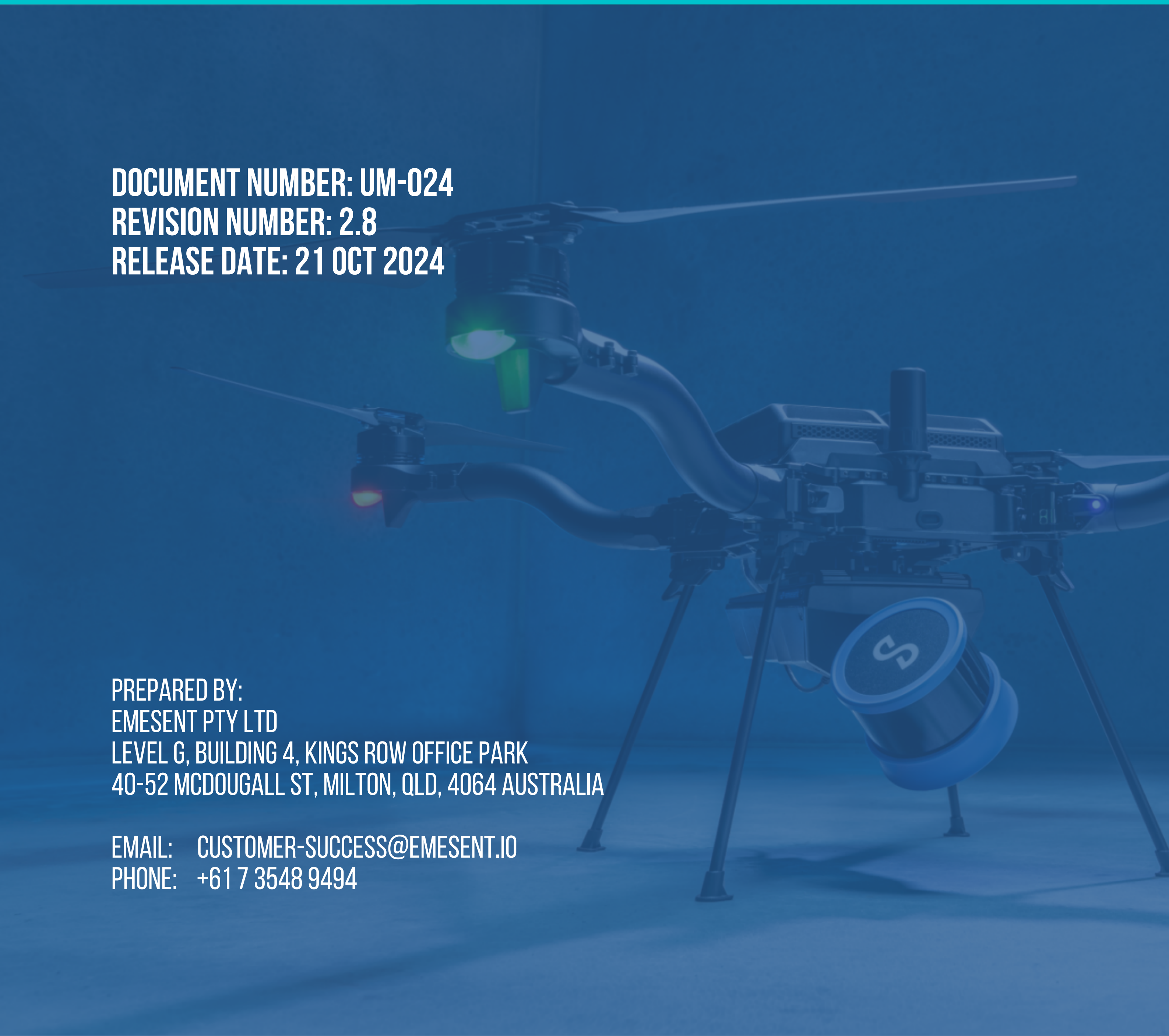
HOVERMAP USER MANUAL



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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 to Hovermap

Hovermap is a smart mobile scanning device that provides autonomous mapping in challenging, inaccessible areas. It uses sophisticated SLAM (simultaneous localization and mapping) technology, allowing for the collection of accurate 3D LiDAR data in almost all environments. With no GPS required for mapping, you can use Hovermap indoors, outdoors, and underground.

Hovermap can easily be mounted to a drone or vehicle, or you can perform a walking or backpack-mounted scan. Switching between these options is easy, with Hovermap's quick-release mechanism.

Hovermap is lightweight, yet robust enough to withstand the demands of harsh environments. Made from a combination of machined aircraft-grade aluminum and reinforced polypropylene components, Hovermap is light, yet strong enough to support its rotating LiDAR while remaining stable in flight.

Benefits of Hovermap

- **Safety:** Eliminates the need for people to enter hazardous areas.
- **Access:** Allows you to capture data in areas not possible with other technologies.
- **Efficiency:** Enables you to survey areas very quickly (including setting up and packing away).
- **Ease of use:** Simplifies your operation, with autonomy and collision avoidance.
- **Versatility:** Hovermap can be mounted according to specific needs, allowing you to use it in many different and creative ways. Hovermap can be used for a wide variety of commercial applications, including mining, construction and engineering, geospatial, and public safety.
- **Rich, survey-grade datasets:** Allows you to create dense and detailed point clouds. The automated ground control feature automatically georeferences point clouds, providing survey-grade accuracy.
- **True color scans:** With Hovermap's optional colorization feature, you can add a new level of reality to your 3D point clouds.

1.1 Mission modes

There are three mission modes for Hovermap, providing options for every scanning need.

1.1.1 Mapping mode

Mapping mode gives you fast, accurate, high-resolution mobile scanning of environments where autonomy is not required. Hovermap can be used for walking or backpack-mounted scans, lowered in a cage, or attached to a vehicle or a pole. It can also be attached to a drone and used in Mapping mode (if autonomy capability is not required).

1.1.2 Pilot Assist mode

Pilot Assist mode provides safe, line-of-sight flight, collision avoidance, and stability control in GPS-denied environments, allowing you to fly indoors or closer to structures. It uses SLAM technology to protect and stabilize your drone. In addition to simply collecting points, the LiDAR sensor is integrated into the drone's flight control system. Features are identified as the point cloud is created, giving the drone an awareness of its surroundings. This feature allows the drone to fly safely, creating a virtual elliptical shield (Shield) around it.

1.1.3 Autonomous mode

Autonomous mode enables flight beyond line of sight and communications range. Place smart waypoints on the live-streamed 3D point cloud, and Hovermap will plan and self-navigate a path to safely complete its mission, even in GPS-denied environments. The drone will also intelligently calculate and optimize the return flight path and ensure that it has adequate battery capacity to safely return home.

1.2 Specifications

1.2.1 Hovermap Interfaces

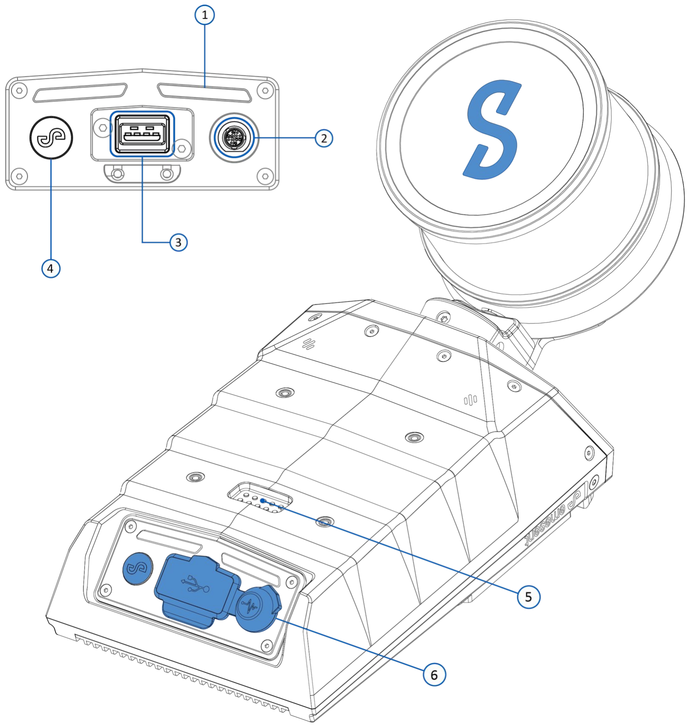


Figure 1 Hovermap rear panel

1. Status LEDs
2. Fischer connector
3. USB connector
4. Power button
5. Smart connector (interfaces with accessories)
6. Protective cover

1.2.2 Hovermap ST

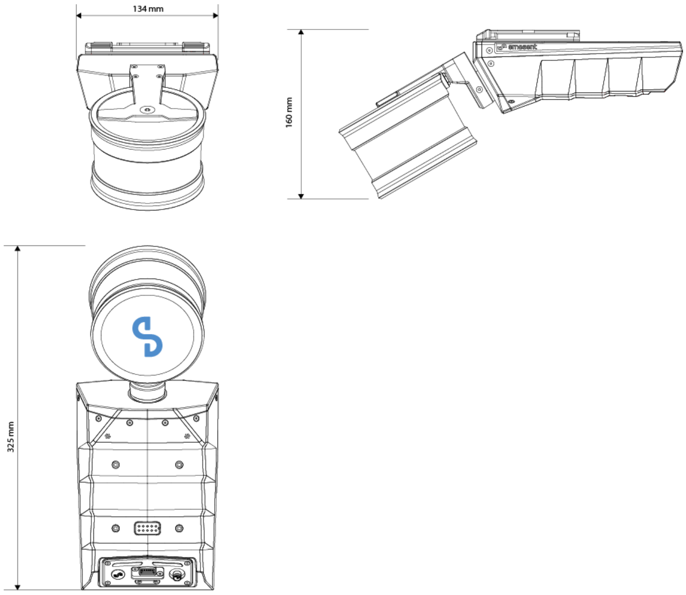


Figure 2 Hovermap ST

MAPPING SPECIFICATIONS

SLAM mapping	Simultaneous Localization and Mapping (SLAM) based LiDAR mapping +/- 0.03% drift
LiDAR range	0.50 m to 100 m
LiDAR accuracy	+/- 30 mm
Mapping accuracy	+/- 20 mm in general environments +/- 15 mm in typical underground and indoor environments +/- 5 mm isolated change detection capability
Angular field of view	360° x 290°
LiDAR data acquisition speed	Single Return Mode: up to 300,000 points/sec Dual Return Mode: up to 600,000 points/sec
Maximum data capture traveling speed	Vehicle: 40 km/h (24.9 mph); flight: 5 m/s (16.4 fps) above ground, 2 m/s (6.6 fps) underground or confined spaces
Start / stop scanning while walking or hovering	Yes
Outputs	Full resolution point cloud, decimated point cloud, trajectory file
Point cloud file format	.las, .laz, .ply, .dxf, E57
Point cloud attributes	Intensity, range, time, return number (strongest & last) and ring number
Processing parameters	Pre-set profiles with 20+ adjustable parameters
USB3	High-speed data offload
Storage	512 Gigabytes – approximately 8 hours of sensor data
Operating temperature	-10 to 45°C (14 to 113°F)

PHYSICAL SPECIFICATIONS

IP Rating	IP65
Weight	1.6 kg (3.63 lb)
Input voltage	14 - 54V, powered from a battery or auxiliary power input
Deployment	Drone/UAV, backpack, vehicle, tether, ground robot
Supported drones	DJI M210v1, DJI M600, DJI M300, DJI M350
Quick release mount	Yes
Auxiliary port	Proprietary connector
USB port	Yes
WiFI Antenna	Internal

AUTONOMY SPECIFICATIONS

Flight modes	Pilot Assist: Non-GPS flight, position hold, assisted flight, collision avoidance, regulated flight speed. Autonomous Waypoint Mode: Autonomous navigation to waypoints
AL2 waypoint types	2D, 3D, planar, height
AL2 navigation modes	Guided exploration, local and global path planning
Autopilot compatibility	DJI
Omnidirectional collision avoidance	360° x 360°; size of an obstacle > 2 mm (5/64 ") wire; range 1.2 to 40 m (3.9 to 131 ft); In-flight adjustable safety distance

Figure 3 Hovermap ST specifications

1.2.3 Hovermap ST-X

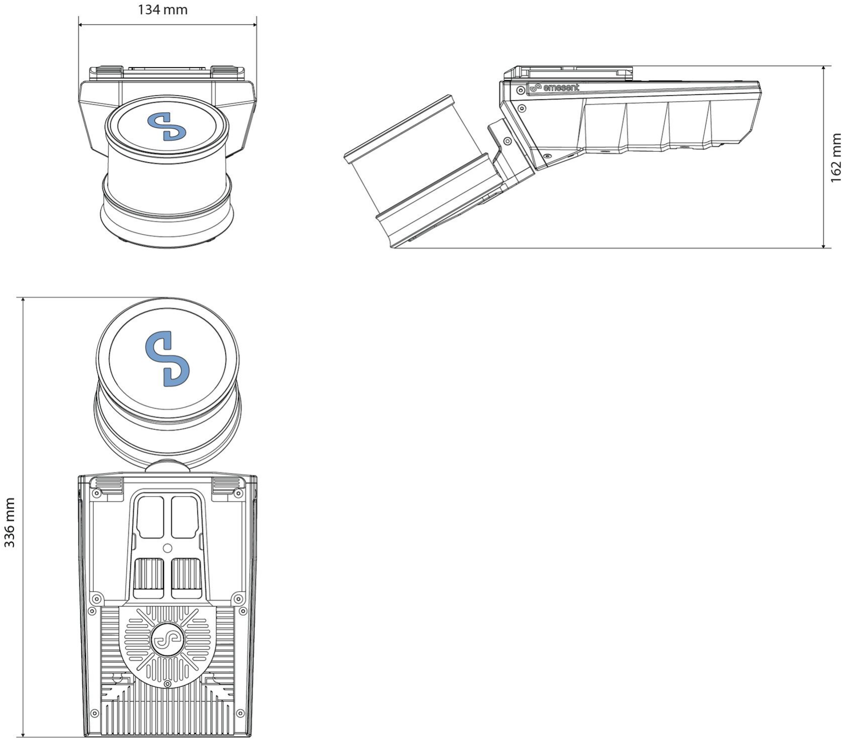


Figure 4 Hovermap ST-X

MAPPING

LiDAR Sensing Range	0.5 to 300 m 1.6 to 984 ft
LiDAR	Single Return Mode: up to 640,000 points/sec Multi Return Mode (3 return): up to 1,920,000 points/sec 360 x 290° field of view Class 1 Eye Safe
Mapping Output	Full resolution point cloud, decimated point cloud, trajectory file. Point cloud file formats: .las, .laz, .ply, .dxf, .E57
Mapping Method	Simultaneous Localization and Mapping (SLAM)
Mapping Accuracy	± 15 mm (19/32 in) in general environments ± 10 mm (3/8 in) in typical indoor and underground environments ± 5 mm (7/32 in) isolated change detection capability
Onboard Storage	512 Gigabytes More than 4 hours of sensor data
Point Cloud Attributes	Intensity, range, time, return number (strongest, first & last), ring number, RGB / true color (optional)

PHYSICAL

IP Rating	IP65 certification pending
Operating Temperature	-10 to 45°C 14 to 113 °F
Weight	1.57kg 3.46 lb
Supported Drones	DJI M210v1 DJI M600 DJI M300 DJI M350 Freefly Astro
Auxiliary port	Propriety Connector
USB port	Yes
WiFi Antenna	Internal

AUTONOMY

Tap-To-Fly and Guided Exploration	Waypoint setting in real time 3D map and autonomous path planning
Collision Avoidance	LiDAR omnidirectional range of 1.2 to 40 m (3.9 to 131 ft) Size of an obstacle > 2 mm wire (3/32 in)In-flight adjustable safety distance
Intelligent Return To Home	Autonomous Return To Home navigation triggered by low battery or excessive dust
Assisted Flight	Non-GPS flight, position hold, assisted flight, collision avoidance, regulated flight speed

Figure 5 Hovermap ST-X specifications

1.3 Inclusions

1.3.1 Standard Hovermap kit

The standard kit for Hovermap includes the following items to set you up on your Emesent journey.

