emesent

EMESENT AURA USER MANUAL

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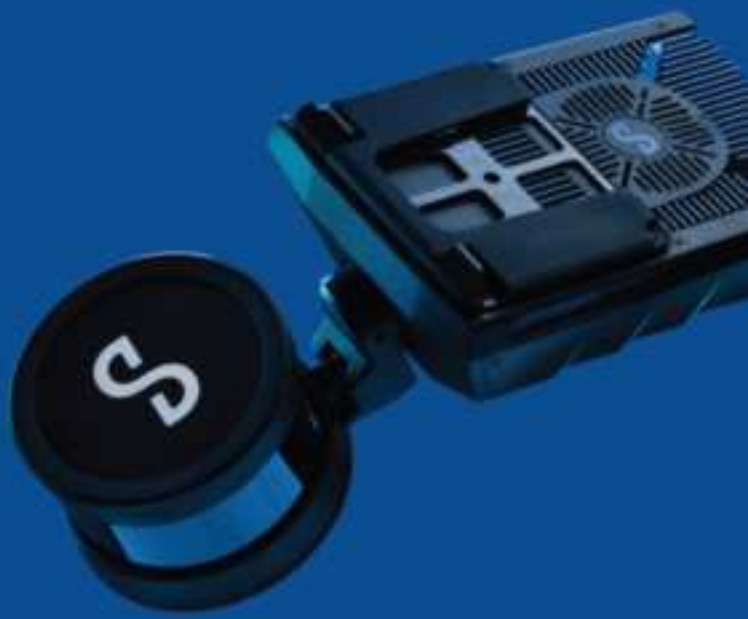

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Using this manual

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.

FCC and IC regulatory information

Please note the following regulatory information related to the radios in the device.

Regulatory notes, statements, health and authorization for use

Radio frequency electromagnetic energy is emitted from radio devices. The energy levels of these emissions, however, are far less than the electromagnetic energy emissions from radio devices such as mobile phones. Radio devices are safe for use by consumers because they operate within the guidelines found in radio frequency safety standards and recommendations. The use of radio devices may be restricted in some situations or environments, such as:

- On board an airplane
- In an explosive environment
- In situations where the interference risk to other devices or services is perceived or identified as harmful.

In cases in which the policy regarding use of radio devices in specific environments is not clear (for example in airports, hospitals, chemical/oil/gas industrial plants, private buildings), obtain authorization to use these devices prior to operating the equipment.

Regulatory information/disclaimers

Installation and use of this radio device must be in strict accordance with the instructions included in the user documentation provided with the product. Any changes or modifications made to this device that are not expressly approved by the manufacturer may void the user's authority to operate the equipment. The manufacturer is not responsible for any radio or television interference caused by unauthorized modification of this device, or the substitution or attachment of connecting cables and equipment other than those specified by the manufacturer. It is the responsibility of the user to correct any interference caused by such unauthorized modification, substitution or attachment.

The manufacturer and its authorized resellers or distributors will assume no liability for any damage or violation of government regulations arising from failure to comply with these guidelines. This device must not be co-located or operated in conjunction with any other antenna or transmitter.

Federal Communications Commission and Industry Canada Compliance statement

This device complies with Part 15 of FCC rules and Industry Canada license exempt RSS standard(s). Operation is subject to the following two conditions:

1. This device may not cause interference.
2. This device must accept any interference, including interference that may cause undesired operation of this device.

Déclaration d'Industrie Canada

Cet appareil est conforme à la RSS concernant les appareils exempt s de licence par Industrie Canada. Son fonctionnement est soumis aux deux condition s suivantes :

1. cet appareil ne doit pas causer d'interférence nuisib le.
2. cet appareil doit accepter toutes les interférences reçues, y compris celles pouvan t causer un mauvais fonctionnement de l'appareil.

FCC interference statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

FCC radio frequency exposure statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines. This equipment should be installed and operated keeping the radiator at least 20 cm or more away from person's body.

Déclaration d’Industrie Canada

Cet équipement est conforme aux limites d'exposition aux rayonnements de la FCC définies pour un environnement non contrôlé et aux directives d'exposition aux radiofréquences (RF) de la FCC. Cet équipement doit être installé et utilisé en gardant le radiateur à au moins 20 cm ou plus du corps de la personne

Export restrictions

This product or software contains encryption code which may not be exported or transferred from the US or Canada without an approved US Department of Commerce export license. Modifications not expressly authorized by manufacturer may invalidate the user’s right to operate this equipment.

Ce produit ou logiciel contient du code de chiffrement qui ne peut être exporté ou transféré du Canada ou des États-Unis sans un permis d’exportation du département du commerce des États-Unis. Toute modification n’ayant pas été expressément approuvée par la société peut annuler le droit de l’utilisateur de se servir du matériel.

Contents

1. Licence Requirements

The Emesent Aura license uses the same physical USB key as our other software. Without a valid license, data processing is disabled. However, you can still access and modify your processed point cloud and GCP data.

- The license is continually monitored while the software is used, make sure to keep it plugged in.
- Click the **License** button in the top-right corner to view the license information. You will get a notification when your license is about to expire.

2. System Requirements

Emesent Aura has the following system requirements:

- **Processor**
  - Minimum: 10th Generation Intel Core i9 Processor
  - Recommended: 12th Generation Intel Core i9 Processor
- **RAM**
  - Minimum: 64GB DDR4 3200Mhz Memory
  - Recommended: 128GB DDR5 4800MT/s Memory
- **Storage Drive**
  - Minimum: 512GB Samsung 980 Pro NVME SSD
  - Recommended: 2TB Samsung 990 Pro NVME SSD
- **External Storage:** High-speed USB 3.1 storage drive, with a minimum of 128 GB storage space for scan transfer from the Hovermap to a PC.
- **Graphics Card**
  - Minimum: Nvidia RTX 3070 8GB Graphics Card
  - Recommended: Nvidia RTX 4070 Ti 12GB Graphics Card
- **Operating System:** Windows 10 64-bit (x86)

> ⚠ Do not process scans on removable storage or network drives as it can lead to performance issues. To ensure faster processing without performance problems, scans must be downloaded and processed directly from your computer's main storage (SSD).

3. Getting Started with Emesent Aura

3.1 Step 1: Collect your data

Go to the following Knowledge Base articles for more information on how to perform your Hovermap scan:

- The Hovermap workflow
- The mission planning process
- Scanning techniques

Once your scan is complete, download the raw Hovermap data onto a USB 3.0 storage device. You must copy this data from the USB drive to your local machine for processing.

> ⚠ Scans from a Hovermap that use Emesent Cortex version 3.3 (or later) can only be processed in Aura 1.7 (or later).

3.2 Step 2: Install Emesent Aura

1. Download all files from the supplied USB flash drive, or our Software downloads page.
2. Run **AuraInstall[version number].exe** to begin the installation.
3. In the Emesent Aura setup wizard, click **Next** on each page to install the software. You must accept the end-user license agreement (EULA) to continue the installation.
4. In the **Setup - Aura** window, click **Install**.
5. On the final page, click **Finish** to complete the installation.

> ℹ Installing Emesent's software requires administrator permissions. If you do not have these permissions contact your IT department or system administrator to install the software. Contact Customer Support if you have any issues.

3.3 Step 3: Open Emesent Aura

To access all the features, you will need to upgrade your key. Without a valid license, data processing is disabled. However, you can still use the app to access and modify your processed point cloud and GCP data. Please contact Customer Support for more information on how to upgrade your license.

> The license dongle can only be used on the same computer where Aura is installed. You will not be able to activate the license on a remote computer.

