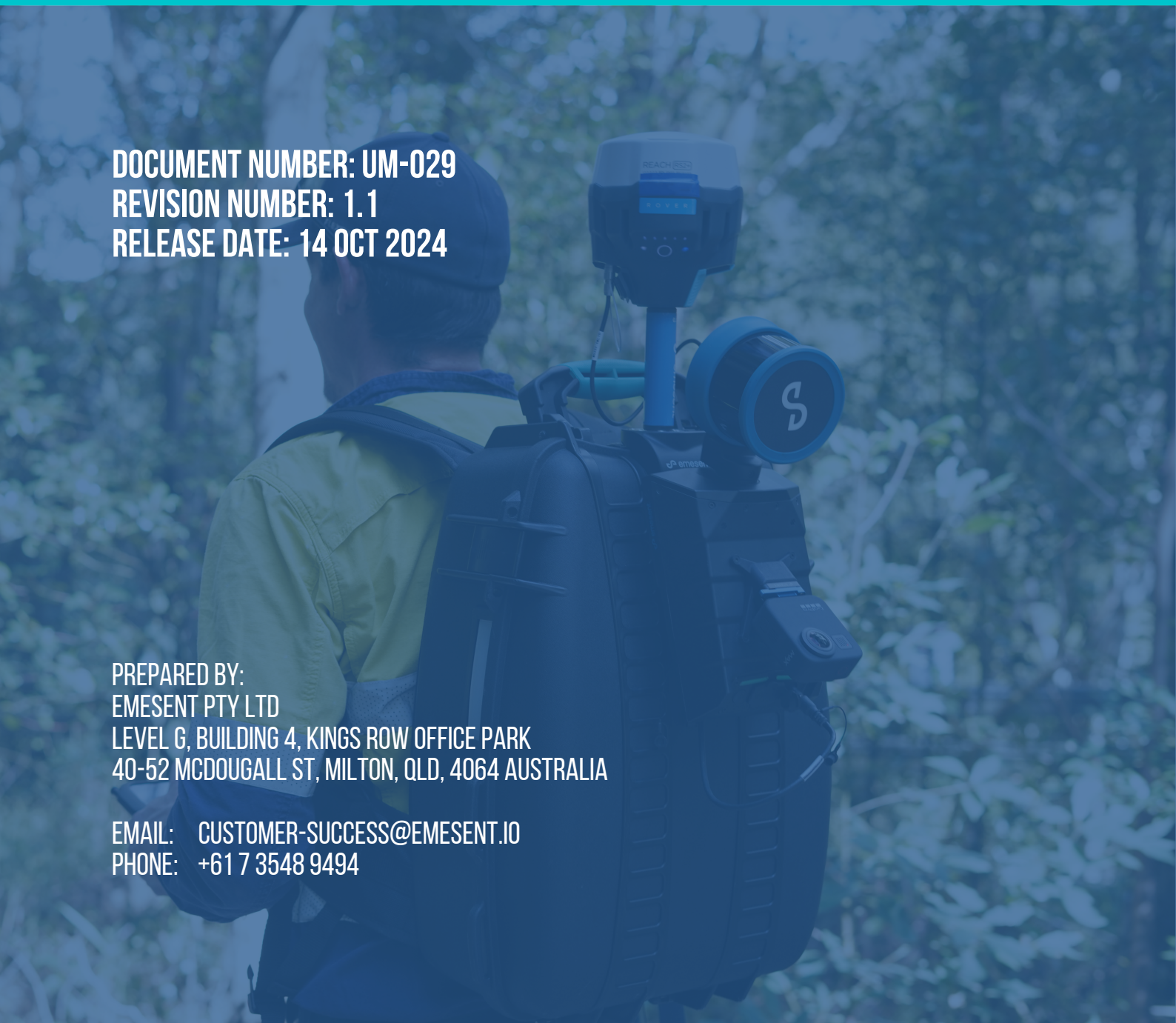
emesent

BACKPACK RTK USER MANUAL



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PREPARED BY:
EMESENT PTY LTD
LEVEL G, BUILDING 4, KINGS ROW OFFICE PARK
40-52 MCDOUGALL ST, MILTON, QLD, 4064 AUSTRALIA

EMAIL: CUSTOMER-SUCCESS@EMESENT.IO
PHONE: +61 7 3548 9494

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Using this manual

Hovermap is a powerful system that can be used as a LiDAR mapping payload, but also as an advanced autopilot for drones and other platforms. We therefore recommended that you read the user manual thoroughly to make use of all its capabilities in a safe and productive way.

Disclaimer and safety guidelines

This product is *not* a toy and must not be used by any person under the age of 18. It must be operated with caution, common sense, and in accordance with the instructions in the user manual. Failure to operate it in a safe and responsible manner could result in product loss or injury.

By using this product, you hereby agree that you are solely responsible for your own conduct while using it, and for any consequences thereof. You also agree to use this product only for purposes that are in accordance with all applicable laws, rules and regulations.