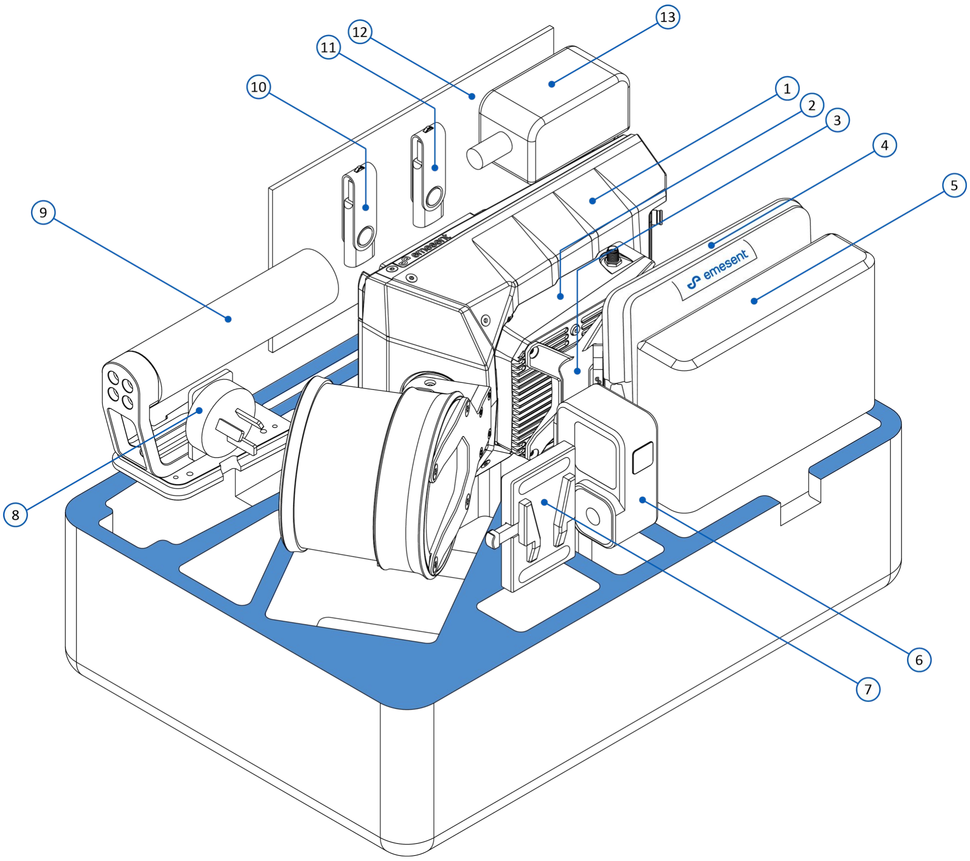


Figure 6 What's in the box

1. Hovermap
2. Long Range Radio (optional)
3. Colorization mount (optional)
4. Cable bag: Contains 1 battery cable for walking scans (1.5 m)
5. Battery
6. GoPro (optional)
7. Battery Belt Clip
8. International adapters (US/Canada, Australia/New Zealand, Europe/Japan)
9. Handle
10. Hovermap manual (on USB flash drive)
11. Emesent Aura license dongle
12. Quick-start guide
13. Battery Charger

1.3.2 Platforms available

The following platforms are available for Hovermap:

- DJI M210
- DJI M600
- DJI M300
- DJI M350
- Freefly Astro (ST-X only)

The following table lists the mission modes and controllers supported on each platform:

Platform	Supported Controller	Mapping	Pilot Assist	Autonomous
DJI M210	DJI Cendence Remote Controller	✓	✓	✓
DJI M300	DJI Smart Controller Enterprise DJI RC Plus Remote Controller	✓	✓	✓
DJI M350	DJI Smart Controller Enterprise DJI RC Plus Remote Controller	✓	✓	✓
DJI M600	DJI M600 Remote Controller	✓		
Freefly Astro	Freefly Pilot Pro	✓	✓	✓

> **Warning**
> The M300 needs to be updated to the latest firmware to be able to support the DJI RC Plus Remote Controller. A firmware update will wipe the Barometer Modification settings (if any).

1.3.3 Accessories available

The following accessories are available for Hovermap.

- Backpack kit
- Boom pole kit
- Car mount kit
- Cavity Monitoring System (CMS) pole kit
- Hovermap protective cage kit
- 360 Colorization kit
- Long Range Radio kit
- Automated ground control targets
- Battery fast charger kit
- Handheld 360 Image Extraction kit
- Hovermap-Astro Interface kit
- Spot Cage for Hovermap
- Vehicle RTK kit
- Backpack RTK kit

2. Hovermap Operating Limitations

To ensure effective data capture and the safe operation of Hovermap, you must be aware of the following limitations.

2.1 Environmental conditions

Hovermap has an Ingress Protection rating of IP65. This means that:

- Hovermap is dust-tight (no ingress of dust).
- Hovermap is protected against water jets from any direction.

Exposure to conditions above this rating may result in hardware failure. We don't recommend using Hovermap in rain or fog.

2.2 Temperature limitations

Hovermap is rated to operate in temperatures between -10°C (14°F) and 45°C (113°F). Operation outside of these temperatures has not been tested and could result in abnormal behavior.

> **Warning**
> We recommend that you give Hovermap time (5 minutes or so) to adjust to the ambient temperature before flying in hot and humid environments, such as in an underground mine. This is especially important if your Hovermap has been kept in an airconditioned environment. Failure to do this could result in lens fogging and a potential crash.

2.3 Range limitations

Hovermap uses a LiDAR with a range of 0.5 m to 100 m for ST and 0.5 to 300m for ST-X. The closer you are to the target, the better the quality of the scan. You will achieve the best quality scan if Hovermap is at a distance of 5 m to 15 m from the target.

2.4 LiDAR limitations

Hovermap's LiDAR uses light reflection to measure the distance of the object from the sensor. This can become a problem if:

- **A surface is highly reflective.** This can cause points to be misrepresented, and the resulting point cloud will have a high level of noise.
- **A surface is non-reflective.** This can cause the points to be absorbed and disappear, and the resulting point cloud will have missing points.

Reflective surfaces	Non-reflective surfaces
Mirrors	Water
Windows and glass	Some gases
Highly polished surfaces	Very dark matt black surfaces

2.5 Collision Avoidance (Shield) limitations

Shield is a key feature of Hovermap that prevents you from flying into static objects. However, it will not actively avoid objects approaching the system and will not combat environmental factors (for example, strong gusts of wind). It can therefore be hit by birds, falling rocks, moving ropes, or other moving objects, and can be affected by external forces. We recommend that you avoid flying too close to movable objects, as these can be disturbed by the drone, or close to objects in very windy conditions.

2.6 Interference limitations

Avoid areas with elevated levels of electromagnetism to minimize interference. A distance of at least 10 m should be maintained between Hovermap and elevated EMI sources such as base stations and radio-cellular transmission towers.

3. Hovermap Basics

3.1 Understanding Hovermap

It is crucial to have a good understanding of the concepts outlined in this section to achieve the best results from your Hovermap. Even though Hovermap is intelligent, it is still just a tool. Like any other tool, its effectiveness depends on your proficiency and expertise when using it. You are still responsible for guiding Hovermap correctly and saving it in case of any trouble.

3.1.1 How does Hovermap work?

3.1.1.1 What can Hovermap see?

LiDAR performance

Hovermap ST and Hovermap ST-X use different LiDAR types. The performances of each are described below.

	Hovermap ST	**Hovermap ST-X**
Number of lasers	16	32
Number of laser returns	2	3
Laser range	100m	300m
LiDAR field of view	30°	40°
Number of points per second	up to 300,000 (single return mode)	up to 640,000 (single return mode)
Hovermap field of view	360°	360°

A small blind spot exists behind the body of Hovermap (shown in gray in the following image). This occurs because the body of the Hovermap blocks the field of view in that direction. When scanning, it is important to consider any platform or individual holding the Hovermap.

Point density

Point density refers to the number of points in an area. To achieve a quality scan, it is important to understand which areas will receive the greatest point density.

While Hovermap does have 360° coverage, it will focus on some areas more than others. The area of greatest point density is directly in front of the LiDAR sensor (shown as a dark blue cone in the following image). This is because a number of lasers will always be facing this direction, even while the sensor head is rotating.

The rest of the sphere will still have good coverage, but the point cloud in these areas will be less dense. This is because the remainder of the lasers are in constant motion, due to the rotation of the scanning head.

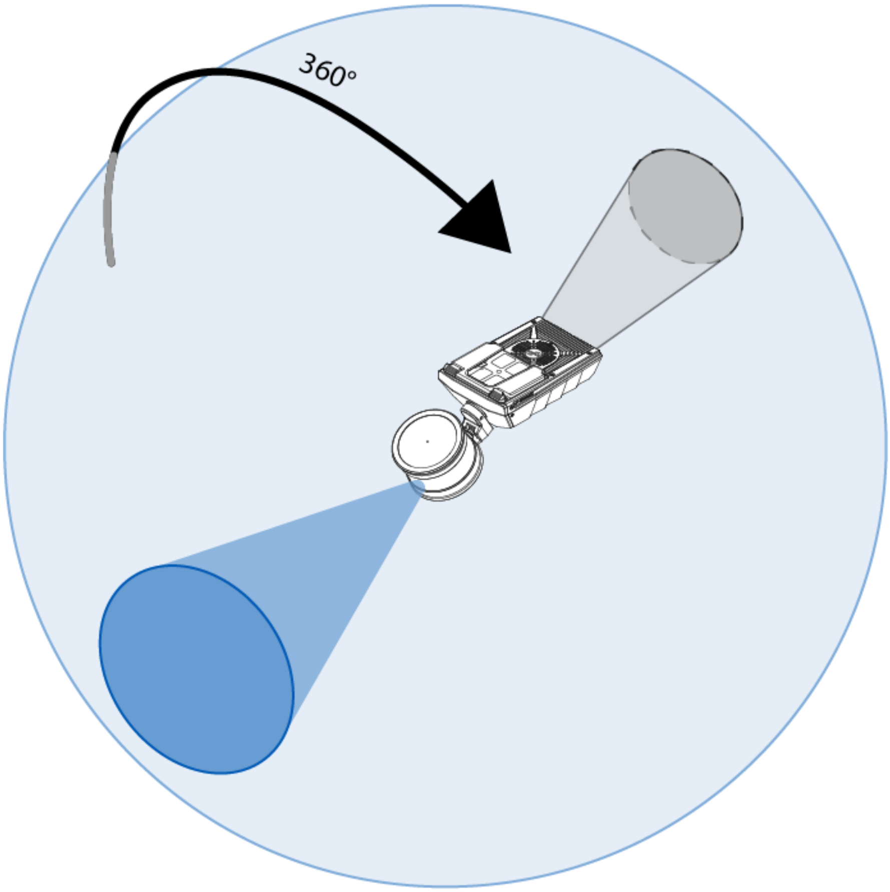


Figure 7 Hovermap's field of view

In practice

The factors above all have implications when using Hovermap. In practice, it can help to visualize the cone of denser points as a flashlight. When scanning, make sure that you focus the cone on any important features that you wish to capture. If you do this, the SLAM process will be able to create a denser, more accurate point cloud, and the possibility of a SLAM slip will be reduced.

Hovermap is also constantly recording points, so simply spending more time in your targeted areas will increase your point density, even if you cannot focus Hovermap directly on your area of interest.

Tips to improve point density

- Move slowly.
- Sweep the cone in all directions to ensure a denser point coverage.
- When attaching Hovermap to a drone or vehicle, face it so that the cone can see the largest number of features.

Resolution

The closer Hovermap is to its target, the greater the accuracy of the points it produces (beyond the minimum scan distance of 0.5 m). If you are close to your target, you are more likely to produce a clean point cloud the first time, without the need for a lot of cleaning in the postprocessing stage. We recommend that you stay within 40 m of your target.

Captured data

The data captured by Hovermap includes characteristics such as range, intensity, and the time that the data was captured.

Mounting Hovermap onto your platform of choice also allows the system to embed GPS data into the collected LiDAR data. This embedded data can then be used in the postprocessing stages.

3.1.1.2 What is SLAM?

SLAM stands for simultaneous localization and mapping. SLAM technology runs in real-time to allow Hovermap to create a map of its environment, while at the same time working out its position, orientation, and speed within that environment.

Hovermap uses this technology for a variety of tasks, including mapping, autonomous navigation, collision avoidance, and position hold in GPS-denied environments.

SLAM relies on distinct geometric features to work effectively. Using these features, Hovermap can build a map of its surroundings and track them as it moves around. This means that there is no need for external infrastructure, such as GPS. As a result, Hovermap can work outdoors, indoors, and underground.

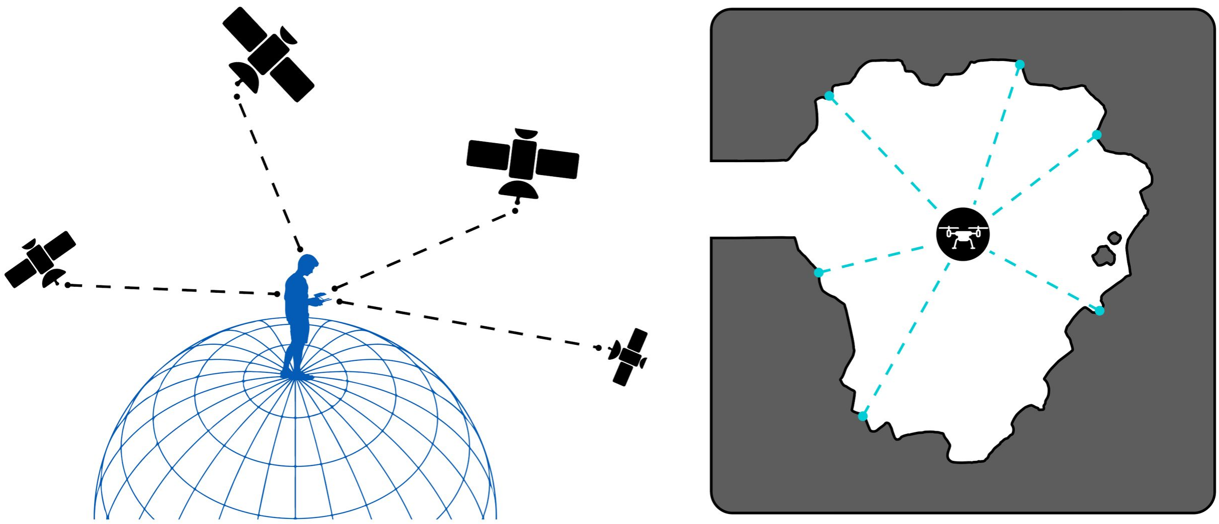


Figure 8 GPS vs SLAM

> Just as you need many GPS satellites to have a good GPS location, SLAM needs recognizable features to calculate a good position.

Why are features important?

For SLAM to work, it requires features to be present in its surroundings. Features are distinct geometric objects that do not move. Hovermap uses these features to determine its position in space and to build a point cloud around itself.

Feature-rich environments are ideal for SLAM, but smooth, featureless environments can present a challenge. If you use Hovermap in a featureless environment, you run the risk of a SLAM slip. This means that Hovermap will completely lose track of its surroundings, which will affect autonomous functionality, ruin your scan, and potentially damage your Hovermap (for more information, refer to the *What is a slip?* section). This is why an understanding of how Hovermap sees the world is so important.

Feature-rich environments

Feature-rich environments contain many distinct, geometric features that do not move. These environments are ideal for Hovermap. A good example is a city center, with large, distinct buildings that can help Hovermap track itself. In this environment, Hovermap is able to operate both more effectively, and at a greater height, than it would be able to in a sparser environment.

