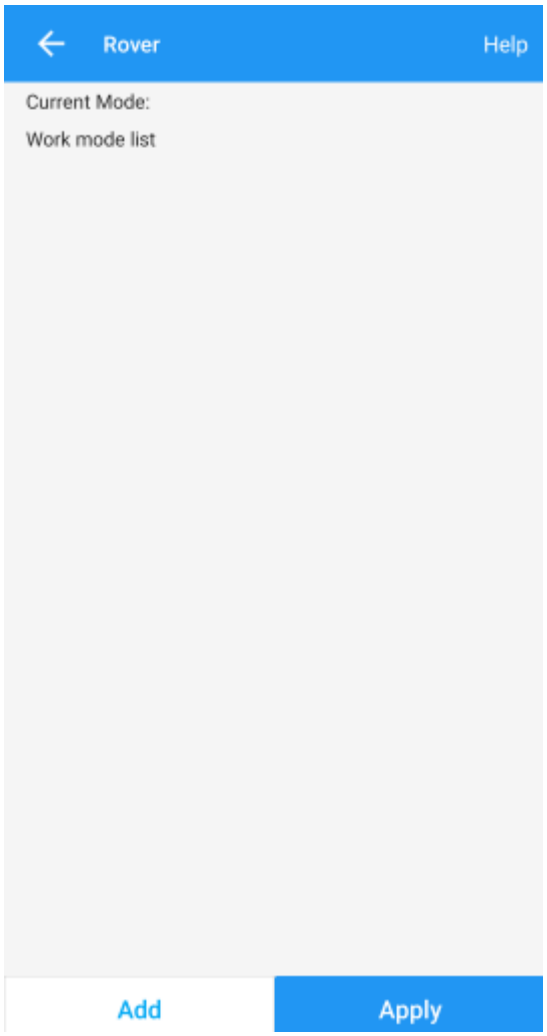


Click the 'Target Device' option to get a list of available Bluetooth devices. Make sure your RTK product is on and you should see the device. In this example 'Express Rover-B022' was chosen.

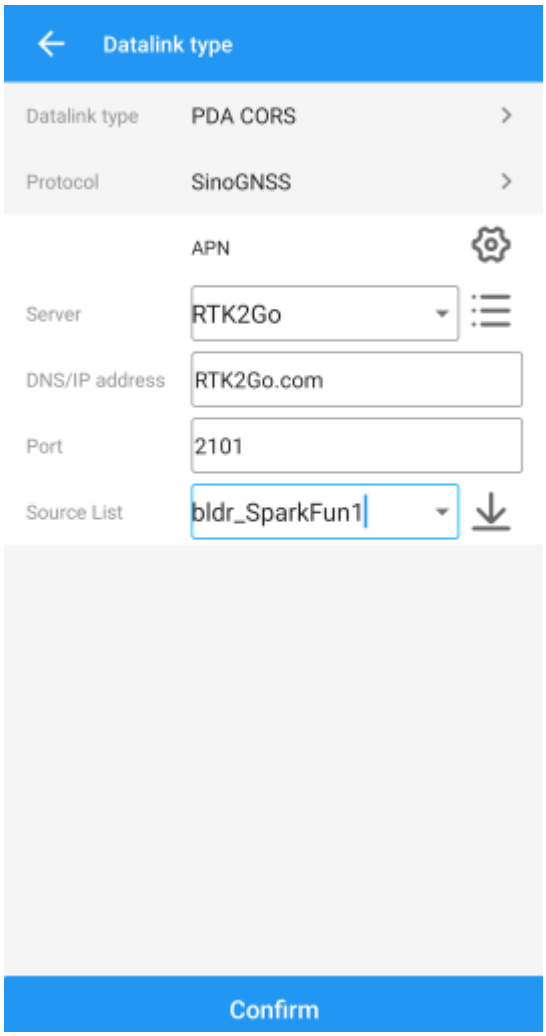
To finish, click 'Connect'. You should see the Bluetooth MAC address on your RTK product change to the Bluetooth icon indicating a connection is established.



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

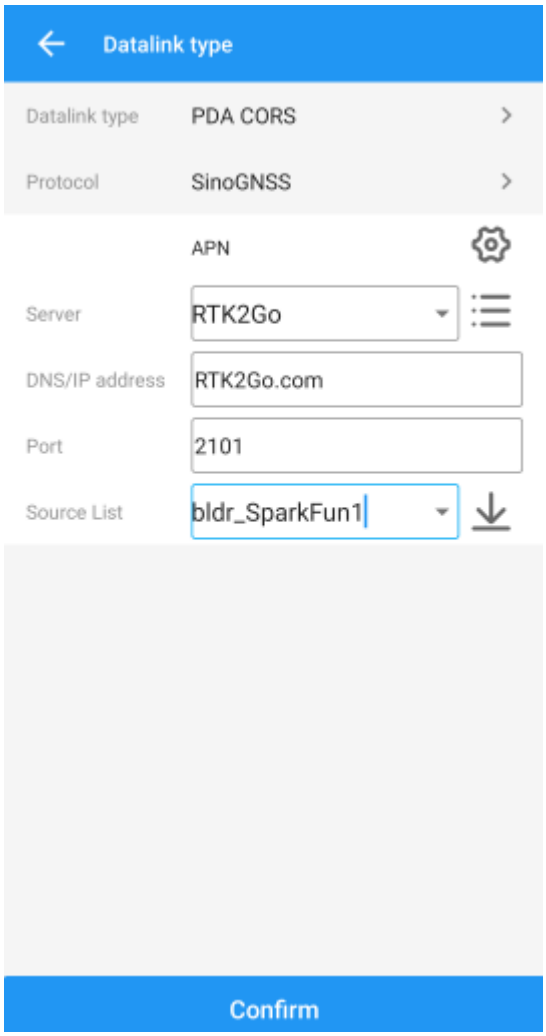


Click 'Add' to create a new work mode.

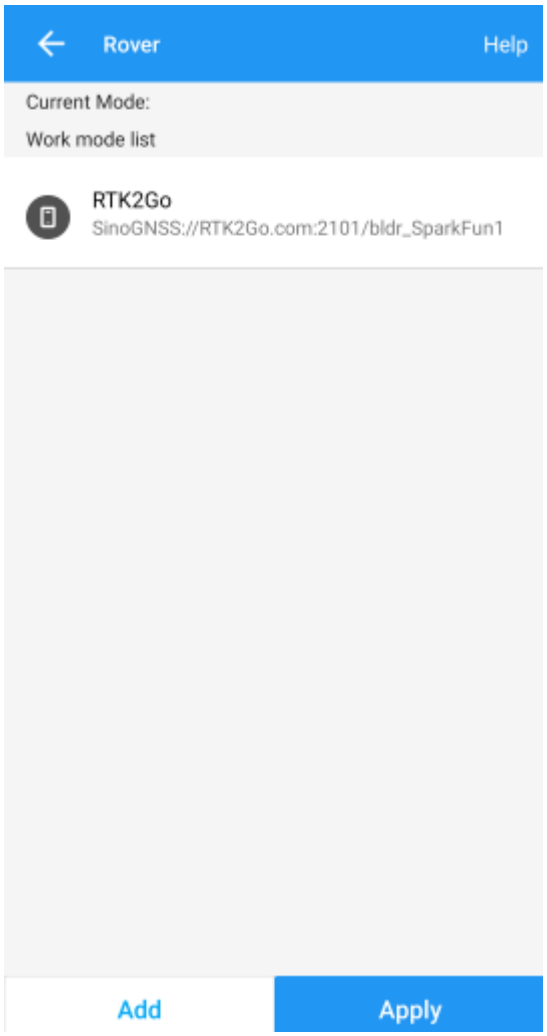


Shown above, we configure the NTRIP Client. Survey Master calls this the 'SinoGNSS' Protocol. Click on the three bars to the right of 'Server' to enter a new NTRIP connection.

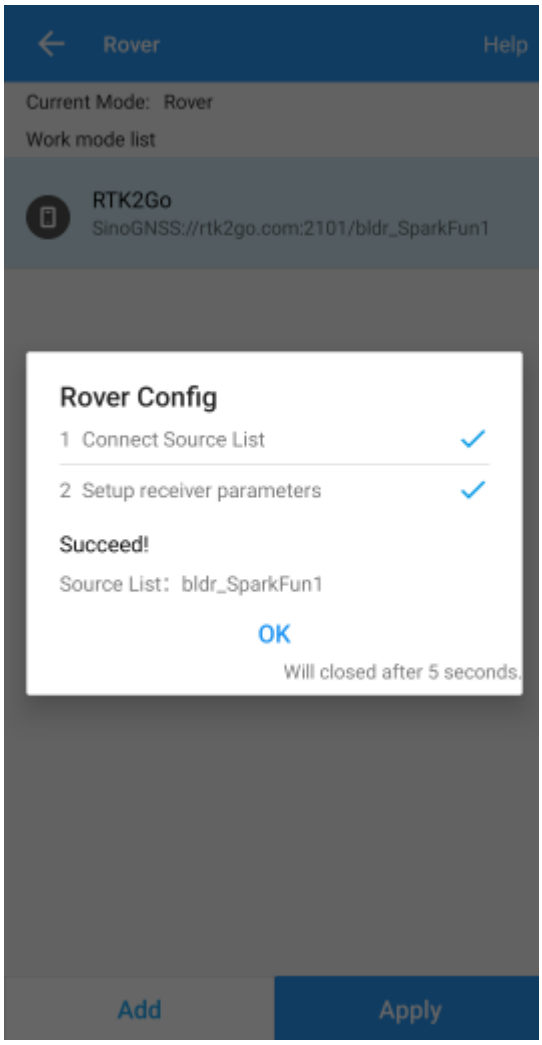
Here you can add different NTRIP Caster providers. If you're using RTK2Go be sure to enter your contact email into the user name.



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 TIM 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:

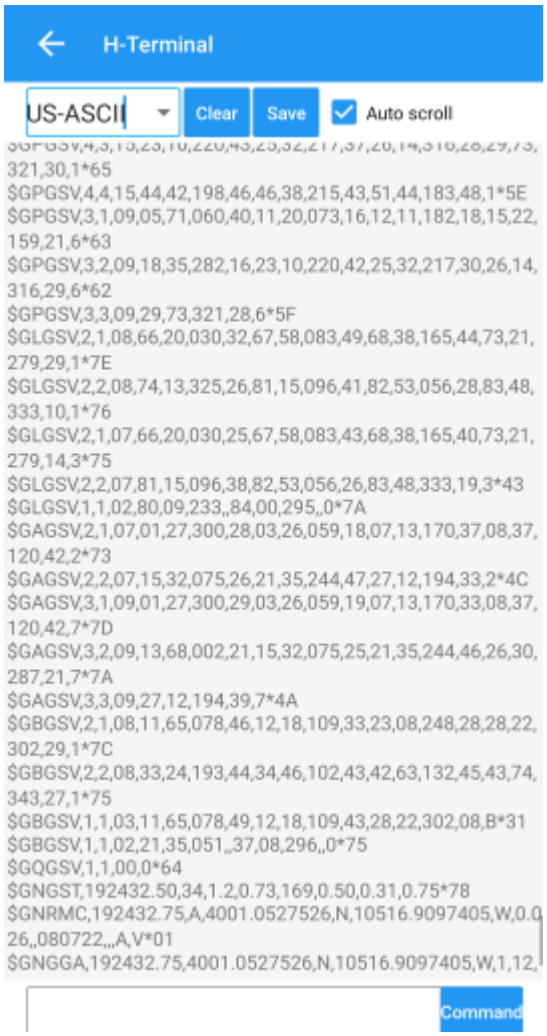
- GGA
- GLL
- GRS
- GSA
- GST
- GSV
- RMC
- VTG
- ZDA

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.

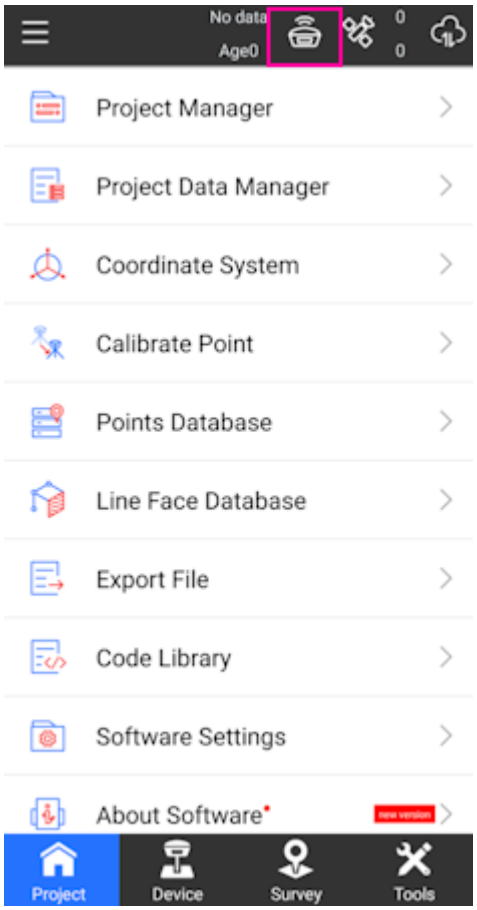


To verify the NMEA sentences are being delivered correctly, Survey Master has a built-in tool. Select the Device->Rover->More->'H-Terminal'.

4.1.4 SurPad

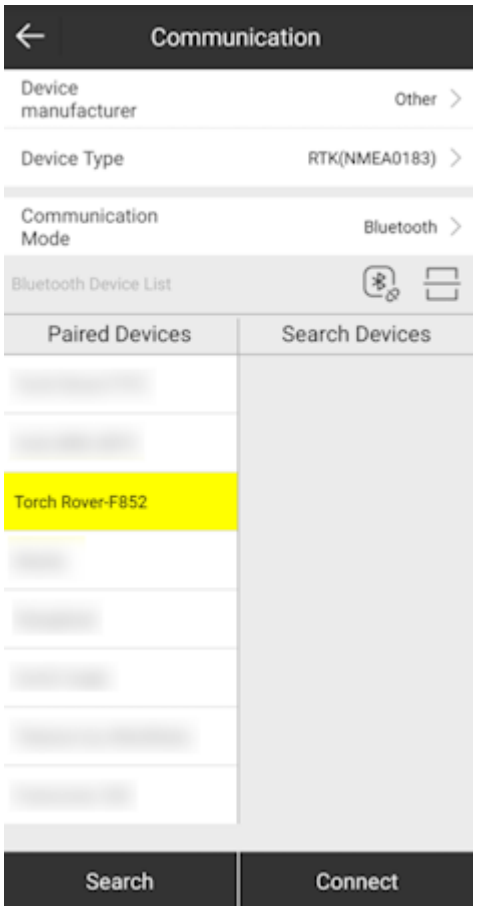
SurPad is an Android app available as a free trial for 30-days. It's loaded as an APK (rather than through Google Play).

Be sure your RTK device has been paired over Bluetooth to your phone.



SurPad Home Screen

Create a project and get to the home screen. Shown above, click on the GNSS receiver icon.

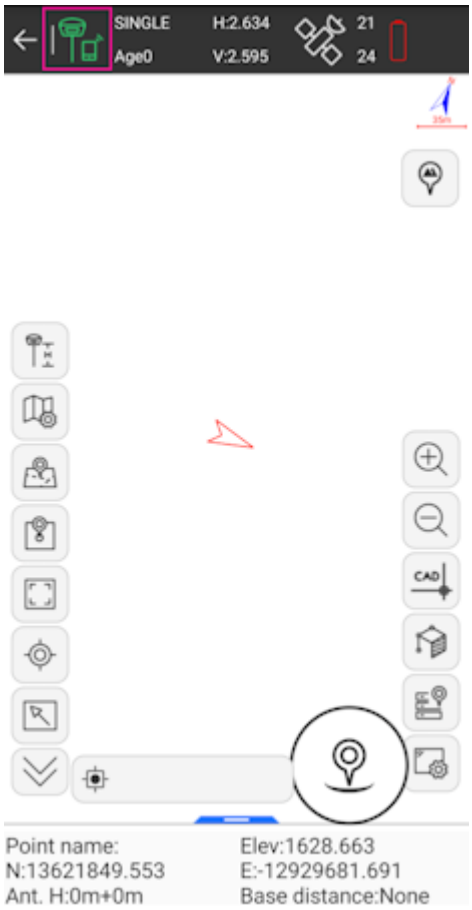


SurPad connecting over Bluetooth

Set the **Device manufacturer** to *Other*, **Device type** to *RTK(NMEA0183)*, and **Communication Mode** to *Bluetooth*. Select the SparkFun RTK device that you would like to connect to on the **Paired Devices** list and then click *Connect*.

Once connected to the device a *Debug* button will appear. This is one of the nice features of SurPad: Running debug will allow you to inspect the NMEA coming across the link.

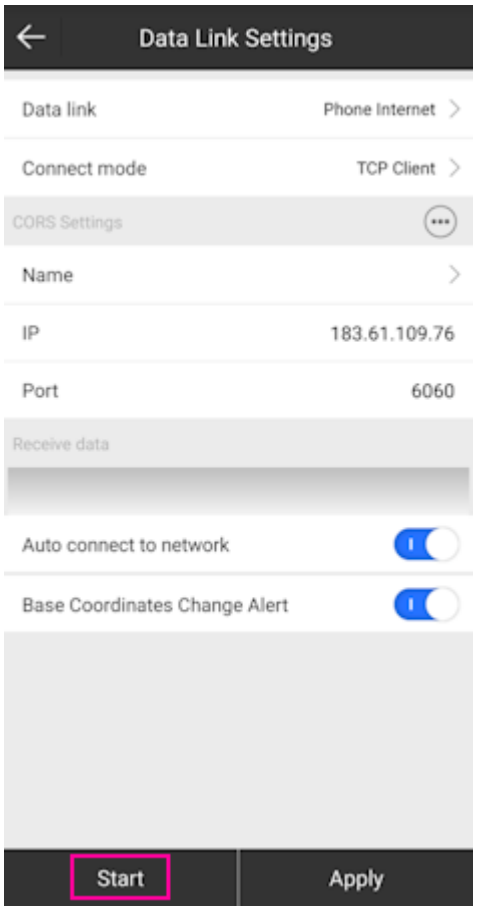
Once done, press the back arrow (top left corner) to return to the home screen.



SurPad Point Survey map

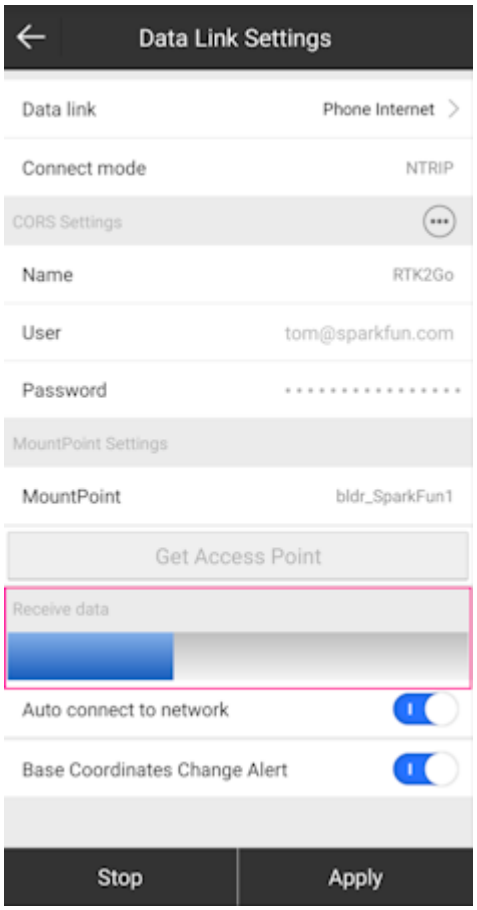
Above: From the home screen press the **Survey** button at the bottom, then **Point Survey** to bring up the map.

In the top left corner, press the green hamburger + cell phone icon. This will open the NTRIP settings.



SurPad Data Link NTRIP Configuration

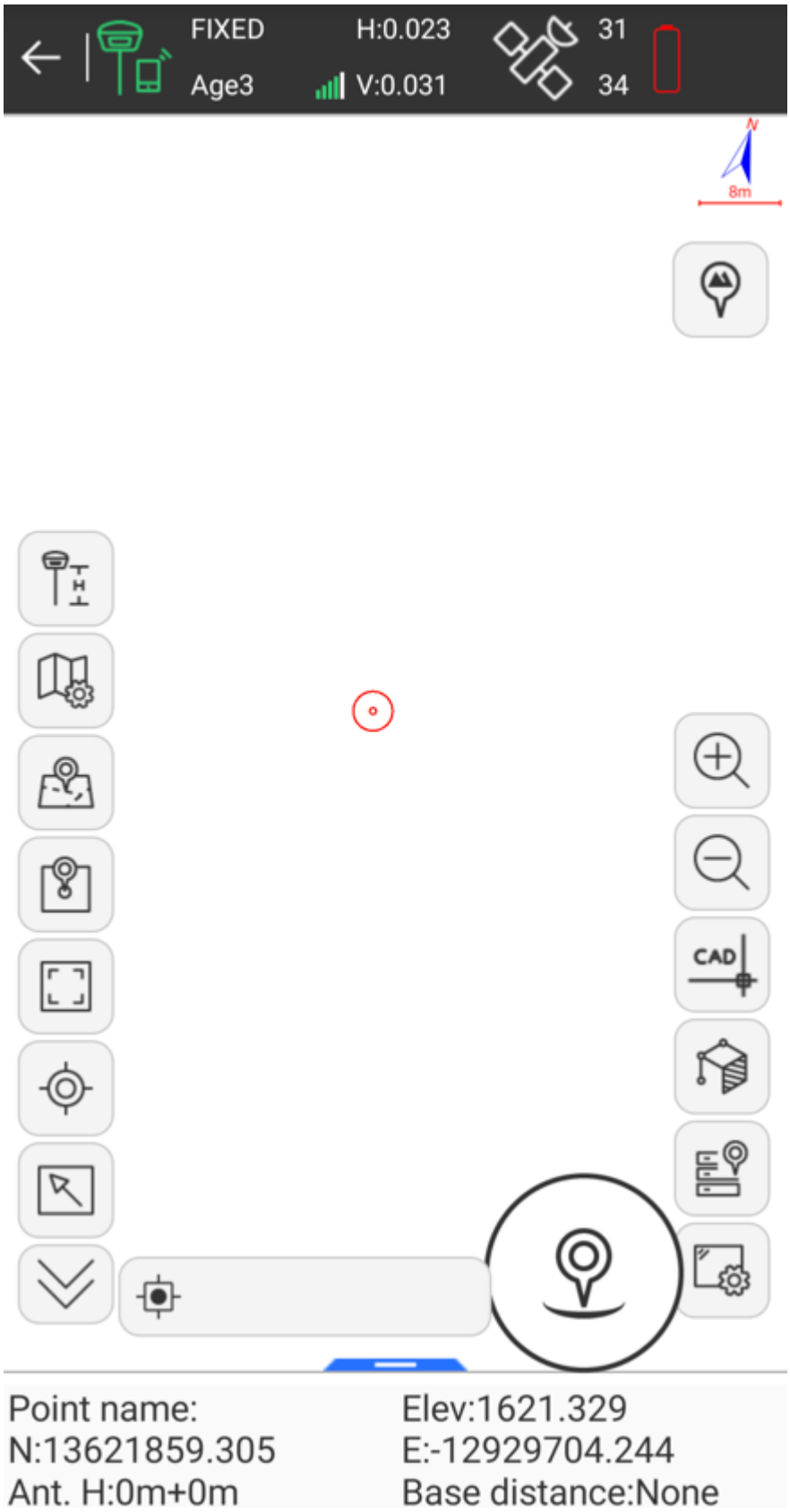
Change the **Connect Mode** from *TCP Client* to *NTRIP*. If you are unable to edit or change the **Connect Mode** from TCP Client be sure the TCP Client is stopped by pressing the *Stop* button in the lower left corner (located in the same spot as the highlighted *Start*).



SurPad NTRIP Connection

Enter the information for your NTRIP caster. In the above example, we are connected to the SparkFun base station on RTK2Go. For RTK2Go you will need to enter a valid email address for a user name but a password is not required.

Click on *Start* and you should see the 'Receive data' progress bar (highlighted above) increase each second indicating a connection. Once complete, press 'Apply' to return to the map.

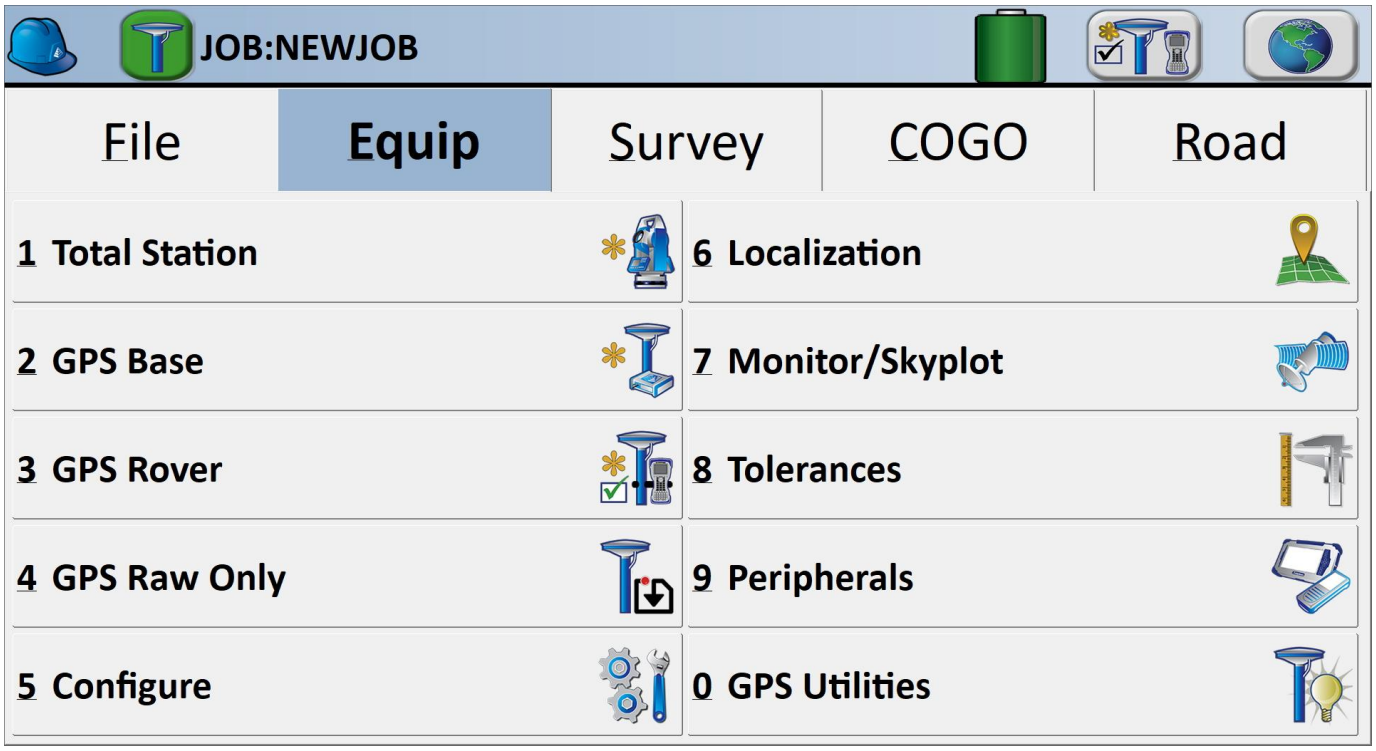


SurPad with RTK Fix

Above: After a few moments, the RTK device should move to RTK Float, then RTK Fix. You can see the age of the RTCM data in the upper bar, along with the horizontal (23mm) and vertical (31mm) accuracy estimates. Now you can begin taking points.

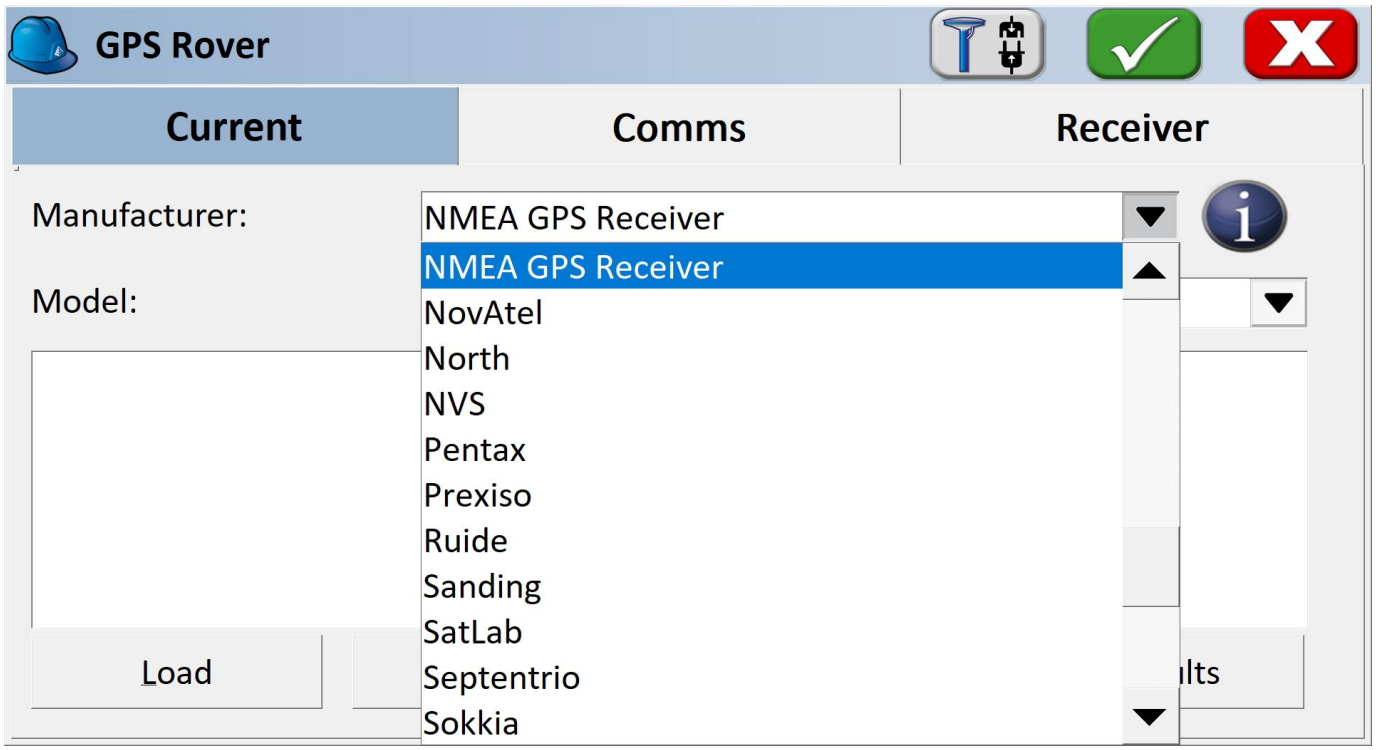
4.1.5 SurvPC

Be sure your device is paired over Bluetooth.



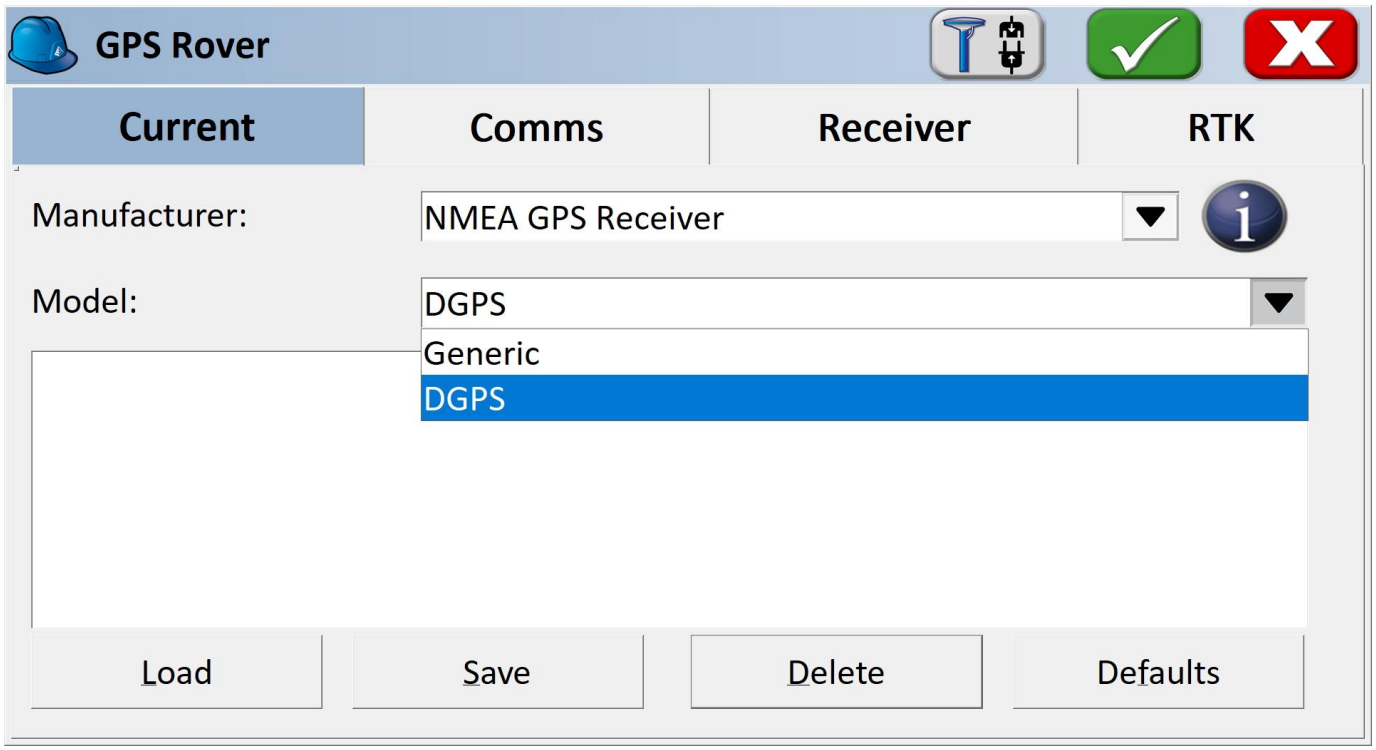
Equip Sub Menu

Select the *Equip* sub menu then `GPS Rover`



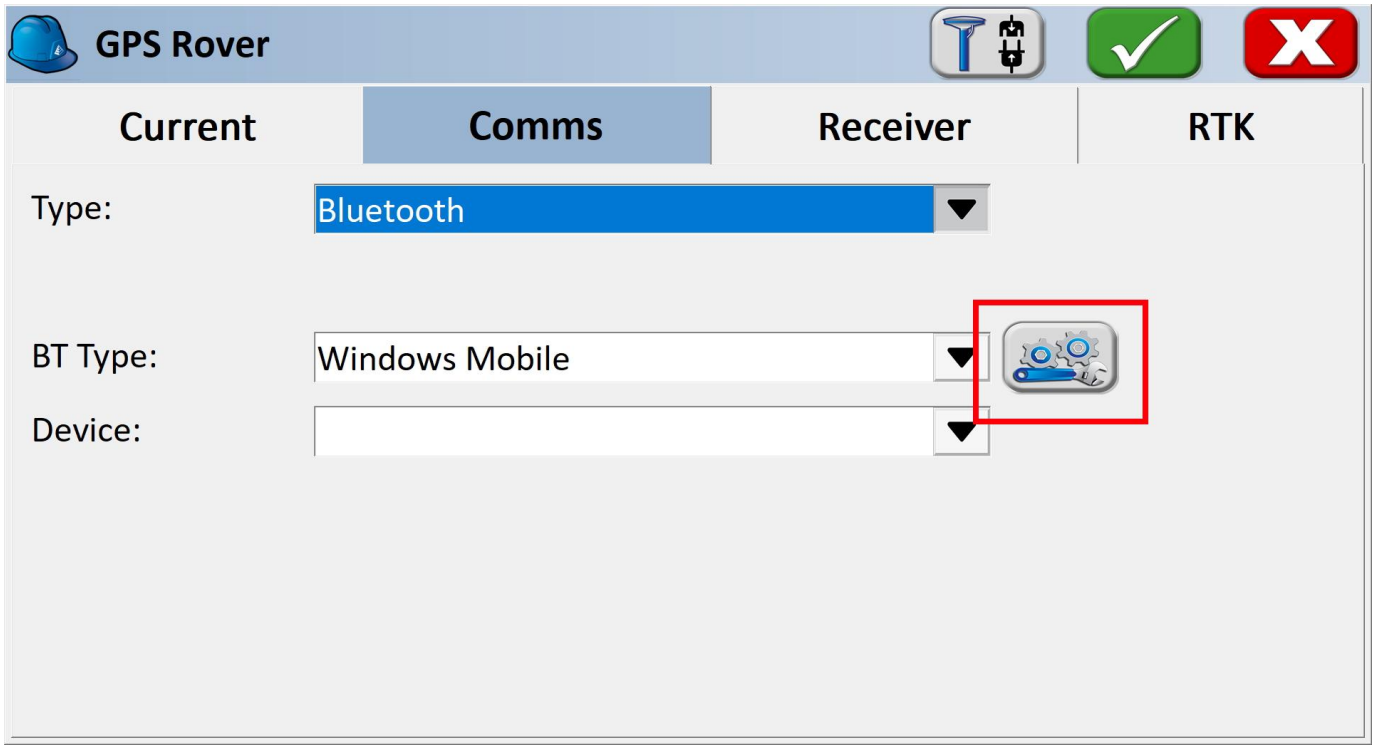
Select NMEA GPS Receiver

From the drop down, select `NMEA GPS Receiver`.



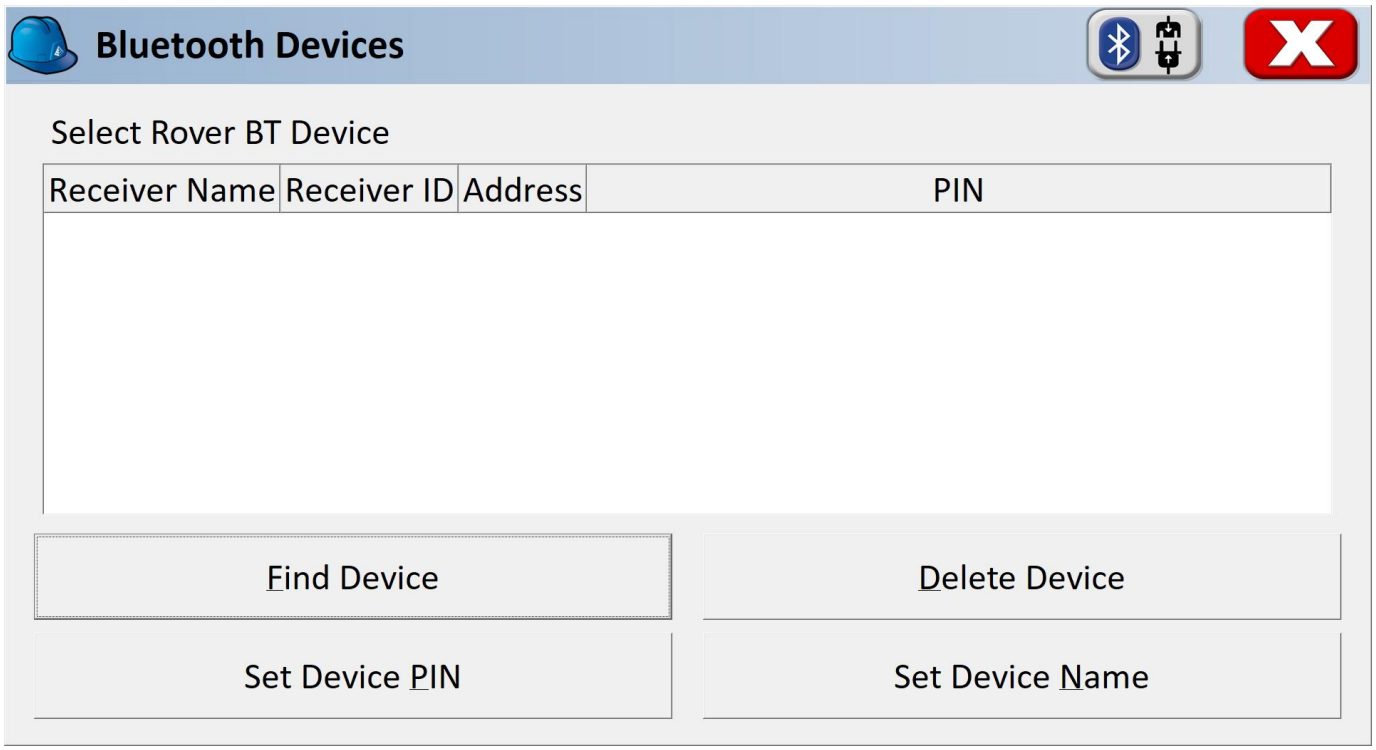
Select Model: DGPS

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.



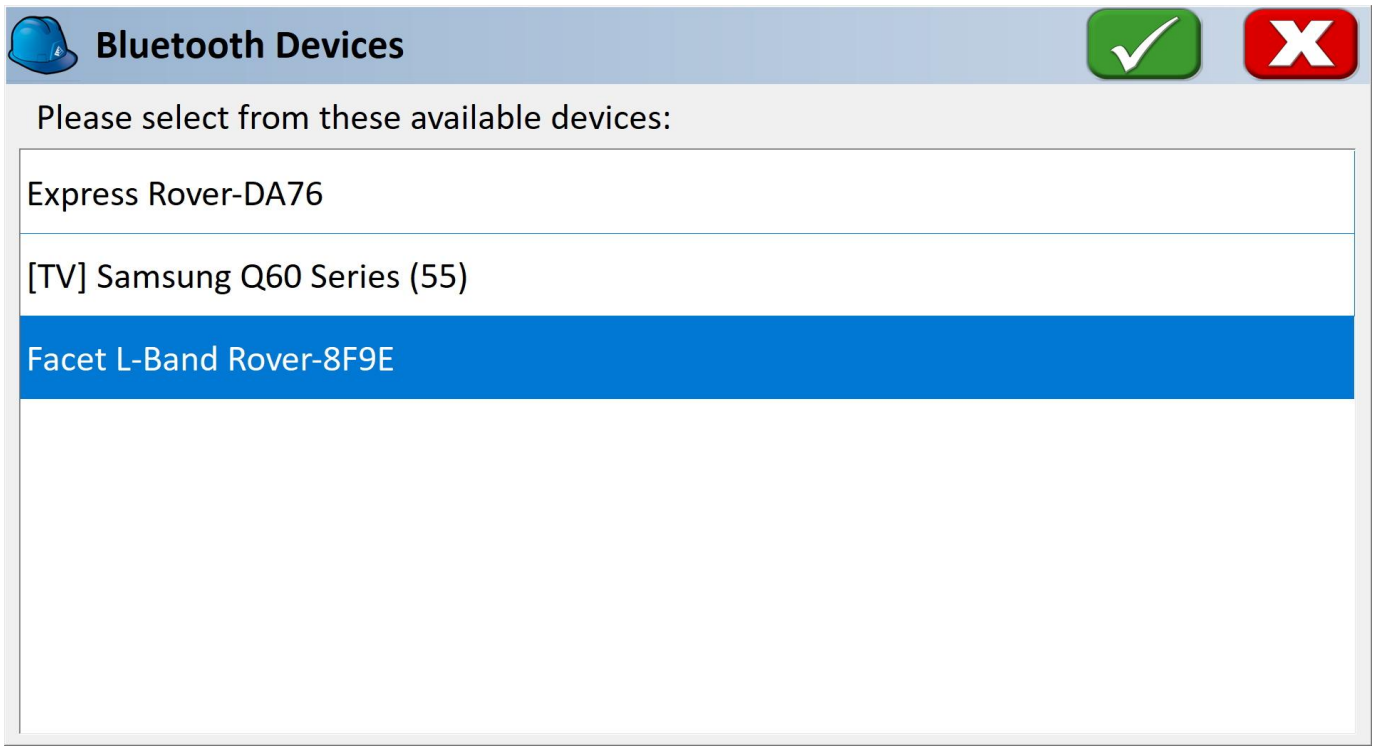
Bluetooth Settings Button

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



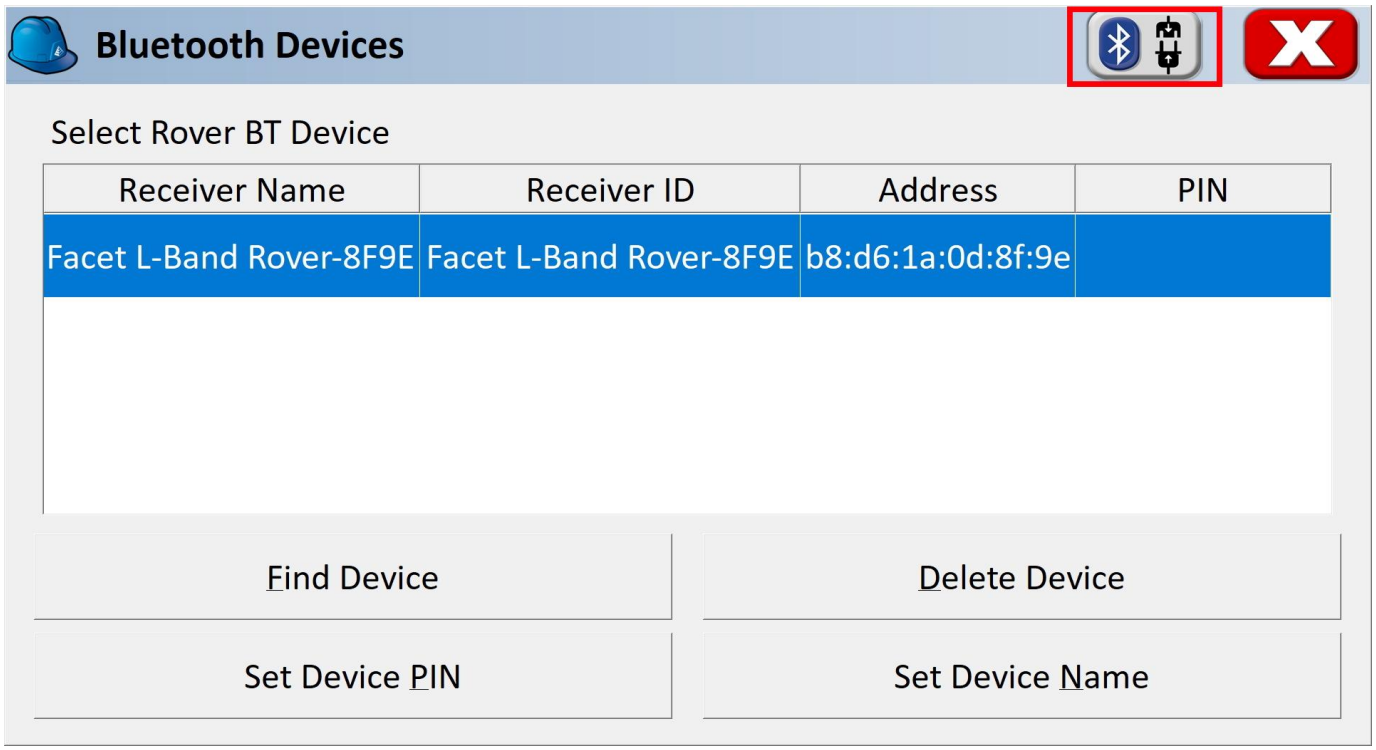
SurvPC Bluetooth Devices

Click `Find Device`.



List of Paired Bluetooth Devices

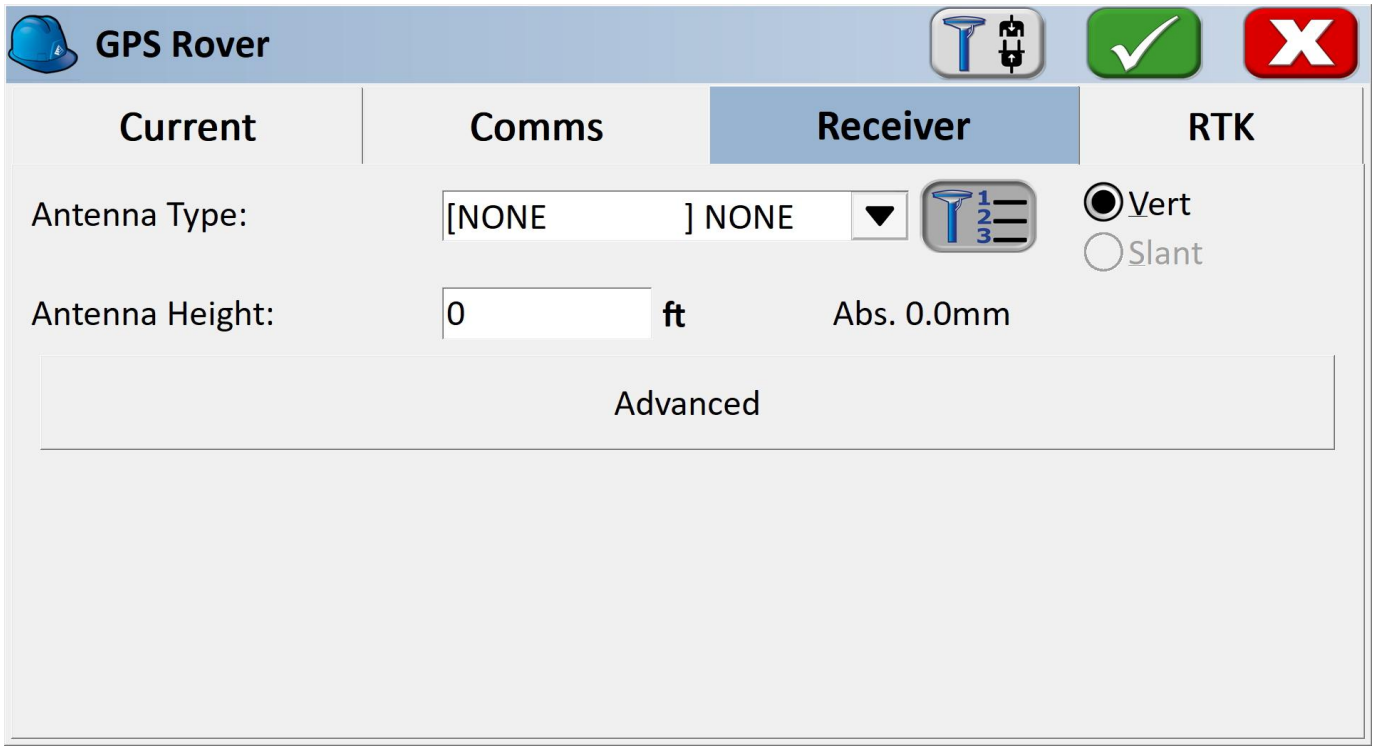
You will be shown a list of devices that have been paired. Select the RTK device you want to connect to.



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.

