



# REACH M2/M+

## USER DOCUMENTATION

Firmware version **30**

Emlid Flow app version **8.1** or newer

June 15, 2023

# Table of contents

<b>1</b>	<b>Before you start</b>	<b>6</b>
1.1	First setup	6
1.1.1	Download Emlid Flow	6
1.1.2	Connect antenna	6
1.1.3	Power up Reach M2/M+	7
1.1.4	Connect to Reach M2/M+	7
1.1.5	Set up Wi-Fi connection	8
1.1.6	Update Reach Firmware	10
1.2	Connecting to Reach M2/M+	12
1.2.1	Setting up Wi-Fi connection	12
1.2.2	Connecting to Reach using Emlid Flow	12
1.3	Antenna placement	13
1.3.1	Clear sky view without obstacles	13
1.3.2	No electronics nearby	14
1.3.3	Ground plane	14
1.4	Hardware integration	15
1.4.1	Connecting UART radio	15
1.4.2	3DR Radio	15
1.4.3	RFD900 Radio	16
1.4.4	Connecting USB radio or LTE modem	16
1.4.5	Connecting LoRa radio	16
<b>2</b>	<b>Quickstart</b>	<b>18</b>
2.1	Connecting Reach to internet via Wi-Fi	18
2.1.1	Get access to Reach in Emlid Flow	18
2.1.2	Configure Wi-Fi connection settings in Emlid Flow	18
2.1.3	Access Reach in your Wi-Fi network	19
2.2	Connecting Reach to internet via mobile hotspot	20
2.2.1	Get access to Reach in Emlid Flow	20
2.2.2	Configure Wi-Fi connection settings in Emlid Flow	20
2.2.3	Access Reach in your Wi-Fi network	22
2.3	Working with NTRIP	22
2.3.1	Overview	22
2.3.2	Add NTRIP profile	22
2.3.3	Connect Reach M2/M+ to the internet	24
2.3.4	Configure Reach M2/M+ as rover	24
2.3.5	Provide Reach M2/M+ with clear sky view	26
2.3.6	How to log data for PPK UAV mapping	27
2.3.7	Configure logging on the rover	27
2.3.8	Configure logging on the base	30
2.3.9	Download logs	31
2.4	How to log data for PPP	32
2.4.1	Overview	32
2.4.2	Recording RINEX logs on Reach	32
2.4.3	Downloading logs	34
2.5	How to log data for OPUS	35
2.5.1	Overview	35
2.5.2	Recording RINEX logs on Reach	35

2.5.3	Downloading logs . . . . .	38
<b>3</b>	<b>Tutorials—Basics</b>	<b>39</b>
3.1	Single-band vs Multi-band . . . . .	39
3.1.1	Getting started . . . . .	39
3.1.2	What's the difference . . . . .	39
3.1.3	Which one to choose . . . . .	41
3.1.4	Conclusion . . . . .	41
3.2	How RTK works . . . . .	41
3.2.1	High real-time precision . . . . .	42
3.2.2	Corrections over NTRIP . . . . .	42
3.3	How PPK works . . . . .	42
3.3.1	Definitions and differences from RTK . . . . .	43
3.3.2	PPK for UAV mapping . . . . .	43
3.4	Placing the base . . . . .	44
3.4.1	Absolute and relative position . . . . .	45
3.4.2	Ways to set the base . . . . .	46
3.4.3	Manual . . . . .	47
3.4.4	Average . . . . .	48
3.4.5	Post-Processed Kinematics . . . . .	50
3.4.6	Precise Point Positioning . . . . .	50
3.4.7	Placing the base station in the field . . . . .	51
3.4.8	Placing Reach RS/RS+ . . . . .	51
3.4.9	Placing Reach RS2/RS2+ . . . . .	51
<b>4</b>	<b>Tutorials—PPK mapping with Reach</b>	<b>53</b>
4.1	Configuring Reach UAV kit for PPK mapping . . . . .	53
4.1.1	Overview . . . . .	53
4.1.2	Reach M2/M+ hardware setup . . . . .	53
4.1.3	Reach RS2/RS2+/RS+ base setup . . . . .	56
4.1.4	Configuring base and rover before flight . . . . .	57
4.1.5	Placing ground control points . . . . .	58
4.1.6	Survey flight . . . . .	59
4.2	Geotagging photos with Emlid Studio . . . . .	59
4.2.1	Overview . . . . .	59
4.2.2	Getting started . . . . .	59
4.2.3	Post-processing . . . . .	60
4.2.4	Geotagging . . . . .	62
4.3	Creating map in Pix4Dmapper . . . . .	64
4.3.1	Overview . . . . .	64
4.3.2	Create a new project . . . . .	64
4.3.3	Import GCPs . . . . .	66
4.3.4	Process data . . . . .	68
4.3.5	Get results . . . . .	69
<b>5</b>	<b>Tutorials—Integration with external software and devices</b>	<b>71</b>
5.1	Getting Reach coordinates on Android via BT . . . . .	71
5.1.1	Overview . . . . .	71
5.1.2	Pairing Reach with Android device . . . . .	71
5.1.3	Access Reach rover using Emlid Flow . . . . .	71
5.1.4	Access an Android device . . . . .	72

5.1.5	Position streaming from Reach to Android . . . . .	73
5.1.6	Android mock location . . . . .	74
5.2	ArduPilot integration . . . . .	77
5.2.1	Overview . . . . .	78
5.2.2	Recommended setup . . . . .	78
5.2.3	Connect Reach to Autopilot . . . . .	79
5.2.4	Configure Reach Module to work with ArduPilot . . . . .	80
5.2.5	Set up a correction link . . . . .	82
5.2.6	Configure Radio to embed corrections Into telemetry . . . . .	82
5.2.7	Configure ArduPilot to accept Reach Module solution . . . . .	82
5.2.8	Set up your base . . . . .	84
5.2.9	Configure mission planner to inject corrections into telemetry . . . . .	85
<b>6</b>	<b>Specifications</b>	<b>88</b>
6.1	Mechanical specs . . . . .	88
6.2	Dimensions . . . . .	88
6.3	Connectors mating parts . . . . .	88
6.4	Electrical specs . . . . .	89
6.4.1	Maximum ratings . . . . .	89
6.4.2	Connectors pinout . . . . .	89
6.5	USB OTG . . . . .	89
<b>7</b>	<b>LED status</b>	<b>90</b>
<b>8</b>	<b>Power supply</b>	<b>90</b>
8.1	Power supply over USB . . . . .	91
8.2	Powering using JST-GH ports . . . . .	92
<b>9</b>	<b>Troubleshooting</b>	<b>93</b>
9.1	How to update firmware . . . . .	93
9.1.1	Overview . . . . .	93
9.1.2	When to update your Reach . . . . .	93
9.1.3	Update firmware . . . . .	93
9.1.4	Roll back from Beta to stable . . . . .	95
9.2	Firmware reflashing . . . . .	95
9.2.1	Reach Firmware Flash Tool installation . . . . .	95
9.2.2	Windows installation . . . . .	96
9.2.3	Ubuntu installation . . . . .	96
9.2.4	macOS installation . . . . .	96
9.2.5	Reflash your Reach M2/M+ . . . . .	96
9.3	How to download Simple system report . . . . .	99
9.3.1	Overview . . . . .	99
9.3.2	Download Simple system report . . . . .	100
9.4	How to download Full system report . . . . .	100
9.4.1	Overview . . . . .	100
9.4.2	Download Full system report . . . . .	100
9.5	How to find serial number . . . . .	101
9.5.1	Overview . . . . .	101
9.5.2	Find serial number . . . . .	101
9.6	How to enable raw data debug option . . . . .	102
9.6.1	Overview . . . . .	102

9.6.2	Enable raw data debug option . . . . .	102
9.7	How to restore initial settings . . . . .	103
9.7.1	Overview . . . . .	103
9.7.2	Workflow . . . . .	103
<b>10</b>	<b>Glossary</b>	<b>106</b>

# 1 Before you start

## 1.1 First setup

In this tutorial, we will walk you through the following steps:

- Installing the Emlid Flow app
- Connecting and placing a GNSS antenna
- Connecting to Reach M2/M+
- Performing firmware update

To do that, you will need Reach itself, an external GNSS antenna, a Wi-Fi network with internet access and a smartphone or tablet.

### 1.1.1 Download Emlid Flow

To manage Reach M2/M+, download the Emlid Flow app on your mobile device [iOS](#) or [Android](#) mobile device.



Download Emlid Flow

**Using Reach with Andoid devices:** *Some Android devices have the Battery optimization setting enabled by default. Make sure you disabled it for Emlid Flow to avoid disconnection.*

### 1.1.2 Connect antenna

To connect the antenna to Reach, follow the steps below:

#### For Reach M2

Plug the antenna cable into MCX socket on Reach M2.

#### For Reach M+

Plug the antenna cable into MCX socket on Reach M+. Place the antenna on the ground plane. It could be a cut piece of metal more than 100 mm in diameter, roof of a car, or metal roof of a building.

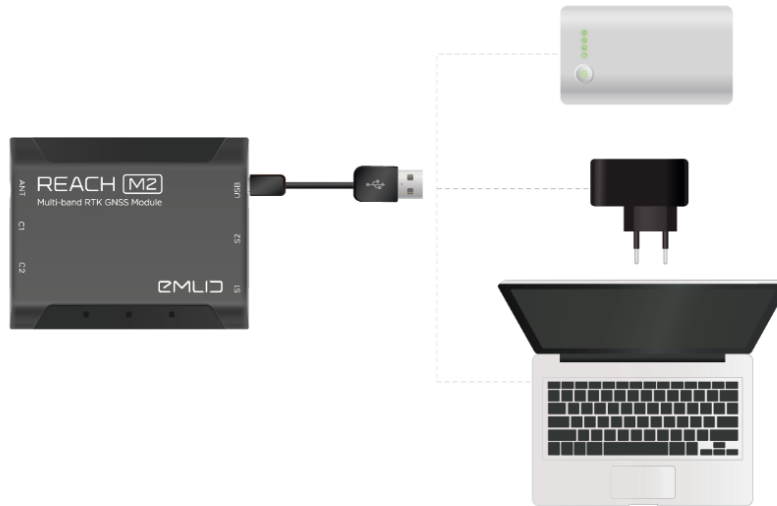
**Caution:** *There should be no obstacles near the antenna that could block the sky view higher than 30 degrees above the horizon. Do not test the device indoors or near buildings. Do not cover the sky view for the antennas with laptops, cars or yourself. RTK requires good satellite visibility and reception.*

**Tip:** *To learn how to properly place the antenna, check the [Antenna placement guide](#).*

### 1.1.3 Power up Reach M2/M+

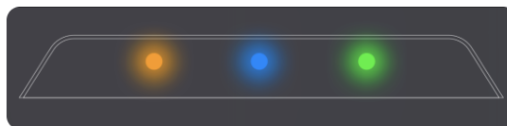
To power up your Reach, follow the steps below:

1. Take a Micro-USB to USB cable that comes with the package.
2. Plug the Micro-USB end of the cable into the Micro-USB port on Reach and plug another end into a 5 V power source such as a USB power bank, USB wall adapter or USB port of a computer.



**Caution:** Do not plug two power supplies at the same time as it may damage the device.

After the device is powered up, the Network LED will be blinking for about 30 seconds and then become solid. Reach is now broadcasting Wi-Fi.



*Tip: You can read more about power supply in the Power supply guide.*

### 1.1.4 Connect to Reach M2/M+

**Using Reach with Android device:** Turn off the mobile data on your device before connecting to Reach's hotspot.

To connect to your Reach, follow the steps below:

- Open a list of Wi-Fi networks on your smartphone or tablet.
- Connect to a network named **reach:xx:xx**.
- Type network password: **emlidreach**.

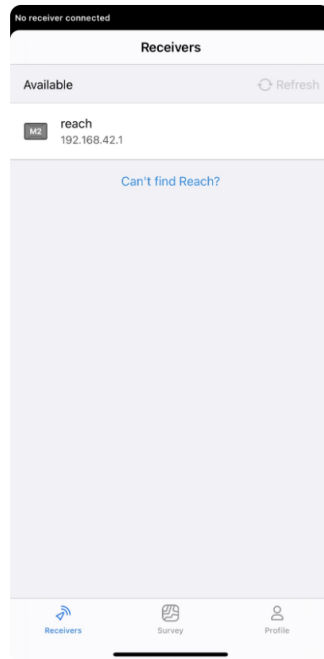
Once you successfully connected to Reach's hotspot, you can go to Emlid Flow and set up connection to your Wi-Fi network.

### 1.1.5 Set up Wi-Fi connection

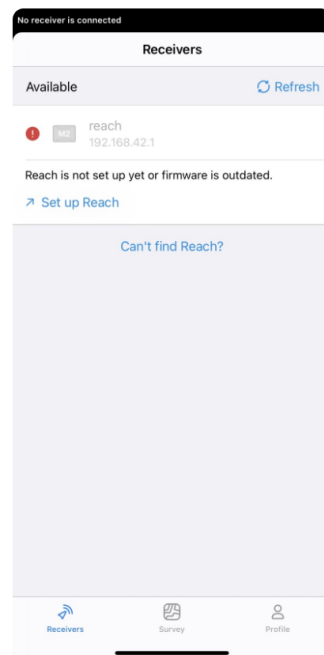
**Note:** Make sure that your Wi-Fi network uses 2.4 GHz band.

To connect Reach to your Wi-Fi network, follow the steps below:

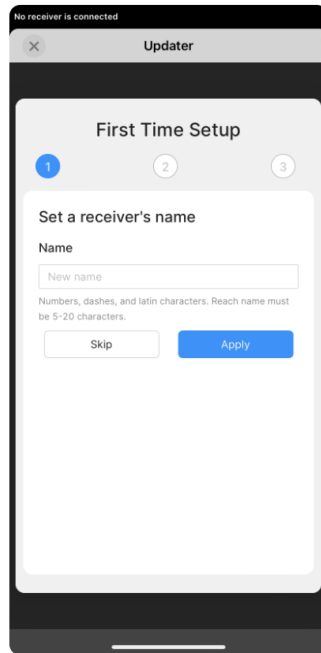
1. Open Emlid Flow and choose your Reach from the list.



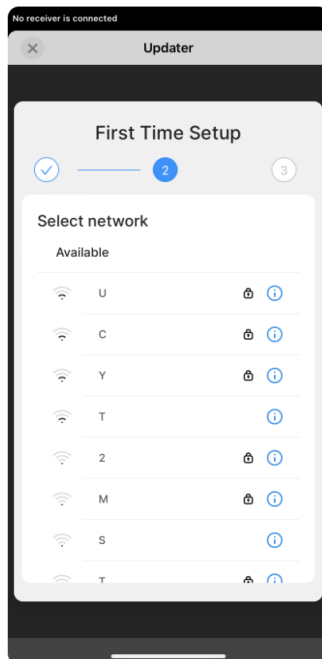
2. Tap the *Set up Reach* button to open Updater for further setup process.



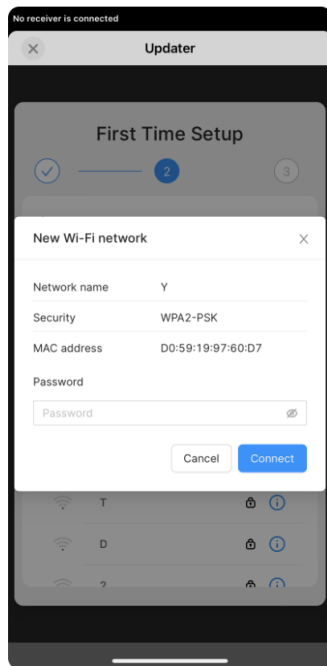
3. Name your Reach and apply changes.



4. Select your Wi-Fi network from the list of available networks.



5. Enter the password and tap *Connect*.



Reach M2/M+ will stop broadcasting Wi-Fi and connect to your network. The Network LED will blink rapidly while scanning for networks. Once Reach connects to Wi-Fi, the LED will start blinking slowly.

When the connection of Reach with the Wi-Fi network is established, you can connect to your unit using Emlid Flow:

1. Connect your smartphone or tablet to the same Wi-Fi network.
2. Open the Emlid Flow app.
3. Choose your Reach from the list of available devices.

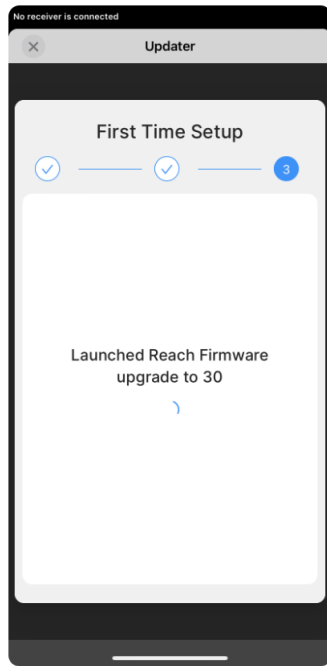
**Note:** *If there is only one receiver, the app will automatically try to connect to this Reach.*

**Tip:** *If your device did not connect to your Wi-Fi network, it will switch back to hotspot mode. In that case, repeat the steps and double-check the network name and password.*

### 1.1.6 Update Reach Firmware

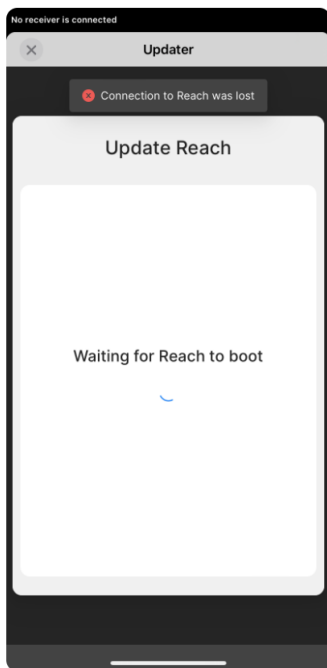
After connecting to Reach M2/M+, the app will check available firmware updates. Follow the steps below to get the latest update:

1. Wait until Emlid Flow checks for the latest update. If there is an update available, it will start the updating process.



**Note:** *The process may take a few minutes.*

2. When the update is complete, wait until your Reach reboots.



3. Wait for the Network LED to stop blinking, showing that Reach M2/M+ has joined your Wi-Fi network again. Close the Updater page.
4. Refresh the list of available devices.
5. Choose your Reach from the list of available devices.

**Note:** *If there is only one receiver, the app will automatically try to connect to this Reach.*

Your Reach M2/M+ is ready for work. Do the same with all other units.

## 1.2 Connecting to Reach M2/M+

Emlid Flow allows controlling Reach receivers with iOS or Android devices. Using the app, you can access your receiver over Wi-Fi network, set it up for the survey, and collect and stake out points.

In this guide, you will find information on how to connect to your Reach RS2/RS2+ using the Emlid Flow app.

**Note:** *The connection process for both iOS and Android devices is similar.*

### 1.2.1 Setting up Wi-Fi connection

Establish Wi-Fi connection between your Reach and your device.

1. Power up the unit and wait until it is loaded.
2. Look at the Network LED of the receiver to check the mode:

#### Hotspot mode

When Reach is in hotspot mode, it shares its own network, and its Network LED is blue. In this case, perform the following steps:

1. Open Wi-Fi settings of your device and turn on Wi-Fi.
2. Find a network with the name **reach:XX:XX**.
3. Type the password **emlidreach** to connect to this network.
4. Wait until it shows that you are successfully connected to the network.

#### Client mode

When Reach is in client mode, it is connected to the external Wi-Fi network, and its Network LED is blinking slowly. In this case, perform the following steps:

1. Open Wi-Fi settings of your device.
2. Connect it to the same Wi-Fi network.
3. Wait until it shows that you are successfully connected to the network.

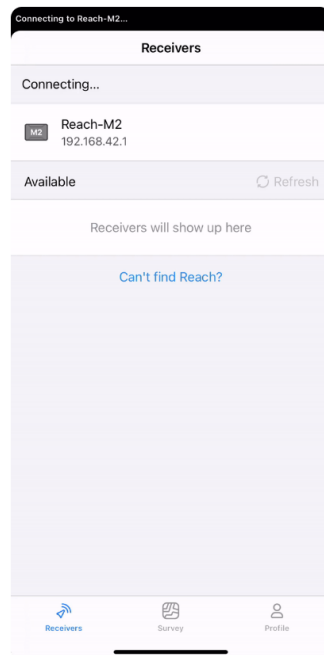
### 1.2.2 Connecting to Reach using Emlid Flow

When the Wi-Fi connection is established, you can connect to your unit using Emlid Flow.

1. Open the app.
2. Choose your unit from the list of available devices.

**Note:** *If there is only one receiver, the app will automatically try to connect to this Reach.*

**Tip:** *When you connect to your Reach, all LEDs will blink simultaneously.*



Once you connect to your Reach RS2/RS2+ via Emlid Flow, you can access the settings and set it up for the survey.

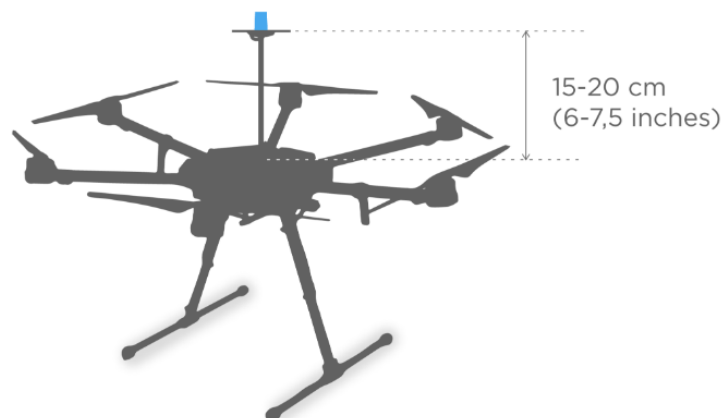
## 1.3 Antenna placement

**Tip:** *A well-placed antenna is essential for achieving good RTK positioning results.*

You can place your smartphone near the window in your house and it will obtain GNSS coordinates after some time, but for RTK such environment will not be sufficient. For RTK to work there are special requirements for antenna placement.

### 1.3.1 Clear sky view without obstacles

An antenna needs to have a clear sky view 30 degrees above the horizon. There should be no obstacles that could block the view like buildings, trees, cars, humans, laptops, etc.



Examples of **good** environments for antenna placement:

- field
- top of the hill
- rooftop

Examples of **bad** environments for antenna placement:

- indoors
- urban areas
- forest
- close to the ground

### 1.3.2 No electronics nearby

Electronic devices may produce RF noise that could affect the reception of the GNSS signal. Keep all electronics (including the Reach itself) as far as possible from the antenna.

### 1.3.3 Ground plane

#### For Reach M2

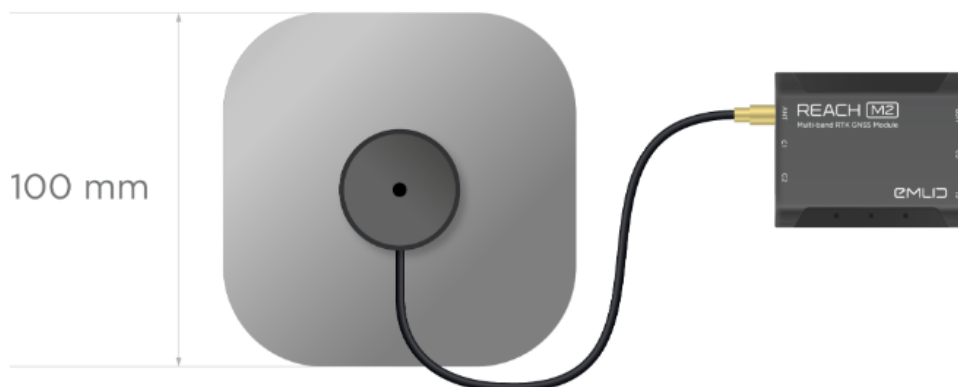
Helical antennas do not require ground planes. They are robust and demonstrate good performance.

Still, a ground plane can improve observation quality significantly. In some cases, it might be reasonable to mount a helical antenna on a ground plane for safety redundancy.

#### For Reach M+

An antenna has to be placed on a ground plane which reduces multipath, provides shielding and improves signal reception. A ground plane is a conductive plate, it may be a piece of metal, a roof of a car, a metal roof of a building, etc.

Tallysman TW4721 requires ground plane no less than 70x70 mm (3x3 inches).



## 1.4 Hardware integration

Reach supports various accessories via its built-in USB OTG port and UART interface on the JST-GH connectors. It is possible to connect radio modules to Reach in order to obtain corrections or send calculated coordinates. Most radios nowadays use UART or USB as a connection.

### 1.4.1 Connecting UART radio

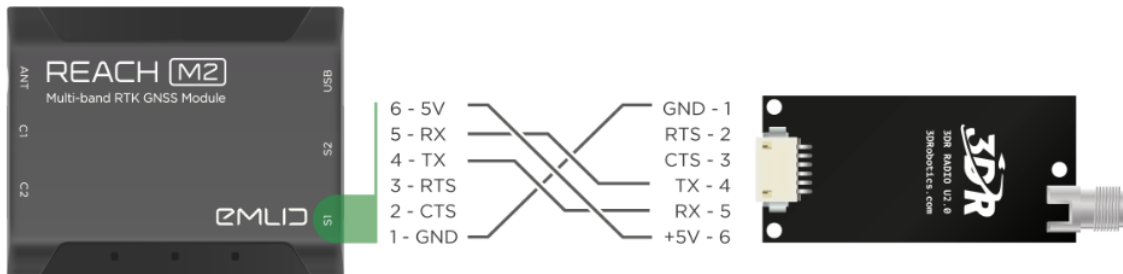
Logic level on UART in Reach is 3.3V but pins are 5V tolerant, so you can use both 3.3V and 5V logic level radios.

UART radio is accessible on Reach as a serial device with the name **ttyMFD2**.

To connect UART radio to Reach use lower JST-GH port (S1).

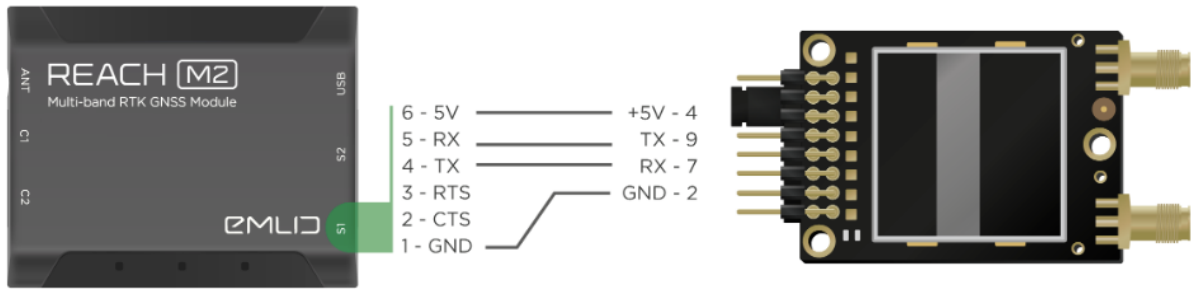
Reach pins	Radio pins
+5 V	+5V
TX	RX
RX	TX
GND	GND

### 1.4.2 3DR Radio



3DR Radio can also be connected over USB.

### 1.4.3 RFD900 Radio



**Caution:** Please mind that RFD can consume up to 800 mA in peaks so make sure that your power source can provide enough power for both Reach and RFD900.

### 1.4.4 Connecting USB radio or LTE modem

**Note:** Make sure the LTE modem you use is compatible with Linux OS.

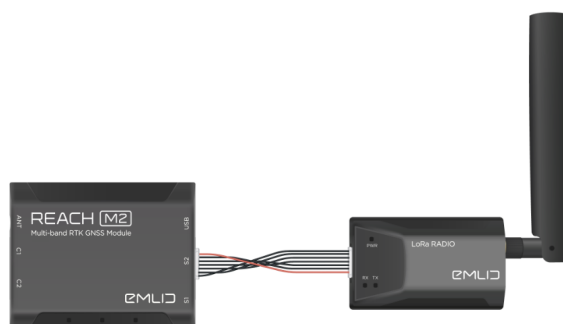


To connect USB radio or LTE-modem to Reach use USB-OTG cable provided with the package. Plug radio into USB-F port and plug Micro-USB end of the cable in Reach.

**Note:** When using USB port in OTG mode, Reach has to be powered over one of the JST-GH ports.

**Connecting LTE modem:** Make sure that Reach is in hotspot mode, and an LTE modem is preconfigured to connect to the internet automatically after powering.

### 1.4.5 Connecting LoRa radio



To connect LoRa radio to Reach use upper JST-GH port (S2).

## 2 Quickstart

### 2.1 Connecting Reach to internet via Wi-Fi

This guide shows how to connect Reach to the internet via your local Wi-Fi network to update the device to the latest firmware or get the corrections from your NTRIP service.

#### 2.1.1 Get access to Reach in Emlid Flow

**Android device:** *Turn off the mobile data before connecting to Reach's hotspot.*

To establish the connection between your mobile device and Reach, follow the steps below:

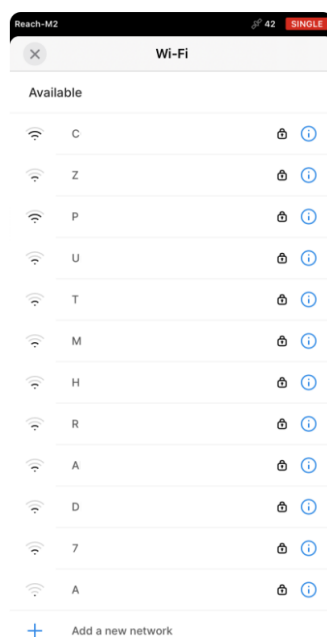
1. Download the app from [Google Play](#) or [App Store](#).
2. Go to *Wi-Fi settings* on your device.
3. Connect to Reach hotspot. It appears as **reach:XX:XX**.
4. Enter password **emlidreach**.
5. Launch the Emlid Flow app.
6. Choose Reach from the list of available devices.

#### 2.1.2 Configure Wi-Fi connection settings in Emlid Flow

**Caution:** *Make sure that your Wi-Fi network uses 2.4 GHz band.*

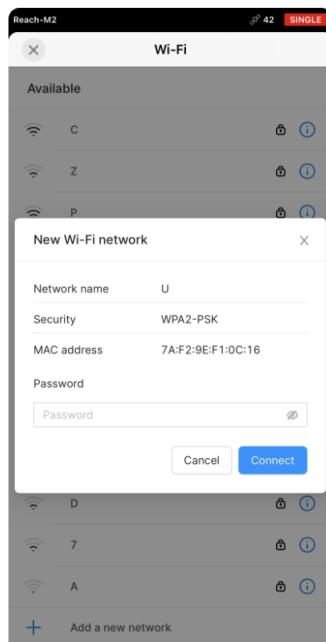
After connecting to the Reach hotspot in Emlid Flow, set up the connection to your local Wi-Fi network:

1. On the *Receivers* screen, tap *Wi-Fi*.
2. Choose your Wi-Fi network from the list.



3. Fill in the password for the selected network.

**Double-check the password:** *You can unmask the password by tapping an eye symbol at the end of the password field.*



4. Check the connection status after the blue LED stops blinking:

- The Network LED starts blinking slowly. It means that Reach is connected to your Wi-Fi network.
- The Network LED is solid. It means that the connection to your Wi-Fi network failed. Reach returned to the hotspot mode.

**Failed connection:** *If the connection to your Wi-Fi network failed, do the following:*

- Check the entered password.
- Check that your network is configured correctly.
- Try connecting to another Wi-Fi network.

### 2.1.3 Access Reach in your Wi-Fi network

After configuring Wi-Fi connection settings in Emlid Flow, connect your smartphone or tablet to Reach:

1. Connect your smartphone or tablet to the same Wi-Fi network as Reach.
2. Go back to Emlid Flow.
3. Refresh the list of available devices.
4. Choose Reach from the list.