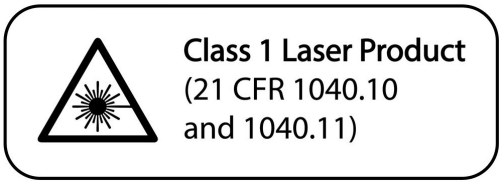
The use of Remotely Piloted Aircraft Systems (RPAS) may result in serious injury, death, or property damage if operated without proper training and due care. Before using an RPAS, you must ensure that you are suitably qualified, have received all necessary training, and read all relevant instructions, including the user manual. When using an RPAS, you must adopt safe practices and procedures at all times.

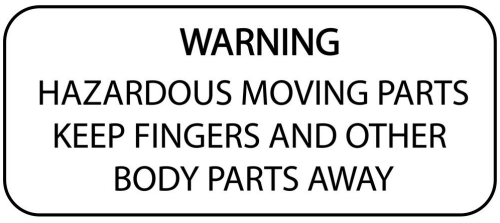
Warnings

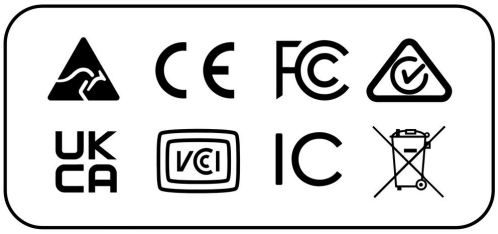
- This document is legally privileged, confidential under applicable law and is intended only for the use of the individual or entity to whom it is addressed. If you have received this transmission in error, you are hereby notified that any use, dissemination, distribution or reproduction is strictly prohibited. If you are not the intended recipient, please notify the sender and delete the message from your system.

- Do not attempt to disassemble, repair, tamper with, or modify the this product. This product contains no user-serviceable parts inside. Any disassembly of the product enclosure will invalidate the IP65 rating and disrupt the factory calibration of LiDAR. Contact Emesent for any repairs or modifications.

- Always be aware of moving objects that may cause serious injury, such as spinning propellers or other components. *Never* approach a drone while the propellers are spinning or attempt to catch an airborne drone.







Contents

1. Introduction

Backpack RTK automates high-accuracy georeferencing and drift correction for backpack-based scans, allowing for rapid and precise scans without the need for ground control points.

The term "GNSS receiver", used throughout this manual, refers specifically to the devices supported by the Backpack RTK. Currently, these include the Emlid RS2, RS2+, and RS3 receivers. Refer to the "*Setup and Configuration*" section for instructions regarding these supported devices.

2. Hardware Requirements

2.1 Backpack RTK Kit

Included in kit		
1	Protectice hardcase backpack	Resin hardcase backpack with RTK and Hovermap mount
2	Cable bag	Contains the following: • **Emlid GNSS cable:** Lemo to Lemo cable suitable for Emlid RS2/RS2+/RS3 GNSS receivers • **Hovermap cable:** Cable for connecting the Hovermap ST/ST-X to the Backpack RTK
	ⓘ When you purchase the Backpack RTK Kit with the Vehicle RTK Kit, you can choose to get the Backpack RTK Kit without the cable bag.	
3	GNSS Spacer Pole	The extension pole attaches to Backpack RTK for mounting the GNSS receiver

Pictured but not included (sold separately)		
4	Hovermap ST/ST-X	Emesent Mapping payload
5	V-mount Battery + Battery Charger	Main power source for the Hovermap and the GNSS receiver
6	Emlid GNSS receiver	The Emlid RS2+ GNSS receiver can be optionally included in the kit purchased from Emesent. Alternatively, you can use your own Emlid GNSS receiver. The Backpack RTK Kit is also compatible with the Emlid RS2 or RS3.

2.2 Other Required Hardware

1	Emlid Base Station setup	Includes the Emlid RS2+ GNSS Receiver and surveying tripod. This is only required if you do not wish to use CORS networks.
2	Smartphone/Tablet	Used to configure GNSS receiver settings (via Emlid Flow) and check RTK status (via Emesent Commander)

3. Software Requirements

> ⚠ Raw scan data from a Hovermap that uses Emesent Cortex version 3.3 (or later) can only be processed in Emesent Aura 1.7 (or later).

Software	Version / Download Link
Emesent Aura	version 1.7 or later
Emesent Cortex	version 3.3 or later
Emesent Commander (optional)	version 1.5 or later
Emlid Flow (App Store)	https://apps.apple.com/us/app/emlid-flow/id1463967138
Emlid Flow (Google Play)	https://play.google.com/store/apps/details?id=com.emlid.reachview3&hl=en_AU&gl=US

4. Setup and Configuration

This section details how to set up your GNSS receiver. Refer to Emlid's official documentation - https://docs.emlid.com/reachrs2/ - for an overview of using the Emlid RS2+.

4.1 Setup the RTK Base Station

4.1.1 Option 1: Place the local base station over a known point

A video from Emlid showing this process can be found at https://youtu.be/FilRoPVDjCs.