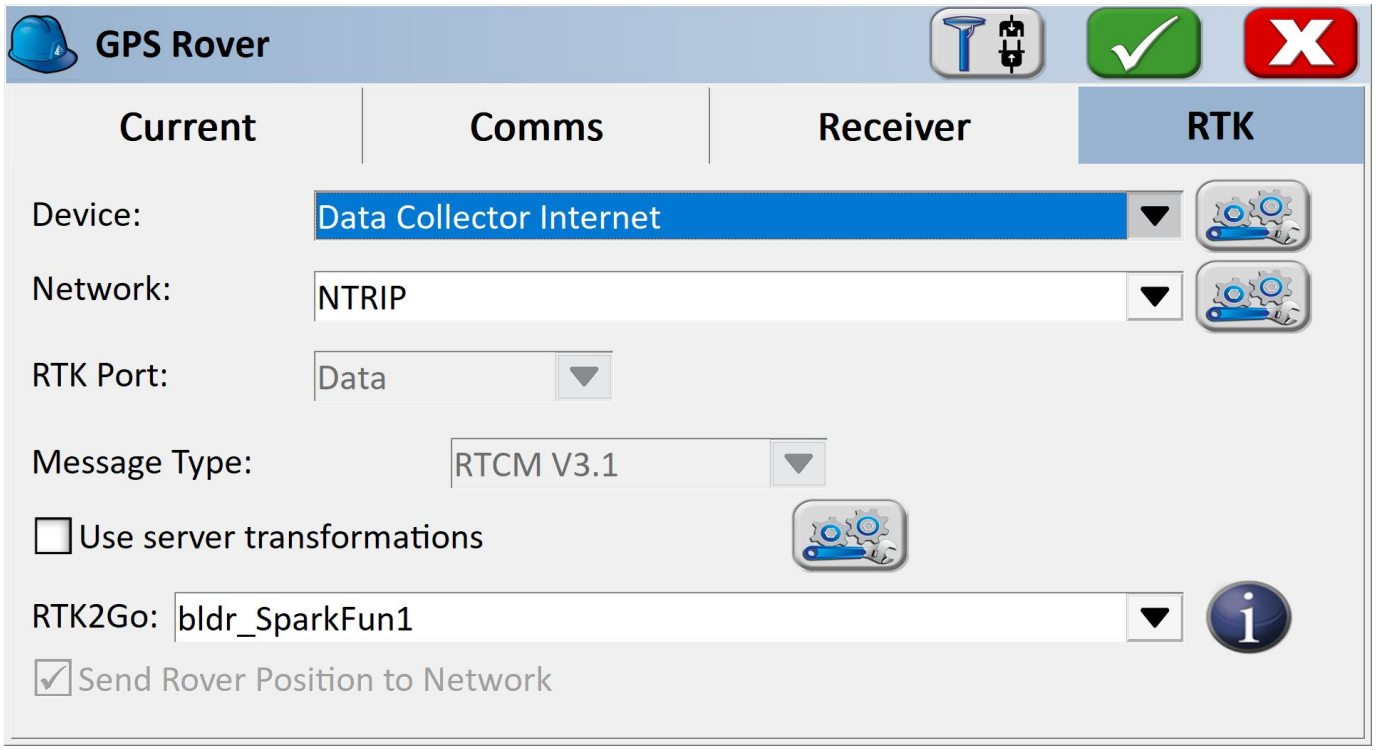


Receiver Submenu

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

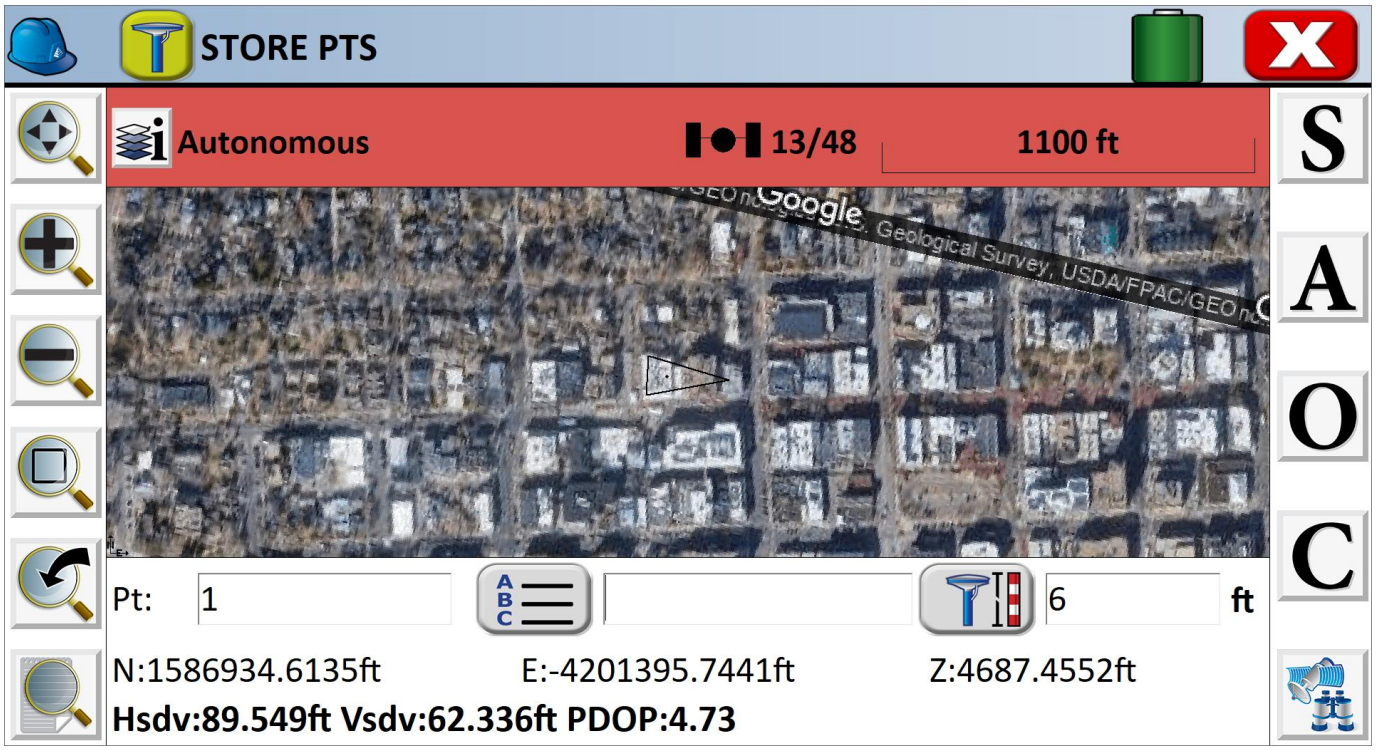
If you selected 'DGPS' as the Model type, the RTK submenu will be shown. This is where you give the details about your NTRIP Caster such as your mount point, user name/pw, etc. For more information about creating your own NTRIP mount point please see Creating a Permanent Base

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.

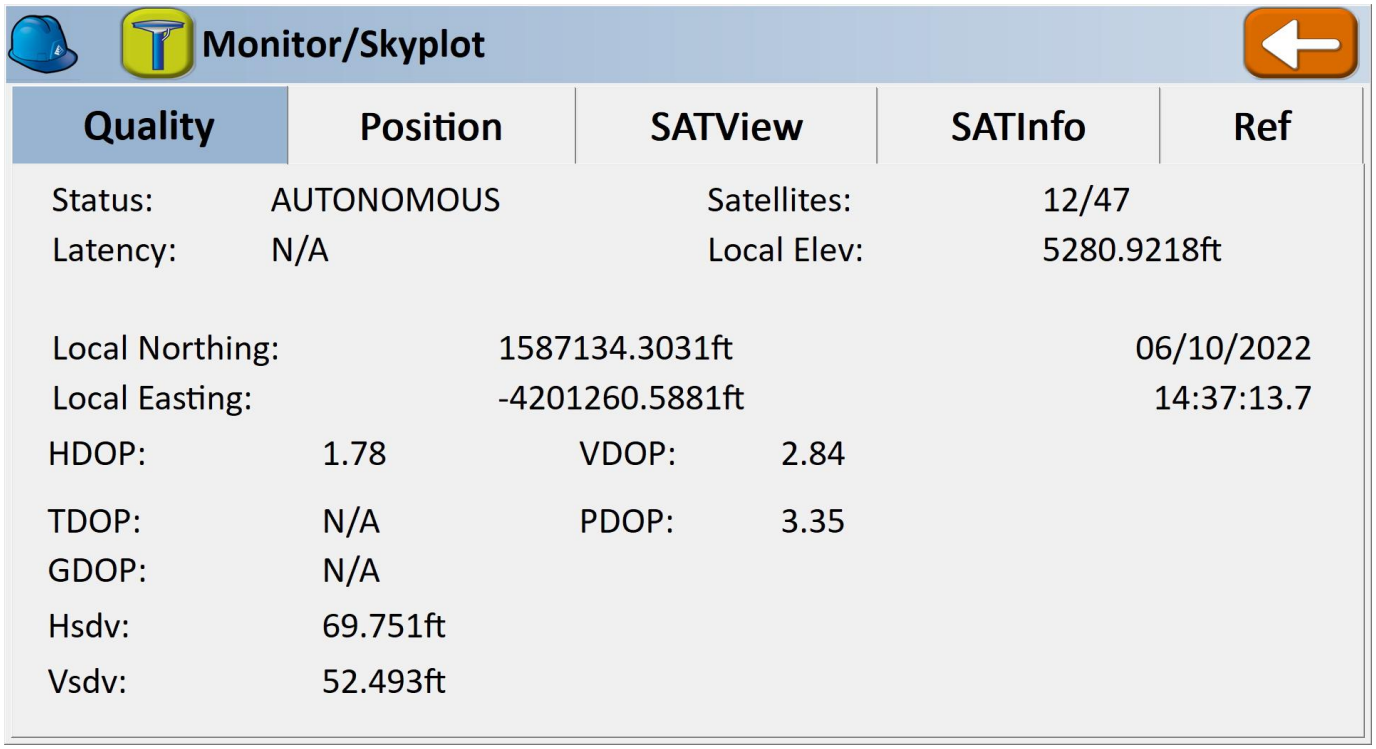
Don't have access to an NTRIP Caster? You can use a 2nd RTK product operating in Base mode to provide the correction data. Check out Creating a Permanent Base. If you're the DIY sort, you can create your own low-cost base station using an ESP32 and a ZED-F9P breakout board. Check out How to Build a DIY GNSS Reference Station](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.



SurvPC Skyplot

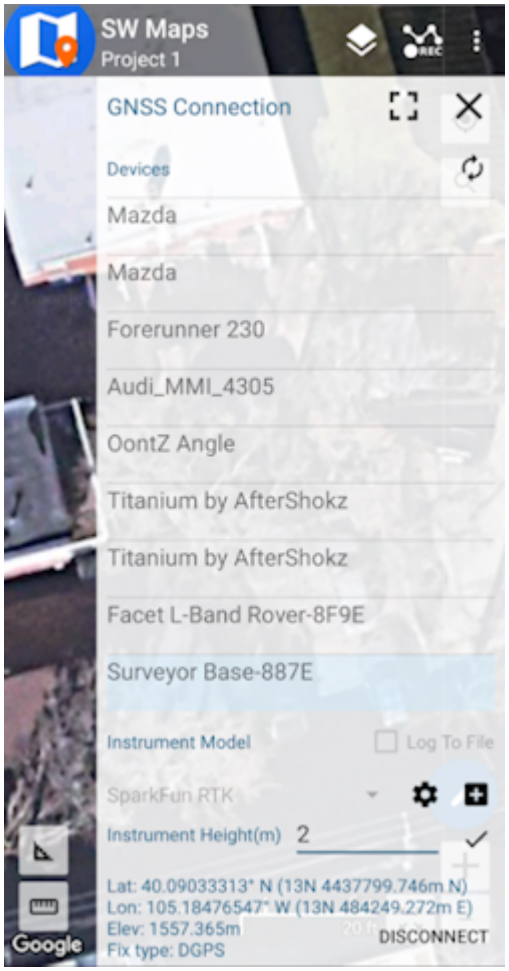
Opening the Skyplot will allow you to see your GNSS details in real-time.

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.

4.1.6 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.

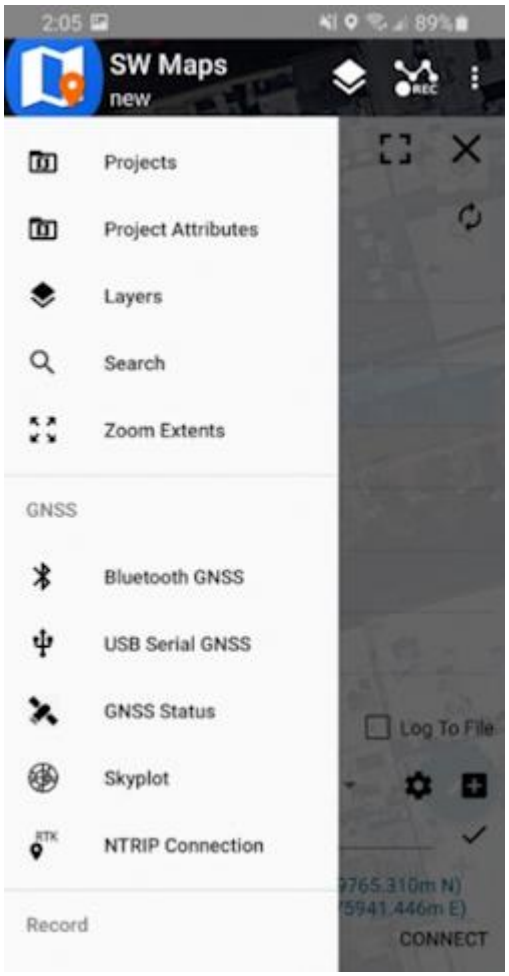
SW Maps with RTK Fix

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

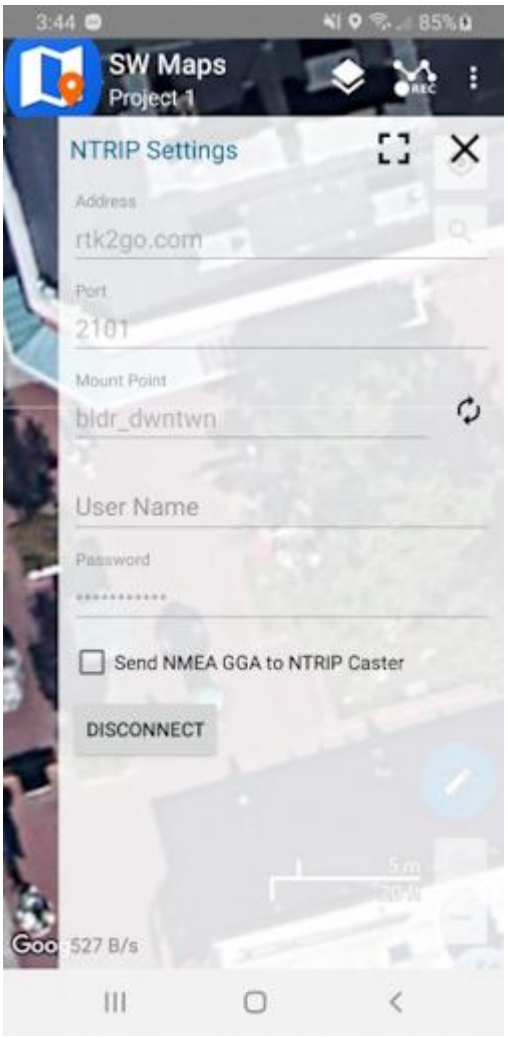
NTRIP Client

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

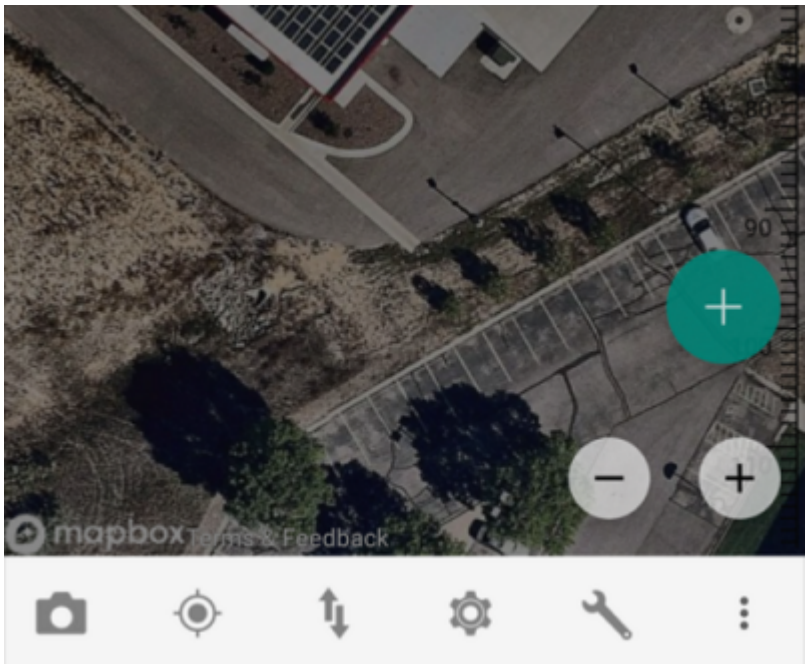
Enter your NTRIP Caster credentials and click connect. You will see bytes begin to transfer from your phone to the RTK device. Within a few seconds, the RTK device will go from ~300mm accuracy to 14mm. Pretty nifty, no?

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.

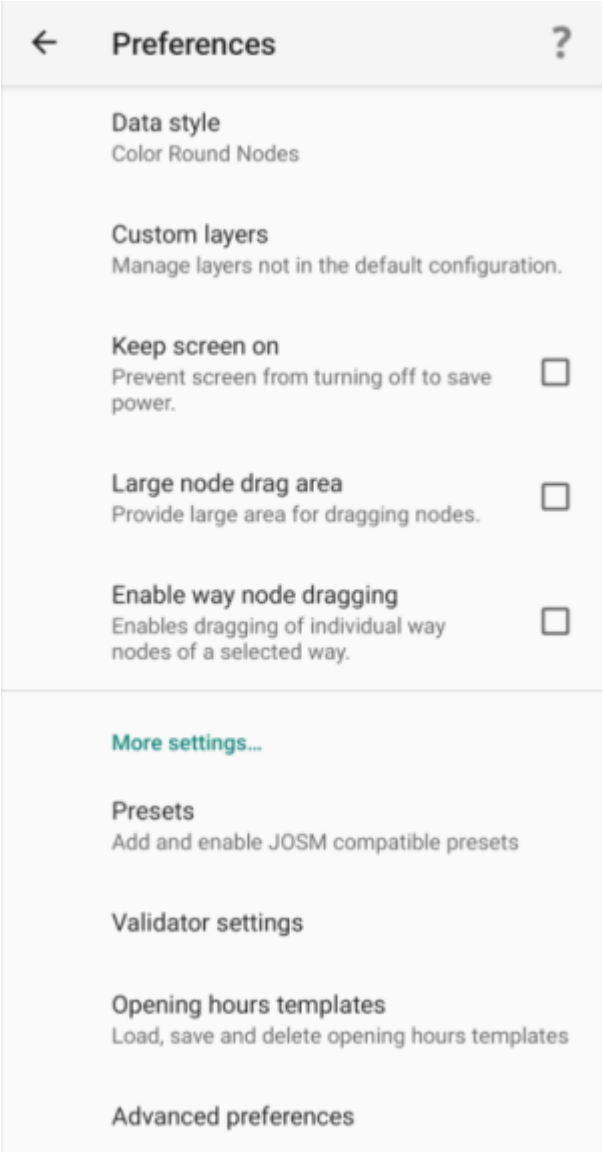
4.1.7 Vespucci

Vespucci is an Open Street Map editor for Android.

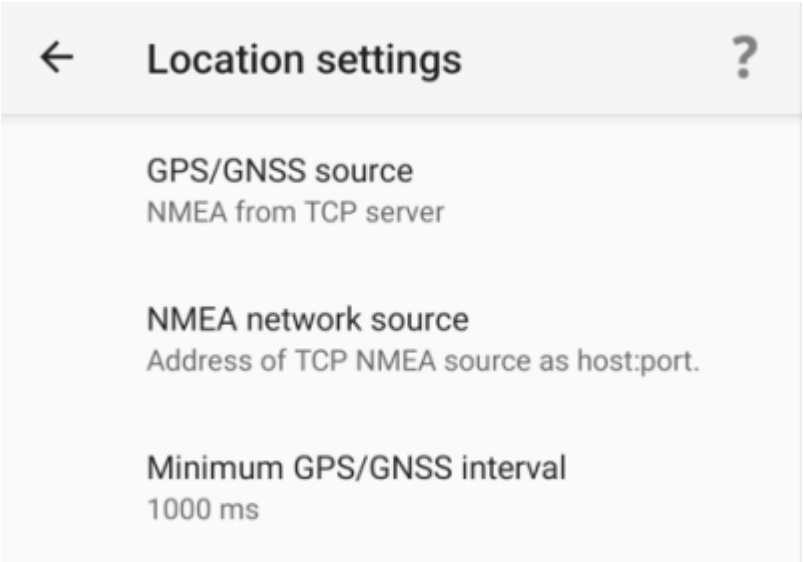
This software requires the RTK device to connect over TCP. Be sure you have a local WiFi network entered into the WiFi Config menu, have a TCP Client or Server enabled, and have noted the TCP port (it's 2947 by default).



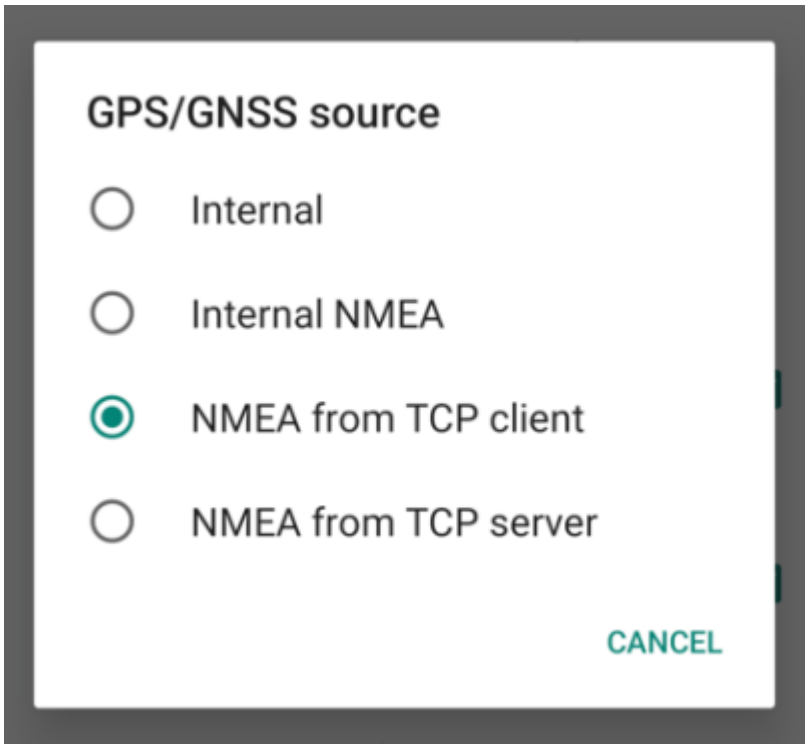
With a map open, select the gear icon on the bottom bar.



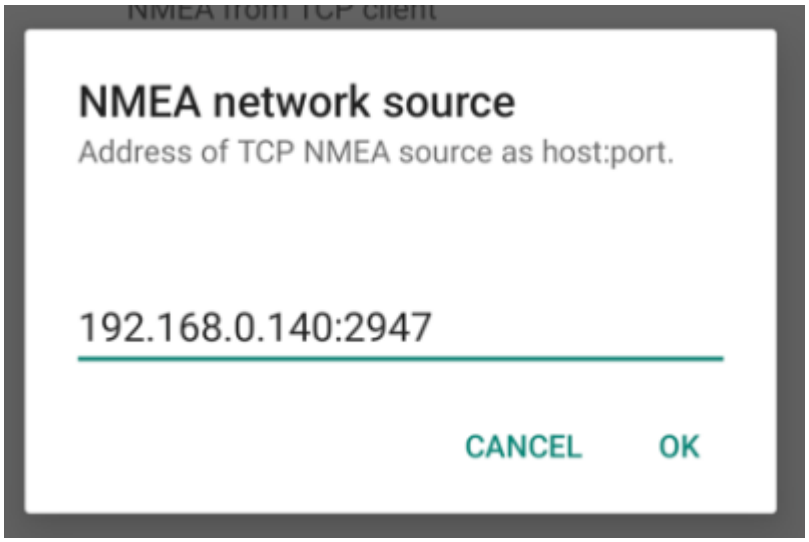
From the Preferences menu, scroll to the bottom and select 'Advanced Preferences'.



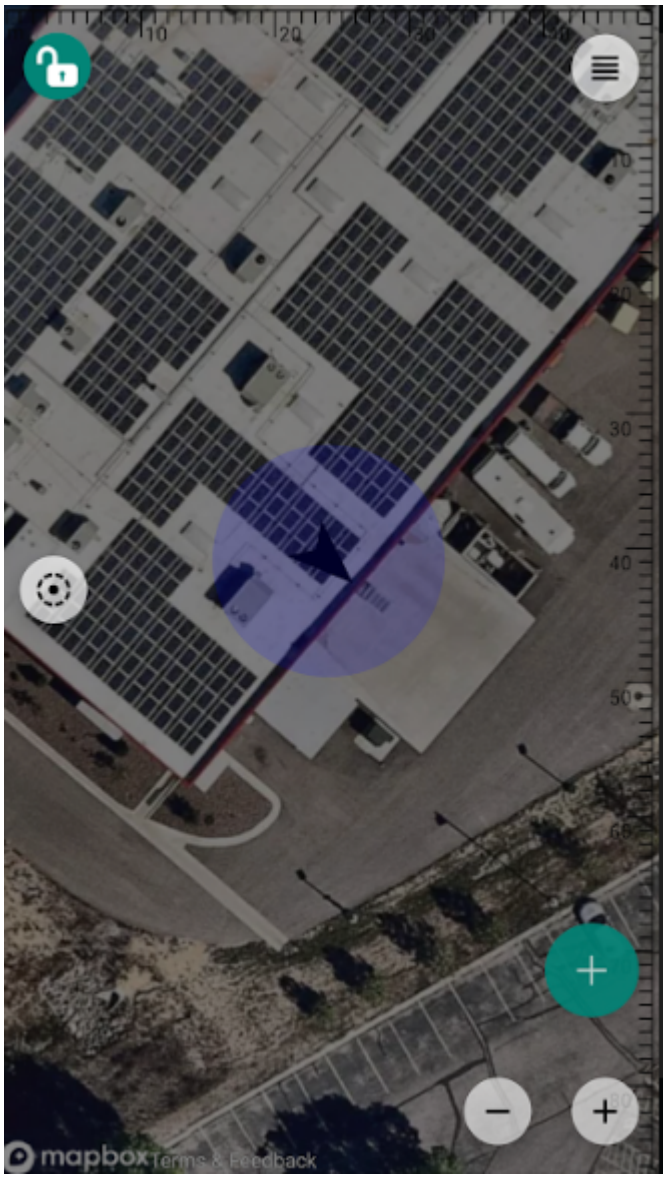
Select **Location settings**.



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.

4.1.8 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.

4.1.9 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.

4.1.10 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 for Android, iOS, and Windows. 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.

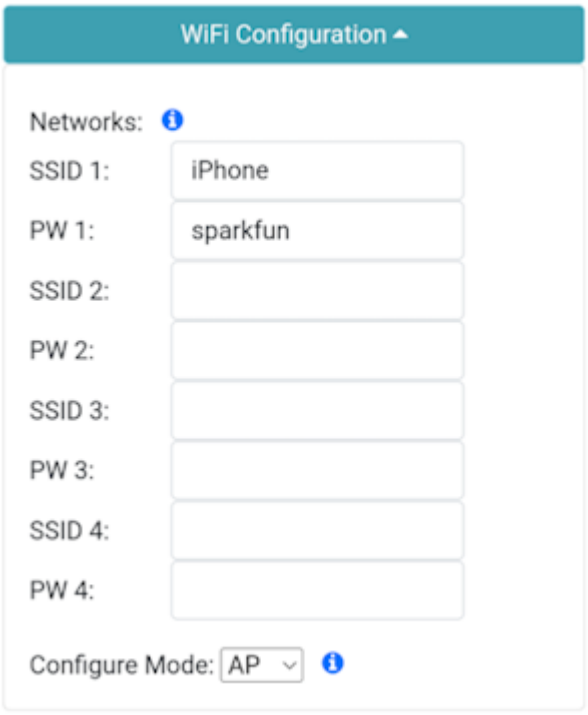
The software options for Apple iOS are much more limited because Apple products do not support Bluetooth SPP. That's ok! The SparkFun RTK products support additional connection options including TCP and Bluetooth Low Energy (BLE).

4.2.1 ArcGIS Survey123

ArcGIS Survey123 Home Screen

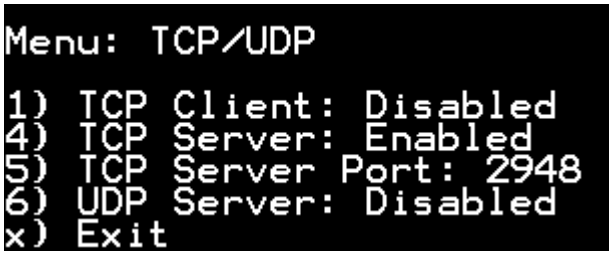
ArcGIS Survey123 is a popular offering from Esri that works well with SparkFun RTK products.

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.



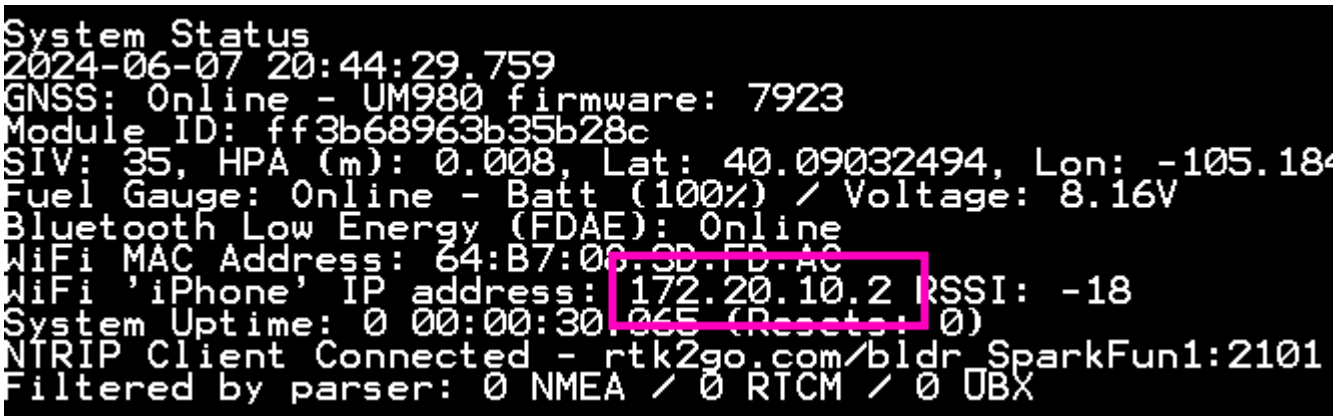
Adding WiFi network to settings

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.



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.

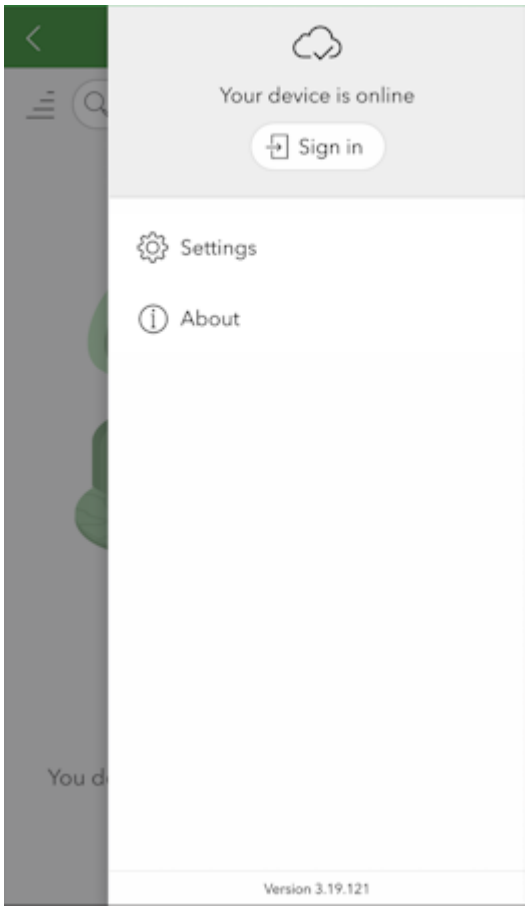


RTK device showing IP address

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.

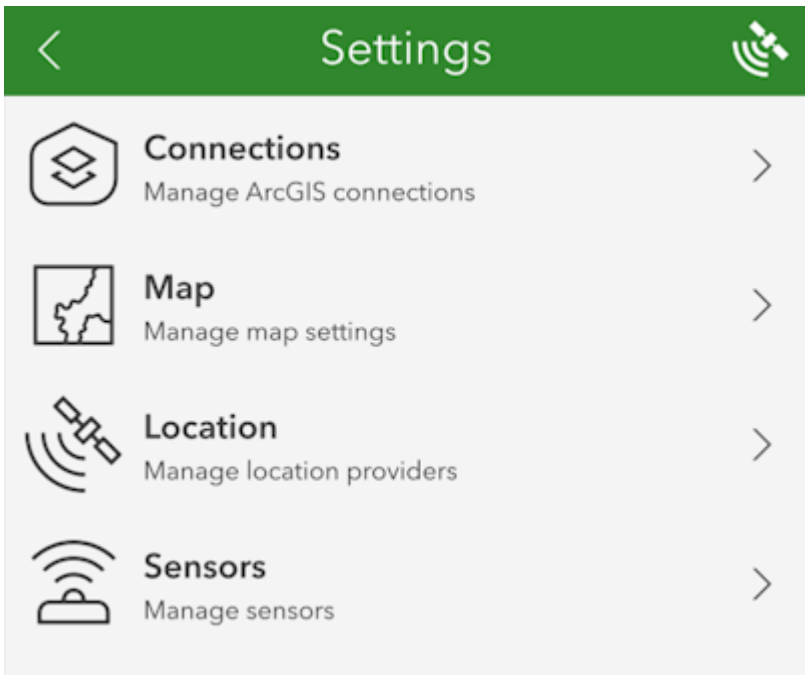
ArcGIS Survey123 Home Screen

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



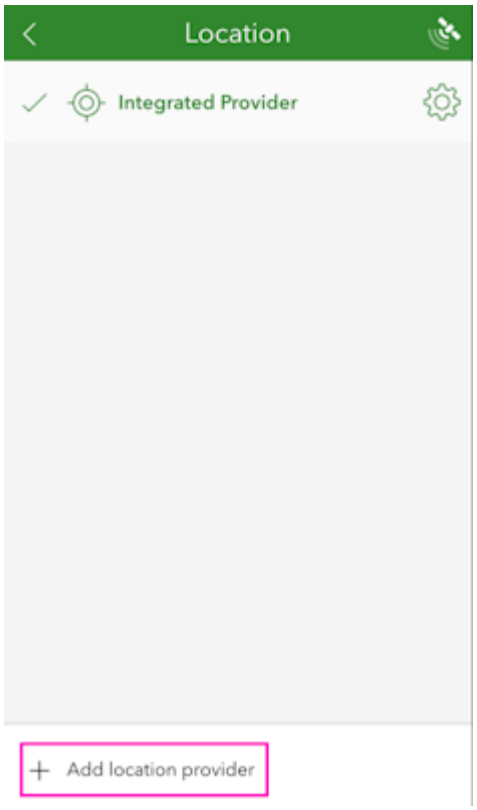
ArcGIS Survey123 Settings Menu

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



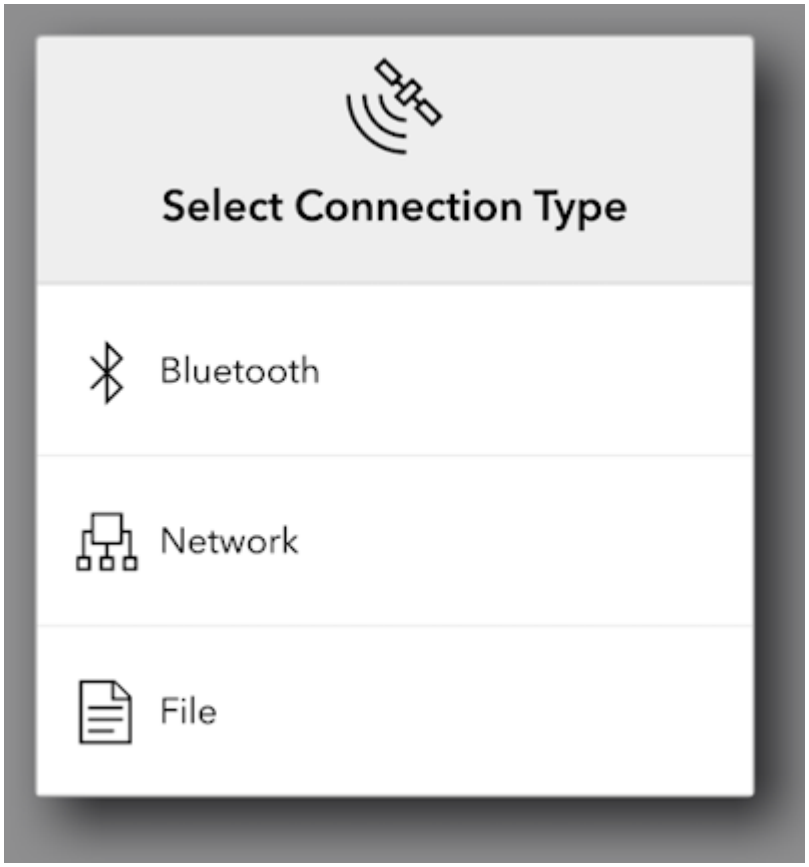
ArcGIS Survey123 Settings List

From the settings list, click on *Location*.



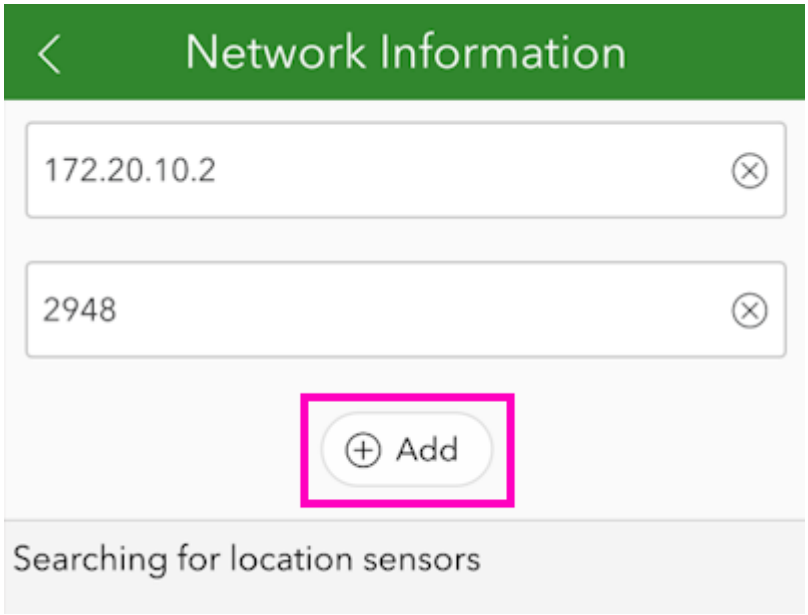
ArcGIS Survey123 List of Location Providers

Click on the *Add location provider*.



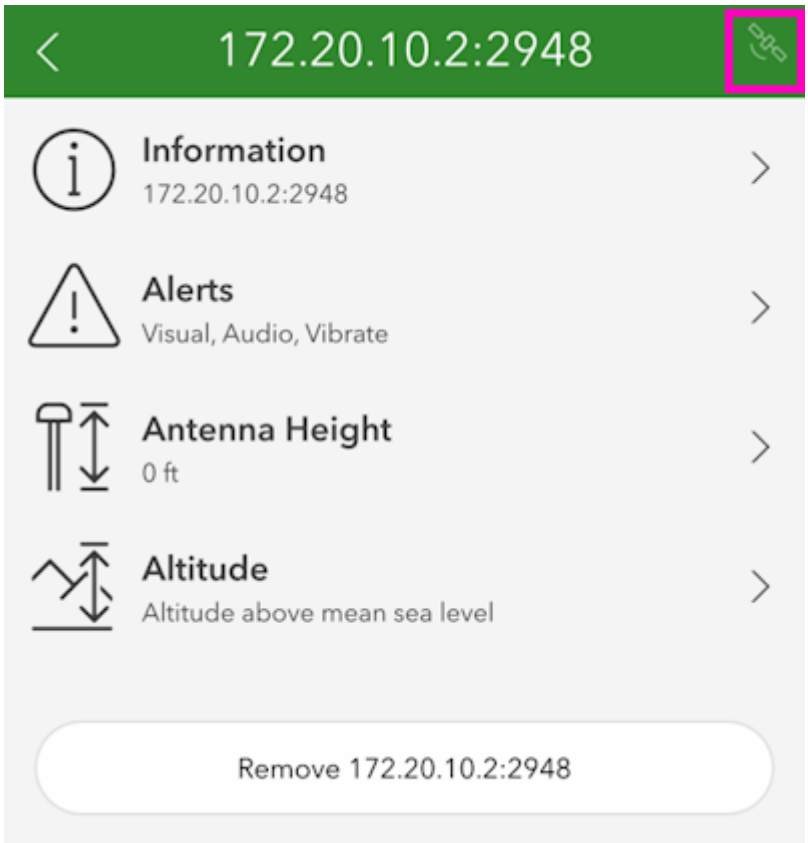
ArcGIS Survey123 Network Connection Type

Select *Network*.



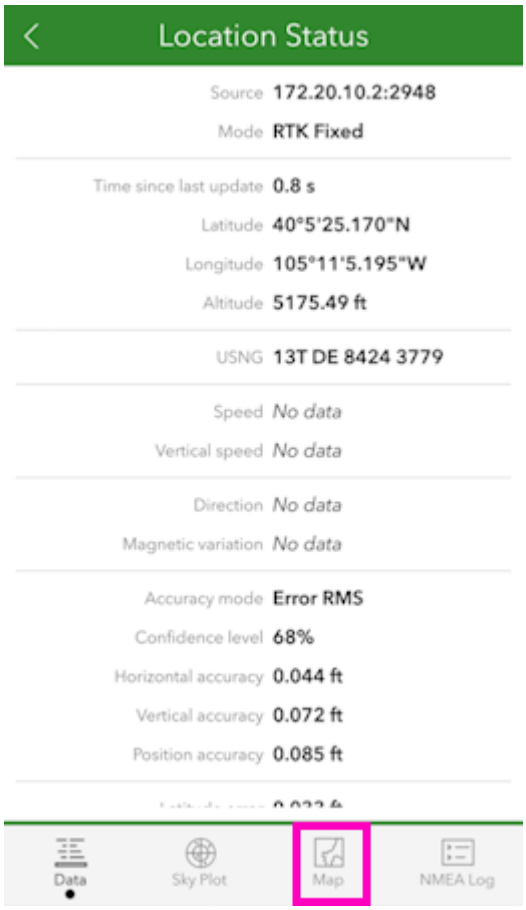
ArcGIS Survey123 TCP Connection Information

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



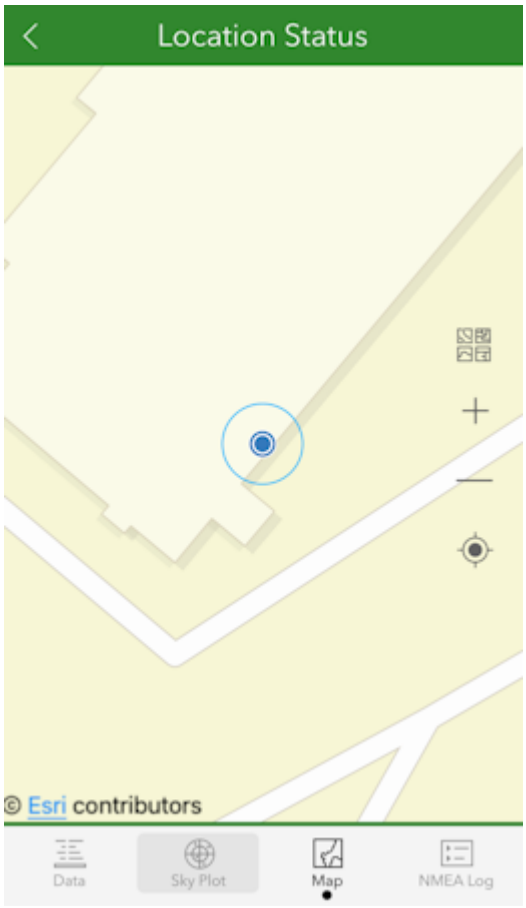
ArcGIS Survey123 Sensor Settings

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.



ArcGIS Survey123 Sensor Data

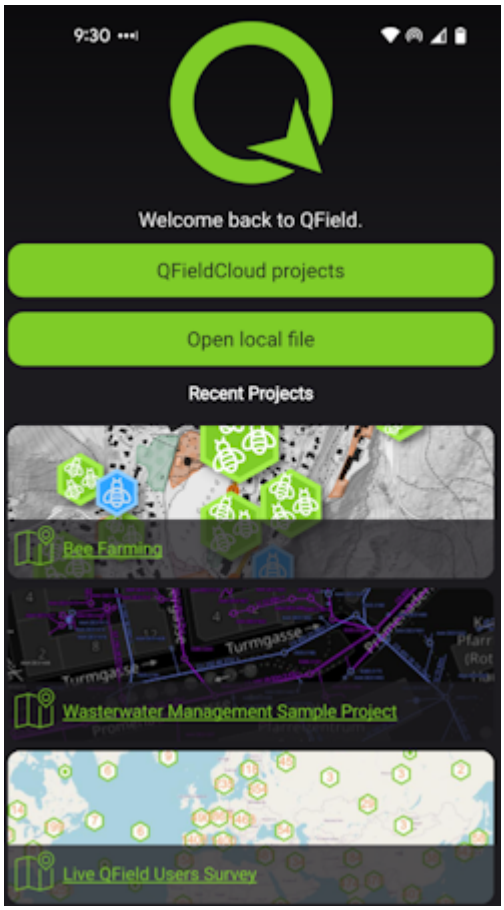
The SparkFun RTK device's data should now be seen. Click on the *Map* icon to return to the mapping interface.



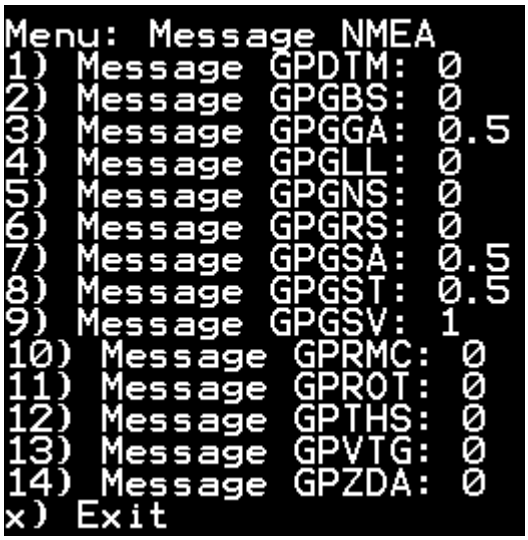
ArcGIS Survey123 Map Interface

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.



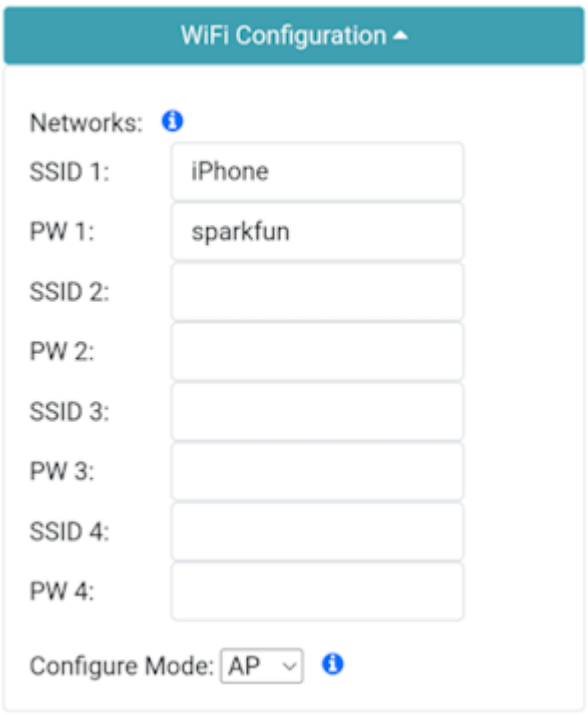
Modified NMEA messages on RTK Torch

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

- GPGGA
- GPGSA
- GPGST
- GPGSV

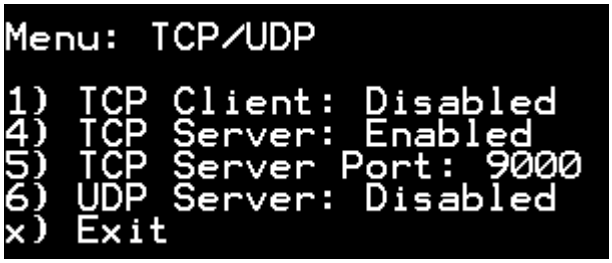
QField currently does not correctly parse other messages such as **GPRMC**, or **RTCM**. These messages will prevent communication if they are enabled.

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



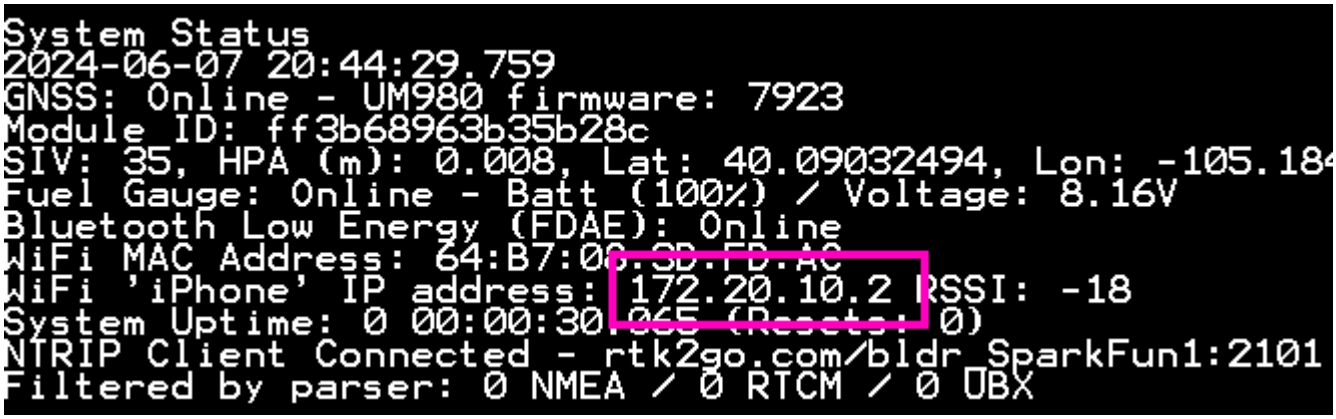
Adding WiFi network to settings

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.



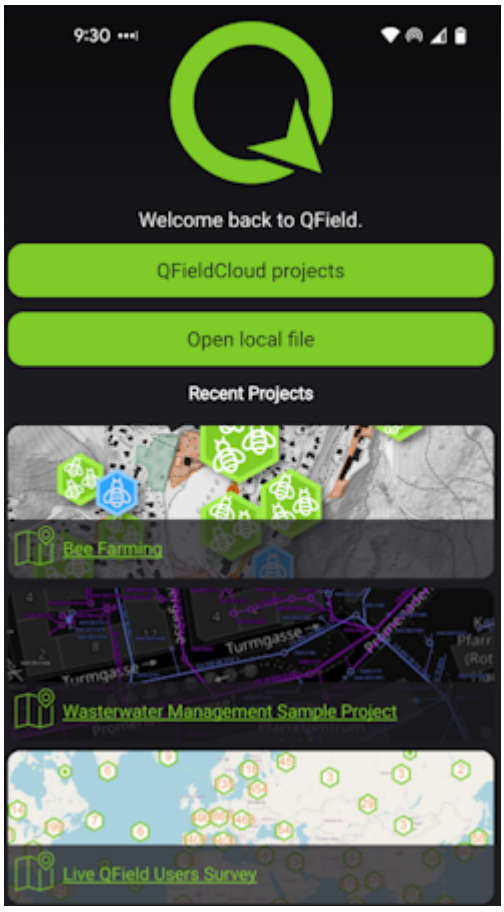
TCP Server Enabled on port 9000

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.