Now Reach is connected to your Wi-Fi network and ready for work.

## 2.2 Connecting Reach to internet via mobile hotspot

This guide shows how to connect Reach to the internet via your control device's hotspot to update it to the latest firmware or get the corrections from your NTRIP service.

### 2.2.1 Get access to Reach in Emlid Flow

**Android device:** *Turn off the mobile data before connecting to Reach's hotspot.*

To establish the connection between your mobile device and Reach, follow the steps below:

1. Download the app from [Google Play](#) or [App Store](#).
2. Go to *Wi-Fi settings* on your device.
3. Connect to Reach hotspot. It appears as **reach:XX:XX**.
4. Enter password **emlidreach**.
5. Launch the Emlid Flow app.
6. Choose Reach from the list of available devices.
7. Configure Wi-Fi connection settings in Emlid Flow

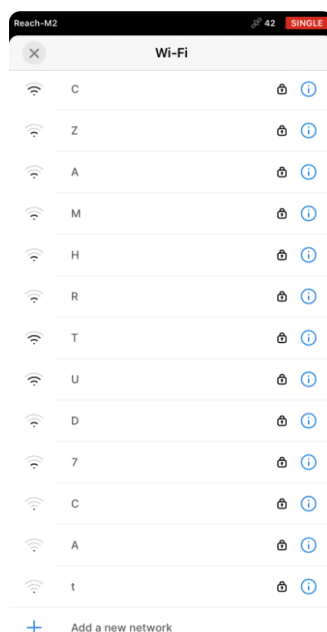
### 2.2.2 Configure Wi-Fi connection settings in Emlid Flow

After connecting to the Reach hotspot in Emlid Flow, set up the connection to your mobile device hotspot:

**Note:** *Check that your device's mobile hotspot is disabled to ensure a successful connection.*

1. On the *Receivers* screen, tap *Wi-Fi*.
2. Tap *Add a new network*. As your device's mobile hotspot has been temporarily disabled, this network is not visible.

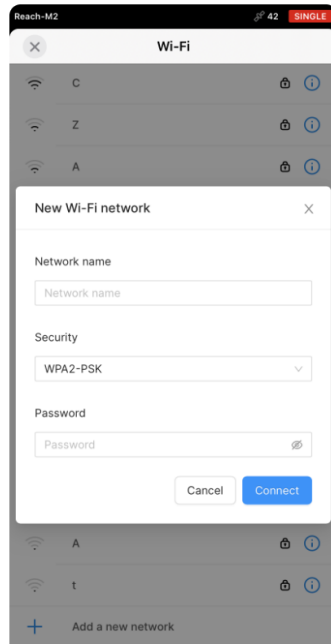
**Caution:** *Make sure that there are no available saved networks to ensure successful connection.*



3. Fill in the credentials of your device's hotspot:

- Type the network name.
- Choose a security type.
- Add a password if you have it.

**Double-check the password:** *You can unmask the password by tapping an eye symbol at the end of the password field.*



4. Press the *Connect* button. The Network LED will start blinking—it means that Reach is trying to connect to your device's hotspot.

But since it is off, Reach will start sharing its hotspot again.

5. To detect your device's hotspot and connect to it, you need to reboot Reach. Plug out the cable from the power source to power your Reach off and then plug it in again.

**Rebooting Reach using Emlid Flow:** *Alternatively, you can reboot your Reach using Emlid Flow. Connect your device to the Reach hotspot again. Then open Emlid Flow and refresh the list of devices to connect to your Reach. After that, tap the name of your Reach and restart it. Finally, proceed to step 6.*

6. Enable the mobile hotspot on your mobile device.

**iOS device:** *To ensure successful connection, pay attention to the following:*

- Make sure that your iOS device is not connected to any other Wi-Fi networks. iOS hotspot may drop once your iOS device finds an available Wi-Fi network and connects to it.
- Starting with the iPhone 12 series, enable the Maximize compatibility option on its Personal hotspot page. This will switch its hotspot to 2.4 GHz and ensure connection to Reach.
- Keep the Personal Hotspot page on the iOS device open while the Reach is loading.

7. When Reach reboots, check the connection status:

**iOS device:** *If the connection to the device's hotspot is successful, you will see the blue notification at the top left corner of the screen.*

- The Network LED starts blinking slowly: it means that Reach is connected to your mobile hotspot.
- The Network LED is solid: it means that the connection to your mobile hotspot failed and Reach returned to the hotspot mode.

**Failed connection:** *If the connection to your device's hotspot failed, do the following:*

- Check the entered password.
- Check that your network is configured correctly.
- Try connecting to another Wi-Fi network.

### 2.2.3 Access Reach in your Wi-Fi network

When your Reach is connected to your mobile hotspot, access it following the steps below:

1. Open Emlid Flow.
2. Refresh the list of available devices.
3. Choose Reach from the list.

Now Reach is connected to your mobile hotspot and ready for work.

## 2.3 Working with NTRIP

This guide explains how to configure your Reach M2/M+ to receive RTK corrections from an NTRIP service via the internet.

### 2.3.1 Overview

An NTRIP service allows you to configure RTK using only one GNSS receiver acting as a rover. With the help of an NTRIP protocol, the service allows your rover to receive corrections from the nearest third-party base, a continuously operating reference station (CORS). This way, there is no need for you to have your own local base.

**Note:** *In order to access NTRIP services, you need to register and get a subscription. The cost and coverage area depends on your NTRIP service provider.*

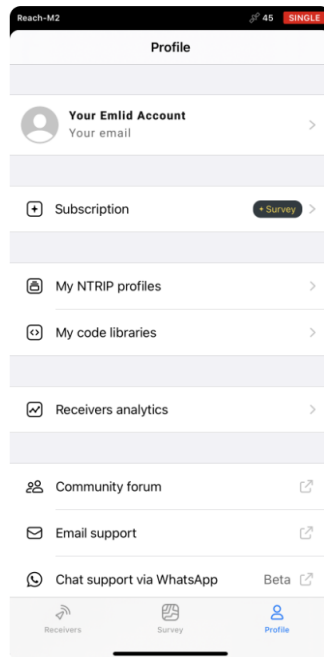
### 2.3.2 Add NTRIP profile

**Tip:** *You can configure an NTRIP connection on your Reach before the survey. However, to make sure it receives RTK corrections, you need to provide it with a clear sky view.*

To configure your Reach to receive RTK corrections from an NTRIP service via the internet, follow the steps below.

Emlid Flow allows you to add an NTRIP profile which you can use later. To add an NTRIP profile, do the following:

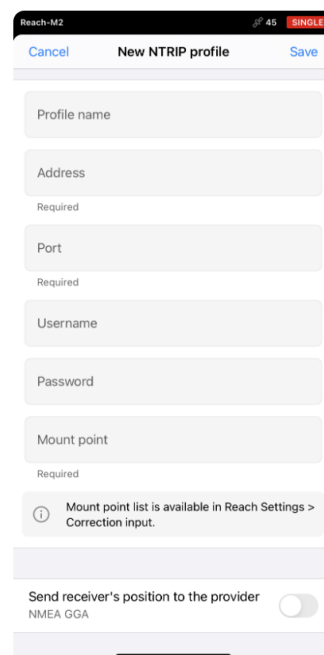
1. Go to the *Profile* tab and tap *My NTRIP profiles*.



2. Add the profile and fill in the information from your NTRIP provider.

**Tip:** To find out which mount point suits you better, check the website of your NTRIP provider. The closer the mount point, the more precise your solution will be.

**Android keyboard tech tip:** On some Android devices, default keyboards do not provide a minus sign. To get access to it, we recommend downloading Gboard, a virtual keyboard app, from the Google Play Store.



**Note:** If you are using a VRS service, you need to enable *Send receiver's position to the provider*.

3. Save the profile.

**Tip:** *If you've already connected to the receiver, the app will offer you to apply the profile for correction input.*

From now, you can use the profile to set up correction input via NTRIP.

### **2.3.3 Connect Reach M2/M+ to the internet**

To get NTRIP corrections, connect your Reach to the internet via your control device's hotspot or built-in cellular modem.

**Tip:** *To learn more about connecting your Reach M2/M+ to the internet, check the following guides:*

- [Connecting Reach to internet via Wi-Fi](#)
- [Connecting Reach to internet via mobile hotspot](#)

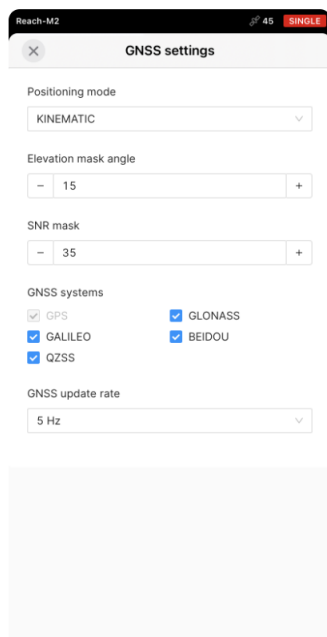
### **2.3.4 Configure Reach M2/M+ as rover**

To set up your Reach as a rover for RTK mode with NTRIP, you need to configure GNSS settings and correction input in Emlid Flow. First, configure GNSS settings following the steps below:

1. Open Emlid Flow and connect to your receiver.
2. Go to *Settings* and tap *GNSS settings*. Make sure you have the following settings:

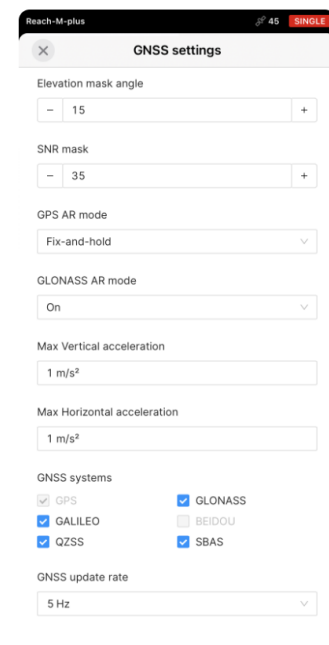
## For Reach M2

- The positioning mode is set to Kinematic.
- The elevation mask angle is set at 15 degrees.
- The SNR mask angle is set at 35 degrees.
- All satellites systems are selected.
- The GNSS update rate is set at 5Hz.



## For Reach M+

- The positioning mode is set to Kinematic.
- GPS Ambiguity resolution mode is set to Fix-and-hold.
- GLONASS Ambiguity resolution mode is set to ON.
- The elevation mask angle is set at 15 degrees.
- The SNR mask angle is set at 35 degrees.
- Each of the possible satellite systems is selected. Choose between GLONASS and BeiDou depending on your location. While GLONASS covers most of the world, BeiDou might be more efficient in the Asia-Pacific region.
- The GNSS update rate is set at 5Hz.

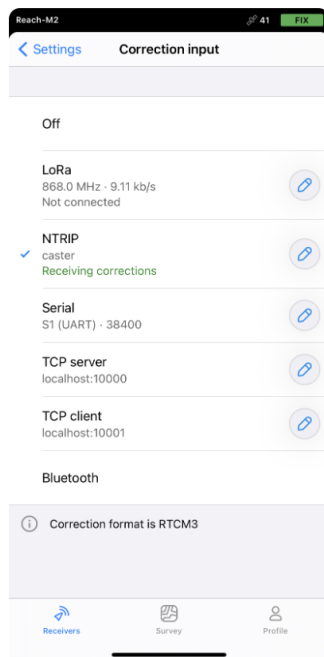


3. Tap *Apply*.

After configuring GNSS settings, set up the correction input as follows:

1. Go to the *Correction input* screen.
2. Select *NTRIP*.
3. Choose the profile you saved.

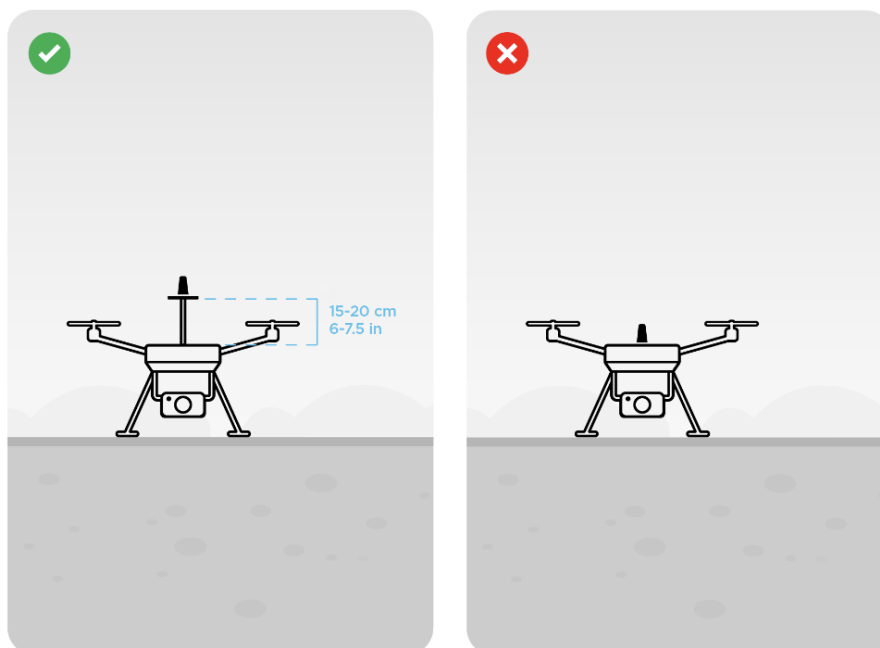
**Note:** *If you've already applied the NTRIP profile, you can skip this step.*



If everything is configured correctly, you will see the "Receiving corrections" notification in the NTRIP cell. Now you're ready for the survey in the field.

### 2.3.5 Provide Reach M2/M+ with clear sky view

Before surveying, make sure your Reach has a clear sky view of at least 30 degrees above the horizon. There should be no obstacles that could block the view like buildings, trees, cars, humans, laptops, etc.



**Tip:** Learn more about Reach setup in the [Antenna placement guide](#).

### 2.3.6 How to log data for PPK UAV mapping

This guide shows how to record logs for PPK UAV Mapping and download them from UAV mapping kits using Emlid Flow.

With PPK workflow, accurate positioning does not happen in real time, all algorithms are applied afterward. Both base on the ground and rover on a UAV record raw GNSS logs which will be further used for post-processing of the data set, geotagging of the resulting photos, and mapping in the photogrammetric software.

**Note:** *To record time marks in the raw data log, you should ensure smooth synchronization of Reach and a camera. We recommend using the Reach M2/M+ hot shoe adapter.*

**Tip: To learn more about PPK mapping, check the following articles:**

- [\*How PPK works\*](#)
- [\*Configuring Reach UAV kit for PPK mapping\*](#)

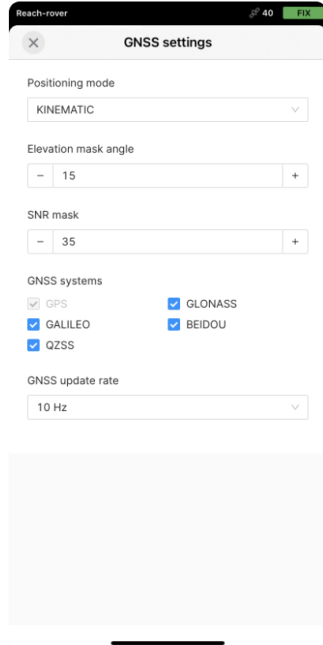
### 2.3.7 Configure logging on the rover

To configure logging on your Reach M2/M+ rover, follow the steps below:

1. Open Emlid Flow and connect to your Reach.
2. On the *Receivers* screen, tap *Settings*.
3. Go to *GNSS Settings* and set the satellite systems and update rate according to the following requirements:

## For Reach M2

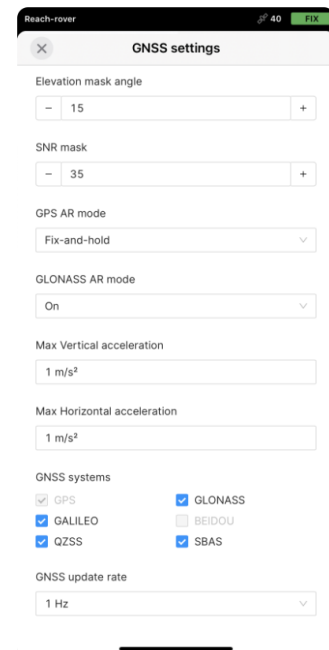
Select the satellite systems and set the update rate at 10 Hz. **Note:** *Reach M2 tracks GPS, GLONASS, Galileo, QZSS, and BeiDou satellite systems.*



## For Reach M+

Select the satellite systems and set the GNSS update rate as follows:

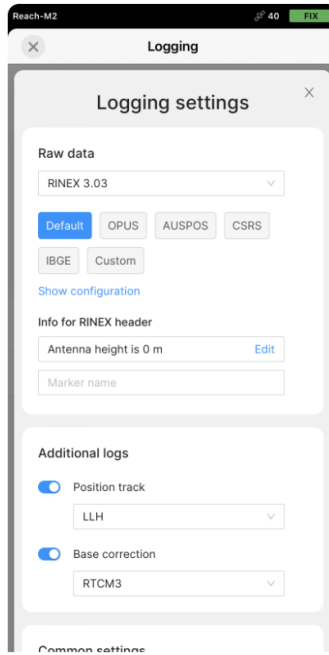
GNSS Selection	Reach M+ allowed update rates
GPS + GLONASS + GALILEO + SBAS + QZSS	1 Hz
GPS + GLONASS + QZSS	5 Hz
GPS + GALILEO	5 Hz
GPS	10 Hz



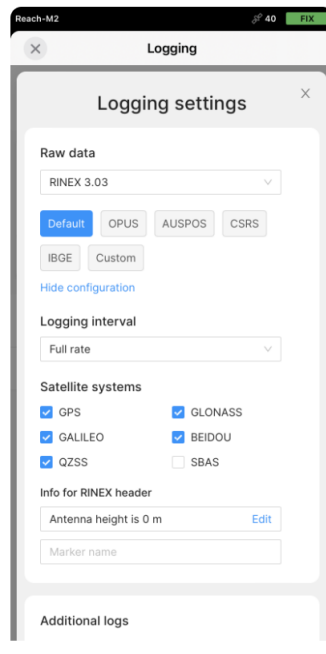
4. Go back to the *Receivers* screen and tap *Logging*.
5. To configure logging, tap the *Settings* button.
6. Choose the required RINEX format in the *Raw data* section.

**Note:** *If you do not know which version of RINEX you need, we recommend using RINEX 3.03.*

**Tip:** *While recording in the RINEX format, you can log the UBX file as a backup. UBX file can be used to adjust RINEX file settings in the Converter tool in Emlid Studio. You can enable logging in the UBX format in the logging settings in Emlid Flow.*



7. Tap *Show configuration* and select the same satellite systems as in GNSS Settings.
8. Set the logging interval at *Full rate*.



9. Do not use antenna height.

**Note:** We recommend leaving the antenna height at 0. Usually, photogrammetric software has the feature of calculating the antenna offset (camera center position relative to the antenna position).

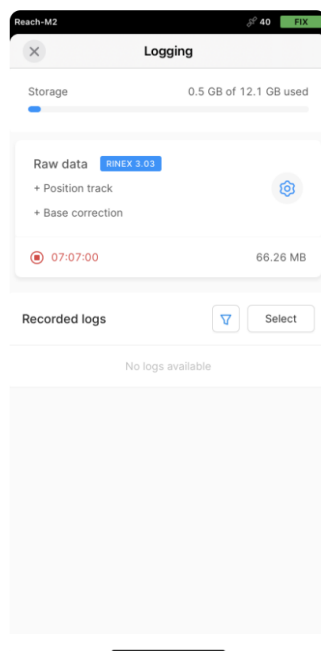
10. Leave the *Marker name* field empty.
11. Tap *Apply and start*.

12. Enable log recording by tapping the *Start recording button*.

*Tip: You can start recording automatically when your receiver is turned on. Tick the corresponding field in the settings.*

13. To finish recording logs, tap the *End recording button*.

**Caution: Wait for data processing to finish.**



14. Turn off the receiver by using the button.

**Caution:** *Before pulling out the cable from a power source, wait for at least 15 seconds for the system to shut down properly.*

### 2.3.8 Configure logging on the base

To configure logging on your Reach base, follow the steps below:

1. Go to *GNSS settings*, select the same satellite systems as for Reach M2/M+ and set the update rate at 1 Hz.
2. Go to the *Logging* screen in Emlid Flow.
3. To configure logging, tap the *Settings* button.
4. Choose the required RINEX format in the *Raw data* section.

**Note:** *If you do not know which version of RINEX you need, we recommend using RINEX 3.03.*

**Tip:** *While recording in the RINEX format, you can log the UBX file as a backup. UBX file can be used to adjust RINEX file settings in the Converter tool in Emlid Studio. You can enable logging in the UBX format in the logging settings in Emlid Flow.*

5. Tap *Show configuration* and select the same satellite systems as in *GNSS Settings*.
6. Set the logging interval at *Full rate*.

7. Enter the measured height to the bottom of the receiver.
8. Leave the *Marker name* field empty.
9. Tap *Apply and start*.

10. Enable log recording by tapping the *Start recording* button.

**Tip:** You can start recording automatically when your receiver is turned on. Tick the corresponding field in the settings.

11. To finish recording logs, tap the *End recording* button.

*Caution:* Wait for data processing to finish.

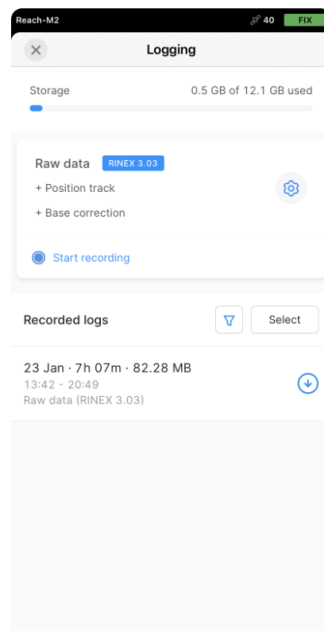
12. Turn off the receiver using the button.

*Caution:* Before pulling out the cable from a power source, wait for at least 15 seconds for the system to shut down properly.

### 2.3.9 Download logs

After you finish raw data logging, you need to download RINEX data from Reach to your mobile device.

1. Go to the Logs section at the bottom of the Logging screen.



**Note:** You can also find information on the logs size and recording date and time here.

2. To export the file, tap the *Download* button.
3. Save your log depending on the device you use.

**Tip:** If you do not need your logs anymore, you can delete them using the *Select* button.

When the logs are downloaded, you can start working with your data in Emlid Studio.

## 2.4 How to log data for PPP

This guide shows how to record logs for the Precise Point Positioning services and download them from Reach M2/M+ using Emlid Flow.

### 2.4.1 Overview

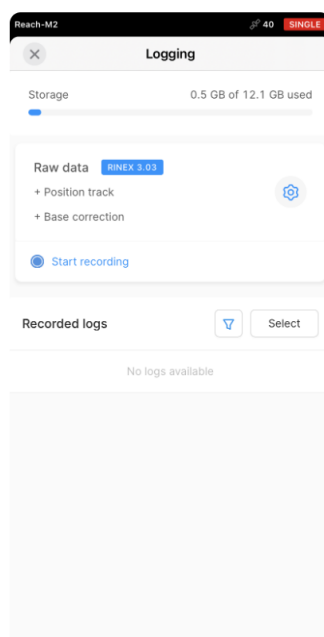
Precise Point Positioning or simply PPP is a technique that requires processing a raw data log from the standalone receiver for further removing or modeling GNSS system errors to provide a high level of position accuracy.

**Tip:** To learn more about PPP, check the [How PPP works](#) article.

### 2.4.2 Recording RINEX logs on Reach

To record logs for PPP, perform the following steps:

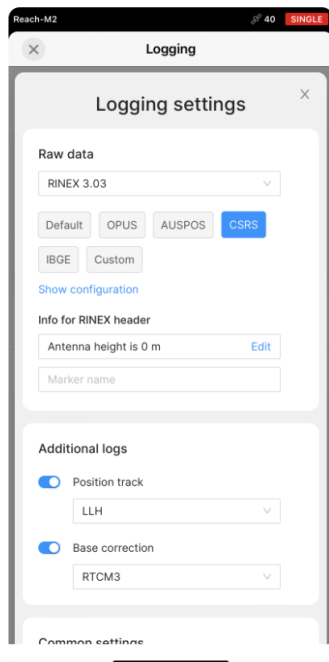
1. Open Emlid Flow and connect to your Reach.
2. Go to the *Logging* screen.



3. On the *Receivers* screen, tap *Settings*.
4. Select the preset depending on the PPP service you choose.

## For Reach M2

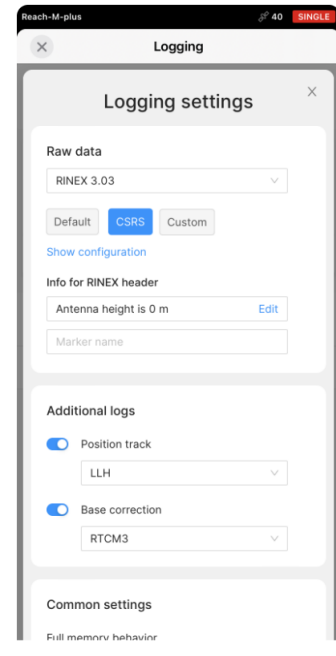
All the PPP services can process logs from Reach M2.



## For Reach M+

Only NRCAN CSRS-PPP and IBGE-PPP services can process logs from Reach M+.

**Note:** With Reach M+ you will get an accuracy of about 30 cm.



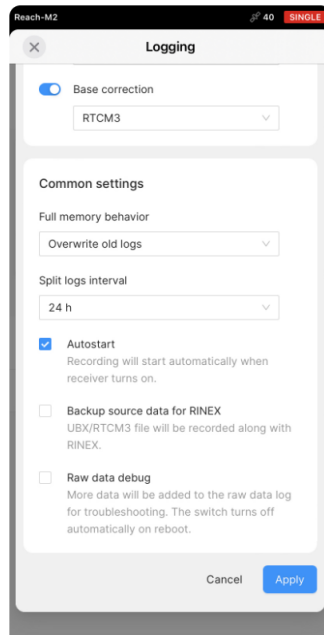
5. Choose the required RINEX format in the *Raw data* section.

**Note:** If you do not know which version of RINEX you need, we recommend using RINEX 3.03. However, make sure the PPP service you choose supports this version of RINEX.

**Tip:** While recording in the RINEX format, you can log the UBX file as a backup. UBX file can be used to adjust RINEX file settings in the Converter tool in Emlid Studio. You can enable logging in the UBX format in the logging settings in Emlid Flow.

6. Tap *Show configuration* and enter the measured height to the bottom of the receiver in the corresponding field.
7. Fill in the point's name in the *Marker name* field.
8. Tap *Apply and start*.

**Tip:** You can start recording automatically when your receiver is turned on. Check the corresponding field on the *Raw data* settings screen.



9. Enable log recording by tapping the *Start recording* button.

**Note:** PPP services requires recording the data for at least 4 hours to get the best accuracy.

10. To finish recording logs, tap the *End recording* button.

**Caution:** Wait for data processing to finish.

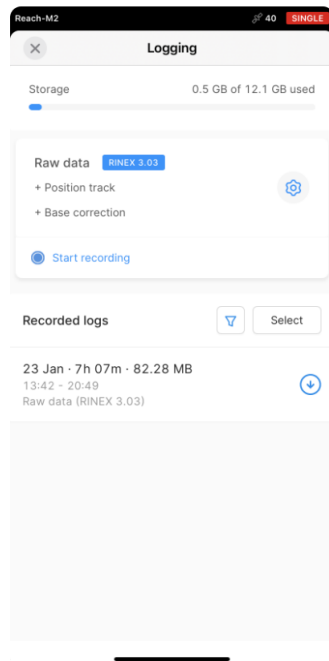
**Tip:** You may log the data for up to 24 hours, depending on the accuracy required.

Once you finish the survey, don't forget to turn off raw data recording in the logging settings.

### 2.4.3 Downloading logs

After you finish raw data logging, you need to download RINEX data from Reach to your mobile device.

1. Go to the *Logs* section at the bottom of the *Logging* screen.



**Note:** You can also find information on the logs size and recording date and time here.

2. To export the file, tap the *Download* button.
3. Save your log depending on the device you use.

**Tip:** If you do not need your logs anymore, you can delete them using the *Select* button.

When the logs are downloaded, you can start working with your data in the PPP service.

## 2.5 How to log data for OPUS

**Note:** You can record logs for OPUS only on Reach M2 as the service supports only multi-band receivers.

This guide shows how to record logs for NOAA's Online Positioning User Service (OPUS) and download them using Emlid Flow.

### 2.5.1 Overview

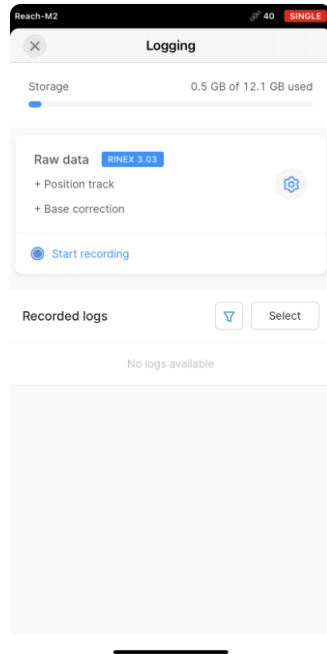
Online Positioning User Service (OPUS) is provided by the National Oceanic and Atmospheric Administration (NOAA). With OPUS, you may accurately determine the coordinates of a static point mostly on the territory of the US without real-time corrections or a base station nearby.

**Tip:** You can learn more about the NOAA's OPUS in this [guide](#).

### 2.5.2 Recording RINEX logs on Reach

To record logs for OPUS, follow the steps below:

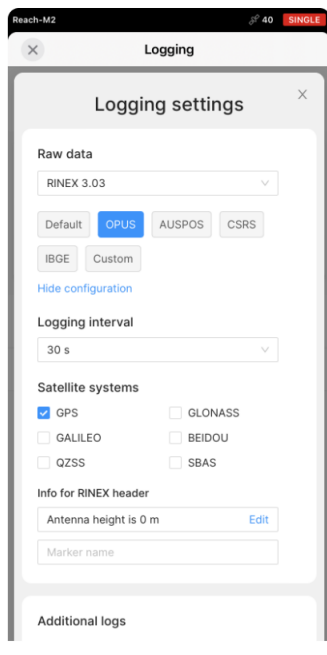
1. Open Emlid Flow and connect to your Reach.
2. Go to the *Logging* screen.



3. Tap the *Settings* button.
4. Select the *OPUS* preset.
5. Choose the required RINEX format in the *Raw data* section.

**Note:** *If you do not know which version of RINEX you need, we recommend using RINEX 3.03.*

**Tip:** *While recording in the RINEX format, you can log the UBX file as a backup. UBX file can be used to adjust RINEX file settings in the Converter tool in Emlid Studio. You can enable logging in the UBX format in the logging settings in Emlid Flow.*

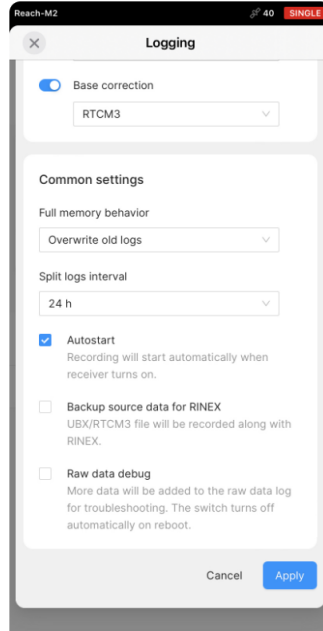


6. Tap *Show configuration* and enter the measured height to the bottom of the receiver in the corresponding field.

7. Fill in the point's name in the *Marker name* field.

8. Tap *Apply and start*.

**Tip:** You can start recording automatically when your receiver is turned on. Check the corresponding field on the *Raw data settings* screen.