4.1.2 Option 2: Connect to an NTRIP server

If connecting to a base station over the internet use, the following setup steps. This process is used for:

- Government or Private CORS networks
- Local base station broadcasting over the internet (e.g. http://caster.emlid.com)
- VRS service

A video from Emlid showing this process can be found at https://youtu.be/YWz0mhOwFAg.

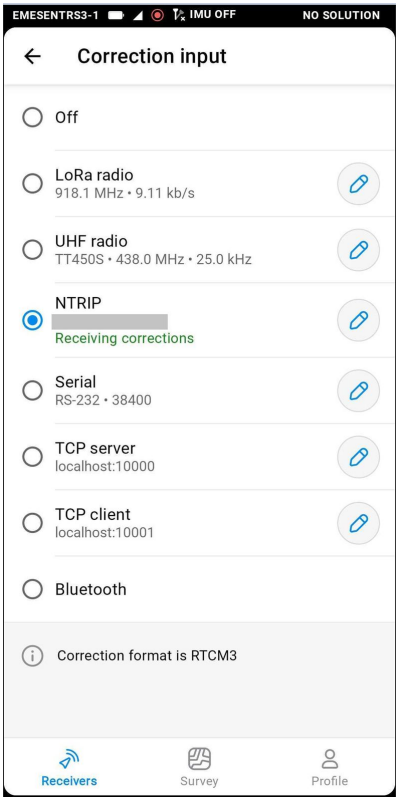
> For best results, set up a local base over a known point on the site (or nearby) where you are scanning. Connecting to a local CORS network is often more convenient if one is available nearby.

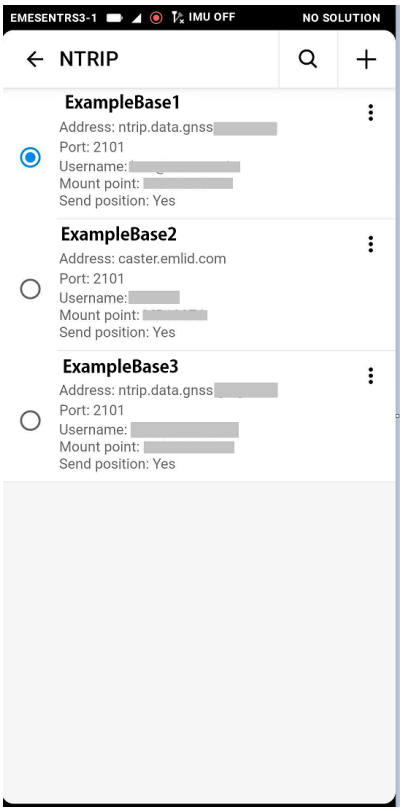
1. Gather the following information before you start. These can usually be found on the website or login page of the service you are using:

Address	IP address of the service you are connecting to. In addition to IP addresses, you can also use a domain name (website address) when configuring the connection in the Emlid Flow app. For example, http://caster.emlid.com or 164.90.243.252).

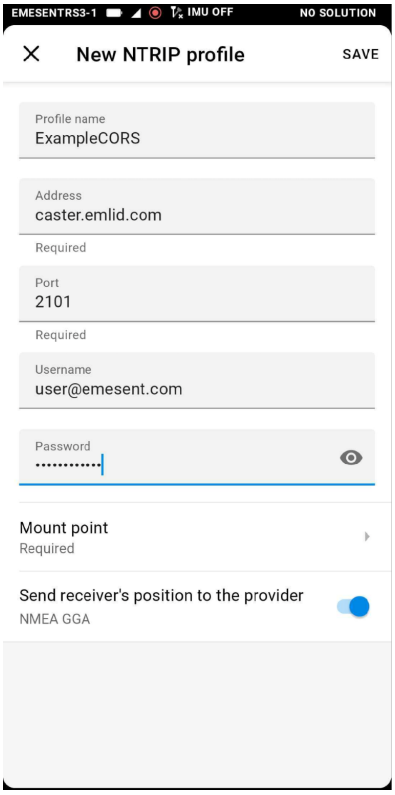
Port	The communication port that the app uses to connect to the base station. For example, the default port number is often 2101, but it can vary depending on the service provider or setup.
Username / Password	Username, Email, or other user name linked to your corrections account, and the password for authentication purposes. ⓘ It may not be the same as your login username and password.
Mount point	The ID of the base station you are connecting to. For example, MP1523.

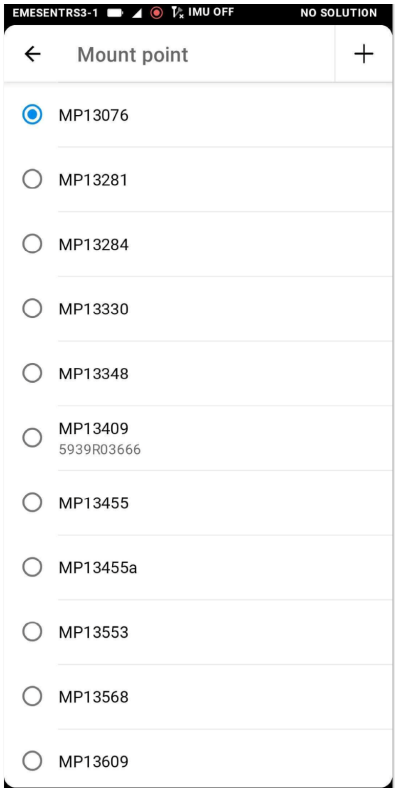
2. Turning on the base station then connect to the Emlid WiFi,
3. Launch the Emlid flow app.
4. Under Correction input, select NTRIP. Then choose a previously created mount point or create a new one by pressing the "**+**" button.