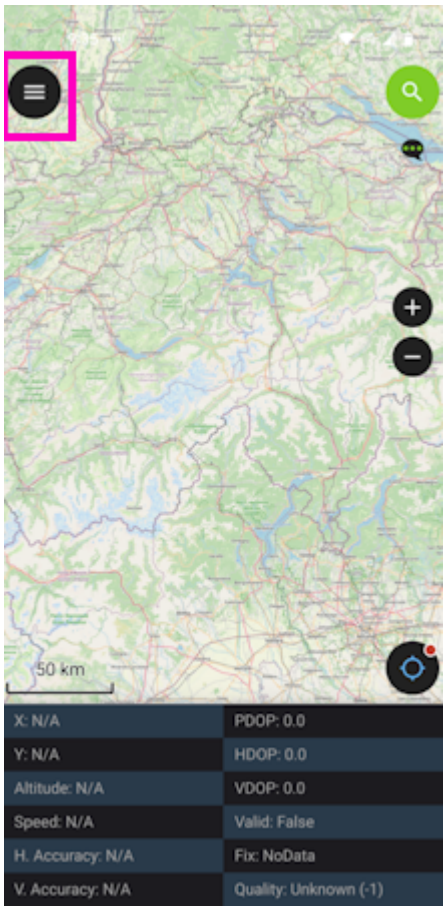
RTK device showing IP address

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.



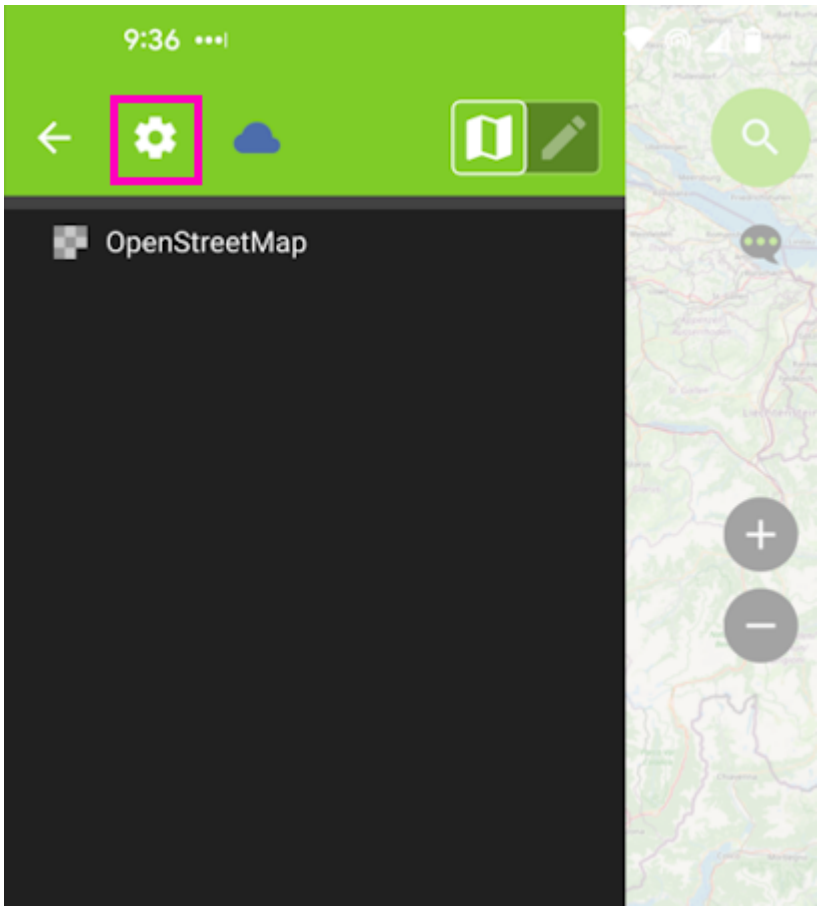
QField Opening Screen

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).



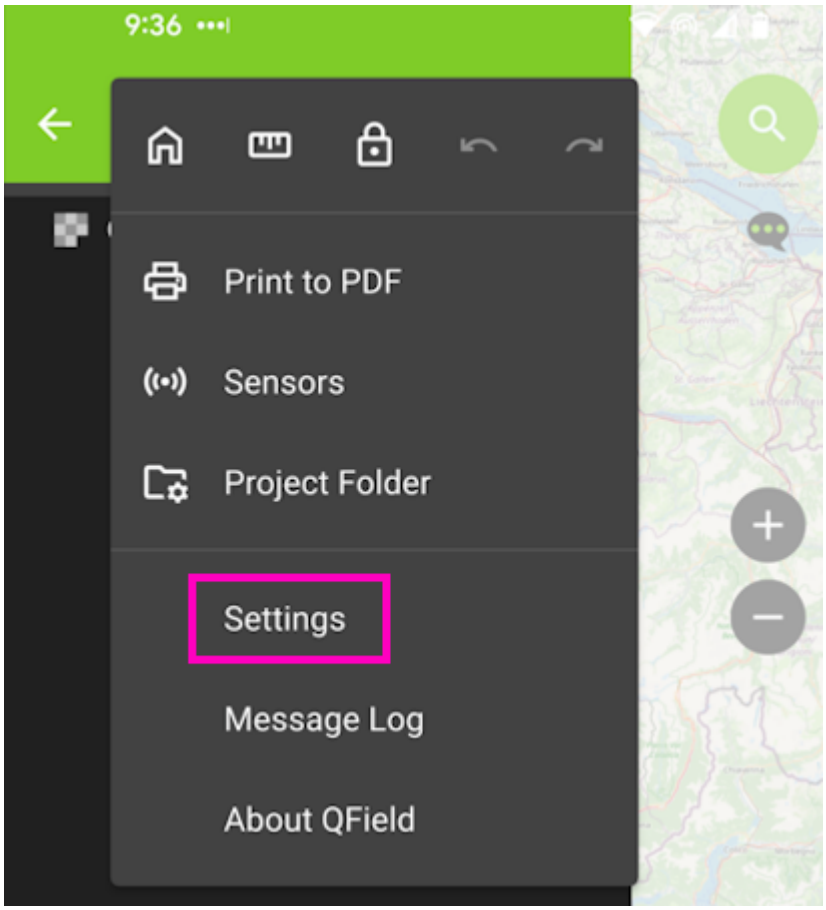
QField Main Map

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

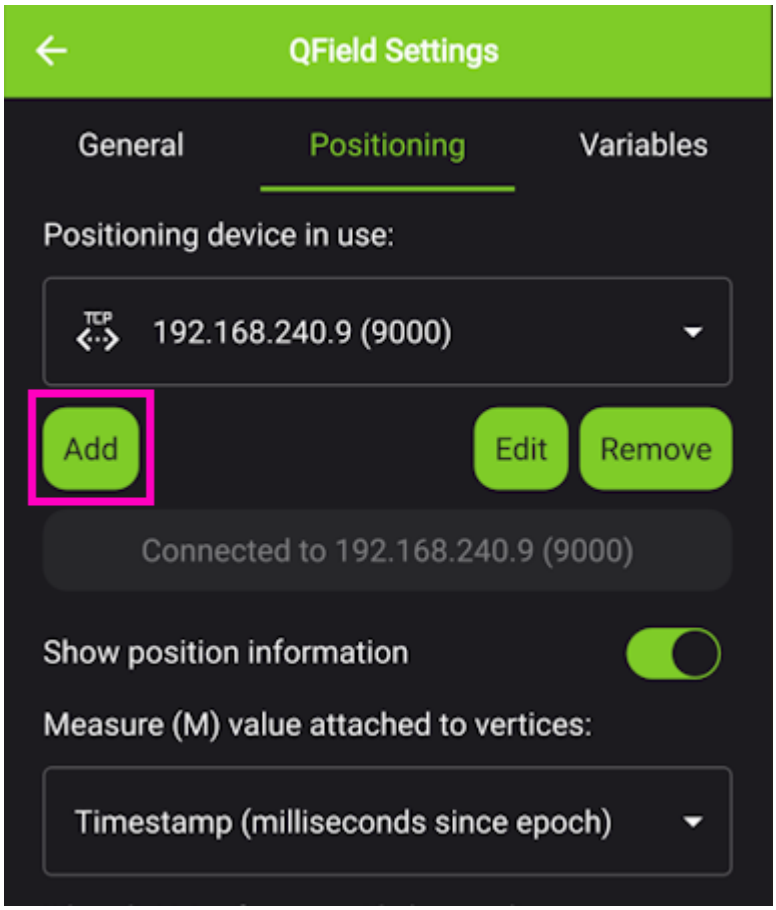


QField Settings Gear

Click on the gear to open settings.

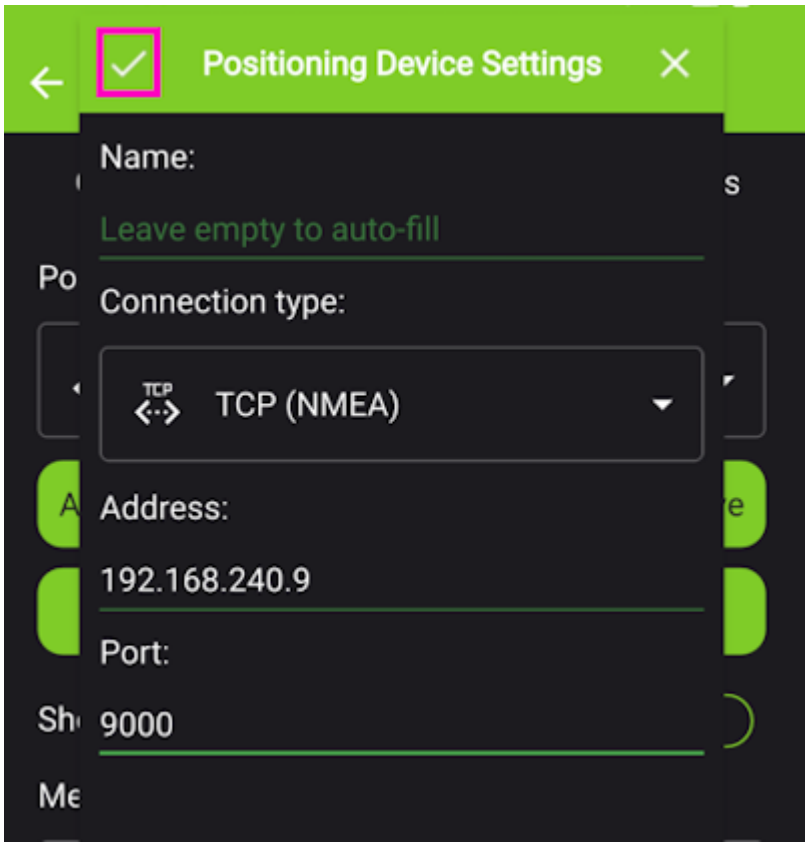


Click on the *Settings* menu.



QField Positioning Menu

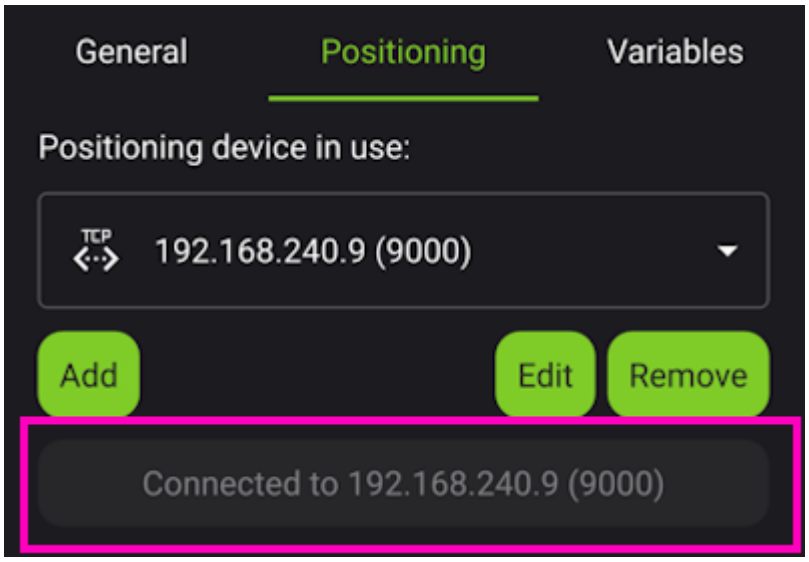
From the *Positioning* menu, click Add.



QField Entering TCP Information

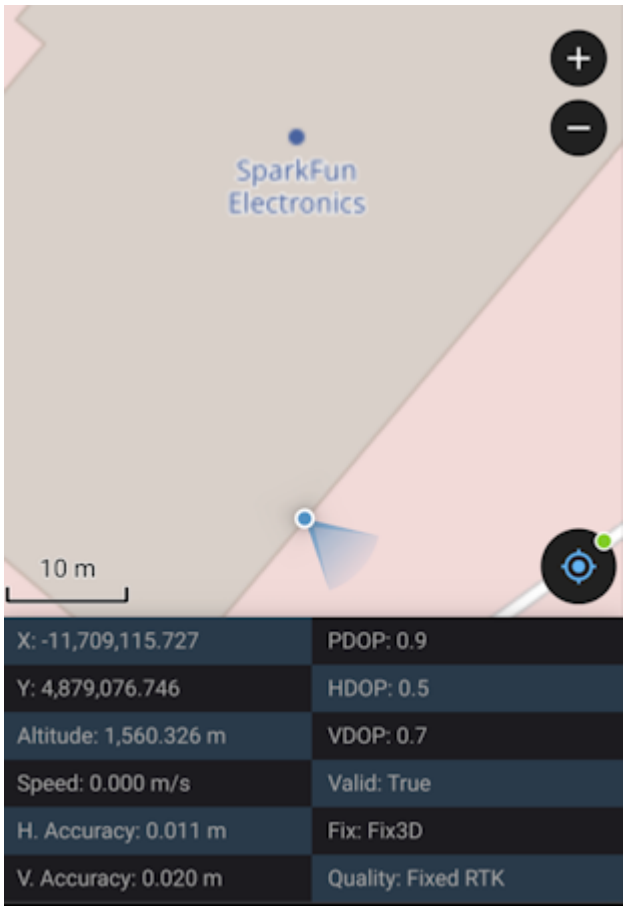
Select TCP as the connection type. Enter the IP address of the RTK device and the port number. Finally, hit the small check box in the upper left corner (shown in pink above) to close the window.

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.

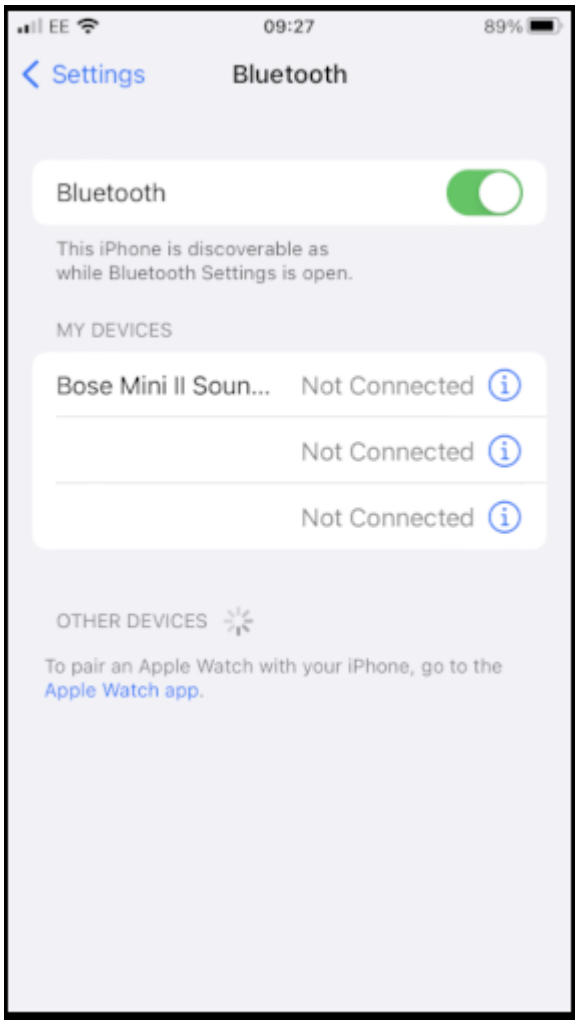
4.2.3 SW Maps

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.

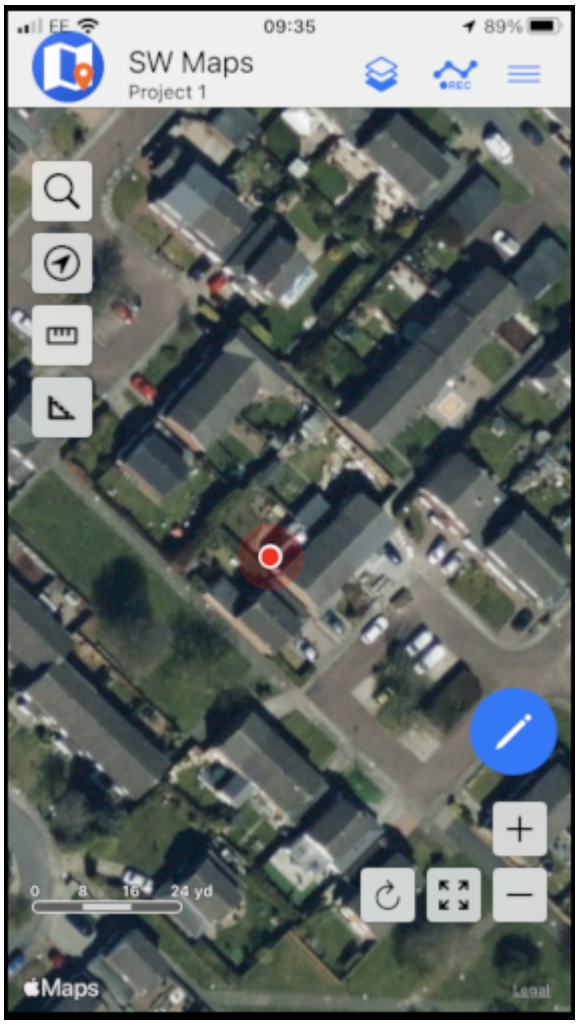


iOS Settings Bluetooth

Open SWMaps.

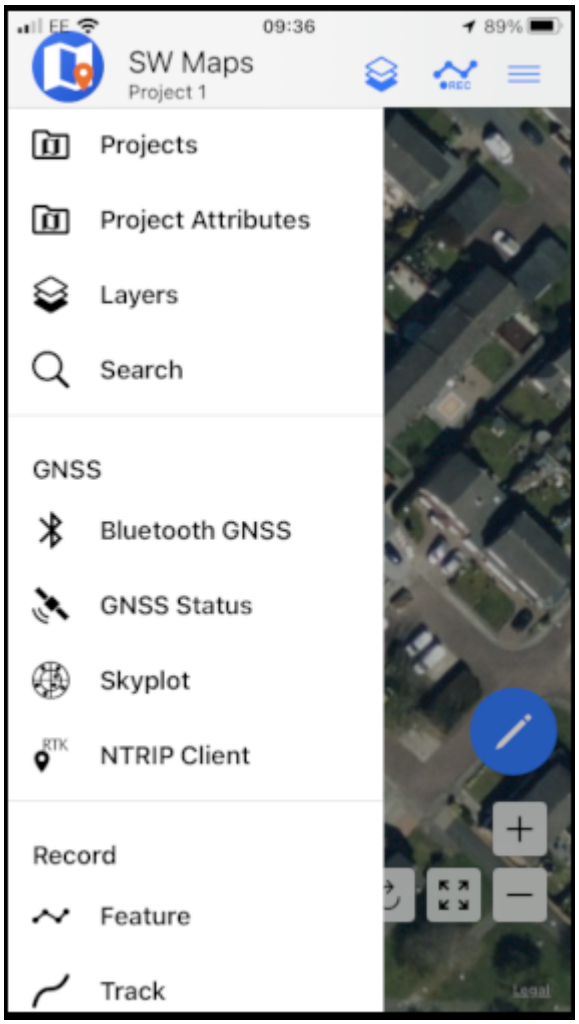
Open or continue a Project if desired.

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



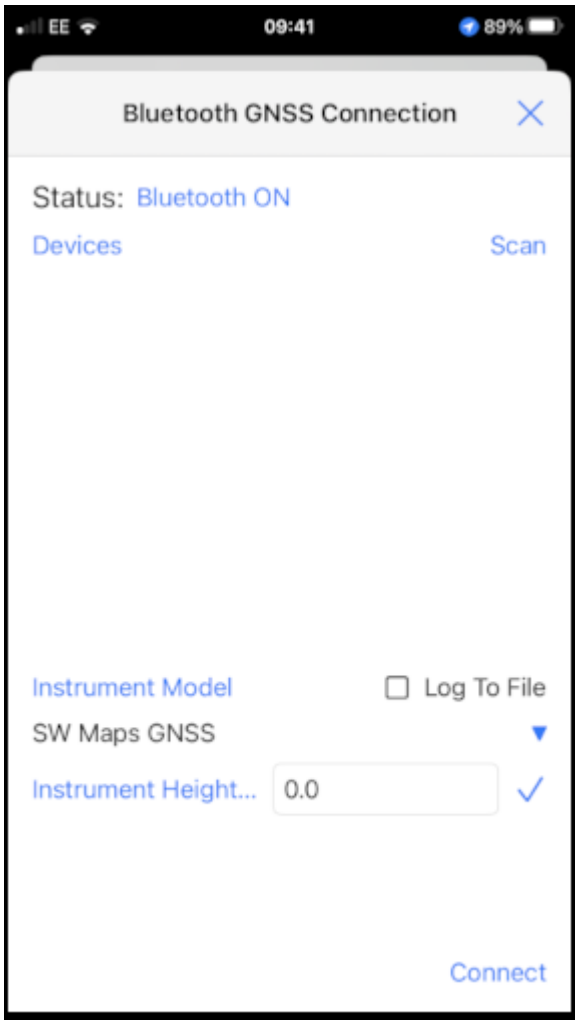
iOS SWMaps Initial Location

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



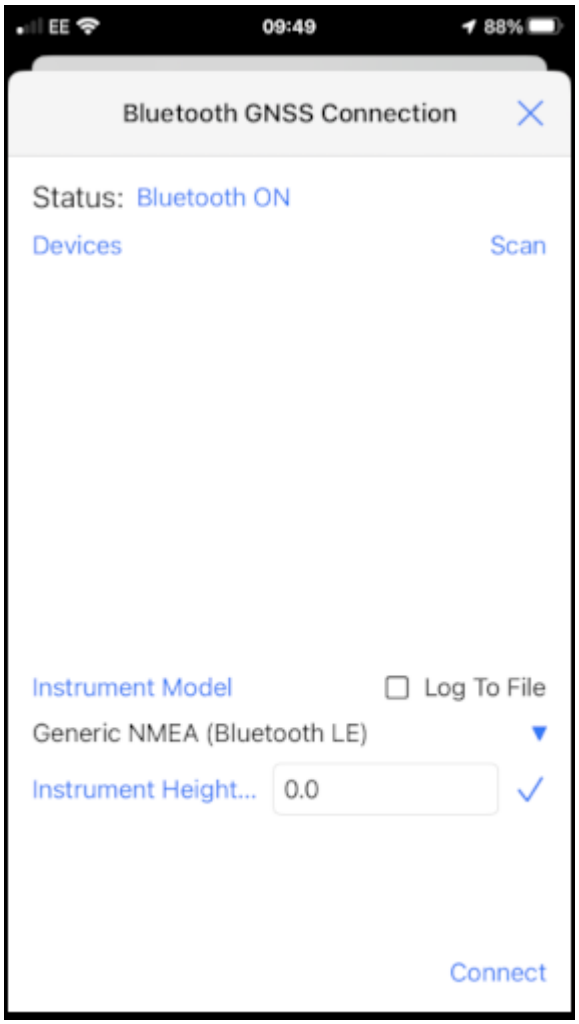
iOS SWMaps Menu

Select Bluetooth GNSS.



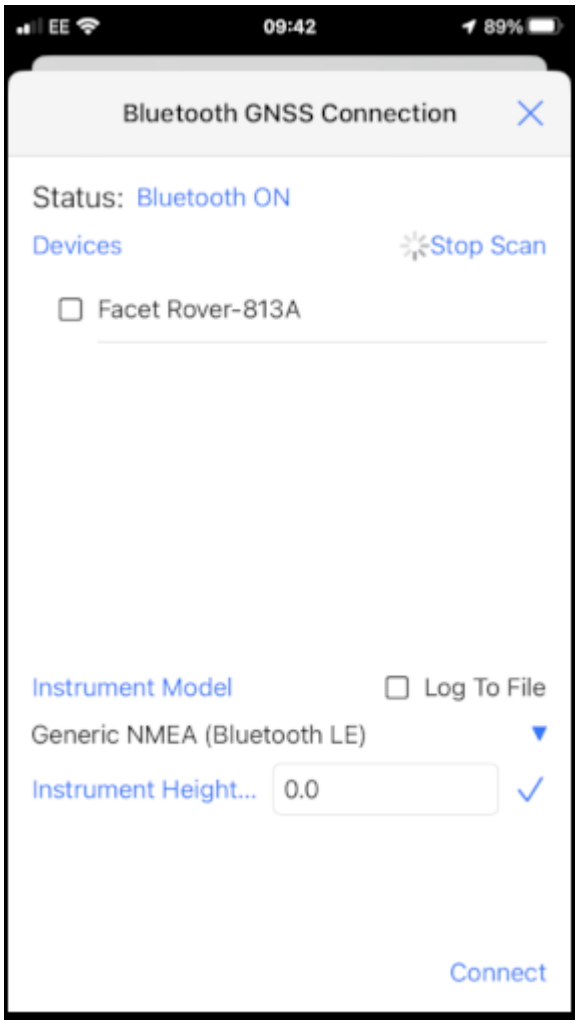
iOS SWMaps Bluetooth Connection

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



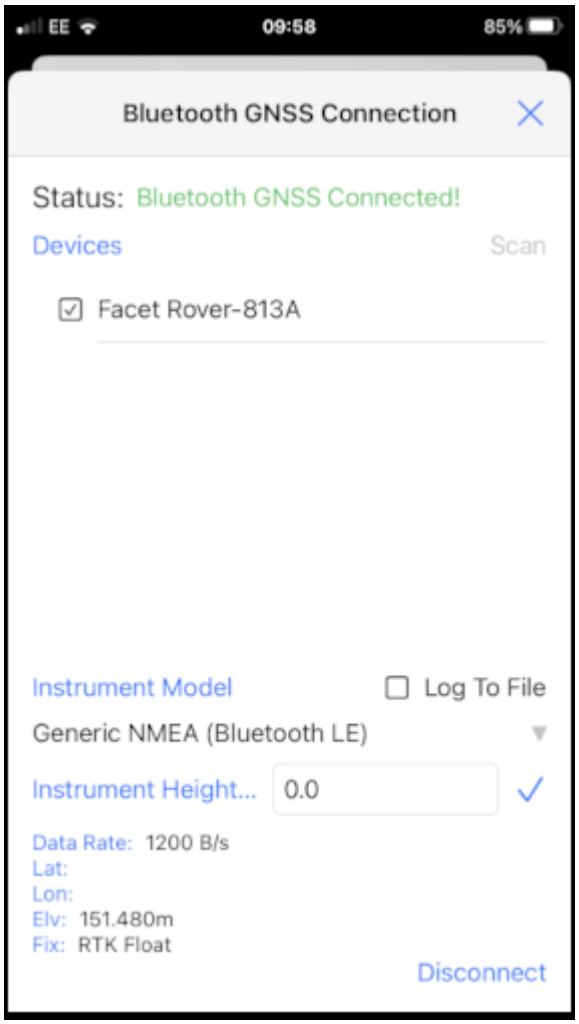
iOS SWMaps Instrument Model

Press 'Scan' and your RTK device should appear.



iOS SWMaps Bluetooth Scan

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



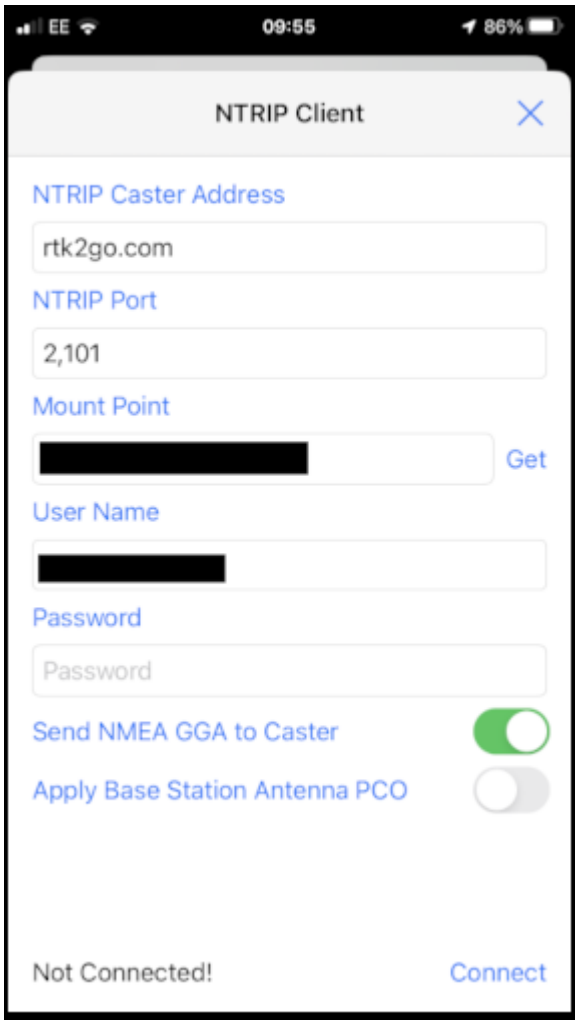
iOS SWMaps Bluetooth Connected

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'.

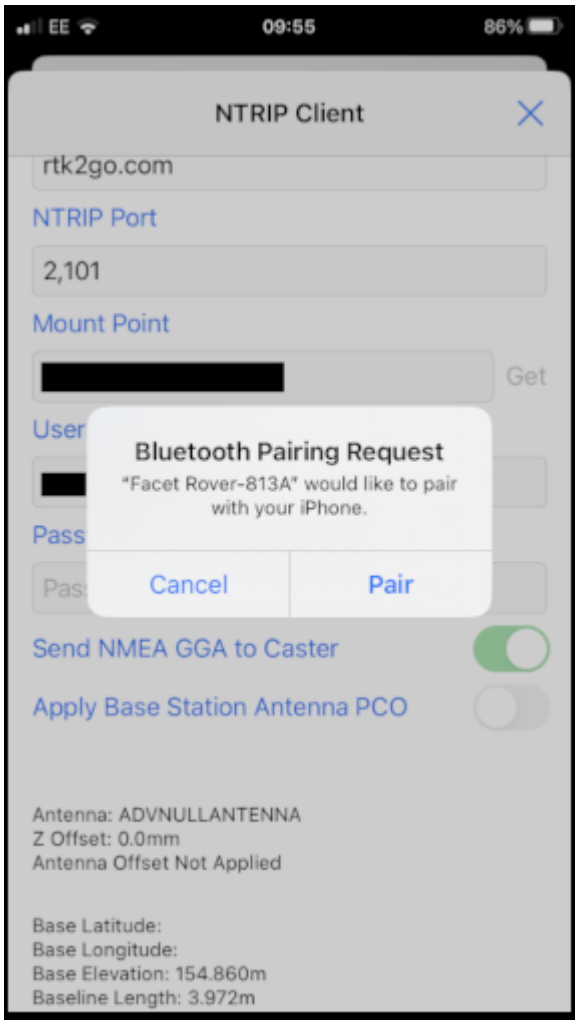
Enter the details for your NTRIP Caster - as shown in the SWMaps section above.



iOS SWMaps NTRIP Client

Click 'Connect'

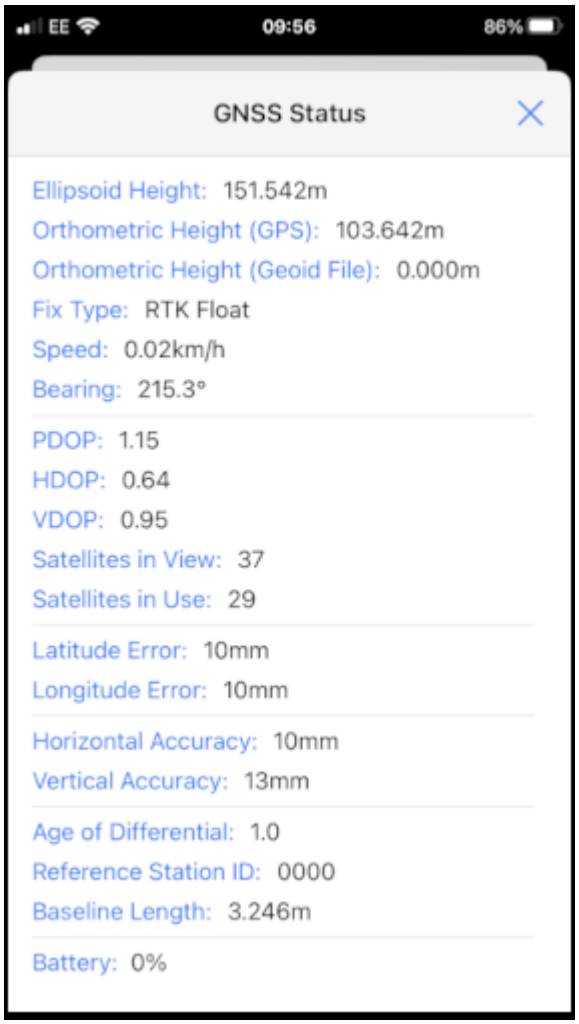
At this point, you should see a Bluetooth Pairing Request. Select 'Pair' to pair your RTK with your iOS device.



iOS Bluetooth Pairing

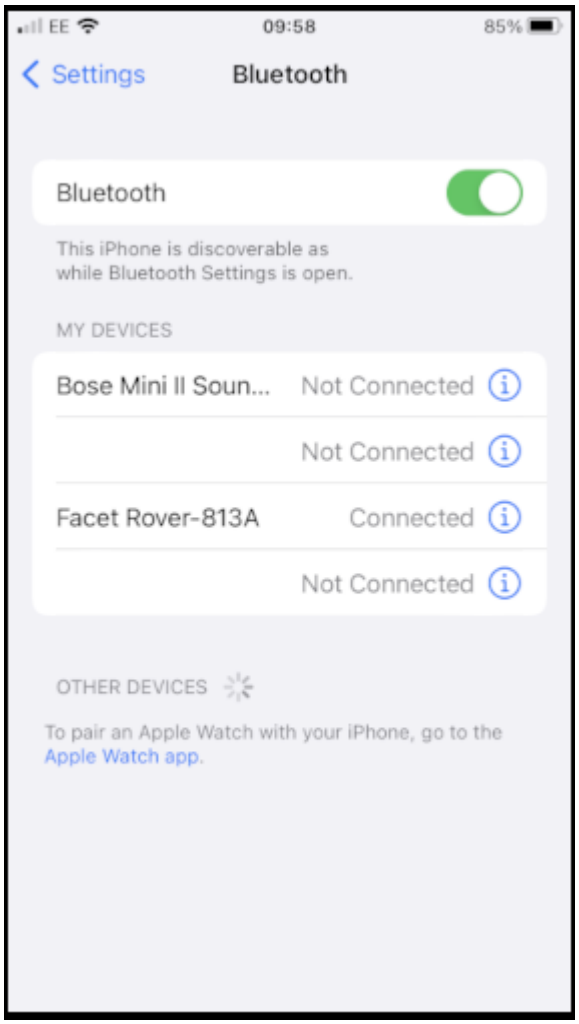
SWMaps will now receive NTRIP correction data from the caster and push it to your RTK over Bluetooth BLE.

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

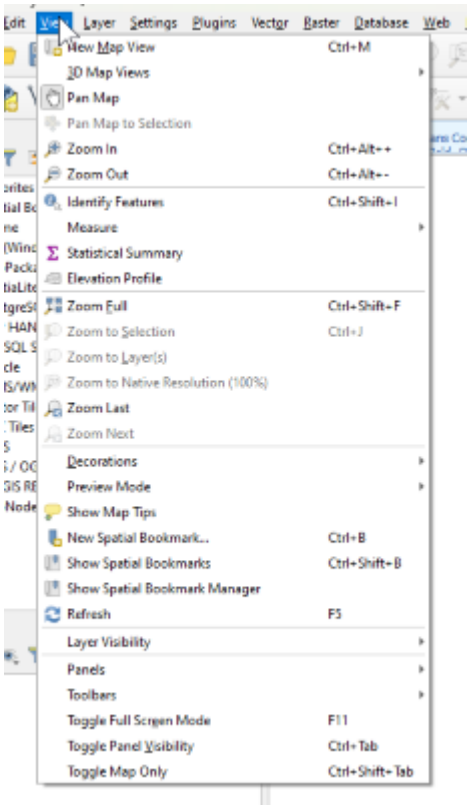
Torch:

There are a variety of 3rd party apps available for GIS and surveying for Android, iOS, and Windows. 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.

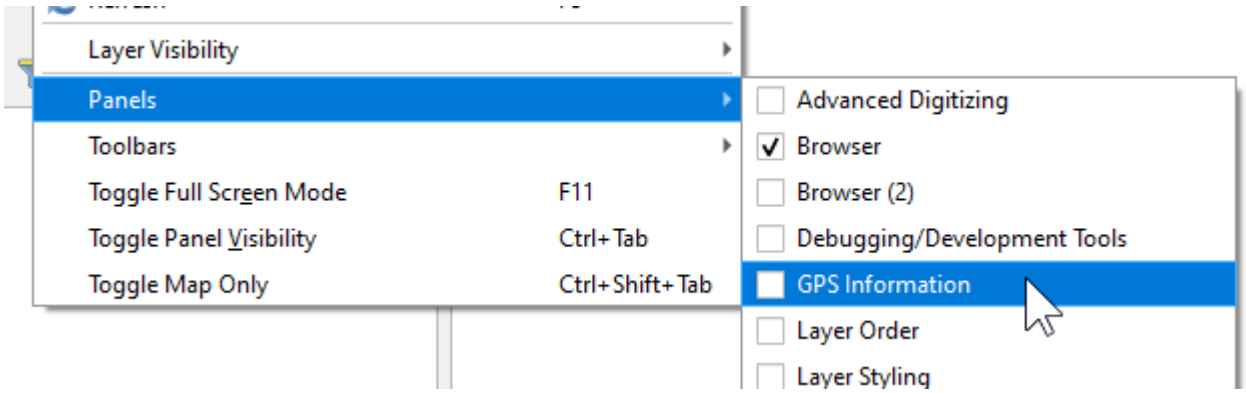
4.3.1 QGIS

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.

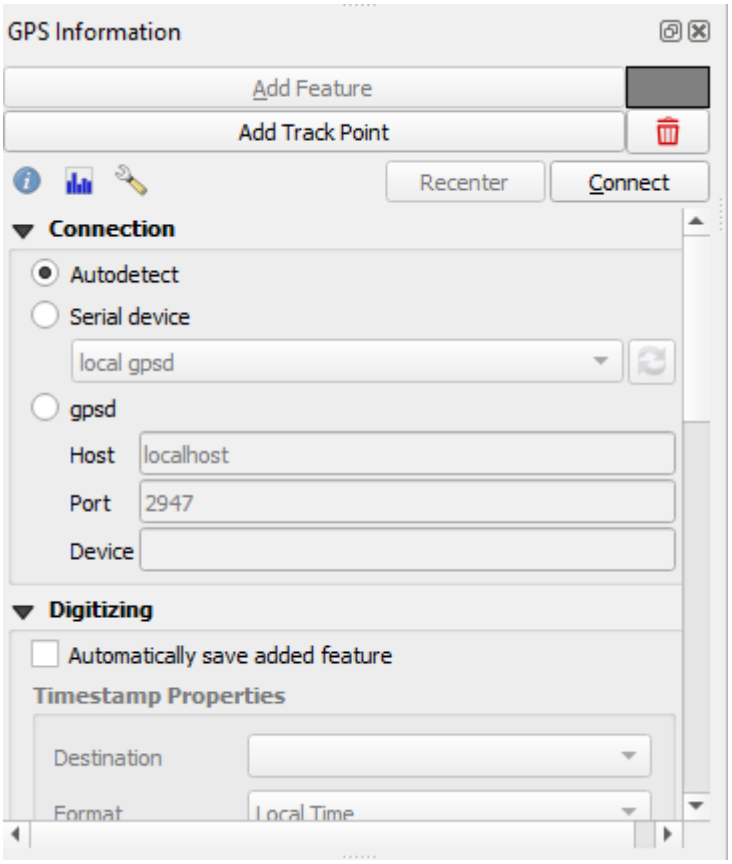


Open the View Menu, then look for the 'Panels' submenu.

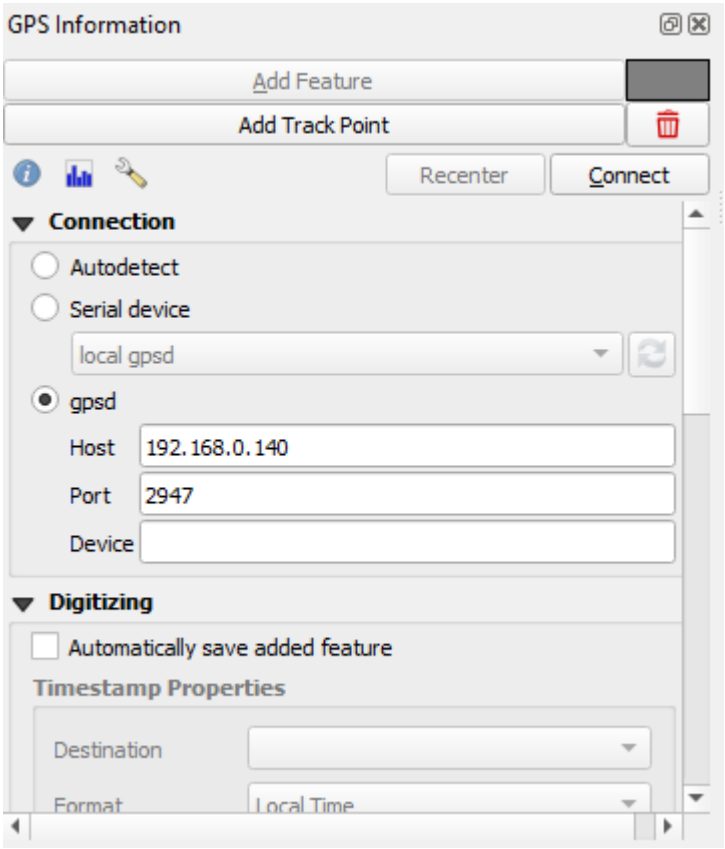


From the Panels submenu, enable 'GPS Information'. This will show a new panel on the left side.

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.

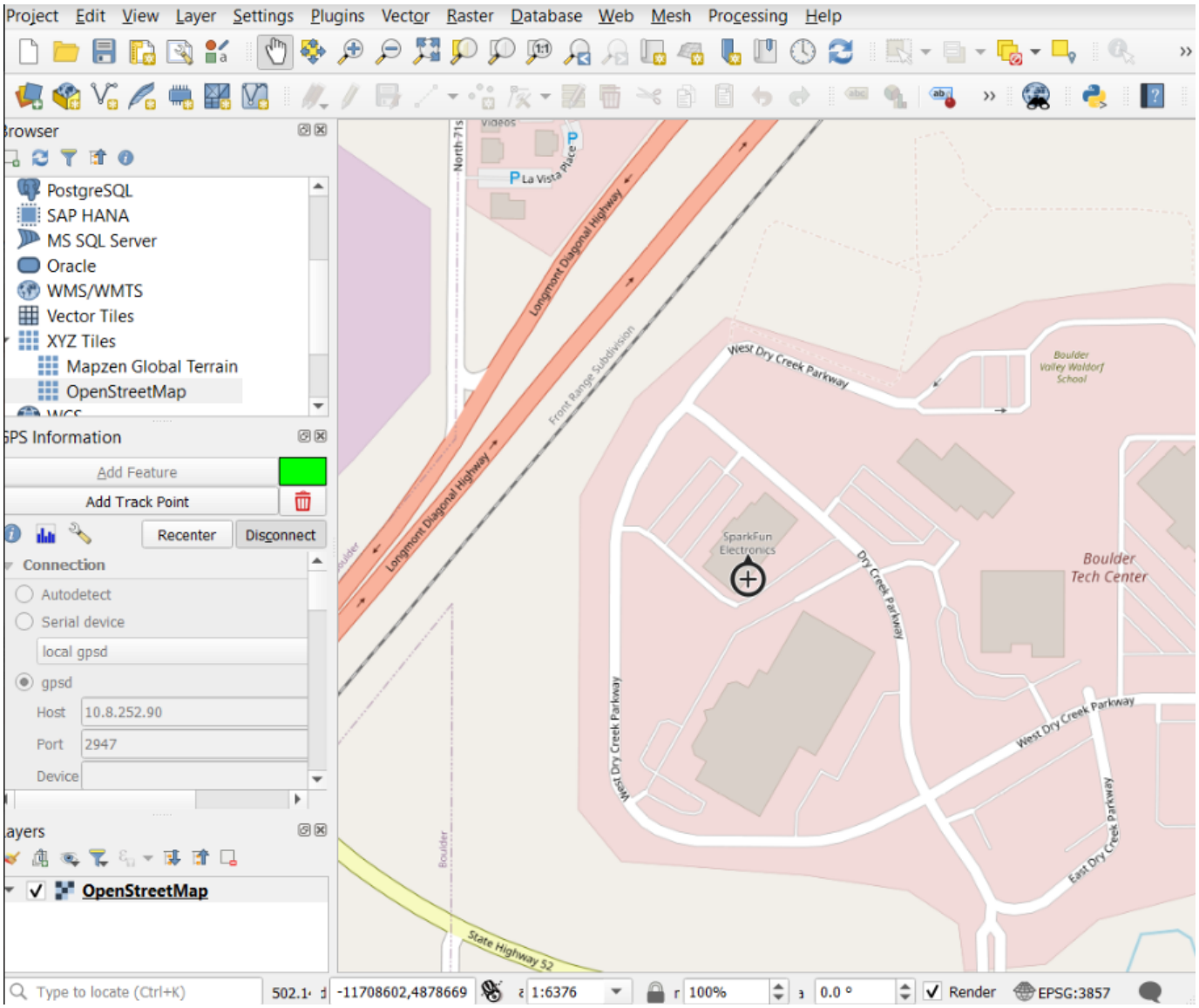


Above: From the subpanel, select 'gpsd'.

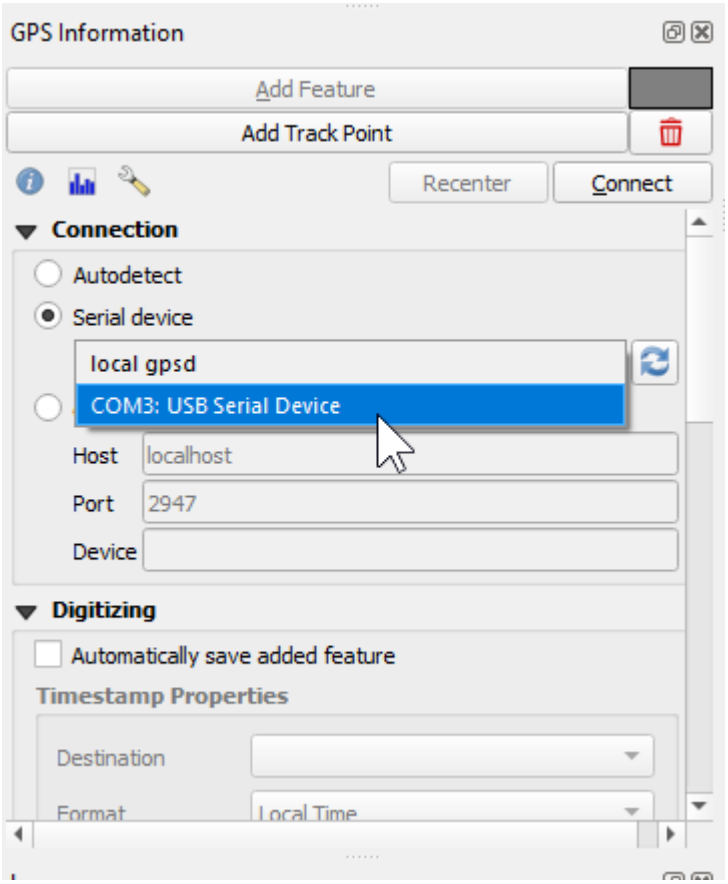


Enter the IP address of your RTK device. This can be found by opening a serial connection to the device. The IP address will be displayed every few seconds. Enter the TCP port to use. By default an RTK device uses 2947.

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 RTK device. See Output GNSS Data over USB 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?

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.

4.3.4 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.

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.

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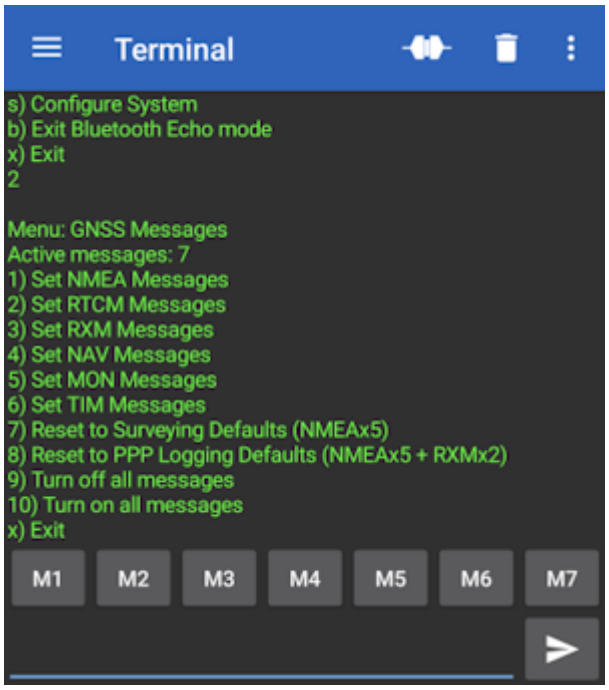
There are services available as well. Syklark provides RTCM coverage for $49 a month (as of writing) and is extremely easy to set up and use. Point One also offers RTK NTRIP service with a free 14 day trial and easy to use front end.

5. Configuration Methods

5.1 Configure with Bluetooth

Torch:

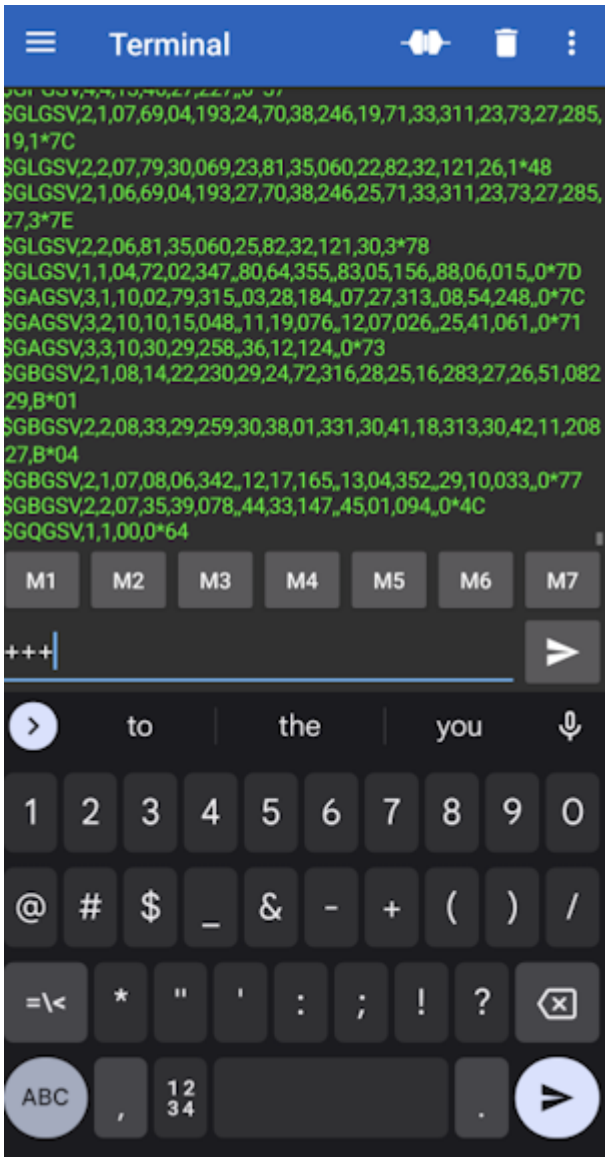


Configuration menu via Bluetooth

Bluetooth-based configuration provides a quick and easy way to navigate the serial menus as if you were connected over a USB cable. For regular users, this is often the preferred configuration method.