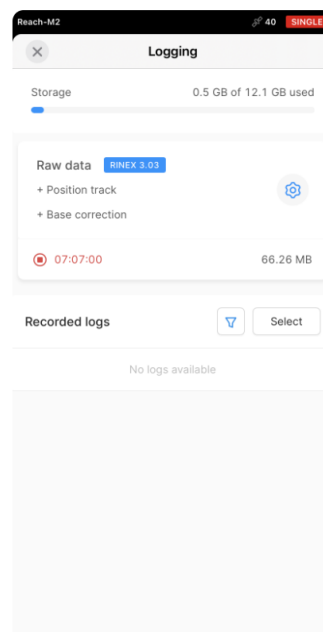


9. Enable log recording by tapping the *Start recording* button.

**Note:** NOAA's *OPUS* requires recording the data for at least 4 hours to get the best accuracy.

10. To finish recording logs, tap the *End recording* button.

**Caution:** Wait for data processing to finish.



**Tip:** You may log the data for up to 24 hours, depending on the accuracy required.

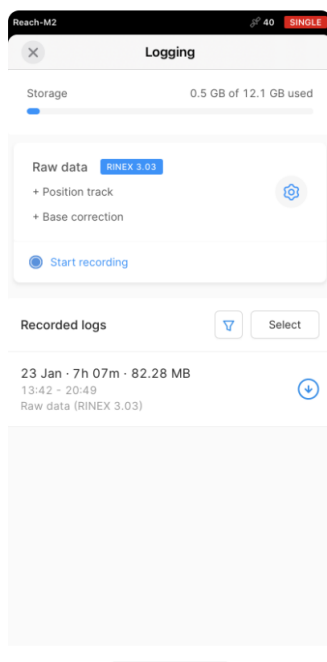
Once you finish the survey, don't forget to turn off raw data recording in the logging settings.

### 2.5.3 Downloading logs

After you finish raw data logging, you need to download RINEX data from Reach to your mobile device.

1. Go to the *Logs* section at the bottom of the *Logging* screen.

**Note:** You can also find information on the logs size and recording date and time here.



2. To export the file, tap the *Download* button.

3. Save your log depending on the device you use.

**Tip:** If you do not need your logs anymore, you can delete them using the *Select* button.

When the logs are downloaded, you can submit the data to NOAA's OPUS for processing.

## 3 Tutorials—Basics

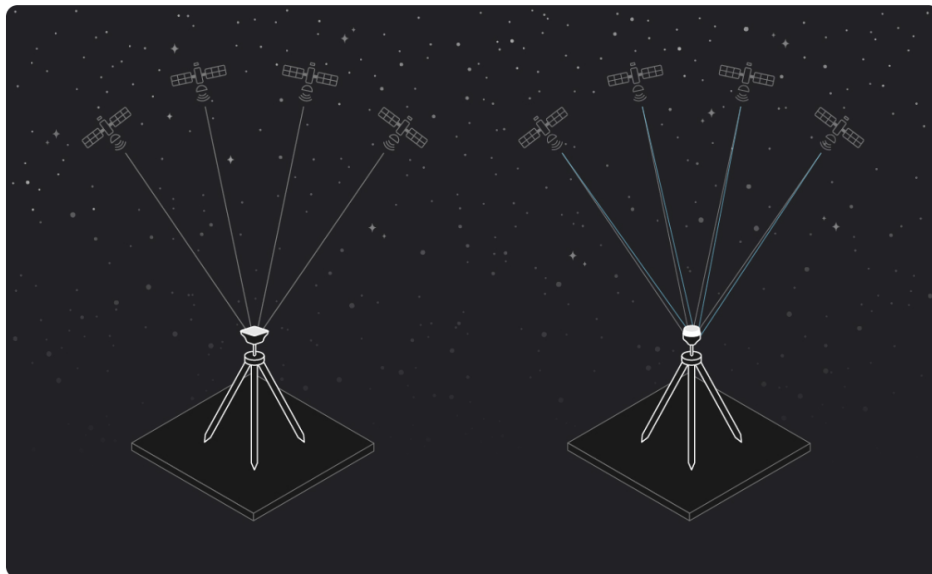
### 3.1 Single-band vs Multi-band

Choosing a suitable receiver for your project can be quite challenging. The article below contains tips and tricks that will help you to make the right decision.

#### 3.1.1 Getting started

The main idea behind the GNSS receiver work is receiving signals from satellites. Each satellite transmits radio signals in one or more frequency bands. Satellites in different constellations use different frequencies.

In the main, all receivers can be divided into two categories: single-band and multi-band. The core difference is that single-band receivers only work with one frequency, while multi-band receivers fetch several frequency bands.



#### 3.1.2 What's the difference

The main difference between single-band and multi-band receivers is the number of frequencies they can work with. Other differences technically are the consequences of it.

	Reach RS2	Reach RS+
Frequency bands	Multi-band	Single-band
Time to first fix	~5 sec	1-2 min
Positioning accuracy in RTK	H: 7 mm + 1 ppm	H: 7mm + 1 ppm
	V: 14 mm + 1 ppm	V: 14 mm + 1 ppm
Baseline in RTK mode	Up to 60 km (36 miles)	Up to 10 km (6 miles)
Baseline in PPK mode	Up to 100 km (60 miles)	Up to 30 km (18 miles)
3.5G modem	Reach RS2 has embedded cellular modem	No
LoRa radio	Yes	Yes

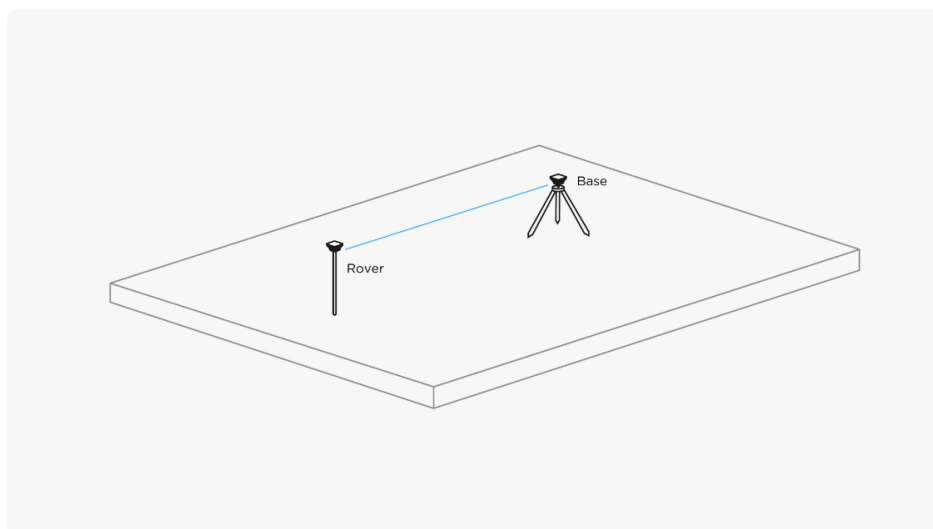
## RTK initialization time

Several factors affect the time required to obtain a fix. This is where the number of tracked frequencies matter.

A multi-band receiver is capable of finding a fix solution much more quickly. Since multi-band receivers can work with more than one frequency band, they can use more satellite signals to establish the fix solution. The more signals that are available, the less time is needed to obtain the fix. Reach M2 requires 5 seconds to get fix solution.

Single-band receivers require more time since they can only process one kind of frequency—the L1 frequency. Reach M+ needs a few minutes to get a fix solution. It doesn't mean you need to wait for several minutes every time you collect a point. This time is only required at the beginning of the survey or in the case where the fix solution was lost.

## Baseline



For different projects, you might need a different distance from the rover to the base. Working near a city, you are more likely to have a base nearby. However, if you mostly work in rural areas, base stations are likely to be further away.

Multi-band receivers can work at a longer baseline. Reach M2, as a multi-band receiver, can operate with the baseline up to 60 km (36 miles) for RTK, while Reach M+ single-band receiver's baseline is limited to 10 km (6 miles) in RTK mode.

### **Accuracy**

Both single-band and multi-band receivers are capable of centimeter-level absolute accuracy. The main difference is that more factors can influence the stable fix solution in the single-band receiver. Thus, when using a single-band receiver, you can obtain the same absolute accuracy, but only if you have reasonable working conditions.

### **Sky view conditions**

In the case of a blocked sky view, the more signals, the better, meaning the more signals you can catch, the sooner you get the fix solution. Due to their ability to process several frequencies and mitigate the multi-path impact, multi-band receivers can keep the reliable fix solution even in urban areas.

Single-band receivers need the open sky to work their best. Otherwise, it might be harder and take longer to establish a fix solution.

### **3.1.3 Which one to choose**

Both single-band and multi-band receivers obtain the same level of accuracy in their perfect conditions – so, first of all, you need to analyze your case.

Single-band receivers are perfect for working in the field with shorter baselines and a clear sky view. Say, you're working in agriculture and you need to divide your field into equal sectors or determine the position for trees in an orchard-to-be, a single-band receiver is enough. They also make a great base for PPK or drone mapping. Multi-band receivers make a perfect fit for PPP, such as NRCan, and high-accuracy surveying in tougher conditions. If you're working in the city and you have a longer baseline, or the base station is too far, plus you want the job to be done fast, a multi-band receiver is your choice. It gets the fix solution faster despite the possible obstacles and distance from the base.

### **3.1.4 Conclusion**

In the majority of cases, the single-band receiver is enough to perform an accurate survey and collect reliable data. It also helps you save yourself a penny budget-wise. However, if you are not sure your working conditions will be perfect or you simply don't want to worry about possible technical limitations, stick to the multi-band receiver. It will be a more reliable option.

If you have any questions or still have doubts about whether you need a single-band or multi-band receiver, do not hesitate to start a thread on the [Community forum](#).

## **3.2 How RTK works**

RTK is a technique used to improve the accuracy of a standalone GNSS receiver. Traditional GNSS receivers, like the one in a smartphone, could only determine the position with 2–4 meters (7–13 feet) accuracy. RTK can give you centimeter accuracy.

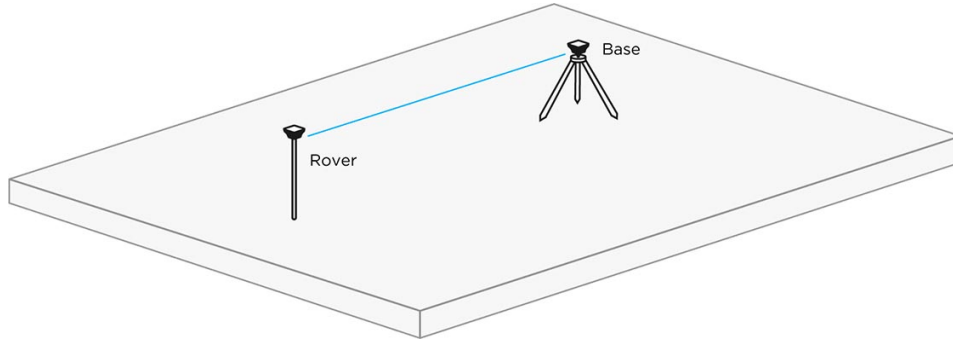
GNSS receivers measure how long it takes for a signal to travel from a satellite to the receiver. Transmitted signals travel through the ionosphere and atmosphere and are slowed down and perturbed on the way. For example, travel time on a cloudy day and in clear sky conditions

would be different. That is why it is difficult for a standalone receiver to precisely determine its position. RTK is a technology that solves this issue.

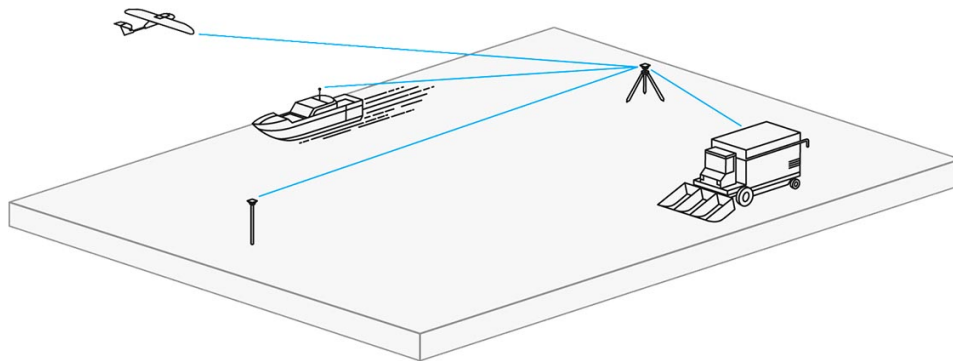
Our YouTube channel has [a video](#) that will show you how RTK technology works.

### 3.2.1 High real-time precision

Two receivers are used in RTK. One of them is stationary, another moves freely. They are called **base station** and **rover**.



The base's mission is to stay in one place and send corrections to a moving receiver. Rover uses that data to achieve centimeter precise position. Any number of rovers can connect to one base if their input settings match the base's output.



### 3.2.2 Corrections over NTRIP

You do not necessarily need a second unit for RTK all the time. Usually, there are local services that share base corrections over the internet. This technology is called NTRIP.

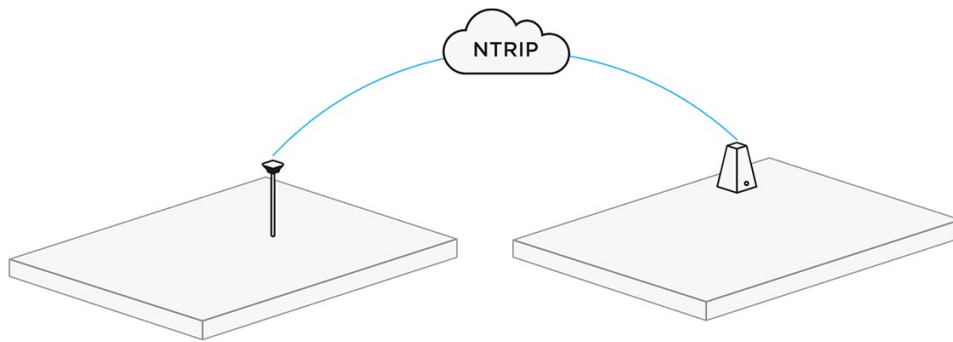
NTRIP is a good option for areas with strong 3G/LTE coverage and a vast network of NTRIP bases nearby. In other cases, using the second receiver as a local base station has two advantages:

- autonomy in remote areas as there's no need in the internet connection;
- independency from local providers, no additional fees by NTRIP service.

## 3.3 How PPK works

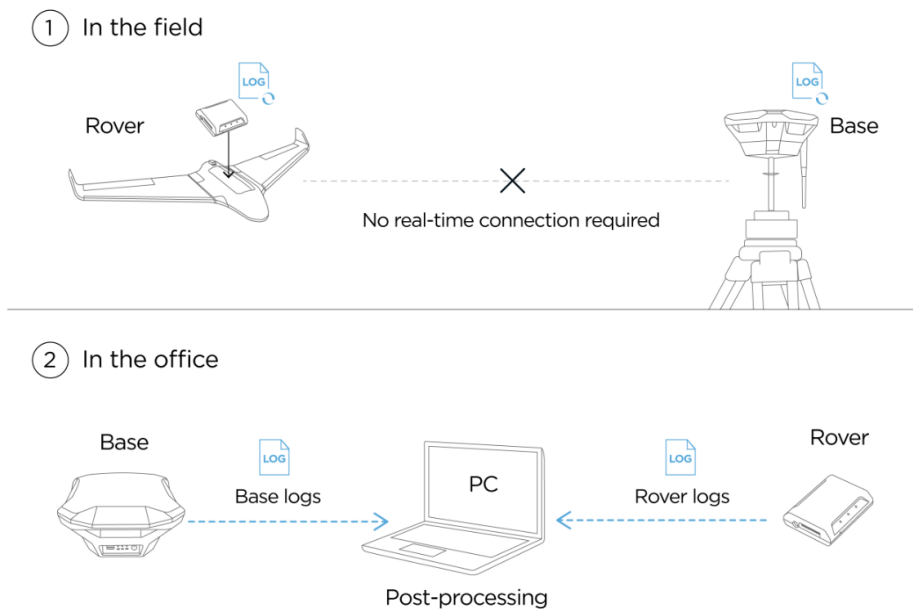
**Note:** To learn more about post-processing with our cross-platform desktop application Emlid Studio, check out our documentation.

PPK stands for Post-Processed Kinematic.



### 3.3.1 Definitions and differences from RTK

Post-Processed Kinematic (PPK) is an alternative technique to Real-Time Kinematic (RTK). With PPK workflow, accurate positioning doesn't happen in real time, all algorithms are applied afterwards. Both base on the ground and rover (usually on a UAV) record raw GNSS logs, which are then processed to receive an accurate positioning track.



While PPK is mainly used in UAV mapping, it can also be used as a back up for RTK for any surveying job. PPK offers more flexible workflow, allowing to run the processing multiple times using different settings. It also doesn't require a correction link between base and rover, making equipment setup simpler.

### 3.3.2 PPK for UAV mapping

**Note:** For PPK mapping, it is recommended to have few GCPs on site for data check (checkpoints).

There are several advantages of using PPK for mapping with a drone. PPK doesn't require placing Ground Control Points (GCPs), which allows to inspect much wider areas. It is especially useful when you need to map large territories or places with difficult terrain.

The most critical part of PPK for UAV mapping is synchronisation of a camera and Reach M+, because:

There is always a delay between camera trigger and the actual moment the photo is taken.

1. When a drone flies at high speeds, the autopilot receives position readings only each several meters. The accuracy of, say, 2 meters is not enough for surveying.
2. Reach M2/M+ solves this by connecting to a camera shutter via hot shoe. The time of each photo is logged with a resolution of less than a microsecond. During PPK you receive coordinates of exact moments of each photo taken.

There's no need in integrating Reach to autopilot for UAV mapping.



As a result of UAV PPK mapping with Reach, you'll have a set of images and a text file containing a list of accurate coordinates corresponding to each photo. This data is then imported in mapping software such as Agisoft PhotoScan, DroneDeploy, Pix4D, etc.

**DJI drones workaround:** *You can't easily integrate Reach M2/M+ with DJI Mavic or Phantom, as their cameras don't have hot shoe. But you can always stick to working with GCPs, which is simple and efficient for small areas – just like your DJI drone.*

### 3.4 Placing the base

Real Time Kinematic technique requires 2 receivers. One of them is stationary and is called "base station", the other one is "rover". The base station measures errors, and knowing that it is stationary transmits corrections to the rover (refer to How RTK works for more information about RTK). Sometimes CORS and NTRIP networks take the place of traditional base stations. They provide accurate absolute position and send corrections over the internet. Typically the distance between the reference station and local rover shouldn't exceed 10-15 km due to the ionospheric effect. So if the reference station is located too far or simply is absent in the area you will need a local base station. Other advantages of your own base are independence from the internet connection and lack of NTRIP subscription fees.

If you are setting up your own base it is important to pay attention to this article. A good understanding of different ways to set up the base will help you to reach the desired accuracy for your application.

### 3.4.1 Absolute and relative position

Emlid Flow has several ways to determine or set the base station position providing various levels of accuracy. Let's take a look at the illustration below (figure 1). RTK algorithm precisely calculates the distance between base and rover. This distance is called the Baseline. The Rover position is precisely determined relative to the Base position. At the same time, the rover coordinates offset from the real location depends on the position accuracy of the base. If the position that has been set in the base station is different from the actual True position on earth the offset equal to this difference will be in the rover position as well.

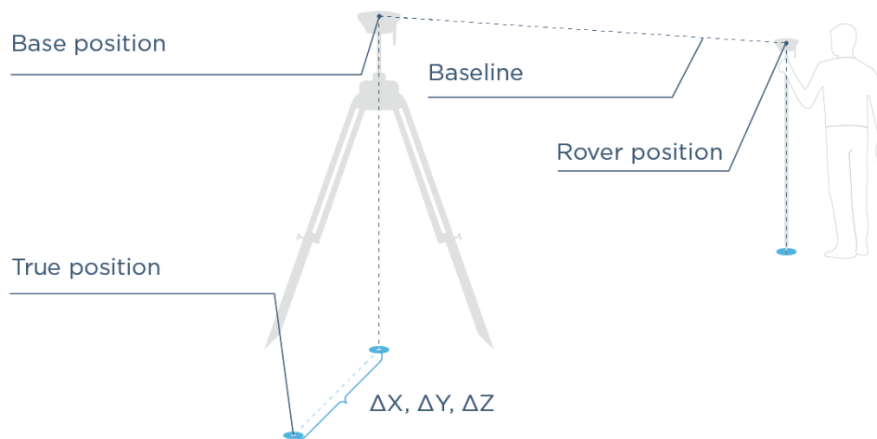
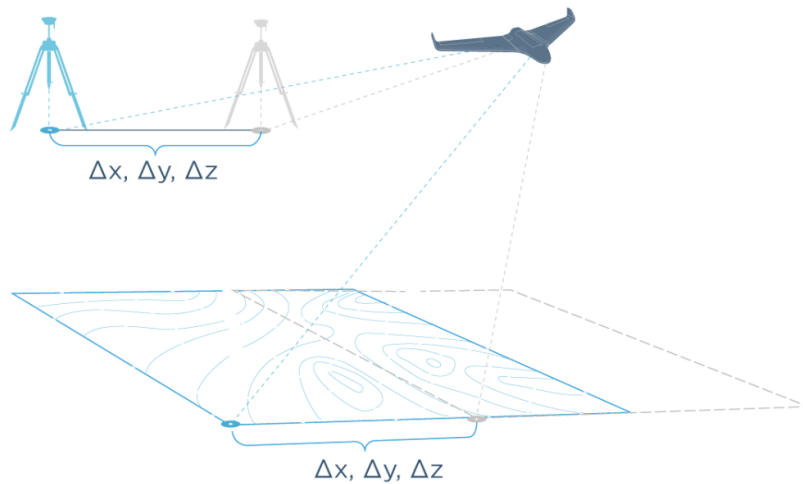


Figure 1

It is often enough to know the precise position of an object relative to the base station but for some applications like survey and mapping it is critical to get an accurate absolute position. In this case, the offset delta X, delta Y, delta Z between actual True position and the Base station position should be avoided or reduced.

**Caution:** *The absolute position of the rover is accurate only to the same accuracy as the position of the base station.*

Proper positioning of the base station is a key to successful data collection. The shift of base coordinates will keep the collected data precise but will make it inaccurate (which is absolutely fine for volumetric measurements but unacceptable if you have to tie collected data to the global coordinates). For example, if you are processing the map using data collected by RTK-equipped drone using corrections from the shifted base your map will be later geo-referenced with the same offset (figure 2).



The same shift producing effect may be noticed if the base is placed inaccurately over a known point or just moved from its determined position without relevant amendments.

**Note:** *If the accurate absolute position of the base has been determined only after the job has been done, the offset of the map can be determined and corrected.*

### 3.4.2 Ways to set the base

As already mentioned Reach used as a base may be positioned using various ways. You can manually enter the base coordinates, use the averaging feature or use PPP and PPK techniques to determine the coordinates.

Base setup method	Accuracy	Requirement	Observation time	Processing time	Cost
Manual, on a known point	same as the point	Known point	0 min	Immediate, no processing required	Free
Average SINGLE position	~2.5 m	-	<5 min	Immediate, processing on Reach	Free
RTK FIX position	H:7mm+1ppm V:14mm+2ppm for Reach RS/RS+ H:7mm+1ppm V:14mm+2ppm for Reach RS2/RS2+	NTRIP stream from base <10km for RS/RS+ <60km for RS2	<5 min	Immediate, processing on Reach	Free/\$\$ depending on local provider
RTK Float position	1.0m	NTRIP stream from base <10km for RS/RS+ <60km for RS2	<15 min	Immediate, processing on Reach	Free/\$\$ depending on local provider
Static processing	H:5mm+1ppm V:10mm+2ppm for Reach RS/RS+ H:4mm+0.5ppm V:8mm+1ppm for Reach RS2/RS2+	RINEX logs from base <30km for RS/RS+ <100 km for RS2	~1 h	15min on PC after log from reference station available, usually posted hourly	Free/\$\$ depending on local provider
Precise Point Positioning	~30cm for RS/RS+ ~1-2cm for RS2	-	~4 h	In ~24h after submitting logs to NRCan online service	Free

*Numbers in the table are approximate and only for reference purposes. Your experience may vary in different conditions, always follow appropriate survey practices!*

No matter which method you use, the relative position of the rover will always be cm-precise, the actual accuracy will be set by the accuracy of the base position.

### 3.4.3 Manual

**Android keyboard tech tip:** *On some Android devices, default keyboards do not provide a minus sign. To get access to it, we recommend downloading Gboard, a virtual keyboard app, from the Google Play Store.*

Manual input of the position is rather straightforward and is used when you have access to a known point. The most popular scenarios include finding a trig point or hiring a surveyor who will set the benchmark point. In this case, absolute accuracy depends on how accurately the point's coordinates were determined.



Triangulation station also known as trig point or trig beacon with Reach RS/RS+ on top (photo by Luke Wijnberg)

Pay attention and carefully place the base over a known point and measure the height of the antenna from the mark. It will help to avoid shifts from the absolute position and keep measurements accurate. Refer to Placing Reach RS2/RS2+ in the field for detailed instructions.

### **3.4.4 Average**

Let's take a closer look at setting up the base using the position averaging with single, float and fix solutions. All these ways provide different levels of base coordinates accuracy and are suitable for different applications.

#### **Averaged single**

This approach is used when you don't require absolute accuracy. The averaging happens in stand-alone GPS mode without using any corrections and this provides you with a several meters absolute accuracy.

The left illustration below (see figure 3) shows the paths of the rover which passes the marked rectangular contour several times. This rover receives the corrections from the base configured using averaged single solution. While the position for each individual path lies within the receiver precision limits, the absolute position may differ by up to a few meters. We can see this if we repeat averaging of the static base station and build the path of rover immediately after each reaveraging. Take a look on the right of figure 3.

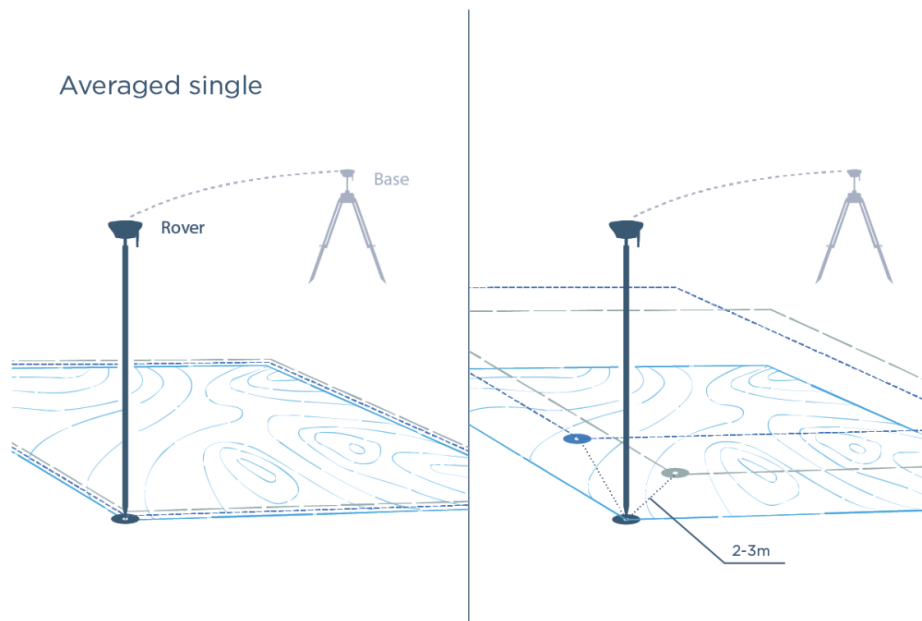


Figure 3

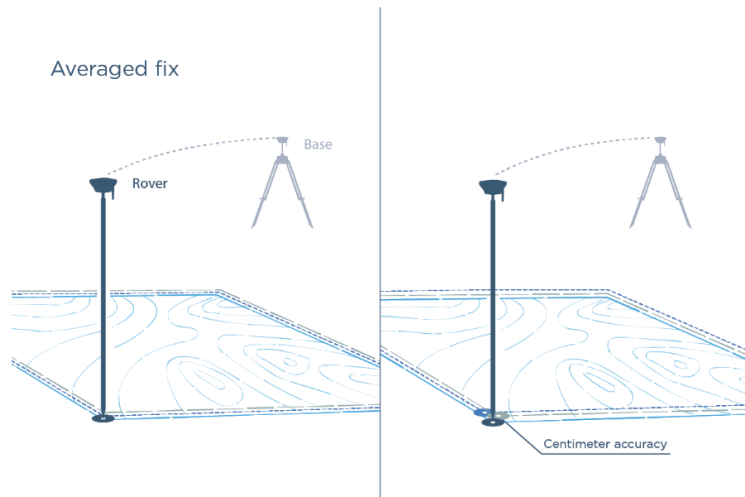
**Perfect for repeatable precise relative positioning (GPS tractor guidance, autonomous flights and landing):** *If you only need accurate relative positioning the easiest way is to average the position using single solution. Just physically mark the point on the ground and save coordinates to manual in Emlid Flow. Day-to-day result would look almost identical to those obtained using NTRIP corrections.*

### **Averaged FLOAT and FIX**

Averaging RTK fix solution is much more accurate than single averaging and is made possible when the receiver used as the base is configured to obtain NTRIP corrections over the internet. This might be useful if the reference station is located far away. Reducing the baseline by installing the local base improves the positioning performance of rover.

On the left of the next illustration (see figure 4) the rover passes the marked rectangular contour several times. This rover receives the corrections from the base configured using averaged fix position.

When the base is set up using averaged fix solution, the coordinates are determined with centimeter accuracy (if obtaining survey-grade NTRIP corrections). In this case, the deviations of each path built immediately after reaveraging several times will be within a few centimeters. Take a look on the right of figure 4.



If the baseline is too long to obtain fix, averaging float solution will still improve the position to 1m level.

**Perfect for data collection and surveying, placing GCPs, and drone mapping:** *The base position averaged using fix solution provides several centimeters accuracy and works great when you need accurate absolute position!*

### 3.4.5 Post-Processed Kinematics

With post processed kinematics technique you may determine base coordinates without real-time corrections with centimeter accuracy. You will need RINEX logs from the reference station in the area of 100 km and the raw data log from the receiver. The process will take you about 15 minutes to calculate the position of your base station using the PPK in Static mode tutorial.

General steps:

1. Enable logging of raw data and record log for about an hour.
2. Export log with the collected data from Emlid Flow to your PC.
3. Refer to the PPK in Static mode tutorial.

After you get the coordinates you may enter them manually in *Base coordinates* section.

Comparing PPK position to the averaged position and applying corrections to the collected data is the way to compensate the shift shown in the example on figure 2.

### 3.4.6 Precise Point Positioning

With precise point positioning technique, you may accurately determine base coordinates anywhere in the world without real-time correction or base station nearby however it may take a considerable time to get coordinates.

General steps:

1. Enable logging of raw data and record log for a few hours.
2. Export log with the collected data from Emlid Flow to your mobile device or PC.
3. Upload the collected file to PPP service (for example, NRCAN).

After you get the coordinates you may enter them manually in *Base coordinates* section.