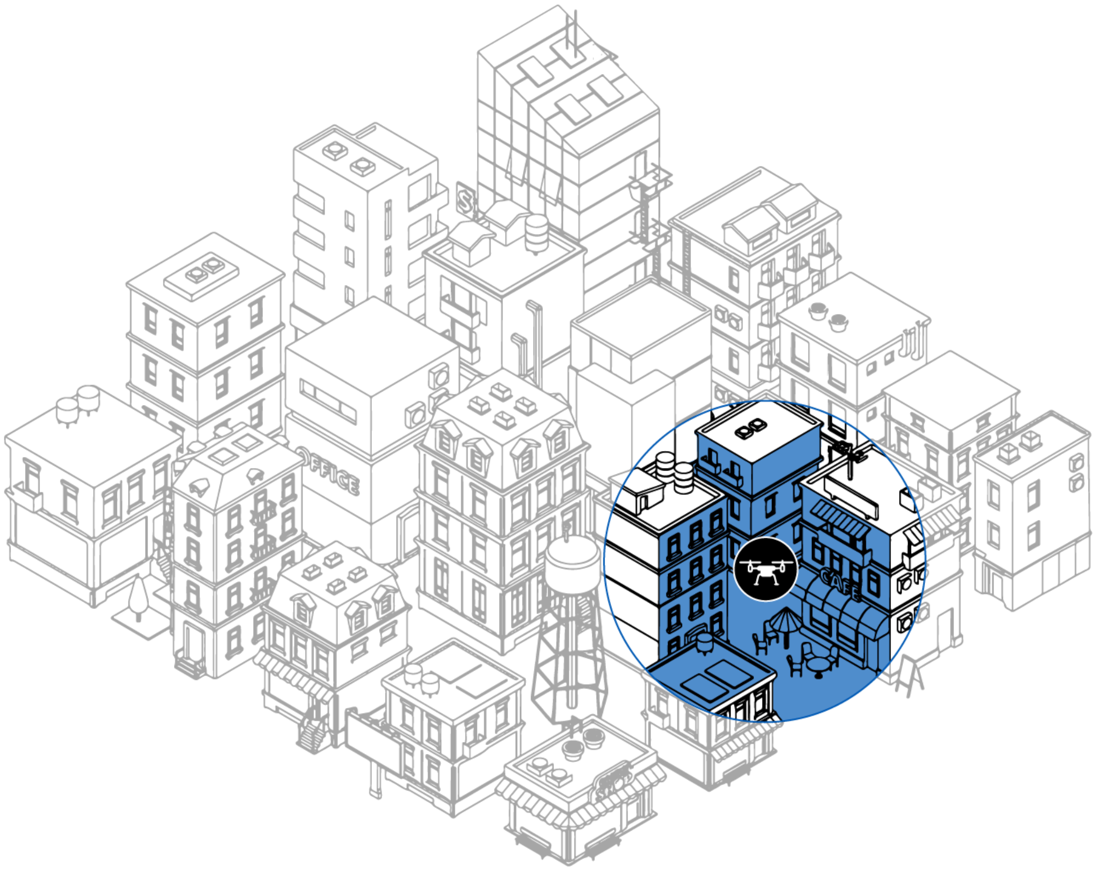


Figure 9 A feature-rich environment

Challenging environments

Environments without distinct geometric features can be more challenging for Hovermap to navigate. There are certain techniques available to help you produce more reliable scans in these environments, but you will need to be mindful of your surroundings and plan your scan carefully in order to avoid a SLAM slip.

Examples of challenging environments include:

- Flat and smooth areas without features, such as large outdoor parking lots, sports fields, and lakes.
- Smooth tunnels or passageways with featureless walls, such as inside concrete water pipes.
- Areas with very similar and repetitive features and patterns.
- Areas dominated by vegetation, such as forest canopies, gardens, and parkland (where the features all look the same, forming a homogenous surface).
- Environments with many moving objects, such as cars, trucks, and plant machinery.

- Environments with many features that can absorb or reflect LiDAR beams, such as water or dark, matt paints.
- Environments that require you to transition through very narrow passages.

It is best to avoid scanning in *completely* featureless environments, as Hovermap will not be able to track itself. However, you can introduce your own features (such as pylons and parked vehicles) to these environments to make them more SLAM-friendly. These introduced features should be geometric if possible, and not able to move. Bear in mind that markings and colors are not features. Features are *objects*.

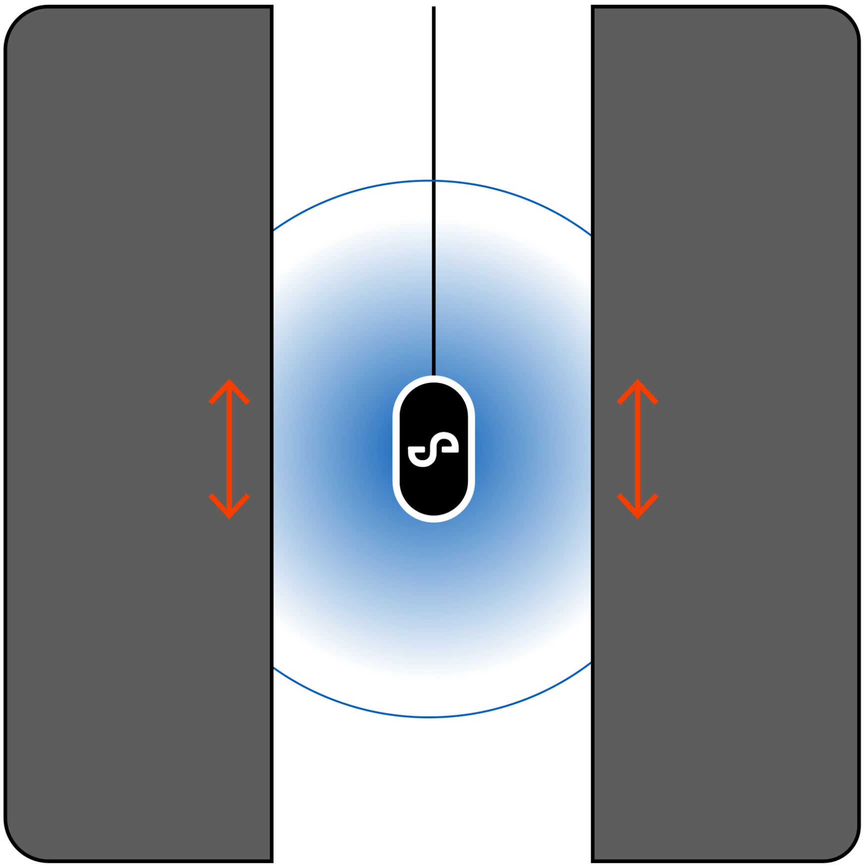


Figure 10 A featureless environment

Somewhere in between

Sometimes an object can be a distinct feature in one context, or the exact opposite in another context. For example, vegetation can either be a distinctive feature *or* relatively featureless, depending on the density of foliage in an area. A single tree could be a distinct feature to Hovermap, but a dense canopy can appear as a homogenous surface. In this case, it is not much better than an open field.

The following image shows a more challenging scenario. This environment has some features (highlighted in blue), but also plenty of open space with no features at all (shown in gray). Hovermap can use the buildings, and possibly the trees, to keep track of its surroundings. But to avoid a SLAM slip in this situation, you will have to make sure that there are some features present throughout your scan. You should avoid venturing out too far into the open square.

When working in these kinds of environments, you must understand how Hovermap works and that you plan your mission carefully. Refer to the Hovermap Mission Planning section for more information.

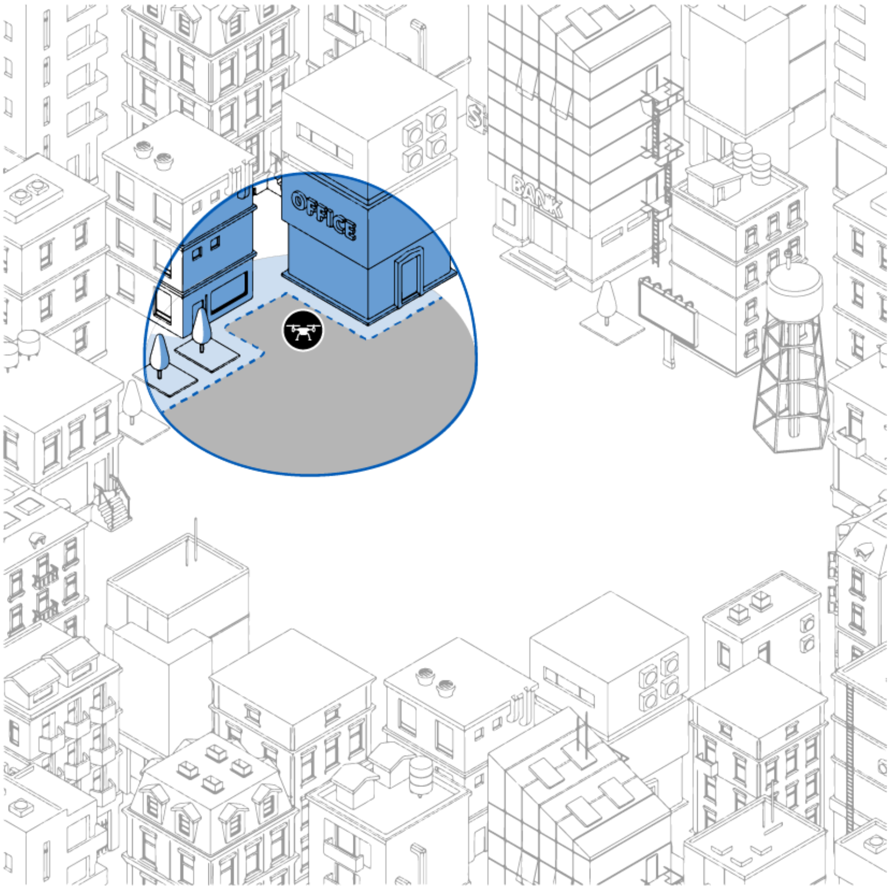


Figure 11 It's complicated

Tips for working with features

- Make sure that there are always enough features within 40 m of Hovermap. The closer they are, the better.
- Keep any features in front of Hovermap as much as possible.
- Where possible, add features to smooth environments.
- Fly as low and as slow as possible.
- Avoid scanning in areas with lots of moving objects.
- Move Hovermap so that it can continuously see where it has been *and* where it is going. This is especially important when you move through narrow passages and doorways.

What is drift?

Drift is the stretching or warping of the point cloud that can happen as SLAM pieces together its surroundings.

Why does drift happen?

Hovermap uses LiDAR to determine its position within its environment. It emits laser pulses and then measures how long it takes for the light to return. Based on the time this takes, Hovermap knows how far away an object is from the sensor. Drift occurs as a result of tolerances in measuring these light return times. The longer a scan takes, and the further the scan travels, the more drift is accumulated.

Some environments, such as those with a lot of vegetation, or long scans that only go in one direction (such as a tunnel or a road), can lead to more drift accumulating in your final scan. Refer to the *Common scenarios* section for more specific information on best practices for scanning in these situations.

Tips to avoid drift

- Limit your scans to the smallest area possible. Long scans can cause significant drift.
- “Close the loop” or scan in a grid pattern to average out drift. For more information, refer to the *Scan patterns* section.

What is a slip?

A slip occurs when Hovermap completely loses track of its location. This happens when Hovermap cannot detect any features in its environment, or if there is not enough overlap between features. If a slip does occur, the following can happen:

- The resulting scan will look nothing like the real-world environment. It will most likely resemble a scrambled line.
- The system will lose all autonomous functionality. If this happens, it will lose its ability to hold position.
- The system will not be able to return to home, as it has lost its ability to know where home is.

Why do slips happen?

Slips can happen for several reasons, such as:

- Flying too high above the ground. In this situation, the LiDAR points will not be able to reach the ground with adequate density to build a suitable map. For this reason, we recommend a flight height of 40 m.
- Flying above bodies of water. Water can't reflect light, so Hovermap can't map its environment effectively.
- Flying across open land (such as open farmland) that has no distinct geometric features.
- Moving through doorways too quickly without looking back over features that have already been scanned. Hovermap can't stitch the old and new environments together if the transition between the two "worlds" happens too quickly.
- Operating Hovermap in a smooth tunnel or shaft with no features. In this scenario, Hovermap won't be able to work out its position, as everything looks the same to Hovermap when no features are present.

> **Tips**
>
> - To avoid a slip, we recommend that you have features present in all directions (on the X, Y, and Z axes) so that Hovermap can more easily determine its position.
> - If a slip occurs, switch to drone control mode and bring the drone home safely. For more information, refer to the *Emergency procedures* section.
> - It may be possible to salvage a scan in Emesent Aura by changing the processing parameters. But be aware that the processing time will increase significantly.

3.1.1.3 What is Shield?

Shield is a virtual safety bubble that Hovermap creates around both itself and the drone. It is available in both Pilot Assist mode and Autonomous mode. Hovermap will not allow the drone to move any closer to obstacles than the distances defined by Shield.

In Pilot Assist mode, Shield distances can be set manually. You will be able to create a larger safe space around the drone, but bear in mind that a larger Shield area will also prevent the drone from flying through narrow gaps.

In Autonomous mode, Shield settings are predetermined and cannot be changed. The settings depend on the type of drone you are using. They will always be slightly larger than the minimum Shield settings for Pilot Assist mode. Shield sizes will also change with speed in the direction of travel.

> **Note**
> It is important to know that Shield is a passive system. It will not protect against objects that are actively moving towards the drone, such as birds, moving ropes or falling rocks.

3.1.1.4 How does Hovermap navigate?

Hovermap can navigate using three methods: SLAM, GPS, or INS (a backup navigation system that relies on the IMU to work). The system automatically determines the type of environment it is in and selects a suitable navigation method.

Navigation Method	Usage	Effect on mission if lost
SLAM	Primary navigation source	Robot will Return To Home as the map quality will degrade if the drone continues to fly into areas with poor SLAM performance. Depending on GPS signal availability, the system will use either GPS or INS as navigation method.
GPS	Used when SLAM is lost and GPS signal is available	Mission will run in a degraded state. The system drops to Hovermap INS.
INS	Used when SLAM is lost and GPS signal is not available	Mission will run in a degraded state. **Warning:** Using INS as a navigation method is prone to errors, and only works until SLAM is recovered. If SLAM is not recovered within 10 seconds, attempting to continue hovering will result in a crash due to the accumulation of errors in the INS. Therefore, it is crucial to attempt an emergency landing in such a situation.

3.1.2 Scanning techniques

3.1.2.1 Scan size

While Hovermap can perform large scans, and store up to 12 hours of scan data, we recommend performing multiple smaller scans instead of larger scans. There are many good reasons for this:

- Smaller scans are often more accurate than larger ones as they will accumulate less drift.
- A slip in a small scan will have less impact on a large multi-scan job.
- Breaking your mission into smaller scans allows you to start processing while you are still scanning other areas. This allows for a faster overall process and gives you the ability to check scan quality as you go.
- Multiple smaller scans are more easily copied, processed, and managed.
- Smaller scans greatly reduce processing and RAM requirements.

> The amount of scan data stored on the Hovermap depends on the complexity of the terrain or environment being scanned. This will be even less if the **Generate preview point clouds option** in the Web UI is enabled.

> **Tips for smaller scans**
>
> - Aim for the scan time to be less than 35 minutes.
> - When surveying a large area in multiple small missions, it is important that you plan your scanning pattern. Refer to the *Scan patterns* section for more information.
> - Ensure that there is some overlap between scans that you intend to merge. We recommend at least 20% overlap between scans.

3.1.2.2 Scan patterns

Closing the loop

One of the most effective ways to eliminate drift and to increase SLAM accuracy is through a practice called “closing the loop”. This means that you should stop your scan in the same general area where you started it. This location does not have to be exact.

Closing the loop works by helping Hovermap to connect features at the end of a scan, where the most drift has accumulated, to the features at the start of a scan, where there is no drift.

Try to close the loop as often as possible during the scan itself by creating many smaller loops along the way, as shown in the following image. In this case, the scan path starts in the center of the room and then loops around each row of desks before moving to the other side of the room.

By creating lots of smaller loops, SLAM will build several smaller “local” maps. Hovermap will then attempt to align these local maps (based on overlapping features) to produce a more accurate “global” map.

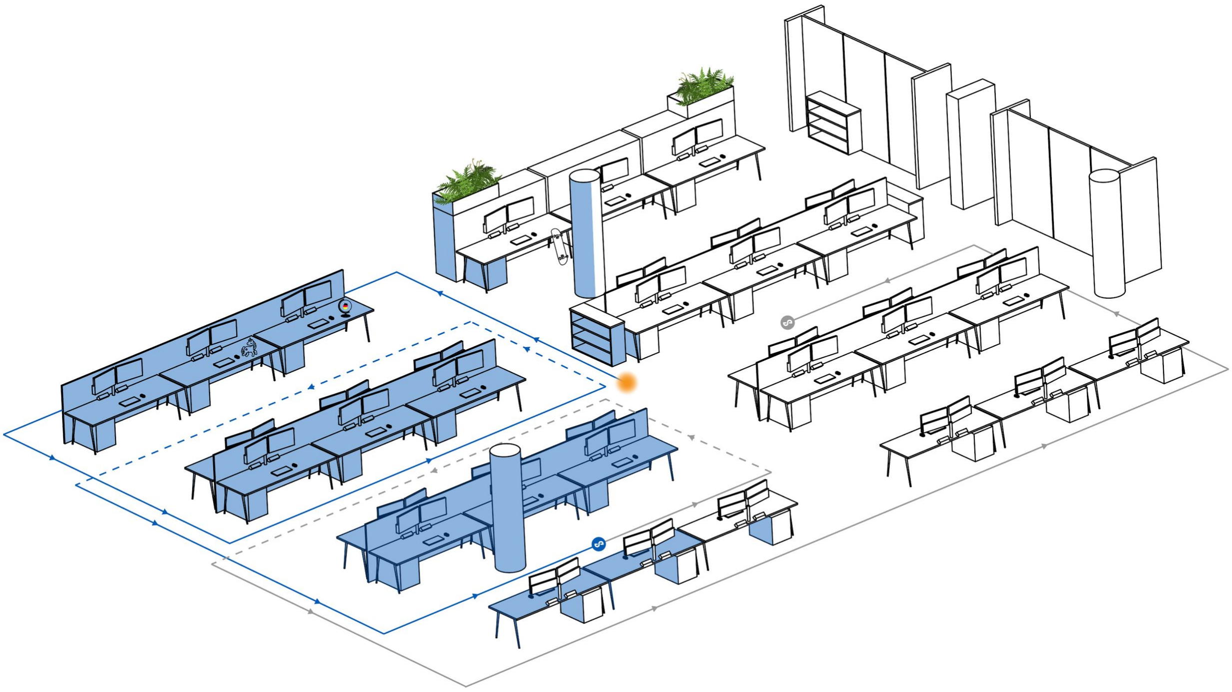


Figure 12 Closing the loop

Grid pattern

Another alternative is to scan in a grid pattern. By doing this, Hovermap can generate denser and more accurate maps. This pattern allows large areas to be covered in a short space of time. When using this scanning pattern, we recommend that you travel at 5 meters per second, and use a 40 m grid. We also recommend at least 20% overlap between each square of the grid.