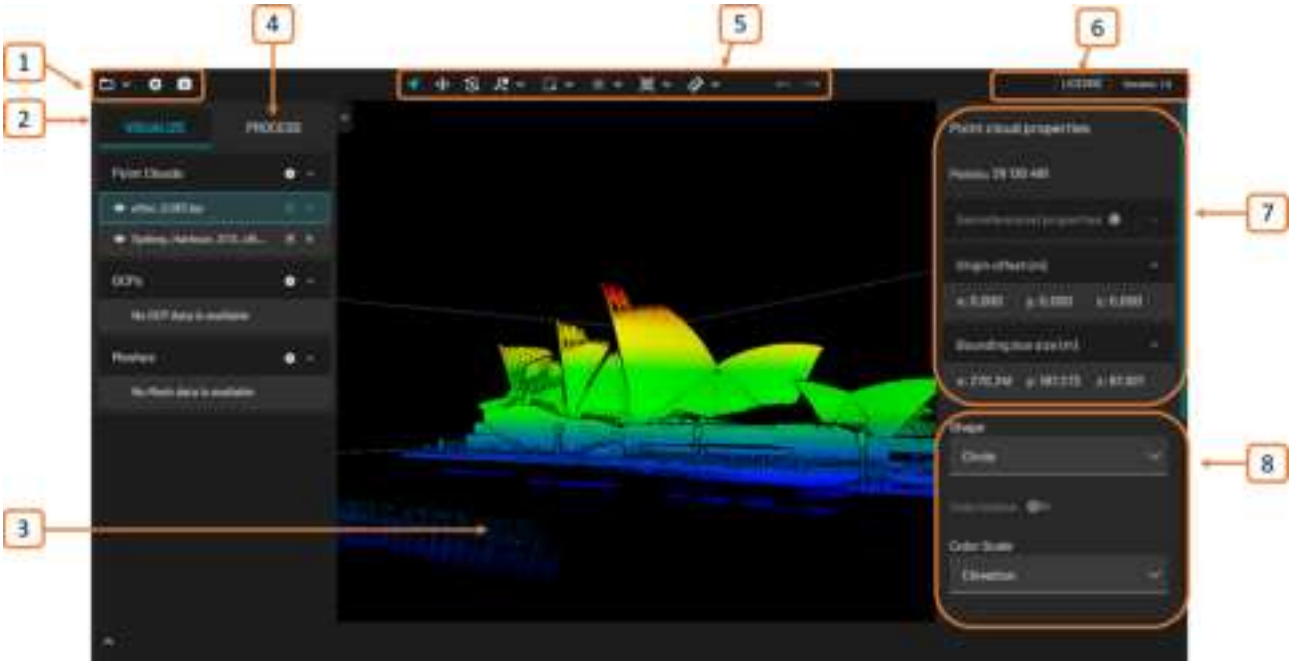


Figure 1 Emesent Aura UI

1. Global Settings
2. Visualize Tab
3. Viewport
4. Process Tab
5. Main Toolbar
6. License and Software Version
7. Point cloud properties panel
   Note: If the selected point cloud is georeferenced, this panel displays the number of points and other important information such as transformations, scaling, and offsets applied. It can be docked or made to float on the screen.
8. Context panel
   Note: This panel is only visible once you have opened a point cloud. It also changes, depending on the selected data. It can be docked or made to float on the screen.

For more information on each panel, go to the Emesent Aura UI section.

Press the **F1 key** in Aura at any time to access Help and see the full range of mouse actions and keyboard shortcuts available to you.

3.4 Step 4: Choose your settings

There are several global settings available that let you choose how you want to view and interact with your point clouds. Go to the Global Settings section for more information on each of these settings.

3.5 Step 5: Open a point cloud

There are three ways to open files in Emesent Aura.

- In the top-left menu, click the **Project Menu** icon then select **Open** from the popup menu.
- Drag and drop your file directly into the **Viewport**.
- Go to the **Visualize** tab then click **Add** next to your chosen section.

- Anti-virus software may conflict with Emesent's software.
- Installing Emesent's software requires administrator permissions. If you do not have these permissions contact your IT department or system administrator to install the software. Contact Customer Support if you have any issues.

The following file formats are supported:

- **LAS:** Contains the point cloud. The industry-standard file format for LiDAR data.
- **LAZ:** A compressed LAS file.
- **E57:** A compact file format used for point cloud storage. Only E57 files generated by Emesent Aura are supported.
- **XYZ:** A widely-supported point cloud format. In the context of Emesent Aura, XYZ files appear in the **Entity panel** as a trajectory point cloud, showing Hovermap's path.
- **PLY:** A standard mesh file format, which also serves as a supported format for point cloud data. When you click the **Add** button, the system automatically loads the PLY file into the appropriate section in the **Visualize** tab, regardless of the location. Currently, Emesent Aura does not offer the capability to generate PLY files; it only supports loading third-party-generated mesh PLY files.

The loading bar will show the loading progress of your point cloud file. If multiple files are loading simultaneously, there will be multiple loading bars (one for each file). The files are loaded in parallel with the smaller-sized files loading faster. There is no limit to the number of files that can be loaded at once but keep in mind that point clouds are loaded into your system's memory and working with large datasets may affect your system's performance.

3.6 Step 6: Create your point cloud from raw data

To create a point cloud from your raw Hovermap data, you must process it first. There are several processing workflows available. To access these workflows, go to the **Process** tab then click **Process Scan**.

> ⚠ Although it is possible to process a scan that is on a shared network, **it is not recommended** as processing directly on the network **will cause performance issues and problems with queuing jobs**.

In the **Configure New Scan Job** panel, do the following:

1. Select any of the following workflows.
   - **Process:** Create a point cloud from your raw Hovermap data. For more information, go to the Process Workflow section.
   - **GCP:** Georeference your point cloud. For more information, go to the GCP Workflow section.
   - **Merge:** Merge multiple scans into one seamless point cloud. For more information, go to the Merge Workflow section.
   - **Colorize:** Augment your point clouds with true color. For more information, go to the Colorization Workflow section.
   - **Extract 360 Images:** Provide additional context to your point cloud by adding 360 contextual reality to your Hovermap point cloud scans. For more information refer to the Emesent asset: 360 Panoramic Image Guide (includes video).
   - **Convergence monitoring:** Integrate the rapid data capture capabilities of the Hovermap with Aura's intuitive processing and analysis to help you manage and monitor your excavation projects. For more information, go to https://4999118.hs-sites.com/en/knowledge/change-monitoring-and-change-detection-pdf.
2. Choose a profile for the selected workflow. This is a collection of settings designed to optimize processing for specific scenarios. For more information, go to the Processing Profiles section.
3. Click **Processing Settings** if you want to make changes to the default settings. Go to the Process Tab section for more information.
4. Click **Start** to begin processing. While processing, you can minimize the processing panel while simultaneously working on another point cloud.
5. Once processing is complete, click **View** to inspect and interact with your point cloud in the Viewport.

3.7 Step 7: Clean up your point cloud

Cleaning up your point cloud after processing is essential for removing unwanted features and noise. To clean your point cloud, it's best to work in small sections. You can begin by using the SOR filter to eliminate noise. Once this is done, you can manually tidy up your point cloud using the tools available in the Main Toolbar.

> Automated filtering can be integrated into the processing workflow. Go to **Processing Settings** then enable the cleaning filter(s) in the **Point Filtering** section of the **General** tab.

For more information, go to the Cleaning your Point Cloud section.

3.8 Step 8: Measure your point cloud

There are several measuring tools available in the Main Toolbar. For more information on the tools available, go to Main Toolbar section.

3.9 Step 9: Create screenshots

Click **Capture Screenshot** to generate a screenshot of your current view. Your screenshot will be automatically saved in the **Documents\Emesent\Aura\Screenshots** folder. Click **Open** to open the folder containing your screenshot.

3.10 Step 10: Save your point cloud

From the **Project Menu**, click **Save** to save the changes to the existing file. Use **Save As** to create a copy of your point cloud with a different name, location, or file format.

Optionally, click **Save Project** in the Project Menu to preserve your current work for future modifications. The **.aura** project file serves as a starting point that can be reopened and edited whenever needed, allowing you to continue working on the project from where you left off.

> We recommend that you avoid the use of special characters in your file names, as the software does not recognize them.

4. Emesent Aura UI

4.1 Global Settings

These settings allow you to open and save files, open and save projects, set global preferences for viewing your point clouds, and capture screenshots. The following options are available.

4.1.1 Project Menu

Click the **Project Menu** icon on the top-left portion to access the following menu options.

Table 1 Project Menu Options

Menu	Description
Open	Opens a file and displays it in the viewport.
Open project	Opens a previously saved **.aura** project file.
Save	Saves the changes made to the current file.
Save as	Creates a copy of your current file with a different name, location, or file format.
Save project	Saves your current work for future modifications. The **.aura** project file serves as a starting point that can be reopened and edited whenever needed, allowing you to continue working on the project from where you left off.
Export reprojection	Reprojects a previously processed/reprojected point cloud into a new coordinate reference system and GEOID model.