### 3.4.7 Placing the base station in the field

**Caution:** *The mismeasured height of the antenna above the mark is probably the most pervasive and frequent blunder in GPS control surveying.*

### 3.4.8 Placing Reach RS/RS+

When placing your Reach RS/RS+ in the field, make sure your Reach device is placed precisely above the marked point on the tripod and leveled. If you are setting up base coordinates manually, you need to measure the antenna height offset. Follow the steps below:

1. Measure the distance between the mark and the bottom of your Reach (h on Figure 5).
2. Specify the measured distance in Emlid Flow. It will automatically calculate the antenna height.

**Reach RS/RS+ antenna height:** *For Reach RS/RS+, the antenna height is the distance between the mark and the bottom of the receiver (h on Figure 5) plus the receiver's height to the antenna reference point (ARP) which is equal to 65 mm and automatically added by Emlid Flow.*

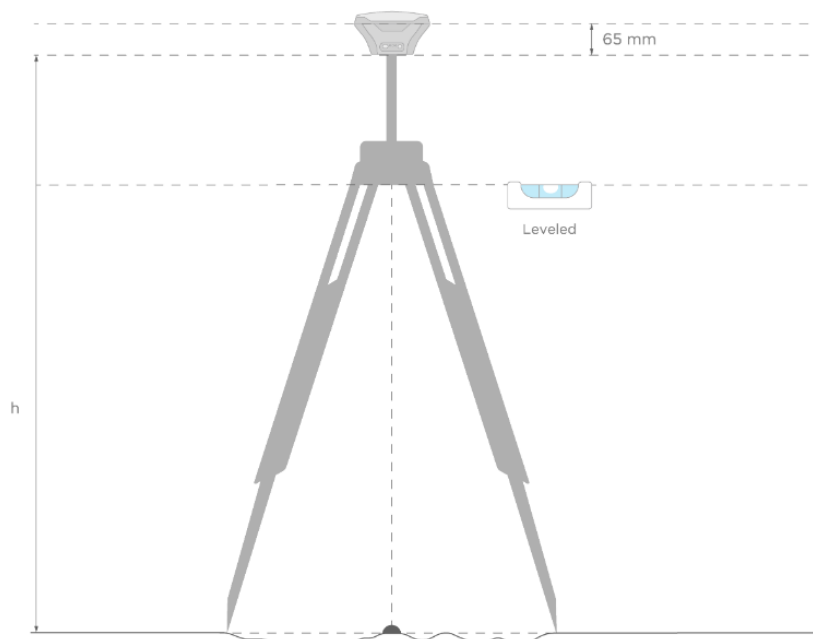


Figure 5

### 3.4.9 Placing Reach RS2/RS2+

When placing your Reach RS2/RS2+ in the field, make sure your Reach device is placed precisely above the marked point on the tripod and leveled. If you are setting up base coordinates manually, you need to measure the antenna height offset. Follow the steps below:

1. Measure the distance between the mark and the bottom of your Reach (h on Figure 6).

- Specify the measured distance in Emlid Flow. It will automatically calculate the antenna height.

**Reach RS2/RS2+ antenna height:** For Reach RS2/RS2+, the antenna height is the distance between the mark and the bottom of the receiver ( $h$  on Figure 6) plus the receiver's height to the antenna reference point (ARP) which is equal to 134 mm and automatically added by Emlid Flow.

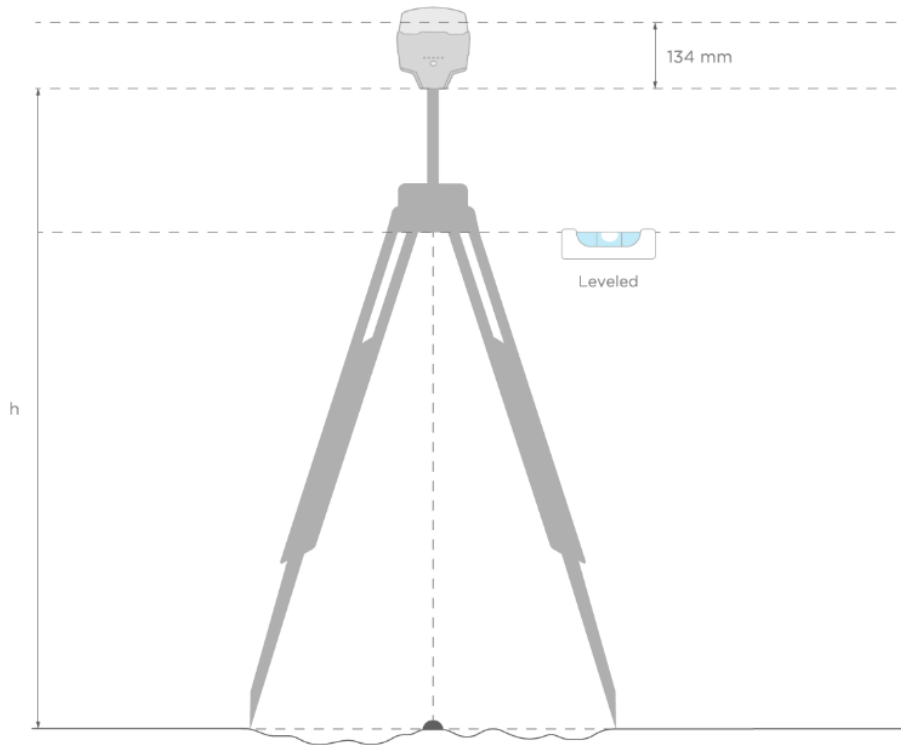


Figure 6

## 4 Tutorials—PPK mapping with Reach

### 4.1 Configuring Reach UAV kit for PPK mapping

This guide explains how to set up your Reach receivers for PPK mapping with UAV.

**Tip:** *We recommend checking the [How PPK works](#) article before you start.*

#### 4.1.1 Overview

To configure Reach UAV kit for PPK mapping, you will need the following:

- Reach RS2/RS2+ or Reach RS+ base
- Reach M2/M+ rover with GNSS antenna
- Hot shoe adapter (HSA) for a camera
- Any camera that provides hot shoe access (e.g. Sony, Canon, Nikon)

**Note:** *Reach RS+ cannot act as a base for a Reach M2 rover as Reach M2 requires multi-frequency corrections. Still, you can use Reach RS2/RS2+ as a base for Reach M+. Note that you will not get all advantages of the multi-band receiver in this case. You can learn more about the differences between single-band and multi-band receivers in the [Single-band vs Multi-band](#) article.*

Additionally, you will need a few Ground Control Points (GCPs). To place GCP, a base and a rover are required, or you can use one receiver connected to an NTRIP.

In this guide, we are mostly focused on the GNSS equipment part of the integration. However, you also need a UAV and a PC with a Ground control station and photogrammetric software. There are 2 main requirements for UAV:

- The presence or ability to install a camera with a hot shoe connector
- Functionality allowing triggering the camera: by camera itself or by autopilot

#### 4.1.2 Reach M2/M+ hardware setup

##### Connecting Reach M2/M+ to a camera using HSA

HSA allows Reach M2/M+ to precisely record a time mark at every moment the camera takes a photo.

**Note:** *The camera requires to have a hot shoe for integration with Reach M2/M+. If you use DJI Mavic or Phantom which does not provide hot shoe access, you can always stick to working with GCPs.*

To connect Reach to a camera with a hot shoe adapter use 5-pin JST-GH cable that comes with Reach M2/M+. Plug the hot shoe connector in a camera hot shoe and the JST-GH connector in the C1 port on Reach M2/M+.

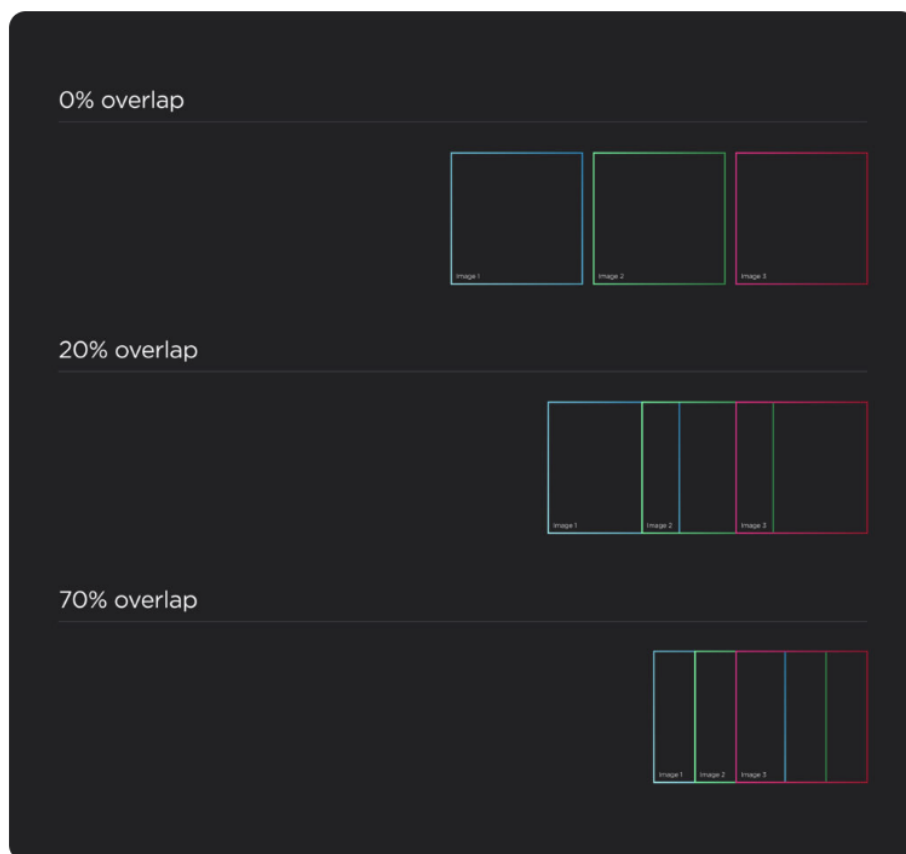


## Camera triggering

Depending on your application, there are several ways you can trigger a camera:

- **Triggering via camera.** Some cameras provide a Timelapse feature that allows taking a photo at regular intervals. If your camera supports this option, we recommend using it as it is the easiest and straightforward way.  
**Tip:** *Each camera uses different ports for triggering. It might be a USB or HDMI port. Read the camera manual to find out how to trigger your camera.*
- **Triggering via autopilot.** There are several options of triggering the camera via autopilots:
  - Triggering the camera shutter at waypoints. Autopilot can trigger the shutter each time the drone reaches a waypoint. If you use a flight controller based on ArduPilot, check the [Camera control in auto missions](#) guide from ArduPilot for more details.
  - Triggering camera shutter at regular intervals. Check the [Camera shutter configuration](#) guide from ArduPilot to learn more.

The majority of Ground Control Station software allows and even requires a mission plan preparation before the flight. You need to configure your camera and autopilot the way it obtains images with overlaps. This is necessary because common points in adjacent images are required to create an orthogonal mosaic. We recommend the front overlap to be at least about 60% and the side—about 30%.



## Antenna placement

GNSS antenna should be placed on a ground plane. An antenna ground plane should be conductive and at least 70 x 70 mm. A usual metal plate should be good for this purpose.

**Note:** Helical antennas do not require a ground plane. Still, a ground plane can improve observation quality significantly.

**Tip:** Check the [Antenna placement guide](#) to learn more.

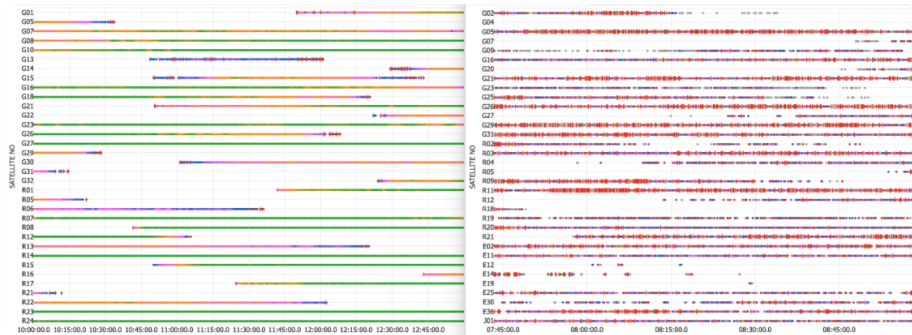
## Isolating Reach M2/M+ from potential interference

In some cases, you might need to isolate your Reach to ensure the best logging quality. The reason is that the transmitted power of GNSS signals is rather low relative to the possible noise from other hardware components installed on your UAV. It means that the antenna signal strength might be unstable and even sometimes interrupted. Interruption and temporary signal loss on RTK receiver are called cycle slip.

To avoid cycle slips we recommend isolating Reach M2/M+ unit and connect it to the ground to eliminate interference. Also, RC components, such as radio transmitters, might affect the signal as well. Reach should be located as far as possible from them.

The effects of bad hardware setup are substantial. Poor signal quality with low SNR values, lots of cycle slips pose issues with getting fixed solutions and missing time marks. Take a

look at the figures below that demonstrate examples of good (the left picture) and bad (the right one) satellite reception.

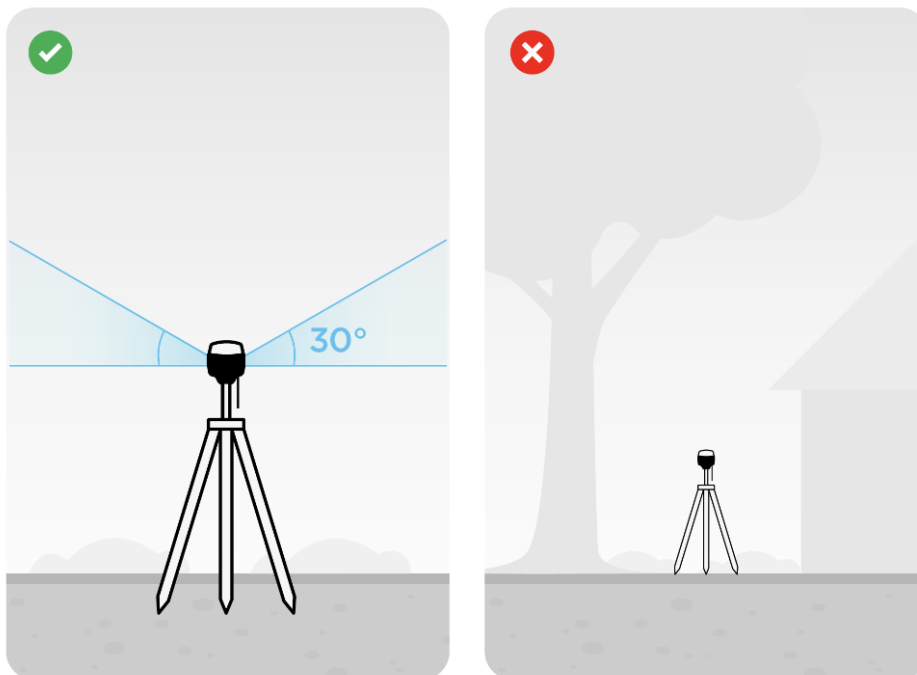


**Tip:** Create a topic on the Emlid community forum in case you experience any difficulties at this stage.

### 4.1.3 Reach RS2/RS2+/RS+ base setup

Check out the figure below and choose an appropriate location to place Reach RS2/RS2+ or Reach RS+ base station. The basic rules are:

- Good sky angle over 30 degrees
- Away from trees and buildings
- No electricity nearby



**Tip:** Check the [Placing the base guide](#) to learn more.

## 4.1.4 Configuring base and rover before flight

### Reach M2/M+ rover settings

1. Power your Reach M2/M+ from an external power source or drone battery.

**Tip:** Check the *Power supply guide* to learn more.

2. Access Reach M2/M+ in Emlid Flow.

**Tip:** Check the *Connecting to Reach* and *Connecting Reach to the internet guides* to learn more.

3. Go to the *RTK settings* and configure one of the recommended GNSS selections and update rate for time mark logging:

#### For Reach M2

Reach M2 tracks GPS, GLONASS, GALILEO, QZSS, and BeiDou satellite systems. The data can be logged with 1 Hz, 5 Hz, or 10 Hz update rate.

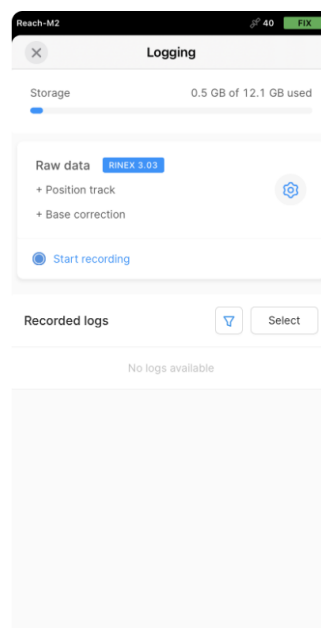
For a drone flight, it is better to set up the update rate to 10 Hz.

#### For Reach M+

GNSS Selection	Reach M+ allowed update rates
GPS + GLONASS + GALILEO + SBAS + QZSS	1 Hz
GPS + GLONASS + QZSS	5 Hz
GPS + GALILEO	5 Hz
GPS	10 Hz

### Reach RS2/RS2+/RS+ base settings

1. Turn on the Reach RS2/RS2+ or Reach RS+ unit.
2. Access the receiver in Emlid Flow.
3. Go to the *GNSS settings* screen.
4. Choose the same GNSS systems as for Reach M2/M+ with 1 Hz GNSS update rate.
5. Enable raw data recording on the *Logging* screen.



### Reach RS2/RS2+/RS+ base settings

1. Turn on the Reach RS2/RS2+ or Reach RS+ unit.
2. Access the receiver in Emlid Flow.
3. Go to the *GNSS settings* screen.
4. Choose the same GNSS as for Reach M2/M+ with 1 Hz GNSS update rate.
5. Enable raw data recording on the Logging screen.

#### 4.1.5 Placing ground control points

Ground control points (GCPs) are points with known coordinates on the ground in the area of your interests. GCPs usually help to improve and check the accuracy, get the correct scale and orientation of the map. Also, they are needed for the absolute positioning of your map in relation to the real world around it.

**Tip:** Check the *Placing the base guide* to learn more about absolute and relative accuracy.

Reach provides centimeter-accurate coordinates in PPK. Also, if you place the base on a point with known coordinates, you will get the coordinates with absolute accuracy. In such a case, GCPs can help you to verify the accuracy.

GCPs should be clearly visible on the drone's images. Make sure the mark is a contrast to its surroundings and that it is big enough. Place a survey pole with a receiver exactly in the center of the mark to take its coordinates.

Enough quantity of GCPs depends on the site area. Usually, it is 5-10 points. There are some basic rules of checkpoints placing:

- They should be allocated evenly in the area where you survey. For example, if you use 5 points, set per one for each corner and the last in the center of the area.
- They must not be on the same line.

Also, it is great if you have the possibility to place GCPs at the highest and lowest points on site. It helps to perform the correct flat projection.



It's important to meet these requirements if you want to get the same accuracy across the entire plot.

**Tip:** Check the *Placing GCPs guide* to learn more.

### 4.1.6 Survey flight

We do not pay much attention to this step due to the differences in the drone flight settings from model to model. Please, check the manual of your drone manufacturer before the flight.

After all the configurations are done, you can proceed to flight with your drone.

*Caution: Make sure raw data logging on both Reach M2/M+ and Reach RS2/RS2+ or Reach RS+ units are enabled before the flight.*

When the flight is finished, you can disable logs recording. Before turning the devices off, please wait until the logs processing is done.

You can download raw data logs from both base and rover later on.

As a result of mapping mission with Reach you will have the following dataset:

- Raw log from a base
- Raw log from a rover
- Set of images from a drone
- List of GCPs

Now you can prepare the dataset for further processing.

## 4.2 Geotagging photos with Emlid Studio

**Note:** *To learn more about post-processing with our cross-platform desktop application Emlid Studio, check out our documentation.*

This guide walks you through the process of geotagging of the drone images in Emlid Studio that are used for further mapping in photogrammetry software.

### 4.2.1 Overview

With the Drone data processing feature, you can easily add geotags to the drone images' EXIF data and process them later in the photogrammetry software. To perform geotagging, you need raw data logs from the base and the rover, or a ready POS file with the events, and drone images.

The process includes two steps: processing and geotagging. You can skip processing and upload your own \_events.pos files to obtain geotagged photos.

### 4.2.2 Getting started

**Tip:** *To learn more, check out the How PPK works and PPK mapping with Reach guides.*

As a result of the mapping mission, you should have the following files:

- RINEX log from a base
- RINEX log from a rover
- Set of images from the drone's camera
- Emlid Flow CSV file with the coordinates of ground control points

The RINEX data will be used to get precise coordinates for the image geotagging. The CSV file is not needed at this step, but it's essential for further mapping in photogrammetry software.

### 4.2.3 Post-processing

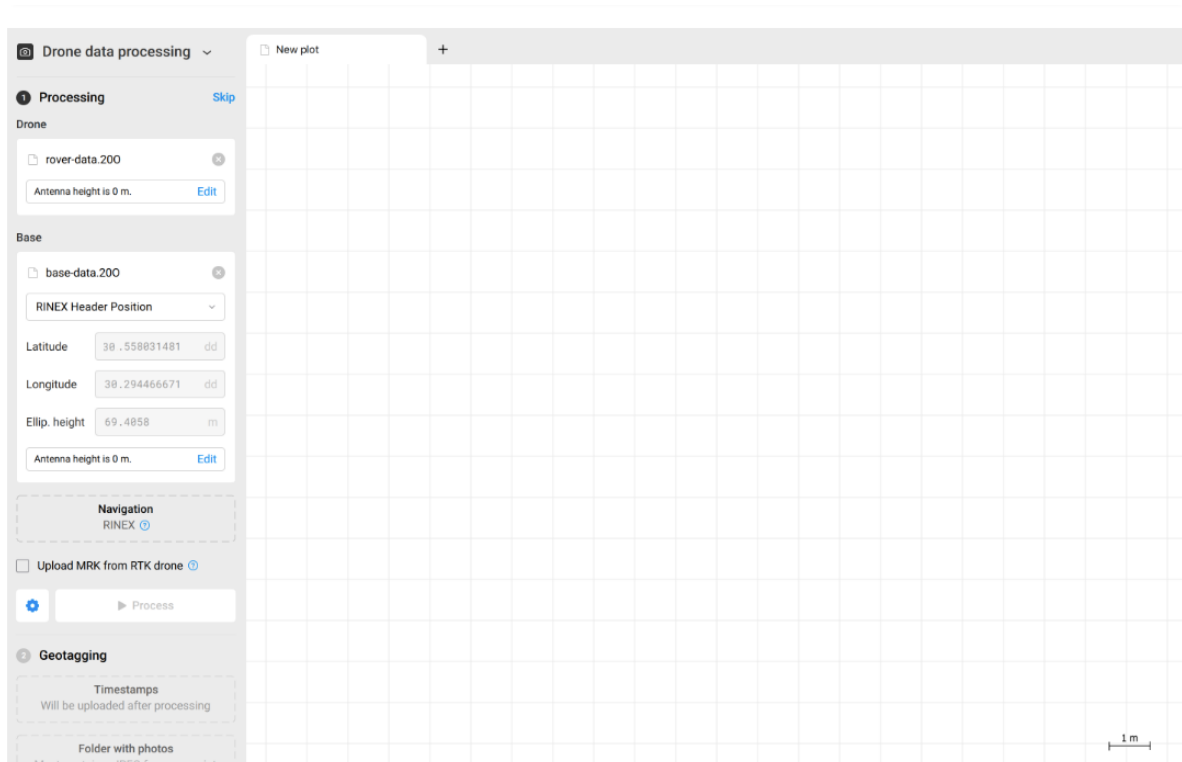
**Note:** *If you already post-processed RINEX files from the base and the rover and obtained the `_events.pos` file, go straight to the Geotagging section.*

To post-process the files from the base and the rover, follow the steps below:

1. Add the RINEX observation file from the rover.
2. Set the antenna height in meters.

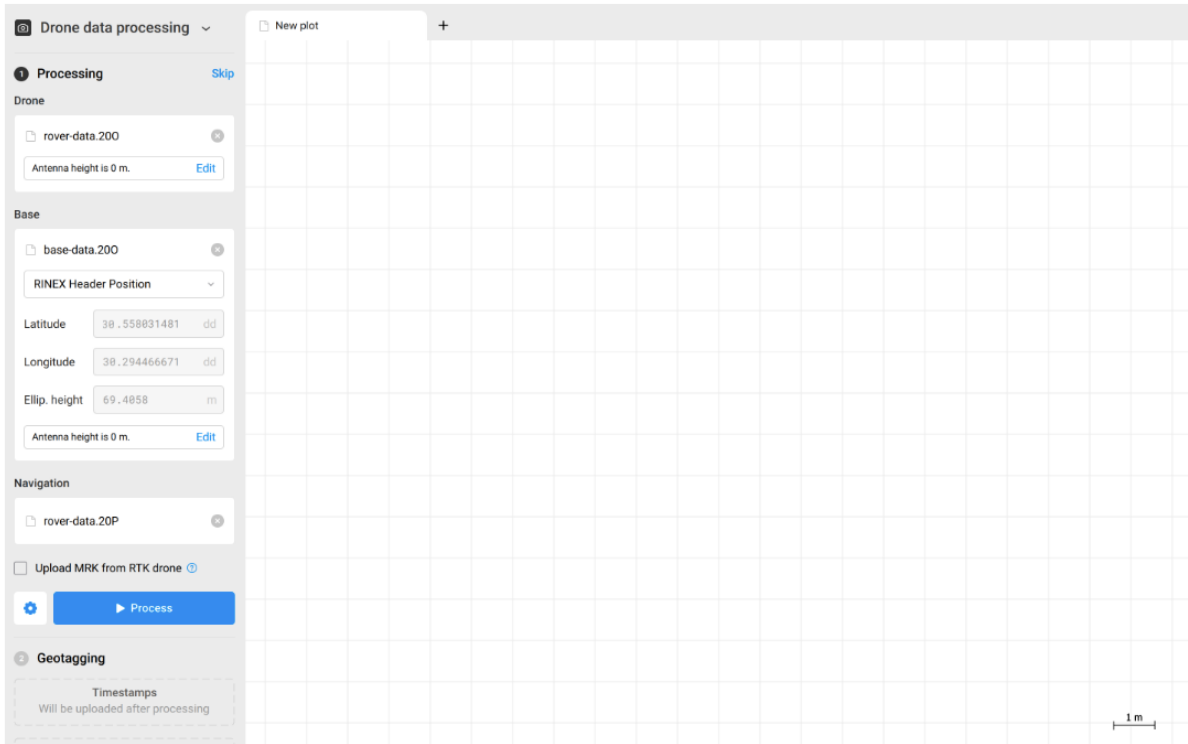
**Note:** *We recommend leaving antenna height to 0. Usually, photogrammetry software has the feature of calculating the antenna offset (camera center position relative to the antenna position).*

3. Add the RINEX observation file from the base.
4. Set the base coordinates.

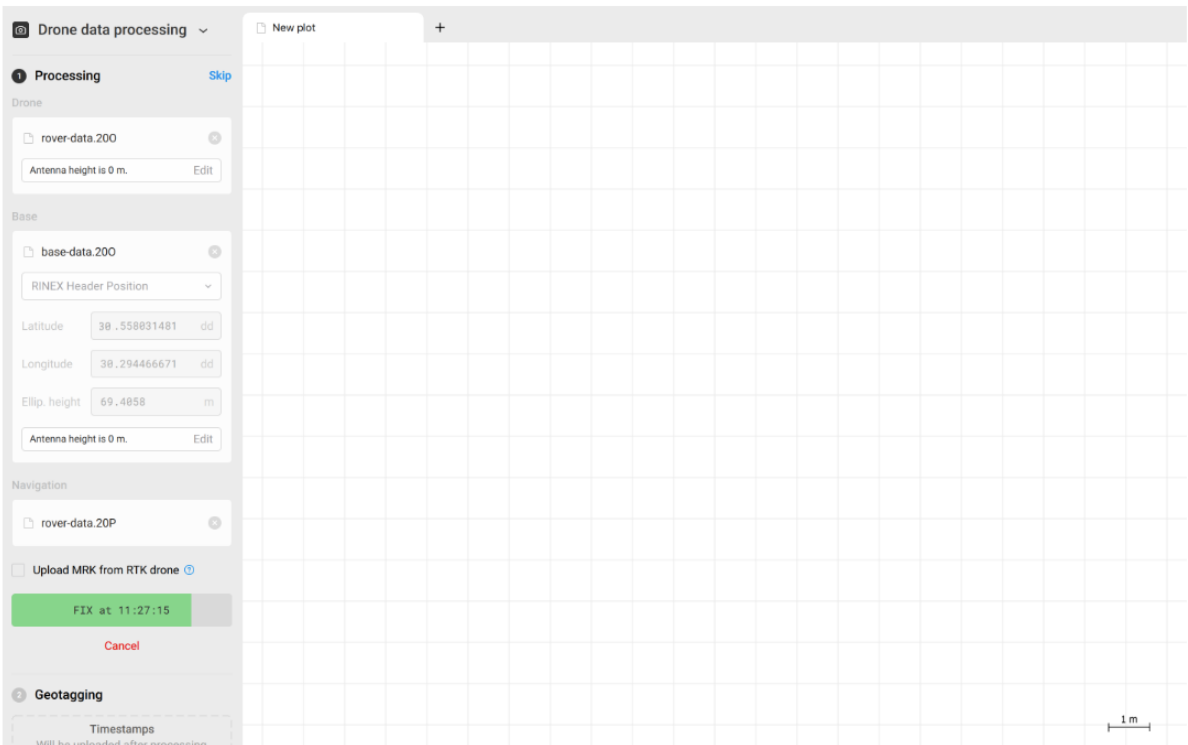


**Note:** *By default, the RINEX Header Position is used. If you place your base over the point with known coordinates, enter the coordinates and the antenna height manually. This way, you will obtain absolute accuracy.*

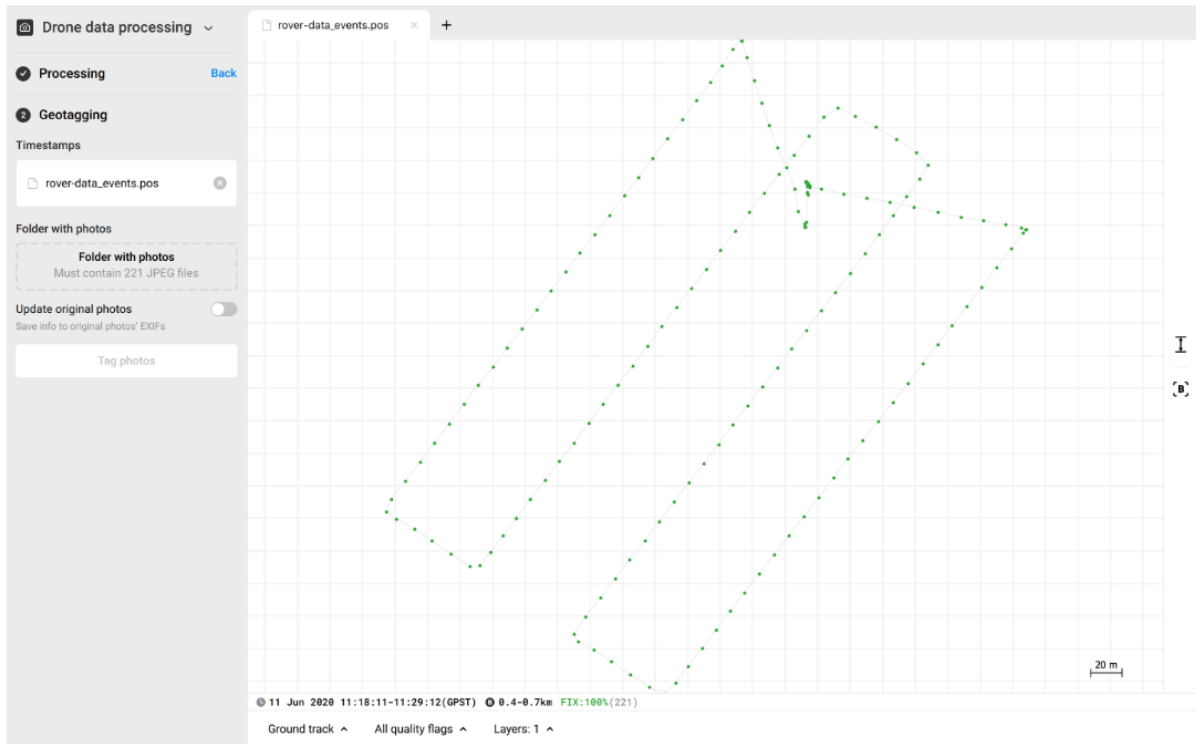
5. Add the RINEX navigation file from the base or the rover.