3.1.2.3 Scan speed

Because Hovermap works by matching the environment it is seeing with what it is already aware of, it is important to make sure that it has enough time to perform this matching operation. We recommend that you move at a slow speed to help Hovermap produce a more accurate result.

Use the following as a guideline:

- **Walking scans:** Make sure that your movements are as slow and fluid as possible.
- **Drone-mounted scans:** Keep your speed below 5 meters per second.
- **Vehicle-mounted scans:** Keep your speed below 20 kilometers per hour (12 miles per hour).

This gives Hovermap enough time to analyze the features in its environment and to piece them together. Moving faster than this can cause Hovermap to lose its place, which can distort your data.

3.1.2.4 Transitions

Sometimes when performing a scan, you will need to transition between two different environments or "scenes". This is an issue generally encountered in indoor environments. For example:

- Moving between two different rooms.
- Going around a corner.
- Moving between two different levels of a building.
- Going outside at the end of an indoor scan.

When making these transitions, you must move in such a way that Hovermap can see both where it has been *and* where it is going at the same time. If you are going through a doorway, for example, you would move through the doorway slowly sideways so that Hovermap can see both the old room and the new room. In this situation, it is a good idea to focus on the doorframe as you move through it so that Hovermap has a feature that it can recognize in both rooms.

When going around a corner, take the widest path possible and give Hovermap some time at the apex to see both the old and new environments together before proceeding.

These techniques allow Hovermap to continue to build an accurate map as it moves. If you move too quickly, Hovermap will lose track of where it is, and a SLAM slip may occur.

3.1.2.5 Scan height

The height you should fly at will be determined by your environment. In environments with lots of features, you will be able to fly higher than in environments with relatively few features. The best practice is to determine the lowest possible height you can fly to efficiently cover the area required.

It is important to be aware that the higher you fly, the less ground coverage you will have, as shown in the following image. If you don't have sufficient ground coverage, Hovermap can more easily lose track of any features on the ground, which can result in a SLAM slip.

For this reason, we recommend that you fly no higher than 40 m. Even at this height, you will need to be careful, as the data can become distorted if the environment lacks distinct features.

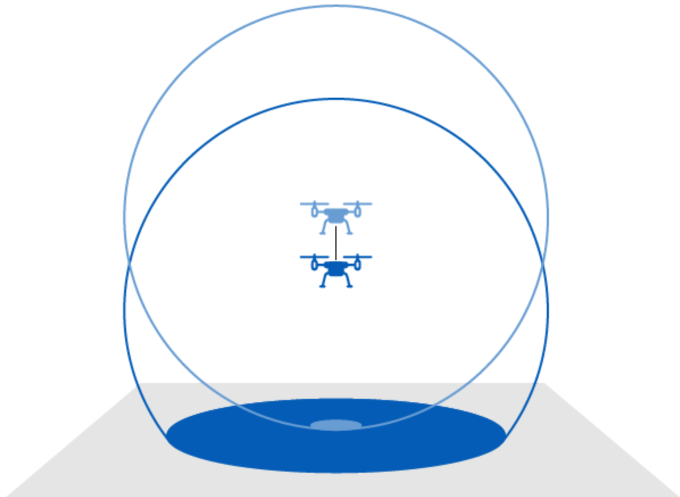


Figure 13 Fly low to produce the best results

3.1.3 Other functionality

3.1.3.1 Georeferencing

Georeferencing your scan allows you to position your point cloud in the correct real-world location. You can do this by either using GPS (if available) or ground control points (GCPs).

- **If you require convenience:** We recommend that you use Hovermap alone. Simply follow the process outlined in *The Hovermap workflow* section. If Hovermap is connected to a drone, GPS data can be incorporated into your scan data.
- **If you require accuracy:** We recommend that you use GCPs. These allow you to produce a more accurate, survey-grade point cloud. If you are scanning outdoors, we recommend that you use GCPs for more accurate results.

Georeferencing using GCPs

Georeferencing your scans using GCPs is the best way to improve the quality of your scan data. GCPs are bright white reflective targets that Hovermap can easily see. They help to improve scan accuracy by removing drift.

You can use GCPs to more accurately scan long, linear assets and large or feature-poor environments, such as roads, stadiums, and tunnels. These kinds of environments have previously been something of a challenge for SLAM.

GCPs can also help you to detect distortions in your point cloud. If you are planning to merge several point clouds, GCPs are invaluable in helping you to align them. Make sure that you have some overlap on the GCPs that border two separate study areas if you want to merge them.

Depending on your requirements for the scan, we recommend that you capture several GCPs. Ideally, they will surround your area of interest.

Follow this process for the best results.

1. Securely screw or glue your targets in place so that they don't move during your scan.
2. Before you start, survey in the center of each target, and make note of the correct coordinates.
3. Install at least three targets. The height is not important. Try to install them at regular intervals (every 10 m to 50 m if possible).
4. While scanning, spend a bit more time near each target so that they show up clearly in the point cloud. If you can do this multiple times during the scan, that is even better (for example, at the start and end of a stope scan).
5. In processing, load the raw scan data and survey coordinates into Emesent Aura. The survey targets will be automatically detected. By doing this, you will greatly increase the accuracy of your scan.

> **Note**
>
> - You can run the processing automatically end-to-end without interaction. Or, if you prefer, you can visualize the target detection and constellation matching results in Emesent's point cloud viewer for confirmation or adjustment. For more information on processing GCPs, refer to our *Ground control points* instruction.

3.1.3.2 Colorization

Hovermap can create world-class true color point clouds, providing additional context for visualization and analysis. This builds on the incredible data that Hovermap already produces to create rich, accurate digital twins and surveys.

The colorization feature uses a GoPro camera that attaches to Hovermap. This modular approach allows you to attach the camera only when colorized scans are needed.

You can use the perspective-based GoPro Hero cameras or the 360° field of view GoPro Max for colorization. Emesent recommends using the 360 GoPro Max when capturing a larger amount of colorization data. However, the perspective Hero cameras may be more suitable in certain cases.

GoPro Hero cameras have a restricted field of vision, which means only the area within the camera's view will be colorized. To ensure optimal results, it is essential to point the GoPro directly toward the specific subject you are interested in capturing.

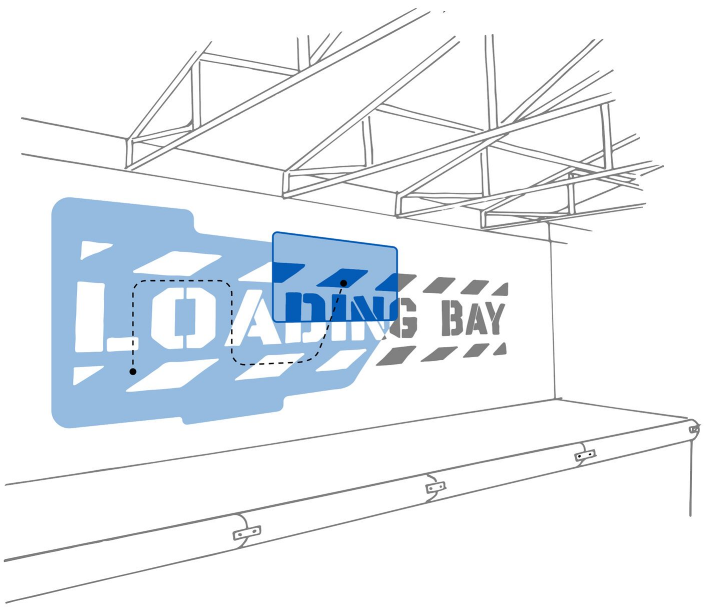


Figure 14 The GoPro Hero perspective camera "painting" motion

Tips for using colorization

- Use the recommended settings for your GoPro.
- Ensure that the GoPro lens is clean and free of dust and other material.
- Only points that fall into the camera's field of view will be colored.
- Keep the Hovermap still for the first 10 seconds after the LiDAR starts to spin, then perform at least three vigorous side-to-side synchronization rotations.
- If using a GoPro Hero perspective camera, we recommend using a "painting" motion to capture as much of the area as possible.
- Minimize vibrational movement to avoid blurry video frames. Move slowly and avoid sharp turns and jerky movements.
- Keep your scanning distance to around 20 m / 65 ft. If you go further than this, the matching of the pixels and points deviates, and you will see a slight decrease in quality.
- It is important to have sufficient lighting in the area being colorized. While Hovermap can operate in complete darkness, the GoPro requires adequate lighting.
- Spend time on subjects to be colorized to improve colorization quality.
- For the best results, make sure to capture each object in the scene from multiple angles using the GoPro camera.
- Limit any movement of objects in the scene being captured, including people walking through the frame.
- Avoid tampering with, or removing, the GoPro mounting bracket. Its exact position has been accounted for during the calibration process.
- Only use colorization when necessary as scanning and processing colorized scans can take longer than a normal scan.
- Each GoPro is calibrated to a specific Hovermap. Do not use a GoPro that has not been calibrated to your Hovermap. Contact your local reseller or Customer Success if you need a new GoPro.
- To help keep your scans and videos in sync, hold your phone in front of the camera after starting the scan and the recording to capture the name of the current scan in the Hovermap Web UI.

3.2 Hovermap Workflow

This section outlines the basic operating procedure for Hovermap. For simplicity, we will focus on using Hovermap in Mapping mode.

To ensure a smooth and successful mapping mission, you must have the following essentials in place:

- **Fully-charged Hovermap Battery:** Make sure that the Hovermap's battery is fully charged. A drained battery could result in a premature end to your mission or data loss.
- **Emesent Commander Installed:** Ensure that the Emesent Commander application is installed on your tablet. The app should be up-to-date with the latest software version to guarantee optimal performance. Refer to the *Emesent Commander App* section for details on what application version should be used with your robot.
- **Full-charged Android Tablet:** Your tablet should also be fully charged to prevent any interruptions caused by a sudden loss of power.

> **Note**
> If the status lights do not follow the sequence outlined in this section, contact Technical Support Services with a description of Hovermap's status and the task you were trying to perform at the time.

3.2.1 Step 1: Connect power to Hovermap

Connect Hovermap to a battery or other approved power source. Hovermap doesn't come with an internal battery, so it will either need to be platform-mounted or powered by an external battery.

> **Warning**
> Never unplug the battery while Hovermap is running. If you do this, your scan data may be corrupted.

3.2.2 Step 2: Start Hovermap

Press the power button to power on Hovermap. The LED will change from OFF to a flashing red indicating that the Hovermap is initializing.

> ⚠ **LED status:** **RED: FLASHING**

3.2.3 Step 3: Wait until Hovermap is ready

After completing initialization, the status LEDs will flash orange then switch to a slow pulsing Emesent blue. This indicates that the Hovermap is now ready to scan. Ensure that Hovermap is positioned in a way that allows the LiDAR sensor to rotate freely.

> ⚠ **LED status:** **EMESENT BLUE: SLOW PULSE**

If, after 90 seconds, the status LEDs are not a slow pulsing blue, the start-up checks have been unsuccessful. If this happens, please restart your Hovermap.

3.2.4 Step 4: Connect to Hovermap using Emesent Commander

Use the Emesent Commander application to access the Mission workflow.

For DJI drones:

1. Launch the application then tap **Connect** to display the **Network Settings** window.
2. Tap **Connect Network** or **Change Network** depending on whether or not there is an existing connection. This takes you to your device's native network manager.

> **Note**
> You only need an IP address if using a Freefly Astro. Also, it is recommended to leave the hostname as **hover.map** for most users.

3. Look for **st_xxxx**, **hvm_xxxx**, or **lrr_st_xxxx** (where **xxxx** = Hovermap device to connect to) in the list of networks.
4. Select that network then enter the Wi-Fi password (**hovermap**).

5. Once the connection is established, you will hear an audio message indicating that you are "Connected". The red banner is removed from the landing page.

For Freefly Astro:

Emesent Commander communicates directly with the Hovermap ST-X via the Freefly PilotPro controller. Connection to the Hovermap's Wi-Fi network is not required.

1. Hold the power button on the Pilot Pro tablet for 4 seconds. This will power on both the tablet and the controller. Press again when prompted on the controller to complete powering on.
2. Turn off the Wi-Fi on the Pilot Pro tablet.
3. Launch the application then tap **Connect** to display the **Network Settings** window.
4. Set **Hostname** to **192.168.144.101** then tap the tick button to connect.
5. Once the connection is established, you will hear an audio message indicating that you are "Connected" and the mission tiles are enabled.

3.2.5 Step 5: Complete pre-mission checks

The Mission Workflow in Emesent Commander guides you through the process of starting the scan. Complete the required mission checks then tap the **Start Scan** button in the Scan setup page of the Mission Workflow.

The LiDAR sensor will start spinning. The status LEDs will start by flashing green, and will then change to a slow green pulse. When the status LEDs start to pulse, keep Hovermap still for the first 10 seconds. This gives Hovermap time to start to build a map and to position itself within its environment.

Refer to the Commander Operations section for more information.

LED status: **GREEN: SLOW PULSE**

Warning
This step is essential! If Hovermap is moved before it has collected enough points to start mapping its environment, it won't be able to create a map successfully.

3.2.6 Step 6: Perform the scan

Once you have given Hovermap time to position itself, you can start your scan. Move as slowly as possible, and focus Hovermap as much as you can on your area of interest. For best mapping results, it is recommended to "Close-the-Loop", that is, to stop the scan around the same area where it was started.

> ⚠ **LED status:** **GREEN: SLOW PULSE**

3.2.7 Step 7: Stop the scan

In the Emesent Commander app, tap the **Stop Scan** button (or short press the power button) to end the mission. The LiDAR sensor will stop spinning after a few seconds, and the status LEDs will return to a slow pulsing blue.

Hovermap is now ready for another scan, or for data retrieval.

> ⚠ **LED status:** **EMESENT BLUE: SLOW PULSE**

3.2.8 Step 8: Download the data

To download the data from Hovermap, insert a USB flash drive into the USB port at the back of the Hovermap unit. The status LEDs will change to a wiping blue bar while the data is being transferred to the USB flash drive. All data that has not previously been transferred will be copied to the USB flash drive.

> ⚠ **LED status:** **EMESENT BLUE: WIPING**

> ℹ You can only download data when Hovermap is in standby (a slow pulsing blue). To retrieve data, the USB flash drive must be formatted in an exFAT file format.

3.2.9 Step 9: Remove the USB flash drive

Once the transfer is complete, the status LEDs will return to a slow pulsing blue. The USB flash drive can now be removed.

> ⚠ **LED status:** **EMESENT BLUE: SLOW PULSE**

> ℹ Scans are stored internally until they are deleted manually.

3.2.10 Step 10: Shut down Hovermap

Press the power button for at least 4 seconds (or until the status light turns off) to shut down Hovermap.

> ⚠ **LED status:** **OFF**

3.2.11 Step 11: Process the data

Once the data has been retrieved from Hovermap, it is in a raw state and will need to be processed. Use Emesent Aura to create a rich 3D point cloud.

4. Hovermap Mission Planning

Being confident and familiar with Hovermap can mean the difference between great results and a failed mission. Hovermap perceives the world differently from traditional LiDAR systems, and you will need to plan your mission effectively to maximize the quality of your results.

Some environments, such as large outdoor areas, can present a challenge for Hovermap, so preparation and planning can make all the difference.

If you are not yet confident operating Hovermap as a payload on a robot, performing a separate walking scan is a perfectly viable solution. The data from the walking scan can be merged with the overall data later on. Make sure that you only operate to your capabilities!