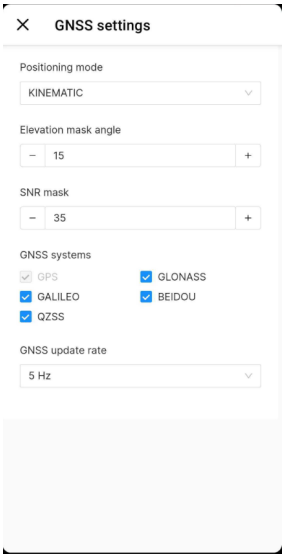
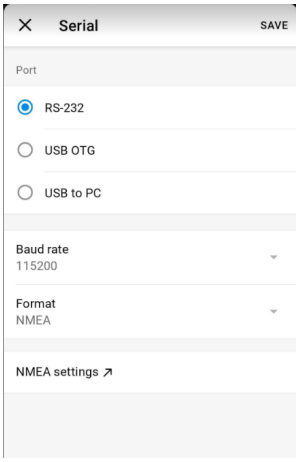
5. Enter the details gathered in Step 1 into the Edit or Add screen. Make sure to select the mount point.



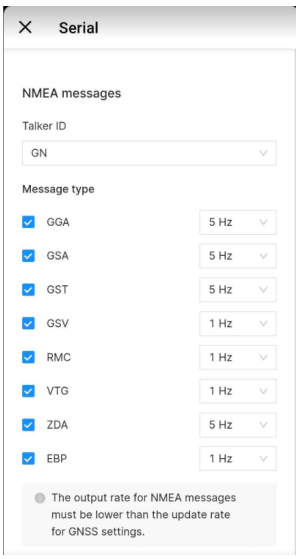


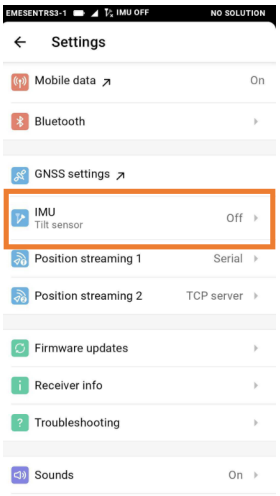
4.2 Configure the GNSS Receiver

Use the following configuration settings for your GNSS receiver to ensure RTK data is properly processed.

Setting	Value	Image
Settings → GNSS settings	• **Positioning mode:** Kinematic (only on Firmware version 30.2 or older) • **GNSS update Rate:** 5Hz	
Settings → Position Streaming 1 → Serial	• **Port:** RS232 • **Baud rate:** 115200 • **Format:** NMEA	

Setting	Value	Image

Settings → Position Streaming 1 → Serial → NMEA settings	• **Talker ID:** GN
	• **Message type**
	  ◦ **GGA:** 5hz
	  ◦ **GSA:** 5hz
	  ◦ **GST:** 5hz
	  ◦ **ZDA:** 5hz
	  ◦ **Others:** 1Hz
		

For Emlid RS3 only **Settings → IMU**	Make sure **Tilt sensor** is turned off for all Backpack RTK use.	

4.3 Setup the Backpack RTK Mount

Follow these instructions to attach the GNSS receiver to Backpack RTK.

1. Upgrade to the latest Emesent Cortex version (3.3 or later). Refer to https://4999118.hs-sites.com/en/knowledge/hovermap-firmware-update-instructions for more information.

2. Attach the spacer pole to the backpack until fully screwed in then attach the GNSS receiver to the other end of the spacer pole.

3. Connect the Emlid data cable into the GNSS receiver's **EXT** port then connect the other end to the backpack's **GNSS** port.

4. Connect the Hovermap cable into the backpack connector then mount the Hovermap.

5. Connect the other end of the Hovermap cable to the Hovermap then attach the battery.

6. Turn on the GNSS receiver and configure it to receive corrections from the selected base (i.e. CORS, local base, etc.) via the Emlid Flow app.

> The settings only need to be set up if you are using the GNSS receiver for the first time, have just upgraded the firmware, or have changed them for another use case.