6. Click *Process*. You will see the progress bar in the bottom left corner.



Once the .pos file is ready, Emlid Studio will show it on the plot.



The `_events.pos` file with the precise photos' positions will be automatically added to the Timestamps field in the Geotagging section.

#### 4.2.4 Geotagging

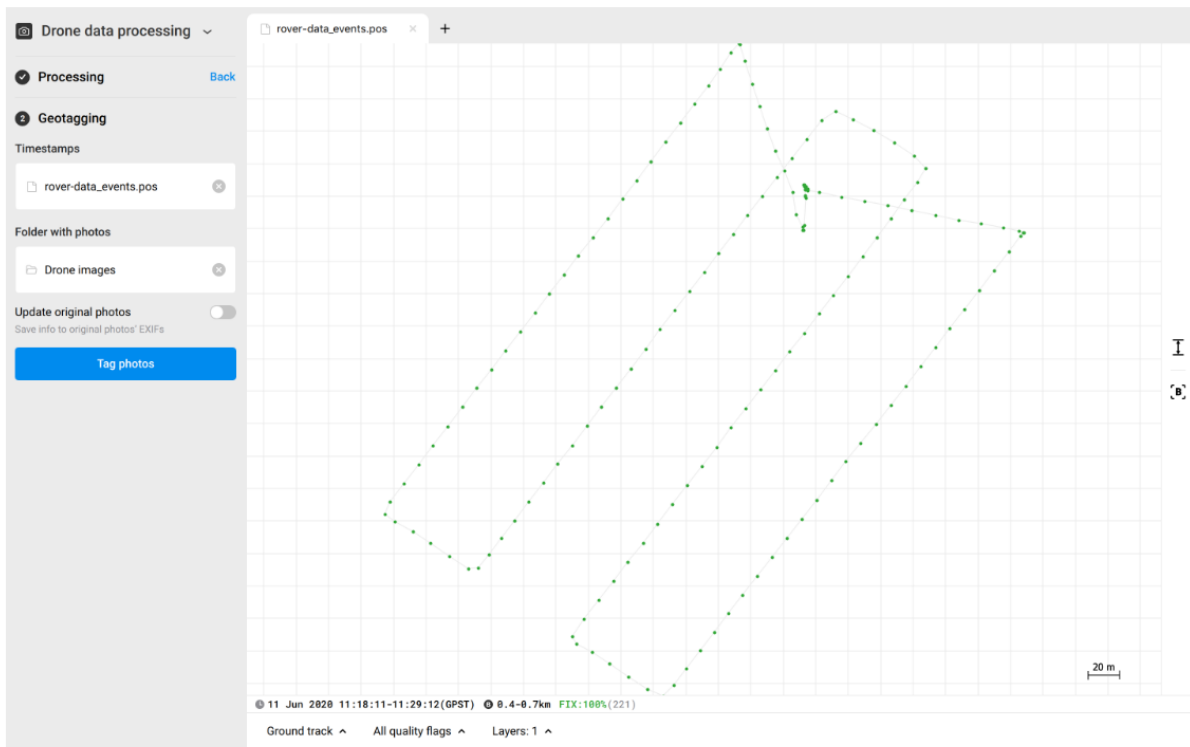
**Note:** *If you skipped the steps above, you need to add the `_events.pos` file manually. Drag and drop it to the Timestamps field.*

To geotag your photos, follow the steps below:

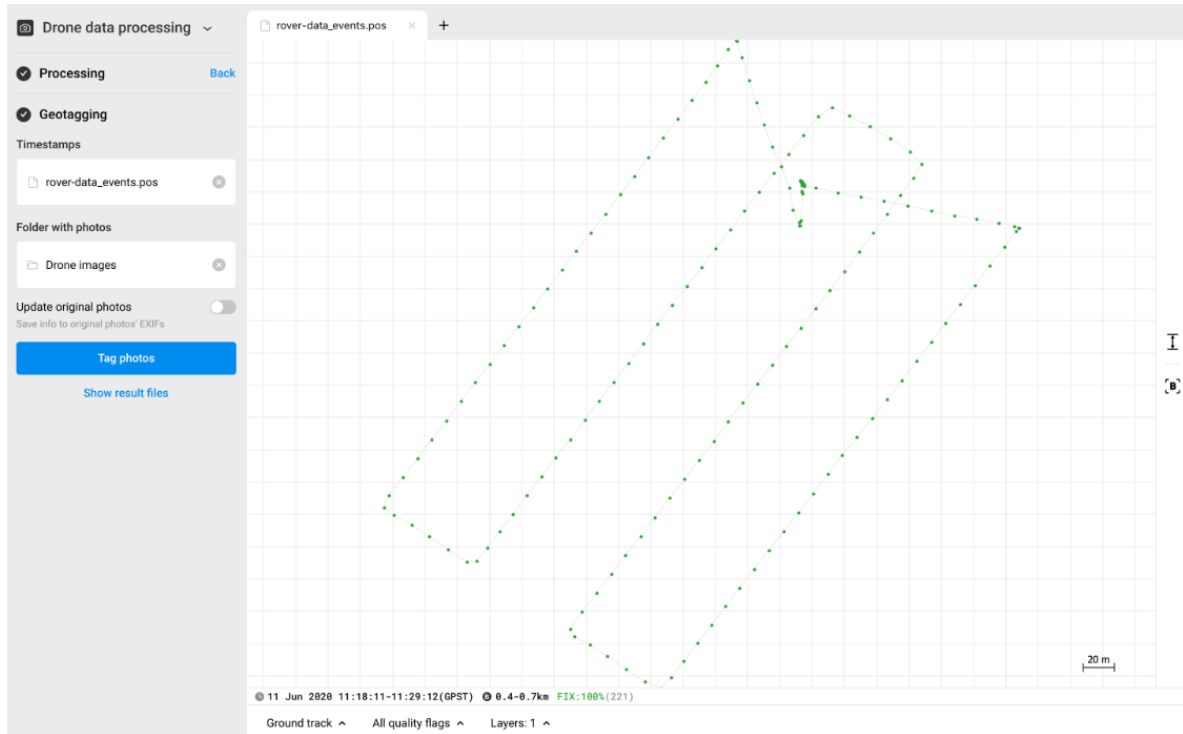
1. Select the folder that contains the photos from the drone's camera.

**Note:** *Emlid Studio can only geotag photos when the number of timestamps is equal to the number of photos.*

**Tip:** *If you want to update the original photos with geotags, toggle Update original photos. By default, Emlid Studio creates geotagged copies of the photos in a new folder.*



2. Click on the *Tag photos* button. The geotagging process will start. When the processing is over, you can click on Show result files to see the geotagged photos.



Once you have the geotagged photos, you can proceed with creating a map in the photogrammetry software.

**Tip:** To create a map using Pix4DMapper, check the *Creating map in Pix4D mapper tutorial*.

## 4.3 Creating map in Pix4Dmapper

**Tip:** This is the third part of a guide describing the PPK mapping workflow with Reach. It implies you already have raw logs from both base and rover, set of images, and Ground Control Points. If you do not, please check the Geotagging photos with Emlid Studio first.

At previous steps, we got centimeter-accurate geotags from Reach and georeferenced a set of images using this data in Emlid Studio. Now, we will turn it into a map.

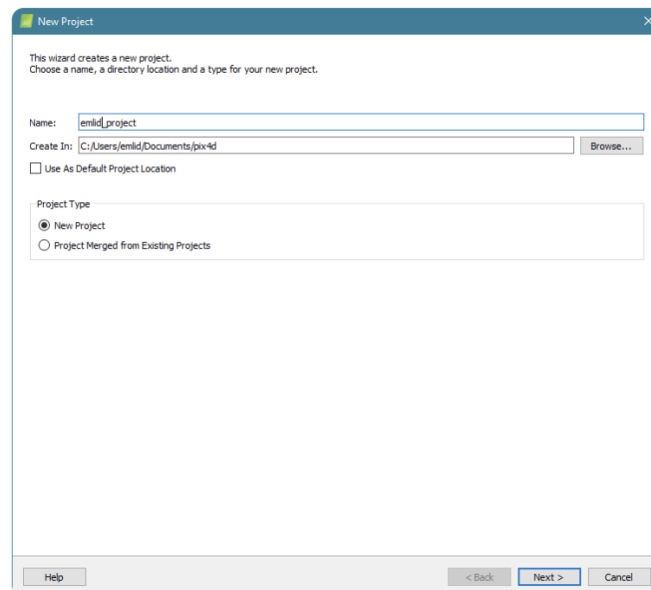
### 4.3.1 Overview

Pix4Dmapper is a photogrammetry software for drone mapping by Pix4D. It provides tools for creating digital maps and models and taking measurements based on them.

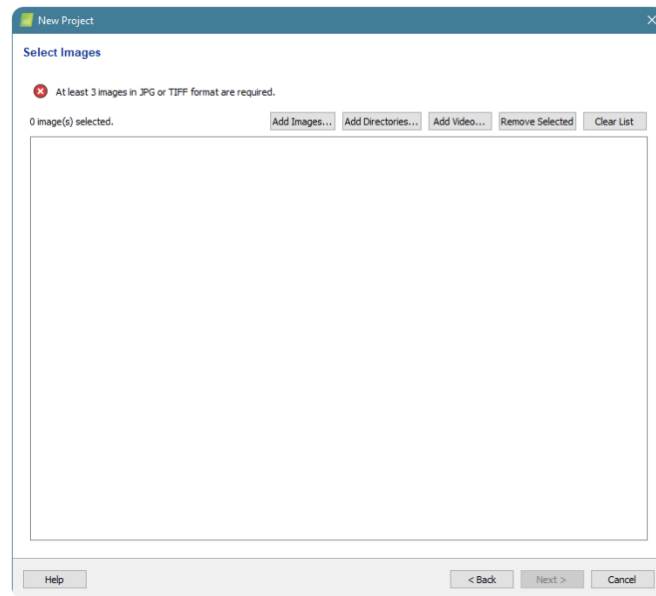
### 4.3.2 Create a new project

To create a new project in Pix4Dmapper do the following:

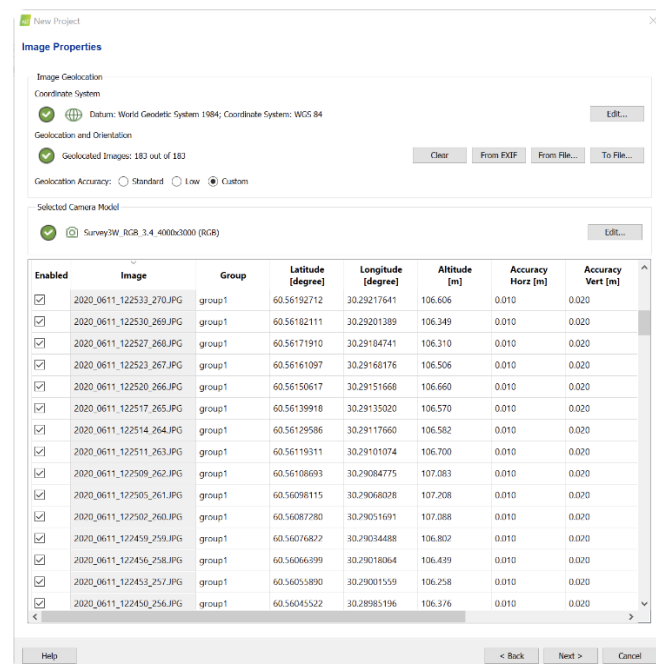
1. Start Pix4Dmapper.
2. Click *Project > New project...*, the *New Project* window will open.
3. In the *New Project* window, enter a name and browse for a directory.



4. Click *Next*. The *Select Images* window will open.



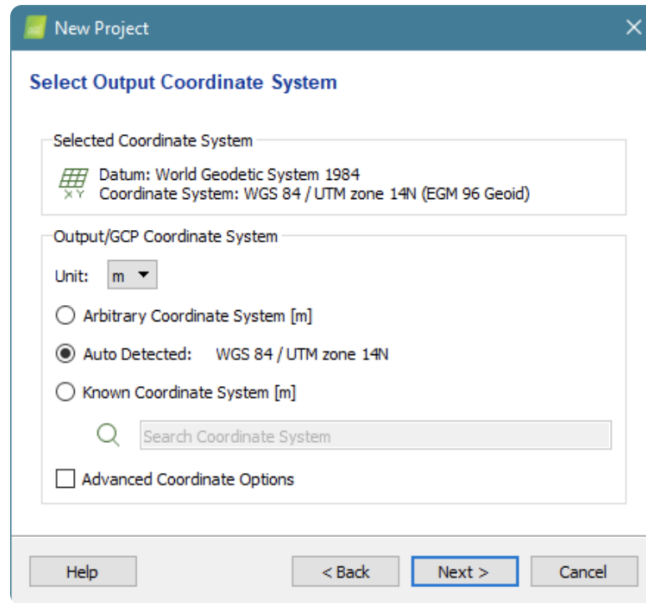
5. Click *Add images*. Browse to the image folder and select the images. They will display in the window. Click *Next*.



6. In *Image Geolocation Editor - Coordinate System*, click *Edit...* and select *WGS 84* and *Geoid Height Above WGS 84 Ellipsoid [m] = 0* in *Advanced Coordinate Options*.
7. In *Image Properties Editor - Images Table* adjust the *Accuracy Horz* and *Accuracy Vert* values to reflect the estimated accuracy of image geolocation.

**Tip:** *The Camera Model is usually defined automatically from images' metadata. However, it can be changed if necessary.*

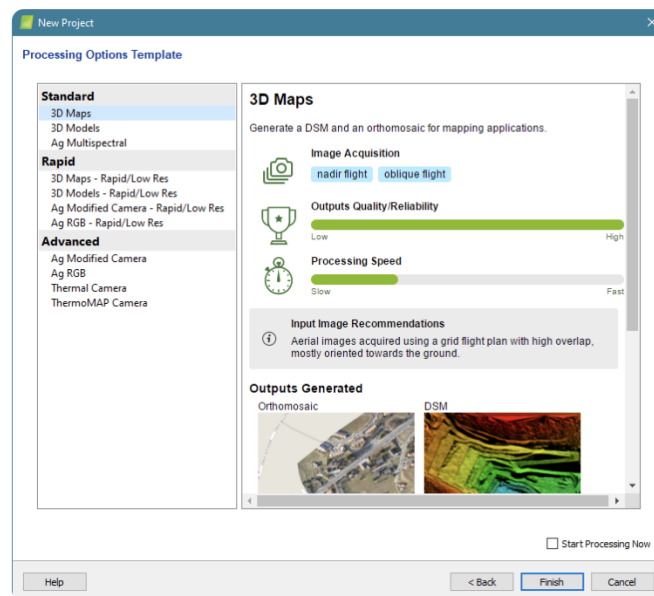
8. Select the *Output Coordinate System* that will be assigned to the generated results, for example, *DSM* and *orthomosaic*. If the images are georeferenced, a corresponding *UTM zone* will be auto-detected by default.



9. Choose *Processing Options Template*. The template defines parameters for each processing step and generated outputs.

The quality of the reconstruction and the processing time depend on the chosen parameters. If the goal is to generate a DSM and an orthomosaic, the 3D Maps template can be selected.

*Tip: Digital Surface Model (DSM) is a raster data format with an elevation value for each pixel. Orthomosaic is a 2D map generated based on multiple images using orthorectification. This method removes the perspective distortions from the images using the DSM.*



### 4.3.3 Import GCPs

**Tip:** *Ground control points are optional for PPK mapping. If you do not have them, please, go to the Processing section.*

For this step, the file with Ground Control Points (GCPs) is needed. The file must be in either a .csv or .txt file format and contain a point name, latitude and longitude in degrees, and altitude for each point. Use a comma to separate the values:

GCP0,46.23456,6.56114,299.931

GCP1,46.23234,6.56234,299.823

...

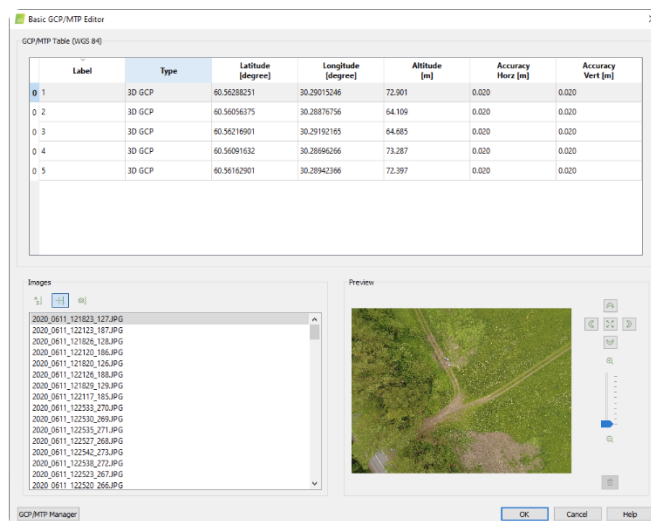
**Tip:** Reach supports points export in .csv format only.

To mark the GCPs on images:

1. Click Project > GCP/MTP Manager.... The GCP/MTP Manager window opens.
2. Click Import GCPs. In the Coordinates Order drop-down list, choose an appropriate option, browse to the points file, press OK.

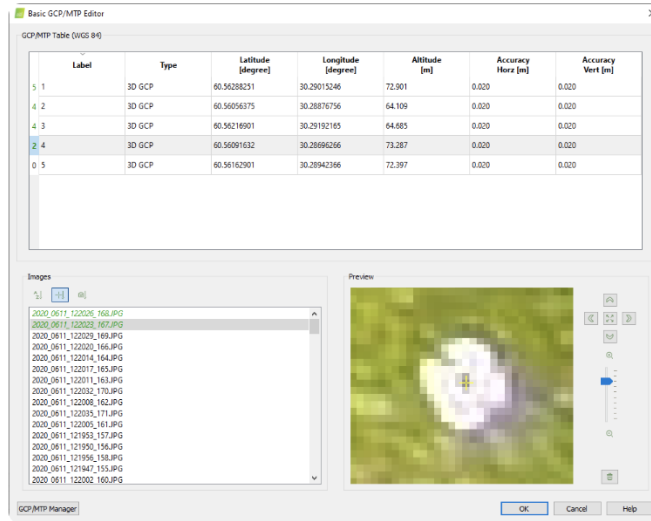
**Tip:** For Reach, the default order of coordinates is longitude, latitude, altitude.

3. In section *GCP/MTP Editor*, click *Basic Editor*.



**Tip:** GCPs can also be marked in the rayCloud after Initial Processing has been completed. Learn more about this method on Pix4D documentation.

4. Choose *Sort Images by Distance to GCP* in *Images* section. The images are displayed in order from the closest to the selected GCP to the farthest.
5. Find and mark every point on 3 images at least. Marking instruments are in the *Preview* window.



6. Once all the points are marked, press OK.

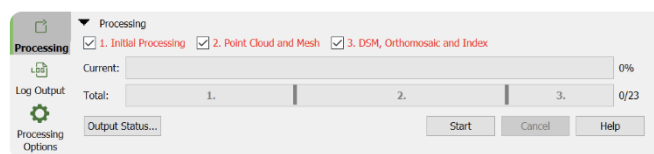
### 4.3.4 Process data

**Note:** There are three parts of processing:

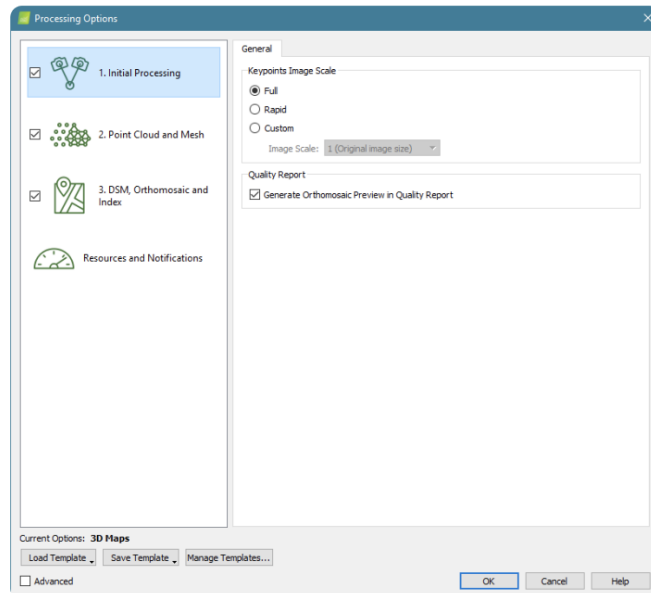
- *Initial processing: Keypoints are identified and matched in neighboring images and used for project reconstruction.*
- *Point Cloud and Mesh: The dense point cloud and 3D triangulated mesh are computed based on the results of the previous step.*
- *DSM, Orthomosaic, and Index: The DSM and orthomosaic are generated based on the dense point cloud.*

To start processing the project:

1. Click *Processing* in the bottom left corner of the main window.
2. Select all three processing steps and click *Start*:



**Tip:** If necessary, processing steps' parameters can be changed in the *Processing Options* menu. For example, the density of point cloud or DSM/orthomosaic resolution. In this guide, we use the standard settings of the 3D Maps template.



At the end of each step, a Quality report is generated and can be used to verify the success of processing.

The processing is finished. Now you can export this orthomosaic to any GIS software to create a vector map based on it.

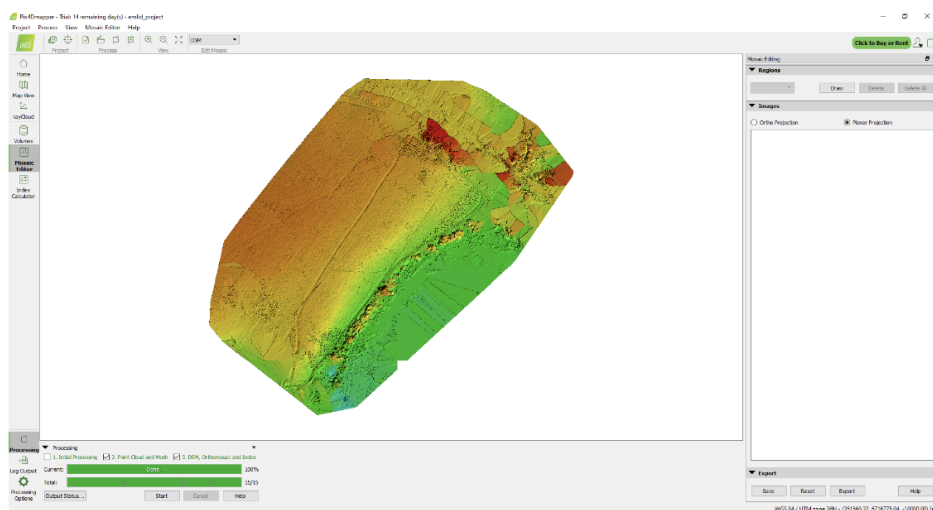
### 4.3.5 Get results

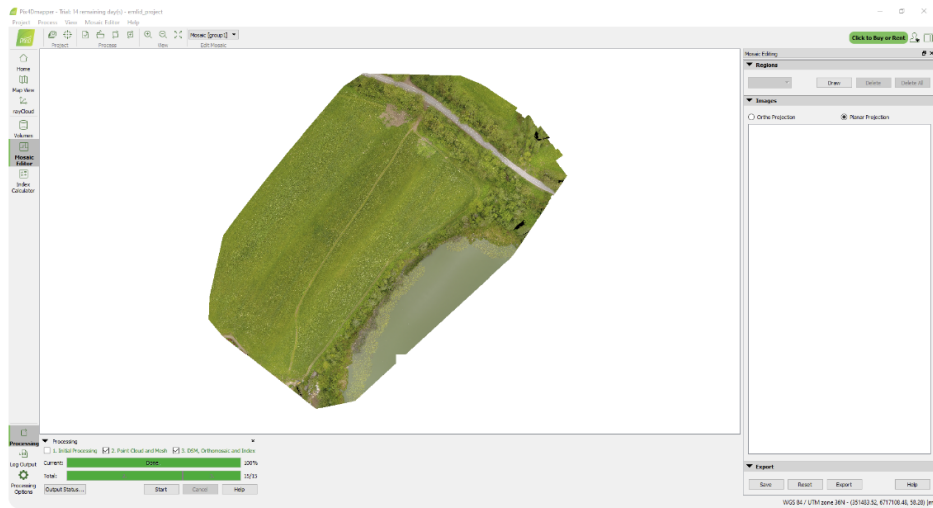
Once the project has been processed, it is possible to analyze and display results directly in Pix4Dmapper or import them in third-party software.

To open the folder with the results, on the *Menu* bar, click *Process > Open Results Folder...*

**Tip:** *The Orthomosaic and DSM are stored in the /3\_dsm\_ortho/2\_mosaic/ folder.*

To visualize the orthomosaic or DSM in Pix4Dmapper, click the *Mosaic Editor* tab.





The processing is finished. Now you can export this orthomosaic to any GIS software to create a vector map based on it.

**Tip:** To learn more about processing projects in the Pix4Dmapper, check the Pix4D documentation.

## 5 Tutorials—Integration with external software and devices

### 5.1 Getting Reach coordinates on Android via BT

This guide describes how to get precise coordinates from Reach on an Android device over Bluetooth.

#### 5.1.1 Overview

**Caution:** *Make sure your Android device provides Bluetooth connectivity.*

Some of the survey and GIS apps for Android used with Reach:

- Mobile Topographer Pro
- PointMan
- ESRI ArcGIS Collector
- Mapit GIS
- LandStar
- Autocad360
- QField

#### 5.1.2 Pairing Reach with Android device

**Tip:** *To output a centimeter accurate position, Reach should be in RTK mode. To learn more, check the [How RTK works article](#).*

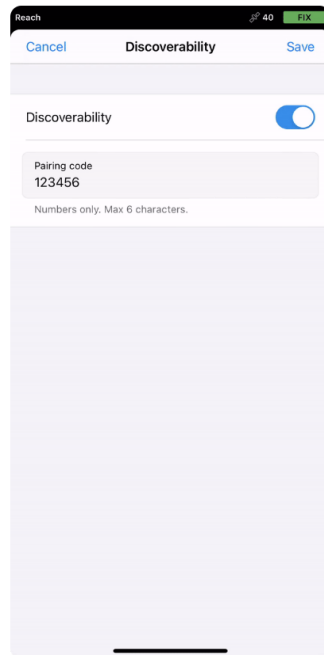
Configure Reach unit to act as a rover in RTK.

**Getting corrections from Reach RS2/RS2+ base on Reach RS2/RS2+ rover:** *Set up RTK communication between 2 Reach RS2/RS2+ units over LoRa radio following this video guide.*

**Getting corrections from NTRIP/CORS:** *Configure NTRIP/CORS network as a source of positioning corrections for Reach rover following this guide.*

#### 5.1.3 Access Reach rover using Emlid Flow

1. Go to Wi-Fi settings on your device.
2. Connect to Reach hotspot. It appears as **reach:XX:XX**.
3. Enter the password **emlidreach**.
4. Open Emlid Flow and connect to your Reach.
5. Go to *Settings* and tap *Bluetooth*.
6. Enable Bluetooth by tapping the *Turn on Bluetooth* button.
7. Tap *Discoverability* and turn on the *Discoverability* option. Tap *Save* to apply changes.

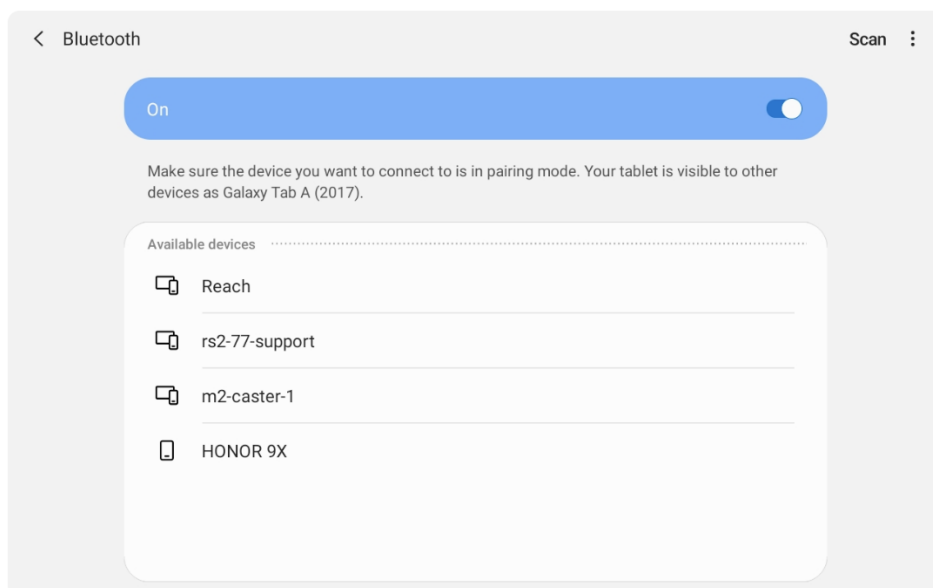


**Note:** *Reach* name is displayed just above its MAC. In this guide, we used the unit named as **Reach**.

#### 5.1.4 Access an Android device

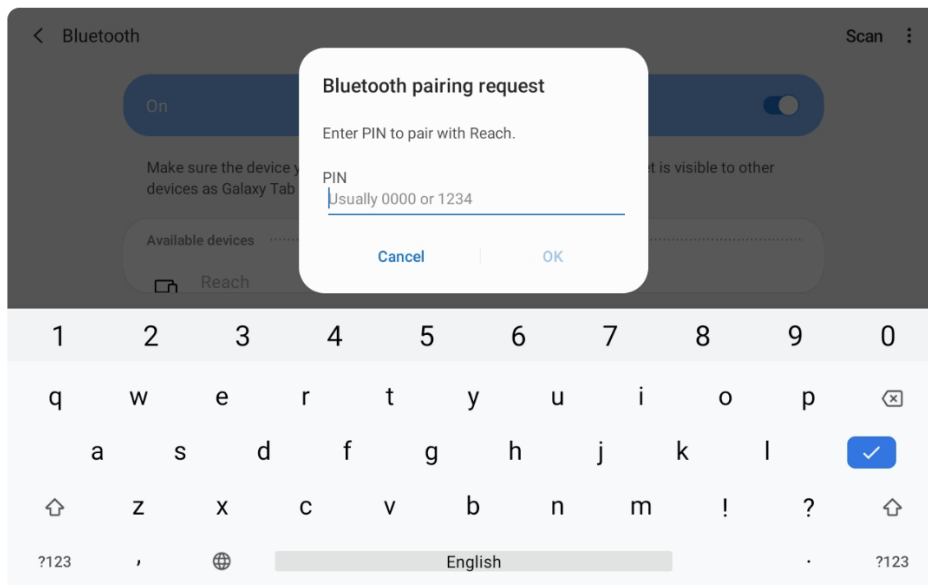
1. Navigate to the *Bluetooth configuration* screen. Activate the Bluetooth connection.
2. Wait for Reach to be listed as an available device.