4.1 The process

In this section, we will outline the process of planning your mission. In each step, we will provide you with a set of questions to help you set yourself up for success.

> **Warning**
> Before you begin, make sure that you are aware of, and can comply with, all legal requirements when operating Hovermap and its associated platforms.

4.1.1 Step 1: Define your objective

The first and most important step is to define your objective. Keep this objective in mind as you plan and execute your mission. The following steps will help you work out *how* to achieve it.

Questions

- What am I hoping to achieve?
- What is my subject of interest?
- What capture method will I be using?
  For example, will it be a walking scan, a vehicle or drone-mounted scan, lowering Hovermap in a cage?
  Or a combination of these?
- What level of accuracy do I need?

- Do I need to use GCPs?
  (Refer to the *Georeferencing* section for more information.)
- What are my limitations?
  - Are there accessibility limitations?
  - How much time do I have to do the job?
  - How many batteries do I have?
  - Are there any other equipment limitations?
- Do I want a colorized scan?
  (Refer to the *Colorization* section for more information.)

4.1.2 Step 2: Analyze your environment

Every environment is unique, and you will need to plan your mission accordingly. Make sure that you have a good understanding of how SLAM works and how environmental features affect your mission before you get started. Refer to the *What is SLAM?* section for more detailed information.

For more specific information on how to plan in some of the more common scenarios, refer to the Common Scenarios Using Hovermap section.

Questions

- Does the environment have enough features to provide a good quality scan?
- If not:
  - Can I add features to the environment to improve the scan quality?
  - Can I mitigate the lack of features in some areas by planning my mission path to account for this?
- Is there a good GPS signal available?
- Are there any moving objects?
- What is the best size scan for this environment?
- Do I need to break up my scan into multiple scans?
- If I need to split it up, how should I scan each different section?

4.1.3 Step 3: Plan your mission path

Your mission path will depend on the environment you are mapping. Make sure that you have read and understood the *Scan patterns* section before planning your mission path.

Questions

- Where is the best starting point?
- What scanning pattern will I use?
  - How will I close the loop?
  - Should I use lots of little loops?
  - Should I use a grid pattern?
  - If performing multiple scans, how will I ensure that there is at least 20% overlap between these scans?
- How will I keep features in front of Hovermap as I perform my scan?
- How close can I get to environmental features?
- Where do I need to place GCPs?
- Where should I place my rally point?
  (Set your rally point in an open space, within visual line of sight. For more information, refer to the *Emesent Commander* section.)
- Where should I place my waypoints?
  (For more information, refer to Emesent Commander App section).
- If you require a colorized scan:
  - How will I keep the GoPro within the 20 m range?
  - How will I keep the GoPro directly focused on the area of interest?

4.1.4 Step 4: Decide on your mission parameters

The height, speed, and scanning patterns that you need to follow will vary according to your environment. Make sure that you have read and understood the *Scanning techniques* section before you continue.

Questions

- What speed do I need to travel at?
  (Remember, the slower, the better.)
- How high should I fly?
  (The lower, the better.)
- Can I easily follow the terrain, keeping to a height of 40 m or less?
- How will I keep my scans as short as possible?
- What mission mode will I be using?
- What primary and secondary navigation methods should I choose?
  (Refer to the *How does Hovermap navigate?* section for more information.)
- What is my turning technique?
  (Remember to turn slowly, and to keep features within Hovermap's field of view while turning.)

4.1.5 Step 5: Prepare an emergency contingency plan

Always have an emergency plan in place in case of unexpected behavior. Be prepared to take over the drone or vehicle if required, especially if you are using Autonomous mode. Make sure that you know how to handle your specific platform in an emergency situation.

Refer to the Hovermap Emergency Procedures section for more detailed information.

Questions

- What is my emergency contingency plan?
- How will I take over control of the drone if necessary?
  (This will be platform-specific.)
- How can I abort the mission if necessary?
- How will I abort the mission if Hovermap is beyond visual line of sight?
- Do I need to think about protecting people, animals, or objects?

4.1.6 Step 6: Prepare your environment

To ensure the most efficient scan, make sure that your surroundings are prepared beforehand.

Questions

- Is my scan path unobstructed?
- Is my scan area free of people?
- Is my scan area free of other moving objects?
- Have I placed my GCPs around the area?
- If colorizing the scan, do I have suitable lighting to create a quality color scan?

4.1.7 Step 7: Perform your pre-mission checks

Perform the appropriate pre-mission checks before operating Hovermap. Our pre-mission checklists help you to ensure that you have chosen the correct settings and tested your equipment so that everything is in working order for your mission.

You can access the checklist of your current mission from the Emesent Commander application. You can also find the following pre-mission checklists in our Knowledge Base:

- Mapping mode
- Pilot Assist mode
- Autonomous mode

Questions

- What is the best name for my scan?
  (Make sure that you name your scan clearly so that you can find it again for downloading and processing. Leave no doubt as to what the scan is.)
- Have I performed all other pre-mission checks?

4.1.8 Step 8: Perform your mission as planned

Perform your mission according to your chosen path and parameters.

As you go, make sure that you check the live point cloud to ensure that your data is being collected correctly.

You can do this in Emesent Commander. You can also do this by connecting to the Hovermap's Wi-Fi, opening a web browser (on any laptop or Android device), and then navigating to **hover.map:8082**.

4.1.9 Step 9: Download and process your data

Download your scan data off Hovermap and then process it using Emesent Aura. Make sure that you download your data after each scan.

Questions

- Have I downloaded all the data collected?
- Do I have enough free space on Hovermap for the next mission?
- If something didn't go to plan, have I downloaded all relevant log files?
- Have I processed the scan using the **Standard** profile?
  (If your results are not as desired using this profile, you can then change the processing parameters. Refer to the Common Scenarios Using Hovermap section for more information about settings for specific environments.)

4.1.10 Step 10: Review your mission

Once your mission has been completed, we recommend that you perform a review to see how it went. This will help you to improve your scanning technique with each mission that you accomplish.

Questions

- What was successful?
- What was unsuccessful?
- What have I learned?
- What can I do better next time?
- Do I need to contact Technical Support Services (or my local reseller) for further assistance?

4.2 Common Scenarios Using Hovermap

This section covers some of the more common scenarios in which Hovermap can be used. It details important considerations, the best techniques, and which settings to use for each scenario.

> **Note**
> Please bear in mind that every situation is unique. These practices serve as a guideline only and may need to be adjusted for your specific environment.

4.2.1 Scanning a stope

Flying in a stope is the perfect scenario for using Hovermap in Autonomous mode. This is because a stope is inaccessible and often has an unknown shape. They also usually have plenty of distinct geometric features, which is ideal for Hovermap.

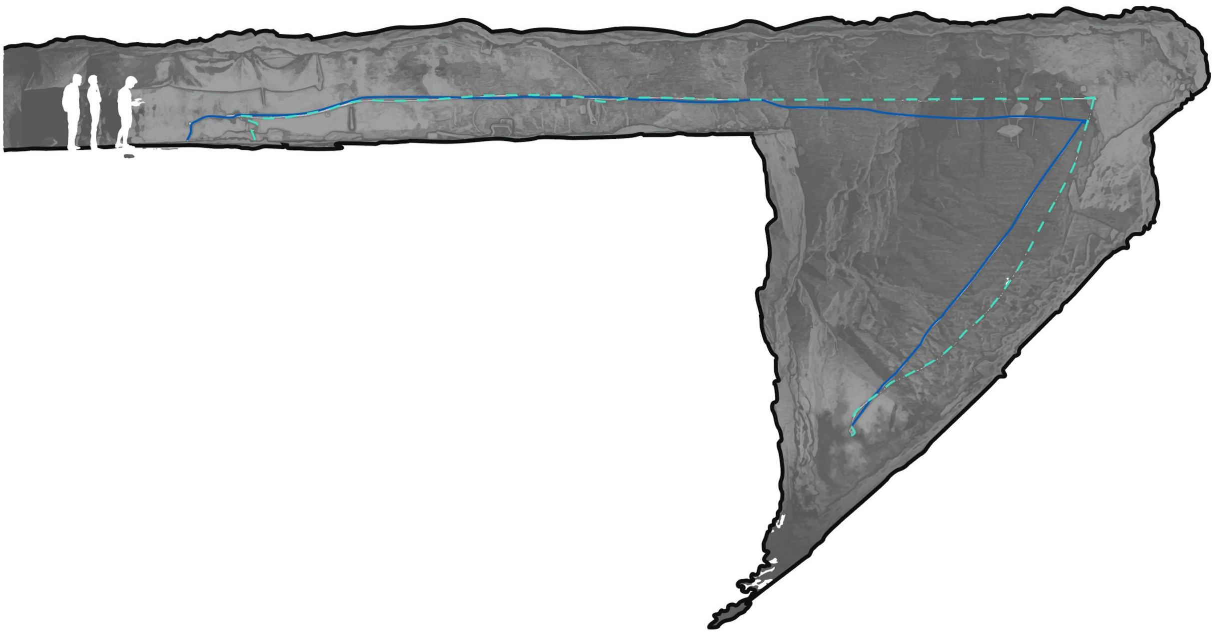


Figure 15 Scanning a stope

We recommend that you follow this process for the best results.

Step 1: Pre-mission checks

Complete the required pre-mission checks. For more information, see the Emesent Commander App section.

Also, refer to the *How does Hovermap navigate?* section for more information on the how system automatically determines the most suitable navigation method based on the environment it is in.

Step 2: Perform your mission

1. Take off in Pilot Assist mode. The reason for this is that the minimum Shield settings are smaller in this mode than in Autonomous mode. This allows you to fly through small gaps to enter the stope.
2. Enable **Shield** and then test it by trying to land the drone. **Shield** should prevent you from landing.
3. Fly the drone within line of sight to the center of the stope.
4. Change to Autonomous mode and set a rally point (refer to the Emesent Commander App section for more information). This is essential, as the drone will treat this rally point as a temporary return to home point. This will allow you to reestablish communications if they are lost during the mission.
5. Wait for the LiDAR points to be streamed to your tablet. When this happens, you can start to plan your mission. When planning, keep in mind that the LiDAR has a range of up to 100 m. It will easily capture sufficient data at a range of 20 m to 30 m, so you will not need to get any closer to obstacles than that.
6. While scanning, check the live point cloud to ensure that your data is being collected correctly. Do this in the Emesent Commander application (refer to the Emesent Commander App section for more information).
7. When the mission is complete and the drone has returned to its rally point, switch back to Pilot Assist mode so that you can fly back out of the stope.
8. Fly the drone back out of the stope and land safely.

> **Warning**
> Don’t fly into a stope within 24 hours of blasting, as certain gases can absorb the LiDAR light. If this happens, you will have no return points and Hovermap will be unable to build a map of its surroundings.

4.2.2 Scanning a shaft

When scanning a shaft, raisebore, or ore pass, it is best to use Hovermap in its cage to protect the scanner. Shafts and passes are not ideal environments for flying, as they can be very smooth, with few features. This lack of features can potentially lead to a SLAM slip, which can lead to a crash.

> **Warning**
> Please bear in mind that you still need *some* features to scan a shaft. Completely featureless shafts won't scan well.

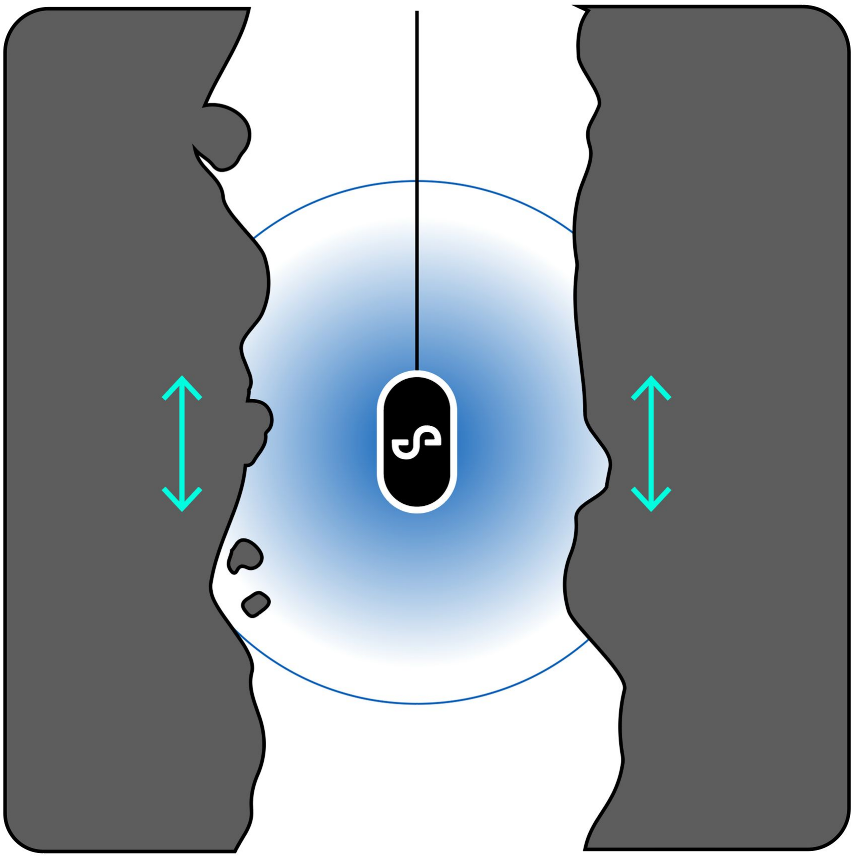


Figure 16 Scanning a shaft

We recommend that you follow this process for the best results.

Step 1: Perform your mission

1. Lower Hovermap in its protective cage slowly towards the bottom of the shaft. A speed of around 1 meter per second is best. The cage will slide along most steep surfaces.
2. If Hovermap becomes stuck on a small ledge, move the lowering cable around gently. The cage should roll out and continue its descent.
3. Avoid hitting the bottom of the shaft. If Hovermap hits the bottom, it will have direct contact with the soil and may become covered in mud. If this happens, it will become “blind” until it can be cleaned. Hovermap can deliver great resolution at large distances, so there is no need to get too close. A distance of 10 m should be fine.
4. While scanning, check the live point cloud to ensure that your data is being collected correctly. Do this in the Emesent Commander application (refer to the Emesent Commander App section for more information). When you reach the top, stop the scan remotely.

Step 2: Process your data

1. Process your scan data using Emesent Aura. Select the **Standard** profile for the first job. You may see that the starting point is not aligned with the endpoint of the scan. This is most likely due to the lack of features, especially horizontal features, that would help Hovermap to better determine its position on the Z-axis.
2. If your results are not as desired, you can then change the processing parameters. For a linear scan such as a shaft, we recommend that you make the following changes to the processing parameters:
    - **Local Mapping:** Voxel size: 0.2
    - **Global Registration:**
        - Voxel size: 0.2
        - Matching: Max Distance: 5.00

> **Note**
> These processing parameters work more often than not. However, it is still dependent on your specific environment, so they may not yield the desired results. If you don’t get the result you are looking for, play around with the rest of the settings. But be aware that this will increase your processing times significantly.

4.2.3 Scanning buildings

Buildings are a great use case for Hovermap. However, they do require careful planning, as there are many factors to consider. We recommend that you start your scan on the outside of the building. Once that is complete, you can then start scanning inside. Depending on the size of the building and the number of floors, we also recommend that you break up your scan into several smaller scans, with plenty of overlap between each scan.

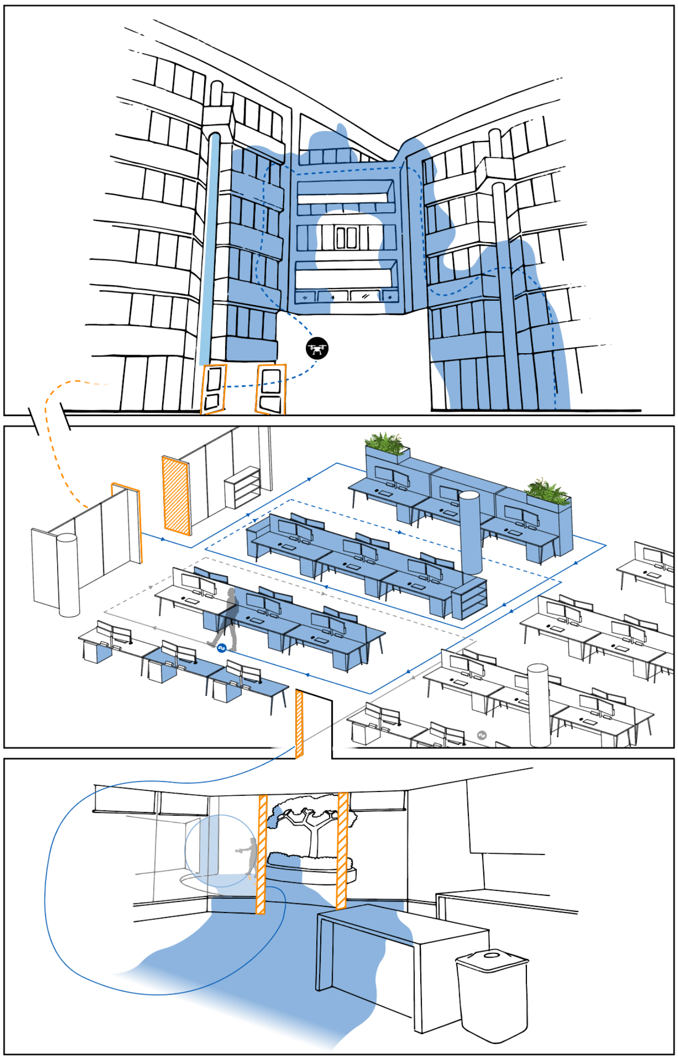


Figure 17 Scanning a building

4.2.3.1 Building scan: Outside

The outside scan is the most straightforward part of the building scan. We recommend that you follow this process for the best results.