5. Monitoring RTK Status

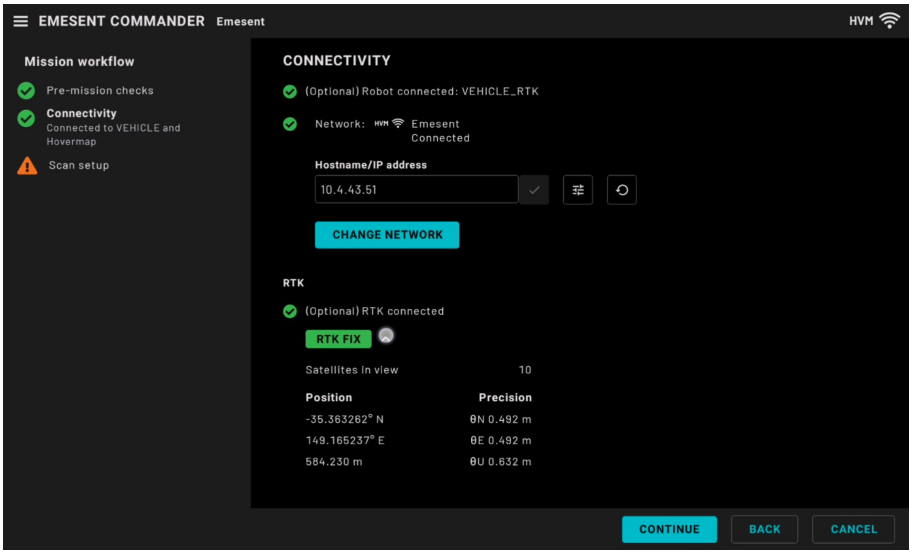
The **Emesent Commander** application provides clear visibility of the RTK status before and during the mission. This enables you to monitor RTK quality without leaving the app to check for information via the GNSS receiver's native application.

> Emesent Commander only provides RTK information from GNSS receivers connected to Vehicle RTK and Backpack RTK devices. RTK data from drones such as the M350 cannot be accessed through the application.

5.1 Mission Workflow

Before a scan is started, RTK information is provided in the **Mission Workflow**. The **Connectivity** page shows if a GNSS receiver is connected to a Vehicle RTK or Backpack RTK.

In addition, tap the drop-down arrow beside the **RTK** section at the bottom to display the RTK quality, number of satellites, position, and accuracy.



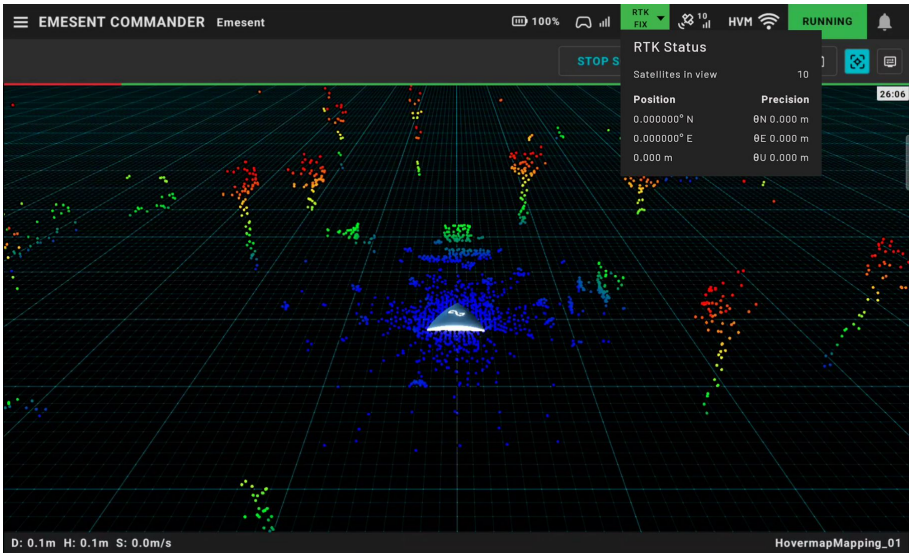
> If Emesent Commander detects a GNSS receiver is connected but is offline, you cannot continue to the next page or start the scan.

> The RTK information is updated in real-time to reflect any changes in connection status, number of satellites in use, or precision.

5.2 Main View

During the scan, the main header displays the **RTK Status** and the number of satellites from which the GNSS receiver gets signals. Tap the drop-down arrow beside the **RTK Status** to display the RTK quality, number of satellites, position, and accuracy.

> Similar to the information provided on the **Connectivity** page, the information displays changes to the RTK status in real-time. See table below for more information.



RTK Status	Description
RTK Fix	This is the best status you can achieve with RTK. It means the GNSS receiver has successfully locked onto enough satellites and received corrections that allow it to determine a very precise position. An RTK fix is highly accurate, often within a few centimeters.
RTK Float	This means the GNSS receiver is using RTK corrections to improve GPS accuracy, but it has not yet achieved a fully stable and accurate fix. There might be slight inaccuracies while the position is being refined.

RTK Status	Description
RTK Single	This status is less precise and is typically used when RTK corrections are not available or when lower accuracy is acceptable. RTK Single can also display when the GNSS receiver is not receiving corrections from the base station. If you are in an environment where RTK Fix or RTK Float is expected, and are only receiving RTK Single, check your GNSS Receiver settings to ensure corrections are configured correctly.
RTK Offline	The GNSS receiver is not sending all required GPS information to the Hovermap. This status can occur when there is a loss in communication with the base station or correction source, such as during signal dropout or when the receiver is not connected to a correction service. You can try the following troubleshooting steps: • Disconnect the GNSS receiver's cable and then reconnect it. • Ensure the GNSS receiver settings are configured correctly. • Reboot the GNSS receiver.
No GPS	The GNSS receiver is online but it has no RTK or GPS signal.