4.1.2 Preferences

Click **Preferences** to see the global settings. Once you have configured the settings, click **Save** to apply the settings or **Close** to exit without saving. You can also click **Reset Preferences** to restore your preferences to their default settings.

The following options are available.

Table 2 Preferences Settings

Field	Data
Rendering	
Point Budget	The total number of points allowed in the Viewport. The upper limit can change, depending on the number of points available in your point cloud. With a large point cloud, you may not see every point on your screen unless you expand this setting to its upper limit. *Default setting: 7 million* (for performance purposes)
Camera Type	• **Perspective:** Objects that are far away appear smaller than those that are closer. The Perspective view is easier on the eye because you use it in real life. • **Orthographic:** All objects appear at the same scale, giving a clearer measure of distances between objects and their relative size. *Default setting: Perspective*
Near Clipping Plane	Removes points from the Viewport that are closest to the camera. These points are not deleted, just not visible. This distance is configurable. This feature is useful if you want to look at a cross-section of your point cloud or look through a wall.

Field	Data
Eye Dome Lighting (EDL)	• **Enabled:** Toggle on to enable eye dome lighting. This improves depth perception by shading the outline of points, accentuating the shape of each object. The point cloud can look a bit flat without this enabled. • **Radius:** The distance/thickness from the point being outlined. Setting the value to **1** outlines the pixels directly adjacent to the point, setting the value to **2** outlines the pixels 2 pixels away from the point and so on. • **Bias:** Controls the minimum depth difference between the points to be outlinde. Setting the value to 0 means that any difference in depth will get outlined, while a higher bias value (e.g. **1**) means that only points that are at least 1 world space units apart will be outlined. • **Strength:** Changes the strength of the outline. A higher strength setting makes the outlines darker, mostly noticeable on surfaces.

Field	Data
Multi-Frame Rendering (MFR)	• **Enabled:** Toggle on to enable multi-frame rendering screenshots, as well as the option to turn on live build-up. *Default setting: Enabled* It will take a few seconds to create the screenshot with multi-frame rendering enabled. • **Live Build-up:** Toggle on to enable the live build-up of the full point cloud in the viewport. This setting allows you to navigate a dense point cloud more easily. MFR uses a lower point budget while navigating, but once you stop, it builds up to the full point budget available. This prevents lag and allows you to view your point cloud in detail. *Default setting: Enabled* • MFR works best with the point size set to 0. • Setting the point budget too high with MFR enabled can result in poor responsiveness. The default value with MFR enabled is 3 million. • Consider disabling MFR and increasing the point budget to 5 or 10 million when using point selection and measurement tools. • There are a number of triggers that initiate re-rendering, including translate/rotate, camera zoom/pan, undo/redo, and changes to file attributes (such as point shape, color scale, or point size).

Field	Data
	• You can only enable this setting if **Multi-Frame Rendering** has been turned on. • We recommend that you don't use MFR when using selection or measurement tools when aligning point clouds using translate/rotate tools or during the GCP constellation matching stage.
View Defaults	
Zoom Speed	• **Fast:** Good for wide, open scans. • **Medium:** Good for underground scans. • **Slow:** Good for close inspection.
Selection Outline Color	Allows you to choose the color of the selection box using either the color picker or RGBA/HEX color codes.

Field	Data
Appearance	
Background	Allows you to configure the background color of the viewport. The standard black background means that you can miss a lot of detail, especially when viewing colorized point clouds. You can now change the background color to make this detail more visible. • **None:** No color selected. The background will be a standard black. • **Solid:** Allows you to choose a solid background color using either the color picker or RGBA/HEX color codes. • **Gradient** ◦ **Linear:** Click the color at each end of the **Gradient** scale to choose a start and an end color. The gradient will be between these two colors. Move the **Angle** dial to change the angle of the gradient. ◦ **Corner:** Allows you to specify individual colors for the top left, top right, bottom left, and bottom right of the Viewport.
Reset Preferences	Reset all settings to the default.

4.1.3 Capture Screenshot

Select **Capture Screenshot** to generate a screenshot of your current view. Your screenshot will be automatically saved in the **Documents\Emesent\Aura\Screenshots** folder.

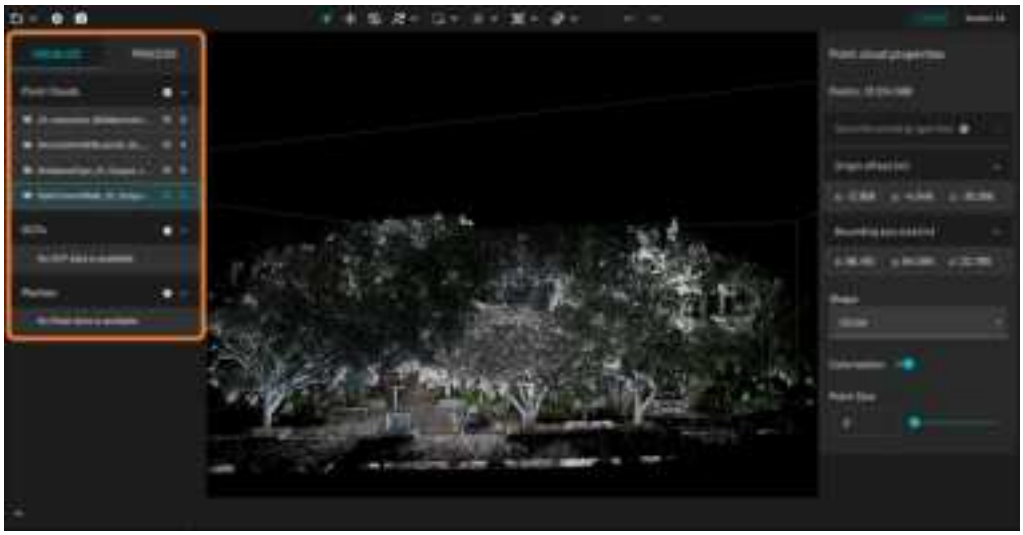
If you have **Multi-Frame Rendering** enabled, a high-quality screenshot will be produced. All settings, such as GCP landmarks, will appear in the screenshot.

Click **Open** to open the folder containing your screenshot.

4.2 Visualize Tab

You can use the **Visualize** tab to see which files you have loaded into Emesent Aura. This tab is divided into three sections: **Point clouds**, **GCPs**, and **Meshes**.

Refer to the Getting Started with Emesent Aura section for instructions on how to open a file.



4.2.1 Supported File Types

The file type determines which section in the tab your file appears in.

- **Point clouds:** las, laz, e57, xyz, ply
- **GCPs:** constellation.yaml
- **Meshes:** ply

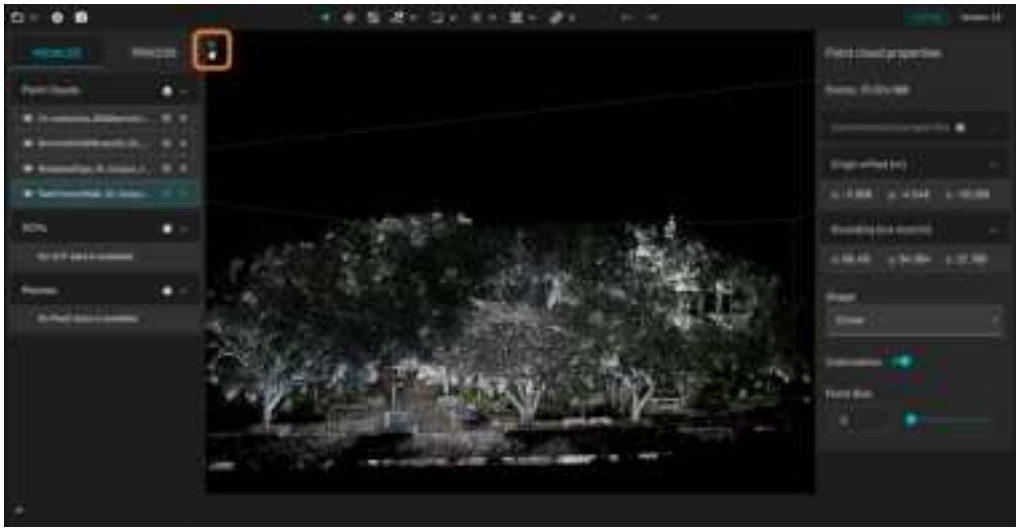
> PLY is a standard mesh file format, which also serves as a supported format for point cloud data. Currently, Emesent Aura does not offer the capability to generate PLY files; it only supports the loading of third-party generated mesh PLY files.
> Also, interaction for imported meshes is fairly limited. This will be improved in future releases.