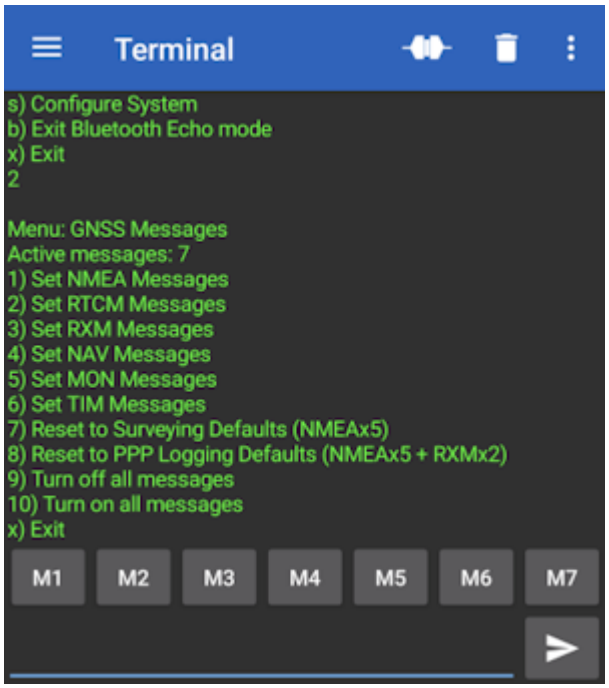
The RTK device will be a discoverable Bluetooth device (both BT SPP and BLE are supported). For information about Bluetooth pairing, please see Connecting Bluetooth.

5.1.1 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 +++.

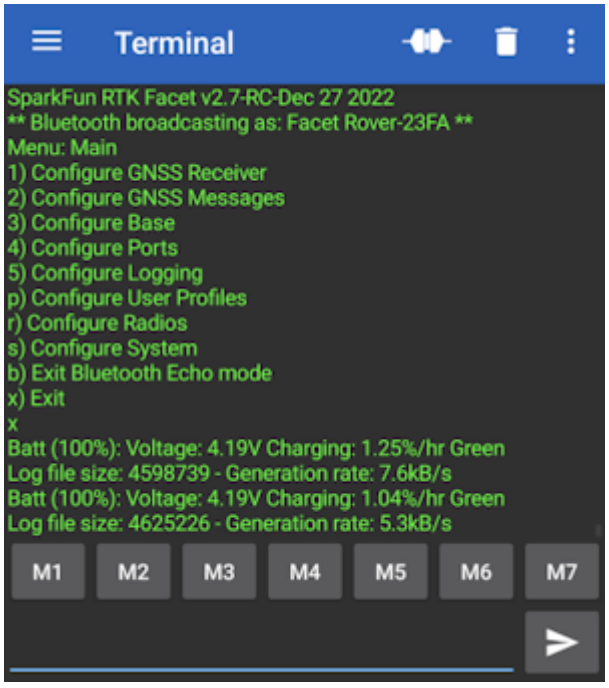
Note: There must be a 2 second gap between any serial sent from a phone to the RTK device, and any escape characters. In almost all cases this is not a problem. Just be sure it's been 2 seconds since an NTRIP source has been turned off and attempting to enter Bluetooth Echo Mode.



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.

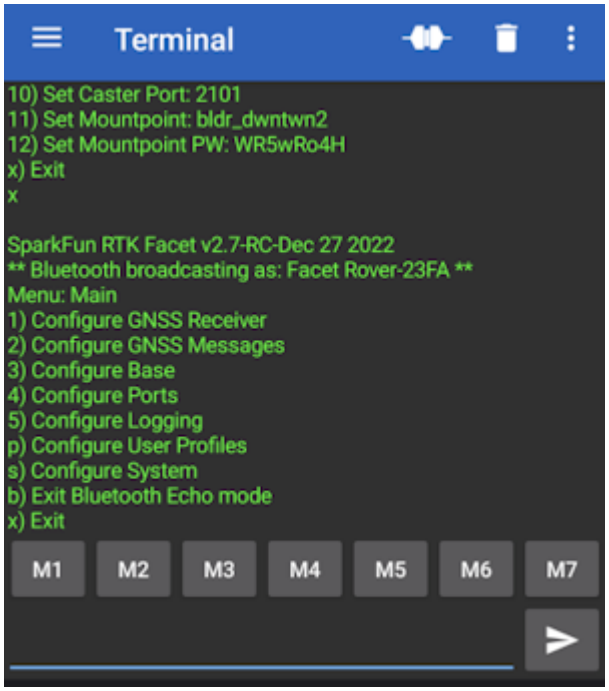


Exit from the Serial Config Menu

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.

5.1.2 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.

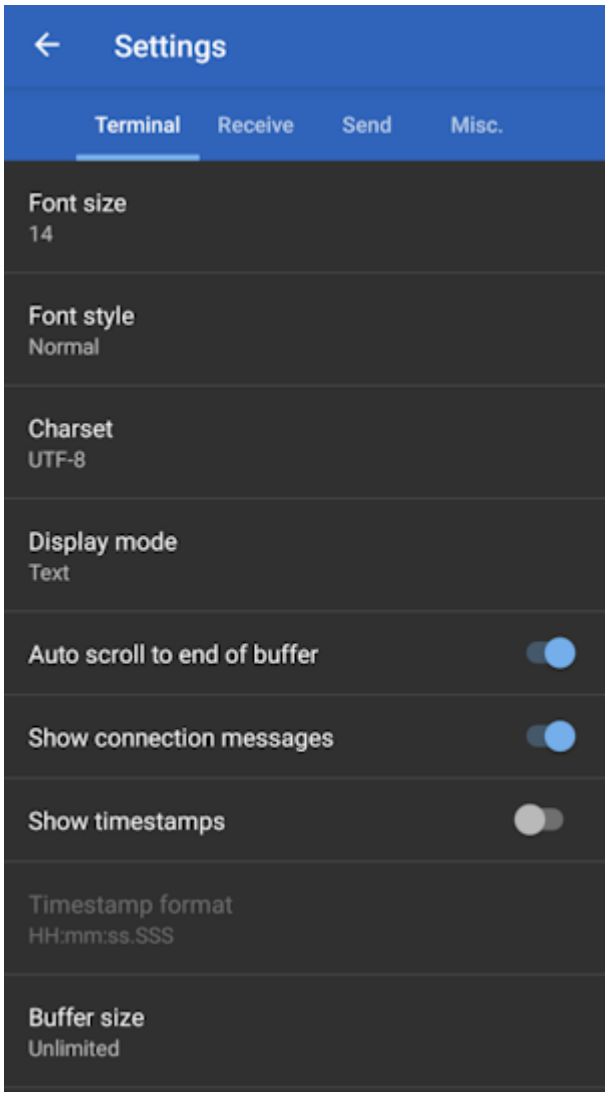


Menu option 'b' for exiting Bluetooth Echo Mode

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.

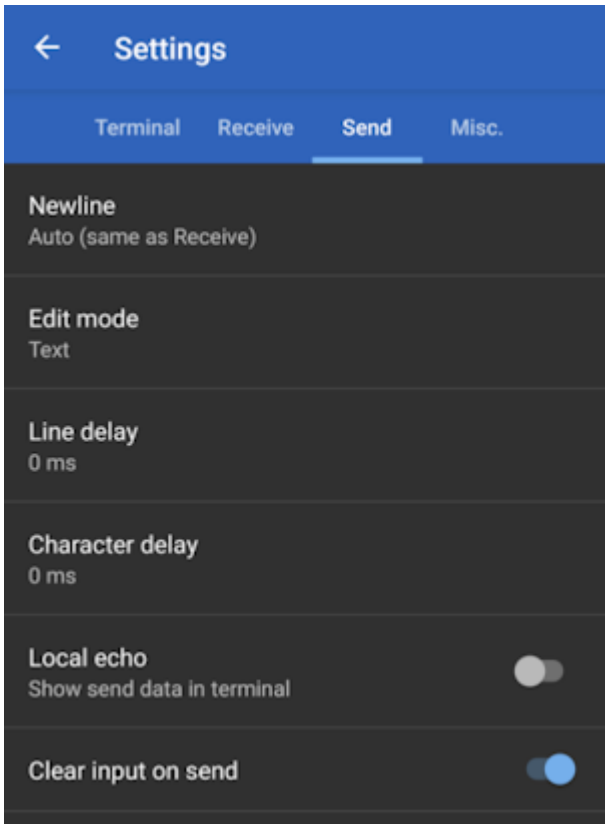
5.1.3 Serial Bluetooth Terminal Settings

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.

5.2 Configure with Serial

Torch: 

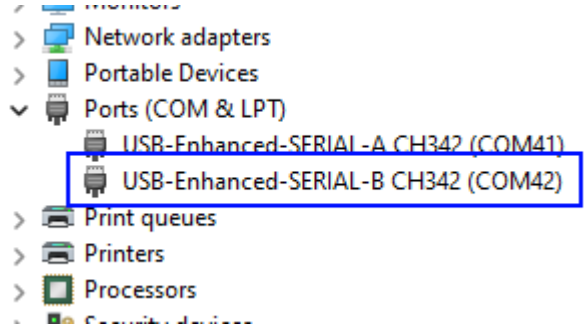
Note: Any serial menu that is shown below can also be accessed over Bluetooth. This makes any configuration of a device much easier in the field. Please see Configure With Bluetooth for more information.

To configure an RTK device using serial attach a USB C cable to the device.

5.2.1 RTK Torch

The USB Connector on the RTK Torch

Pull back the silicone cover and insert a USB C and power on the device. Once the device is powered on, open the `Device Manager` in Windows and look under the Ports branch to see what COM port the device is assigned to.



SparkFun RTK Torch Two Enumerated Ports

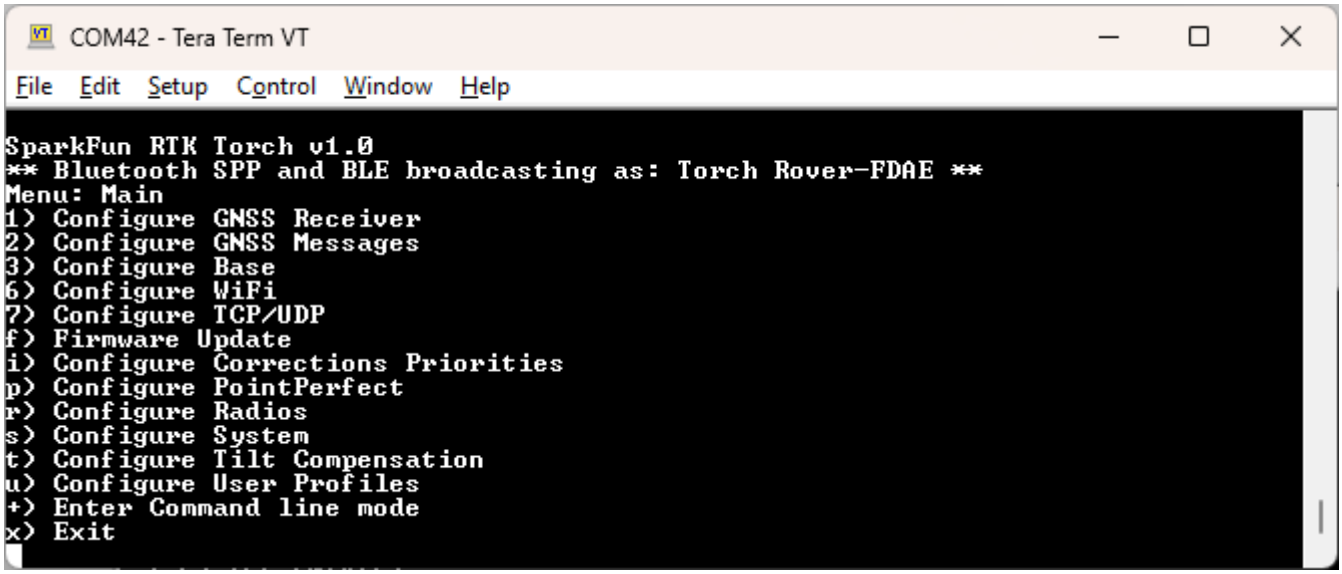
Configuring the RTK device is done over the *USB-Enhanced-SERIAL-B CH342* COM port via the serial text menu. Various debug messages are printed to this port at 115200bps and a serial menu can be opened to configure advanced settings.

Don't See 'USB-Enhanced-SERIAL-B CH342'? If you've never connected a CH34x 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.

5.2.2 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 RTK device when the terminal connection is closed. You can disconnect the USB cable first to prevent this from happening.

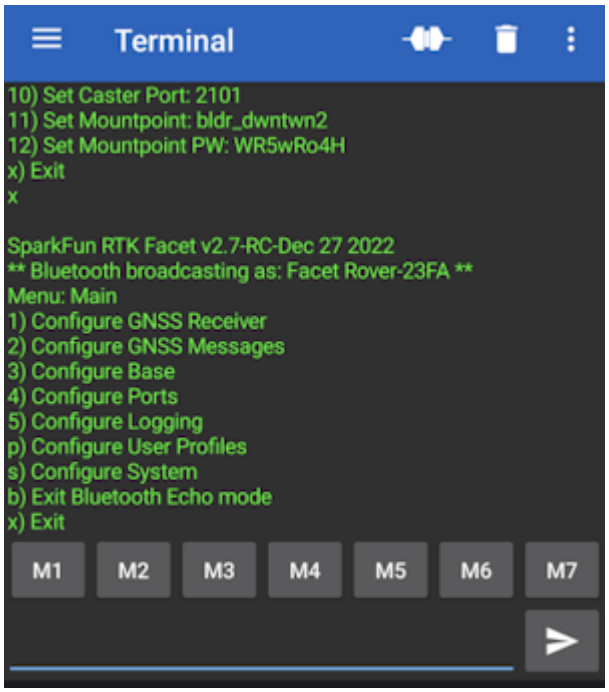


The Main Menu

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 'Torch', 'EVK', 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.

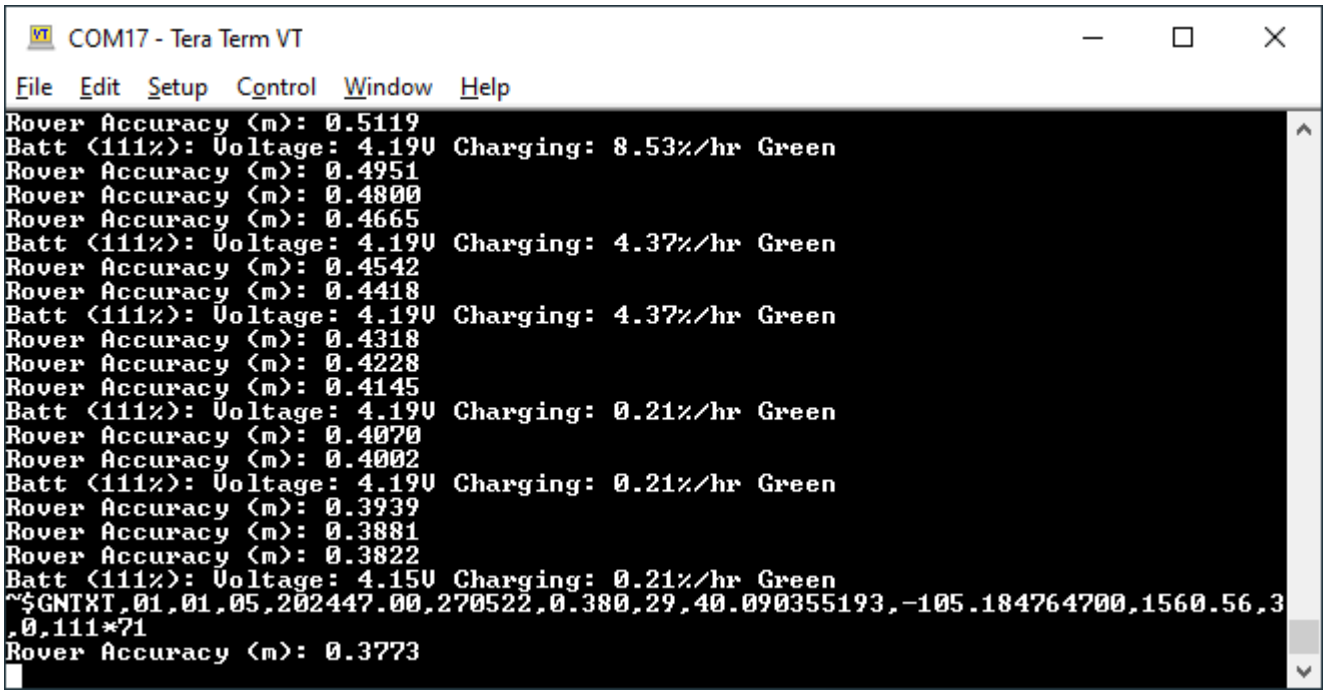


Configuration menu via Bluetooth

Note: Bluetooth-based configuration is supported. Please see Configure With Bluetooth for more information.

5.2.3 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.



Terminal showing System Status

Below is an example system status report sentence:

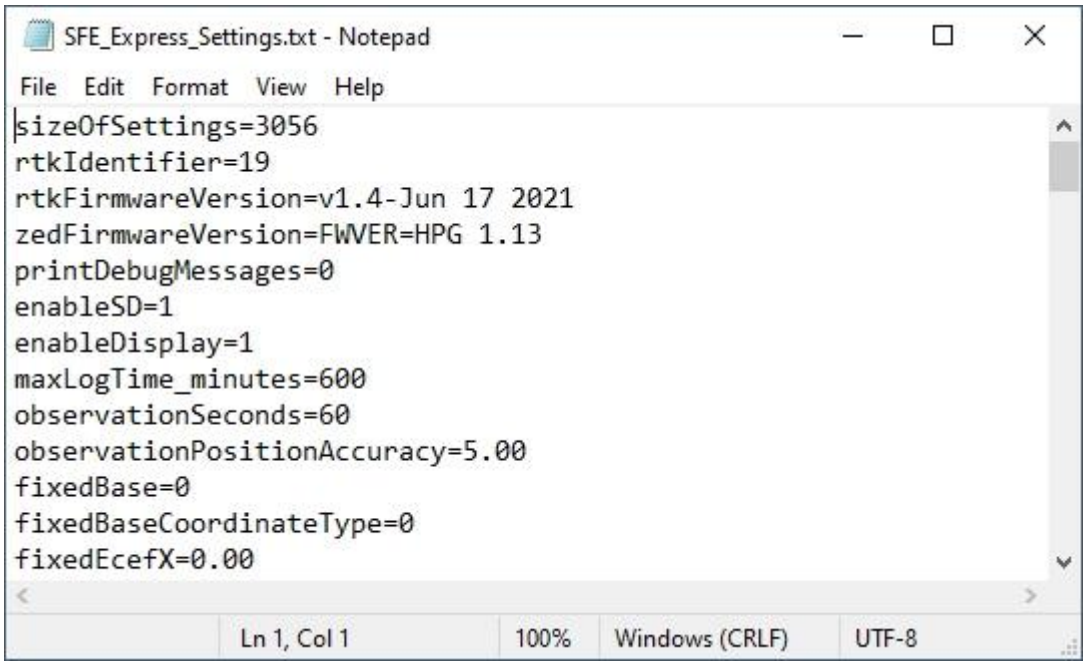
$GNTXT,01,01,05,202447.00,270522,0.380,29,40.090355193,-105.184764700,1560.56,3,0,86*71

- $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 Reackoning, 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 Configure with Settings File

Torch: 



SparkFun RTK Settings File

All device settings are stored both in internal memory and an SD card (if supported and 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 an external settings file then the external 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:

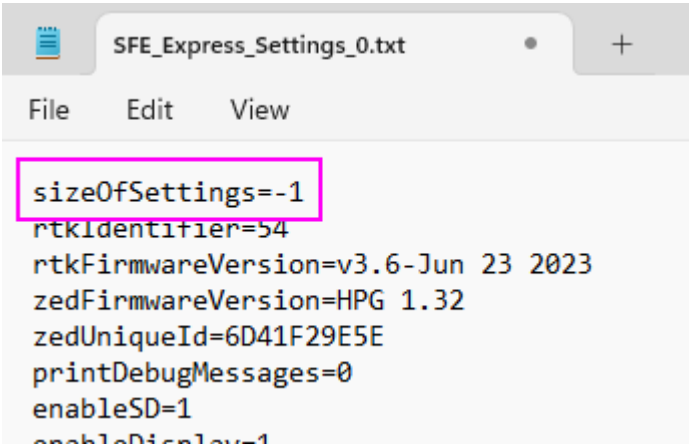
- Not all devices have an SD card slot (ie, RTK Torch) and therefore do not support this configuration method.
- The settings file contains hundreds of settings.
- The SD card file "SFE_EVK_Settings_0.txt" is used for Profile 1, SD card file "SFE_EVK_Settings_1.txt" is used for Profile 2, etc. (note 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
enableTcpServer=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.

5.3.1 Forcing a Factory Reset



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_EVK_Settings_**0**.txt, SFE_EVK_Settings_**1**.txt, etc). All settings files found on the SD card must be modified to guarantee the factory reset.

5.4 Configure with u-center

Torch: 

On devices that have a u-blox GNSS receiver, the ZED-F9P GNSS 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.

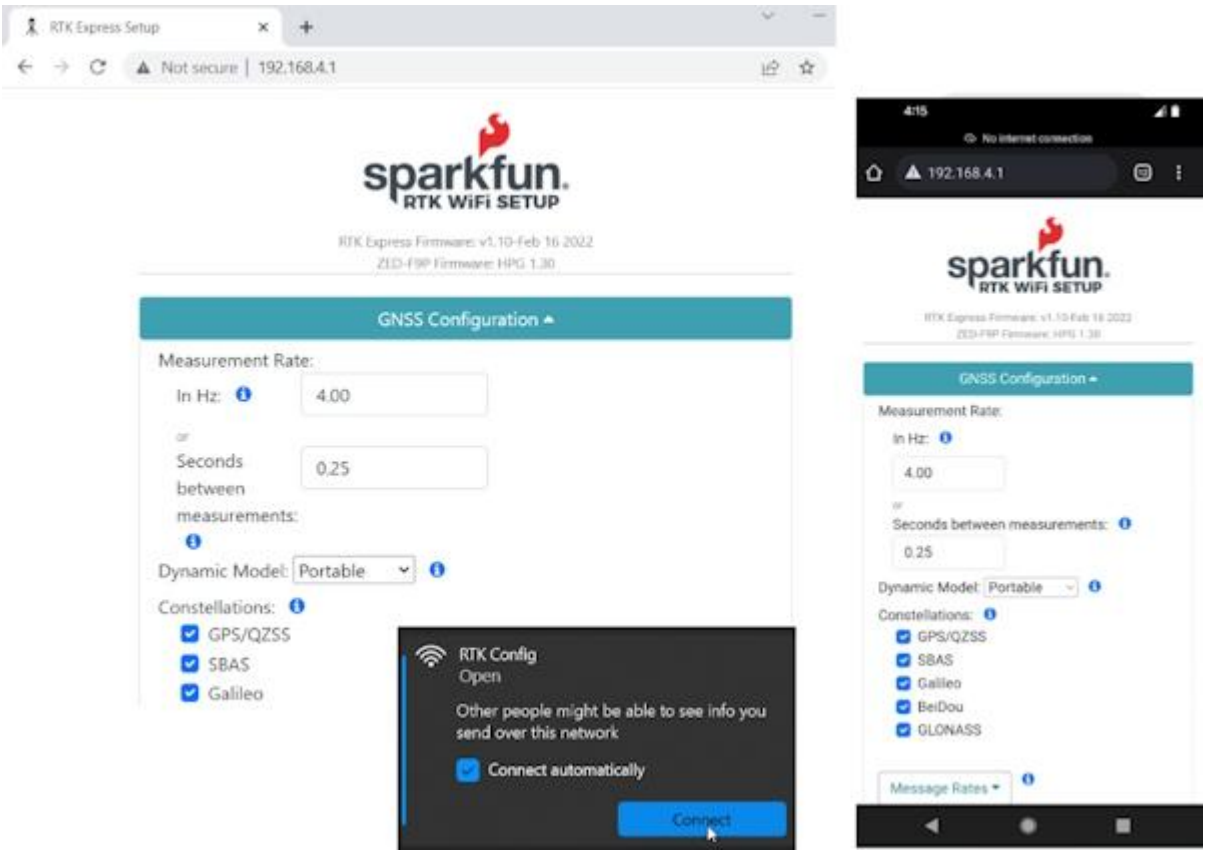
However, because the ESP32 does considerable configuration of the ZED-F9P at power on it is not recommended to modify the settings of the ZED-F9P using u-center. Nothing will break but your changes will likely be overwritten at the next power cycle.

5.5 Configure with WiFi

Torch:

SparkFun RTK WiFi Configuration Interface

During WiFi configuration, 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.

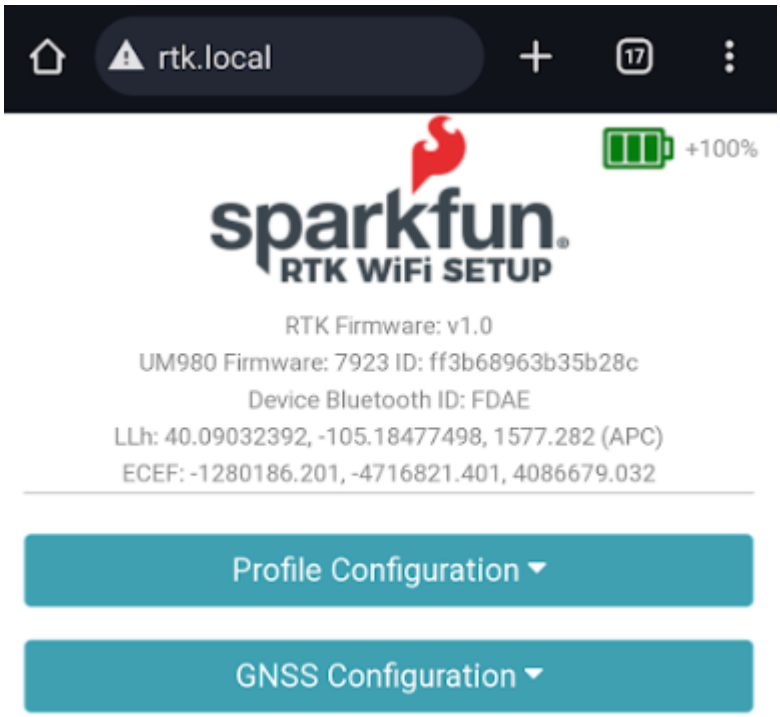


Desktop vs Phone display size configuration

5.5.1 RTK Torch

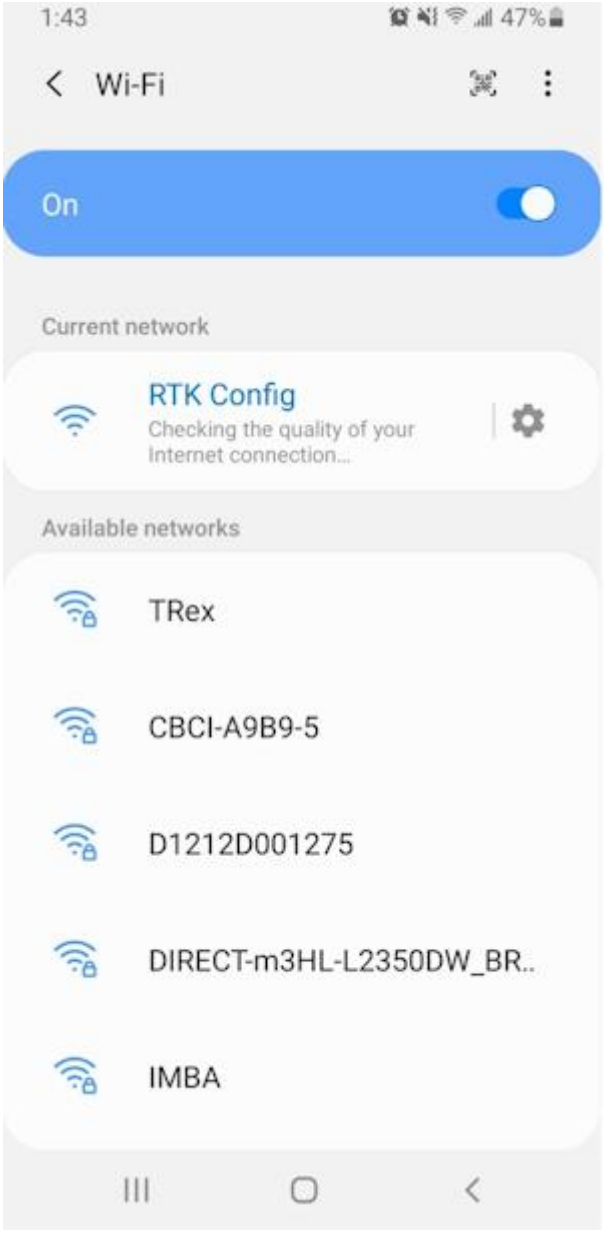
To get into WiFi configuration follow these steps:

1. Power on the RTK Torch
2. Once the device has started press the Power Button twice within 1 second (double tap).
3. The display will beep twice indicating it is waiting for incoming connections.
4. Connect to WiFi network named ‘RTK Config’.
5. You should be automatically re-directed to the config page but if you are not, open a browser (Chrome is preferred) and type **rtk.local** into the address bar.



Browser with rtk.local

5.5.2 Connecting to WiFi Network

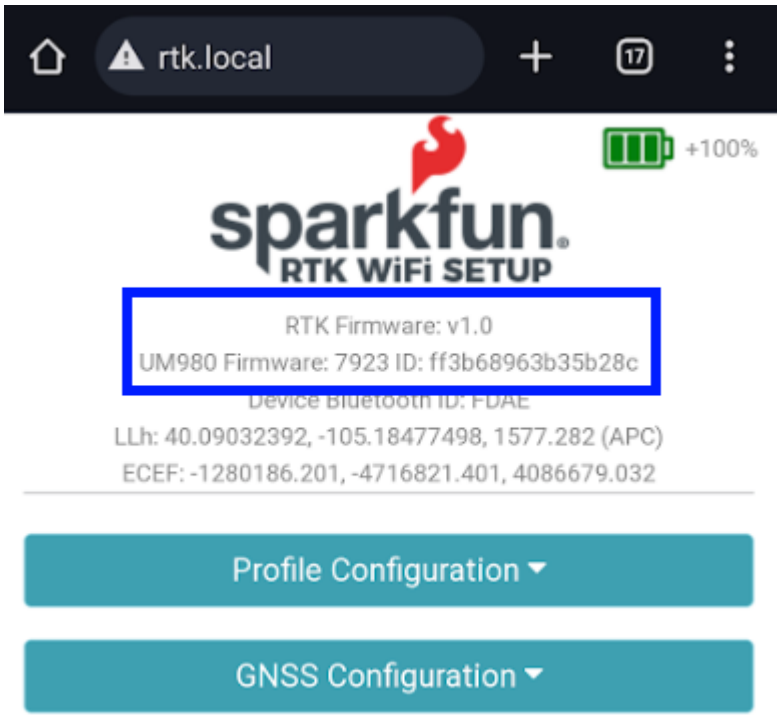


The WiFi network RTK Config as seen from a cellphone

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.

Connected to the RTK WiFi Setup Page

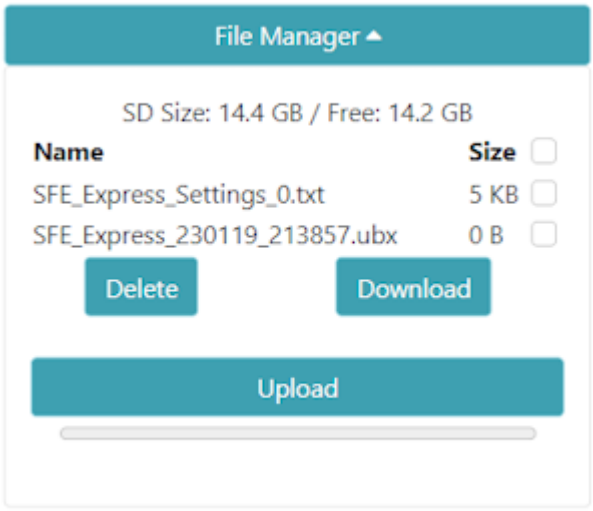
Clicking on the category 'carrot' will open or close that section. Clicking on an ‘i’ will give you a brief description of the options within that section.



This unit has firmware version 1.0 and a UM980 GNSS receiver

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

5.5.3 File Manager



On devices that support an external SD card, 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.

5.5.4 Saving and Exit

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.

6. Configuration Menus

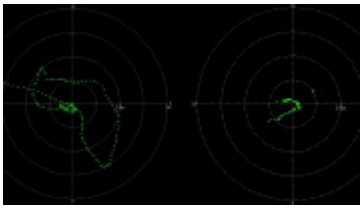
6.1 Base Menu

Torch:

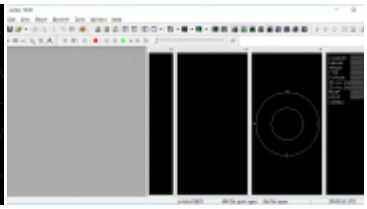
In addition to providing accurate local location fixes, SparkFun RTK devices can also serve as a correction source, also called a *Base*. The Base doesn't move and 'knows' where it is so it can calculate the discrepancies between the signals it is receiving and what it should be receiving. Said differently, 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 ~~Force~~ 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.

Please see the following tutorials for more information:



What is GPS RTK?



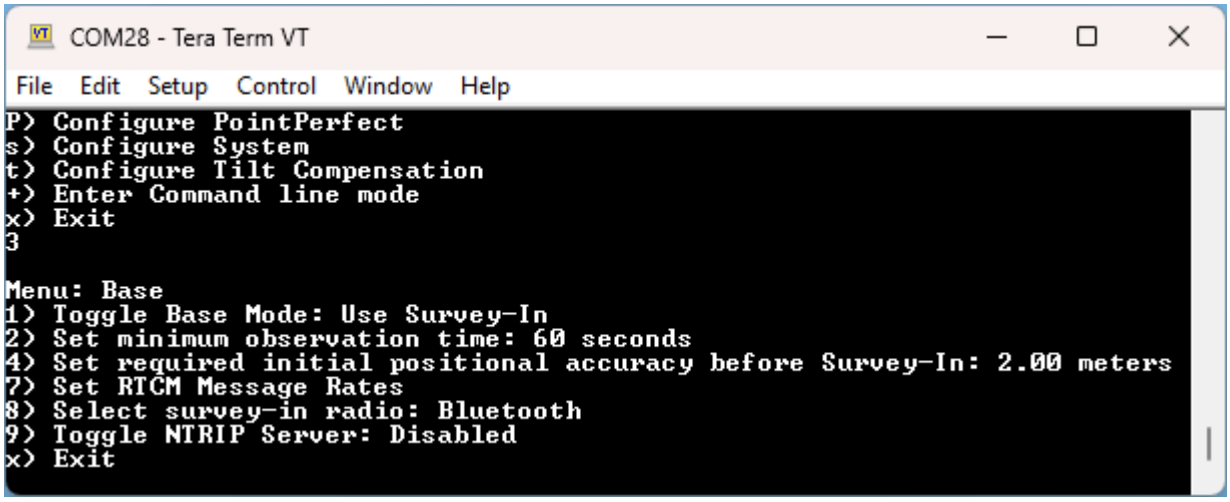
Getting Started with u-center for u-blox

Setting up a Rover Base RTK System

How to build a DIY GNSS reference station

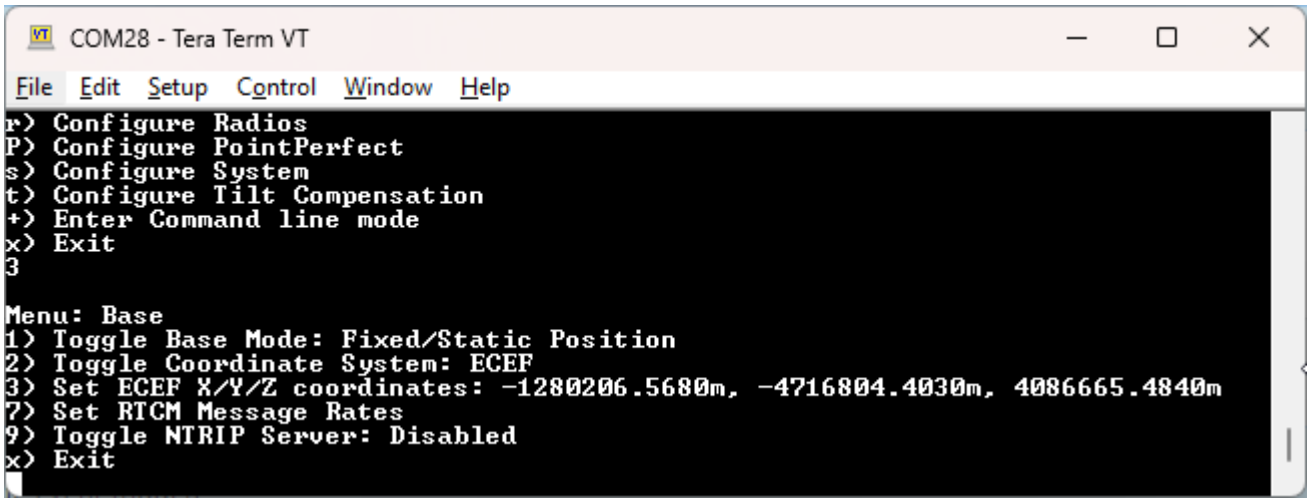
6.1.1 Mode

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



Base Menu showing Survey-In Mode

In **Survey-In** mode, the minimum observation time can be set. The default is 60 seconds. 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 is not going to significantly improve the accuracy of the survey - use PPP instead.



Base Menu showing Fixed Base Mode with ECEF Coordinates

In **Fixed** mode, the coordinates of the antenna need to be set. These can be entered in ECEF or Geographic coordinates.

Once the device has been configured, a user enters Base mode by changing the mode in the System Menu.

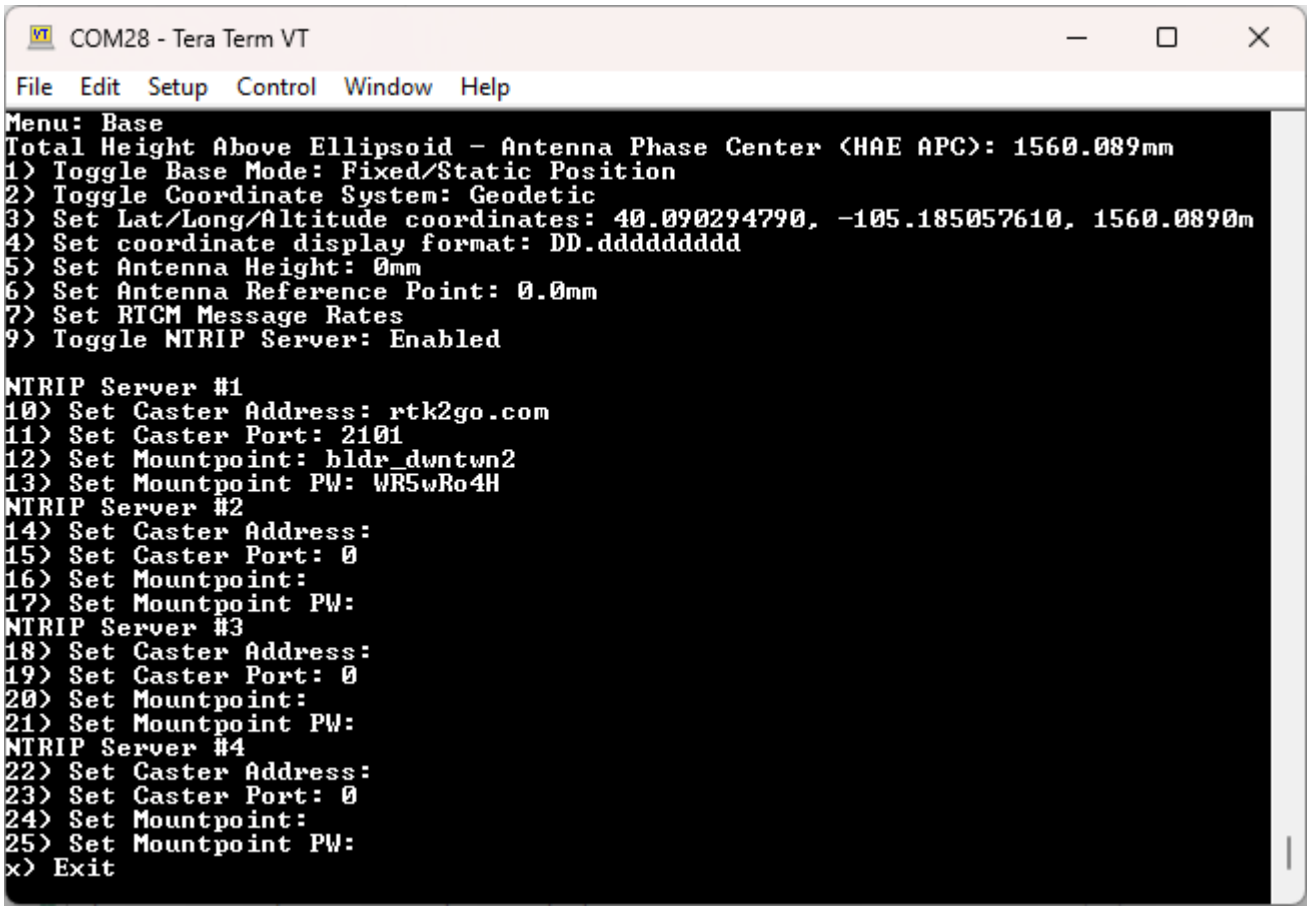
If the device is configured for *Survey-In* base mode, the survey will begin. The mean standard deviation will be printed as well as the time elapsed. For most Survey-In setups, the survey will complete in around 60 seconds.

In *Fixed Base* mode the GNSS receiver will go into Base mode with the defined coordinates and immediately begin outputting RTCM correction data.

6.1.2 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:



Settings for the NTRIP Servers

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 up to **4 Casters**. This eliminates the need for a radio link between one Base and one Rover. Providing more than one caster is a unique RTK Everywhere feature that allows a single base installation to push corrections to a public Caster (such as RTK2Go) as well as payment-generating casters (such as Onocoy or Geodnet).

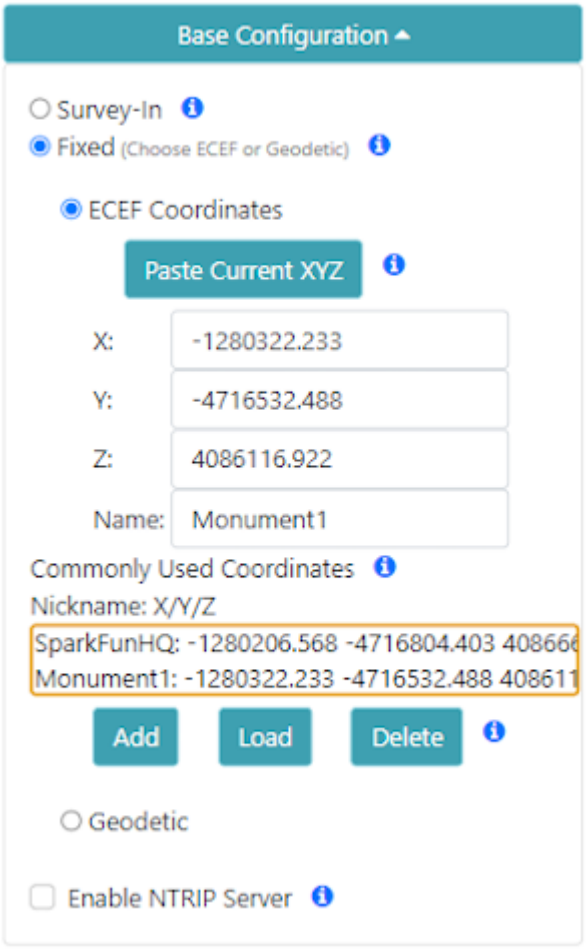
Once the NTRIP server is enabled you will need a handful of credentials:

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

If the NTRIP server is enabled the device will first attempt to connect to WiFi. Once WiFi connects the device will attempt to connect to the NTRIP mount point. Once connected, every second a few hundred bytes, up to ~2k, will be transmitted to your mount point.

The RTK device will monitor each NTRIP Server connection and automatically attempt to restart it if WiFi or if the Caster is disconnected.

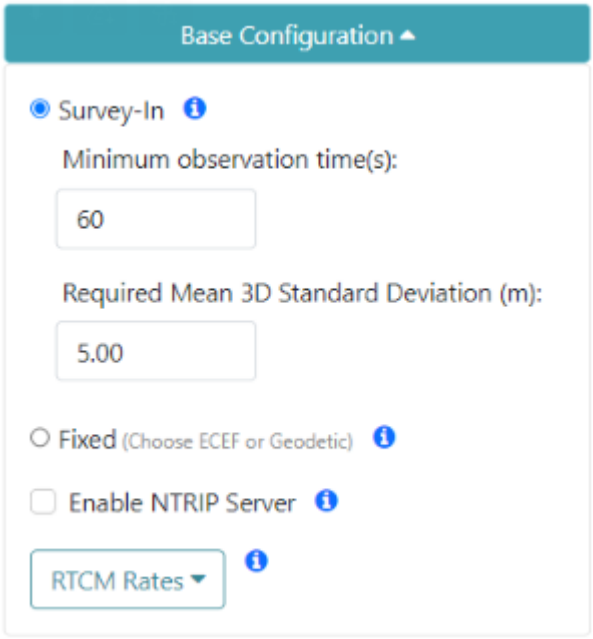
6.1.3 Commonly Use Coordinates



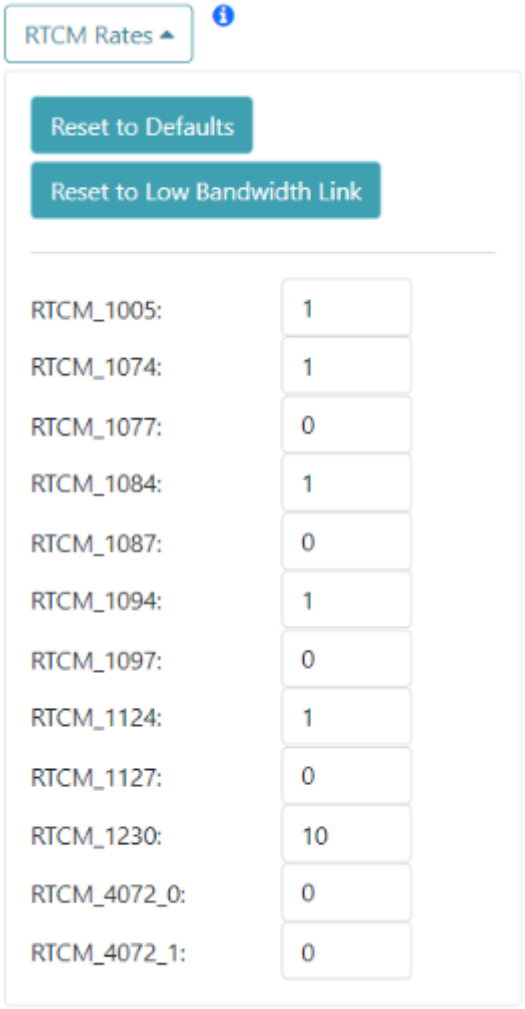
A list of common coordinates

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.

6.1.4 RTCM Message Rates

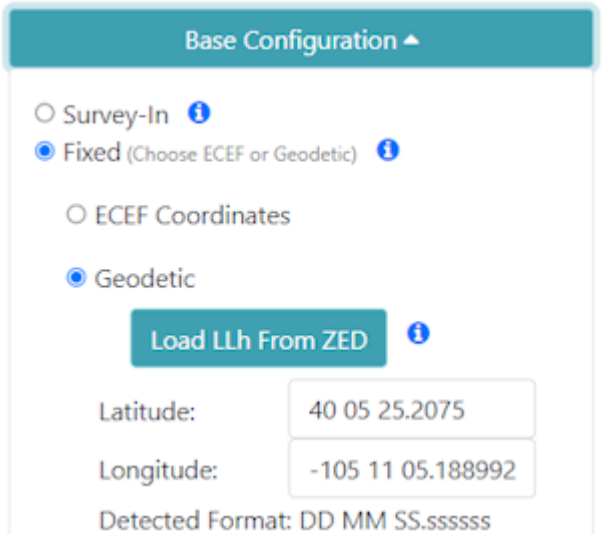


When the device is in Base mode, the fix rate is set to 1Hz. This will override any Rover setting.



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.