5.3 Expected RTK accuracy

The table below displays the approximate accuracy for each RTK status. However, it is important to note that the actual accuracy can vary due to multiple factors and the stated accuracy is not guaranteed.

GPS Status	Approx. Horizontal Georeferencing Accuracy
RTK Fixed	3cm
RTK Float Fix	30cm
GPS	1.5 - 3m
No GPS Fix	N/A

For more information, refer to the Vehicle RTK accuracy report which tests the RTK accuracy in a real-world environment.

> It is important to understand that the global (georeferencing) accuracy is different than that of local point cloud accuracy. Poor RTK quality might only slightly affect point cloud accuracy. This means that when you scan with poor RTK, the scan might be less accurate compared to the ground truth, but measurements between objects within the point cloud will still be accurate.

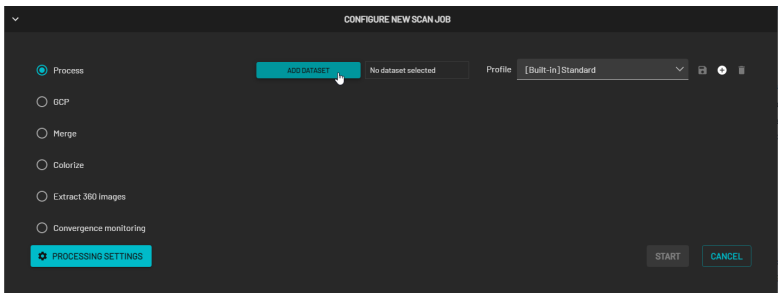
6. Processing your Scan

Once data has been captured, you can process it using Emesent Aura. Ensure your license includes the ability to process RTK datasets (SLAM and RTK). If you need to upgrade your license, contact licensing@emesent.io.

> After processing your scan in Aura, you can review the accuracy report to understand the GPS signal quality throughout your scan.
> However, if your scan only contains GPS quality georeferencing data and not RTK data (RTK Fix or RTK Float), you will not receive an accuracy report.
> For more information, refer to the RTK Accuracy Report section.

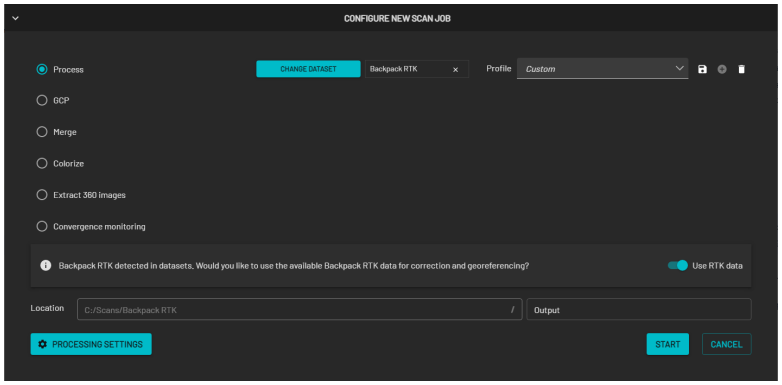
6.1 Process Scan in Emesent Aura

1. Download and install **Emesent Aura 1.7** or later.
2. Go to the **Process** tab then click **Process Scan**. The **Configure New Scan Job** panel displays.
3. Select the **Process** workflow.
4. Click **Add Dataset** then add the folder containing the raw scan file with RTK data. The **Profile** is automatically updated depending on the detected payload used in the scan.

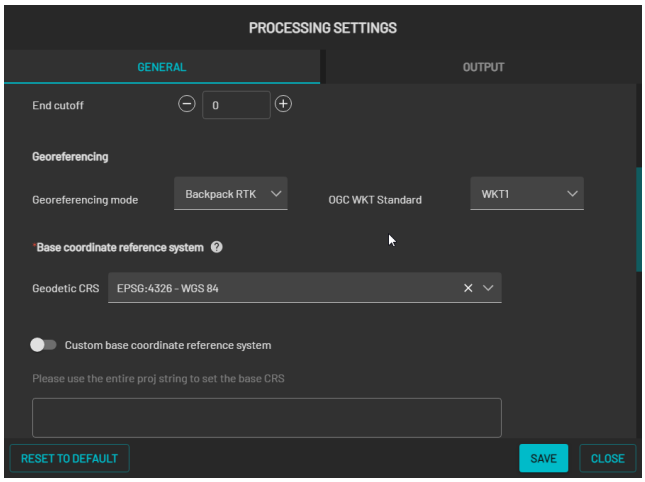


> If the Backpack RTK data in the selected dataset is insufficient, you will be notified that georeferencing will be disabled.

5. You will be prompted once RTK is detected in your dataset. Click **Use RTK data**. The **Profile** changes to **Custom** and you will get a notification that georeferencing will be set to RTK.