Table 3 Options

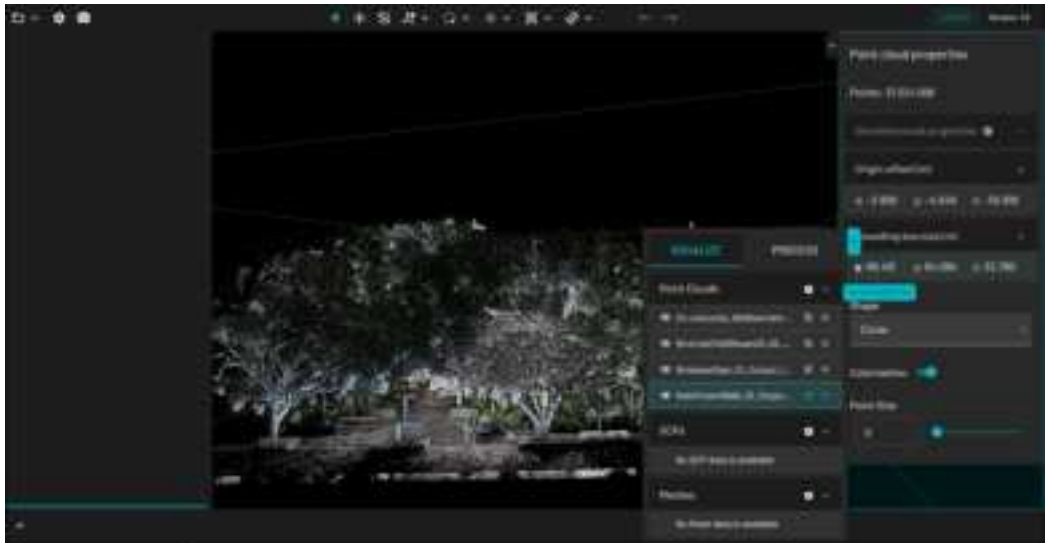
Button	Name	Action
	Display	Shows the file the in viewport. You can display multiple files at the same time.
	Hide	Hides the file in the viewport.
	Remove	Removes the file from Emesent Aura.
	Focus	Allows you to focus on *this particular file* in the viewport.

4.2.2 Moving the Panel

To move the panel containing the **Visualize** tab, hover over the upper left or right portion (depending on where it is located) until you see the **Dock** icon.



Click and hold the **Dock** icon then drag the panel to the left or right until you see a blue border to indicate that the panel will dock at that location once released.

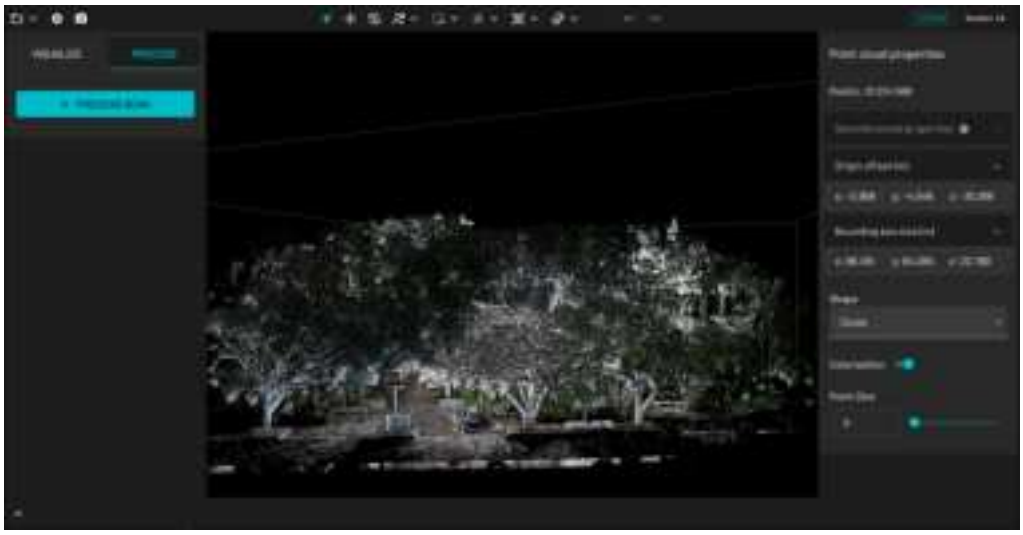


Alternatively, you can make the panel float anywhere on the screen.

4.3 Process Tab

You can use the **Process** tab to start a scan processing job (workflow) or view the **Processing Queue**.

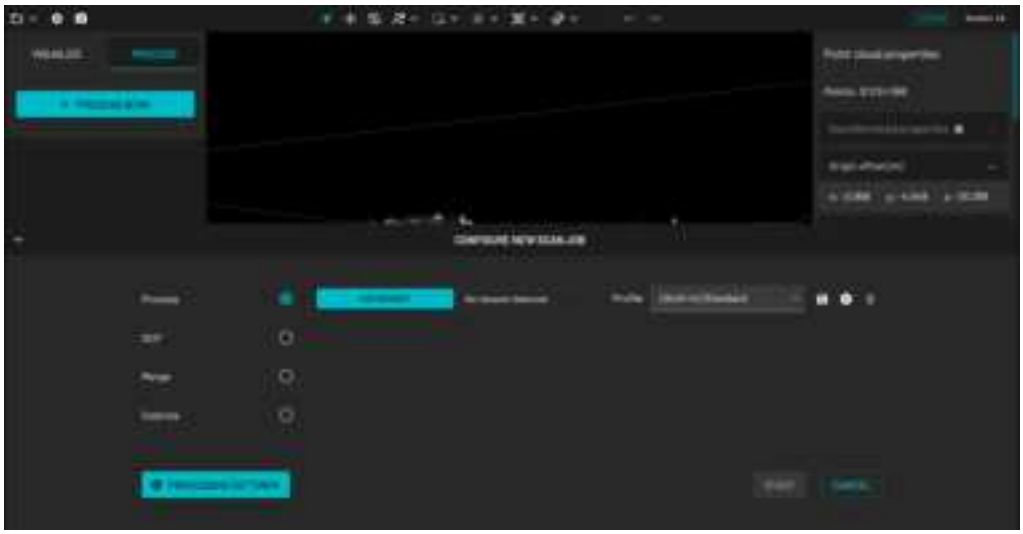
> Refer to the Visualize Tab section for docking instructions or making the panel float on the screen.



4.3.1 Configure New Scan Job Panel

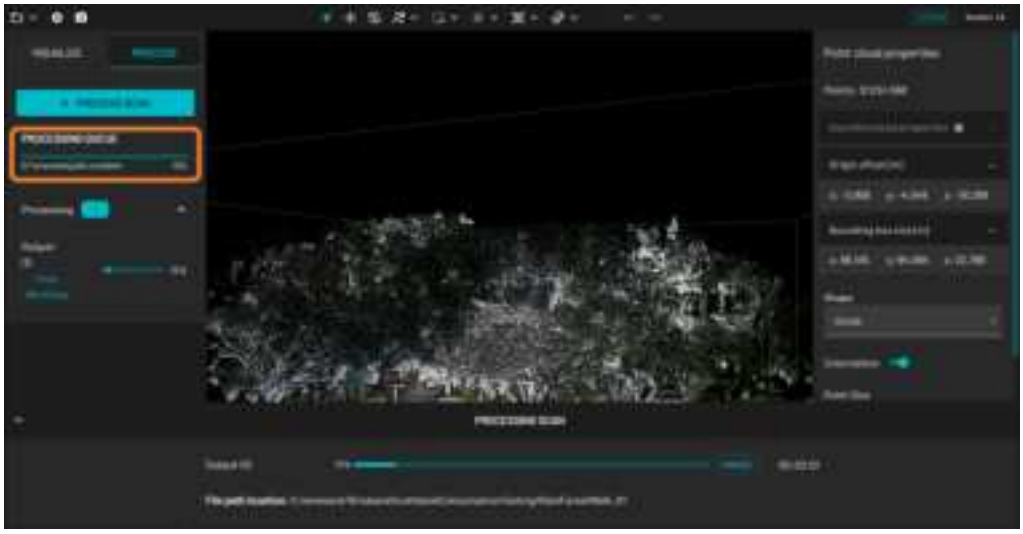
Clicking on **Process Scan** displays the **Configure New Scan Job** panel, which allows you to process a point cloud or GCP data. Once processed, enhance your scans using the **Merge** or **Colorize** features. You can then load these processed scans for editing in the **Visualize** tab.