**Tip:** *Keep Reach within a few meters from your Android device.*

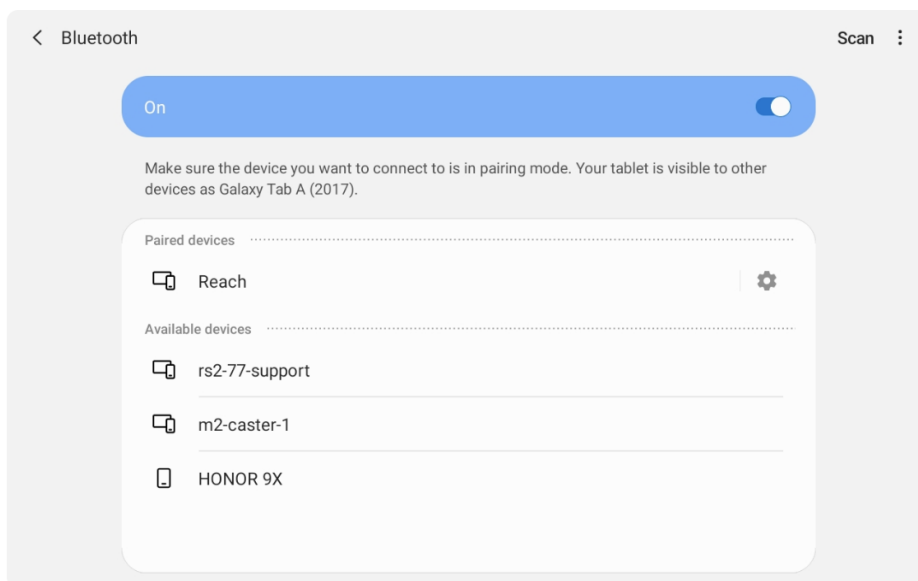


3. Tap the name of your Reach in the list of available devices on the Android device.
4. You should receive a pairing request from Reach.

5. Enter the PIN code of your Reach unit and confirm it.

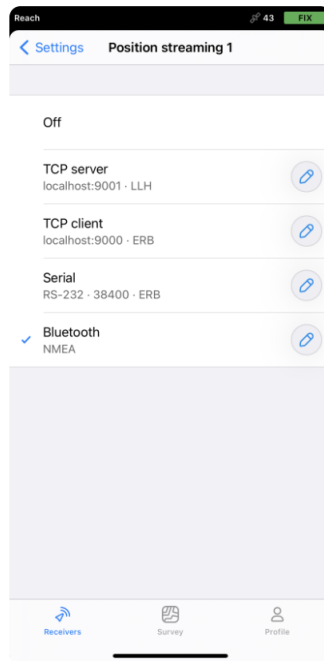


Reach and Android device are now paired.

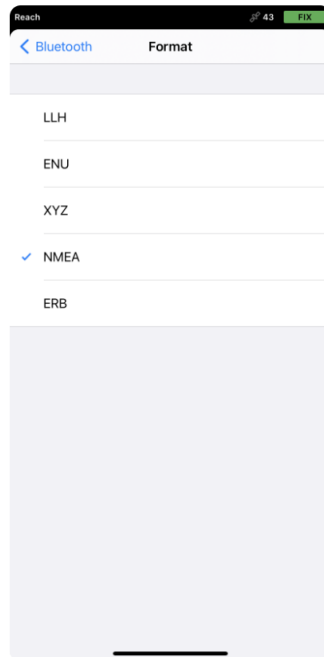


### 5.1.5 Position streaming from Reach to Android

1. Open Emlid Flow and connect to your Reach.
2. Go to *Settings* and tap *Position streaming 1*.
3. Select *Bluetooth*.
4. To configure position streaming, tap the *Edit button* in the *Bluetooth* cell.



5. Tap *Format* and choose *NMEA*. Apply changes.



### 5.1.6 Android mock location

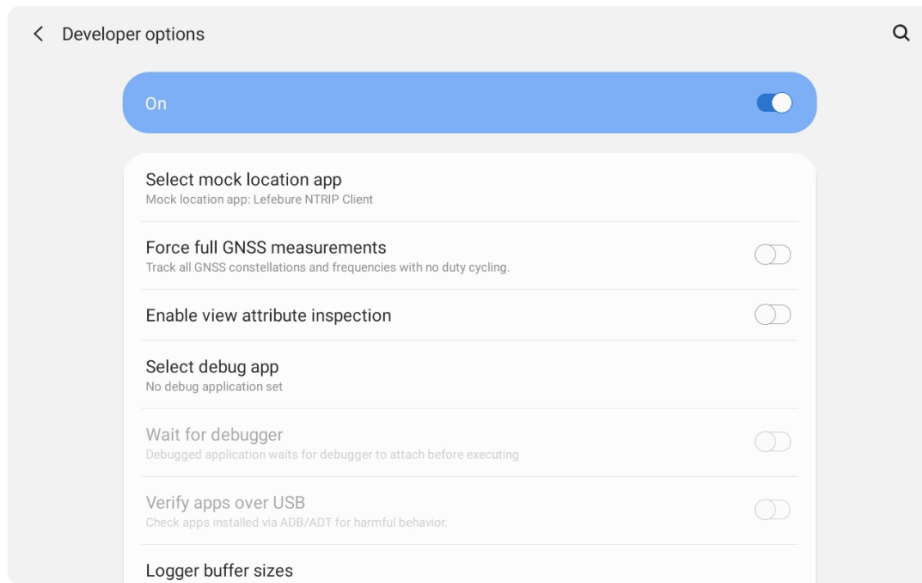
We provide a guide on how to use Reach with Lefebure NTRIP Client.

Besides being an NTRIP Client, this app also allows NMEA data input via Bluetooth and supports Android feature called **mock location**. This feature allows substituting your device's built-in GPS receiver with an external location provider.

**Note:** *Lefebure NTRIP Client allows the survey and GIS apps on the Android device to use accurate coordinates from Reach.*

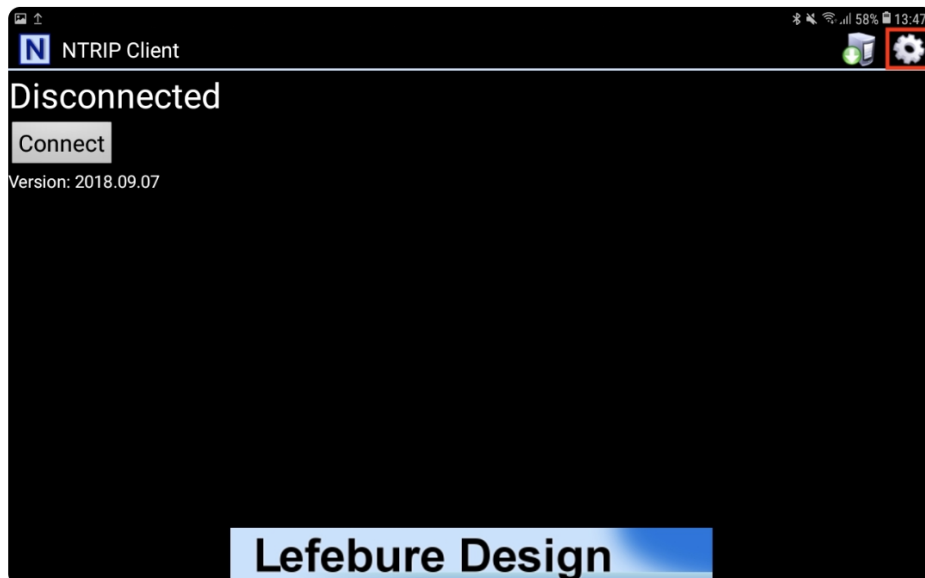
1. Install the app Lefebure NTRIP Client on your Android device.

2. Open *Developer options* on your Android device and choose Lefebure NTRIP Client in the *Select mock location app* field.

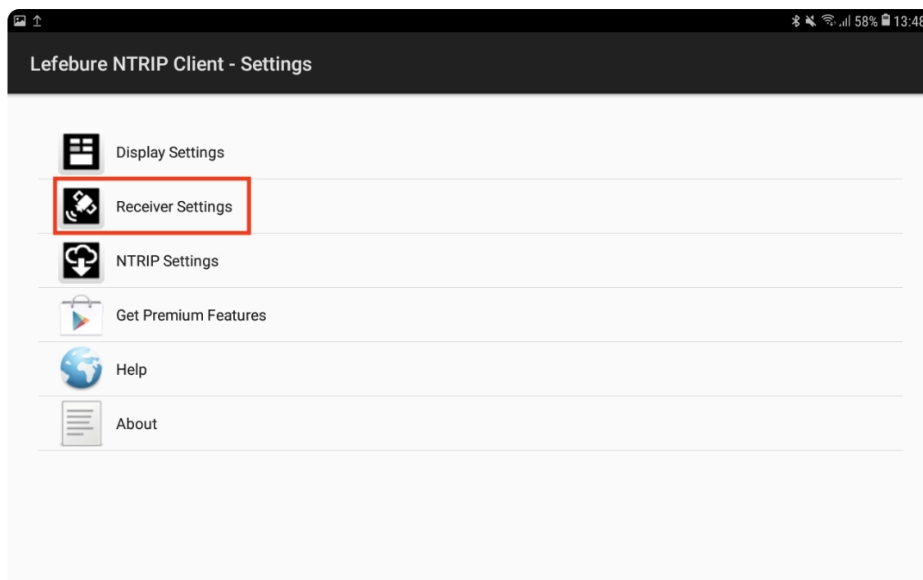


**Note:** *It is recommended to switch off the power-saving mode on your phone as it may limit background data usage for the Lefebure NTRIP client app.*

3. Launch the Lefebure NTRIP Client app and tap on the settings icon (gear in the upper right corner).

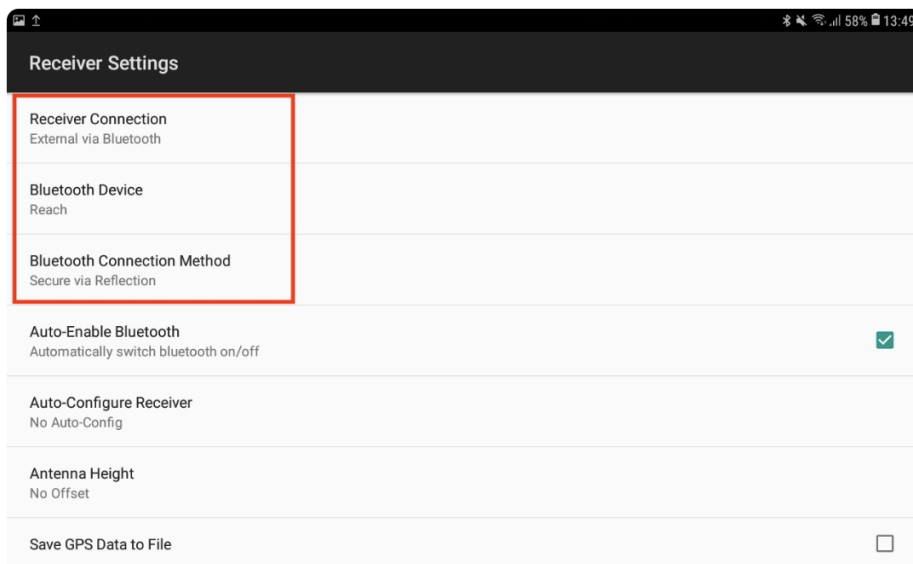


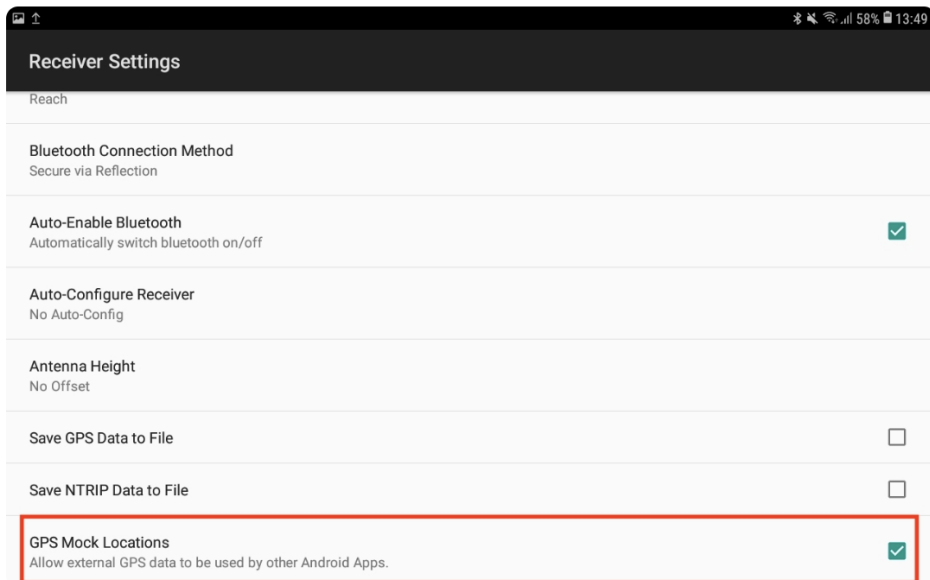
4. Go to the *Receiver Settings*.



Inside the receiver's settings, set the following:

- *Configure Receiver Connection as External via Bluetooth.*
- *Change Bluetooth device to the Reach you are paired with.*
- *Change Bluetooth Connection Method to Secure via Reflection.*
- *Enable GPS Mock Locations.*





5. Go back to the main screen and tap the *Connect* button.

**Tip:** Check the log messages to confirm the Bluetooth connection got established and the information about satellites is updated.



From this moment on, all apps on the Android device that use location services will automatically have access to the positional data streamed from Reach. You can just open a surveying or GIS app you want to use and start surveying.

**Note:** Tapping the *Disconnect* button in the Lefebure NTRIP Client will revert back to the Android built-in GNSS.

## 5.2 ArduPilot integration

This guide shows how to configure Reach to send the position to ArduPilot autopilots.

## 5.2.1 Overview

Reach supports RTK-enhanced coordinates output to Navio2 and Pixhawk. To make this possible, we implemented a custom GPS protocol named ERB. If needed, you can use the industry-standard NMEA format instead.

**ArduPilot requirements:** *ERB support is included to ArduPilot starting with the following versions:*

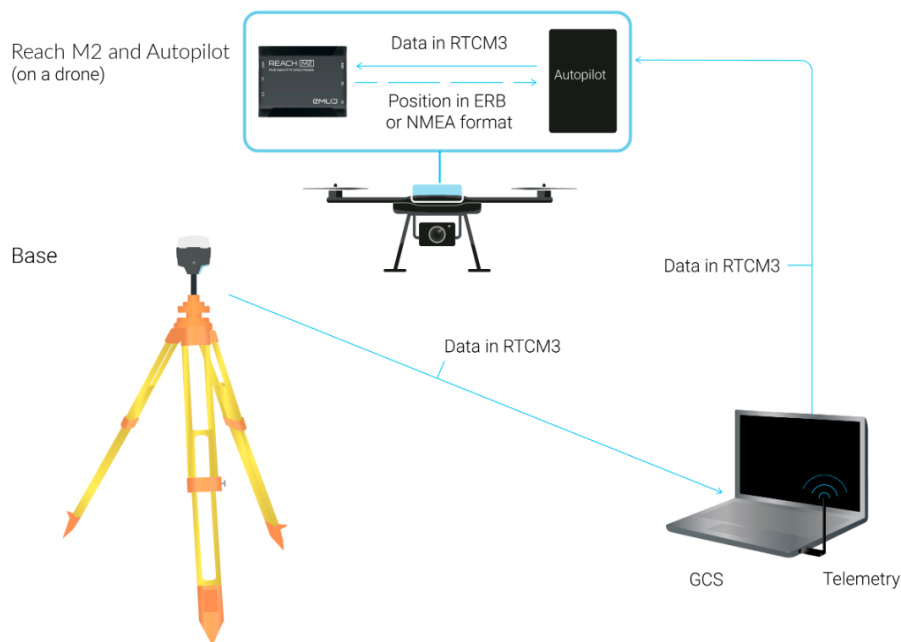
- *ArduCopter 3.4*
- *ArduPlane 3.5.0*
- *APMrover 3.1*

*You can check the ERB protocol description [here](#).*

You can find a [demo video](#) with our results on YouTube.

## 5.2.2 Recommended setup

We recommend the following setup:



- Navio2, Edge, or Pixhawk with the ArduPilot firmware. It is preferable to use the last stable version.
- Base station is the Reach RS2/RS2+/RS2+ or Reach RS/RS+ unit in Wi-Fi AP mode, configured as a TCP server.
- GCS (Ground Control Station) is a laptop with Mission Planner (version 1.3.35 and higher), connected to the base Reach Wi-Fi hosted network.
- Telemetry connection that is provided via a serial radio.
- Rover Reach M2 or Reach M+ unit is mounted on a drone and connected to Navio2 or Pixhawk via the 6P-to-6P wire. This connection type will solve three issues at once: power Reach, allow ArduPilot board to pass base corrections and allow Reach to pass RTK solution back.

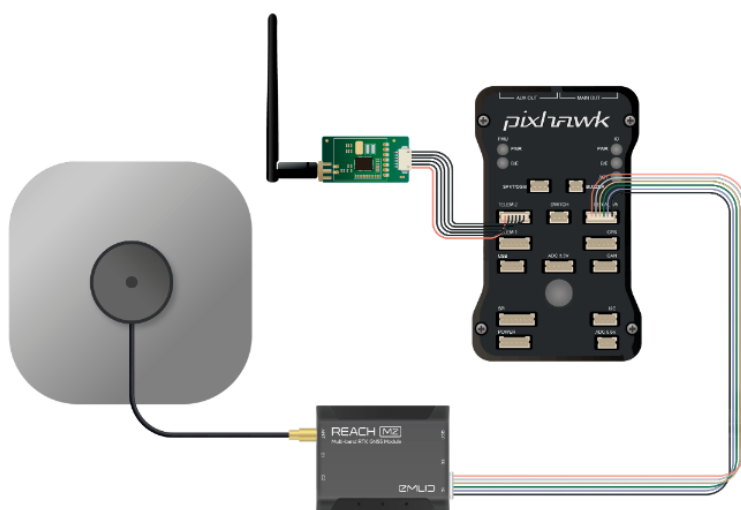
The following guide will show you how to configure Navio2 or Pixhawk and Reach to work in this setup. If you want to change the workflow, it should be easy to do so, as every part of the system is independent of others.

### 5.2.3 Connect Reach to Autopilot

To pass the position data from Reach, connect it to your autopilot. You can connect your Reach to Pixhawk, Navio2, and Edge.

#### Connect Reach to Pixhawk

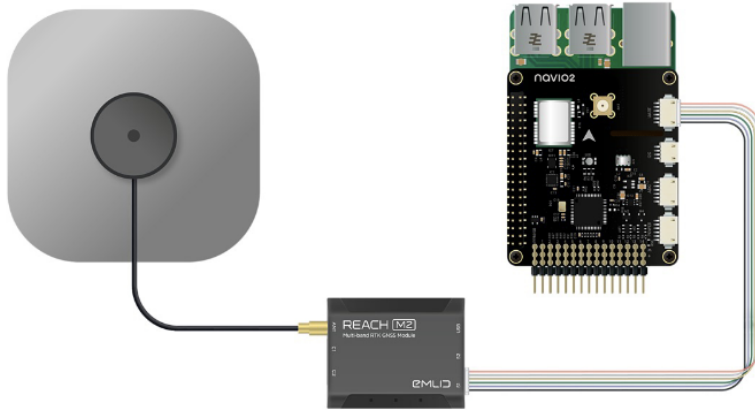
To provide RTK solution to Pixhawk, Reach needs to be connected via a serial port. You can do that by plugging the serial cable into Reach receiver's JST-GH port and Pixhawk's Serial 4/5 connector.



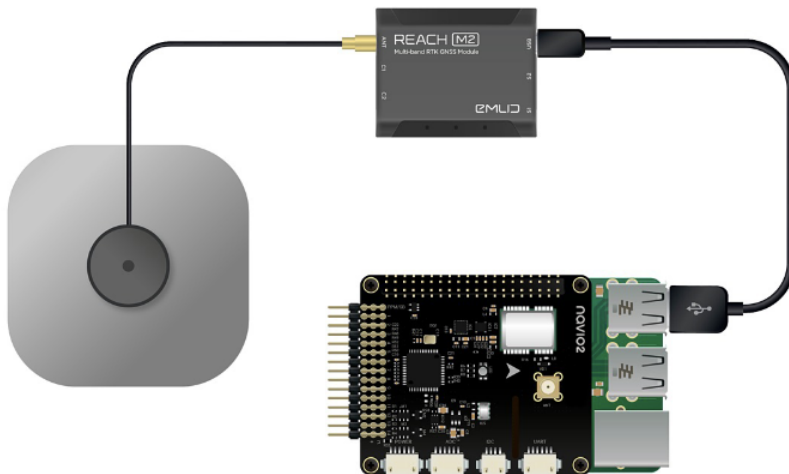
**Note:** *It is recommended to supply Reach from an external power source. Pixhawk may not provide enough power for Reach in some cases.*

#### Connect Reach to Navio2

You can connect Reach receiver to Navio2 in two ways: over UART or USB. To provide Navio2 with RTK solution over UART, connect Reach receiver's JST-GH port with the UART port on Navio2.



To work with USB, connect Reach receiver's Micro-USB port with a USB port on your Raspberry Pi.



## 5.2.4 Configure Reach Module to work with ArduPilot

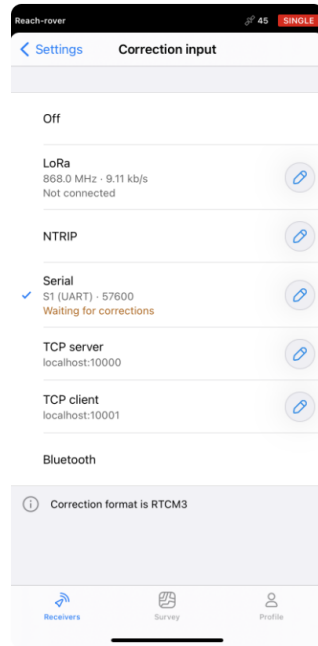
### Set up your rover

**Note:** *The serial connection is used to accept base corrections and send solution at the same time.*

First, configure the corrections input:

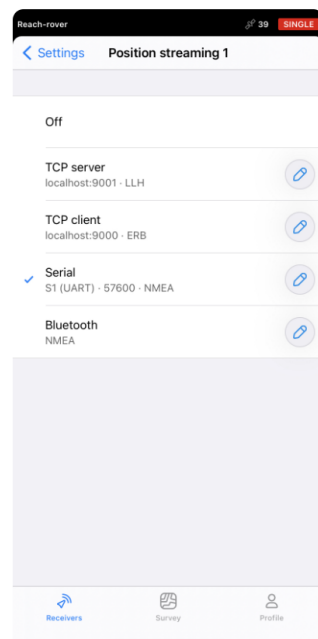
1. Open Emlid Flow and connect to your rover.
2. Tap *Correction input*.
3. Select *Serial*.
4. Choose *S1 (UART)* or *USB to PC* as the port.
5. Choose the desired baud rate (57600 for default).

6. Tap *Save* button to save settings.



After that, configure the position streaming:

1. Return to the *Receivers* screen and go to *Settings*.
2. Tap *Position streaming 1*.
3. Select *Serial*.
4. Choose *S1 (UART)* or *USB to PC* as the port.
5. Choose the desired baud rate (57600 for default).
6. Choose *NMEA* or *ERB* as position streaming format.
7. Tap *Save* button to apply changes.



## 5.2.5 Set up a correction link

Reach supports a number of ways to accept base corrections, including the popular in UAV area serial radios. However, having a separate radio link for base corrections only is highly ineffective. To solve this, you can use the telemetry radio as a carrier for RTK corrections. GCS can pass these corrections to the autopilot with a feature called GPS inject. This functionality is available in Mission Planner only.

## 5.2.6 Configure Radio to embed corrections Into telemetry

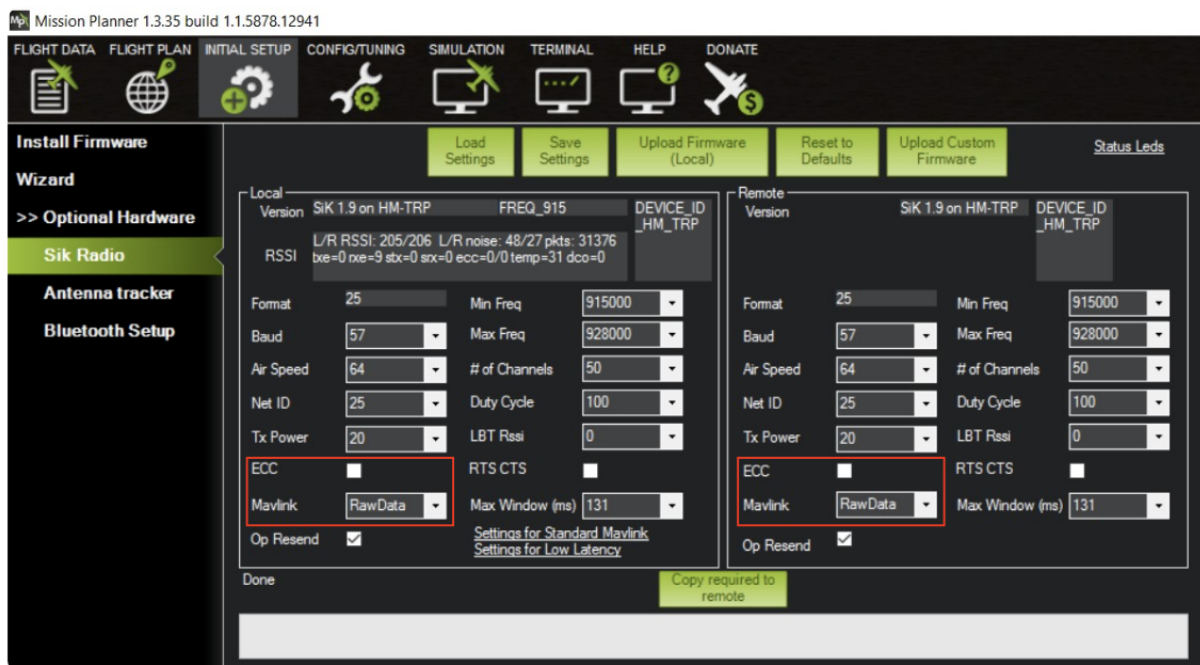
With default settings, radio telemetry is not optimised for sending RTK corrections. This may cause correction data delivery delays and even loss. These slips will deteriorate RTK solution quality, so you need to minimize them.

**Note:** *Radio configuration is done with telemetry disconnected.*

To configure a radio, do the following:

**Caution:** *Make sure MAVLink connection is disabled before changing radio settings.*

1. Click *INITIAL SETUP* in the menu bar.
2. Go to *Optional Hardware* and select *Sik Radio* in the side menu.
3. Click *Load Settings* and wait for the parameters of both radios to load.
4. Uncheck the *ECC* field.
5. Choose *RawData* in the *Mavlink* field.
6. Click *Save Settings*.



## 5.2.7 Configure ArduPilot to accept Reach Module solution

**Caution:** *It is recommended to use Reach as a second GPS unit only.*

To launch ArduPilot on Navio2, add to your starting command one of the following arguments:

- For UART connection:

```
-E /dev/ttyAMA0
```

- For USB connection:

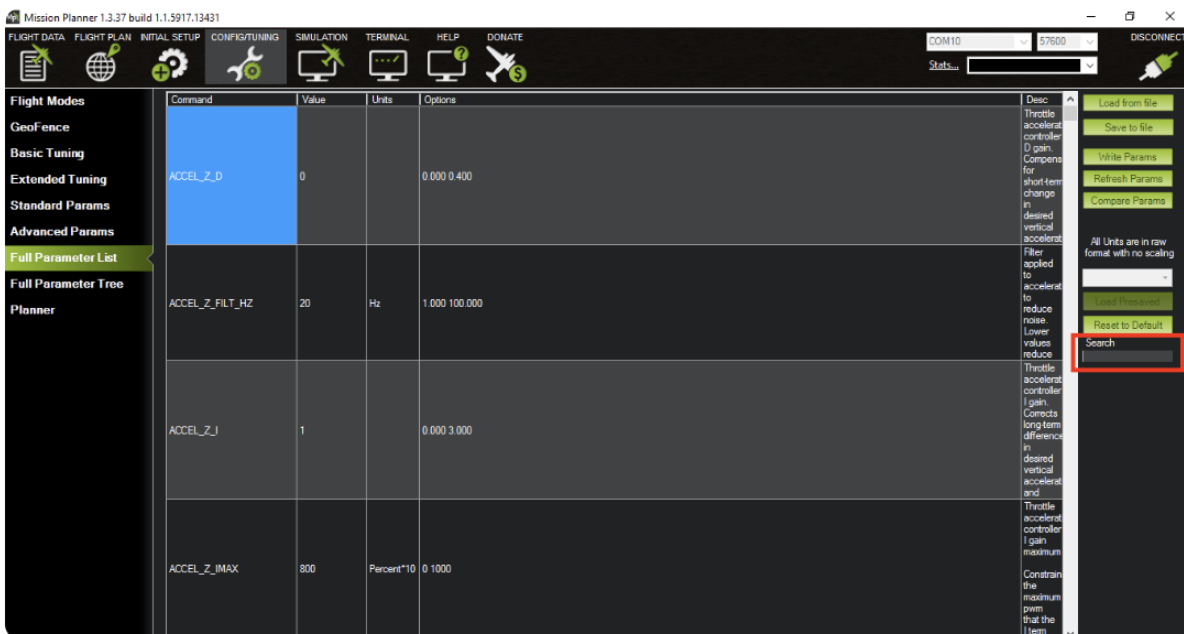
```
bash -E /dev/ttyACM0
```

This will allow using Reach as an external GPS.

ArduPilot configuration will require setting some parameters via Mission Planner. After connecting, do the following:

1. Go to the *CONFIG* menu.
2. Select *Full Parameter List* in the left side menu. To find the desired parameter quickly, use a search box on the right (highlighted in red).

**Caution:** *If you are working with Pixhawk, reboot it each time you set a parameter for a change to take effect. Unplug it and plug in back to the USB port again.*



3. Set *GPS\_TYPE2* parameter to 5 - *NMEA* or 13 - *ERB*. This will enable the second GPS input.

**Note:** *Make sure to select the same parameter you set in Position streaming on your rover.*

Command	Value	Units	Options	Desc	Fav
EK2_ALT_SOURCE	0		0:Use Baro 1:Use Range Finder 2:Use GPS 3:Use Range Beacon	Primary height sensor used by the EKf. If the selected option cannot be used, baro is used. 1 uses the range finder and only with optical flow navigation (EK2_GPS_TYPE = 3). Do not use "1" for terrain following. NOTE: the EK2_RING_USE_HGT parameter can be used to switch to range finder when close to the ground.	<input type="checkbox"/>
EK2_GPS_TYPE	0		0:GPS 3D Vel and 2D Pos 1:GPS 2D vel and 2D pos 2:GPS 2D pos 3.No GPS	This controls use of GPS measurements : 0 = use 3D velocity & 2D position, 1 = use 2D velocity and 2D position, 2 = use 2D position, 3 = Inhibit GPS use - this can be useful when flying with an optical flow sensor in an environment where GPS quality is poor and subject to large multipath errors.	<input type="checkbox"/>
GPS_TYPE	9		0:None 1:AUTO 2:uBlox 3:MTK 4.MTK19 5.NMEA 6.SIRF 7:HIL 8.SwifNav 9.UAVCAN 10.SBF 11.GSOF 13.ERB 14.MAV 15.NOVA 16.HemisphereNMEA 17.uBlox-MovingBaseline-Base 18.uBlox-MovingBaseline-Rover	GPS type	<input type="checkbox"/>
GPS_TYPE2	5		0:None 1:AUTO 2:uBlox 3:MTK 4.MTK19 5.NMEA 6.SIRF 7:HIL 8.SwifNav 9.UAVCAN 10.SBF 11.GSOF 13.ERB 14.MAV 15.NOVA 16.HemisphereNMEA 17.uBlox-MovingBaseline-Base 18.uBlox-MovingBaseline-Rover	GPS type of 2nd GPS	<input type="checkbox"/>

- Set `SERIAL4_BAUD` parameter to the same baud rate as chosen in *Emlid Flow Position streaming* settings. Note the options corresponding to the different baud rates.
- Set `SERIAL4_PROTOCOL` parameter to 5 - *GPS*.