6. Click **Processing Settings** to specify any additional configuration including selecting the **Geodetic CRS** under **Base coordinate reference system**. You will notice that the **Georeferencing mode** is auto-selected to **Backpack RTK**. Changing to another mode will still process the point cloud, but with georeferencing disabled.



> When processing Backpack RTK, **Point Filtering** is enabled by default while **Moving Object Filtering** is disabled.

7. Click **Start** to process your scan. Once the scan is processed, all the relevant files will be in the "**Output**" folder.

6.2 Colorizing a Backpack RTK Scan

When colorizing a Backpack RTK scan, we recommend the following:

- Always use the GoPro Max 360 when colorizing Backpack RTK.
- Remove irrelevant content from being colorized by enabling the **Image Masking** option in **Processing Settings (Colorize tab)** and using the **[Built-in] GoProMax-backpack-RTK** mask template.

> Emesent Aura comes with several other pre-defined masks that you can use, but you can also create your custom mask in case none are suitable for your dataset. For more information on creating a custom mask, refer to the Emesent Aura user manual.

- Maintain all points in the cloud - including those not seen by the GoPro - by disabling the **Remove Uncolored Points** option in **Processing Settings (Colorize tab)**.

6.2.1 Improving Colorization Quality

The following changes to the **Processing Settings (Colorize tab)** in Emesent Aura may help you improve colorization quality if desired for your project. Note that higher quality settings will increase processing time.

- Decrease **Visibility Gamma** to **-.0001** to increase color richness.
- Decrease **Visibility Voxel Size** to **0.01** to increase color resolution, particularly in detailed areas.
- Increase **Colorization Distance** to colorize points that are further away.

> Colorization quality is also affected by the number of points you have captured. Therefore, spending a longer time at points of interest will typically improve colorization quality.
> For more information on colorization generally, refer to the Emesent Aura user manual.

6.3 Reproject your Point Cloud

Reprojection in Emesent Aura is an automated workflow that allows for RTK scans to be processed with the correct coordinates by simply selecting the target coordinate reference system (horizontal) and converting from ellipsoidal height to orthometric height using a GEOID model (vertical). This can be done via **Processing Settings** when processing raw data or **Export reprojection** from the **Project menu** if exporting a georeferenced point cloud.

For more information on the reprojection workflow, refer to https://4999118.hs-sites.com/en/knowledge/working-with-point-clouds-reproject-your-point-cloud.

6.4 RTK Accuracy Report

A report is generated as part of the output to aid in understanding how well the RTK and SLAM were aligned during the scan. Click **View** beside the output CSV to display the **RTK Accuracy Report**.

> In Emesent Aura, only a summary of the report is provided, which is usually sufficient. To view a more detailed report, click **Open CSV** to view the report from your native CSV application. To view the accuracy report from a previously processed dataset, drag and drop the CSV file into the **Viewport**.

The report is categorized into the following sections:

- **GPS data:** Percentage of the GNSS receiver's scan time in each GPS state.
- **RTK Quality:** Accuracy of the GNSS position reported.
- **RTK → SLAM distance:** Reported distance between the GNSS and SLAM trajectory after correction.

6.5 Maximizing Georeferencing Accuracy

GPS quality is impacted by many factors, which can affect the georeferencing accuracy. While Emesent's Wildcat SLAM can compensate for poor-quality GPS signals to create a locally accurate point cloud, it cannot improve georeferencing accuracy. Accordingly, the GPS quality you can achieve at the site will determine the georeferencing quality.

Some of the key factors to consider are outlined below. To learn more about RTK, review the Emlid documentation at https://docs.emlid.com/reachrs2/rtk-quickstart/rtk-introduction/.

Factor	Description
Clear line of sight	A clear line-of-sight view of the satellites is the minimum requirement for GPS to work effectively for position calculation and signal tracking. Buildings, tall structures, trees, etc., can block signals, impact satellite geometry, and result in poor positional estimation.
Baseline length	Generally, each additional kilometer of baseline length will decrease georeferencing accuracy by 1mm. The recommended maximum baseline length is 10km, though acceptable results can be achieved with a baseline of up to 25km depending on the project requirements. Select a closer CORS base station (if available) or use a local base station setup to reduce the baseline length.
Receiver configuration	It is critical to configure your receiver appropriately to receive GPS corrections that can be used by Hovermap.
Urban canyons	In addition to blocking out the view of satellites, tall buildings can reflect GPS signals which can cause errors when the GPS receiver is calculating its position.
Man-made interference	GPS signals can be interfered with by man-made sources such as GPS repeaters, TV broadcast stations, signal jamming devices, and personal privacy devices.
Satellite arrangement	Satellites constantly orbit the Earth, and different configurations can cause slight variances in precision.

6.6 Choosing between CORS networks and a base station

A CORS network subscription is preferable if:

- You do not want the extra expense of a base station.
- Your local area has a good quality CORS network.

> CORS networks have the additional benefit of requiring less equipment and a shorter setup and configuration.

A base station is preferable if:

- You require the highest accuracy georeferencing.
- Your local CORS network is poor quality.
- Your closest CORS network base is more than 10km* away.