For instructions on how to process a scan, refer to the Working with Point Clouds section.



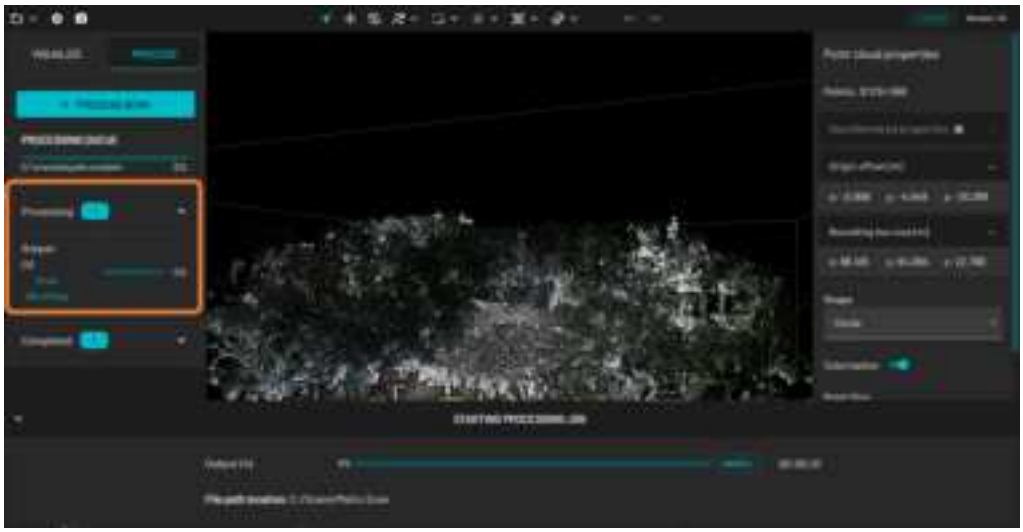
4.3.2 Processing Queue

The **Processing Queue** lists all current, pending, failed, and completed workflows. The first section displays the overall percentage of completed workflows to those remaining in the queue.



4.3.2.1 Processing

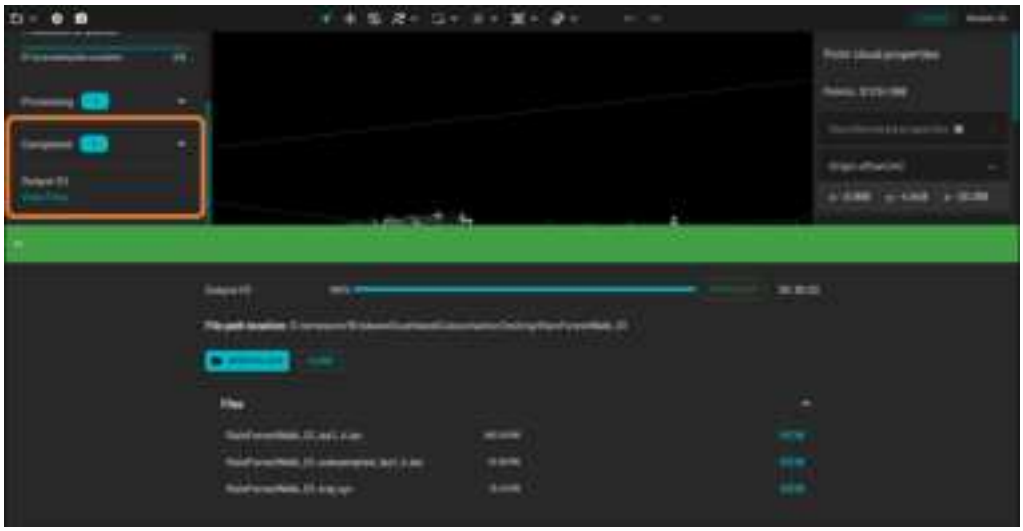
All current and pending workflows are shown in the **Processing** section. Each workflow shows the folder name where the output files are saved. Clicking on **View Workflow** displays the progress of that particular workflow at the bottom.



4.3.2.2 Completed

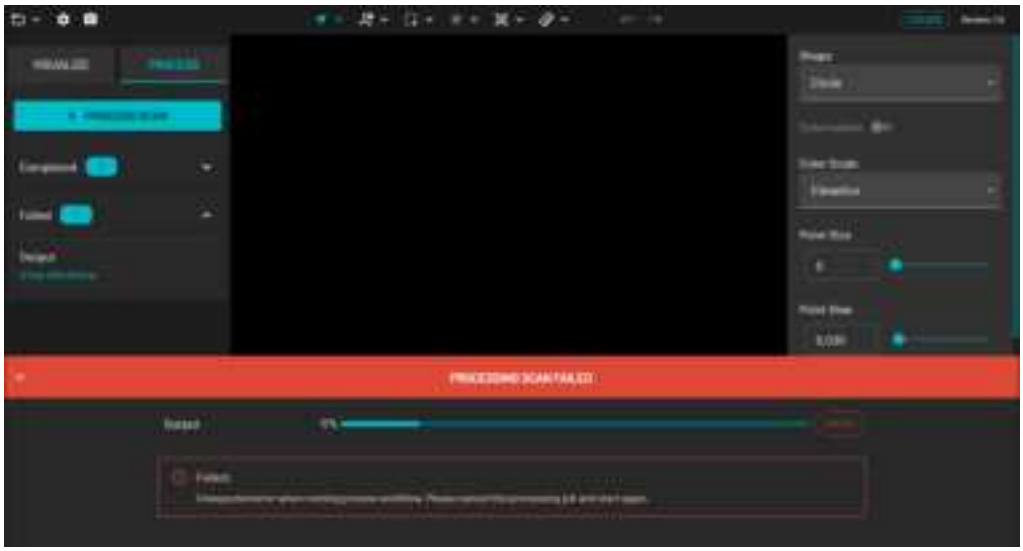
Once the processing is finished, the workflow is moved to the **Completed** section.

- Click **View Files** to open a panel at the bottom, which lists the generated output files.
- Click **Open Folder** to open the folder where the generated output files are saved.
- Click **View** beside the output file to display it in the **Viewport**. Doing this also loads that particular output file in the **Visualize** tab so you can edit it further.
- Click **Close** to exit from the panel.



4.3.2.3 Failed

Any workflow that is processed unsuccessfully is displayed in the **Failed** section. A general error description is also provided.



If the Aura application closes unexpectedly or the scan you are processing in Aura won't complete, it's important to Recover Aura log files, generate a DirectX Diagnostic file, and report the incident through the Customer Support form online.

4.3.3 Processing Settings

Select a workflow then click **Processing Settings** to access advanced customization settings. In addition to the **General** and **Output** tabs, an additional tab specific to the selected workflow may be available.