Command	Value	Units	Options	Desc	Fav
SERIAL4_BAUD	38		1:1200 2:2400 4:4800 9:9600 19:19200 38:38400 57:57600 111:111100 115:115200 256:256000 500:500000 921:921600 1500:1500000	The baud rate used for Serial4. Most stm32-based boards can support rates of up to 1500. If you setup a rate you cannot support and then can't connect to your board you should load a firmware from a different vehicle type. That will reset all your parameters to defaults.	<input type="checkbox"/>
SERIAL4_OPTIONS	0			Control over UART options. The InvertRX option controls invert of the receive pin. The InvertTX option controls invert of the transmit pin. The HalfDuplex option controls half-duplex (onewire) mode, where both transmit and receive is done on the transmit wire.	<input type="checkbox"/>
SERIAL4_PROTOCOL	5		-1:None 1:MAVLink1 2:MAVLink2 3:Frisky D 4:Frisky SPort 5:GPS 7:Alexmos Gimbal Serial 8:S To RM32 Gimbal Serial 9:RangeFinder 10:Frisky SPort Passthrough (OpenTX) 11:Lidar360 13:Beacon 14:Volz servo out 15:SBUS servo out 16:ESC Telemetry 17:Devo Telemetry 18:OpticalFlow 19:RobotisServo 20:NMEA Output 21:WindVane 22:SLCAN 23:RCIN 24:MegaSquirt EFI 25:LTM 26:RunCam 27:HotT elem 28:Scripting 29:Crossfire 30:Generator 31:Winch	Control what protocol Serial4 port should be used for. Note that the Frisky options require external converter hardware. See the wiki for details.	<input type="checkbox"/>

- Set `GPS_AUTO_SWITCH` to 1 - *Enabled*. Autopilot will automatically switch between the two GPS receivers picking the one with better solution.

Command	Value	Units	Options	Desc
GPS_AUTO_SWITCH	1		0:Disabled 1:Enabled	Automatic switchover to GPS reporting best lock.

- Set `GPS_INJECT_TO` parameter to 1. Here, it stands for the second GPS input. If you configured Reach as the first input, set this parameter to 0.

Command	Value	Units	Options	Desc
GPS_INJECT_TO	1			

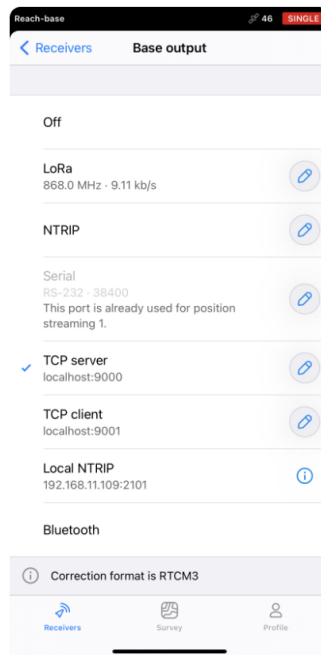
**Bad GPS signal health** If Mission Planner reports *Bad GPS Signal Health* error, make sure GNSS update rate on Reach is 5 Hz or higher.

## 5.2.8 Set up your base

Now you need to configure your Reach base to send the corrections. Follow the steps below:

- Open Emlid Flow and connect to your base.
- Tap *Base output*.

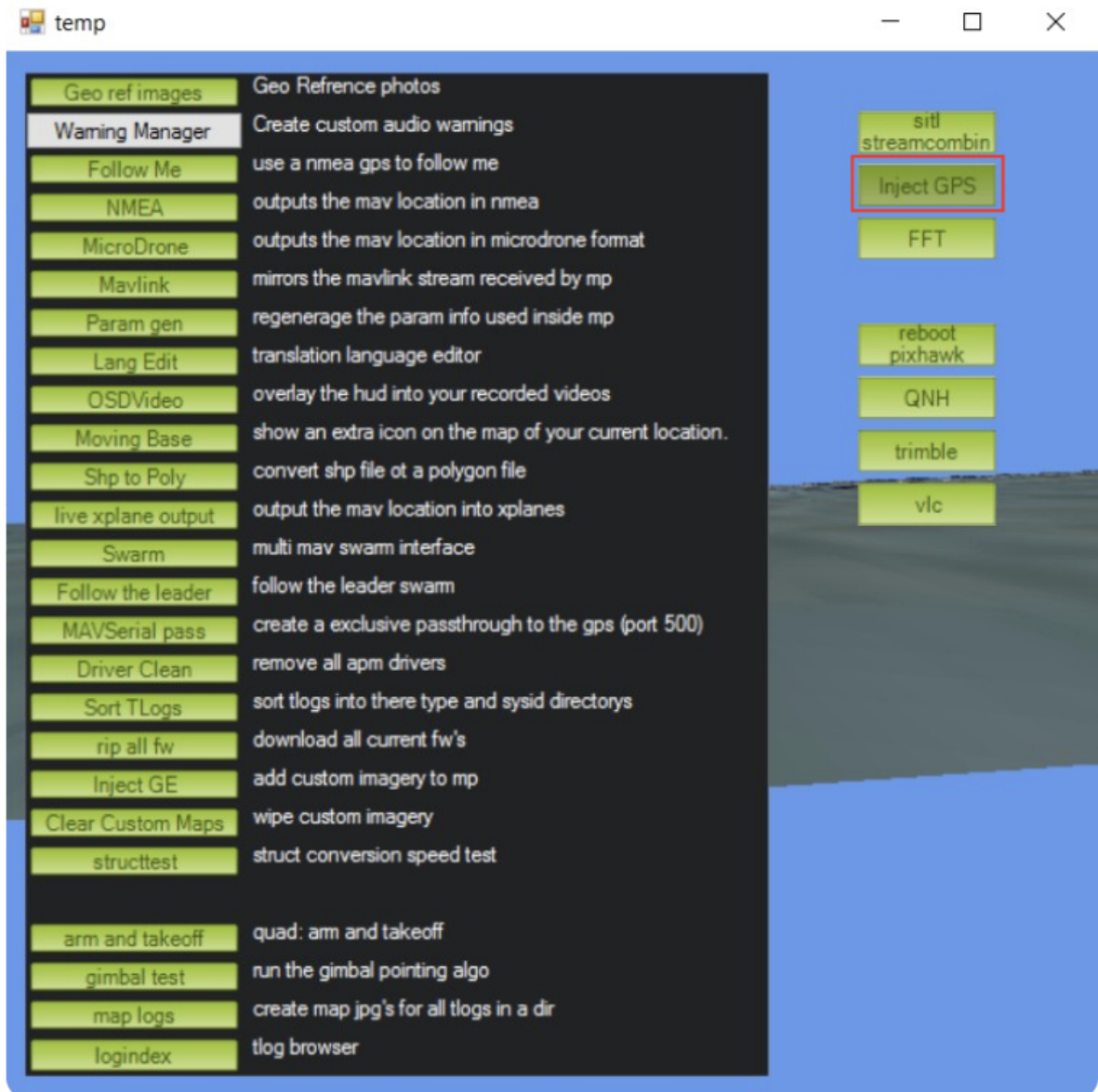
3. Choose *TCP server*.
4. Set 9000 as a port.
5. Tap *Save* button to save settings.



### 5.2.9 Configure mission planner to inject corrections into telemetry

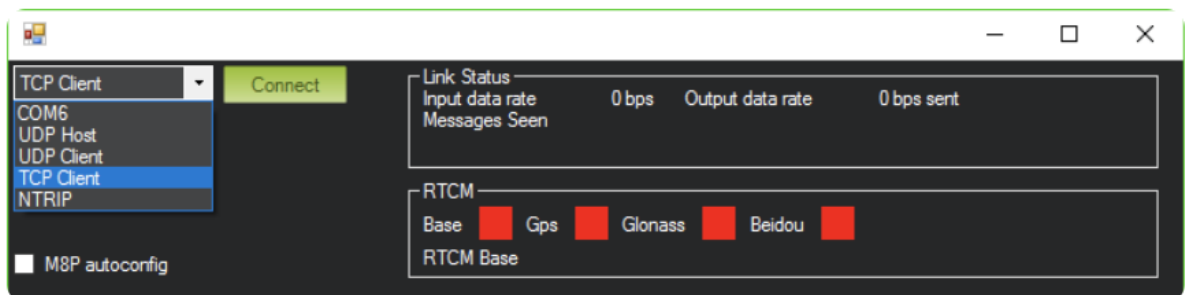
To enable and configure GPS inject options in Mission Planner, you need to open a window with advanced GCS settings. Do as follows:

1. Press *CTRL+F* button combination. This will open a window with advanced GCS settings.
2. Click *Inject GPS* button on the right.

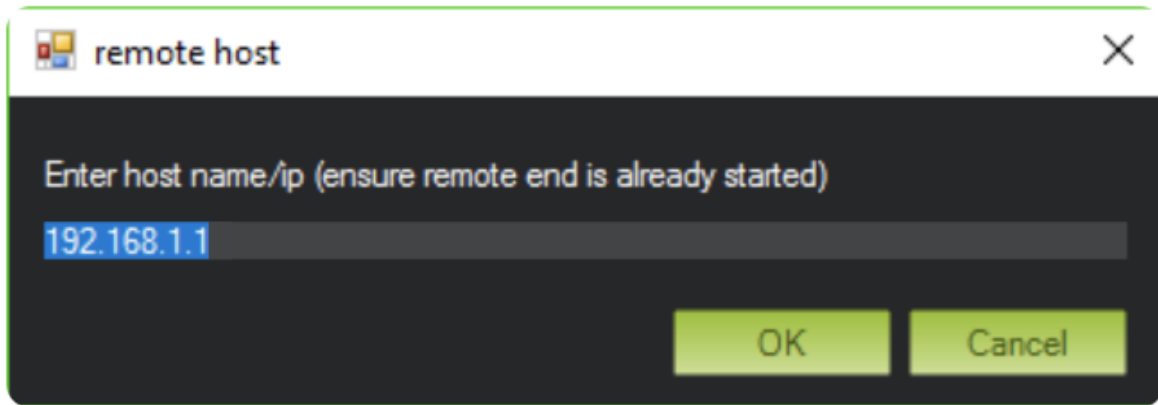


After that, in the new window, you need to choose parameters for base connection. Follow the steps below:

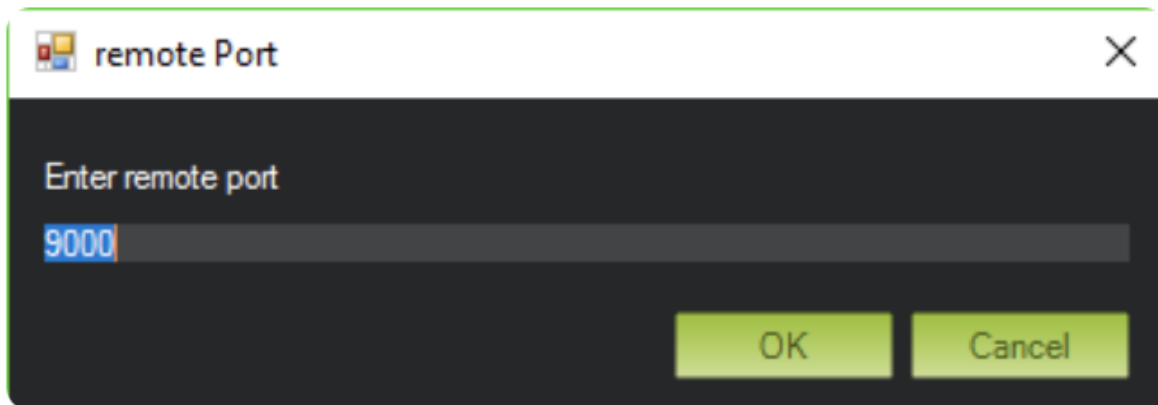
1. Choose *TCP Client* and press *Connect*.



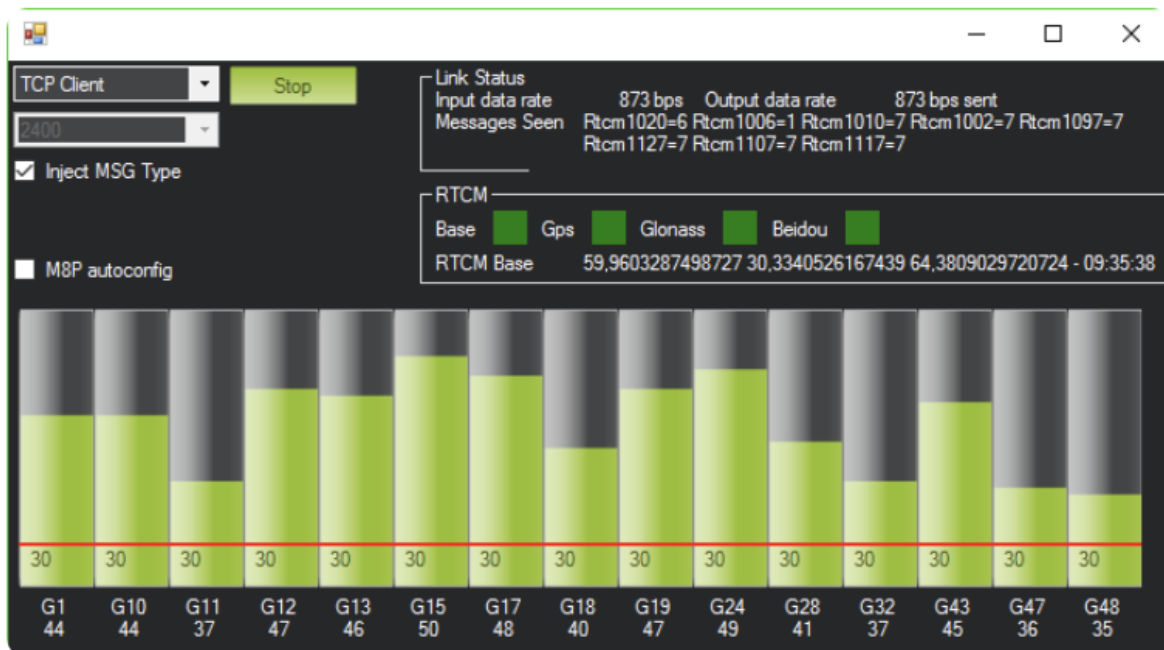
2. Enter the Reach base's IP address and press *OK*.



3. Enter the server port number and press *OK*.



4. Finally, check the corrections are coming in.



## 6 Specifications

### 6.1 Mechanical specs

File name	Download link
Reach 3D model in STEP format	<a href="#">Reach [STEP, 2.1 MB]</a>
Reach 3D model in IGES format	<a href="#">Reach [IGES, 3.6 MB]</a>
Reach LoRa radio 3D model in STEP format	<a href="#">LoRa radio [STEP, 344 KB]</a>
Reach LoRa radio 3D model in IGES format	<a href="#">LoRa radio [IGES, 661 KB]</a>
Reach M2 GNSS antenna 3D model in STEP format	<a href="#">GNSS antenna [STEP, 2.8 MB]</a>

### 6.2 Dimensions



Reach M2/M+ weights 35g.

### 6.3 Connectors mating parts

Reach has 4 JST-GH connectors and comes with all required cables to connect to other devices. Antenna connector is MCX, to connect to SMA or TNC antenna cable you can use one of the numerous adapters.



## 6.4 Electrical specs

### 6.4.1 Maximum ratings

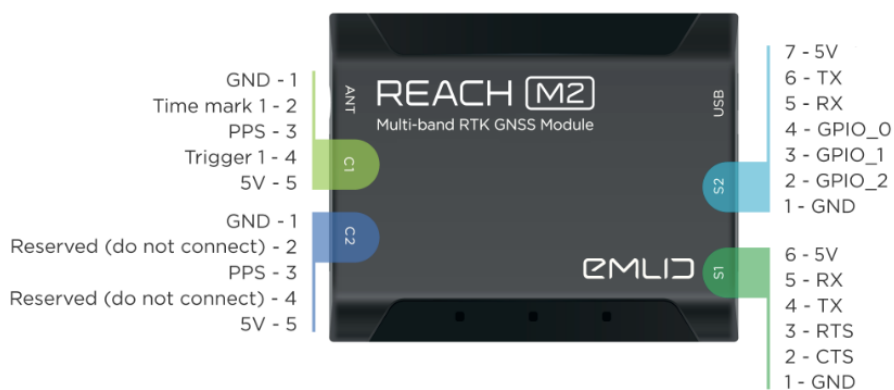
#### For Reach M2

Name	Value
Power supply voltage on USB or JST-GH connectors	4.75 - 5.5 V
Logic level on all digital interfaces	3.3 V
Maximum voltage on all digital pins	3.3 V
Antenna DC bias	3.3 V
Antenna output current	100 mA
Peak current consumption @5V	3 A
Typical current consumption @5V	300 mA
Current limit on USB OTG	1000 mA
Temperature range	-20...+65°C (-5...+150°F)

#### For Reach M+

Name	Value
Power supply voltage on USB or JST-GH connectors	4.75 - 5.5 V
Logic level on all digital interfaces	3.3 V
Maximum voltage on all digital pins	3.3 V
Antenna DC bias	3.3 V
Antenna output current	100 mA
Peak current consumption @5V	2 A
Typical current consumption @5V	250 mA
Current limit on USB OTG	1000 mA
Temperature range	-20...+65°C (-5...+150°F)

### 6.4.2 Connectors pinout



## 6.5 USB OTG

Reach can both receive power from USB, acting as a device and source power to the port acting as a host. To use Reach in OTG mode you will need to connect 5V power source to JST-GH connector pins (5 V, GND) and use OTG USB cable.

## 7 LED status

Reach has three LEDs which are used as status indicators for three different parts of the system.



### Power

This LED turns yellow when Reach is connected to a power source.

### Network

During boot, Reach enters a network scan state in which it will try to connect to any known Wi-Fi network it can find. This might result in connecting to a previously added network or creating its own hotspot. This LED turns blue and blinks fast when Reach is scanning networks, blinks slowly when Reach is in Client mode, and stays solid when Reach is in Hotspot mode.

### Status

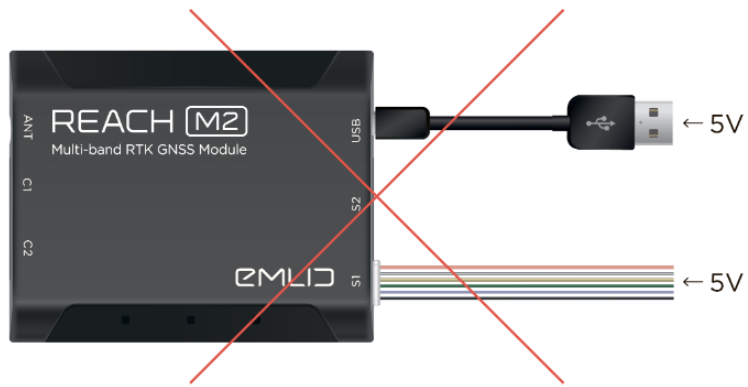
This LED is used to display Emlid Flow status. The LED turns green and blinks slowly when Reach passes time sync, stays solid during normal operation, blinks fast when Reach is in Point collection mode, and fades away when Reach has an internal error.

## 8 Power supply

Emlid Reach M2/M+ can be powered using Micro-USB port or JST-GH ports. Power circuit is shared for all ports, so when you power the device over one port it will pass power to other ports.

**Note:** Make sure that you have a stable power source for Reach. We recommend using USB 3.0 or 4.75 - 5.5V source. Only the red LED lights up when Reach lacks power.

**Caution:** Do not plug two power supplies at the same time as it may damage the device.

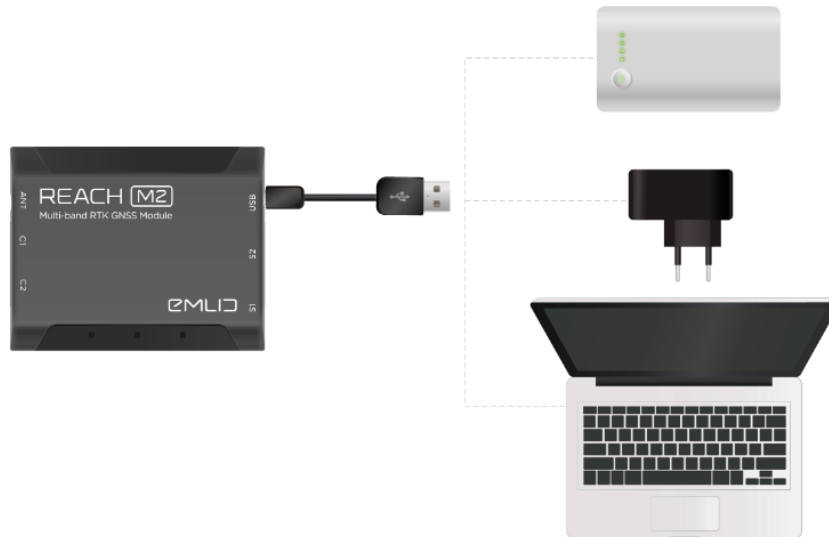


## 8.1 Power supply over USB



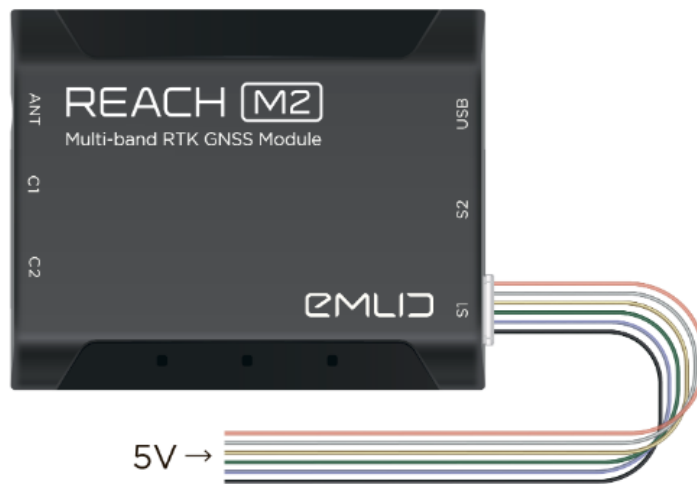
You can power Reach over Micro-USB cable using power supplies like:

- Power bank
- USB wall adapter
- Computer USB ports



## 8.2 Powering using JST-GH ports

Reach can be powered by providing 5 Volts to corresponding pins on any of the four JST-GH ports.



## 9 Troubleshooting

### 9.1 How to update firmware

This guide explains how to update the firmware on your Reach M2/M+ using the Updater tool in the Emlid Flow app.

#### 9.1.1 Overview

Updater is a tool in Emlid Flow that helps update the firmware on your receiver. Firmware refers to the background program that runs your receiver and requires updates to upgrade the receiver with new features, optimize its performance, and protect it from vulnerabilities.

**Tip:** *We recommend updating firmware every time it is available.*

**Note:** *You can also subscribe for Beta updates in Emlid Flow. In Settings, go to Firmware updates, tap Beta Updates and enable Beta updates.*

#### 9.1.2 When to update your Reach

You need to update firmware on your Reach when you use the receiver for the first time or when the update is available. To get access to Updater, follow the steps below.

##### When you use a receiver for the first time:

1. Check the First setup guide and perform the following steps:
2. Install the Emlid Flow app.
3. Connect to the receiver.
4. Update the firmware following the on-screen instructions.

##### When the update is available:

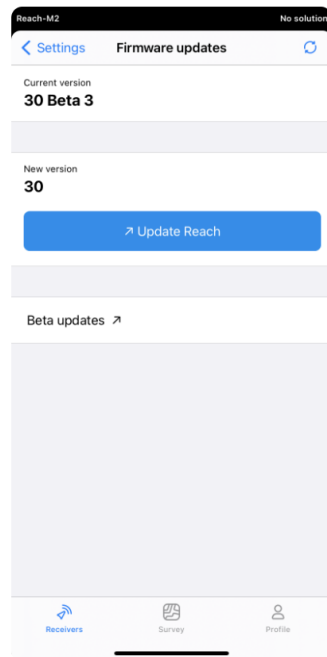
1. Connect the receiver to the internet following one of the guides:
  - Connecting to the internet via Wi Fi
  - Connecting to the internet via mobile hotspot
2. Open Emlid Flow. If the update is available, you will see the notification in Settings.
3. Tap the notification.
4. Update the firmware following the on-screen instructions.

#### 9.1.3 Update firmware

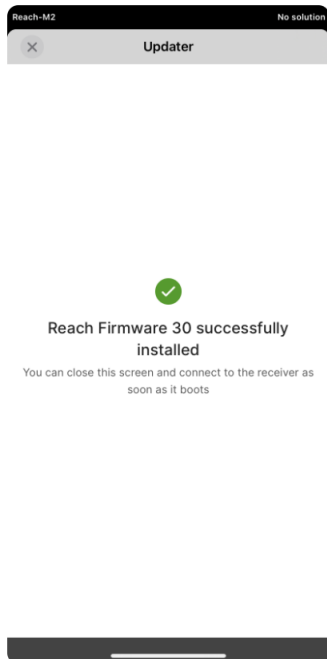
**Note:** *You can allow using mobile data for updates by turning on the Allow updates using mobile data option on the Mobile data screen. However, we recommend updating your Reach using Wi-Fi network due to the large bulk of data.*

To update the receiver, perform the following steps:

1. Tap the *Update Reach* button.



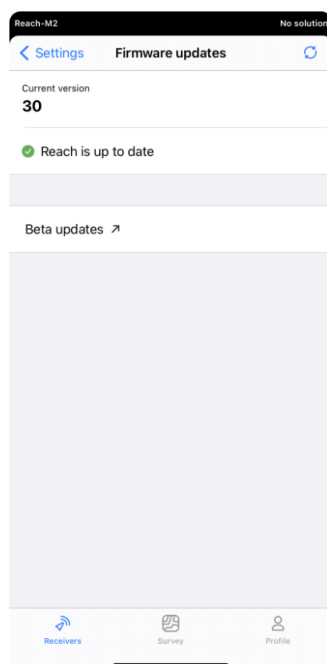
2. On the *Updater* screen, tap the *Upgrade Reach Firmware* button to start the update.
3. Wait until Reach reboots. Keep the Wi-Fi network on.



4. After reboot, wait for the Network LED to start blinking slowly, showing that Reach M2/M+ has joined your network again.
5. Close the *Updater* screen.
6. Go back to the *Receivers* tab.
7. Refresh the list of available devices.
8. Connect to your receiver.

**Note:** *If there is only one receiver, the app will automatically try to connect to this Reach M2/M+.*

9. Go to the *Firmware updates* screen and make sure you are up to date.



Now your Reach M2/M+ is ready for work.

#### 9.1.4 Roll back from Beta to stable

**Caution:** *Rolling back from Beta to stable will reset Reach settings to default.*

You can roll back to the stable firmware version via Updater. Follow the steps below:

1. Go to *Settings* and select *Firmware updates*.
2. Go to *Beta updates* and tap *Roll back to stable version*.
3. Tap the *Roll back to version XX.X* button and wait until the firmware downgrading and installing process is over.

## 9.2 Firmware reflashing

**Note:** *You do not need to reflash the firmware unless you want to bring your Reach to its initial state. This will delete all the data on your unit.*

This tutorial shows how to reflash Reach M2/M+ firmware using Reach Firmware Flash Tool.

**Tip:** *Most new features are released via the Emlid Flow app and can be updated simply via its interface. You can find more information in the Settings overview section.*

### 9.2.1 Reach Firmware Flash Tool installation

To flash your Reach M2/M+, you'll need to download and install Reach Firmware Flash Tool on your computer which is available for Windows, Ubuntu, and macOS. Please, refer to [the guide](#) in our official online documentation to get the links.

Follow the instructions to install Reach Firmware Flash Tool on your PC.

### 9.2.2 Windows installation

1. Double-click on the downloaded file.
2. Follow the instructions to install Reach Firmware Flash Tool on your PC.
3. Reboot your PC.

### 9.2.3 Ubuntu installation

**Tip:** We recommend using the terminal to install the Flash Tool on your PC.

**Tip:** If your Flash tool version is 1.7.1 or older, to update to the latest version you will need to add the new GPG key. Run the following command in the terminal:

```
sudo apt-key adv --keyserver keyserver.ubuntu.com --recv-keys 90F3927E0416B765
```

1. Press Ctrl+Alt+T to open the terminal.
2. Navigate to the directory with the downloaded file using `cd ~/Downloads` command.
3. Run `sudo dpkg -i reach-firmware-flash-tool_1.9.2_amd64.deb` to start installation.

**Caution:** Please confirm adding the current user to `plugdev` and `dialout` groups during the installation process. In case of a negative answer, the application might not work as expected.

4. Reboot your PC.

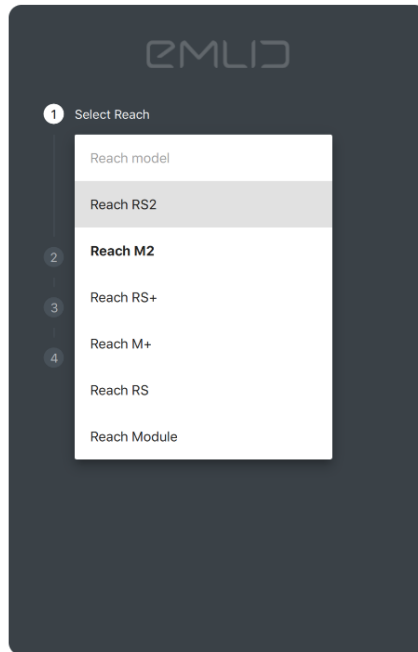
### 9.2.4 macOS installation

1. Double-click on the downloaded file.
2. Follow the instructions to install Reach Firmware Flash Tool on your Mac.
3. Drag the application icon to the Applications folder.