6.1.5 Supported Lat/Long Coordinate Formats



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

- DD.ddddddddd (ie -105.184774720, 40.090335429)
- DDMM.mmmmmmm (ie -10511.0864832)
- DD MM.mmmmmmm (ie 40 05.42013)
- DD-MM.mmmmmmm (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) Set RTCM Message Rates
9) Toggle NTRIP Server: Disabled
x) Exit
```

Coordinates shown in DD MM SS.ssssss format

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.

6.1.6 Assisted Base

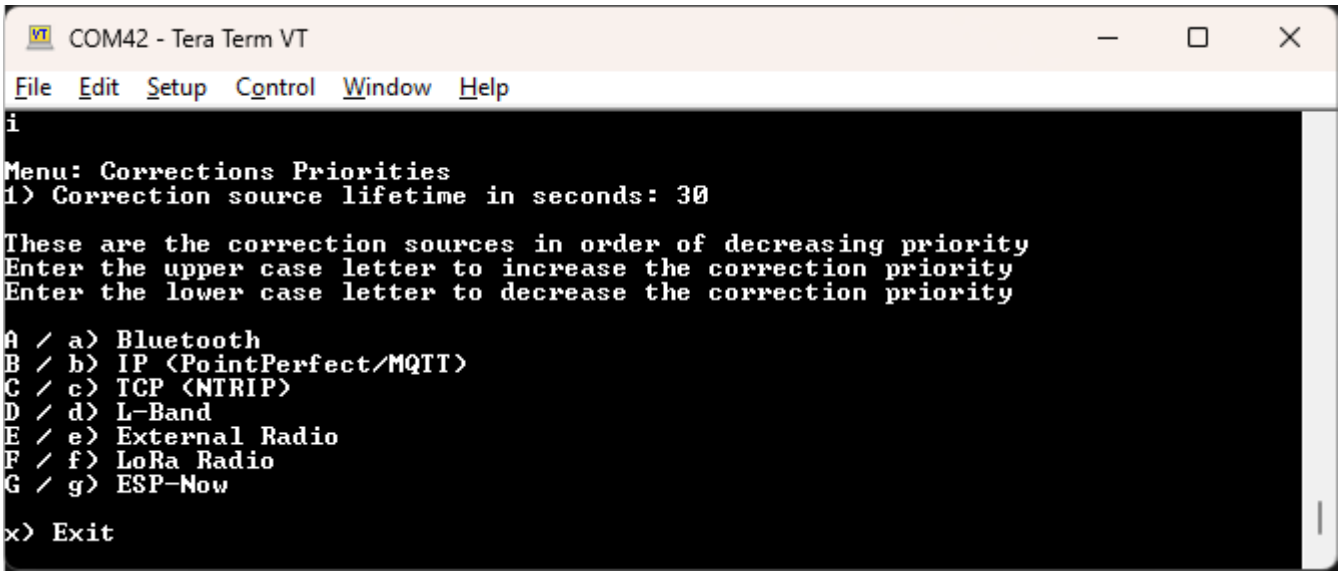
An Assisted Base is where a temporary base is set up to Survey-In its location but is simultaneously provided RTCM corrections so that its Survey-In is done with very precise readings. An assisted base running a Survey-In removes much of the relative inaccuracies from a Rover-Base system. We've found 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.

6.2 Corrections Priorities

Torch:

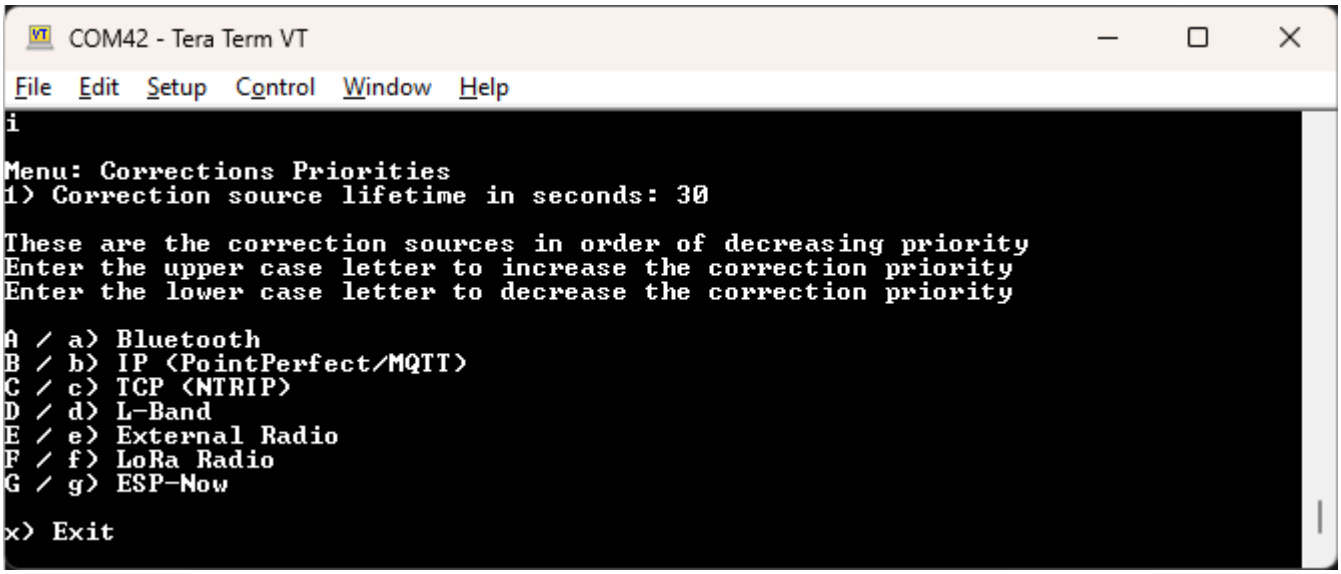


RTK Corrections Priorities Menu

To achieve an RTK Fix, SparkFun RTK products must be provided with a correction source. An RTK device can obtain corrections from a variety of sources. Below is the list of possible sources (not all platforms support all sources) and their default priorities:

- Bluetooth
- IP (PointPerfect/MQTT)
- TCP (NTRIP)
- L-Band
- External Radio
- LoRa Radio
- ESP-Now

The *Corrections Priorities* menu allows a user to specify which correction source should be given priority. For example, if corrections are provided through Bluetooth and L-Band simultaneously, the corrections from L-Band will be discarded because the Bluetooth source has a higher priority. This prevents the RTK engine from receiving potentially mixed correction signals.



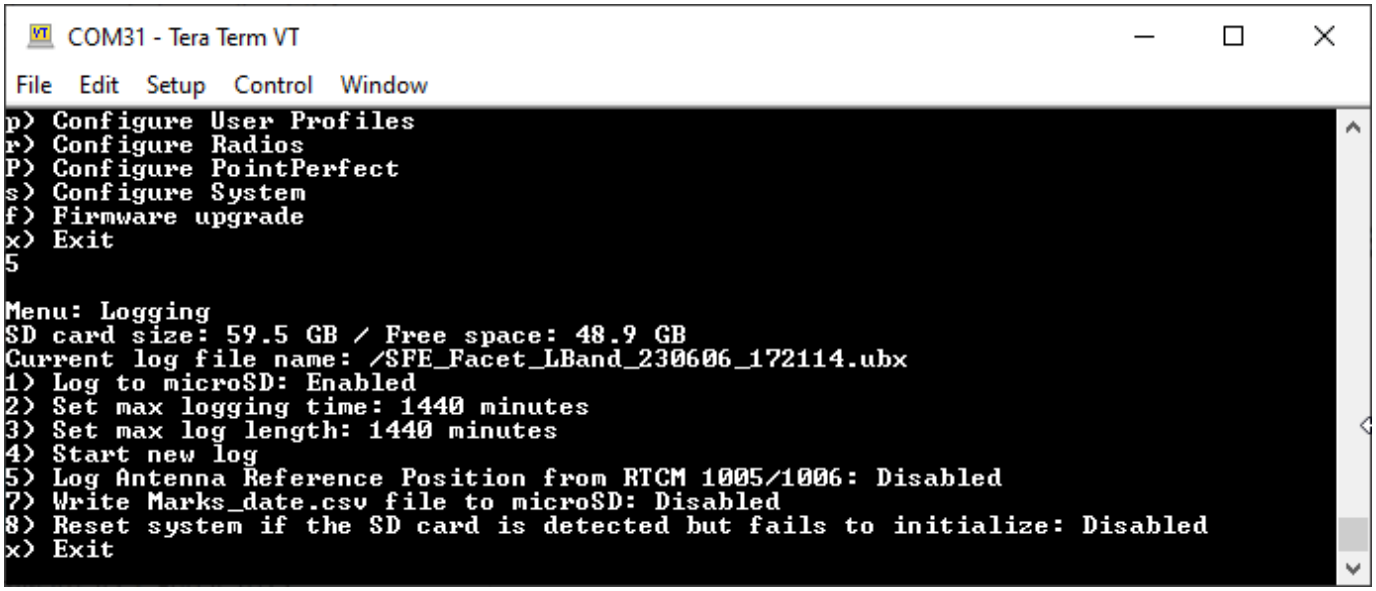
In the serial terminal menu, pressing a letter will increase or decrease the position of a priority. For example, in the image above, pressing **D** will raise the `L-Band` priority above `TCP (NTRIP)`.

Please see Correction Sources for a description of where to obtain corrections.

6.3 Data Logging Menu

Torch:

Note: Not all devices support external SD (ie, RTK Torch). This section applies only to devices that support an external SD card, and have one inserted.



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 'EVK', 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.

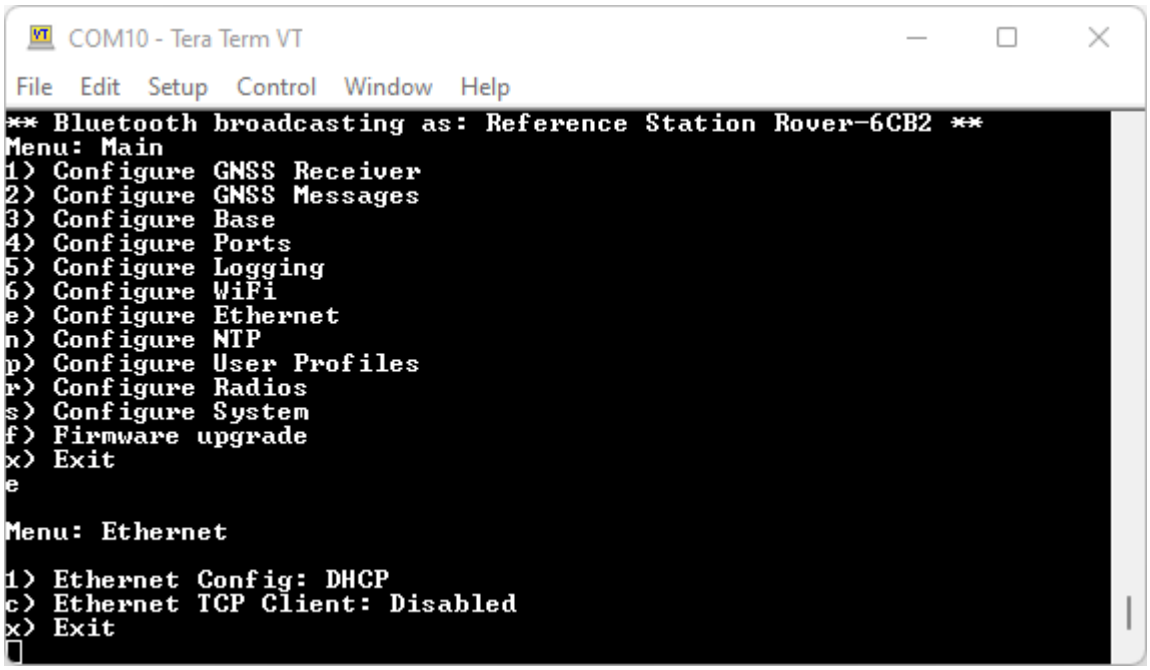
Note: If you want to log RAWX sentences to create RINEX files useful for post-processing the position of the receiver please see the GNSS Configuration Menu. For more information on how to use a RAWX GNSS log to get a higher accuracy base location please see the How to Build a DIY GNSS Reference Station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

6.4 Ethernet Menu

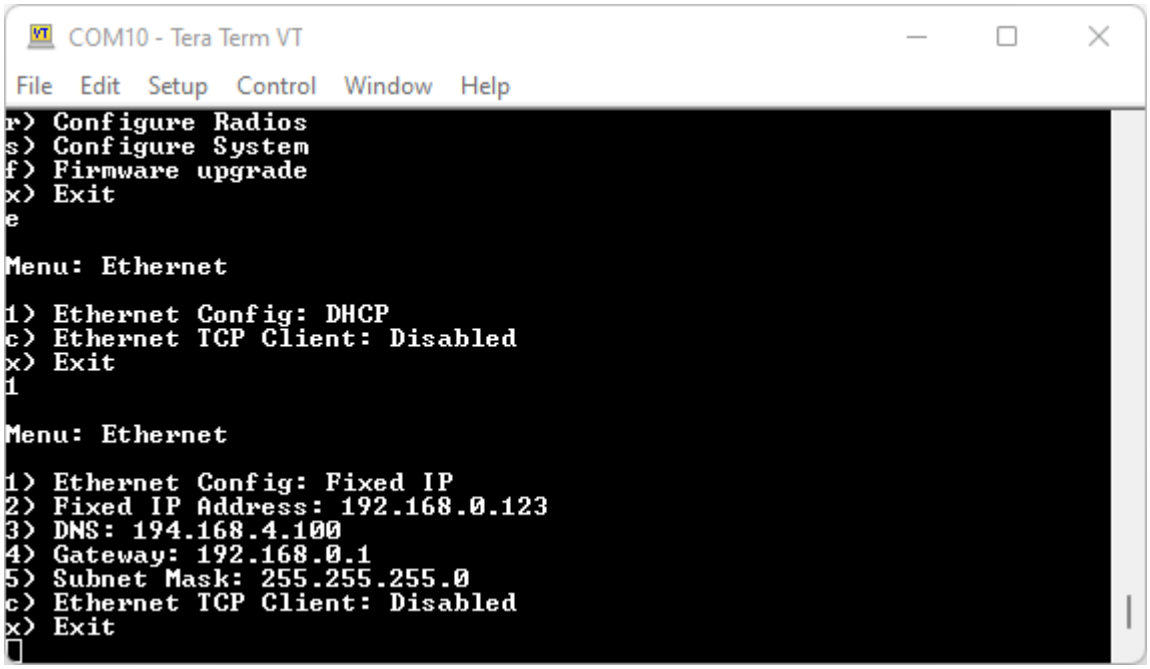
Torch: 

An Ethernet-equipped RTK device 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 RTK device will use DHCP to request an IP Address from the network Gateway. But you can optionally configure it with a fixed IP Address.



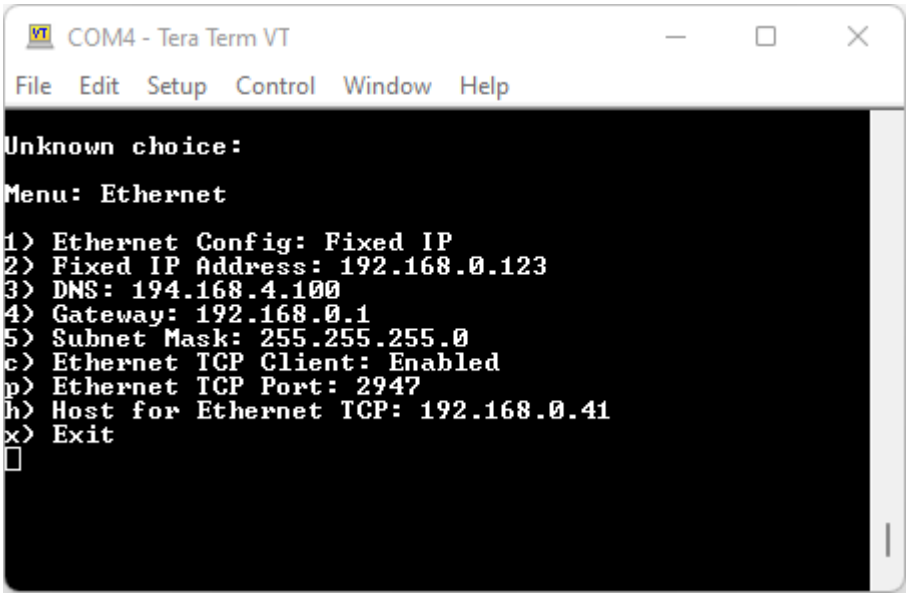
The Reference Station Ethernet menu - with DHCP selected

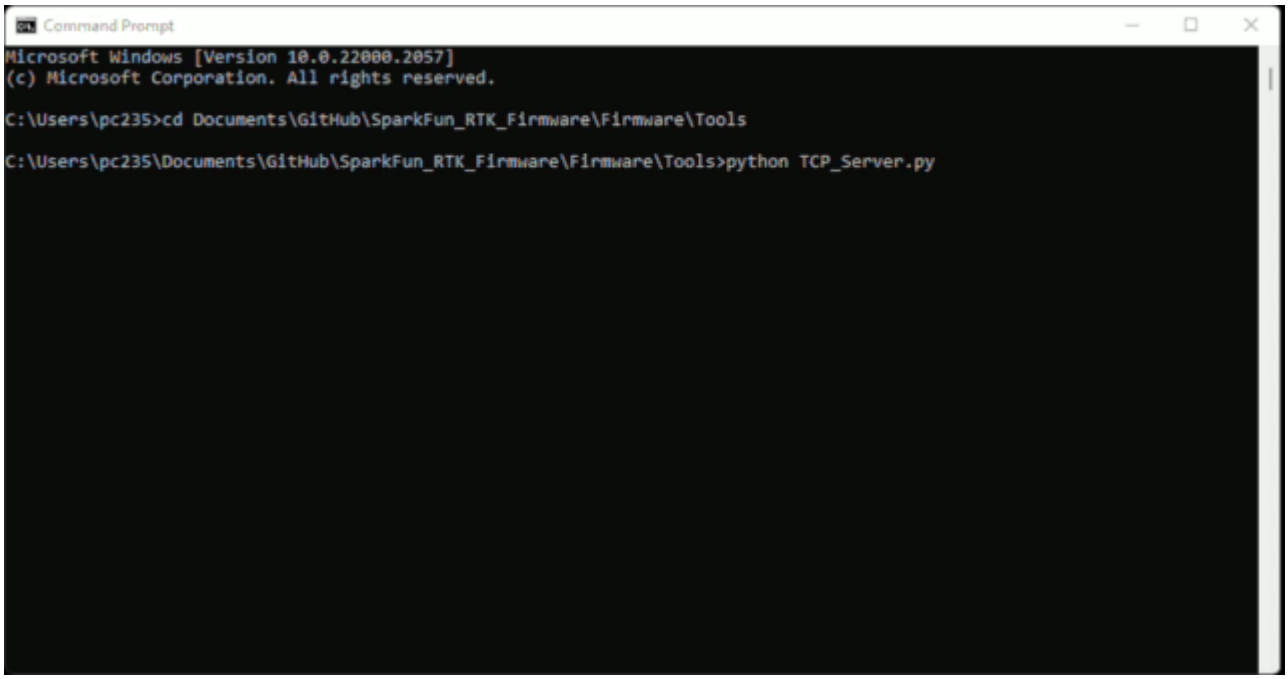


The Reference Station Ethernet menu - with a fixed IP address selected

6.4.1 Ethernet TCP Client

Ethernet-equipped RTK devices 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"

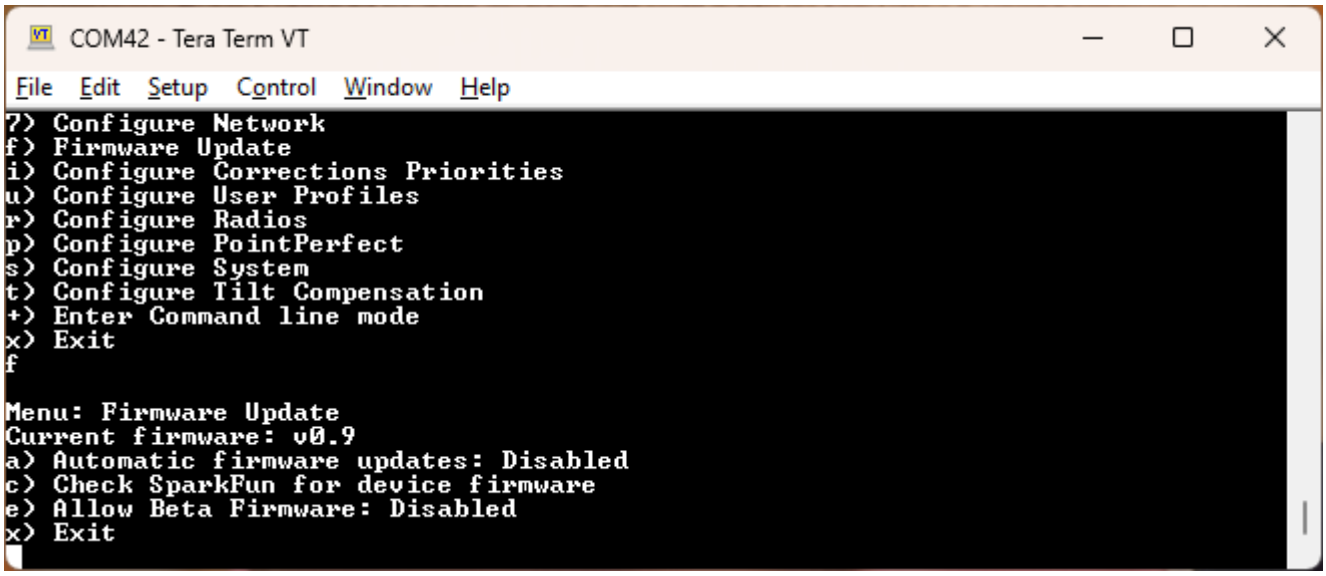




The above animation was generated using TCP_Server.py.

6.5 Firmware Update Menu

Torch:



Firmware Update menu

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.

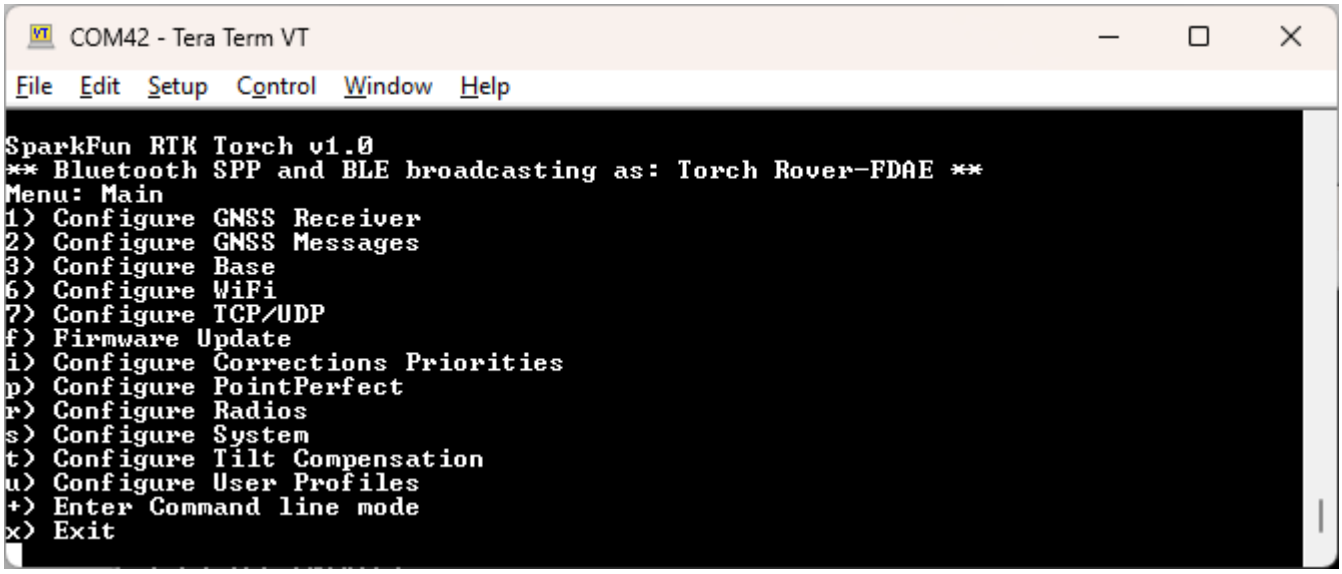
The Firmware Update menu allows users to check for and install updates. Turning on *Automatic firmware updates* will cause the device to periodically check and install updates when they become available. This can be helpful for remote stations that cannot have manual interventions.

6.6 GNSS Menu

Torch: 

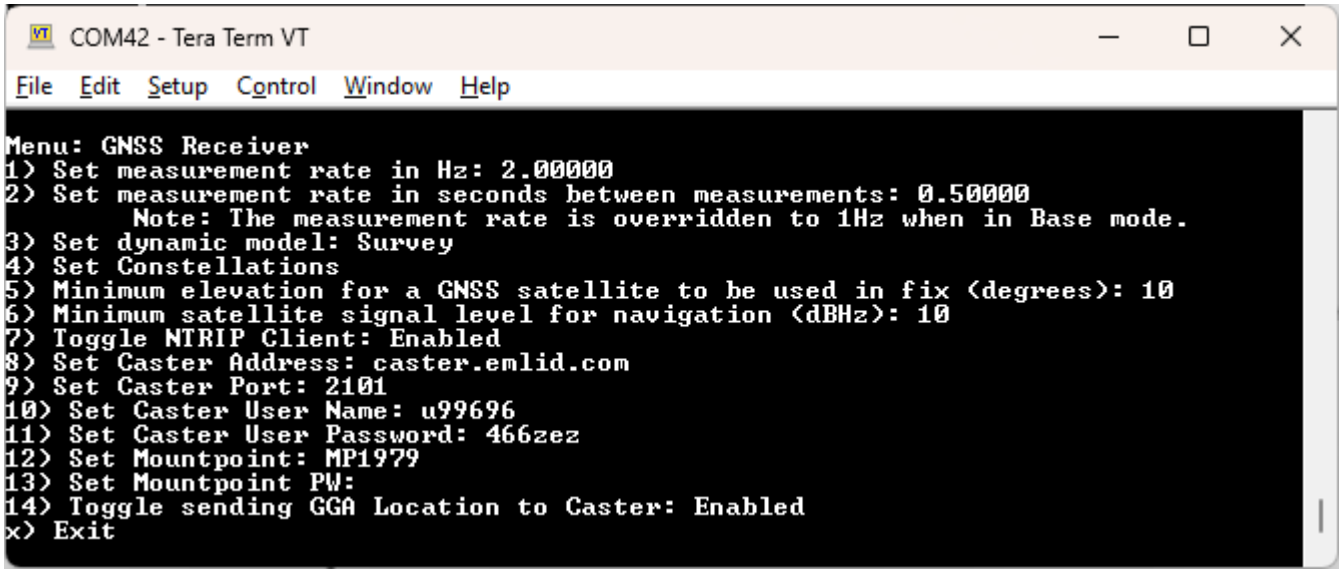
The SparkFun RTK product line is immensely configurable. The RTK device will, by default, put the GNSS receiver into the most common configuration for rover/base RTK for use with *SW Maps* and other GIS applications.

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



RTK Everywhere main menu

Pressing any key will show the *Main Menu*. From the main menu, pressing 1 will bring up the *GNSS Receiver* configuration menu.



GNSS menu showing measurement rates and dynamic model

6.6.1 Measurement Frequency

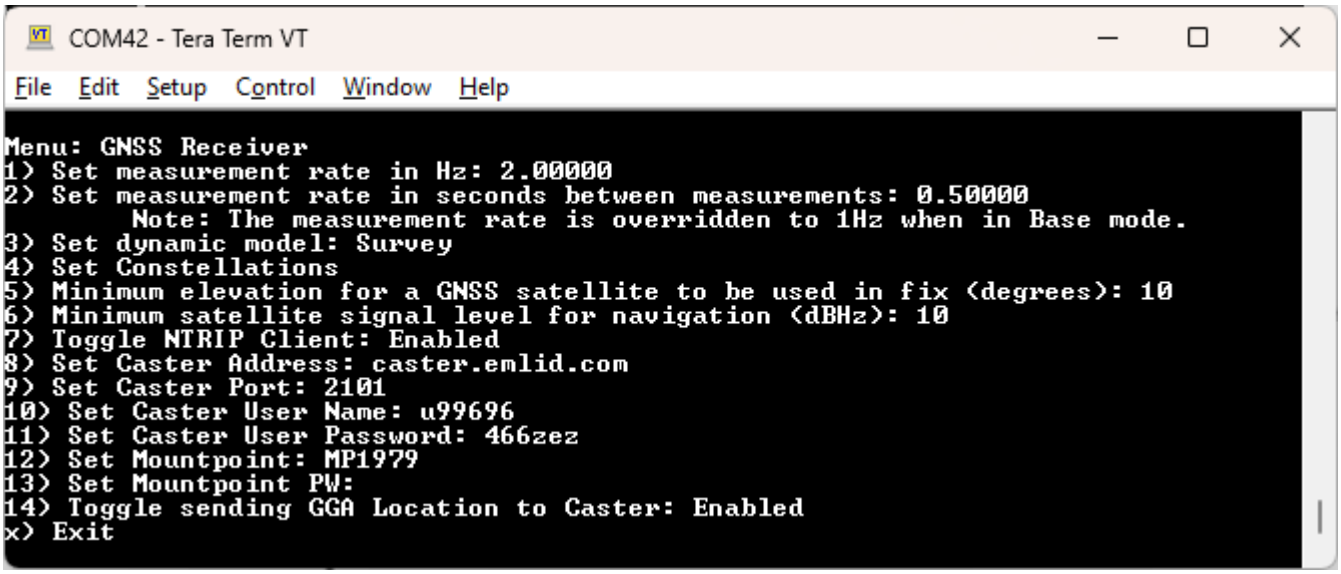
Measurement Frequency can be set by either Hz or by seconds between measurements. Some users need many measurements per second; RTK devices support up to 20Hz with RTK enabled. Some users are doing very long static surveys that require many seconds between measurements; the GNSS receiver supports up to 65 seconds between readings.

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.

6.6.2 Dynamic Model

The Dynamic Model can be changed but it is recommended to leave it as *Survey*. For more information, please see the list of reference documents for your platform.

6.6.3 Min SV Elevation and C/N0

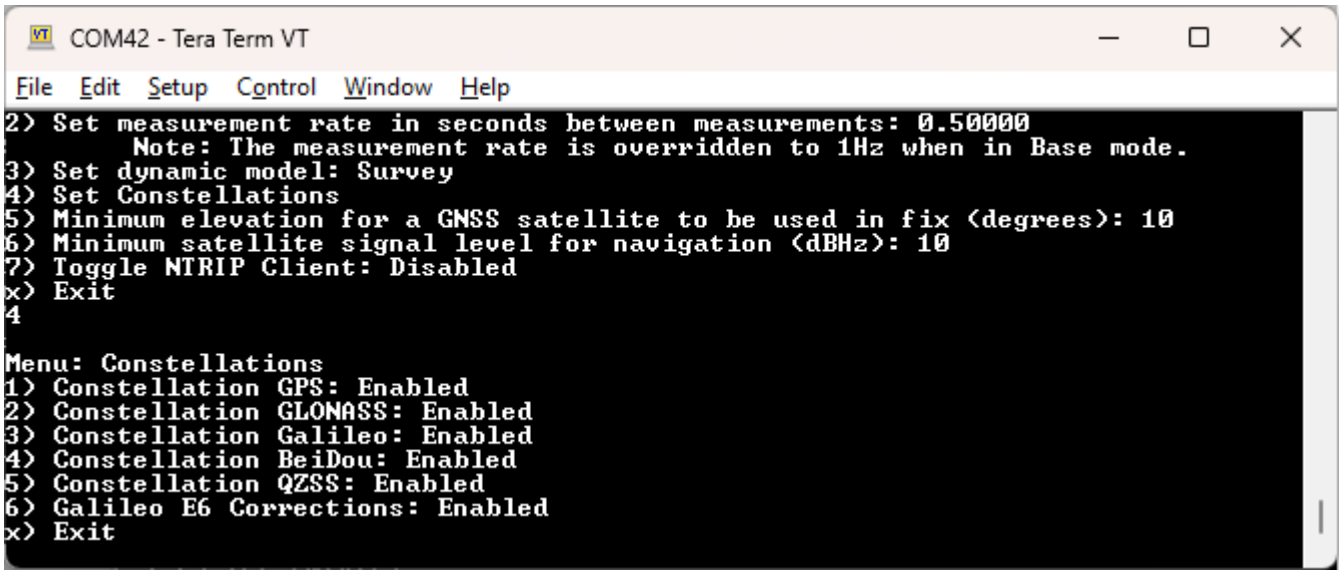


GNSS menu showing Minimum SV Elevation and C/N0

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.

6.6.4 Constellations Menu



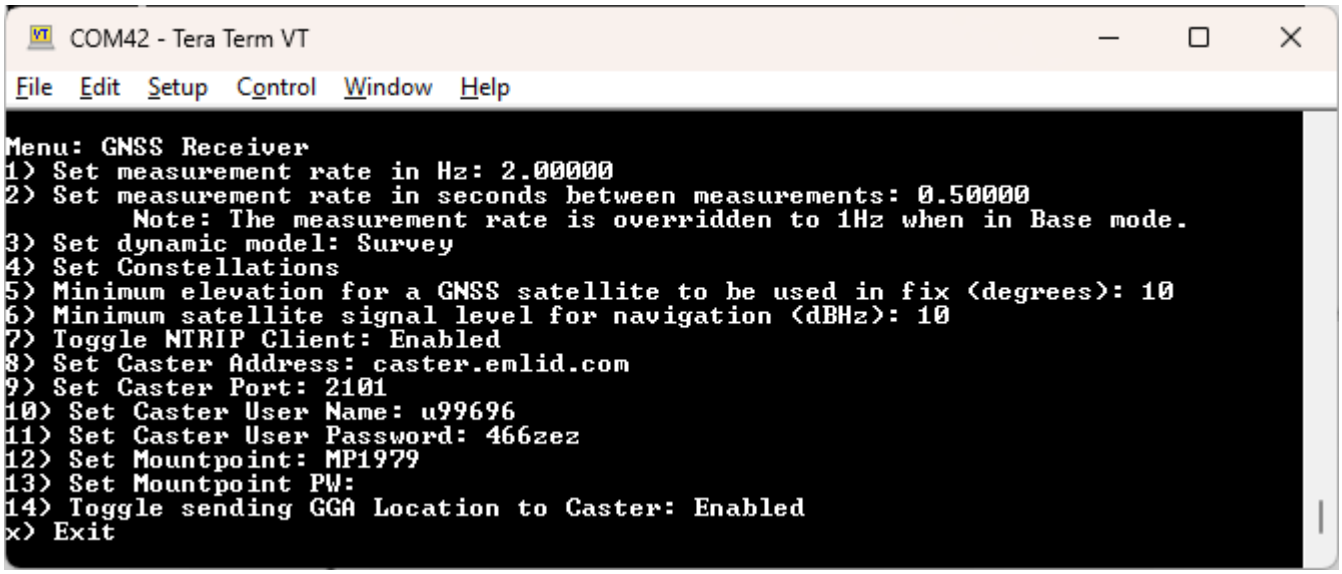
Enable or disable the constellations used for fixes

The GNSS receiver is capable of tracking multiple channels across four constellations, each producing their own GNSS signals (ie, L1C/A, L1C, L2P, L2C, L5, E1, E5a, E5b, E6, B1I, B2I, B3I, B1C, B2a, B2b, etc). The supported constellations include 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 GNSS receiver to ignore those signals when calculating a location fix.

Galileo E6 Corrections

If supported by hardware, Galileo E6 corrections are enabled by default to support High Accuracy Service. They can be disabled if desired. For detailed information see High Accuracy Service corrections.

6.6.5 NTRIP Client



NTRIP Client enabled showing settings

The SparkFun RTK Everywhere devices can obtain their correction data over a few different methods.

- 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 pushed from the phone to the RTK device. No NTRIP Client needs to be setup on 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 an obtain RTK Fix, while Bluetooth is used to connect to the GIS software for data mapping and collection.

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

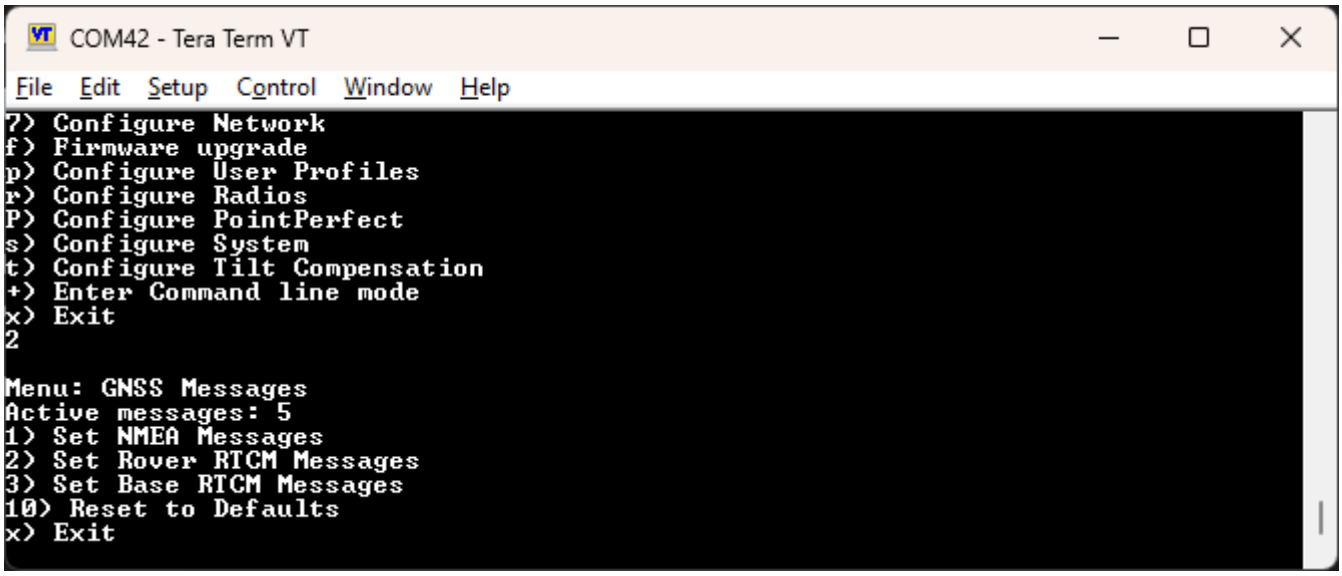
- Local WiFi SSID and password (WPA2)
- A casting service and port such as RTK2Go or Emlid (the port is almost always 2101)
- A mount point (required) and password (optional)

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.

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.

6.7 Messages Menu

Torch:



The messages configuration menu

From this menu, a user can control the output of various NMEA, RTCM, 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 Defaults

RTCM can also be enabled in both Rover and Base modes.

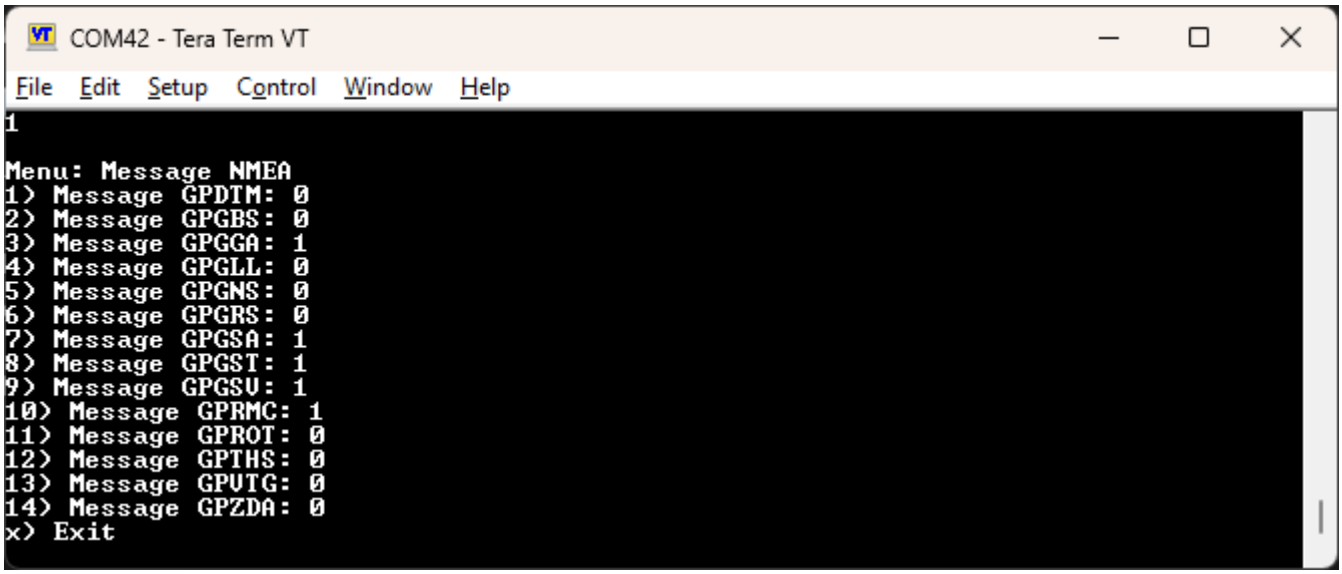
6.7.1 Reset to Defaults

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.

6.7.2 Individual Messages



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 messages are supported for Bluetooth output and logging (if available):

• NMEA-DTM	• NMEA-GBS	• NMEA-GGA
• NMEA-GLL	• NMEA-GNS	• NMEA-GRS
• NMEA-GSA	• NMEA-GST	• NMEA-GSV
• NMEA-RMC	• NMEA-ROT	• NMEA-THS
• NMEA-VTG	• NMEA-ZDA	
• RTCM3x-1001	• RTCM3x-1002	• RTCM3x-1003
• RTCM3x-1004	• RTCM3x-1005	• RTCM3x-1006
• RTCM3x-1007	• RTCM3x-1009	• RTCM3x-1010
• RTCM3x-1011	• RTCM3x-1012	• RTCM3x-1013
• RTCM3x-1019	• RTCM3x-1020	• RTCM3x-1033
• RTCM3x-1042	• RTCM3x-1044	• RTCM3x-1045
• RTCM3x-1046	• RTCM3x-1071	• RTCM3x-1072
• RTCM3x-1073	• RTCM3x-1074	• RTCM3x-1075
• RTCM3x-1076	• RTCM3x-1077	• RTCM3x-1081
• RTCM3x-1082	• RTCM3x-1083	• RTCM3x-1084
• RTCM3x-1085	• RTCM3x-1086	• RTCM3x-1087
• RTCM3x-1091	• RTCM3x-1092	• RTCM3x-1093
• RTCM3x-1094	• RTCM3x-1095	• RTCM3x-1096
• RTCM3x-1097	• RTCM3x-1104	• RTCM3x-1111
• RTCM3x-1112	• RTCM3x-1113	• RTCM3x-1114
• RTCM3x-1115	• RTCM3x-1116	• RTCM3x-1117
• RTCM3x-1121	• RTCM3x-1122	• RTCM3x-1123
• RTCM3x-1124	• RTCM3x-1125	• RTCM3x-1126
• RTCM3x-1127		

6.8 Network Time Protocol Menu

Torch:

Ethernet-equipped RTK devices 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 an 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.

Ethernet-equipped RTK devices can be placed into dedicated NTP mode, by pressing the **MODE** button until NTP is highlighted in the display and pausing there.

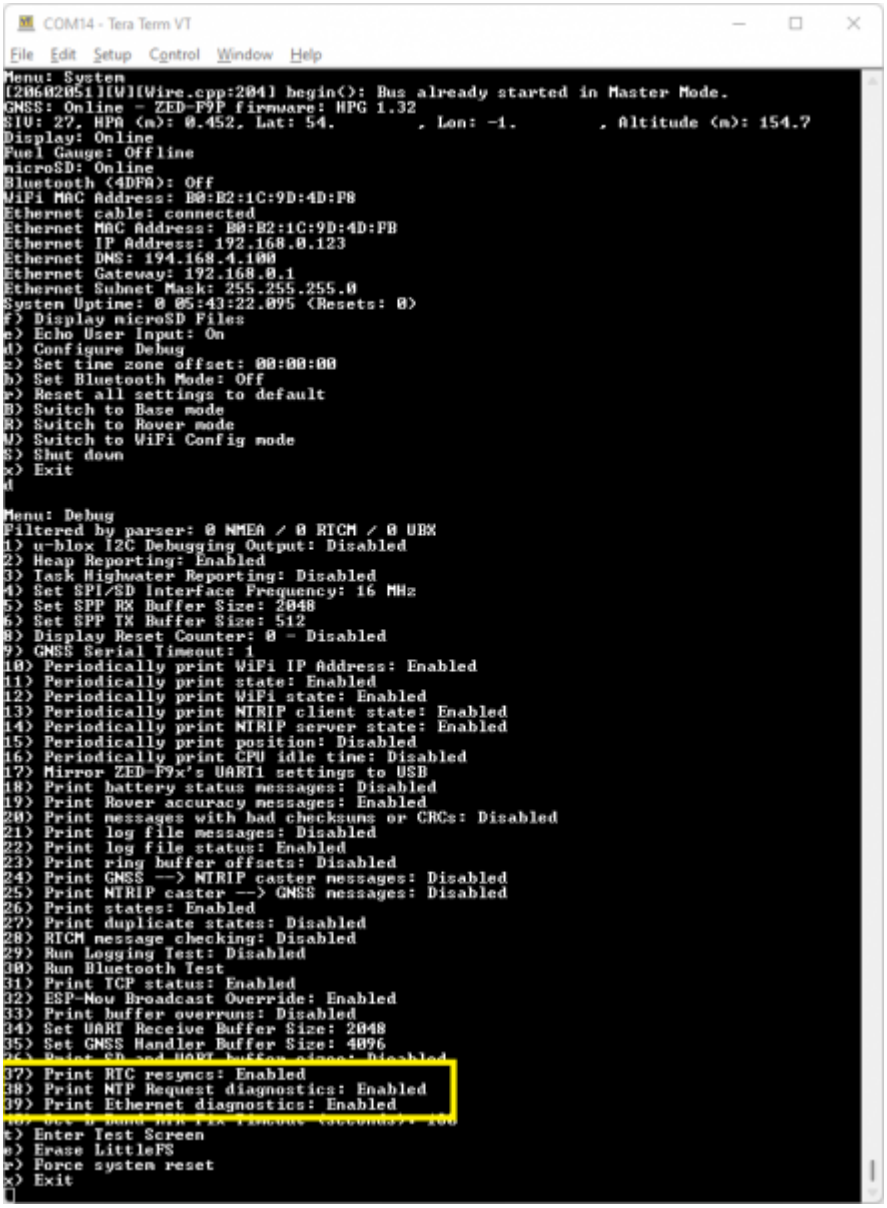
Selecting NTP mode

Ethernet-equipped RTK devices 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.

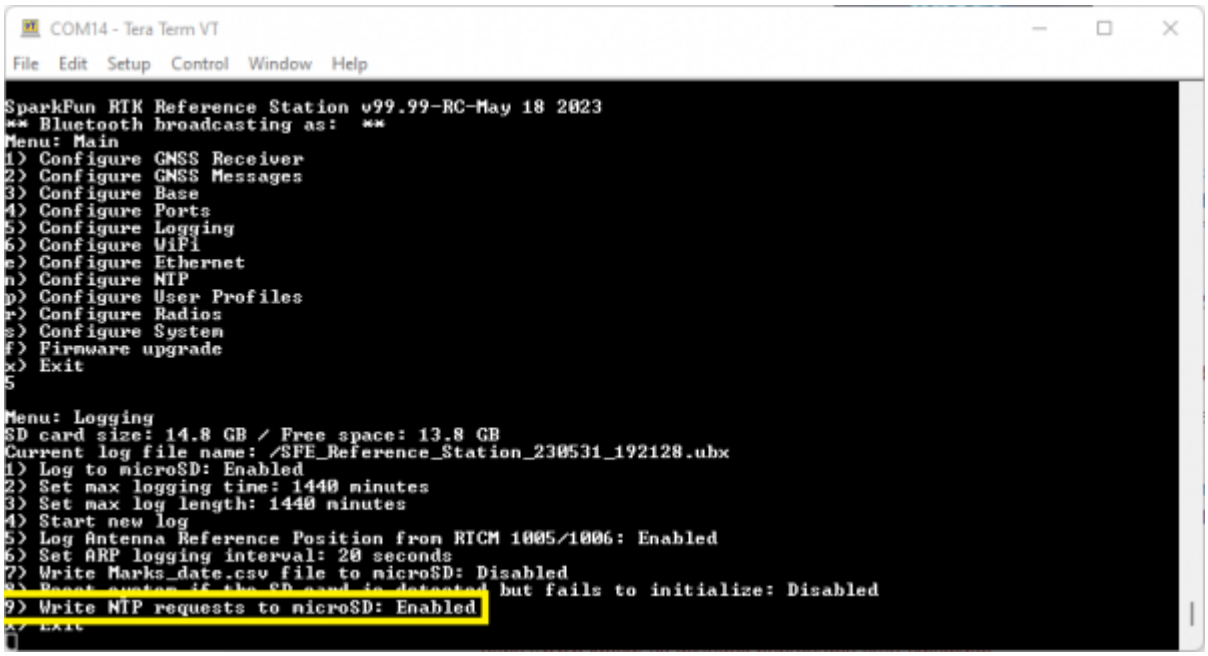
The WIZnet W5500 interrupt signal is also connected to the ESP32, allowing the ESP32 to accurately log when each NTP request arrives.

The RTK device 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.

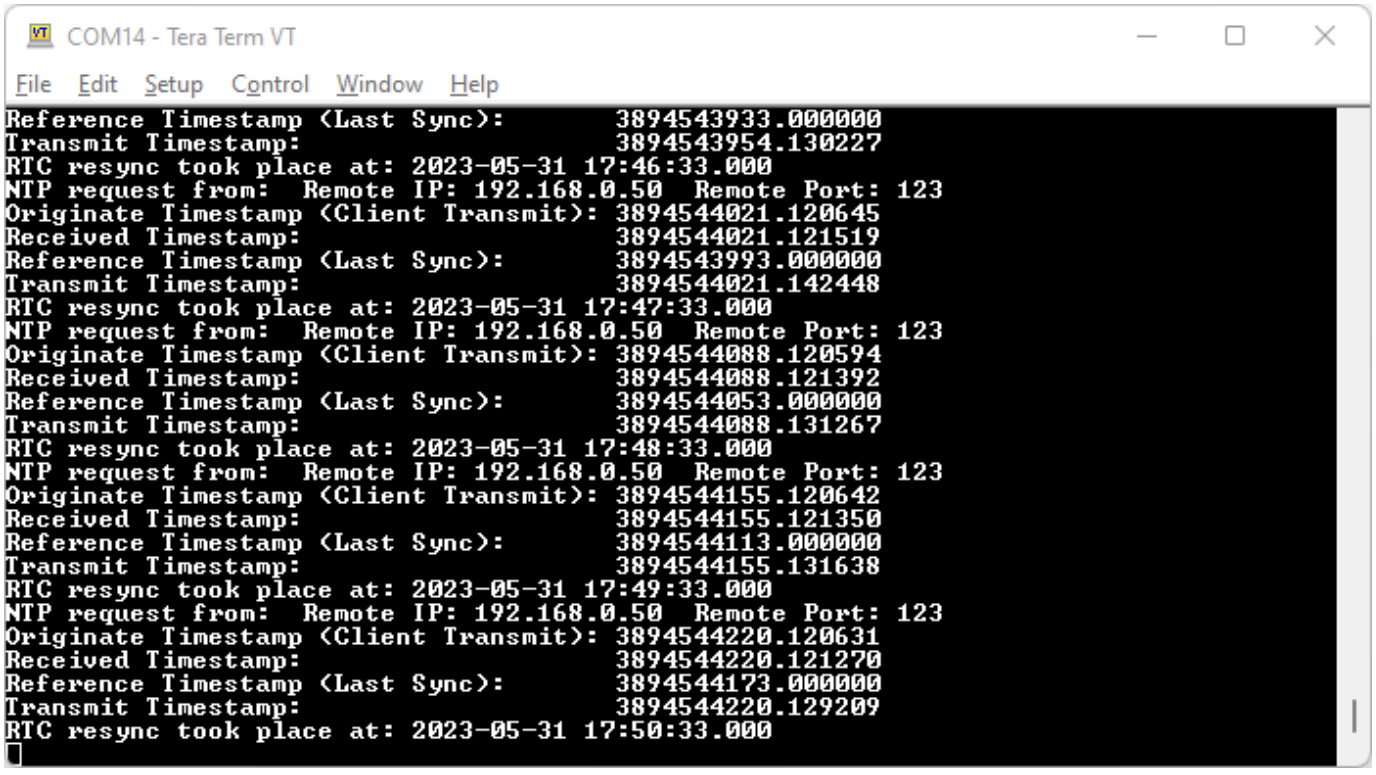


System Debug Menu - NTP Diagnostics (Click for a closer look)



Logging Menu - Log NTP Requests

Logged NTP Requests



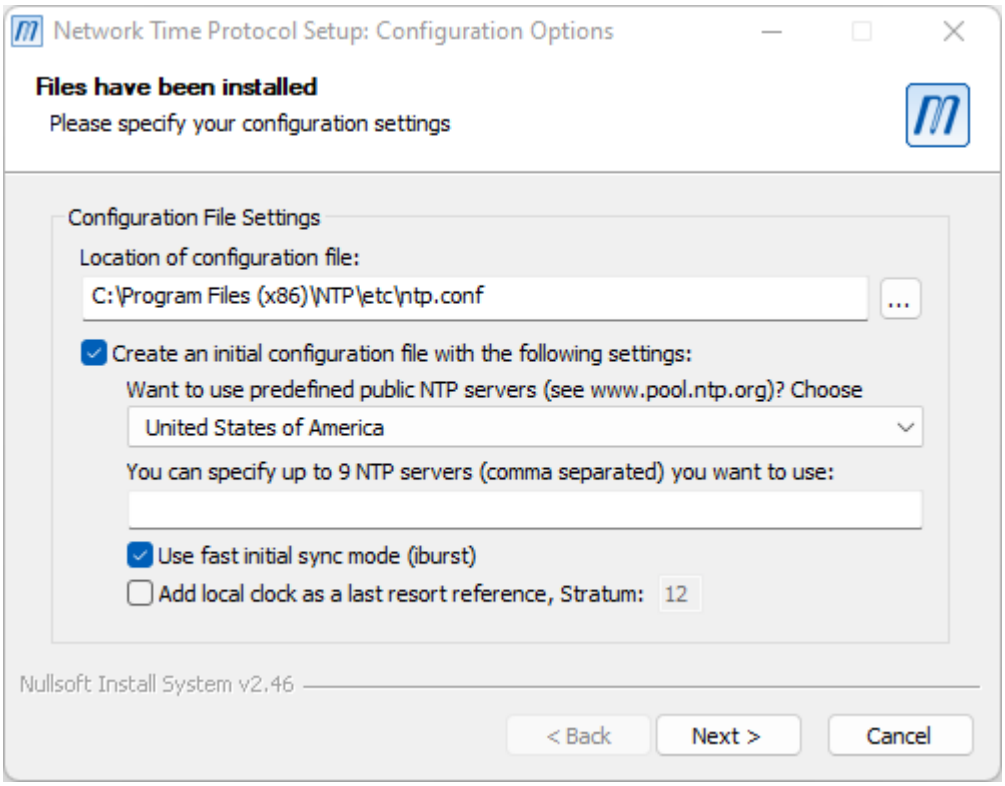
NTP uses its own epoch - midnight January 1st, 1900. This is different than the standard Unix epoch - midnight January 1st, 1970 - and the GPS epoch - midnight January 6th, 1980. The times shown in the log and diagnostic messages use the NTP epoch. You can use online calculators to convert between the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

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

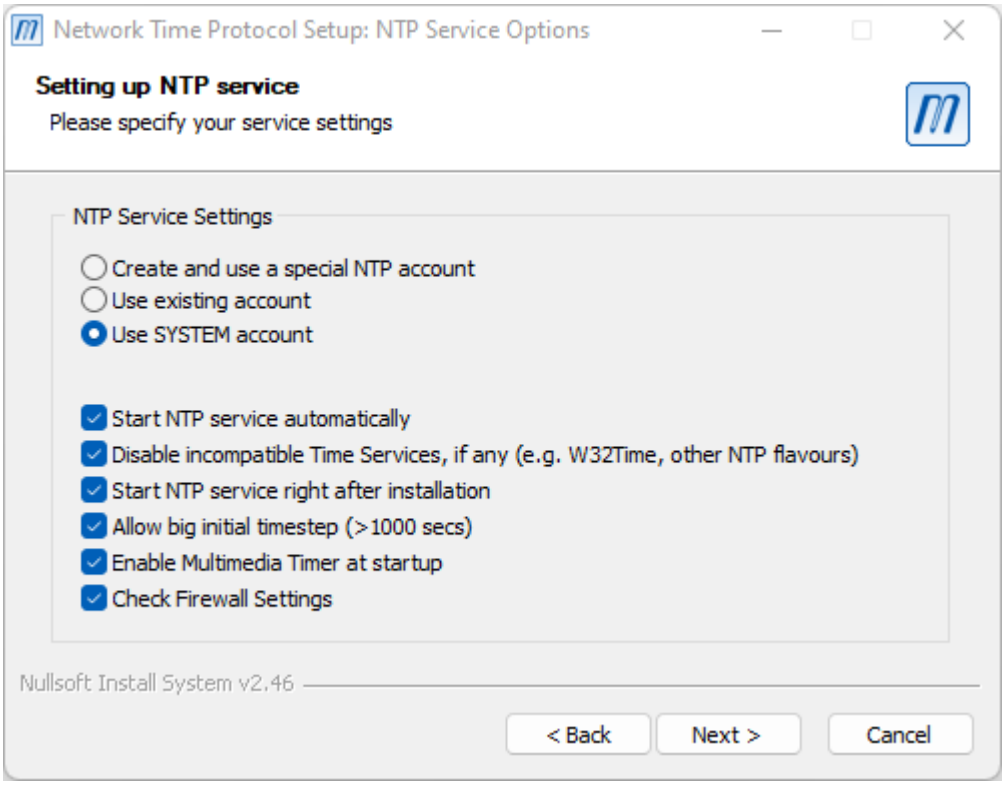
NTP on Windows

If you want to synchronize your Windows PC to a RTK device running as an NTP Server, here's how to do it:

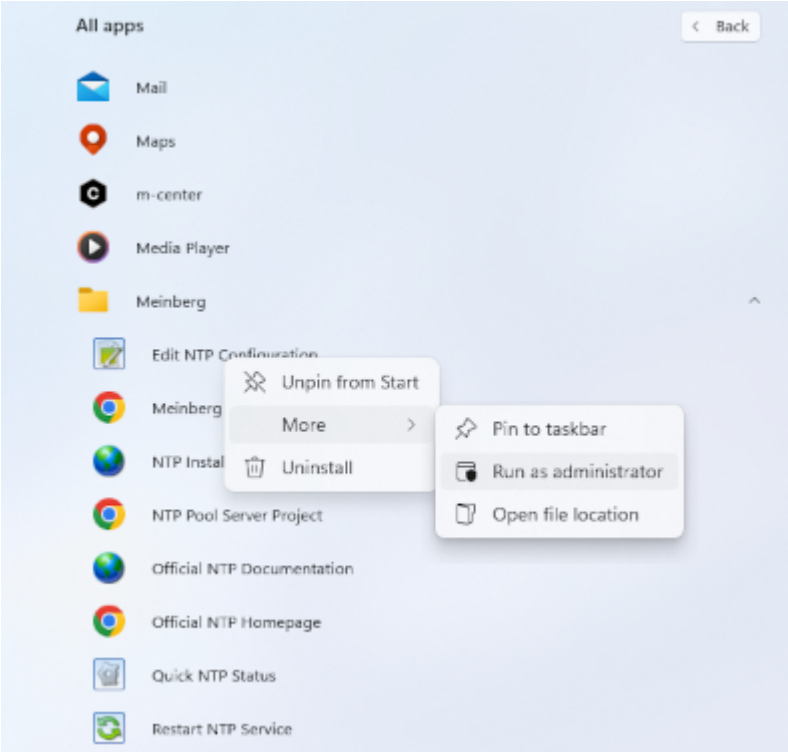
- Install Meinberg NTP - this replaces the Windows built-in Time Service



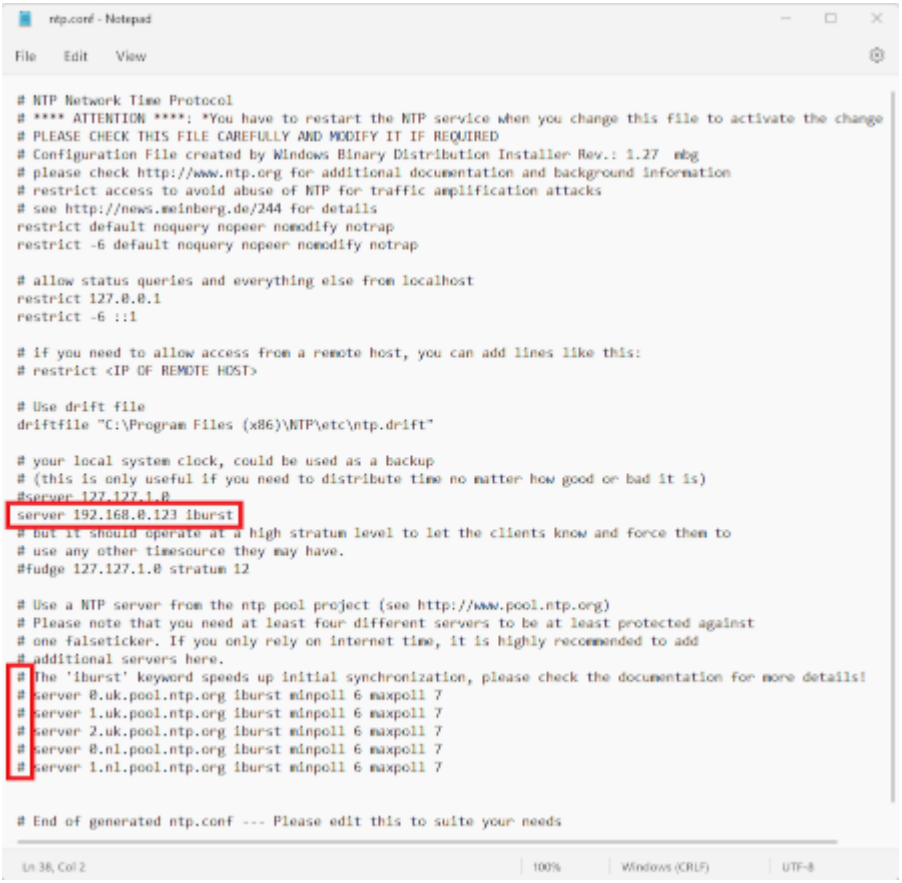
- During the installation, select "Create an initial configuration file" and select the NTP Pool server for your location
- Select "Use fast initial sync mode" for faster first synchronization



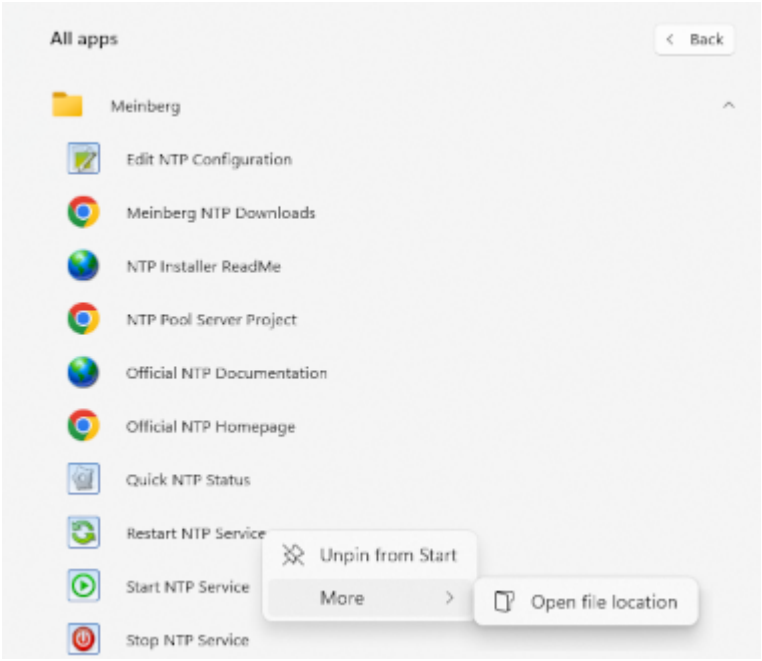
- The next step is to edit the NTP Configuration File
- Editing the file requires Administrator privileges
- Open the *Start* menu, navigate to *Meinberg*, right-click on *Edit NTP Configuration* and select *Run as administrator*



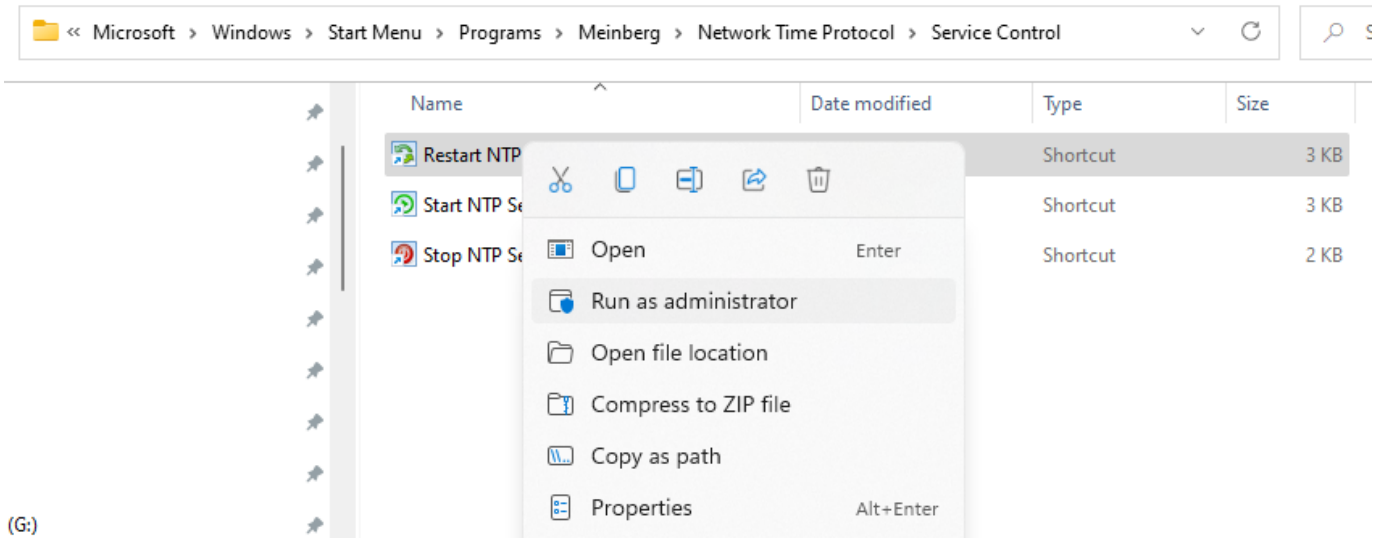
- Comment the lines in *ntp.conf* which name the pool.ntp servers
- Add an extra *server* line and include the IP Address for your RTK device. It helps to give your RTK device a fixed IP Address first - see Menu Ethernet
- Save the file



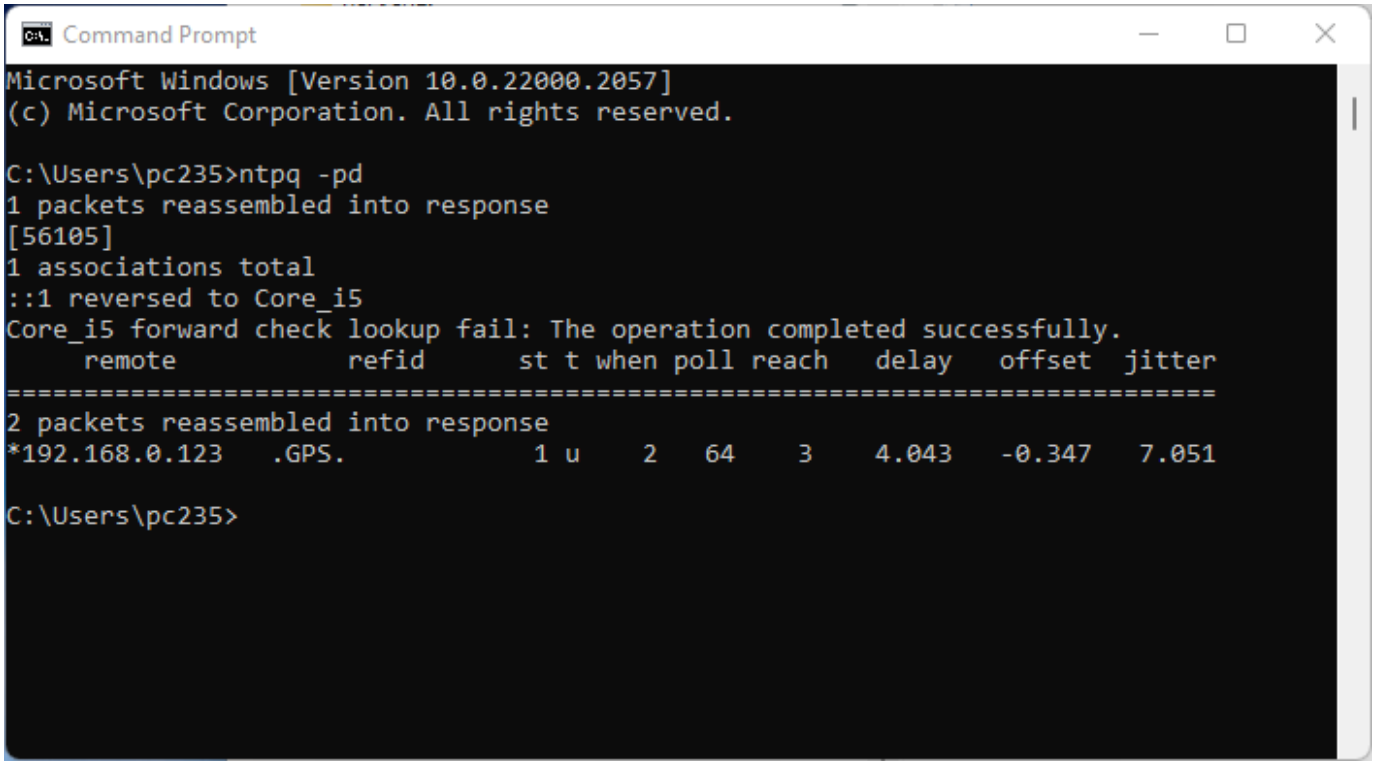
- Finally, restart the NTP Service
- Again this needs to be performed with Administrator privileges
- Open the *Start* menu, navigate to *Meinberg*, right-click on *Restart NTP Service* and select *Open file loctaion*



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



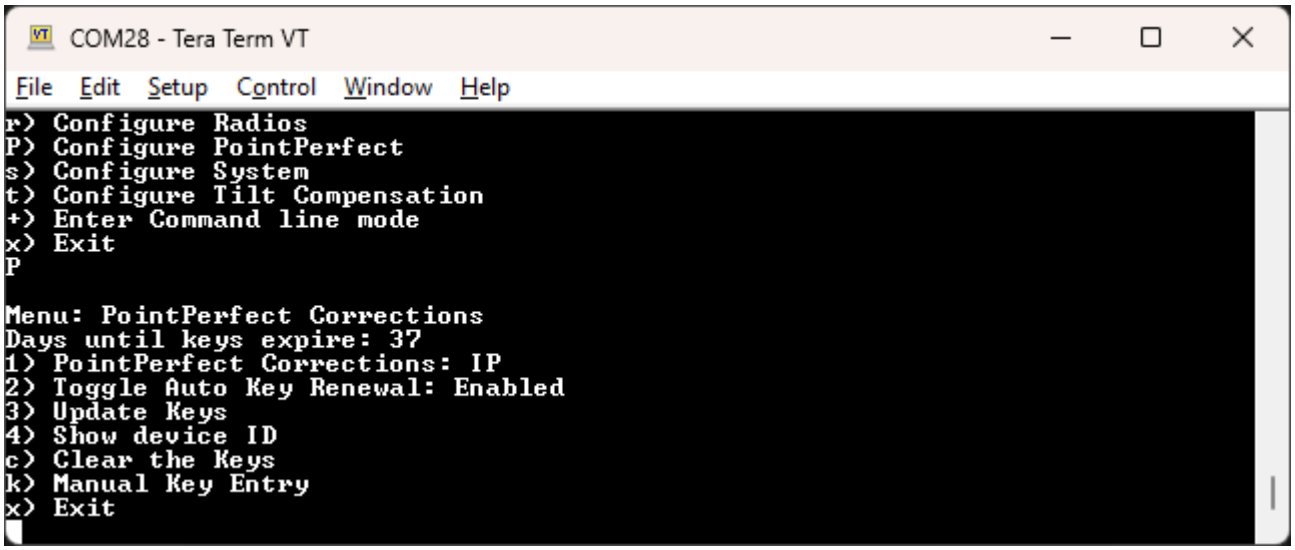
• You can check if your PC clock synchronized successfully by opening a *Command Prompt (cmd)* and running *ntpq -pd*



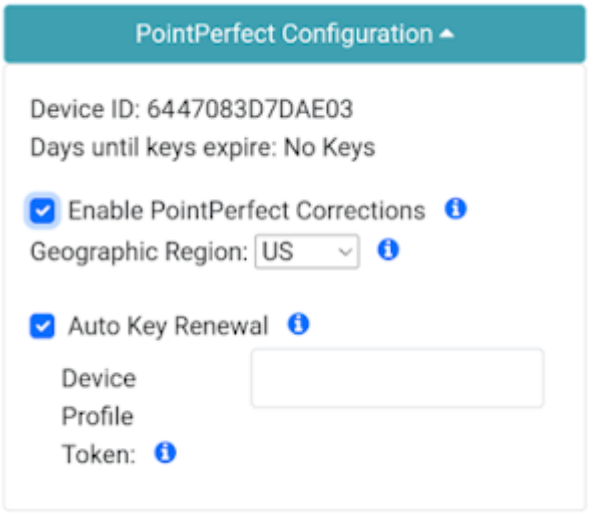
If enabled, your Windows PC NTP requests will be printed and logged by the RTK device. See above.

6.9 PointPerfect Menu

Torch:

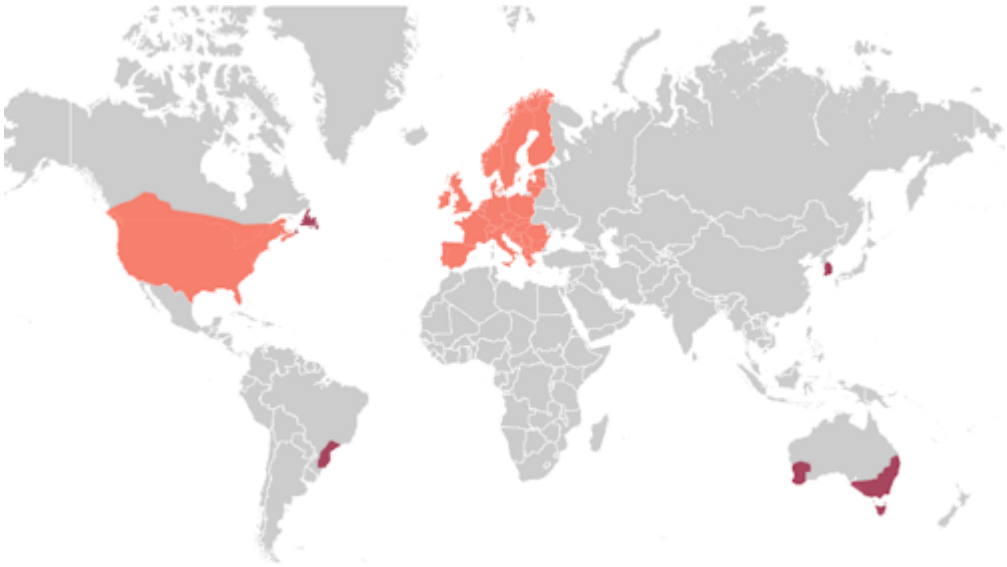


Configuring PointPerfect settings over serial



PointPerfect Configuration Menu

6.9.1 Coverage



PointPerfect Coverage map including L-Band and IP delivery methods

SparkFun RTK devices are equipped to get corrections from a service called PointPerfect.

PointPerfect has the following benefits and challenges:

- Most SparkFun RTK devices come with either a pre-paid subscription or one month of free access to PointPerfect. Please see the product details for your device. Go here to enable or renew your subscription.
- A SparkFun RTK device can obtain RTK Fix anywhere there is coverage. This includes the US contiguous 48 states, the EU, Korea, as well as parts of Australia, Brazil, and Canada. Note: L-Band coverage is not available in some of these areas.
- You don't need to be near a base station - the PPP-RTK model covers entire continents.
- Because PointPerfect uses a model instead of a dedicated base station, it is cheaper. However, the RTK Fix is not as accurate (3-6cm) as compared to getting corrections from a dedicated base station (2cm or better but depends on the baseline distance).
- Because PointPerfect uses a model instead of a dedicated base station, convergence times (the time to get to RTK Fix) can vary widely. Expect to wait multiple minutes for an RTK Fix, as opposed to corrections from a dedicated that can provide an RTK Fix in seconds.

PointPerfect corrections are obtained by two methods:

- **L-Band**: Corrections are transmitted from a geosynchronous satellite. Coverage areas are limited to the US contiguous 48 states and the EU. This delivery method requires special equipment (see the RTK Facet L-Band for more information). No cellular or internet connection is required.
- **IP**: Corrections are transmitted over the internet. The RTK device will need access to a WiFi network. This is most commonly a hotspot on a cell phone so this delivery method is generally confined to areas with cellular and/or WiFi coverage.

6.9.2 Registration

Three stickers showing Device ID and QR code to registration page

All SparkFun RTK products must be registered before they are allowed on the PointPerfect network. To facilitate this, most products ship with a printed Device ID sticker and registration QR code included with the product. The QR code will prefill the registration page with the device's unique ID. If you do not have these materials, don't worry! Please visit the registration page and obtain your device ID through the software interface.

6.9.3 Keys

To gain access to the PointPerfect system, the device must be given WiFi. Once provided, the RTK device will automatically obtain **keys**. These keys allow the decryption of corrections.

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

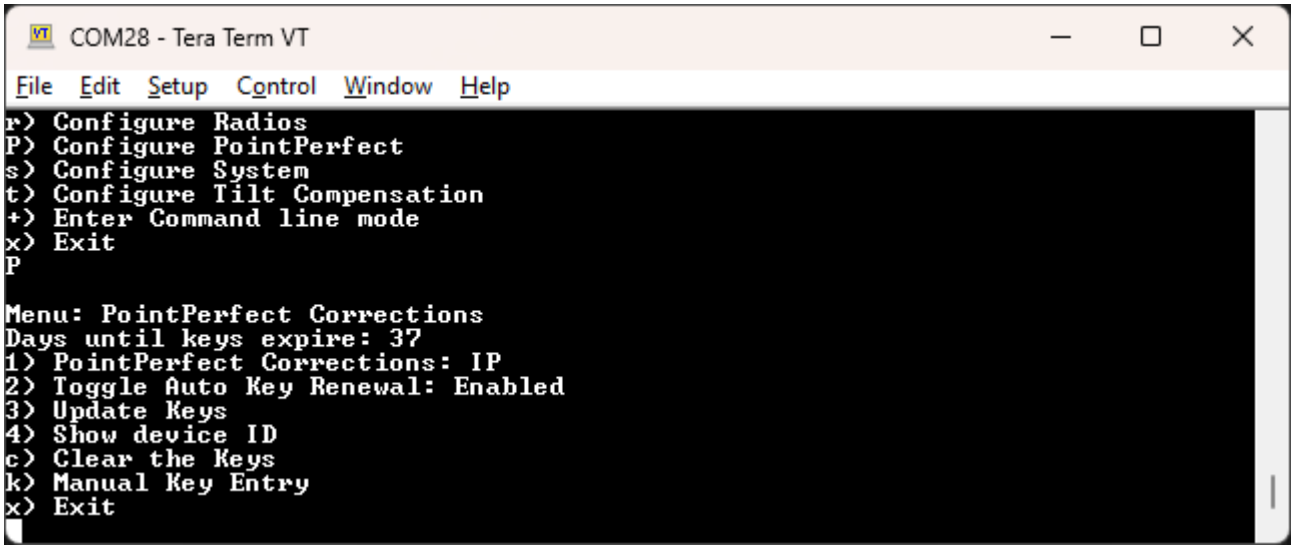
On RTK L-Band equipped devices, if the keys fully expire, the device will continue to receive the L-Band signal but will be unable to decrypt the signal. The RTK Facet L-Band will continue to have extraordinary accuracy (we've seen better than 0.15m HPA) but not the centimeter-level accuracy that comes with RTK.

Note: All RTK devices (including those equipped with L-Band) are capable of receiving RTCM corrections over traditional means including NTRIP data over Bluetooth or a serial radio.

Display showing 14 days until keys expire

On devices that have a display, the unit will display various prompts to aid the user in obtaining keys as needed.

6.9.4 PointPerfect Serial Menu



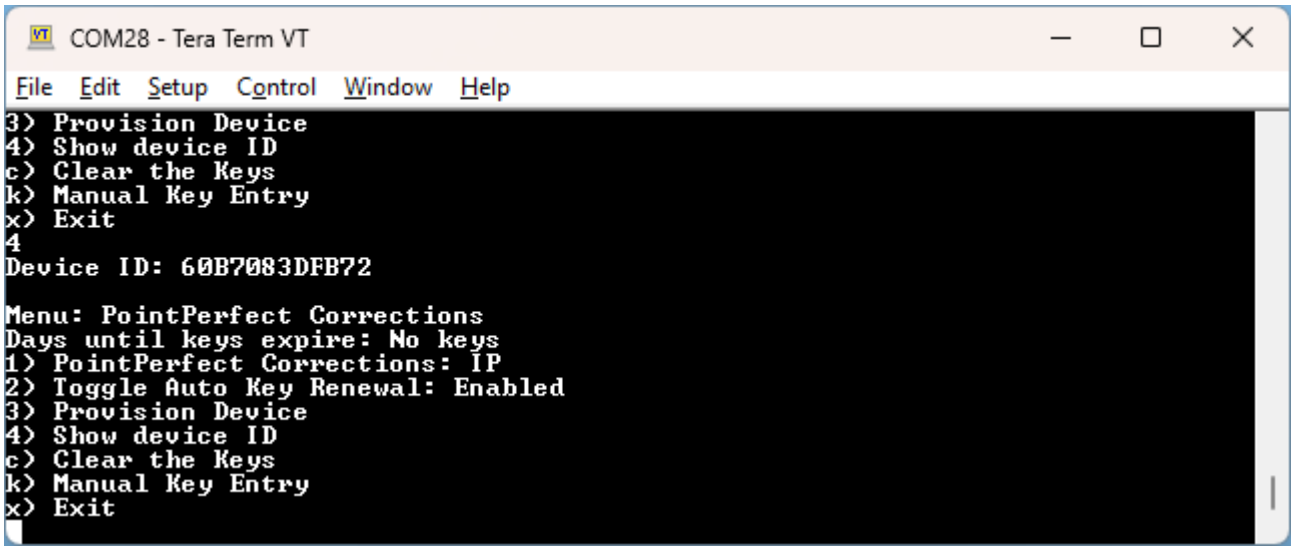
PointPerfect Menu

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.

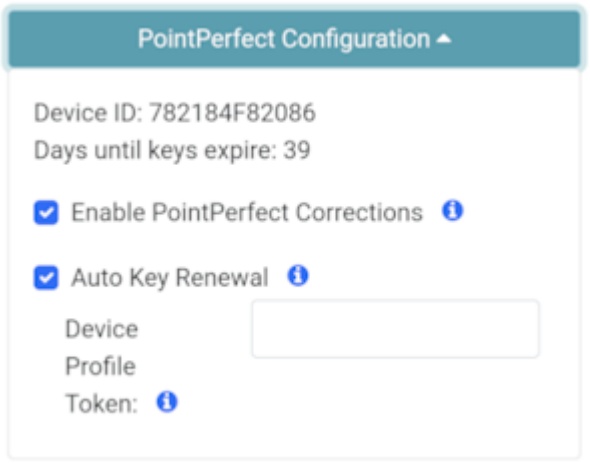
- **1** - Disable the use of PointPerfect corrections.
- **2** - Disable the automatic attempts at WiFi connections when key expiry is less than 28 days.
- **3** - Trigger an immediate attempt to connect over WiFi and provision the device (if no keys are available) or update the keys (if provisioning has already been completed).
- **4** - Display the Device ID. This is needed when a SparkFun RTK device needs to be added to the PointPerfect system. This is needed when first registering the device, or modifying a subscription. Go here to manage subscriptions.
- **c** - Clear the current keys.
- **k** - Bring up the Manual Key Entry menu.

6.9.5 Obtaining the Device ID

The device ID is unique to each RTK device and must be entered by SparkFun into the PointPerfect network.



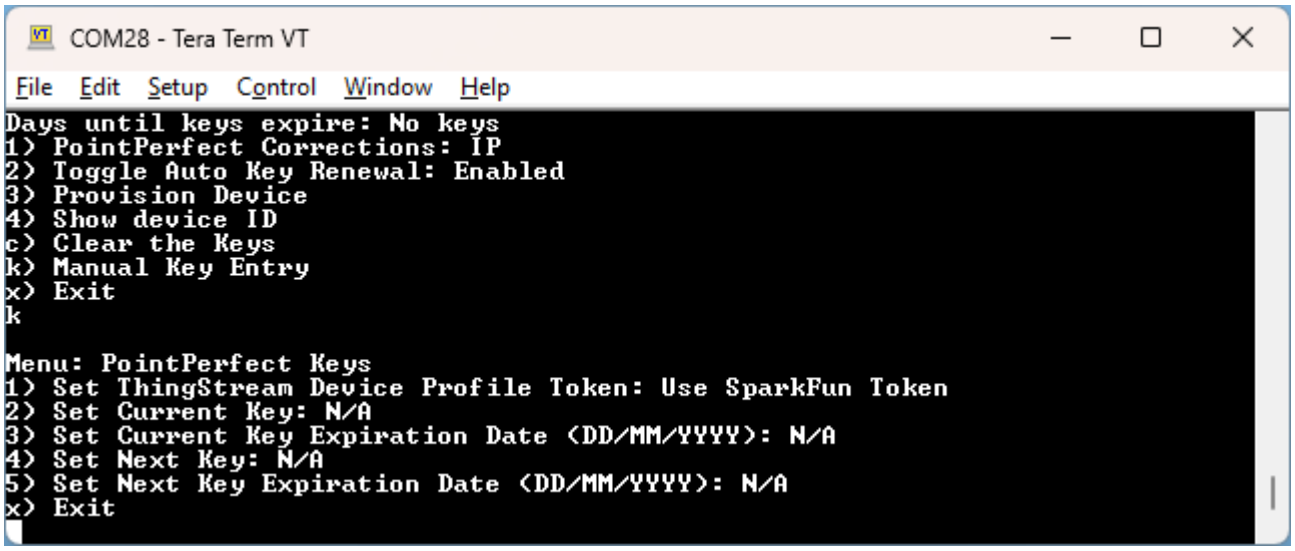
Device ID within the serial menu



Device ID within the WiFi Config page

This ID can be obtained by using option **4** from the *PointPerfect* menu or by opening the PointPerfect section within the WiFi Config interface in the PointPerfect Configuration section.

6.9.6 Manual Key Entry



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.

6.9.7 L-Band Decryption Icon

Three-pronged satellite dish indicating L-Band reception

On devices that have a display, upon successful reception and decryption of PointPerfect corrections delivered over L-Band, 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.

6.9.8 Error Messages

There are various messages that may be reported by the device. Here is a list of explanations and resolutions.

No SSIDs