4.3.3.1 General Tab

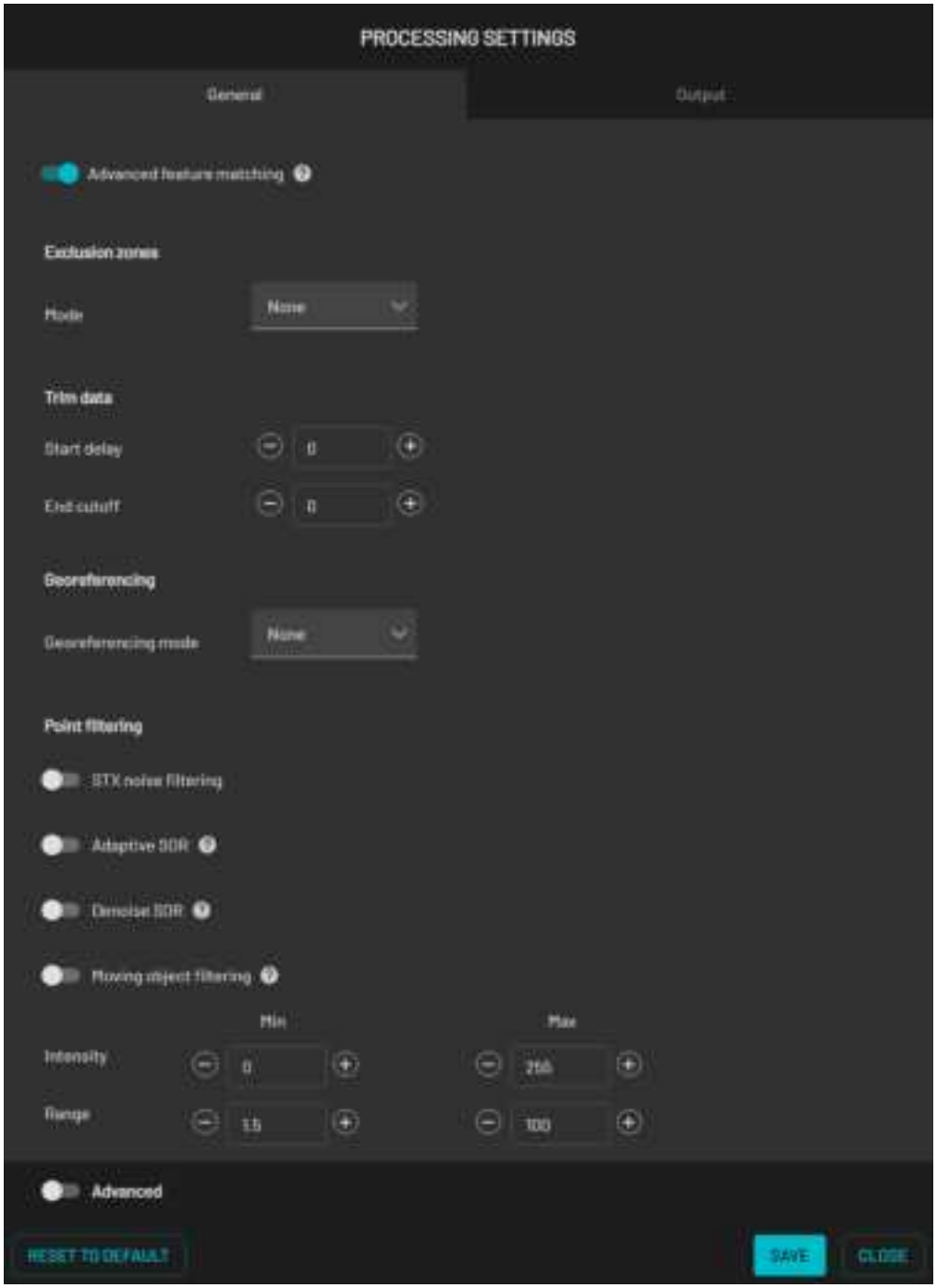


Table 4 Processing Settings - General Tab

Field	Data
Advanced feature matching	Enabling this stage of SLAM processing can improve results in most environments, but disabling it may provide better results in complex or repeating environments.
Exclusion Zones	You can use this setting to exclude points close to Hovermap that may interfere with the SLAM algorithm or add noise to the point cloud (for example, those created by Hovermap itself, a drone, vehicle, or operator). We recommend that you use the default setting. **Mode:** • **Bounding Box:** This option allows you to configure the minimum and maximum distance *on each axis*. ◦ **X Min / Forward:** Points within this minimum distance *at the front* of Hovermap are not processed. *Default setting: 1.5 m* ◦ **X Max / Backwards:** Points within this maximum distance *at the back* of Hovermap are not processed. *Default setting: 1.5 m* ◦ **Y Min / Left:** Points within this minimum distance *to the left* of Hovermap are not processed. *Default setting: 1.5 m* ◦ **Y Max / Right:** Points within this maximum distance *to the right* of Hovermap are not processed. *Default setting: 1.5 m* ◦ **Z Min / Down:** Points within this minimum distance *underneath* Hovermap are not processed. *Default setting: 1.5 m* ◦ **Z Max / UP:** Points within this maximum distance *on top* of Hovermap are not processed. *Default setting: 1.5 m*

Field	Data
Trim Data	Use this setting to specify the time (in seconds) to ignore data from either end of your dataset. This can be useful, for example, if your scan gets off to a difficult start. • **Start Delay:** The number of seconds to be dismissed from the beginning of the scan. • **End Cutoff:** The number of seconds to be dismissed from the end of the scan (working backward).
Georeferencing	• **Georeferencing Mode:** Select the method used to obtain location data for accurately referencing the point cloud in real-world coordinates. ◦ **Drone RTK / Vehicle RTK / Backpack RTK:** Select the device used to capture the scan data. ◦ **GPS:** Use standard GPS data without real-time correction through RTK. This could still provide reasonably accurate georeferencing but might not achieve the same level of precision as RTK.

Field	Data

	• **OGC WKT Standard:** Select the Well-Known Text (WKT) format, which is used to represent coordinate reference systems and transformations. WKT provides a standardized way to describe spatial reference systems in a textual format.
	  ◦ **WKT1:** The original version of the Well-Known Text format. It describes coordinate reference systems and coordinate transformations in a textual representation and is widely used in various geospatial applications.
	  ◦ **WKT2.2018:** An updated version of the Well-Known Text standard released in 2018. This version includes improvements, additional functionalities, and other updates.
	• **GNSS receiver type:** The GNSS receiver used to capture the RTK data.
	
	⚠ For optimal results, ensure that the **Georeferencing mode** and **GNSS receiver type** match the hardware used during data collection. While the resulting point cloud remains usable, the accuracy may be compromised.

Base coordinate reference system	Select the CRS in which the data was originally collected. This information is essential for accurate transformations and reprojections to the target CRS.
Reprojection	Toggle on to reproject the point cloud being processed. • **Horizontal:** Reproject to a different map projection or coordinate system. • **Vertical:** Convert from ellipsoidal height to orthometric height using a GEOID model.

Field	Data
Point Filtering	You can integrate automated filtering into the processing workflow by enabling any of the following noise filters. This may eliminate the need for a separate filtering step after processing. Note that only default settings are used, there are no options to adjust the filtering parameters. Refer to the Main Toolbar section for more information on each filter and its associated parameters. • **STX Noise Filtering:** Filters out stray points by analyzing the range, intensity, and number of LiDAR points returned. Keep in mind that this process only applies to data collected from a Hovermap ST-X and will not have any effect on point cloud data gathered from other Hovermaps. • **Adaptive SOR:** Removes points that seem fuzzier than nearby points such as noise thickness from walls and floors. ◦ **Nearest neighbor:** The number of point neighbors used for evaluation. A lower setting will result in quicker processing times but removes less sparse noise. ◦ **Alpha:** Threshold for noise filtering. A lower setting will result in more aggressive filtering. • **Denoise SOR: :** Removes outlier point which are less likely to be real such as reflections. ◦ **Nearest neighbor:** The number of point neighbors used for evaluation. A lower setting will result in quicker processing times but removes less sparse noise. ◦ **Log scale:** Threshold for noise filtering. A lower setting will result in more aggressive filtering.
	• **Moving object filtering:** Removes moving points over 5 second intervals and keeps fixed point in the environment. ◦ **Motion level:** Detects movement over 5 second intervals. The higher the value, the lesser moving points are selected. ◦ **Distance:** The maximum distance for recovering fixed points. The higher the value, the more points are selected. A value of 1 to 2 cm are recommended for most scans.

Field	Data
	• **Intensity:** Set the minimum and maximum intensity values of points to be written to the output point cloud. • **Range:** Set the minimum and maximum range values of points to be written to the output point cloud.
Reset to Default	Reset all settings to the default.
Advanced The advanced settings contain additional processing parameters that can be adjusted to improve the output of the SLAM algorithm in certain circumstances. You should only use these settings when you are unable to achieve a quality output using the standard processing profiles. We recommend that you only use these settings after talking to Customer Support.	
Local mapping	
Time Window (**Auto SLAM**)	• **Time Window Sliding Size in Seconds:** The length of the sliding window when running the optimization part of the SLAM process. Increase this value to improve the chance of a good output when there are a low number of geometric features in the scan. Increasing this number comes at the cost of increasing the processing time. *Default setting: 5 seconds* • **Time Window Sliding Shift in Seconds:** Indicates how far the above window is shifted in each optimization loop. Decrease this value to improve the chance of a good output when there are a low number of geometric features in the scan. Decreasing this number comes at the cost of increasing the processing time. *Default setting: 1 second* • **Auto SLAM** dynamically adjusts the Time Window processing parameters in real time when encountering challenging environments, such as tunnels, culverts, or expansive open areas with minimal geometric features. The parameter values configured in the user interface serve as optimal-case constraints; Auto SLAM will only exceed these thresholds when required to maintain tracking performance. This feature eliminates the need for manual intervention in most cases, such as switching to the "Low Feature" profile or modifying time window settings.