> *****Depending on georeferencing accuracy requirements. Up to 25km can work for lower accuracy use cases.*

6.7 Using Ground Control Points

Using GCPs is necessary if your accuracy requirements are greater than what is obtained using RTK, and there is a need to further constrain the point cloud.

In addition, use GCPs if you want to verify the georeferencing accuracy achieved through RTK. Comparing the coordinates of the GCPs in the point cloud against their known coordinates allows you to assess the accuracy of the RTK georeferencing process.

The table below sets out the expected accuracy for each GPS status to help you decide whether GCPs are needed. The accuracy can vary for many reasons and the stated accuracy is not guaranteed.

GPS Status	Approx. horizontal accuracy
RTK Fix	3cm
RTK Float	30cm
GPS	1.5-3m
No GPS Fix	N/A

To learn more about expected RTK accuracy, please see the Vehicle RTK accuracy report which tests RTK accuracy in a real world environment.

6.8 Merging RTK Data and Correcting RTK Data with GCP

Merging RTK data or further constraining RTK data with GCPs are currently not supported in Emesent Aura. The following third-party software can be used with Hovermap RTK data to achieve this.

- TerraScan - https://terrasolid.com/products/terrascan/
- Cyclone 3DR - https://leica-geosystems.com/products/laser-scanners/software/leica-cyclone/leica-cyclone-3dr

7. Troubleshooting

7.1 Scanning with Backpack RTK

Issue	Potential cause(s)	Potential solutions
When configuring the GNSS receiver, it is not receiving corrections in the Emlid Flow app	The GNSS receiver settings are misconfigured.	Ensure the receiver is configured with the correct settings. Also, check if the NTRIP details (i.e. IP address, user name, password) are spelled/entered correctly. If using a SIM card, turn off the device, remove and re-insert the SIM card, and restart. Restart the device. If issues persist, contact Emesent support.
When the GNSS receiver is plugged into the Hovermap, Web UI / Commander shows 'No GPS'	The Hovermap was turned on before the GNSS receiver. The GNSS receiver is not turned on. The Emlid cable is not fully inserted.	Remove the GNSS receiver's cable and re-insert. Ensure the GNSS receiver is configured with the correct settings. Reboot the GNSS receiver. Reboot Hovermap.
Web UI / Commander shows 'RTK Error'	The GNSS receiver's settings are misconfigured.	Ensure the GNSS receiver is configured with the correct settings.

Issue	Potential cause(s)	Potential solutions
I'm not getting RTK Fix I'm seeing No GPS Fix	Correction is settings are not configured properly. The baseline length is >15km. The current environmental conditions are not ideal for obtaining a good-quality RTK signal.	Georeferencing accuracy decreases by approximately 1mm for every kilometer of baseline length. Select a closer CORS base station if one exists, or use a base station setup to reduce the baseline length.
I do not see the RTK status in Emesent Commander	Incompatible software versions	Ensure you are using the latest versions of Emesent Cortex (3.3 or later) and Emesent Commander (1.5 or later). Use the Web UI to see the RTK status. However, this has less functionality and you cannot see number of satellites, precision or coordinates.

7.2 Processing Backpack RTK Data

Issue	Potential cause(s)	Potential solutions
Processing the scan with RTK is causing the scan to "split"	The **Advanced feature matching** setting is disabled. The GNSS receiver is returning a high-confidence incorrect GPS data due to an urban canyon or other environmental conditions.	Go to the **Processing Settings (General tab)** and enable **Advanced feature matching**. Review the site to determine if tall reflective buildings may be interfering with the GPS signal.
I'm seeing myself throughout the point cloud	The bounding box is not large enough to exclude the user from the point cloud.	Go to the **Processing Settings (General tab)**. Under **Exclusion Zone,** change the **Mode** to **Bounding Box** and adjust the values.

Issue	Potential cause(s)	Potential solutions
Backpack RTK data is not in the desired coordinate system	The scan has not been reprojected.	Reproject the scan into your desired coordinate system. See Reproject your Point Cloud.
Colorization is low-quality	Low point density A mask is applied to the area requiring colorization.	Review the extracted frames to determine if the desired area has been masked. Change the mask if necessary. Change the orientation of the Hovermap during scanning to ensure the GoPro MAX 360 camera has a sufficient view of the area.
Areas of my point cloud I expect to be colorized are not colorized	A mask is applied to the area requiring colorization. The area requiring colorization is too far away	Review the extracted frames to determine if the desired area has been masked. Change the mask if necessary. Change the orientation of the Hovermap during scanning to ensure the GoPro MAX 360 camera has a sufficient view of the area. Go to the **Processing Settings (Colorize tab)**. Under **Processing Quality**, increase the **Colorization Distance** value.

emesent

PREPARED BY:
EMESENT PTY LTD
LEVEL G, BUILDING 4, KINGS ROW OFFICE PARK
40-52 MCDOUGALL ST, MILTON, QLD, 4064 AUSTRALIA

EMAIL: CUSTOMER-SUCCESS@EMESENT.IO
PHONE: +61 7 3548 9494