```
Error: Please enter at least one SSID before getting keys
```

This message is seen when no WiFi network credentials (SSID and password) have been entered. The device needs WiFi to obtain the keys to decrypt the packets provided by PointPerfect. Enter your home/office/cellular hotspot WiFi SSID and password and try again.

Not Whitelisted

```
This device is not whitelisted. Please contact support@sparkfun.com to get your subscription activated. Please reference device ID: [device ID]
```

This message is seen whenever the PointPerfect service is not aware of the given device. Please use the subscription form or contact support@sparkfun.com with your device ID (see Obtaining the Device ID above).

Device Deactivated

```
This device has been deactivated. Please contact support@sparkfun.com to renew the PointPerfect subscription. Please reference device ID: [device ID]
```

This message is seen whenever the device's subscription has lapsed. Please use the subscription form or contact support@sparkfun.com with your device ID (see Obtaining the Device ID above).

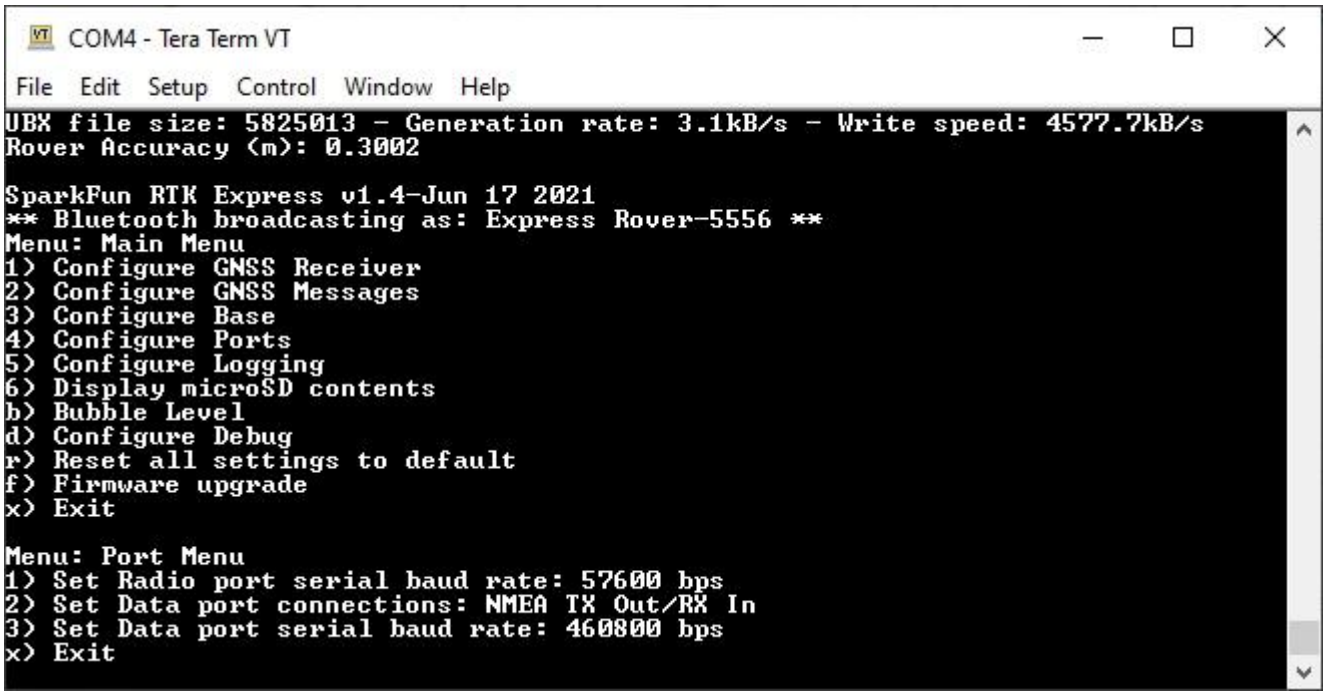
HTTP response error -11 - Read Timeout

The connection to PointPerfect did not respond. Please try again or try a different WiFi network or access point (AP).

6.10 Ports Menu

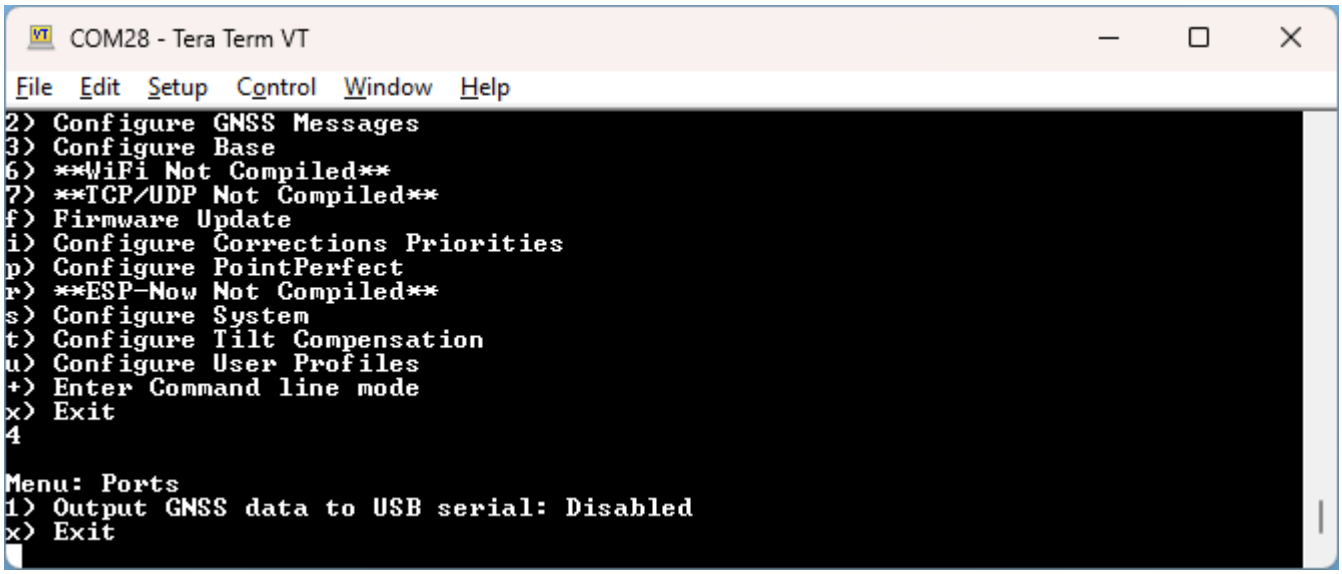
Torch:

Setting the baud rates of the two available external ports



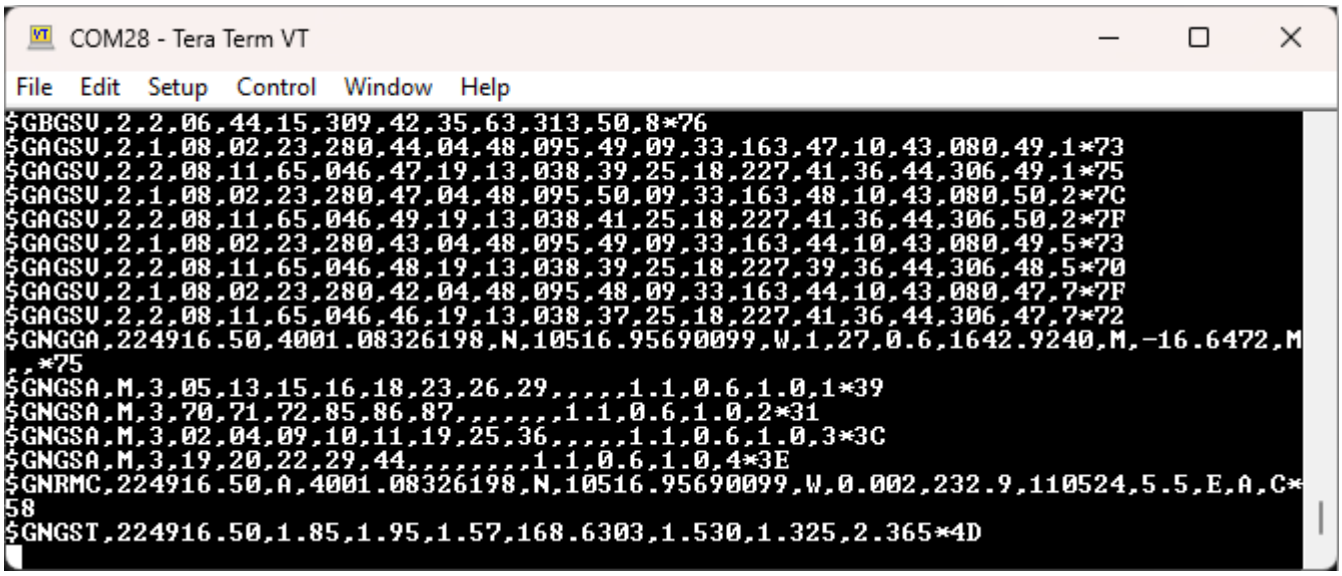
Baud rate configuration of Radio and Data ports

6.10.1 Output GNSS Data over USB



Set output to GNSS data over USB Serial

Enabling **Output GNSS data to USB serial** will pipe all GNSS output (generally NMEA but also RTCM) to the USB serial connection. This permits a wired connection to be made on devices, such as the RTK Torch, that have only one external port (USB). To exit this mode, press **+++** to open the configuration menu.



Example NMEA output over USB

6.10.2 Radio Port

Available on devices that have an external **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.

6.10.3 Mux Channel

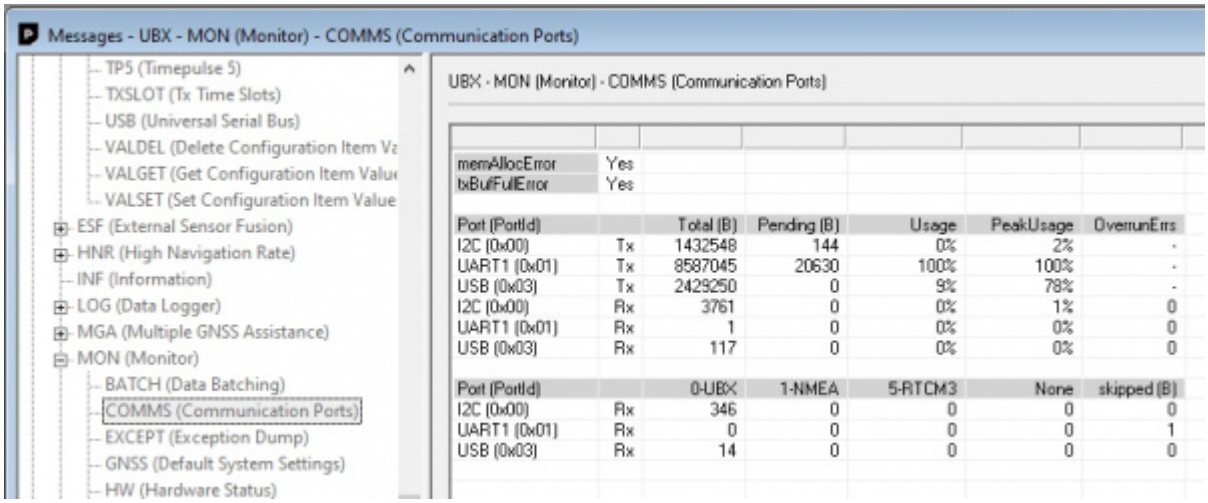
Available on devices that have a built-in multiplexer on the **DATA** port.

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.

6.10.4 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.

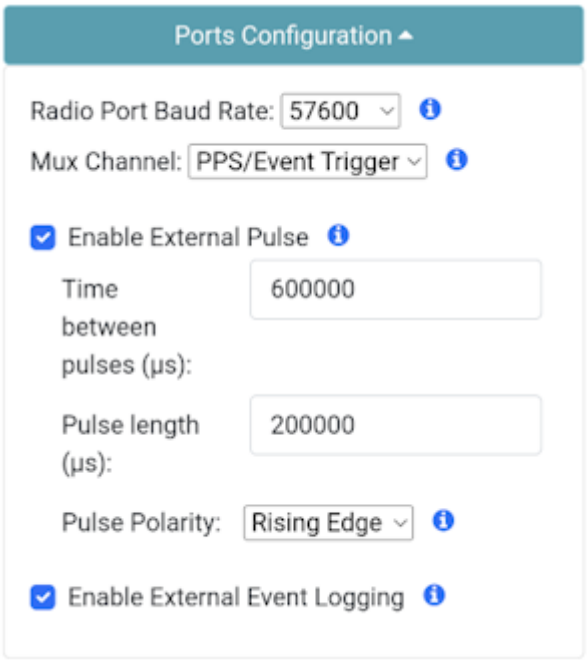


Monitoring the COM ports on the ZED-F9P

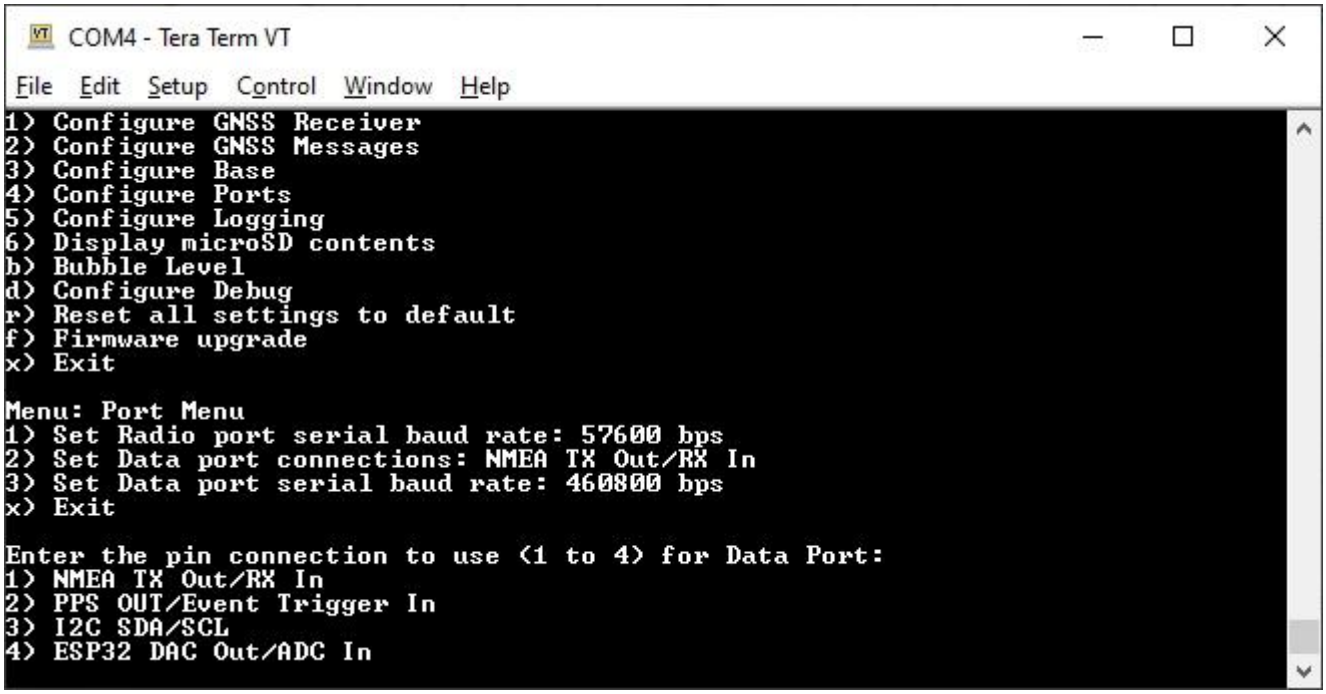
If you must run the data port at lower than 460800bps, and you need to enable a large number of messages and/or increase the fix frequency beyond 4Hz, be sure to verify that UART1 usage stays below 99%. The image above shows the UART1 becoming overwhelmed because the ZED cannot transmit at 115200bps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

Pulse Per Second



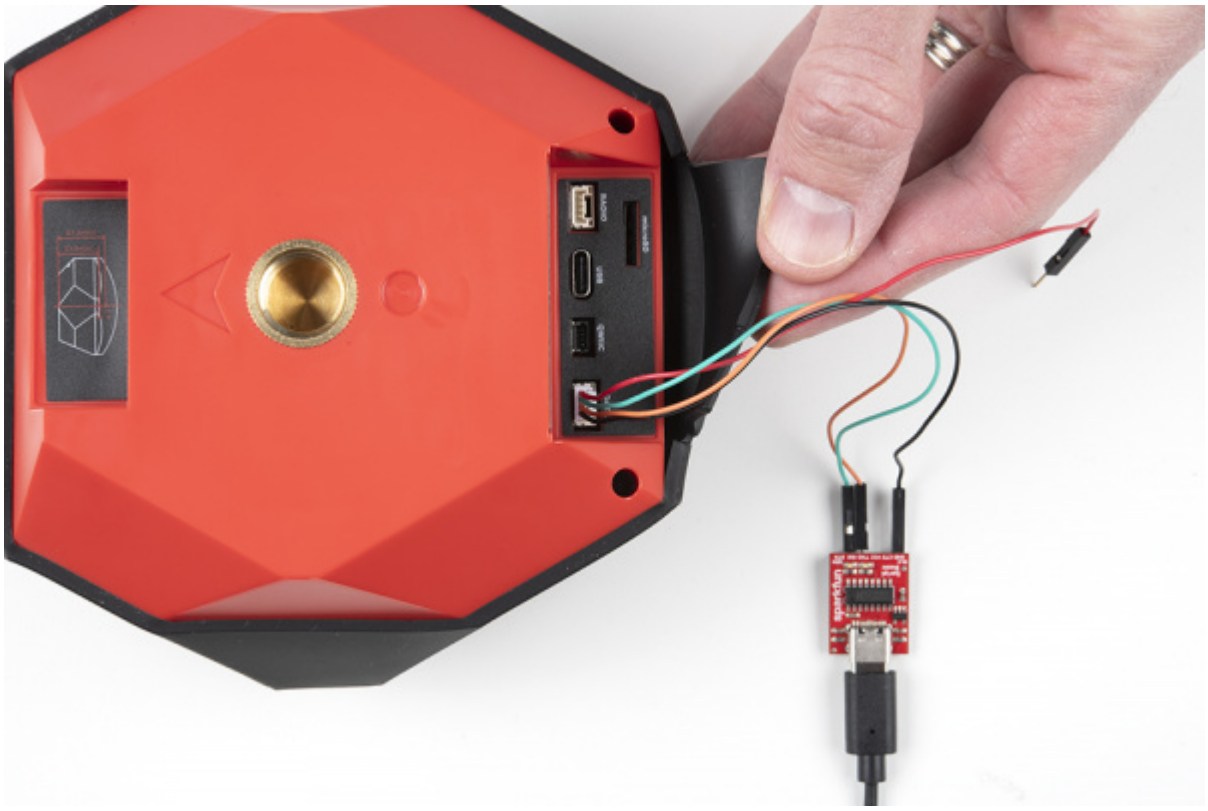
Configuring the External Pulse and External Events over WiFi



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.

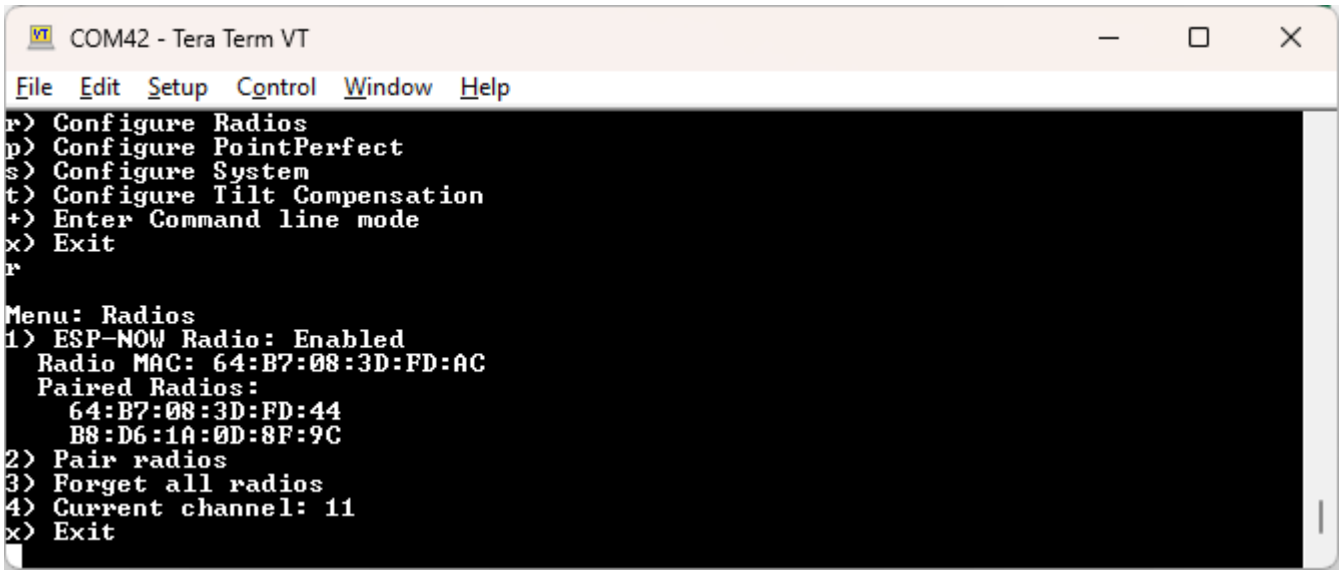
- **Red** - 3.3V
- **Green** - TX (output from the RTK device)
- **Orange** - RX (input into the RTK device)
- **Black** - GND

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

6.11 Radios Menu

6.11.1 ESP-Now

Torch:



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 (or multiple Rovers) 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.

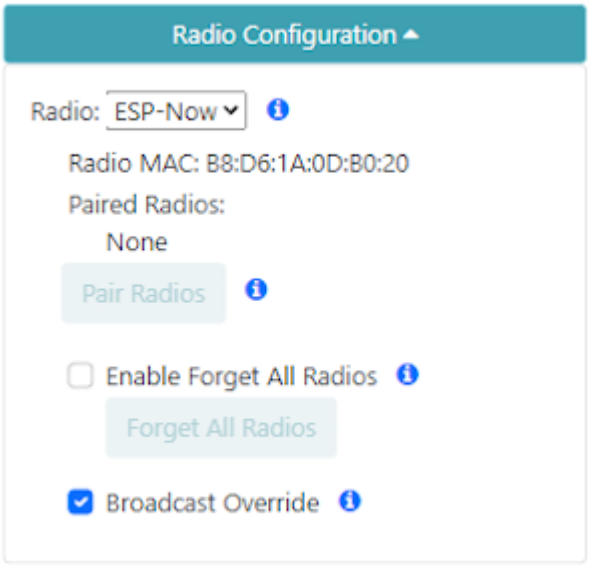
ESP-Now is a free radio included in every RTK product and works well, but it has a few limitations:

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. Another option is to use ESP-Now for the Base-Rover link and a GIS app such as Vespucci or QGIS that can obtain PVT data over WiFi (TCP) rather than use Bluetooth to gather the NMEA data from the RTK device.

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. ESP-Now can co-exist with WiFi, but both the receiver and transmitter must be on the same WiFi channel.

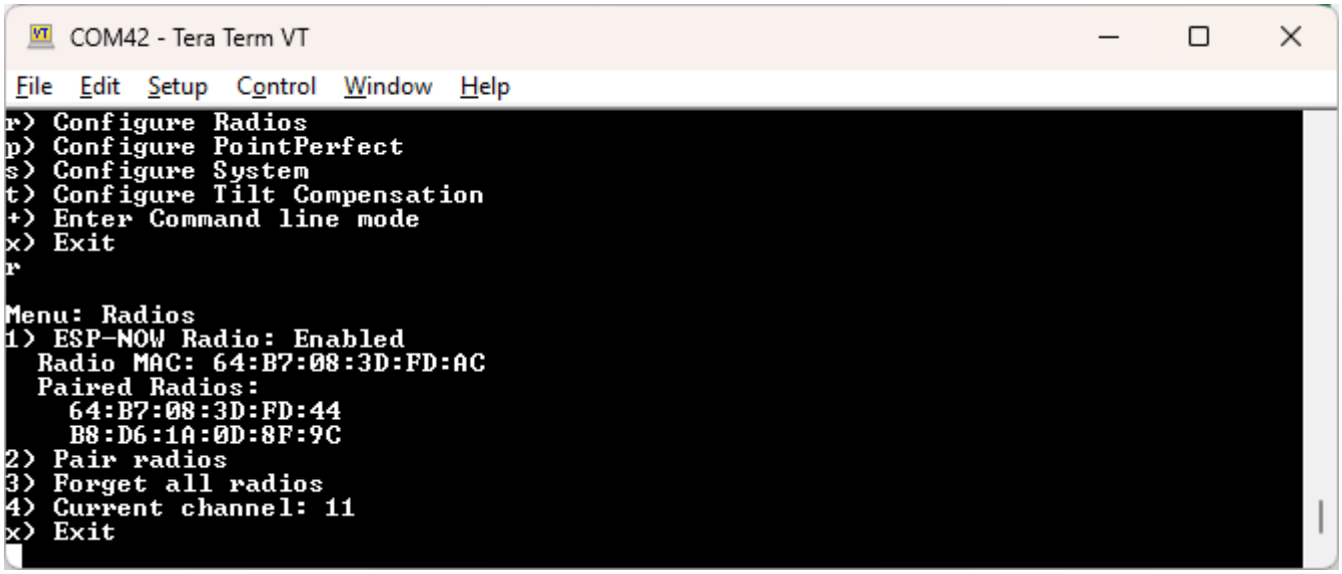
6.11.2 Pairing

On devices that have a display, pressing the Power/Setup button 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

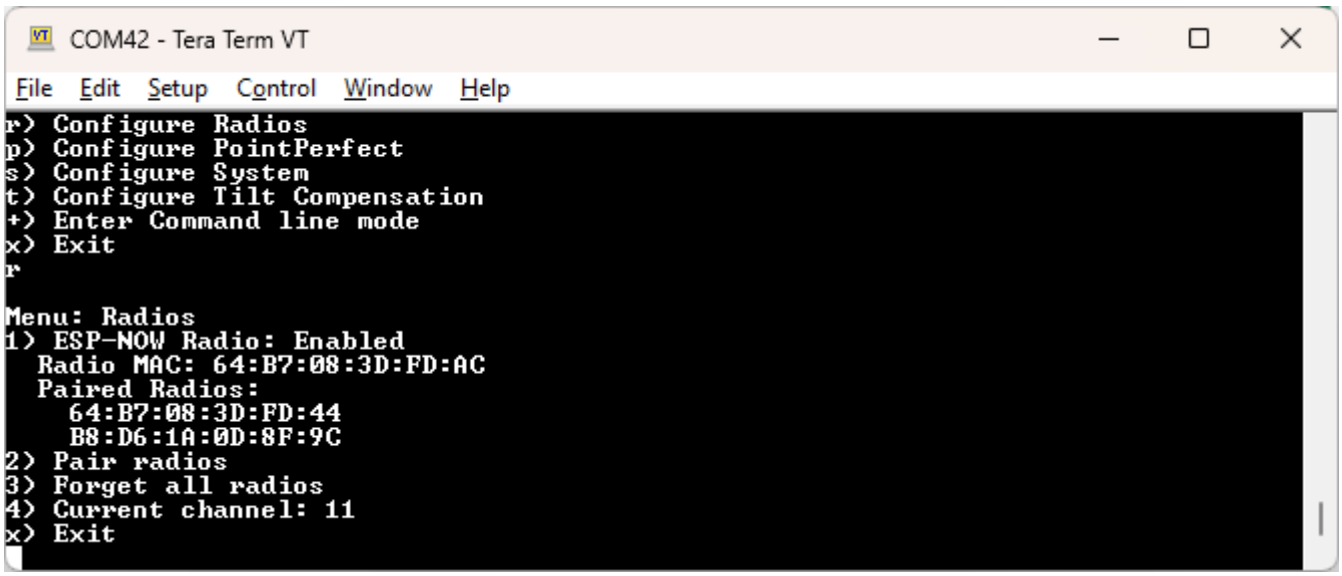
The radio system can be configured over WiFi. The radio subsystem is disabled by default. Enabling the radio to ESP-Now will expose the above options. The unit's radio MAC can be seen as well as a button to forget all paired radios. This button is disabled until the 'Enable Forget All Radios' checkbox 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.



Radio menu showing ESP-Now

A serial menu is also available. This menu allows users to enter pairing mode, change the channel (ie, set of frequencies) used for communication, 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.

6.11.3 Setting the WiFi Channel



Radio menu showing channel 11

All devices must be on the same WiFi channel to communicate over ESP-Now. Option **4 - Current channel** shows the current channel and allows a user to select a new one. Allowable channel numbers are 1 to 14. By default, devices will communicate on Channel 1. A user may select any channel they prefer.

Note: ESP-Now can operate at the same time as WiFi but the user should be aware of the channel numbers of the devices. When a device connects to a WiFi network, the ESP-Now channel number may be altered by the WiFi radio so that the RTK device can communicate with the WiFi Access Point.

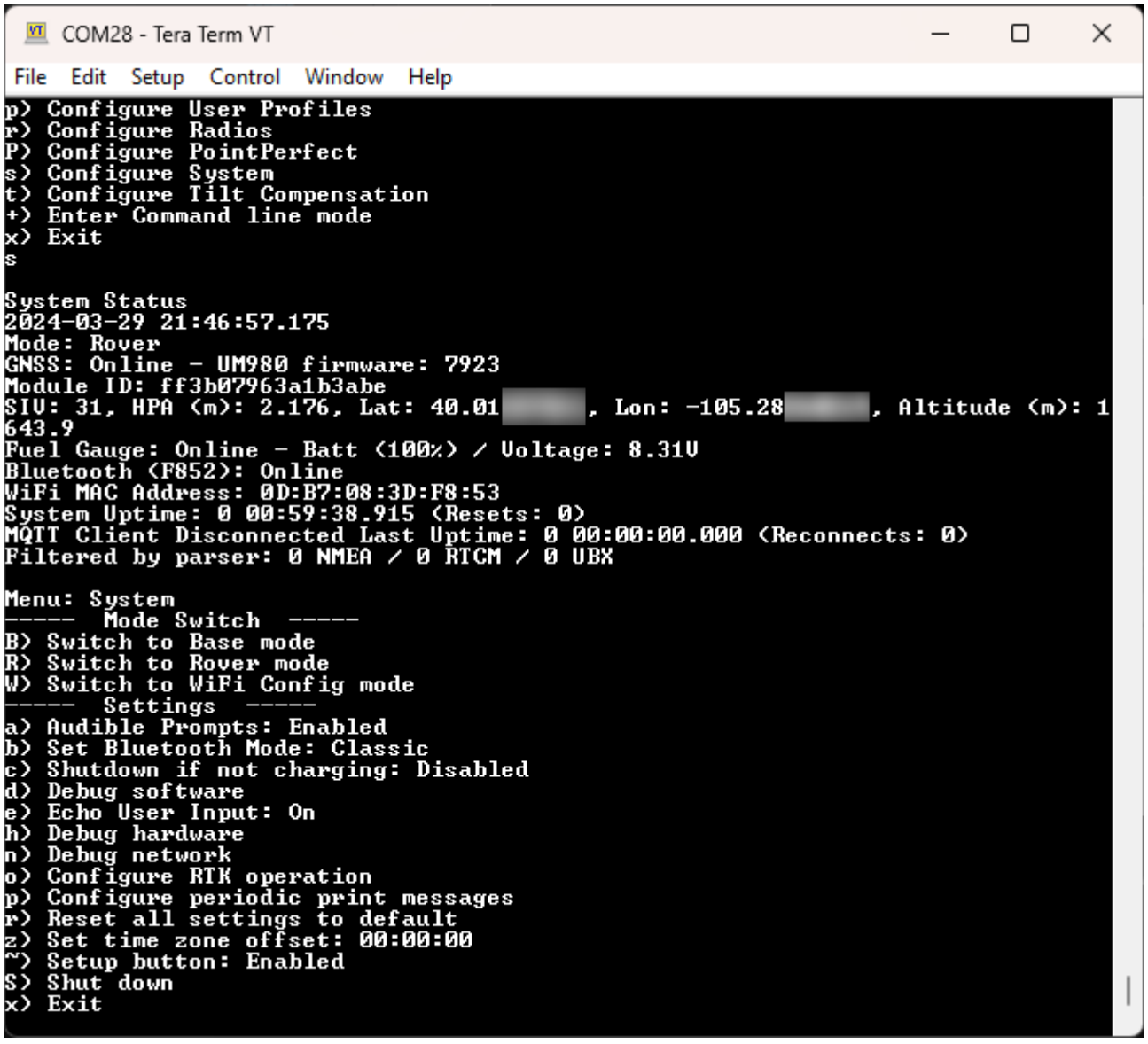
Using a single device to communicate corrections to multiple devices (no WiFi involved) is the most common use case for ESP-Now.

Using WiFi on one of the devices in an ESP-Now network is possible. Take the example of a Base that needs to communicate corrections over ESP-Now and will also be pushing the corrections to a Caster over NTRIP using WiFi: The Base is started, WiFi is activated, and the channel is overwritten to 9 (for example) when the device connects to the Access Point. All rovers in the area who wish to obtain corrections over ESP-Now also need to have their channels set to 9.

Using multiple devices on *different* WiFi networks, while attempting to use them in an ESP-Now network, is likely impossible because the device's channel numbers will be modified to match the different channels of the Access Points.

6.12 System Menu

Torch: 



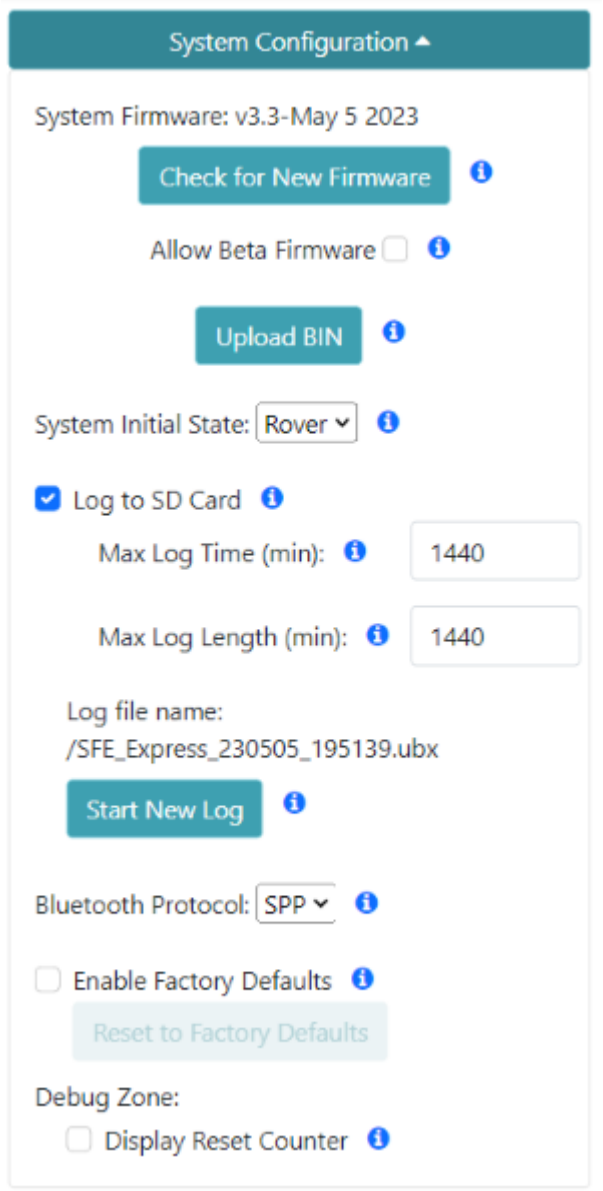
System Menu accessed over serial

The System Menu shows a variety of system information 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 RTK devices have all hardware options. For example, the RTK Torch does not have an SD slot so its status and configuration will not be shown.

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

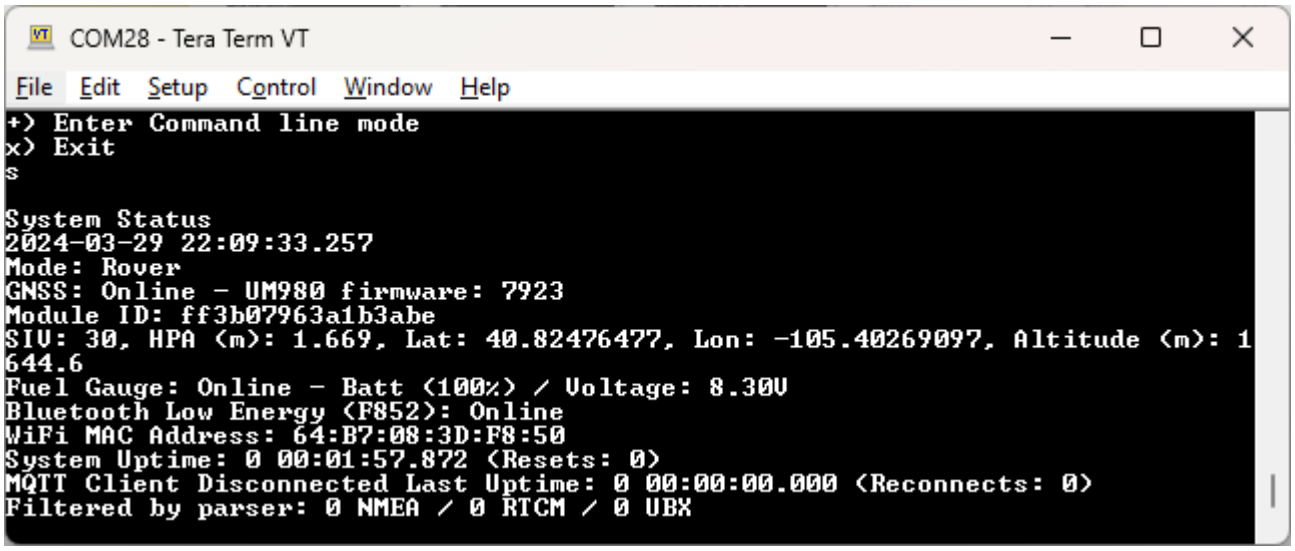
6.12.1 WiFi Interface

Because of the nature of these controls, the WiFi Config page shows different information than the Serial configuration.



System Config Menu on WiFi Config Page

6.12.2 System Information



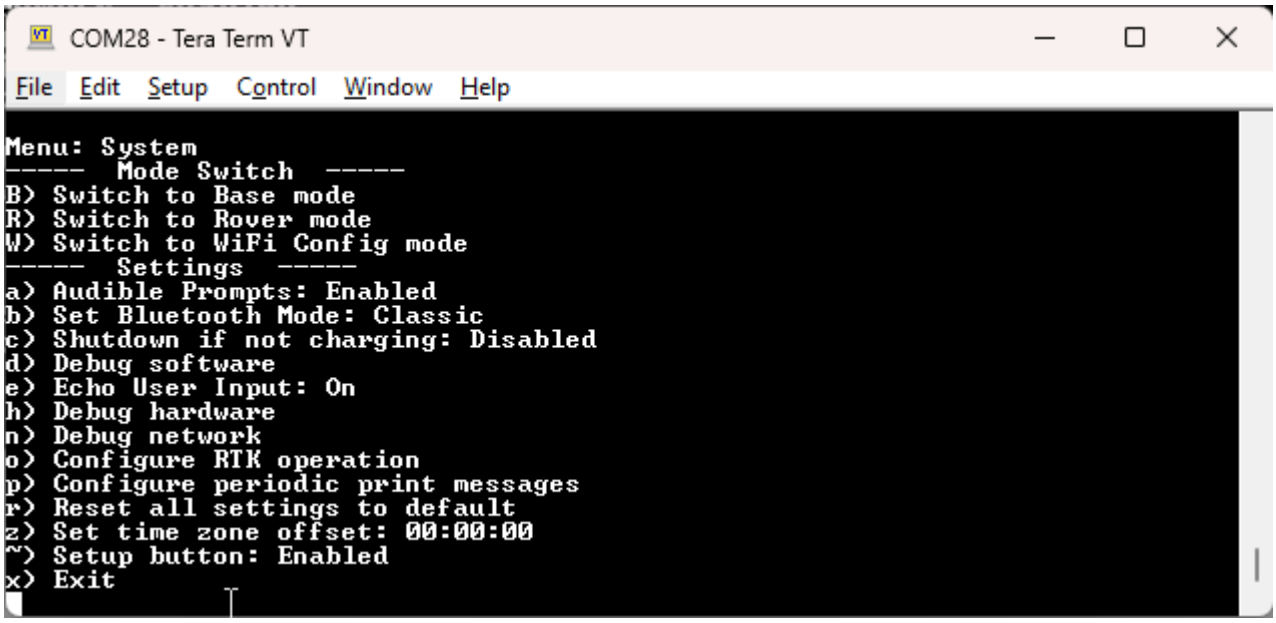
System Menu Header Information

The header of the system menu contains various system metrics.

In order of appearance:

- System Date/time
- Device Mode
- GNSS status including receiver type and firmware version
- Unique ID assigned to the GNSS receiver
- GNSS information including SIV, HPA, Lat/Lon/Alt
- Battery information (if supported)
- Bluetooth MAC (ending) and radio status
- WiFi MAC (full)
- System Uptime
- NTRIP Client/Server uptime (if enabled)
- MQTT Client uptime (if enabled)
- Parser statistics

6.12.3 Mode Switch

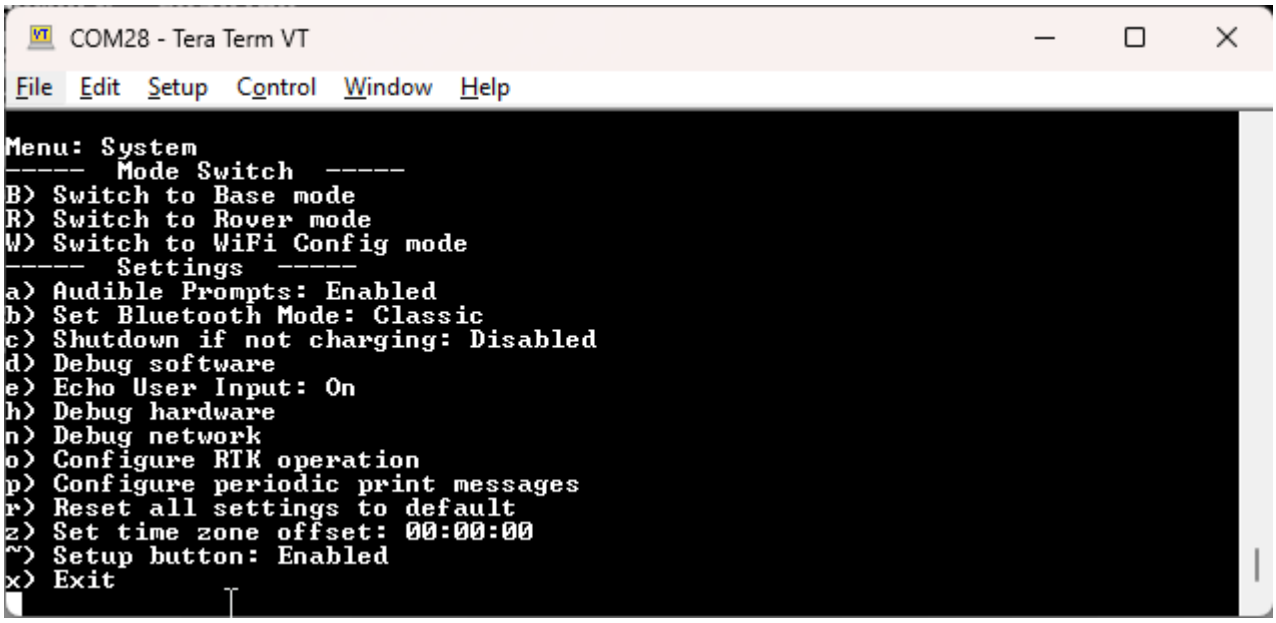


System Menu Options serial menu

The device can be in Rover, Base, or WiFi Config mode. The selected mode will be entered once the user exits the menu system.

- **B, R, W, or S** - Change the mode the device is in.
- Rover - This is the default mode. The device transmits its NMEA and other messages (if enabled) over Bluetooth. It can receive corrections over Bluetooth (or other transport methods such as NTRIP Client) to achieve RTK Fix.
- Base - The device will reconfigure for base mode. It will begin transmitting corrections over Bluetooth, WiFi (NTRIP Server, TCP, etc), or other (ESP-Now, external radio if compatible, etc).
- WiFi Config - The device will shut down GNSS operations and begin broadcasting as a WiFi Access Point (or will attempt to connect to local WiFi). Once started, the device can be connected to over WiFi for configuration.
- Shut Down - If supported, the device will immediately shut down.

6.12.4 Settings



System Menu Options serial menu

- **a** - On devices that support it, a beeper is used to indicate various system states (system power on/off, tilt compensation in use, etc). This can be disabled if desired.
- **b** - Change the Bluetooth protocol. By default, the RTK device begins dual broadcasting over Bluetooth Classic SPP (Serial Port Profile) **and** Bluetooth Low-Energy (BLE). The following options are available: *Dual*, *Classic*, *BLE*, or *Off*. Bluetooth v2.0 SPP (Serial Port Profile) is supported by nearly all data collectors and Android tablets. BLE is used for configuration and to be compatible with Apple iOS-based devices. Additionally, the Bluetooth radio can be turned off.
- **c** - On devices that support it, a device will continue to operate until the battery is exhausted. If desired, a timeout can be entered: If no charging is detected, the device will power off once this amount of time has expired.
- **d** - Enters the Debug Software menu that is for advanced users.
- **e** - Controls the printing of local characters (also known as 'echoing').
- **f** - On devices that support it, show any files on the microSD card (if present).
- **h** - Enters the Debug Hardware menu that is for advanced users.
- **n** - Enters the Debug Network menu that is for advanced users.
- **o** - Enters the Configure RTK operation menu that is for advanced users.
- **p** - Enters the Configure periodic print menu that is for advanced users.
- **r** - Reset all settings to default including a factory reset of the GNSS receiver. This can be helpful if the unit has been configured into an unknown or problematic state. See Factory Reset.
- **u** - Change between metric and Imperial units. This only modifies the units shown on serial status messages and on the display (if available), it does not change NMEA output.
- **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.
- **~** - If desired, the external button(s) can be disabled to prevent accidental mode changes.

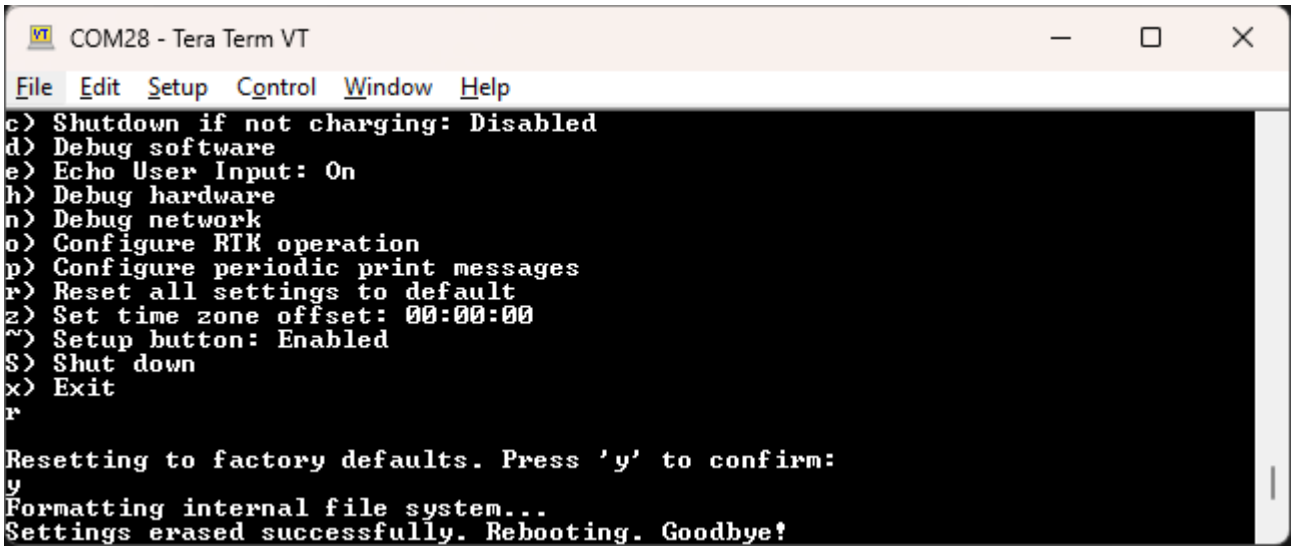
Note: Bluetooth SPP cannot operate concurrently with ESP-Now radio transmissions. Therefore, if you plan to use the ESP-Now radio system to connect RTK products, the BLE protocol must be used to communicate over Bluetooth to data collectors. Alternatively, ESP-Now works concurrently with WiFi so connecting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

6.12.5 Factory Reset

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

Note: On devices that support an SD card, a factory reset can also be accomplished by editing the settings files. See Force a Factory Reset for more information.

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



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. If SD is supported, any settings file and commonly used coordinate files on the SD card associated with the current profile will be removed.

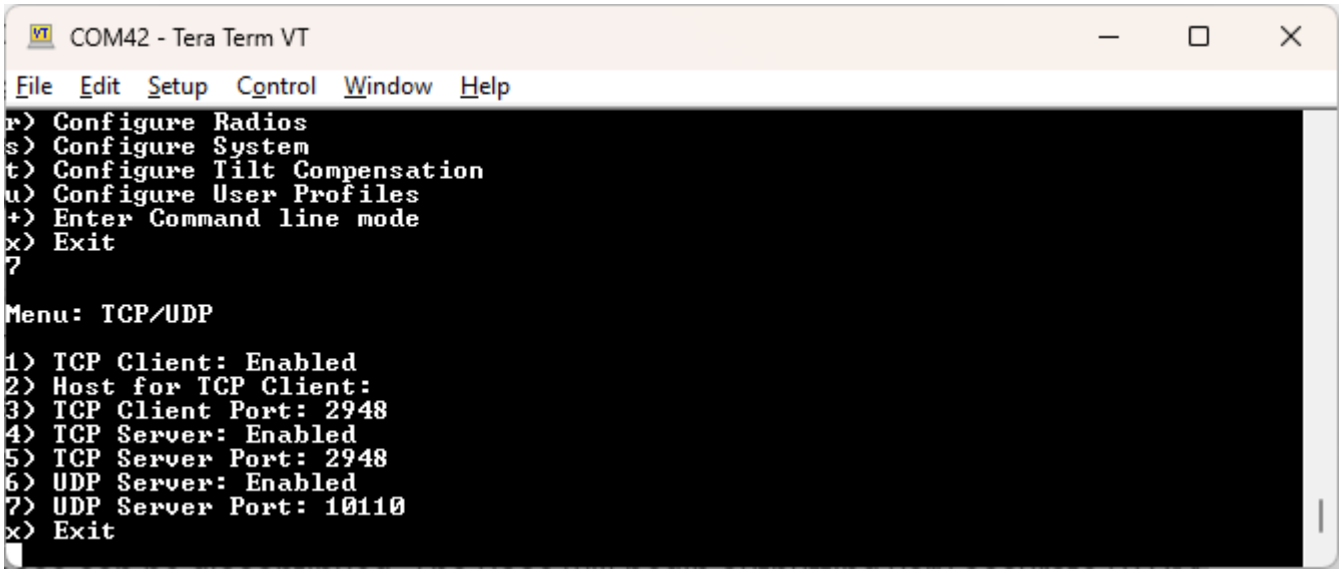
Enabling and Starting a Factory Reset

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.

6.13 TCP/UDP Menu

Torch:

NMEA data is generally consumed by a GIS application or Data Collector. These messages can be transmitted over a variety of transport methods. This section focuses on the delivery of NMEA messages via TCP and UDP.

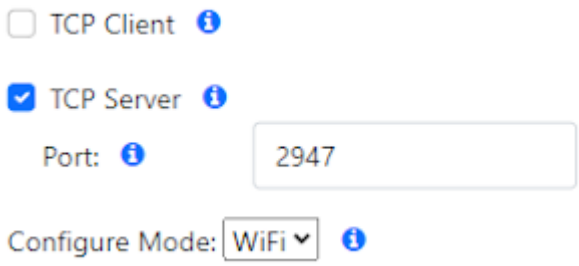


TCP/UDP Menu showing various Client and Server options

6.13.1 TCP Client and Server

The RTK device supports connection over TCP. The TCP Client sits on top of the network layer and sends position data to one or more computers or cell phones for display. 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.



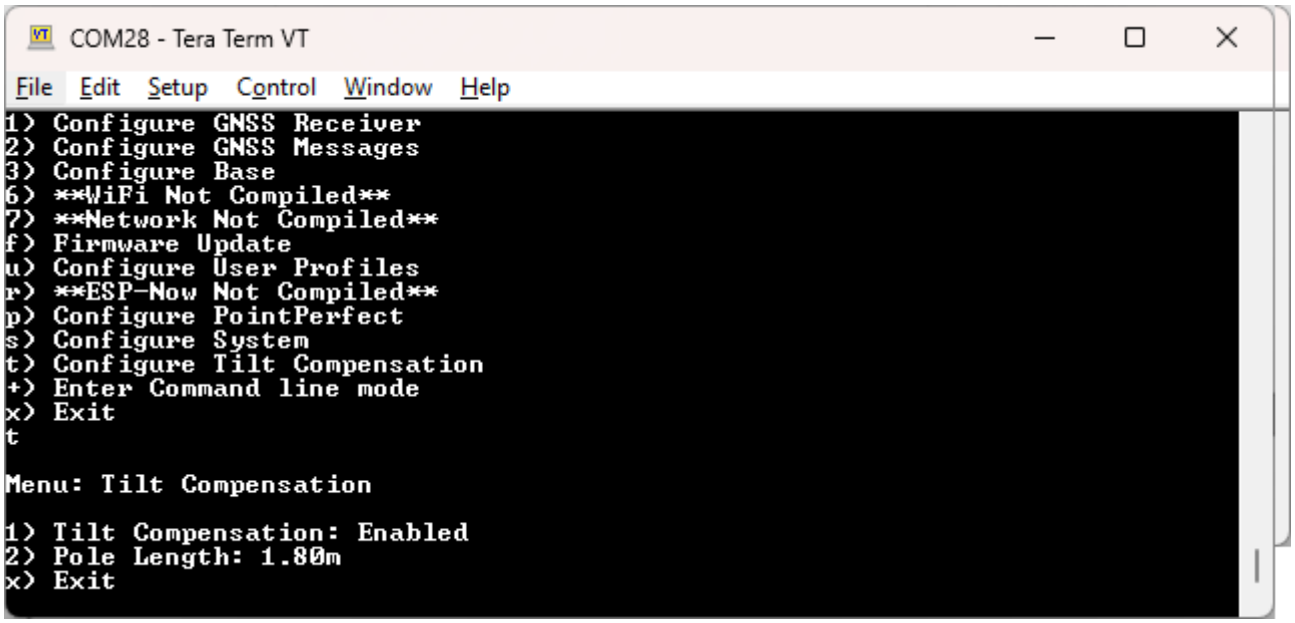
If either Client or Server is enabled, a port can be designated. By default, the port is 2947 (registered as *GPS Daemon request/response*) but any port 0 to 65535 is supported.

6.13.2 UDP Server

NMEA messages can also be sent via UDP rather than TCP. If enabled, the UDP Server will begin broadcasting NMEA data over the specific port (default 10110).

6.14 Tilt Compensation Menu

Torch:



Tilt Compensation menu

The Tilt Compensation menu controls how the tilt sensor is configured.

- **1** - By default, tilt compensation is enabled but can be disabled if desired.
- **2** - The pole length must be set accurately to enter tilt compensation mode. The default is 1.8 meters.

6.14.1 Entering Tilt Compensation Mode

To use Tilt Compensation, the user must indicate to the IMU to begin calibration by shaking the device. Then, once the IMU has calculated its position on the end of the pole, Tilt Compensation will be active.

During Tilt Compensation, all outgoing NMEA messages are modified to output the location *of the tip of the pole*. The Data Collector software will not be aware that the position of the GNSS receiver position is being modified. Moving the tip of the pole is allowed. Tilt up to 30 degrees will introduce less than 10mm of inaccuracy. Tilt up to 60 degrees will introduce less than 20mm of inaccuracy.

If the audible beeper is enabled, a long beep will be heard when the IMU starts calibration (by shaking). A short beep will be heard when the IMU completes calibration and Tilt Compensation is active. A short beep will continue every 10 seconds to let the user know Tilt Compensation is being applied.

Tilt Compensation mode will be exited when the user short presses the power button, and a long beep will be heard. Additionally, Tilt Compensation mode will be exited if RTK Fix is lost. When this happens, the IMU will attempt to re-enter Tilt Compensation mode if RTK Fix is re-achieved.

Tilt compensation mode can be entered using the following steps:

1) The device must be in Rover mode.

2) The device must achieve an RTK Fix.

3) The pole length must be accurately configured. By default, this is 1.8 meters.

4) Once the above requirements are met, the device must be shaken. This is normally a strong up/down vertical motion. However, if it is more comfortable, the device can be positioned horizontally over the shoulder and shaken with a strong forward/backward motion.

5) On devices that support it, the device will emit a chirp once Tilt Mode is started.

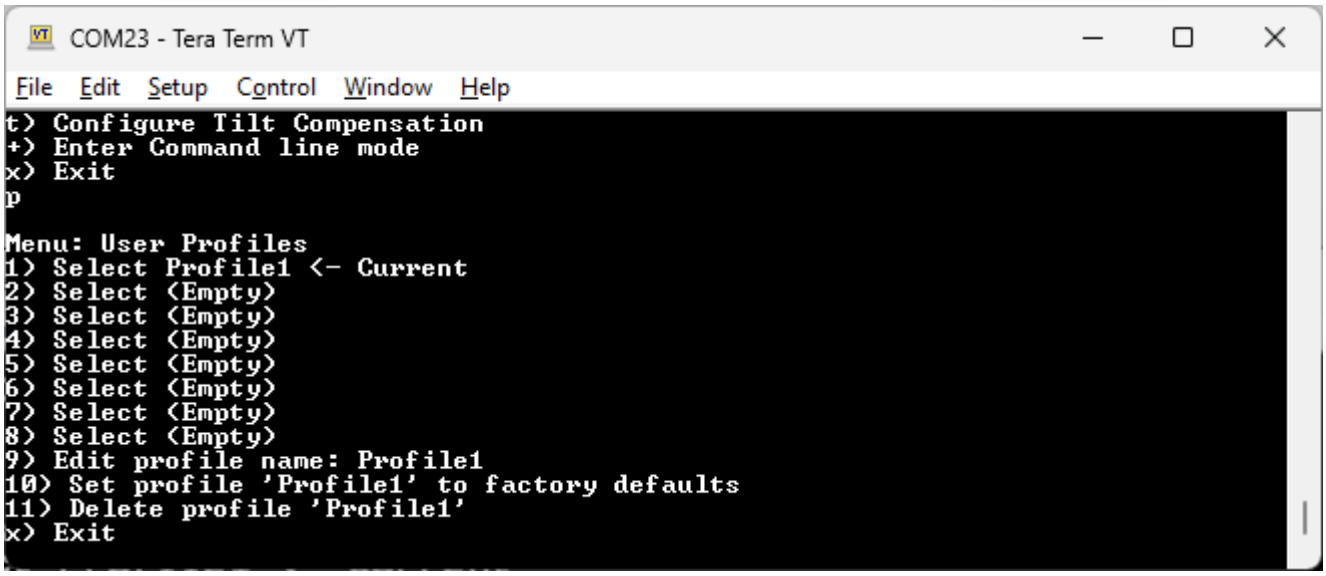
6) Place the tip of the device on the ground. Move the head of the device back and forth up to ~30 degrees of tilt. Repeat on the opposite axis.

7) On devices that support it, the device will emit a long chirp once Tilt Compensation Mode is active. The device is now outputting the *location of the tip* of the pole.

8) Exit Tilt Compensation Mode by short pressing the power button.

6.15 User Profiles Menu

Torch:



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.

Profiles can be selected, renamed, reset to defaults, and completely erased from the **User Profiles** menu.

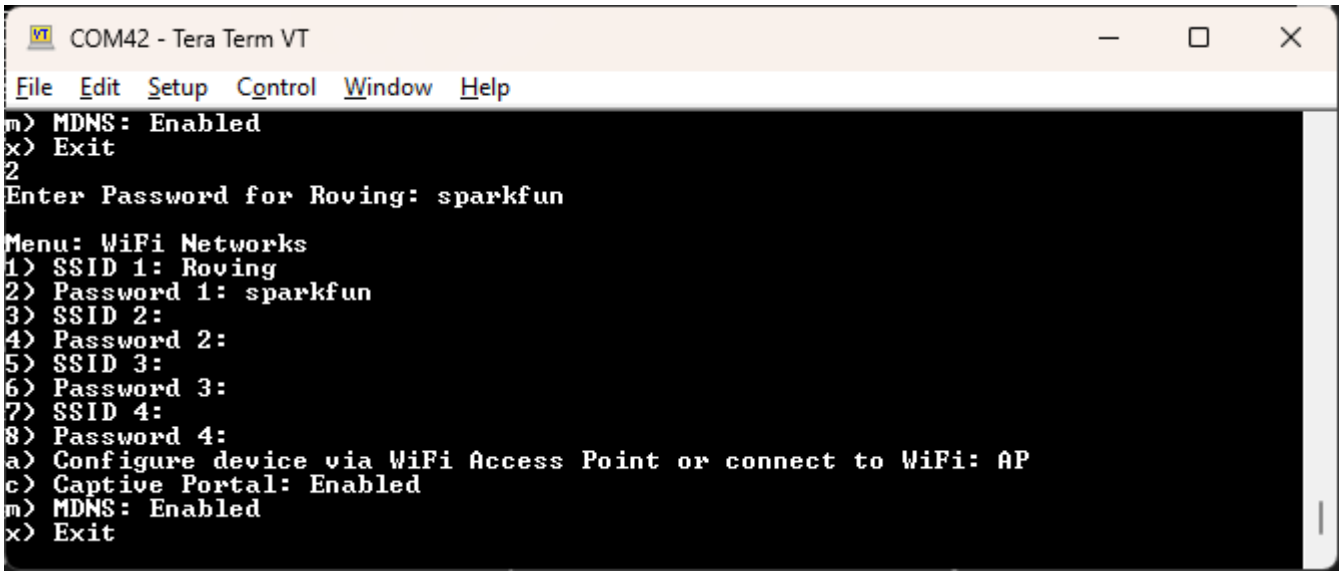
6.15.1 User Profile Selection via Display

Multiple Profiles on Menu

On devices that have a display, if more than one profile is defined, the profiles will be displayed and selectable by using the **Power/Setup** button. Only the first 7 characters of a profile's name will be shown on the menu. Once a profile has been selected, the device will reboot using that profile.

6.16 WiFi Menu

Torch:



WiFi Menu containing one network

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.

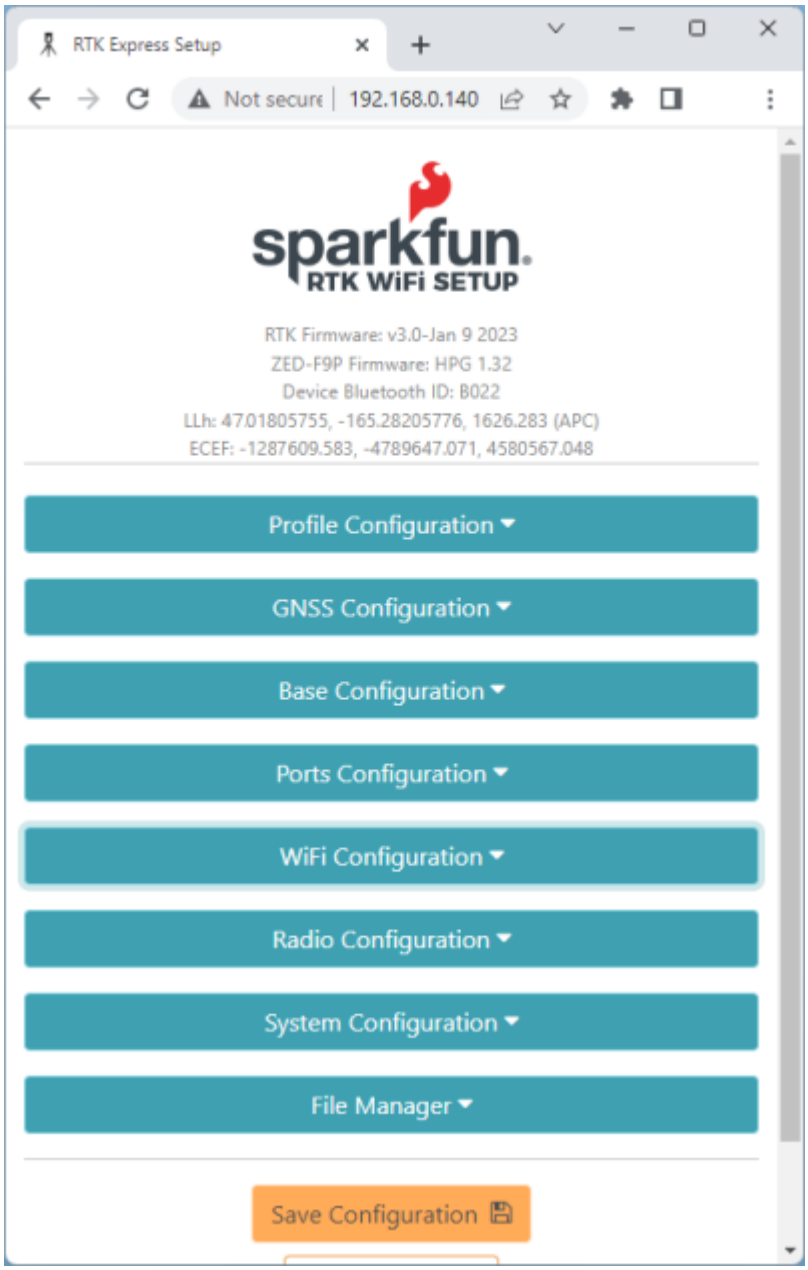
Additionally, the device will continue to try to connect to WiFi if a connection is not made. The connection timeout starts at 15 seconds and increases by 15 seconds with each failed attempt. For example, 15, 30, 45, etc seconds are delayed between each new WiFi connection attempt. Once a successful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

6.16.1 Configure device via WiFi Access Point of connect to WiFi

By default, when a user enters the WiFi config mode (either by using the external button or with the System Mode Switch), the device will stop what it is doing and enter WiFi Config mode. If this setting is set to `AP` then the RTK device will broadcast as an access point with the name *RTK Config*. If this setting is set to `WiFi`, then the device will attempt to connect to that WiFi network. The `AP` setting is best for in-field configuration, and the `WiFi` setting is handy for configuration from a laptop or desktop on the same WiFi network.



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.

On devices that have a display, when the device enters WiFi config mode it will display the WiFi network it is connected to as well as its assigned IP address.

6.16.2 Captive Portal

If **Captive Portal** is enabled, when a user connects to the Access Point the user will automatically be directed towards the correct page. This works with most, but not all phones.

6.16.3 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.

7. Hardware

7.1 Update Firmware

Torch:

The device has two primary firmwares:

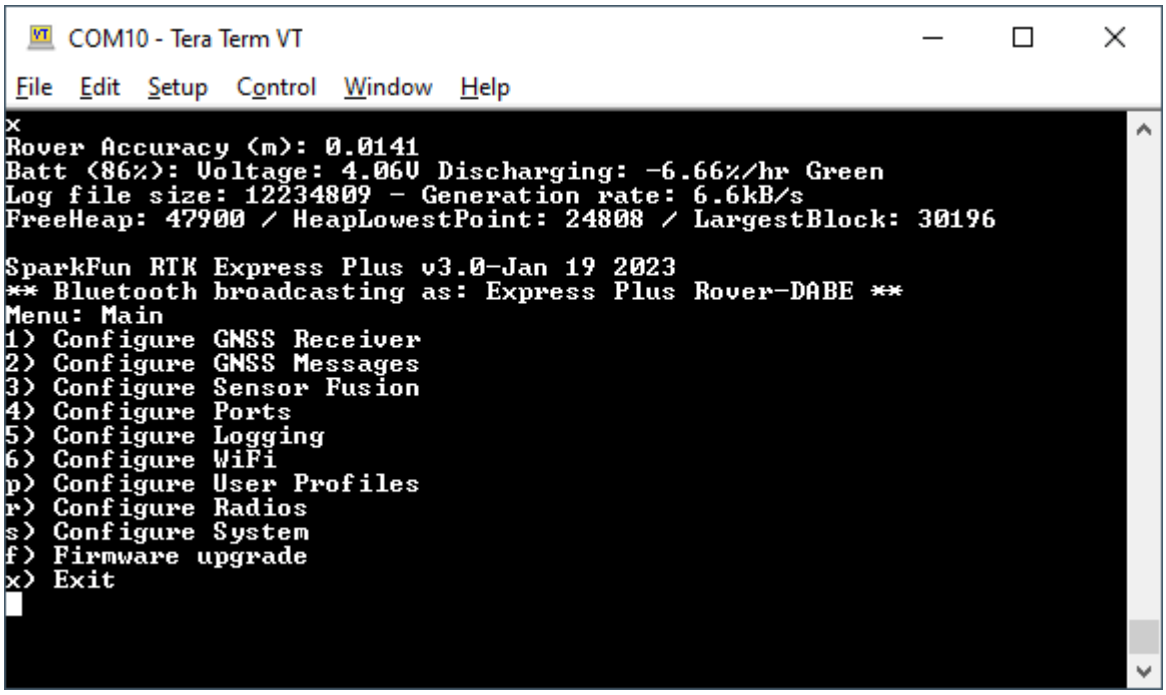
- Firmware on the ESP32 microcontroller
- Firmware on the GNSS receiver. See below.

The device firmware is displayed in a variety of places:

- Power On (if a display is supported)
- Serial Config Menu
- WiFi Config

RTK Express with firmware v3.0

During power-on, on devices that have a display, the firmware version will be shown.



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.

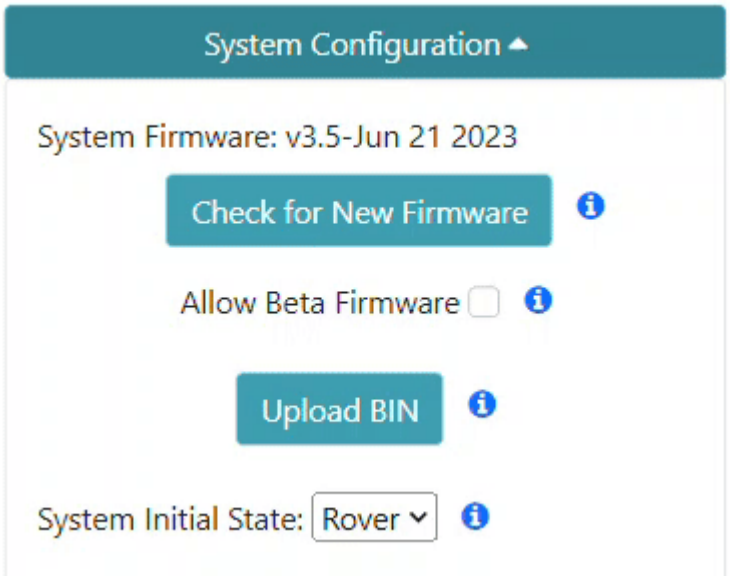
From time to time SparkFun will release new firmware for the RTK product line to add and improve functionality. For most users, firmware can be upgraded over WiFi using the OTA method.

- 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*

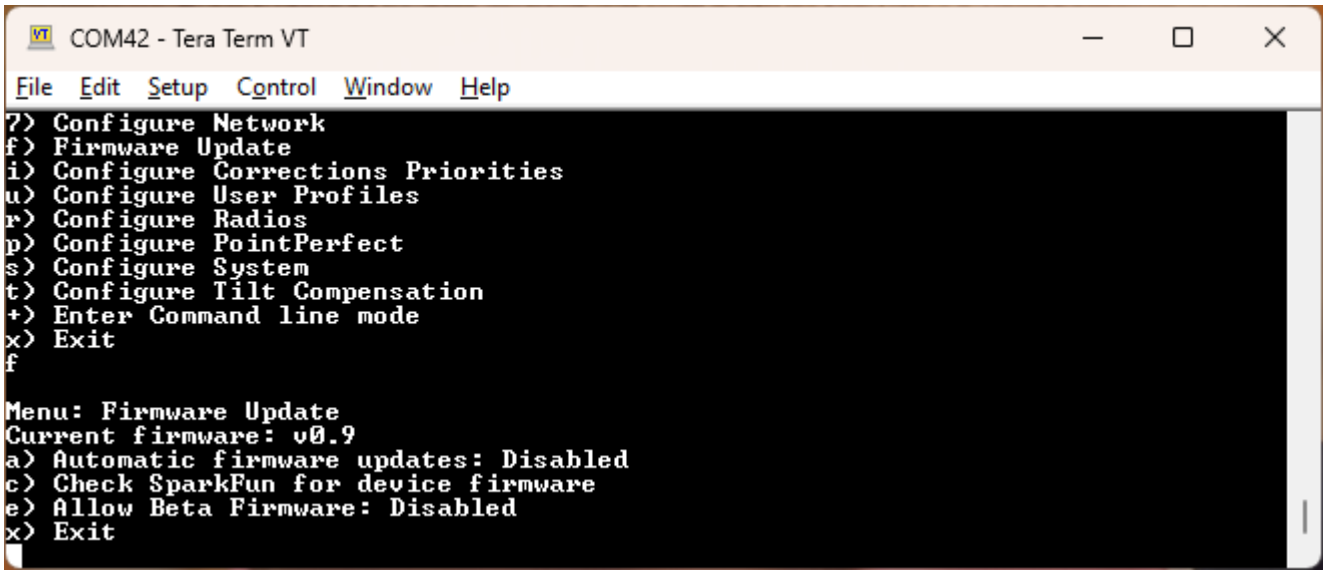
The OTA method is generally recommended. For more information see here.

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



Updating the firmware via Firmware serial menu

Firmware can be updated 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.

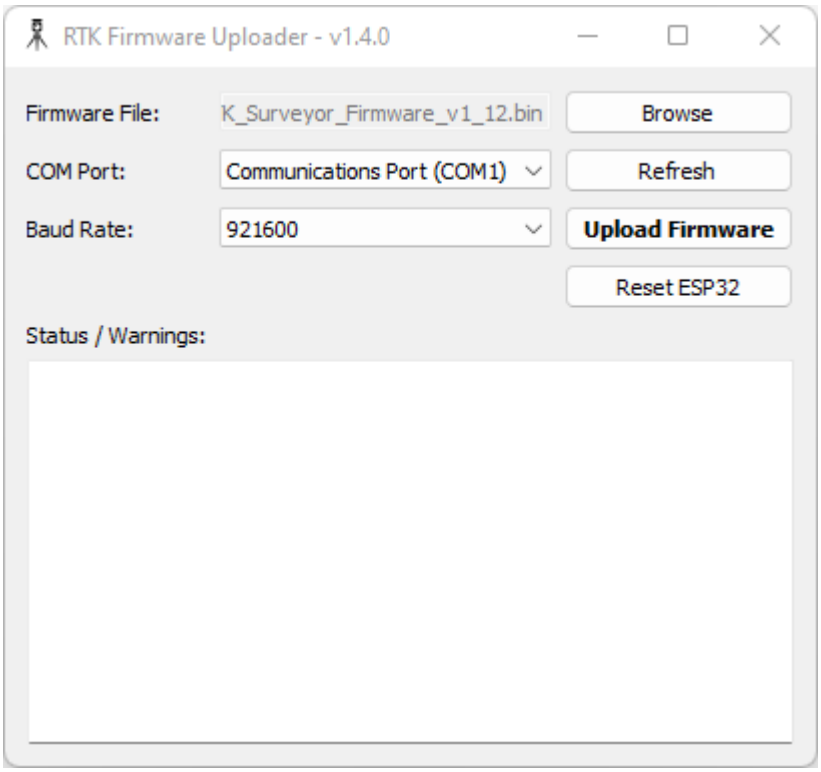
Additionally, users may opt to check for Beta firmware. This is the latest firmware that may have new features and is meant for testing. Beta firmware is not recommended for units deployed into the field as it may not be stable.

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.

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*

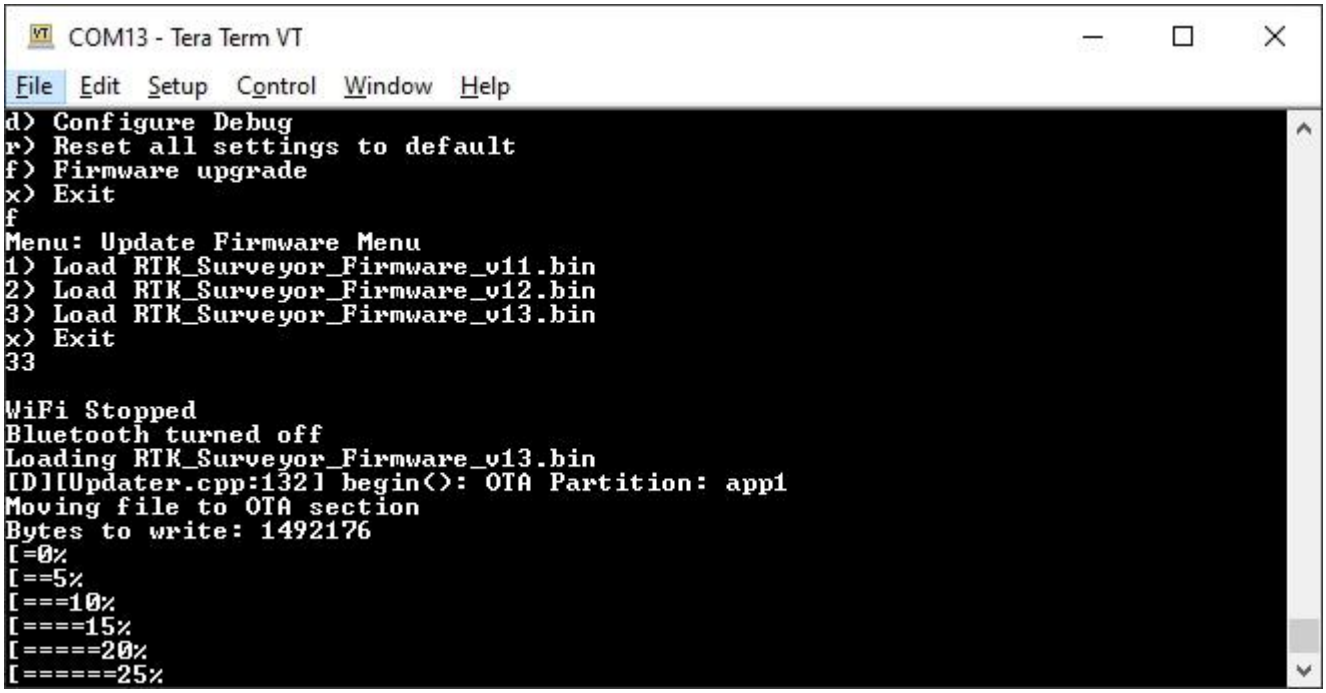
Once complete, the device will reset and power down.

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

7.1.3 Updating Firmware From the SD Card

Torch: 

On devices that support it, the firmware can be loaded from an SD card.



Firmware update taking place

Download the latest binary file located on the releases page or from the binaries repo.

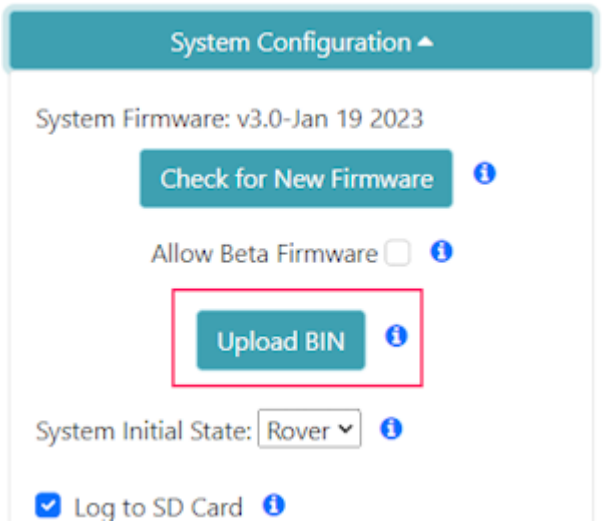
The firmware upgrade menu will only display files that have the "RTK_Surveyor_Firmware*.bin" file name format so don't change the file names once loaded onto the SD card. Select the firmware you'd like to load and the system will proceed to load the new firmware, then reboot.

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.

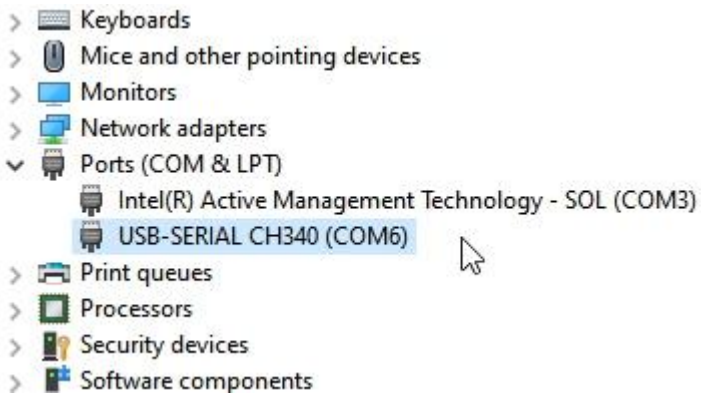
Firmware may be uploaded to the unit by clicking on 'Upload BIN', selecting the binary such as 'RTK_Surveyor_Firmware_v3_x.bin' and pressing upload. The unit will automatically reset once the firmware upload is complete.

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).

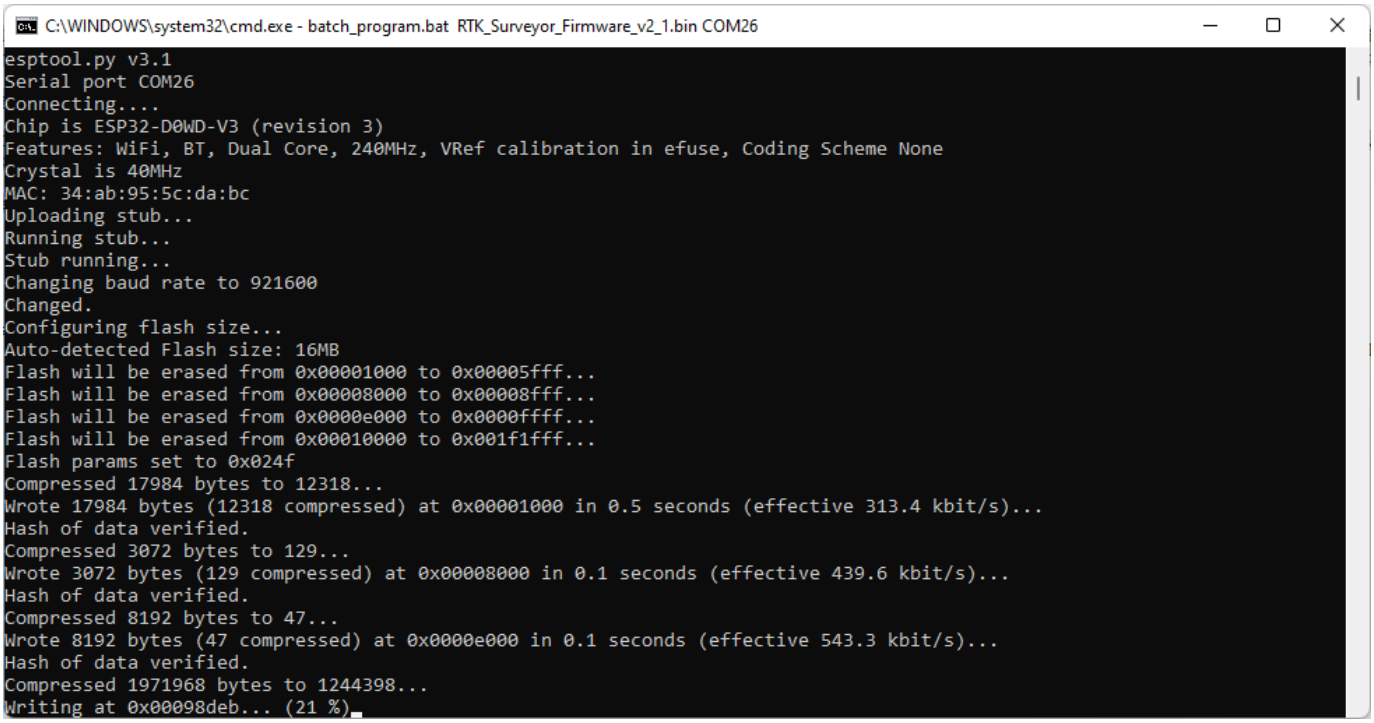
Windows

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').



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.

7.1.6 Updating u-blox Firmware

Torch:

The following products contain the following u-blox receivers:

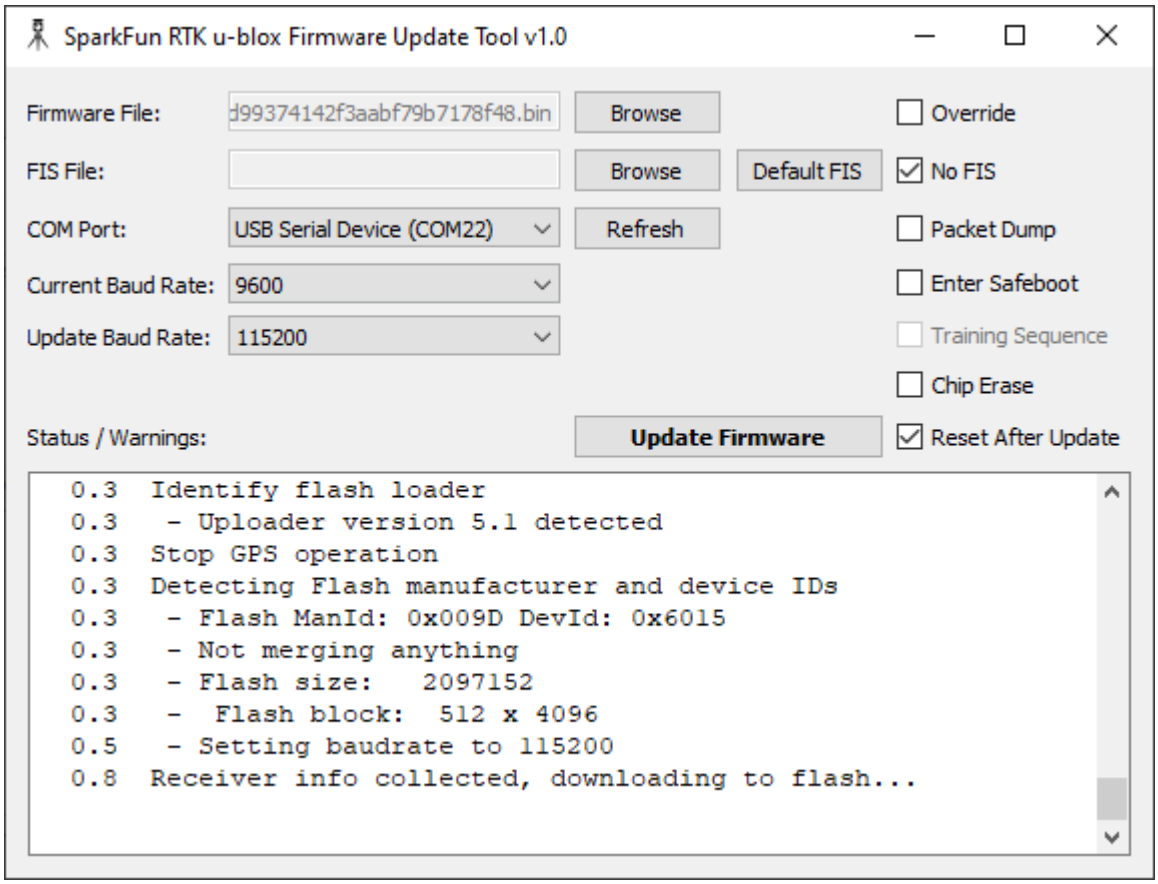
- RTK EVK: ZED-F9P

The firmware loaded onto the ZED-F9P 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.

Update Using Windows GUI

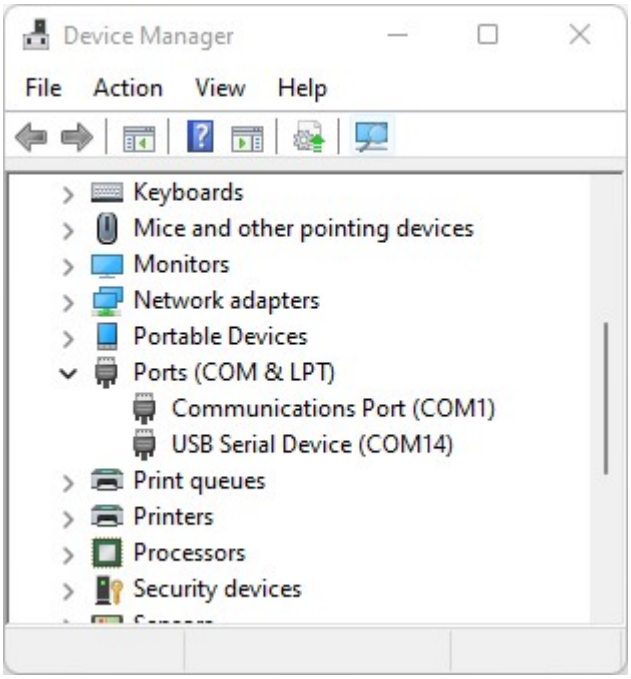


SparkFun RTK u-blox Firmware Update Tool

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.

Update 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.

- v1.32 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.
- v1.30 has a few RTK and receiver performance improvements, I^2C communication improvements, and most importantly support for SPARTN PMP packets. 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.
- v1.12 has the benefit of working with SBAS and an operational RTK status signal (the LED illuminates correctly). 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.

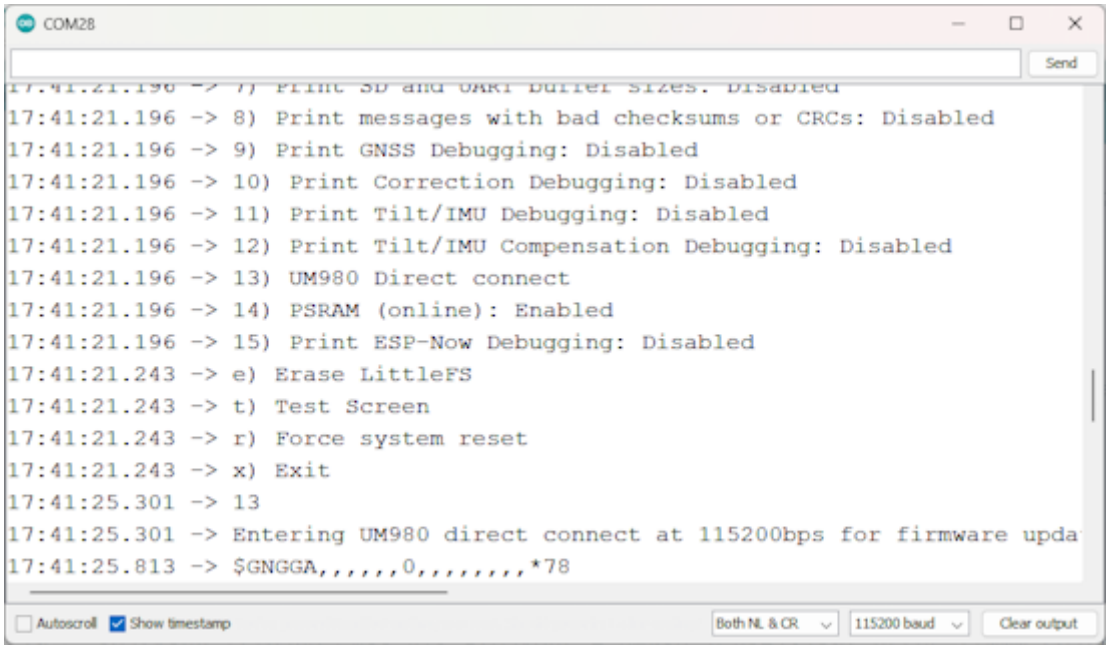
This binary file can be found in the NEO Firmware folder.

- v1.04 Initial release.

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

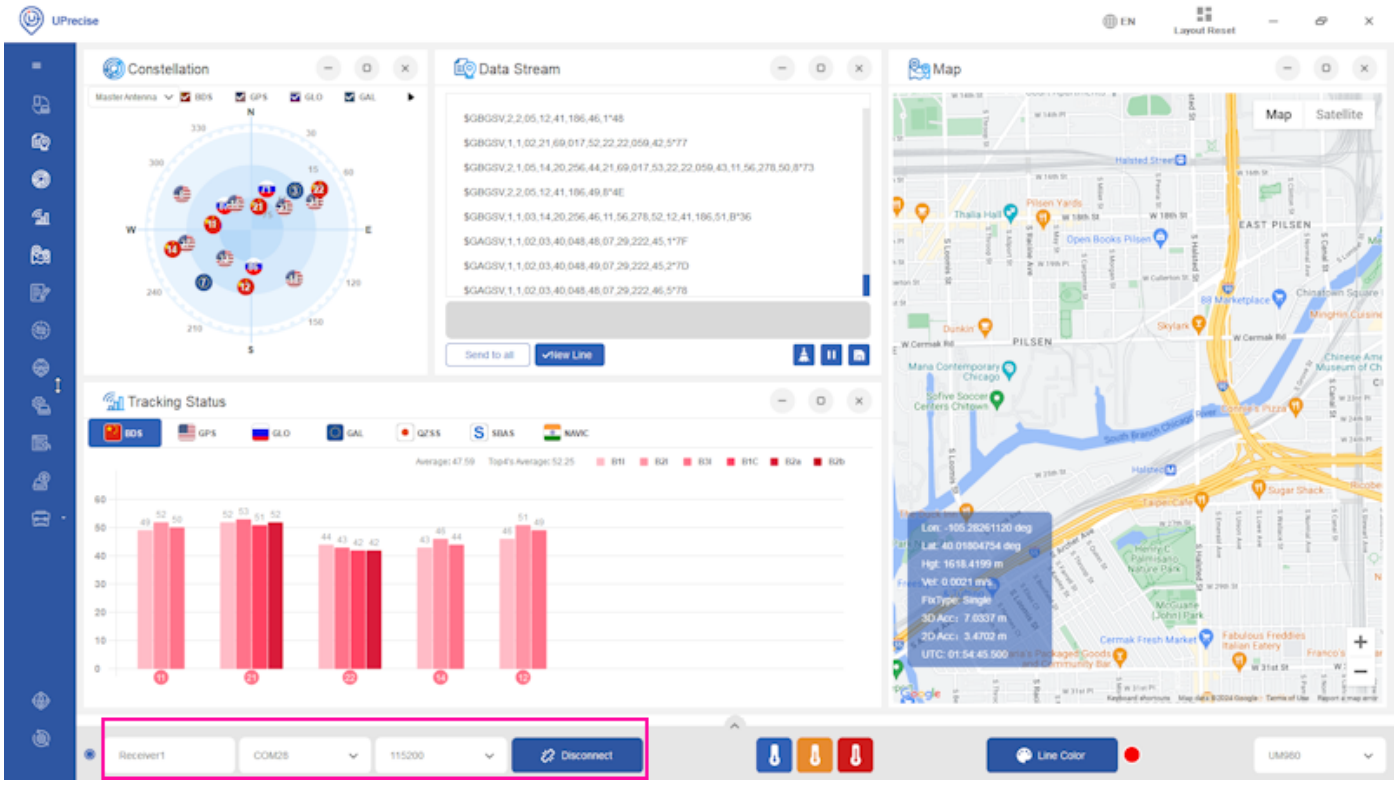
7.1.7 Updating UM980 Firmware

1. Download the latest UM980 firmware. As of writing, the UM980 firmware is v11833. See the RTK Torch repo for the latest firmware.
2. Download and install UPrecise. UPrecise is the software created by Unicore to configure and view output from Unicore GNSS modules. v2 of the software can be downloaded here but newer versions may be available.



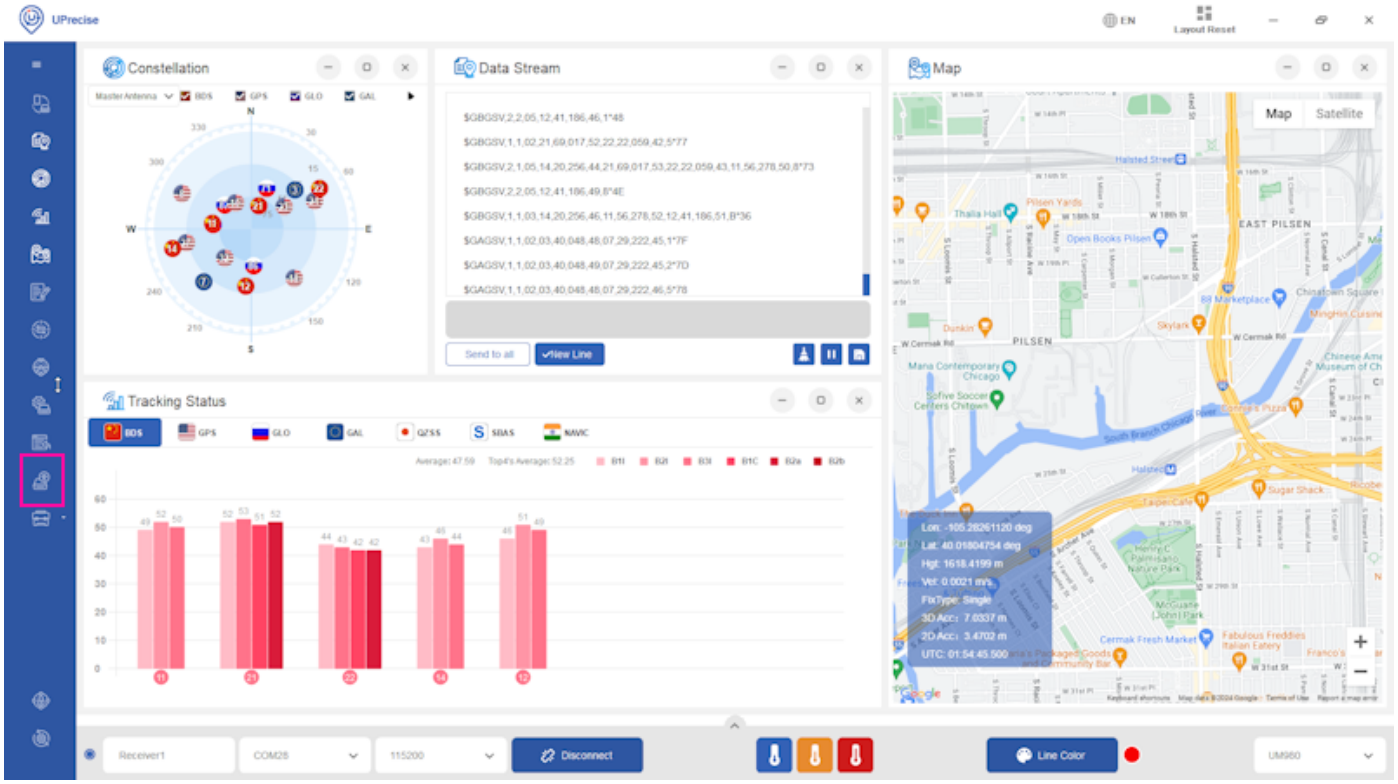
Serial Configuration via Arduino Serial Terminal

3. Put the device into passthrough mode. From the main menu navigate to System 's'->Hardware 'h'->UM980 Direct Connect '13'. This will put the device into a pass-through mode, but with special character monitoring that allows the UM980 to be reset when bootloading is detected. Close the terminal connection so that UPrecise can connect to the COM port. **Note:** Some terminals cause the ESP32 to reset when closing the port. This reset causes the UM980 pass-through mode to exit. TeraTerm is known to cause this issue. To enter pass-through mode we recommend using the Arudino terminal.



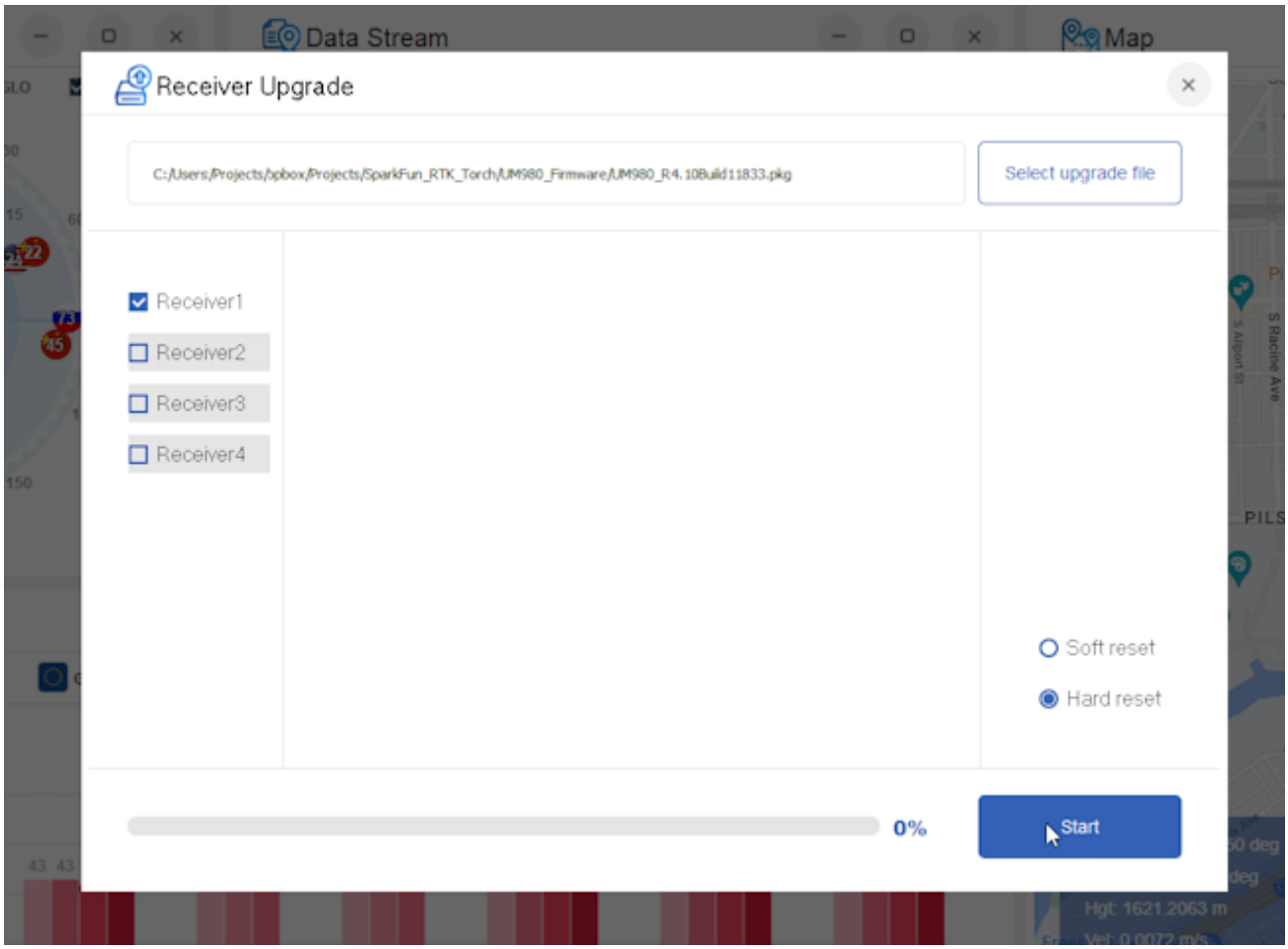
Connect button and connection settings in UPrecise

4. Select the COM port and set the baud rate to 115200, then press 'Connect'



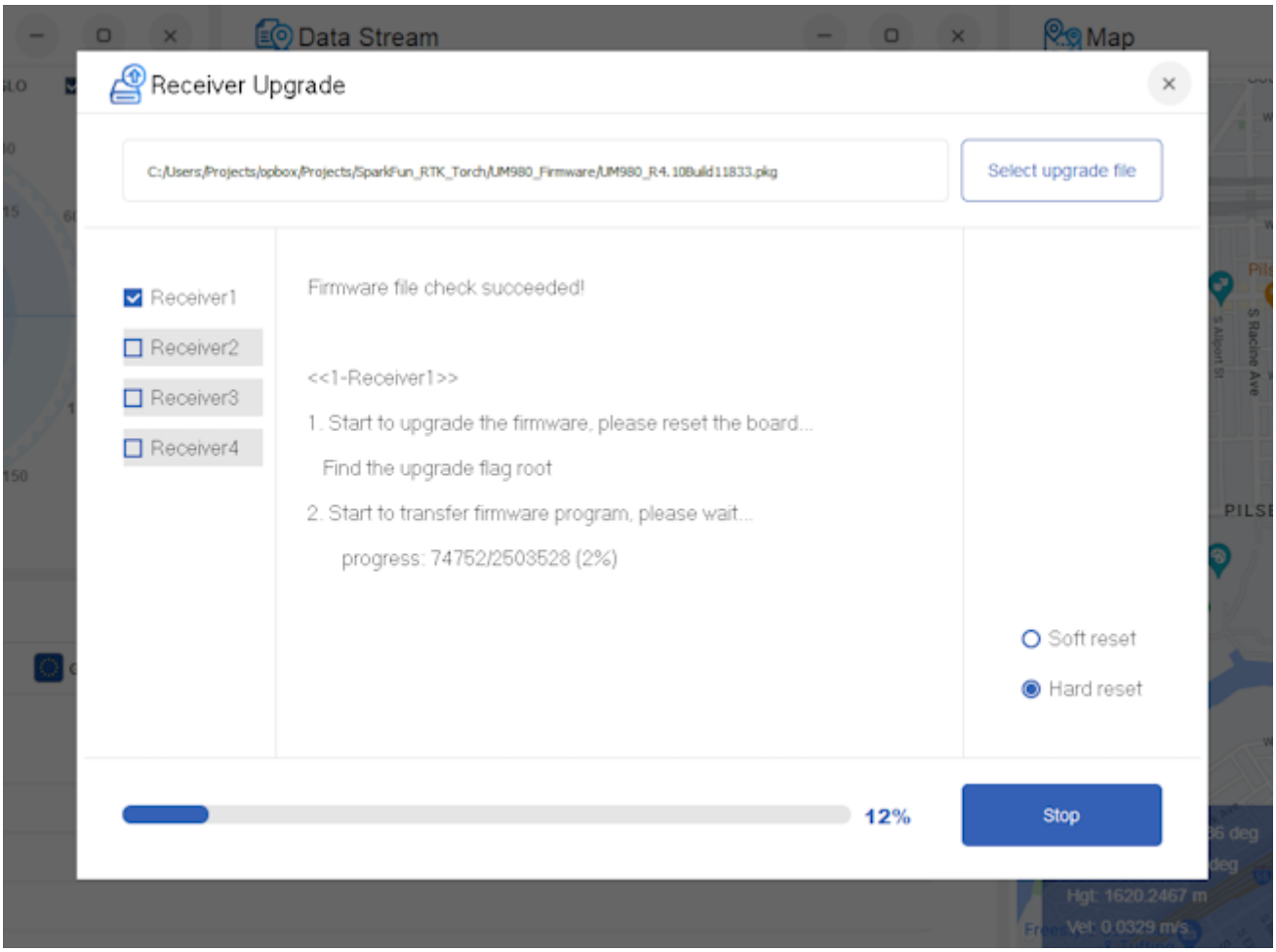
Receiver Upgrade Button

5. Once connected, press the **Receiver Upgrade** button.



Firmware selection window

6. Select the latest firmware file that was previously downloaded (See the RTK Torch repo for the latest firmware). Then press Start.



Firmware update process

7. The update process can take multiple minutes. Once completed, close UPrecise, and power cycle the RTK Torch.

UM980 Firmware version shown in System Menu

8. Upon power-up, the firmware will be updated. Open the System Menu to confirm the firmware version.

7.1.8 Compiling Source

Windows

The SparkFun RTK Everywhere Firmware is compiled using Arduino CLI (currently v0.35.3). To compile:

1. Install Arduino CLI.
2. Install the ESP32 core for Arduino:

```
arduino-cli core install esp32:esp32@2.0.11
```

Note: Use v2.0.11 of the core.

Note: We use the 'ESP32 Dev Module' for pin numbering.

1. Obtain each of the libraries listed in the workflow either by using git or the Arduino CLI library manager. Be sure to obtain the version of the library reflected in the workflow. Be sure to include the external libraries (You may have to enable external library support in the CLI).
2. RTK Everywhere uses a custom partition file. Download the RTKEverywhere.csv file.
3. Add *RTKEverywhere.csv* partition table to the Arduino partitions folder. It should look something like

```
C:\Users\\[user name]\AppData\Local\Arduino15\packages\esp32\hardware\esp32\2.0.11\tools\partitions\RTKEverywhere.csv
```

   This will increase the program partitions, as well as the SPIFFs partition to utilize the full 16MB of flash.

4. Compile using the following command

   arduino-cli compile 'Firmware/RTK_Everywhere' --build-property build.partitions=RTKEverywhere --build-property upload.maximum_size=3145728 --fqbn esp32:esp32:esp32:FlashSize=16M,PSRAM=enabled

5. Once compiled, upload to the device using the following command where `[COM_PORT]` is the COM port on which the RTK device is located (ie `COM42`).

```
arduino-cli upload -p [COM_PORT] --fqbn esp32:esp32:esp32:UploadSpeed=512000,FlashSize=16M 'Firmware/RTK_Everywhere'
```

   If you are seeing the error:

   text section exceeds available space ...

   You have either not replaced the partition file correctly or failed to include the 'upload.maximum_size' argument in your compile command. See steps 4 through 6 above.

   Note: There are a variety of compile guards (COMPILE_WIFI, COMPILE_AP, etc) at the top of RTK_Everywhere.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).

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 Everywhere 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 Everywhere Firmware sources
17. mkdir ~/SparkFun/RTK

18. cd ~/SparkFun/RTK
19. git clone https://github.com/sparkfun/SparkFun_RTK_Everywhere_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_Everywhere_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

7.2 Displays

Torch: 

A variety of RTK devices utilize a 0.96" or 1.3" high-contrast OLED display. While small, the display packs various situational data that can be helpful in the field. This section describes each possible display state.

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.

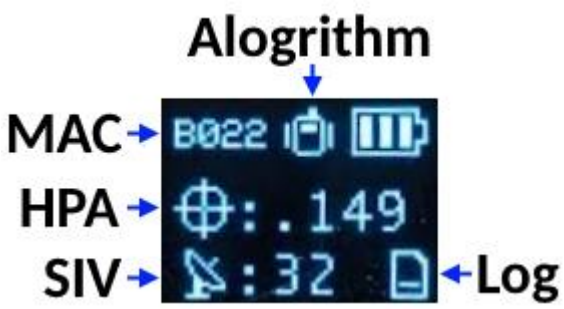
The device's firmware version is shown during the Power On display.

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.

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 
- Standard (three lines) is shown when the standard 5 NMEA messages are being logged
- PPP (capital P) is shown when the standard 5 NMEA + RAWX and SFRBX messages are recorded. This is most often used for post process positioning (PPP) and 12 to 24-hour logs for fixed permanent bases.
- Custom (capital C) is shown when a custom set of messages are being recorded (not standard, and not PPP).

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

Torch:

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 Antenna Detection

Torch:

On devices that support it, open circuit and short circuit detection is available 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 and ethernet-equipped RTK device 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.

7.3 Output to an Embedded System

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. For RTK devices that have an external connection, a user can obtain the NMEA data over serial directly.

7.3.1 USB

Torch:

Most SparkFun RTK devices have a USB port for programming and status reports. This USB port can also be configured to output full NMEA/RTCM output that can be used to create a wired connection to an embedded system. See Output GNSS Data over USB for more information.

7.3.2 DATA Port

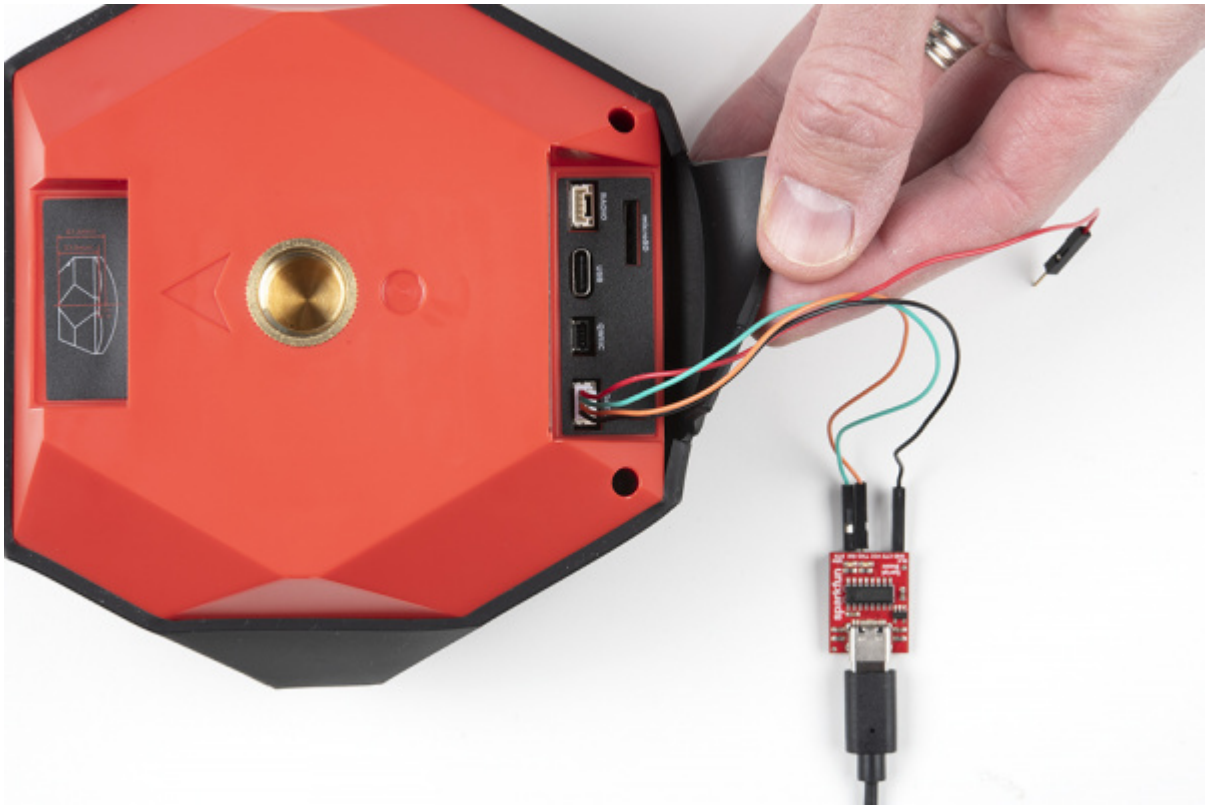
Torch:

For this example, we will connect the output from the **DATA** port of an RTK Facet to a USB to Serial adapter so that we can view the serial data over a terminal connection.

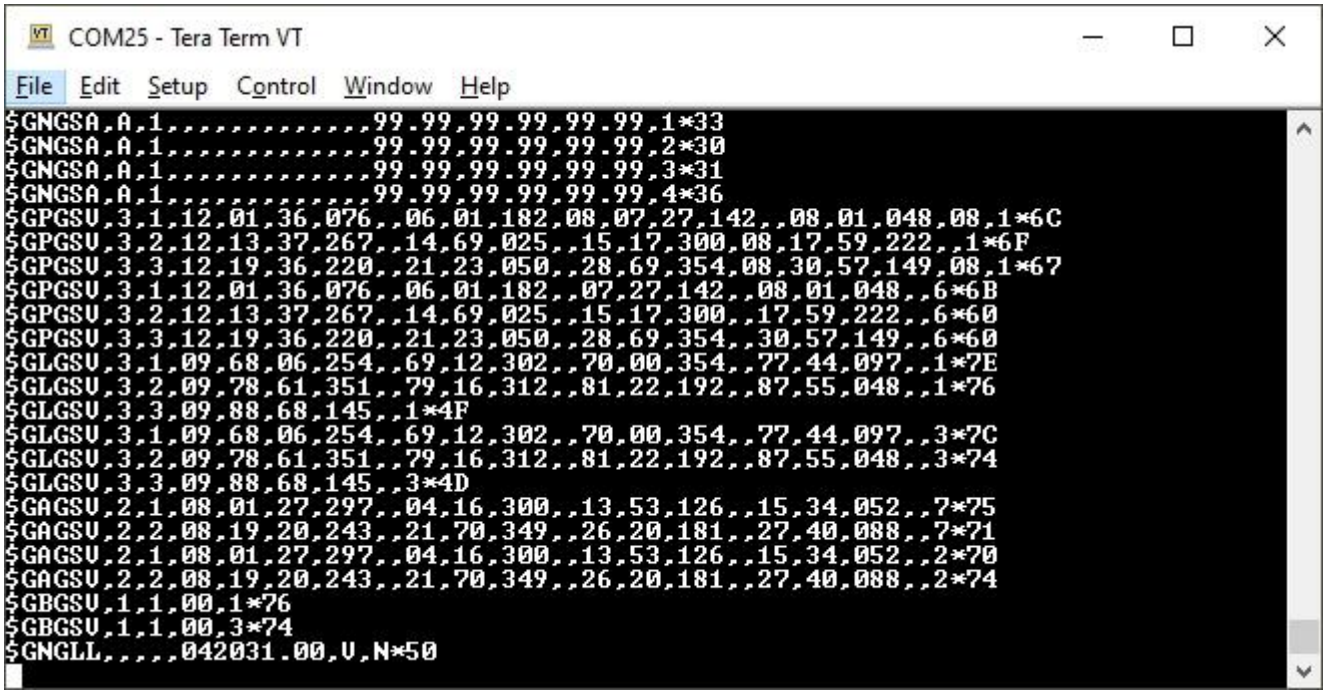
The **DATA** port on the RTK Facet can be configured to output a variety of different signals including NMEA Serial data. Be sure to check out the Ports Menu section to be sure your device is configured to output NMEA.

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:



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.

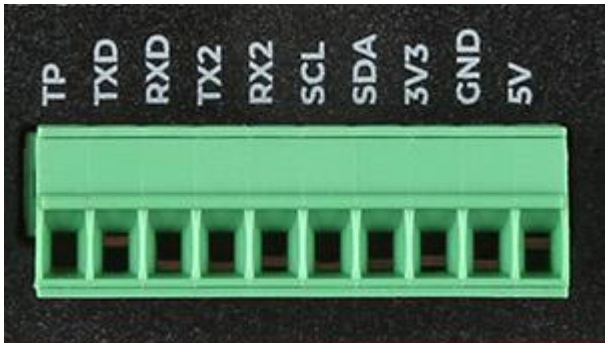
Warning! All data in and out of RTK products is **3.3V**. Exposing these pins to **5V** or higher voltage logic will damage the device.

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.

7.3.3 External Terminals

Torch: 

On devices that support it, external screw terminals provide direct access to the 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.

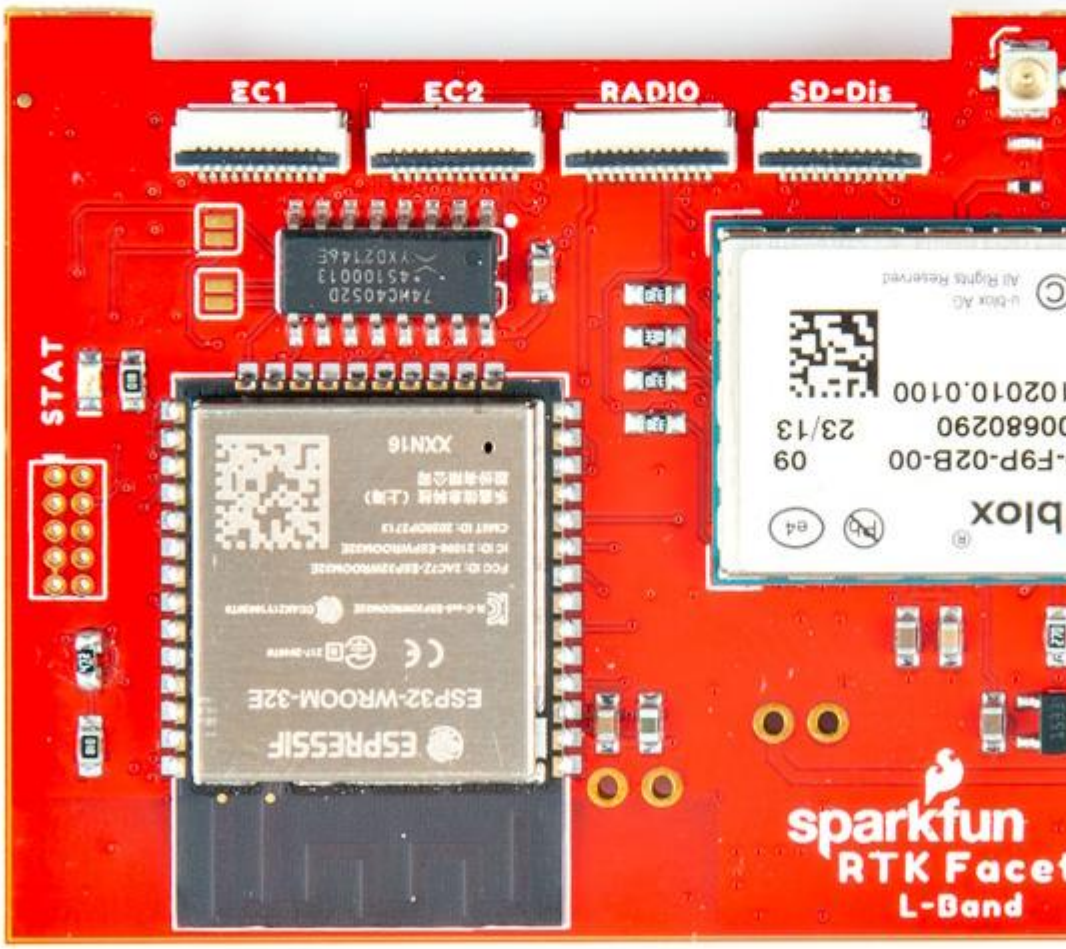
7.4 Disassembly / Repair

Torch: 

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 Torch.

Repair Parts:


UNITED STATES OF AMERICA
LIBERTY
QUARTER DOLLAR


EC1
EC2
RADIO
SD-Dis
STAT
ESP32-WROOM-32E
ESPRESSIF
sparkfun
RTK Face
L-Band