Field	Data
Point Filtering	• **Intensity:** Set the minimum and maximum intensity values of points to be written to the output point cloud. The defaults have been chosen to ensure that noise points from the sun are excluded. We recommend that you use the default settings. *Min default setting: 0* *Max default setting: 255* • **Range:** Set the minimum and maximum range values of points to be written to the output point cloud. The default values include all points out to the maximum range of the LiDAR. *Min default setting: 0* *Max default setting: 300*
Iterations	• **Local Iterations:** The maximum number of iterations that the main optimization loop performs during local mapping. Use this when you want to reduce local slips. Increasing this number will cause processing to take longer. *Default setting: 5* • **Local Iterations Internal:** The maximum number of iterations that the internal optimization loop performs during local mapping. Use this when you want to reduce local slips. Increasing this number will cause processing to take longer. *Default setting: 5*

Field	Data
Voxels	• **Voxels Size:** The lowest size of voxel used to generate surfels in SLAM. Use this inside smooth tunnels/bores, as most of the information within the points will be in the subtle variations in the surface direction that occur in relatively small dimensions. Increasing this number can significantly increase processing time. *Default setting: 0.4 m* • **Voxel Levels:** The number of levels used to generate surfels in SLAM. Each level is twice the size of the previous level. Use this inside tunnels/bores, as most of the information within the points will be in subtle variations in the surface direction that occur in relatively small dimensions. *Default setting: 5* • **Voxel Minimum Points:** The minimum number of points in a voxel to use for SLAM. Use this to reduce the impact of noisy data on SLAM, or to ensure that features with a low number of points are included in environments with few geometric features. *Default setting: 8*

Field	Data
Global registration	
Point Filtering	• **Intensity:** Set the minimum and maximum intensity values of points to be written to the output point cloud. The defaults have been chosen to ensure that noise points from the sun are excluded. To include all points, use the default settings. *Min default setting: 0* *Max default setting: 255* • **Range:** Set the minimum and maximum range values of points to be written to the output point cloud. The default values include all points out to the maximum range of the LiDAR. *Min default setting: 0* *Max default setting: 300*
Iterations	• **Global Iterations:** The number of loops performed as part of the global registration process. Use this to reduce global slips. Increasing this number increases the likelihood of a quality output, but it will significantly increase processing time. *Default setting: 10* • **Global Iterations Internal:** The minimum number of iterations required to complete SLAM.

Field	Data
Voxels	• **Voxel Size:** The lowest size of voxel used to generate surfels in SLAM. Use this inside smooth tunnels/bores, as most of the information within the points will be in the subtle variations in the surface direction that occur in relatively small dimensions. Increasing this number can significantly increase processing time. *Default setting: 0.4 m* • **Voxel Levels:** The number of levels used to generate surfels in SLAM. Each level is twice the size of the previous level. Use this inside tunnels/bores, as most of the information within the points will be in subtle variations in the surface direction that occur in relatively small dimensions. *Default setting: 5* • **Voxel Minimum Points:** The minimum number of points in a voxel to use for SLAM. Use this to reduce the impact of noisy data on SLAM, or to ensure that features with a low number of points are included in environments with few geometric features. *Default setting: 100*
Velocity	• **Local Linear Velocity Confidence:** Allows you to decide how much confidence the global registration stage should place in the linear velocity results of the local mapping stage. The number is measured in standard deviation/error, so the higher the number, the lower the confidence. This is useful, for example, for long driving scans (over 500 m), where the start and end of the scan should overlap, but do not do so cleanly, or where there are sharp changes in the trajectory that are inconsistent with the actual scan. Significantly decreasing these values can help to keep the trajectory from being snapped to the correct global slips. *Default setting: 0.5*

Field	Data
	• **Local Angular Velocity Confidence:** Allows you to decide how much confidence the global registration stage should place in the angular velocity results of the local mapping stage. The number is measured in standard deviation/error, so the higher the number, the lower the confidence. *Default setting: 0.8*
Matching	• **Number of Matches:** Set the number of voxel matches that the SLAM algorithm will search for within the given restrictions. Increase this value to make the global registration more aggressive in searching for matching voxels and then adjusting the trajectory to make similar areas overlap. This is useful for long driving scans, where increasing the number of global iterations fails to get the start and end of the scan to align. Increasing these values usually requires decreasing the **Local linear Velocity Confidence** and the **Local Angular Velocity Confidence** values. *Default setting: 5* • **Max Distance:** The maximum distance (in voxel units) that the SLAM algorithm will search for voxel matches. Increase this value to make the global registration more aggressive in searching for matching voxels and then adjusting the trajectory to make similar areas overlap. *Default setting: 10*

4.3.3.2 GCP Tab

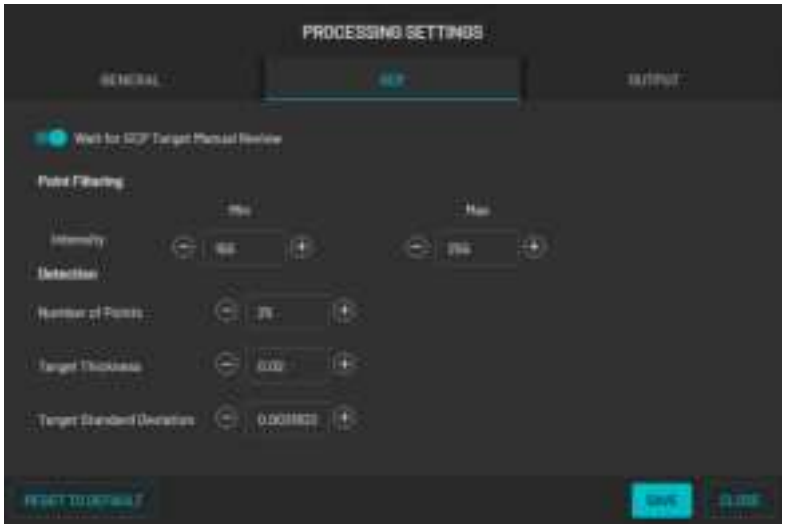


Table 5 Processing Settings - GCP Tab

Field	Data
Wait for GCP Target Manual Review	Select this checkbox to pause the software while the targets are confirmed. If unselected, Emesent Aura will assume that the constellation of detected targets has been successfully matched to the survey points provided.
Point Filtering	**Intensity:** The filter intensities should be between 150 and 255, assuming no change to the target material.

Field	Data
Detection	These parameters help to identify a target. • **Number of Points:** The minimum number of points required before a cluster (in the global and local stage) can be considered a target. • **Target Thickness:** The maximum thickness of the cluster of points representing the target. • **Target Standard Deviation:** Specifies target thickness. It helps to detect and identify targets more accurately. As this number increases, GCPs will be more easily detected. *Default setting: 0.003 m (3 mm)*
Reset to Default	Reset all settings to the default.