Step 1: Pre-mission checks

Complete the required pre-mission checks. For more information, see the Emesent Commander App section.

Also, refer to the *How does Hovermap navigate?* section for more information on the how system automatically determines the most suitable navigation method based on the environment it is in.

Step 2: Perform your mission

1. Fly in Pilot Assist mode, and keep the drone within line of sight.
2. Fly so that Hovermap is facing the building at all times. Make sure that you thoroughly capture the outside of the building all the way around.
3. While scanning, check the live point cloud to ensure that your data is being collected correctly. Do this in the Emesent Commander application (refer to the Emesent Commander App section for more information).
4. Avoid flying too high, as this may cause a SLAM slip. Fly as close to the building as possible, and try to stay within 20 m of the roof. The distance will be determined by the size of the building. With a smaller building, you could fly at 15 m, but a larger building might require more distance above to finish the scan in one flight (20 m to 30 m is a reasonable distance for a larger building). Anything further away is likely to reduce accuracy, especially if you want to colorize the scan.

4.2.3.2 Building scan: Inside

Once you have completed the outdoor scan, you can then move indoors. This is the more complex part of a building scan. Indoor environments can present certain issues for SLAM-based scanners, as they contain many small apertures, such as doorways, that can cause issues if you don't know how to navigate them correctly.

We recommend that you follow this process for the best results.

Step 1: Pre-mission checks

Complete the required pre-mission checks. For more information, see the Emesent Commander App section.

Also, refer to the *How does Hovermap navigate?* section for more information on the how system automatically determines the most suitable navigation method based on the environment it is in.

Step 2: Plan your mission path

1. Break your inside scan down into small, practical sections, such as one room or floor at a time. It is best practice to keep your scan time short. We recommend 20 to 25 minutes. Make sure that your scan time doesn't exceed 35 minutes.
2. If you are breaking your scan down into multiple sections, such as rooms or levels, make sure that you have a significant area of overlap between each scan so that they can be aligned during processing. If you are scanning multiple levels, make sure that you capture the stairwell between each level in every scan.

Step 3: Prepare your environment

1. Before you start the scan, make sure that all doors to rooms are open.
2. Make sure no people are moving through the area. People moving through your scan can cause drift, slips, and "ghosting", which can ruin your dataset. Ghosting also means that you will have to do additional postprocessing of your point cloud to clean out the false points.
3. If you are georeferencing your scan, place GCPs around the scan area. Place four GCPs around the corners of your study area, and one in the center. Make sure that the square is slightly off-kilter (not perfectly square) so that, during processing, it is easier to identify which GCP is which. For more detailed information on GCPs, refer to the *Georeferencing* section.

Step 4: Perform your mission

1. Perform your scan according to the mission path that you have already planned. Make sure that you have plenty of overlap between each scan.
2. When moving through doorways or around corners, make sure that Hovermap can see both where it has been *and* where it is going. Do this by slowly moving sideways or backward through a doorway to introduce the new environment. When going around a corner, take the widest path possible and give Hovermap some time at the apex to see both the old and new environments together before proceeding. By doing this, Hovermap won't lose track of where it is, and you will avoid a SLAM slip.
3. While scanning, check the live point cloud to ensure that your data is being collected correctly. Do this in the Emesent Commander application (refer to the Emesent Commander App section for more information).
4. Finalize your inside scan by going outside and capturing the front of the building. This serves as an area of overlap between the inside and outside scans. Capture as much as possible of the front of the building. Ensure that you scan around the two corners to the left and right of the entrance.

Step 5: Process your data

Process your scan data using Emesent Aura. You can do this at the same time as you perform your next scan. Process the scan as follows:

1. Process and check each scan individually.
2. Align the inside and outside scans manually, as GPS won't be available for the inside part of the scan.
3. Copy the translation matrix into Emesent Aura.
4. Process the combined scan.
5. Enable **Individual output** to allow you to load the scans both individually and together.

> **Note:** It is important to consider your computer's ability to handle large datasets. The combined output might be quite large in size.

6. Once you have processed the scan, align the GCPs to the correct coordinates in your point cloud viewer. This will show you whether your capture methodology was successful and will help you to achieve the most accurate merge. If you are merging a set of individual point clouds and one of those scans is quite badly distorted, it can decrease the accuracy of the other scans. To help maintain accurate results, make sure that you don't include poor-quality scans in your merge. When merging, choose the most accurate model to be the basis of your transformation matrices.

4.2.4 Scanning a bridge

If planned correctly, it is fairly easy to produce a good quality bridge scan. However, it is important that you plan carefully, as Hovermap can experience SLAM slips when operating over large areas of water.

In the event of a SLAM slip occurring while the drone is underneath a bridge, where the GPS signal is severely degraded, the system might be unable to transition to GPS mode. In such a scenario, you may have to assume manual control of the drone.

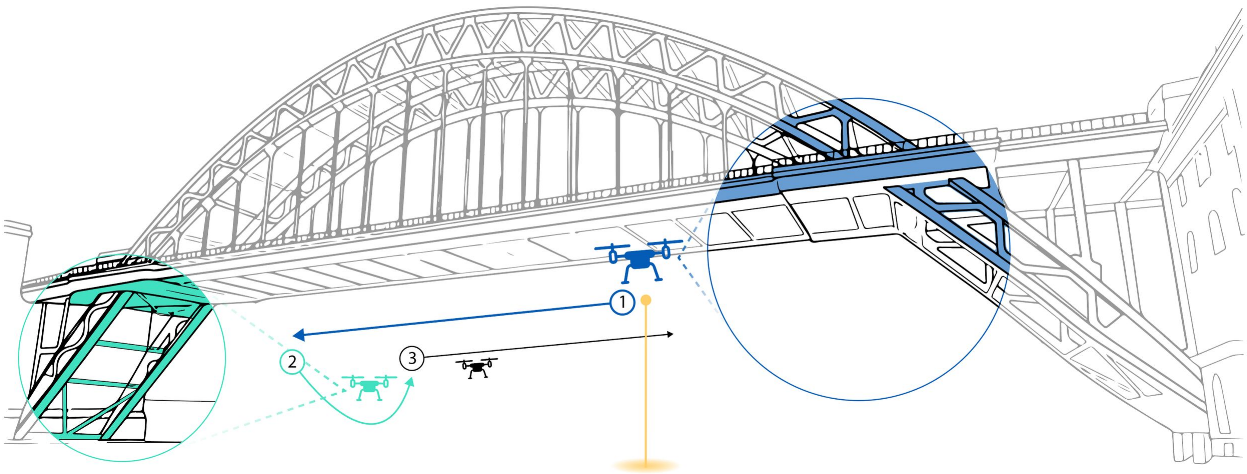


Figure 18 Scanning a bridge

Step 1: Pre-mission checks

Complete the required pre-mission checks. For more information, see the Emesent Commander App section.

Also, refer to the *How does Hovermap navigate?* section for more information on the how system automatically determines the most suitable navigation method based on the environment it is in.

Step 2: Perform your mission

1. Perform the scan in Pilot Assist mode and keep the drone within visual line of sight for the entire mission.
2. Start and finish your mission on the same side of the bridge. This will be your home point, so make sure that it is in a safe and controlled area.
3. Enable **Shield** then test it by trying to land the drone. **Shield** should prevent you from landing.
4. Fly the drone so that Hovermap is facing the bridge at all times. This will ensure that Hovermap has a distinct feature in its sight, which will prevent SLAM slip. Avoid turning the drone so that Hovermap faces open water!
5. While scanning, check the live point cloud to ensure that your data is being collected correctly. Do this in the Emesent Commander application (refer to the Emesent Commander App section for more information).
6. Fly at a distance of around 5 m to 10 m from the bridge. Stay roughly level with the street.
7. When you reach the other end of the bridge, turn the drone 90 degrees so that Hovermap can still see the bridge. After you have done this, you can fly underneath the bridge.
Note: Be careful at this stage not to fly too close to the underside of the bridge. This is so that you

can retain a good GPS signal. In this situation, it helps to dip the drone a little bit so that it retains a clear “view” of the sky.

8. When you reach the other side of the bridge, turn the drone 90 degrees again so that Hovermap continues to face the bridge.
9. Fly the drone back towards you in the same way you flew it on the other side. Fly at street level, and a distance of 5 m to 10 m from the bridge. Make sure that you face the bridge at all times.
10. Fly below the bridge and return to your home point to land.
11. Download the scan folder off your Hovermap.
12. Perform a second mission if necessary.

> **Tip**
> If you are using your drone with a camera, it is a good idea to have a second operator to control the camera. This allows you to focus on flying the system.

4.2.5 Scanning roads and tunnels

Long, linear scans are the most difficult for mobile-based LiDAR, as there can be very limited features in these situations. This makes it harder for Hovermap to remove accumulated drift, and there is the risk of a SLAM slip if you are not careful. The most common error is a bend in the scan or a split on the way back.

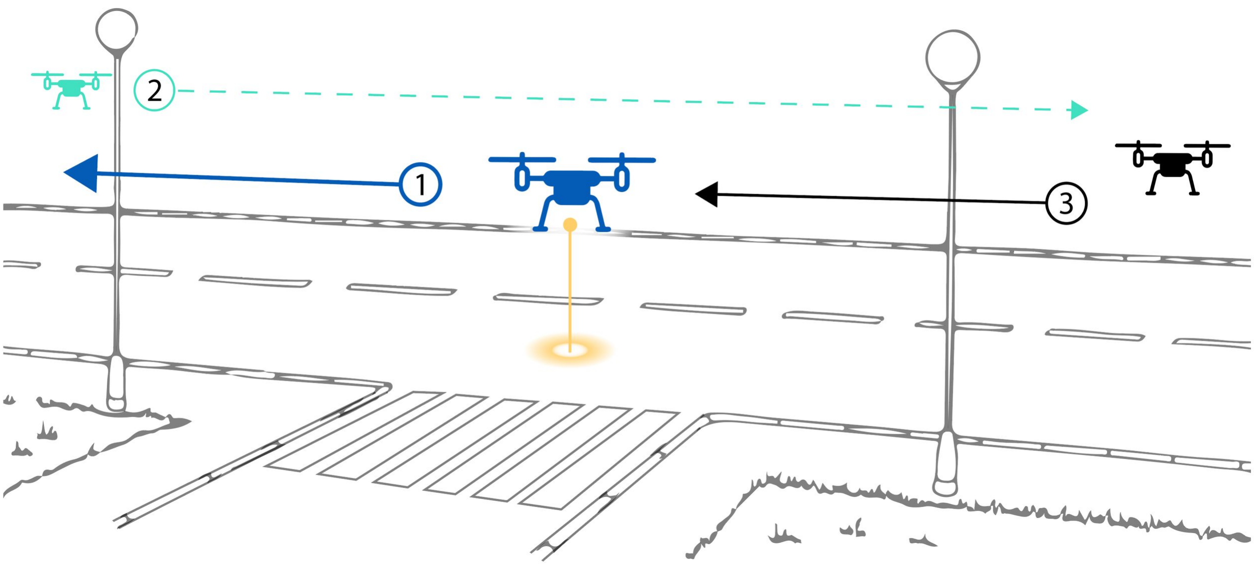


Figure 19 Scanning roads and tunnels

We recommend that you follow this process for the best results.

Step 1: Pre-mission checks

Complete the required pre-mission checks. For more information, see the Emesent Commander App section.

Also, refer to the *How does Hovermap navigate?* section for more information on how the system automatically determines the most suitable navigation method based on the environment it is in.

Step 2: Prepare your environment

If you are scanning outdoors, we recommend that you use GCPs for more accurate results. Ideally, these will surround your area of interest and will be placed along the entire length of the road or tunnel. For more detailed information on GCPs, refer to the *Georeferencing* section.

Step 3: Perform your mission

1. Start your scan halfway down the road or tunnel.
2. While scanning, check the live point cloud to ensure that your data is being collected correctly. Do this in the Emesent Commander application (refer to the Emesent Commander App section for more information).
3. Move Hovermap as slowly and as close to the ground as possible.
4. Move Hovermap in a zig-zag pattern toward one end of the road or tunnel. The zig-zag pattern helps to capture more of Hovermap's surroundings, allowing for a more accurate scan.
5. Turn around slowly, giving Hovermap time to see both new and old features while turning.
6. Move back toward the other end of the road or tunnel in a zig-zag pattern. Continue past the halfway starting point.
7. Once you reach the other end of the road or tunnel, turn around slowly, giving Hovermap time to see both new and old features while turning.
8. Move back towards the halfway starting point in a zig-zag pattern. Continue slightly past the halfway point to finish the scan.

Step 4: Process your data

1. Process your scan data using Emesent Aura. When processing, select the **Standard** profile for the first job.
2. If your results are not as desired, you can then change the processing parameters. For a linear scan such as a road or tunnel, we recommend that you make the following changes to the **Local Mapping** processing parameters:
    a. **Sliding size in seconds:** 15
    b. **Sliding shift in seconds:** 0.6

> **Note**
> These parameters work more often than not. However, it is still dependent on your specific environment, so they may not yield the desired results. If you don't get the result you are looking for, play around with the rest of the settings. But be aware that this will increase your processing times significantly.

4.2.6 Scanning a large outdoor area

Scanning in large, feature-poor outdoor areas is one of the most difficult scenarios for Hovermap. The key to a successful scan is to plan your mission path effectively. Start your mission in the center of the target area, or in the area with the most features, and then follow a path that avoids any large open spaces. Some examples of flight paths could be an outward spiral or a grid-type mission. Make sure that you close the loop, and that there is plenty of overlap between scans.

We recommend that you follow this process for the best results.

Step 1: Plan your mission path

1. Start in the center of your area, or the area with the most features, so that you can begin the process with a good quality scan.
2. If you are scanning a large area, you may need to break it up into smaller scans. If you do this, we recommend that you break it up into unique assets. Make sure that there is at least 20% overlap between each scan, as this helps Hovermap to more easily keep track of its position.
3. For each of these smaller scans, make sure that you close the loop as often as possible. Refer to the *Scan patterns* section for more information.
4. Give careful consideration to where you will place your GCPs. These will be extremely helpful when aligning each of your smaller scans should you choose to merge. Make sure that you always have at least two GCPs between overlapping scans.

> **Note:** This is not referring to Emesent's automated GCP system.

5. If particular areas are of high importance, consider performing additional walking scans so that the area is sufficiently targeted. These walking scans can then be merged with the flight data.

Step 2: Decide on your mission parameters

Decide on which mission mode you will be using.

- **Mapping mode:** You can use Hovermap with third-party mission planning software by operating Hovermap as a passive payload. In this mode, Hovermap will have no control over the platform.
- **Pilot Assist mode:** Hovermap will provide you with collision avoidance protection from obstacles such as trees. If you decide to use Pilot Assist mode, it can be a bit more challenging to fly a regular pattern. But the benefit of this approach is that this mode is also highly adaptable to unforeseen conditions.
- **Autonomous mode:** Using this mode can make it easy to scan your target area. However, you should keep in mind that Hovermap will always face forward, so you might want to take over control occasionally to focus on an area of interest.

Step 3: Prepare your environment

Make sure that you place your GCPs carefully.

Step 4: Pre-mission checks

Complete the required pre-mission checks. For more information, see the Emesent Commander App section.

Also, refer to the *How does Hovermap navigate?* section for more information on the how system automatically determines the most suitable navigation method based on the environment it is in.

Step 5: Perform your mission

1. Perform your scan in accordance with your carefully planned mission path.
2. Fly as low and slow as possible. Keep below 40 m flight height, and keep your speed below 5 meters per second. Make sure that you stay 5 m to 10 m above the tallest obstacle for that particular flight.