### 9.2.5 Reflash your Reach M2/M+

Reflash your Reach following the steps below:

1. Open Reach Firmware Flash Tool and choose Reach M2/M+.



2. Connect your Reach in Firmware mode.

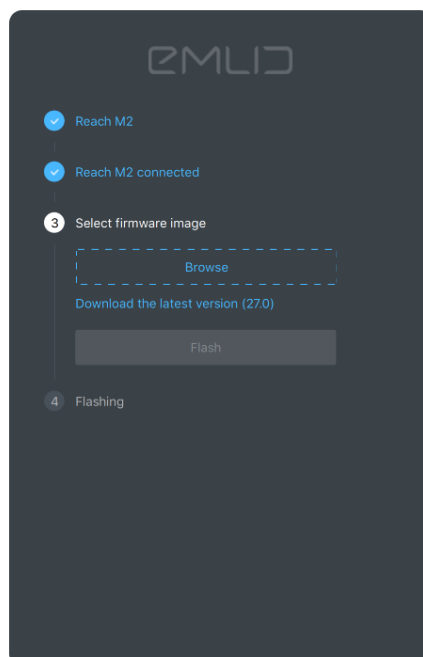
**How to switch your Reach to Firmware mode:**

*Make sure that your unit is disconnected from the PC and perform the following steps:*

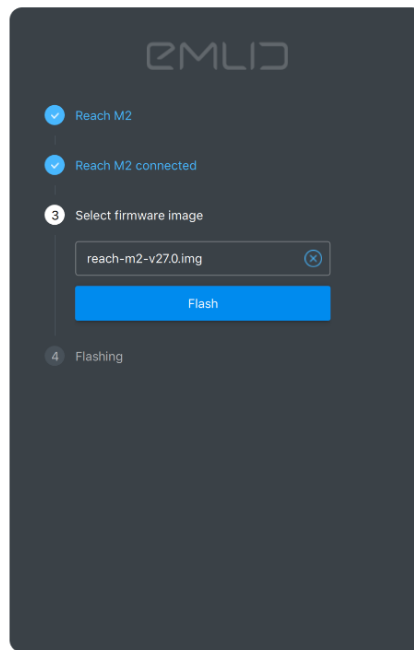
- *Use a pin to press and hold the button located in the pinhole under the power LED.*
- *Plug the USB into PC. No LEDs should blink.*

3. Download the proposed Reach Firmware .zip file.

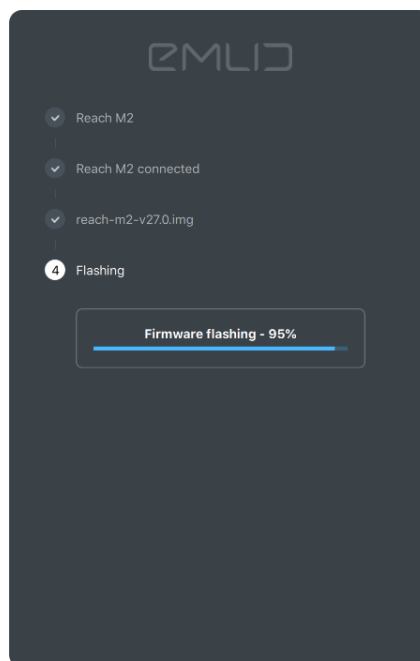
**Note:** *Make sure you have enough disk space. Reach Firmware Flash Tool creates 2 folders: one to download the image and another one to unpack it. Once you close the Flasher tool, the folder with the unpacked image will be deleted.*



4. Click *Flash*.

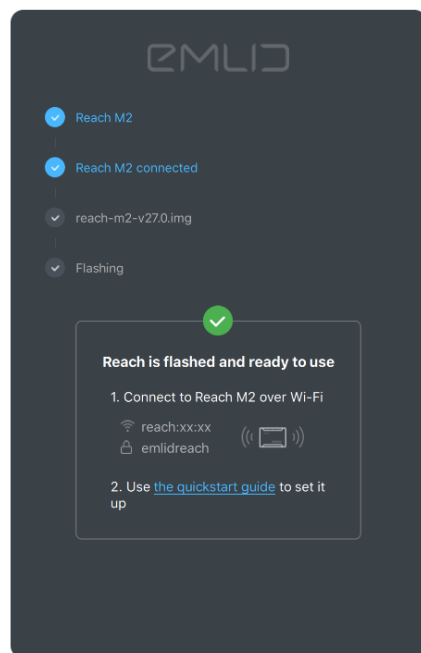
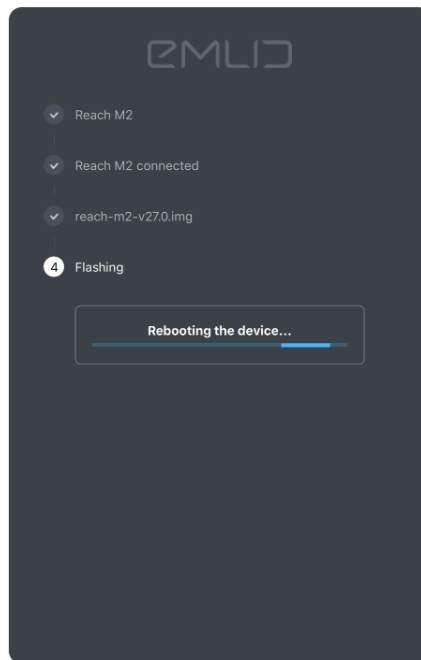


5. Wait until the end of the flashing process.



6. Wait until Reach reboots after reflashing. When Reach successfully reboots, you will see "Reach is flashed and ready to use" message.

**Caution:** *Do not unplug your unit on this step.*



7. Set up your Reach.

**Tip:** You can check the *First setup guide* to ease setup process.

## 9.3 How to download Simple system report

This guide explains how to download a Simple system report (SSR) in the Emlid Flow app to facilitate Reach troubleshooting.

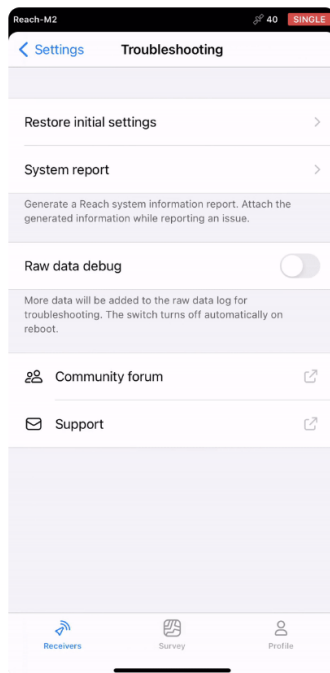
### 9.3.1 Overview

An SSR is a tool used to facilitate Reach troubleshooting. It provides information about your Reach configuration, network, and the Emlid Flow version in a plain text format.

### 9.3.2 Download Simple system report

To generate and download an SSR, perform the following steps:

1. Open the Emlid Flow app and connect to your Reach.
2. Go to `textitSettings`.
3. In *Troubleshooting*, tap *System report*.
4. Select *Simple report* and generate it.



5. Save the report depending on your device.

Now you can send the SSR of your Reach to the Support team at [support@emlid.com](mailto:support@emlid.com).

## 9.4 How to download Full system report

This guide explains how to download a Full system report (FSR) in the Emlid Flow app to facilitate Reach troubleshooting in complicated cases.

### 9.4.1 Overview

An FSR is a tool used to facilitate Reach troubleshooting. It comes in a ZIP archive and contains system logs and technical details of your Reach.

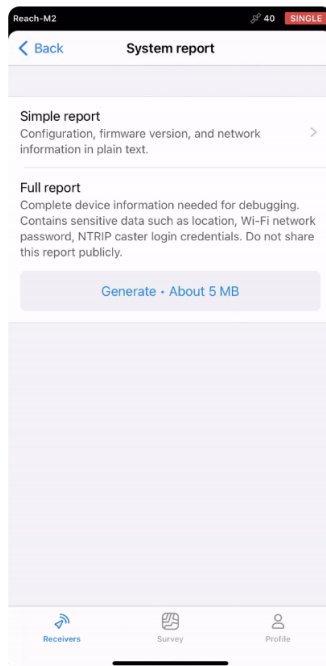
**Caution:** *We do not recommend sharing FSR publicly—it contains information such as your location, Wi-Fi network password, NTRIP caster login credentials.*

### 9.4.2 Download Full system report

To generate and download an FSR, perform the following steps:

1. Open the Emlid Flow app and connect to your Reach.

2. Go to *Settings*.
3. In *Troubleshooting*, tap *System report*.
4. In the *Full report* section, tap *Generate*.



5. Save the report depending on your device.

Now you can send the FSR of your Reach to the Support team at [support@emlid.com](mailto:support@emlid.com).

## 9.5 How to find serial number

This guide explains how to find the serial number of your Reach.

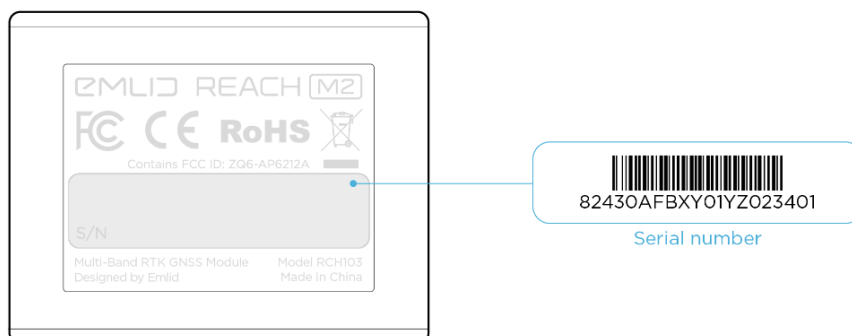
### 9.5.1 Overview

The serial number is assigned to your Reach unique string of numbers and letters.

### 9.5.2 Find serial number

To find the serial number of your Reach, perform the following steps:

1. Turn your Reach upside-down. The serial number is located under the bar code.



2. Write down or take a photo of the serial number.

Now you can send the serial number of your Reach to the Support team at [support@emlid.com](mailto:support@emlid.com).

## 9.6 How to enable raw data debug option

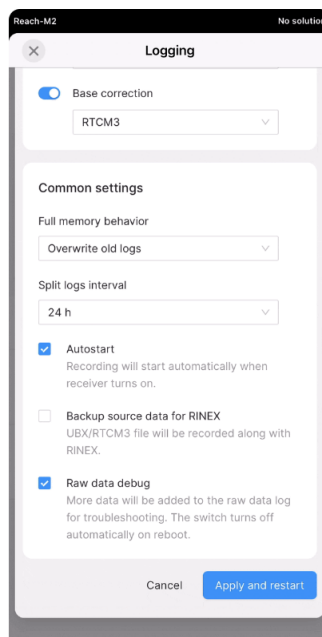
**Caution:** We recommend enabling the option only on the Support team request since the debug data adds extra weight to the logs.

This guide explains how to enable the raw data debug option on your Reach to facilitate troubleshooting in complicated cases.

### 9.6.1 Overview

**Caution:** The raw data debug option works only for the raw data logs in the UBX format. You can enable logging in the UBX format in the logging settings in the Emlid Flow app.

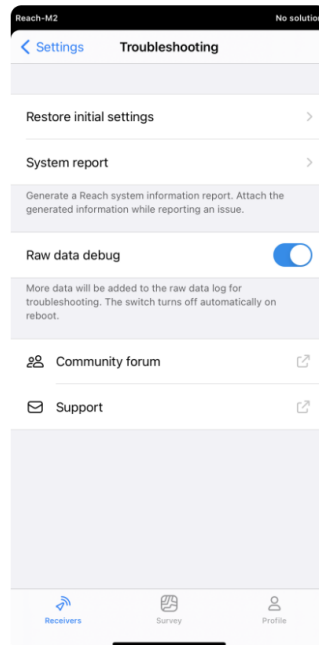
The raw data debug option adds additional internal information to the raw data logs in the UBX format. This feature provides more detailed information on the RTK calculation processes that can be used for debugging purposes in particular cases.



### 9.6.2 Enable raw data debug option

To enable the raw data debug option on your Reach, take the following steps:

1. Open the Emlid Flow app and connect to your Reach.
2. Go to *Settings*.
3. In *Troubleshooting*, turn the Raw data debug option on.



4. Record raw data logs as usual.

**Tip:** *You can read how to record logs here.*

5. Save the raw data logs depending on your device.

6. Go back to *Troubleshooting* and turn the *Raw data debug* option off.

**Tip:** *The raw data debug option turns off automatically on a reboot of your Reach.*

Now you can send the raw data logs recorded using the raw data debug option to the Support team at [support@emlid.com](mailto:support@emlid.com).

## 9.7 How to restore initial settings

This guide explains how to restore the initial settings on your Reach RS2/RS2+.

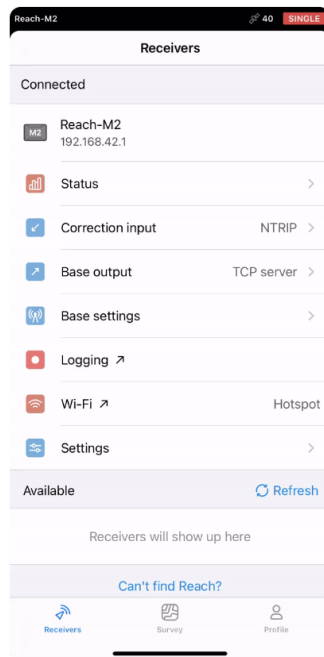
### 9.7.1 Overview

You can restore initial settings on your Reach using the Restore initial settings option in Emlid Flow. The option allows restoring GNSS settings, Correction input, Base output, and Base mode to an initial state. All other settings, including receiver name, Wi-Fi settings, logs, and projects will be saved.

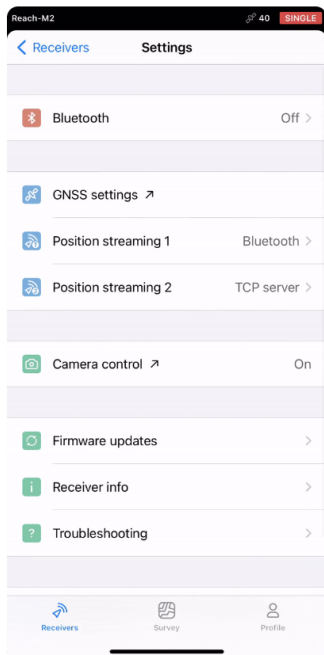
### 9.7.2 Workflow

To restore the initial settings on your receiver, follow the steps below:

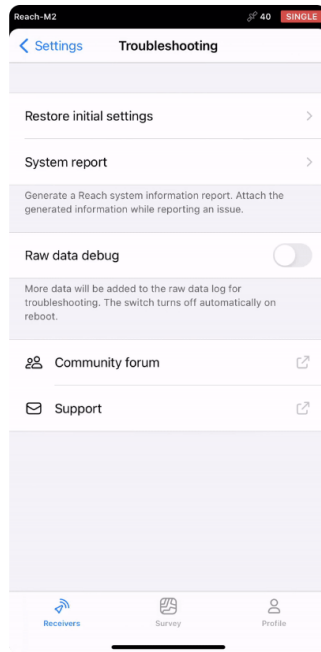
1. Connect to your Reach via Emlid Flow.



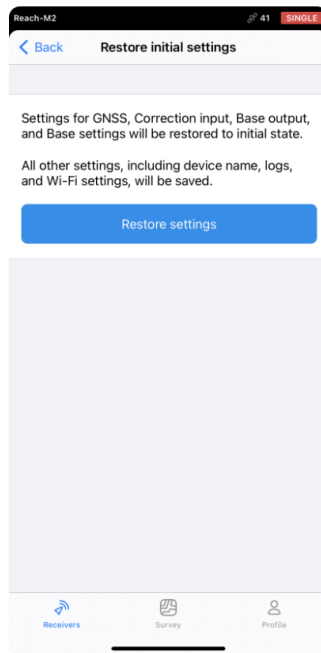
2. Tap *Settings* and go to the *Troubleshooting* section.



3. Tap *Restore initial settings*.



4. Tap the *Restore settings* button.



Once it's done, you will see that the button becomes gray and its name changes to Done. After that, you can proceed to set up your Reach.

## 10 Glossary

### **Absolute positioning**

Absolute positioning shows your actual global coordinates relative to the Earth's surface. Absolute positioning is a key to RTK surveys where you need absolute geographical accuracy (e.g, mapping, surveying the borders of the property, etc). In this case, your base absolute position is crucial for high accuracy results.

### **Accuracy**

Accuracy is the closeness of the measurements to a specific value. In surveying, accuracy refers to whether the coordinates you collected are true relative to the global coordinates. Not to be confused with Precision.

### **Age of differential**

Age of differential is the measure of how old are the corrections your receiver is getting. It is calculated by subtracting the time when the correction message has been generated from the current receiver time. The standard Age of Differential for RTK is normally 1-2 seconds.

### **Antenna Phase Center**

Antenna Phase Center could be referred to as the antenna's source of radiation. All GNSS measurements referred to the phase center. The phase center does not correspond to the physical center of the antenna and its real position depends on the direction of the coming radio signal. In addition, every band has its own phase center respectively.

### **Antenna Reference Point**

The antenna reference point is the center point on the bottom of the receiver. It is used for calculation of the antenna height.

### **AR ratio**

This is a result of the ratio test performed on the potential "Fix" solution, it shows how many times is the best solution better than the next one. If this number is more than 3, Reach will consider RTK solution Fixed.

This parameter corresponds to single-band Reach devices only (Reach RS/RS+, Reach Module/M+).

### **Base**

Base is one of the receivers that act as a reference station in RTK or PPK scenarios. It is a static unit with the determined coordinates that sends corrections to the moving unit or rover. If the base is set over the known point, it provides absolute accuracy.

### **Base Correction log**

This log contains the corrections from the base station in RTCM3 format.

### **Baseline**

Baseline is the distance between a rover and a base. If the baseline is bigger than recommended, the solution will be less accurate, the fix time will be longer or it won't be calculated at all.

### **BeiDou**

BeiDou is a Chinese navigation system. Back in 2000, BeiDou-1 was only covering China. Then, in 2012, BeiDou-2 began covering the Asia-Pacific region. Since 2015, BeiDou offers global coverage. We recommend using this system if you are located in the Asia-Pacific region.

## **Client mode**

The client mode means that Reach is connected to an external Wi-Fi network.

## **Continuous**

Continuous is a strategy for solving the ambiguities in RTK and PPK. In this case, ambiguities are resolved epoch by epoch. Less stable than Fix-and-Hold, but no risk of holding a false fix.

## **Coordinate system**

Coordinate system is a coordinate-based local, regional or global system used to locate geographical entities. A spatial reference system defines a specific map projection, as well as transformations between different spatial reference systems.

## **Correction input**

This is the part of the rover's settings that is responsible for configuring the acceptance of the corrections. Using the correction input configuration in the Emlid Flow app, you can choose the way your rover receives the corrections: via Serial, TCP, NTRIP, Bluetooth, or LoRa. Reach receivers support the correction input in RTCM3 format.

## **Corrections**

The corrections are the data that is used to eliminate ionospheric and tropospheric delays, and satellite clock errors. The static base transmits corrections to the moving rover in the RTK scenario.

## **CORS**

Continuously Operating Reference Stations or CORS network is the network of the static stations that provide exact GNSS data (carrier phase, code range, etc) and corrections as well. Surveyors can access this information to increase the accuracy of their post-processed survey data or to work in RTK on site.

## **Dilution of Precision or DOP**

Dilution of Precision or DOP is the term used to evaluate the geometrical position of the satellites relative to the receiver. When the satellites are too close to each other in the field of view, it means the satellite geometry is weak (a high DOP value). If the distance between the satellites is sufficient and they are allocated evenly and cover more space, the geometry is considered strong, therefore, the DOP value is low. The lower the DOP, the more accurate your data is. A good DOP value is considered to be below 2.

## **Elevation mask**

Elevation mask can be configured in RTK settings in the Emlid Flow app. Satellites lower than set elevation will be excluded from the computation. The default setting is 15 degrees. Usually, satellites with a lower elevation provide too noisy measurements as the signal passes through the most atmosphere.

## **ENU**

One of the formats for Position Streaming available for Reach devices. Simple text protocol for East, North and UP components of the baseline as well as solution status.

## **ERB**

One of the formats for Position Streaming available for Reach devices. Used for communication to ArduPilot. ERB stands for Emlid Reach Binary protocol.

## **Fix-and-Hold**

Fix-and-Hold is a strategy for solving the ambiguities in RTK and PPK. After the first ambiguity fix holds them constrained. Fix is more stable but in case first initialization was not correct it will take longer to recover and initialize correctly. You can think of it as if Fix had inertia.

## **Full System report**

A full system report is a tool used to facilitate issues reports. It comes in ZIP archive, and contains system logs and technical details of your device as well as some sensitive information like your NTRIP credentials or network passwords. That is why we do not recommend sharing the report publicly. These are used to debug complicated cases in support.

## **Galileo**

Galileo is a European satellite navigation system. It first started operating in 2011 and now has global coverage.

## **Ground Control Point or GCP**

Ground Control Point is a point on a surface with known coordinates. The GCPs are actively used in aerial mapping and photogrammetry. The surveyors set GCPs over the area, mark them so they can be visible from the drone. The GCPs are then surveyed to find their exact coordinates and used as reference points for future data processing.

## **GIS**

Geographic Information System or GIS is a system for collecting, storing, analyzing, and graphically visualizing spatial data and related information about required objects.

## **GLONASS**

GLONASS is a global satellite navigation system. It was created as an alternative to GPS in Soviet Union and first launched in 1982.

## **GLONASS AR mode**

A processing parameter enabling to turn on and off the ambiguity resolution for the GLONASS signal separately. Contrary to GPS, all GLONASS satellites transmit on different frequencies, which results in Inter Channel Biases (ICB) that are unique for each receiver model.

Reach devices can correct GLONASS ICBs, allowing for GLONASS AR with non-Reach bases such as NTRIP casters. The general recommendation is to always have GLONASS AR set to on.

This parameter corresponds to single-band Reach devices only (Reach RS/RS+, Reach Module/M+).

## **GNSS**

Global Navigation Satellite System or GNSS is a system designed to determine the location (geographical coordinates) of land, water, and air objects. Such systems consist of space equipment, a ground segment called control systems, and individual receivers. The operation of GNSS is based on measuring the distance from the antenna on the object (receiver) to satellites whose position is known with great accuracy.

## **GPS**

Global Positioning System or GPS is a global satellite navigation system that measures distance, time, and location in the WGS 84 world coordinate system. The system was developed in 1978, and is operated by the United States.

## **Ground plane**

A ground plane is a conductive plate providing insulation for the antenna. It may be a piece of metal, a roof of a car, a metal roof of a building, and etc. It is recommended to use at least a 70x70 mm ground plane.

**Hot shoe adapter** Hot shoe is a point on the top of a camera that is used to attach accessories or other equipment to the camera. Using hot shoe adapter, you can connect your camera to Reach M2/M+ for UAV mapping.

## **Hotspot mode**

The hotspot mode means that the Reach is broadcasting its own Wi-Fi network.

## **Kinematic Positioning**

Kinematic positioning is one of two positioning modes. It implies that the rover is moving during the positioning process.

**LLH** One of the formats for Position Streaming available for Reach devices. Simple text protocol for Latitude, Longitude, and Height as well as solution status.

## **LoRa radio**

Long Range or LoRa radio is used for Reach receivers to send or receive corrections without an internet connection. Reach RS2/RS2+/RS+ is equipped with internal Lora radio. Reach M2/M+ has external LoRa radio available: you can connect it via S2 port. The radio works only one way: it either sends correction or receives them. Using LoRa modulation it is possible to hit up to 19 km (11.8 mi) in line of sight.

## **Mock location**

Mock location feature of Android devices enables you to manually change the location of your device to any other place. In the case of Reach devices, it enables the GPS collector apps to get the GPS observations directly from the receiver instead of the internal GPS of the unit.

## **Mount Point**

Mount point is a correction data source related to the specific physical or virtual reference station chosen or created based on your location respectively. When you get corrections from a VRS, you need to enable sending your receiver's position in the NMEA format.

## **Multi-band receiver**

A multi-band receiver is a receiver that can accept signals from the satellite on more than one frequency band. It means the receiver takes less time to establish the first fix solution, has a longer baseline, and has more chances to maintain fix solution in the blocked sky view conditions.

## **Multipath**

Multipath is an effect occurring when the GPS signal is deflected from the obstacles, so the GNSS receiver detects signals not only directly from the satellites but also from the local objects. Multipath effect results in an error in pseudo-range measurements and thus affects the positional accuracy.

## **Night mode**

Night mode allows you to turn off the LEDs until the next reboot of the Reach device.

## **NMEA 0183**

One of the formats for Position Streaming available for Reach devices. The most popular standard in the industry. Supported messages: GNRMC, GNGGA, GPGSA, GLGSA, GAGSA, GPGSV, GLGSV, GAGSV, GNGST, GNVTG, GNZDA.

## **NTRIP**

The Networked Transport of RTCM via internet Protocol or NTRIP network is an alternative source of corrections. NTRIP allows your rover to accept corrections over the internet with no need for the second local receiver acting as a base. A reference station collects data, then sends it to NTRIP caster, where it is retransmitted through the internet port to the client rover connected via a particular port and authorized.

## **Point cloud**

Point cloud is a set of vertexes in a three-dimensional coordinate system. Point clouds are created with 3D scanners and are used in photogrammetry and 3D-modeling.

## **Point Collection**

Point collection is a feature in the Emlid Flow app that allows you to find the exact coordinates of the point. The receiver determines the coordinates (x, y, z) of a ground point and records it to your project for further processing .

## **Point Stakeout**

Point stakeout is a feature in the Emlid Flow app that allows finding points with known coordinates on the site.

## **Pole Height**

When preparing for point collection, configure the height of your survey pole in Emlid Flow. It will help the app to automatically calculate the antenna height.

## **Position log**

This log contains positional information. Reach devices can log their position in LLH, XYZ, ENU, NMEA, and ERB formats.

## **Position Streaming**

Reach devices can send the position data to third-party GIS apps and external devices including tractors, drones, robots, and more. The position could be out shared via Serial, TCP, and Bluetooth. Various applications require different formats of the positional data, that is why Reach outputs its position in LLH, XYZ, ENU, NMEA, and ERB.

## **PPK**

Post-Processed Kinematic is one of the techniques used for highly accurate surveys. Same as in RTK, one needs two units: a base and a rover. The core difference is that in PPK scenario there is no need for a real-time connection between two units. Base and rover record logs separately, and these logs are processed together later using specific post-processing software, for example, RTKLib.

## **PPP**

Precise Point Positioning or PPP is a technique used for determining the centimeter-level accurate coordinates of the point. The receiver put over a point is recording data for a certain period. Then this data is sent to the PPP services.

## **Precision**

Precision is the closeness of two or more measurements to each other. Precision means that the coordinates you collected are true relatively to another object. In this case, you do not need exact georeferencing coordinates of the points, you only need to know that the collected points are, say, situated on the same distance from each other. Not to be confused with Accuracy.

## **Raw data log**

A raw data log contains GNSS observations from the receiver without the calculation of accurate coordinates. It can be recorded in UBX or directly in industry-standard RINEX format.

## **Emlid Flow**

Emlid Flow is the mobile app created by Emlid. It is used to control and configure the Reach receivers, create projects, collect points, etc.

## **Relative positioning**

Relative positioning shows your coordinates relatively to another reference object. The base sends information about its absolute position to the rover. Using this information, the rover determines its position relative to the base with centimeter accuracy.

## **RINEX**

RINEX is a standard raw-data format that allows storing satellite observations and navigational data measurements made by the receiver. It also allows the post-processing of the received data by various applications from different manufacturers of receivers and programs.

## **RMS**

The square root of the average of the squared error. The RMS calculations are used to evaluate the accuracy of the position measurement. A horizontal or vertical dilution of precision multiplied by three RMS could give the horizontal or vertical precision value respectively.

## **Rover**

Rover is one of the two GNSS receivers that is used for collecting data in RTK or PPK scenarios. Rover is a moving unit: the surveyor uses rover to record the points, while rover receives the corrections from the static base.

## **RTCM3**

RTCM3 is an industry standard format for correction output.

## **RTK**

Real-Time Kinematic or RTK is one of the techniques used to improve the accuracy of the data collected from the satellites by the receiver. For RTK one needs two receivers: a base and a rover. The base sends corrections to the moving rover during data collection.

## **RTKCONV**

RTKCONV is a tool in RTKLIB that converts UBX raw data or RTCM3 base correction data from a receiver to RINEX format.

## **RTKLIB**

RTKLIB is an open-source program package for standard and precise positioning with GNSS. It is used for PPK data processing. Works with signals from GPS, GLONASS, Galileo, QZSS, BeiDou, and SBAS. Emlid produces the version of RTKLib tailored for Reach products.

## **RTKPLOT**

RTKPLOT is a tool in RTKLIB that allows viewing and plotting the position solutions from RTKPOST as well as observation data from RTKCONV.

## **RTKPOST**

RTKPOST is a tool for post-processing raw logs in RTKLIB. The result is stored in the position solution file in LLH WGS 84 – POS file. In this file, we will get centimeter-accurate track of the receiver.

## **Serial Port (UART, USB, RS-232)**

A serial communication interface in which the information transfers in or out sequentially one bit at a time. That kind of communication could be realized via various devices like UART, USB, or RS-232. Reach receivers can use a serial port to exchange the position and correction data with 3rd party devices.

## **Signal-to-noise ratio**

Signal-to-Noise Ratio or SNR is the primary indicator of how good the reception is. The value is equal to the ratio of the power of the useful signal to the noise power. You can find the SNR indicator on the main screen of the Emlid Flow app. When the SNR of a satellite is over 45, it will be marked green. Grey bars indicate SNR of the base station. The more satellites are in a green zone, the more precise your measurements are and the faster your ambiguity resolution is.

## **Simple System report**

A Simple System report is a tool used to facilitate issues reports. It provides information about the Emlid Flow version, configurations, and network in a plain text format.

## **Single-band receiver**

A Single-band receiver is a device that accepts signals from the satellite on one frequency band. It has the same level of accuracy as the multi-band one. Single-band receiver has shorter baseline in comparison to multi-band, and might not even find fix solution in blocked sky view conditions.

## **SNR mask**

Signal-to-Noise ratio mask or SNR mask is a tool that filters the satellites used for the fix solution. Satellites with low SNR will be excluded from the computation. The default setting in the Emlid Flow app is 35.

## **Solution status (fix, float, single)**

Solution status defines the precision that can be achieved at the moment. There are three solution statuses you can see when working with Reach devices.

SINGLE means that the rover has found a solution relying on its own receiver and base corrections are not applied. In this case, the receiver calculates its position with the precision of a few meters.

FLOAT means that the rover receives corrections from the base but cannot resolve all ambiguities and calculate its position with the centimeter accuracy.

FIX means that the rover using corrections from the base resolved the ambiguities in its positional calculation and achieved the solution with the centimeter-level precision.

## **Static Positioning**

Static positioning is one of the positioning modes. It assumes that the Reach rover is static. Constraining the system helps to resolve ambiguities faster as well as produce measurements with higher precision.

## **TCP**

Transmission Control Protocol or TCP is one of the main internet data transfer protocols designed to control data transfer. Typical scenario for using TCP is sending correction data to an application on the same network or to a server with public IP.

## **Time mark**

The time mark function verifies the exact moment when the camera takes a photo. After the flight, you can process the raw logs from the base and a rover to get an «\*\_events.pos» file. This file includes information about the time and coordinates of each photo. You can use geotagging software to write this information to the photos' EXIF data.

## **UBX**

UBX is the GNSS raw data format. The UBX protocol is a u-blox proprietary binary protocol that outputs in hexadecimal format.

## **Update rate**

The update rate is a value that shows how frequently the receiver calculates and reports its position. For Reach receivers, we recommend having 1 Hz update rate on the base and 5 Hz on the rover.

## **VRS**

Virtual Reference Station or VRS is a useful tool for long baselines. It is an imaginary, unoccupied reference station generated nearby the RTK user. The rover sends data back to the NTRIP caster. NTRIP allows the uniting of the data from your rover and the data from dense NTRIP bases and models a virtual base next to you.

## **WGS 84**

World Geodetic System 1984 or WGS 84 is the global system of geodetic parameters of the Earth, including the system of geocentric coordinates. It was accepted in 1984 and defines coordinates relative to the Earth's center of mass, with an error of less than 2 cm.

## **XYZ**

One of the formats for Position Streaming available for Reach devices. Simple text protocol for X, Y, Z ECEF coordinates as well as solution status.