> **Note:** The height you can successfully fly at varies, depending on your environment. In feature-poor environments, your maximum height will be significantly lower. Experiment with flight heights in similar environments before committing to a specific height.

3. Make sure that you focus specifically on your GCPs during the scan.
4. While scanning, check the live point cloud to ensure that your target area is covered sufficiently. Do this in the Emesent Commander application (refer to the Emesent Commander App section for more information).

Step 6: Process your data

1. Process your scan data using Emesent Aura. When processing, select the **Standard** profile for the first job.
2. If your results are not as desired, you can then change the processing parameters. For large outdoor areas, we recommend that you use either the **Low Features** or **Forest** profile.
3. To merge your data, start with the most accurate individual scan. This will ideally be the scan from the center of your target area. From there, you can align all your other scans to the central scan. By doing this, you will avoid accumulated errors.

> **Note**
> These parameters work more often than not. However, it is still dependent on your specific environment, so they may not yield the desired results. If you don't get the result you are looking for, play around with the rest of the settings. But be aware that this will increase your processing times significantly.

4.2.7 Scanning power lines

Power lines can be very tricky to scan, as they are relatively high, small, linear, and long. None of these factors are ideal for Hovermap, but following this process will enable you to create consistent scans of power lines, towers, and the surrounding vegetation.

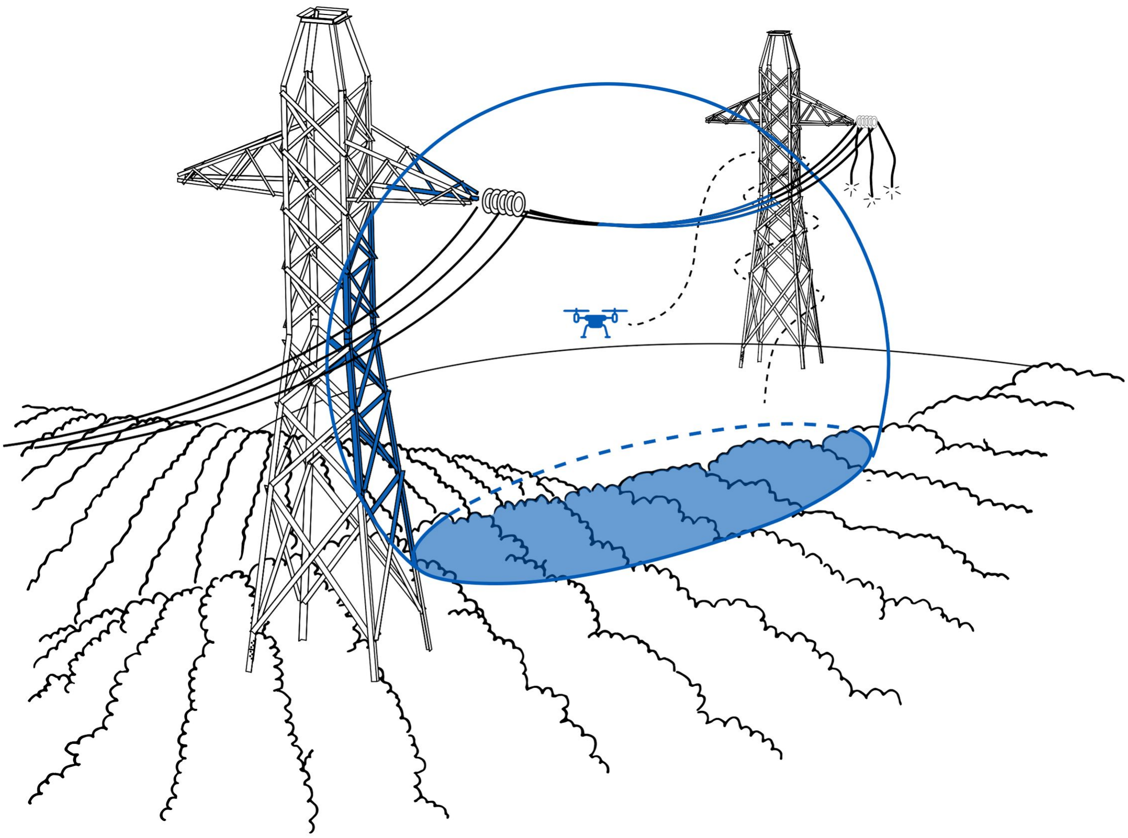


Figure 20 Scanning power lines

We recommend that you follow this process for the best results.

Step 1: Analyze your environment
Make sure that you analyze the terrain before starting your scan. This is particularly important when scanning power lines, as the power lines themselves are not a suitable feature and Hovermap needs to retain visibility of features on the ground.

Consider the following when planning your mission:

- We recommend a flight height of no more than 40 m. Follow the terrain as much as you are able so that you are consistently at this height.

- If you encounter power lines that span a valley that is deeper than 100 m, you will not be able to use Hovermap, as the absolute range of Hovermap is 100 m.
- Heavily vegetated areas may pose a problem, especially on windy days. Hovermap relies on the environment being relatively static. If a tree or branch is moving, it could lead to inaccuracies in your scan data.
- If you plan on capturing a long stretch, break down your scan into around 500 m increments, with about 100 m overlap.

Step 2: Pre-mission checks

Complete the required pre-mission checks. For more information, see the Emesent Commander App section.

Also, refer to the *How does Hovermap navigate?* section for more information on the how system automatically determines the most suitable navigation method based on the environment it is in.

Step 3: Perform your mission

1. Take off next to the first tower in Pilot Assist mode. Make sure that you are facing the tower as you take off, as it will be an important feature in your scan.
2. Enable **Shield** and then test it by trying to land the drone. **Shield** should prevent you from landing.
3. While scanning, check the live point cloud to ensure that your data is being collected correctly. Do this in the Emesent Commander application (refer to the Emesent Commander App section for more information).
4. Scan the tower by spiraling upward around it. Make sure that you continue to face the tower at all times while you are doing this.
5. Fly the drone down to below the height of the power lines. Make sure that you keep to a flight height of 40 m as much as possible. Remember, Hovermap needs to retain visibility of the ground.
6. In Pilot Assist mode, fly in a zig-zag pattern underneath the power lines. The zig-zag pattern helps to capture more of Hovermap’s surroundings, allowing for a more accurate scan.
7. When you reach the other end, spiral upward around the tower, as you did previously.
8. Bring Hovermap back down to below the height of the power lines.
9. Return to the original tower, flying back in a zig-zag pattern and keeping to a height of 40 m.
10. Perform one final lap around the original tower. This final lap only needs to be a single circle around the tower (facing the tower at all times). This helps Hovermap understand where it is. You don’t need to capture the tower again.
11. Land the drone.

Step 4: Process your data

1. Process your scan data using Emesent Aura. When processing, select the **Standard** profile for the first job.
2. If your results are not as desired, you can then change the processing parameters. For a linear scan such as power lines, we recommend that you make the following changes to the **Local Mapping** processing parameters:
   - **Sliding size in seconds:** 15
   - **Sliding shift in seconds:** 0.6

> **Note**
> These parameters work more often than not. However, it is still dependent on your specific environment, so they may not yield the desired results. If you don't get the result you are looking for, play around with the rest of the settings. But be aware that this will increase your processing times significantly.

5. Hovermap Controls

5.1 Hovermap Web UI

Hovermap provides a user interface, known as the Web UI. You can use the Web UI to:

- Remotely start and stop a scan. This is useful when physical access to the unit is inconvenient (for instance, if Hovermap is mounted on a backpack, or a vehicle bonnet while driving).
- Set the scan name.
- Find out how much storage space is available on the internal solid-state drive.
- Update firmware.
- Download files.

5.1.1 Access the Web UI

To access the Web UI:

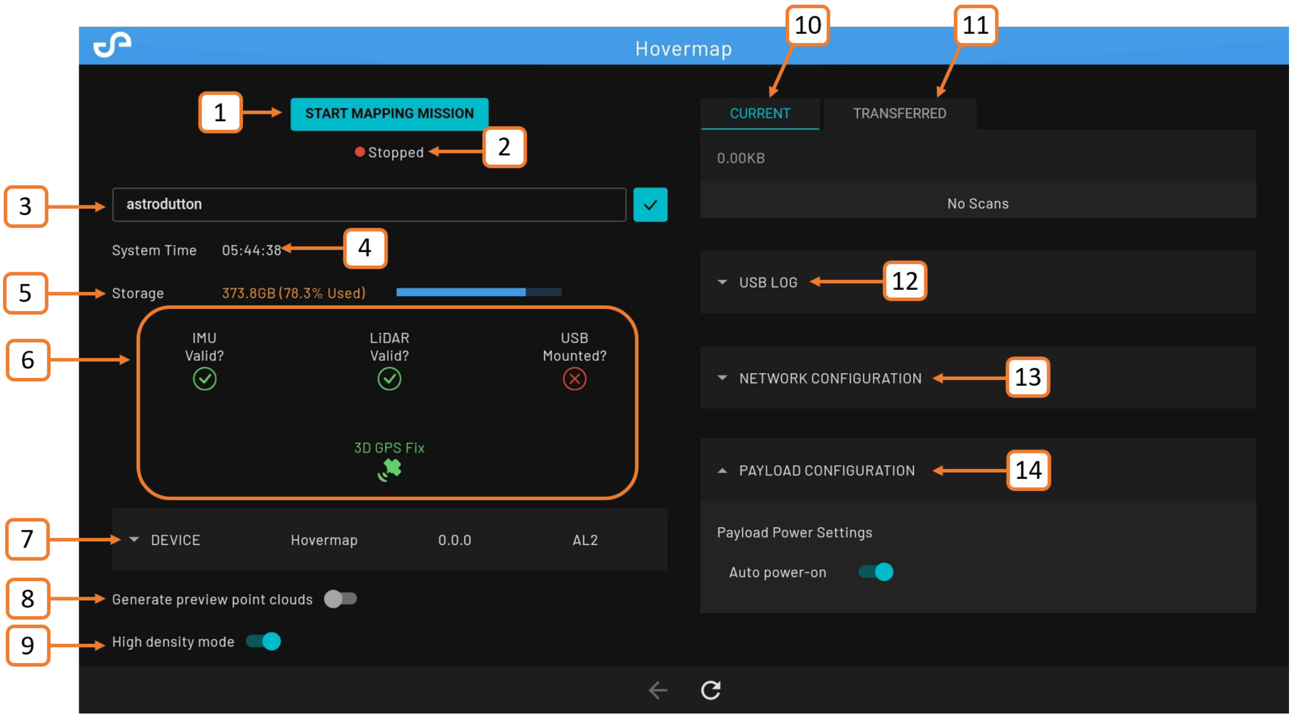
1. Connect Hovermap to a power source.
    - 12 to 54 VDC, 60W (HVM 100)
    - 14 to 55 VDC, 60W (HVM ST / HVM ST-X)
2. Press the power button on the back of the Hovermap to power the unit.
3. On your tablet or smartphone, open the Wi-Fi settings and connect to Hovermap's Wi-Fi.
   Hovermap creates a Wi-Fi network with the name of the serial number of the unit.
   For example, for Hovermap **ST0035** the network name will be **st_0035**.
4. Enter the network password: **hovermap**
5. Once you have accessed Hovermap's Wi-Fi, open an internet browser:
    a. To access the Web UI, type **hover.map** into the address bar.

Tip

- If the Web UI doesn't load, type **10.9.0.1**.
- Save this page as a shortcut on the home screen for easy access in the future.

> **Note**
> Certain Web UI components may fail to load when using the Samsung tablet's native browser. In such cases, we recommend using Google Chrome, as it offers compatibility with the Web UI and can help resolve any loading issues.

5.1.2 Web UI layout



1. **Start Mapping Mission** button
2. System state
3. Scan name
4. System Time
5. Storage
6. Hovermap status icons
7. Device details
8. Generate preview point clouds
9. High density mode
10. **Current** tab
11. **Transferred** tab
12. USB Log
13. Network Configuration
14. Payload Configuration

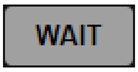
5.1.3 Web UI functions

The following functions are available in the Web UI.

5.1.3.1 Start

Use the **Start Mapping Mission** button to remotely start or stop a scan. This button will change, depending on the current Hovermap operation.

Button	Action
START MAPPING MISSION	When Hovermap is ready to scan, the teal **Start Mapping Mission** button appears. Press **Start** to begin scanning and collecting data.
STOP	While Hovermap is scanning, the button will change to a red **Stop** button. Press **Stop** to stop Hovermap and return it to a ready state.

Button	Action
	When Hovermap is in a transition or transfer state, the button will change to a gray **Wait** button.

5.1.3.2 System state

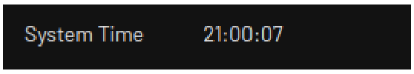
This indicator shows the current state of Hovermap. It is located just beneath the **Start** button. The text will tell you exactly what Hovermap is doing.

- **Green:** A green dot indicates that Hovermap is active.
- **Red:** A red dot indicates that Hovermap is stopped.

5.1.3.3 Scan name

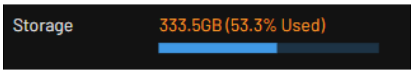
Type your scan name into the **Scan name** field. The text will turn orange to indicate that it has changed. Press the tick button to confirm, and the text will return to white to indicate it has been saved.

5.1.3.4 System time



The system time is shown in 24-hour format.

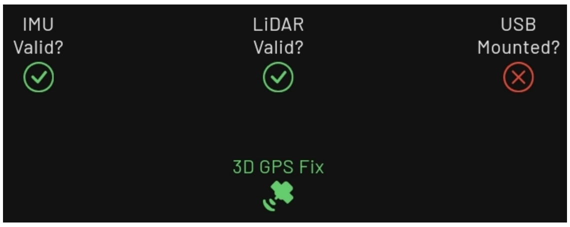
5.1.3.5 Storage



This indicator shows the available free space on the internal solid-state drive.

If Hovermap is more than 50% full, the text will change to orange. If Hovermap is more than 90% full, the text will change to red.

5.1.3.6 Hovermap Status Icons

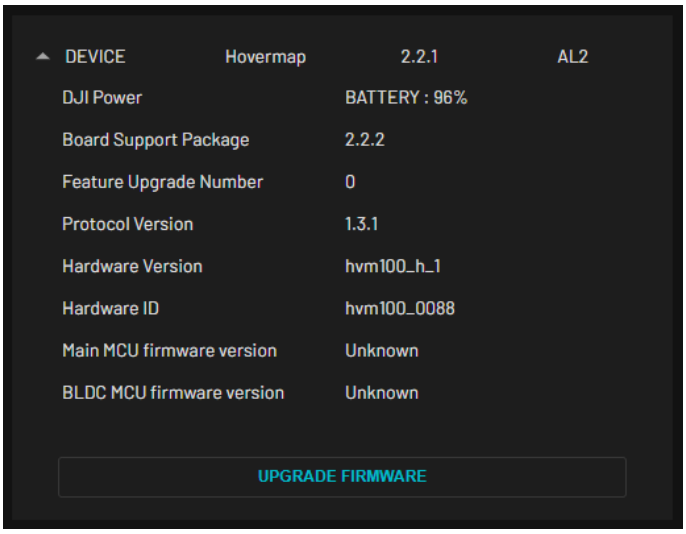


The Hovermap status icons show the status of the IMU, the LiDAR, and the USB connection.

- **IMU and LiDAR:** If the icon is green, go ahead with the scan. If it is red or orange for an extended period, contact Technical Support Services.
- **USB:** The USB icon will remain red unless the USB is mounted and actively processing. The icon will only be green during the processing period. Once it has stopped, it will turn red again.
- **GPS/RTK**: These icons are present when connected to a supported GPS or RTK module.

5.1.3.7 Device Details

Expand the **Device** section to show a list of Hovermap's properties.



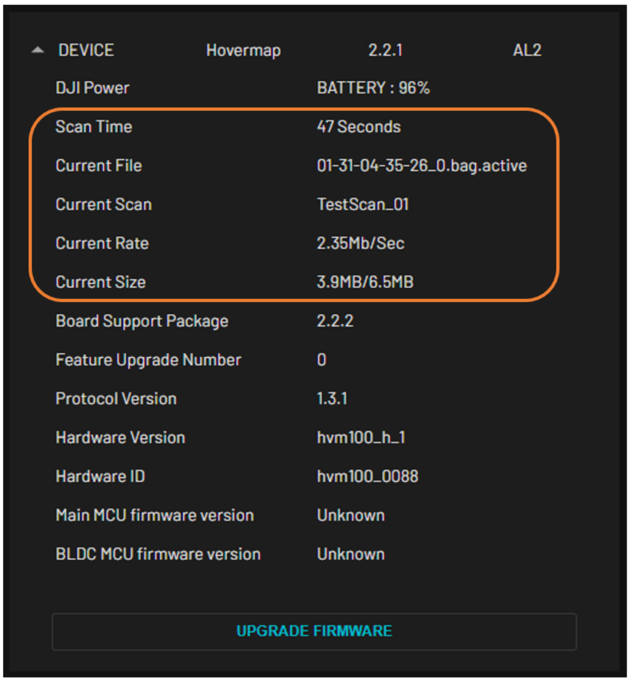
In this section, you will find:

- The current Emesent Cortex version (top row).
- The supported autonomy level (top row).
- The unique identifier for your particular Hovermap (**Hardware ID** field).

You can also press the **Upgrade Firmware** button to access the update page. From there, you can update the operating system, change your autonomy entitlement, and upload/update colorization calibration files. Refer to the Upgrading Emesent Cortex instruction guide for more information.

Scan Details

While Hovermap is scanning, the scan details appear in the **Device** section. These will disappear when the scan is stopped.



The following scan details are available.

Table 1 Scan details

Field	Data
Scan Time	Shows the length of time that the scan has been running.

Field	Data
Current File	Shows the active file where the data is currently being stored. This information can be used for investigation purposes.
Current Scan	Shows the name of the current scan.
Current Rate	Shows the rate at which data is saved to your scan file. This tells you how quickly you will run out of space on your Hovermap. • **White:** Ideally, the rate should be above 2Mb/Sec. In this case, the text will be white. • **Orange:** If the text is orange, the rate has dropped to less than 2Mb/Sec. • **Red:** If the text is red, the rate has dropped to less than 1Mb/Sec.
Current Size	Shows the size of the current scan file.

5.1.3.8 Generate preview point clouds

When the **Generate preview point clouds** toggle is on, a point cloud preview will be generated. Be aware that turning this on will increase both your file size and the time it takes to transfer to the USB flash drive.

5.1.3.9 High density mode

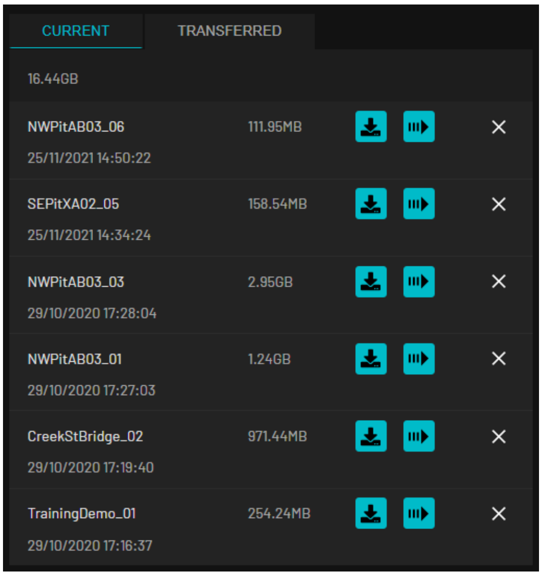
This setting is only available when using the Hovermap ST-X. When toggled on, the ST-X uses 32 lasers instead of 16, which enables you to capture more points faster.

5.1.3.10 Scan File Management

The Web UI allows you to manage and download your scan files to the connected device.

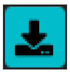
Current tab

The **Current** tab shows the scan data that has not yet been transferred from Hovermap. This tab provides a number of helpful functions for managing individual scan files.



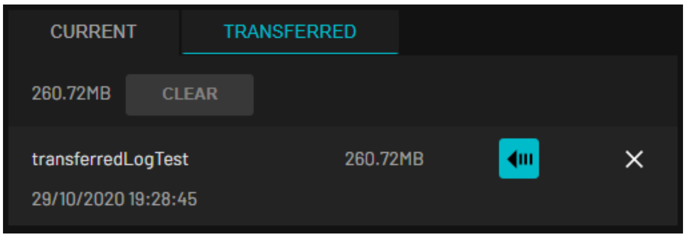
The following options are available for each scan.

Table 2 Current tab

Button	Action
	**Download:** When you press the download button, a message will appear asking you to confirm that you would like to continue with the download. The download may take a few minutes. **DO NOT** navigate away from the page until it is complete.
	**Move:** When you press the move button, the scan data will be moved from the **Current** tab to the **Transferred** tab.
	**Delete:** When you press the delete button, a confirmation message will appear. Press **OK** to delete the scan from Hovermap. Be aware that the scan may not have been downloaded or copied off the device, and will be unrecoverable once deleted.

Transferred tab

The **Transferred** tab shows the scan data successfully transferred to an external USB flash drive. It provides several helpful functions for managing individual scan files.



The following options are available for each scan.

Table 3 Transferred tab

Button	Action
	**Move:** When you press the move button, the scan data will be moved back to the Current tab from the Transferred tab.
	**Delete:** A confirmation message will appear when you press the Delete button (unless you have turned off this option on your tablet or smartphone). Press **OK** to delete the scan from Hovermap. Be aware that the scan may not have been downloaded or copied off the device, and will be unrecoverable once deleted.

Clear data

The **Clear** button at the top of the **Transferred** tab removes all system log files and transferred scans. Tap **Yes** when prompted to proceed. Scan data located in the Current tab will remain unchanged.

> **Note**
> The **Clear** button will only be enabled if Hovermap is *not* scanning. You can't clear data if a scan is in progress.

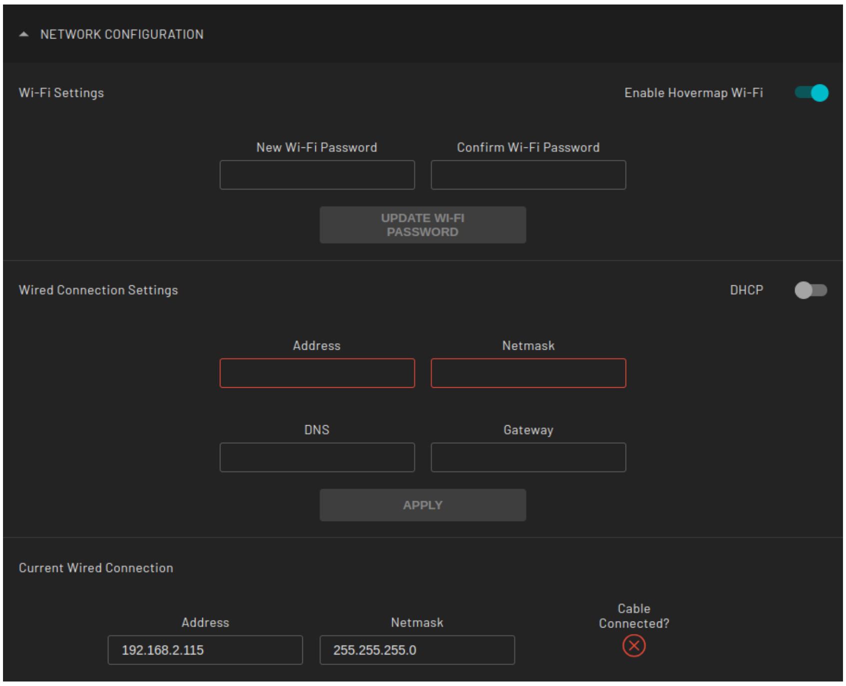
5.1.3.11 USB log

The USB log is an expandable area beneath the scan file management tabs. This section automatically expands when a USB flash drive is inserted into Hovermap. It will show the log output as it updates and the scans are transferred.

> **Note**
> If you have a lot of scans on Hovermap, this section may have moved off the bottom of your screen.

5.1.3.12 Network Configuration

Network Configuration enables you to disable the Hovermap Wi-Fi. In addition, it shows the current wired connection settings and allows you to change them if needed.



Disable Hovermap Wi-Fi

This toggle allows you to enable or disable Hovermap's Wi-Fi. By default, Hovermap Wi-Fi is enabled. To disable the Wi-Fi:

1. Click the **Enable Hovermap Wi-Fi** toggle.
2. Click **Yes** when prompted to turn off Hovermap's Wi-Fi.
3. Turn Hovermap off and on again for the change to take effect.

4. If you are turning off the Wi-Fi for security reasons, we recommend that you scan for Hovermap's SSID to confirm that it is no longer advertised.

> **Warning**
> If you disable the Wi-Fi, it cannot be turned back on using your smartphone or tablet. You will have to go through the following process:
>
> 1. Plug an ethernet cable from the USB-Ethernet adaptor into your PC.
> 2. Configure a static IP address on your PC depending on which Hovermap you want to connect.
>   - HVM 100
>   - IP Address: 192.168.2.113
>   - Subnet Prefix Length: 24
- or -
Subnet Mask: 255.255.255.0
>   - Gateway: 192.168.2.115
>   - HVM ST / STX
>   - IP Address: 192.168.3.113
>   - Subnet Prefix Length: 24
- or -
Subnet Mask: 255.255.255.0
>   - Gateway: 192.168.3.115
> 3. Once configured, you can connect to the Hovermap by entering the IP address into your browser's address bar.
>   - HVM 100
>   - http://192.168.2.115
>   - HVM ST / ST-X
>   - http://192.168.3.115
> 4. Go to the Web UI and toggle on **Enable Hovermap Wi-Fi**.
> 5. Turn Hovermap off and on again.

Changing the Wi-Fi Password

> ⚠ Ensure you have tested connecting to the Hovermap via a USB-Ethernet adapter, as described in the previous section, before changing the password. **You can still connect via the wired method detailed above and then reset the password**.

1. Connect to Hovermap's Wi-Fi network.
2. In your web browser, navigate to `hover.map`.

> ⚠ Ensure you are connected to the correct Hovermap before proceeding.

3. Tap **Network Configuration** located on the right side of the page (bottom of the page for narrow screens) to expand the settings.
4. Enter the desired new Wi-Fi password in both text fields. The password requirements are as follows (consistent with WPA-PSK standards):
   - Must be at least 8 characters long
   - Must be less than 64 characters long
   - Must only contain printable ASCII text
5. Tap **Update Wi-Fi Password** then read and acknowledge the warning prompt.
6. Restart your Hovermap.
7. The new password should now protect the Wi-Fi access point.

   Devices previously connected to this Hovermap must have their configurations modified to provide the new password to connect.
8. If the password is forgotten, connect to the payload via one of the direct wired methods (see linked instructions) and navigate to the web page again - repeating this process to set the desired password

Wired Connection Settings

> These settings apply specifically to the Fischer ethernet interface.

1. Enter the desired **Address** (IPv4) and **Netmask**.

> These settings are configured automatically when connecting to specific drones. When you toggle on **Enable DHCP**, it sets up the Fischer Ethernet to automatically obtain an IP address from the network it connects to.

2. Click **Apply** and confirm the connection is successful under **Current Wired Connection**.

Current Wired Connection

The displayed values indicate the present IPv4 Address and Netmask of the network to which the payload is connected, and they should correspond to the values set in the **Wired Connection Settings**.

> These settings apply specifically to the Fischer ethernet interface.

The **Cable Connected** icon turns from a red cross into a green tick when a wired network connection (ethernet) has been established. This relates to network connections through the Fischer connector on the Hovermap back panel.

> "Cable Connected" refers to physical carrier detections and does not guarantee an established TCP/IP connection due to potential misconfigurations in Hovermap or the connected network.

5.1.3.13 Payload Configuration

Payload Configuration enables you to set the power settings for your Hovermap. If the **Auto power-on** setting is enabled, Hovermap will boot automatically as soon as power is supplied. This setting persists until manually disabled.

6. Hovermap Emergency Procedures

In most situations, you can rely on Hovermap's failsafes to help keep your system safe. However, if you find yourself in a situation where your drone is behaving erratically and you need immediate control, use one of the following procedures.

> **Important**
> Before operation, make sure that you are familiar with your platform-specific emergency procedures.

> **Note**
> For more information on failsafes, refer to the Hovermap Operational Failsafes section.

6.1 Critical error or erratic drone behavior

Switch to drone control mode

If a critical error (in red) appears, or if your drone is behaving erratically, do the following:

1. Switch to drone control by changing the flight mode switch out of Hovermap mode.
   If GPS is available, switch to the appropriate position hold mode.
   For DJI drones:
   If GPS is not available, switch to Atti mode (for DJI).
   For Freefly Astro (ST-X only):
   Hovermap ST-X will automatically revert to Altitude mode if there is no adequate GPS available.
2. Manually fly the drone home safely.
3. Keep a close eye on your drone, as the controls will be sensitive and it will move at greater speed.
4. Contact Technical Support Services with flight logs and scan data for more details about any errors encountered.

> **Warning**
> This procedure should *only* be used in an emergency. Avoid flying in drone control mode unless you are an experienced pilot.

> **Note**
> For more detailed information on errors, refer to the Hovermap Notifications section.

6.2 Loss of tablet control

Switch to Pilot Assist mode

If you are flying in Autonomous mode and need to revert to Pilot Assist mode, use the following procedure. There are a number of reasons why you would want to do this, such as losing the connection between the drone and the tablet (for example, if the Wi-Fi connection has been lost or the tablet battery has been drained).

1. Tap the **Pilot Assist** button then confirm the action when prompted. Ensure that the switch is returned to the Hovermap position.
2. The system will change to Pilot Assist mode. Shield will be activated and position control will be active.
3. Manually fly the drone back to the home location or a safe recovery location.
4. Once you have reached this location, land the drone by one of the following methods:
    - Descend until the Shield limit is reached, then switch to drone control using the flight mode switch.
      If no GPS is available, this will put the system into Atti mode.
      Carefully land the drone.
    - Allow the drone to hover at the home location until the critical battery autolanding failsafe is activated. Once the failsafe is triggered, the drone will autonomously initiate its landing procedure.

7. Hovermap Maintenance

Keeping Hovermap in good condition will ensure that it is operating at peak performance at all times. For best results, we recommend that you send your Hovermap in for a service and calibration once a year.

We also suggest that you regularly clean the sensor lens. Refer to the Knowledge Base to see how to do this without damaging the lens.

7.1 Battery Care / Notes

- Never leave a battery unattended while it is charging.
- Only use the charger provided with the battery.
- Always charge batteries in an open area, away from flammable materials, liquids and surfaces.
- Charge the battery in ambient temperature range of between 0 C ~ 45 C. For best results, charge in an environment between 10 C ~ 30 C. Charging in any other conditions will not allow the battery to reach maximum charge capacity.
- Never charge batteries in freezing weather conditions where the temperature is less than 0°C(32°F).
- Never charge batteries that are too hot to touch. *Do not* handle the batteries until they are cool.
- Do not attempt to disassemble the battery.
- Never store Li-ion batteries in direct sunlight or in extreme temperatures.
- Never alter, puncture, or impact the battery or related components.
- Make sure to keep battery contacts clean.
- Keep battery pack dry and avoid use in extremely humid environments.
- If there are any signs of damage to the battery, stop using it.
- Always check the batteries before use for any damage or deformation.
- Always check the power cables before use for any cuts or breakage.
- Always check the charger before use for any signs of damage.
- Never discharge batteries at an amperage rate higher than that specified on the label.
- If a battery does not seem to function properly, *do not* use it anymore. The battery may need to be replaced. Notify Emesent immediately, and safely dispose of your battery, or if it can safely be transported, return to Emesent for investigation.

- If the battery is not going to be used for an extended period of time. store the battery 25% charged in an environment between 10 C ~ 30 C. Every 2 months the battery should be charged due to minimal self-discharge.

8. Hovermap Support

Our Technical Services team is here to help you at every stage of your Emesent experience. If you have any questions, concerns, or technical issues, please visit our Customer Portal.

From here, you can:

- Contact our support team
- Report an incident
- Suggest a new feature
- Download the latest firmware and software updates.
- Access our Knowledge Base for user guides, training, tips, tutorials, and troubleshooting.
- Access our e-store for Hovermap accessories, add-ons, and spare parts.

When requesting support, please provide as much information as possible to ensure a timely and helpful response.

Thank you!

9. Hovermap Glossary

Term	Definition
CMS	Cavity monitoring system
double-toggle	Toggle the flight mode switch in and out of Hovermap mode twice. Ensure that the switch is returned to the Hovermap position. (Hovermap > drone control > Hovermap > drone control > Hovermap)
FPV	First person view
GCP	Ground control point
GPS	Global positioning system
IMU	Inertial measurement unit
INS	Inertial navigation system. A backup navigation system that relies on the IMU to work. This is a good mode to use either below ground or indoors.
LiDAR	Light detection and ranging
RC	Remote control
RX	Receive
SDK	Software development kit
SLAM	Simultaneous localization and mapping
TX	Transmit
UI	User interface
UTC	Coordinated universal time

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