4.3.3.3 Merge Tab

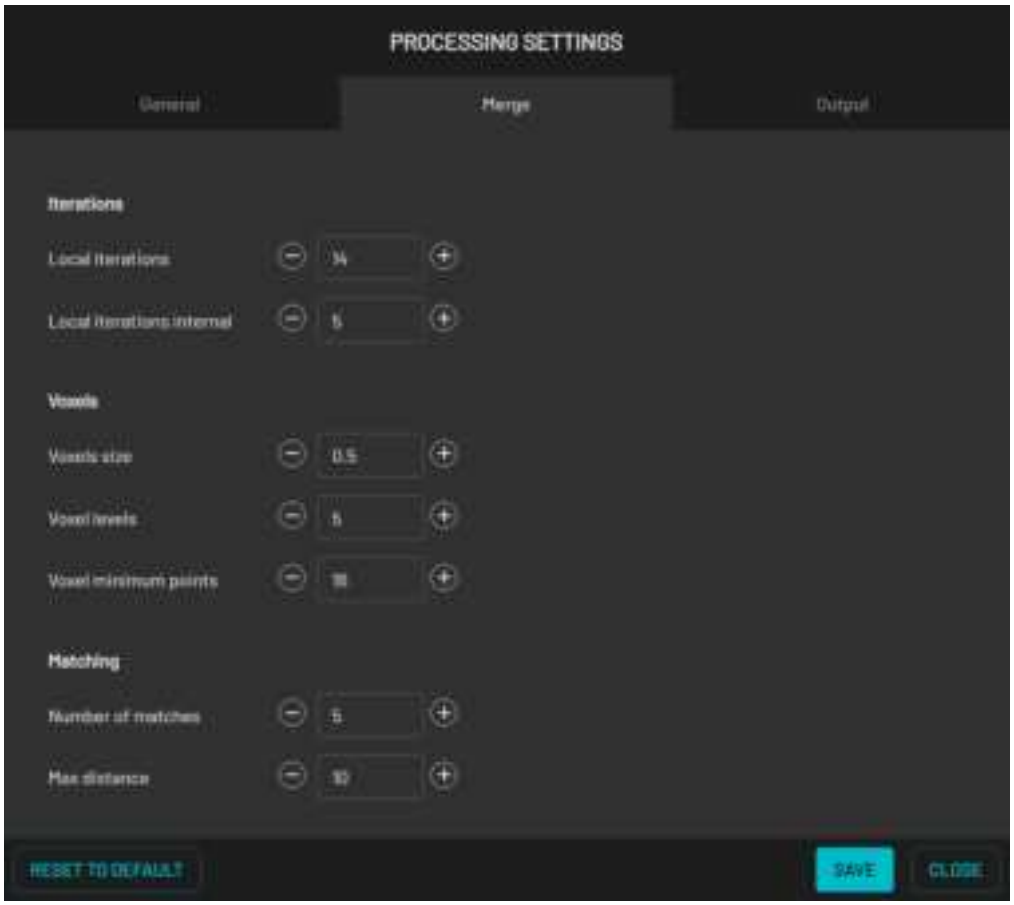


Table 6 Processing Settings - Merge Tab

Field	Data
Voxels	• **Voxels Size:** The lowest size of voxel used to generate surfels in SLAM. Use this inside smooth tunnels/bores, as most of the information within the points will be in the subtle variations in the surface direction that occur in relatively small dimensions. Increasing this number can significantly increase processing time. *Default setting: 0.4 m* • **Voxel Levels:** The number of levels used to generate surfels in SLAM. Each level is twice the size of the previous level. Use this inside tunnels/bores, as most of the information within the points will be in subtle variations in the surface direction that occur in relatively small dimensions. *Default setting: 5* • **Voxel Minimum Points:** The minimum number of points in a voxel to use for SLAM. Use this to reduce the impact of noisy data on SLAM, or to ensure that features with a low number of points are included in environments with few geometric features. *Default setting: 8*
Matching	• **Number of Matches:** Number of surfels to look for matches during SLAM. • **Max Distance:** Maximum distance (in voxels) to search for surfel matches.

Field	Data
Georeferencing	• **Georeferencing Mode:** Select the method used to obtain location data for accurately referencing the point cloud in real-world coordinates. ◦ **Drone RTK / Vehicle RTK:** A satellite navigation technique used to enhance the precision of position data obtained from GPS (Global Positioning System). It relies on a fixed base station and a mobile receiver. The base station precisely knows its location and communicates correction signals to the mobile receiver. Select this mode to allow the point cloud data to be aligned and referenced using highly accurate, real-time corrected GPS signals obtained through RTK technology. **GPS:** A satellite-based navigation system that provides location and time information anywhere on Earth. Choosing GPS as the Georeferencing Mode might mean that the software will use standard GPS data without real-time correction through RTK. This could still provide reasonably accurate georeferencing but might not achieve the same level of precision as RTK. ◦ **OGC WKT Standard:** Select the Well-Known Text (WKT) format, which is used to represent coordinate reference systems and transformations. WKT provides a standardized way to describe spatial reference systems in a textual format. WKT1 is recommended for best compatibility. **WKT1:** The original version of the Well-Known Text format. It describes coordinate reference systems and coordinate transformations in a textual representation and is widely used in various geospatial applications. **WKT2.2018:** An updated version of the Well-Known Text standard released in 2018. This version includes improvements, additional functionalities, and other updates.

Field	Data
	• For PLY and trajectory files in UTM or WGS84 coordinates, an additional PRJ file containing the projection information in OGC WKT format is written. LAS files contain the projection information in the file header. • If there is no GPS data recorded by Hovermap in the dataset, the output will only be in local coordinates, with the origin at the start of the scan.
Reset to Default	Reset all settings to the default.

4.3.3.4 Colorize Tab

Table 7 Processing Settings - Colorize Tab

Field	Data
Video Time Range	Sets the start and end time when frames are extracted from the video. The time represents the elapsed video time, not the number of seconds to trim from the end of the total video duration. Setting the **Video end time** to **0** will include everything after the start time.
Frame extract interval	Uses the maximum time, distance, and angle to determine the number of video frames to skip between image extractions, keeping only the necessary images. • **Time:** We recommended this setting is turned off to avoid repetitive extractions when the camera is not moving. The recommended range is between **1** to **20**. • **Distance:** Extracts images based on the distance the camera travels to avoid repetitive images when standing still. The recommended settings are **1** to **2** for small, confined spaces and **5** to **10** for moving capture in open spaces. • **Angle:** Extracts images based on changes to the camera angle. The recommended settings are **10** to **15 degrees** when using a perspective camera and **45** to **90** degrees when using a 360 camera.

Field	Data
Processing Quality	• **Point Color Radius:** Adjusts the occlusion size of the points for colorization. A smaller value may cause color of foreground objects to bleed onto background points, larger values may result in background points that are near foreground points not to get colored. The recommended range is between **0.01** and **0.03**. • **Visibility Voxel Size:** Determines the resolution of 3D pixels (in meters). A lower setting results in finer colorization quality and increased processing time. The recommended range is between **0.01** and **0.1**. • **Colorization Distance:** Adjusts the maximum distance of points from the GoPro camera to be colorized. A higher setting results in more points being colorized and increased processing time. The recommended range is between **10** and **300**.

Field	Data
Reduce blue sky bleeding	Allows you to reduce and mask out the color bleed or the blending of blue or gray sky on buildings and other objects. • **Strength:** Adjust the intensity of the filter to mask the blue or gray sky. Use the **Low** setting for clear blue skies. For gray overcast conditions or scenes with complex features like trees, varying colors, or cloud patterns, a **Medium** to **High** setting is recommended. Note that higher strength settings may increase the likelihood of masking light-colored buildings. Alternatively, toggle on the **Advanced** option and configure the following: • **RGB blue:** Set the minimum value of the blue channel to detect blue sky. A value of **200** is recommended for most sky types, **120** for blue skies with light-colored buildings, and **150** for low-light conditions such as dawn and dusk. • **Gray intensity:** Used to detect gray sky. A value of 0 is ideal for blue skies, 20 for overcast (gray skies), and 50 for darker gray clouds. Higher values may result in unintentional masking of gray or light-colored buildings. • **Color detection:** Identifies and masks colors with the specified RGB values. Use a setting of **25** for detecting gray skies, **35** for blue or light blue skies, **50** for blue skies with trees, and **75** for gray clouds with trees. Note that higher values may lead to unintentional masking of gray or light-colored buildings.
	When reviewing the frames between extraction and colorization, you should see the sky effectively masked in most frames. Some frames might still show minor visible patches of sky or unintended masking of building parts, but this should not impact the final colorized point cloud significantly if these issues occur only occasionally. In cases like these, it is generally better to increase the filter strength rather than decrease it, as remaining bits of visible sky are more likely to be noticeable in the final point cloud than a few mistakenly masked building parts, especially if the building is clearly visible in other frames.

Field	Data
Image Masking	This allows you to hide unwanted features from all your extracted frames. Choose from the available mask templates depending on the accessory/ platform you are using. To create your own, Refer to the Creating a Custom Mask section for instructions.
Output	• **Remove Uncolored Points:** This allows you to include or exclude points from the original scan that could not be colorized. *Default setting: Unselected* • **Keep Frame Images:** This allows you to keep or remove the GoPro image frames from the colorization output folder. Select this option to use image frames and pose data in third-party software. De-select this option to save hard drive space. *Default setting: Selected*
Reset to Default	Reset all settings to the default.

4.3.3.5 Extract 360 Images Tab

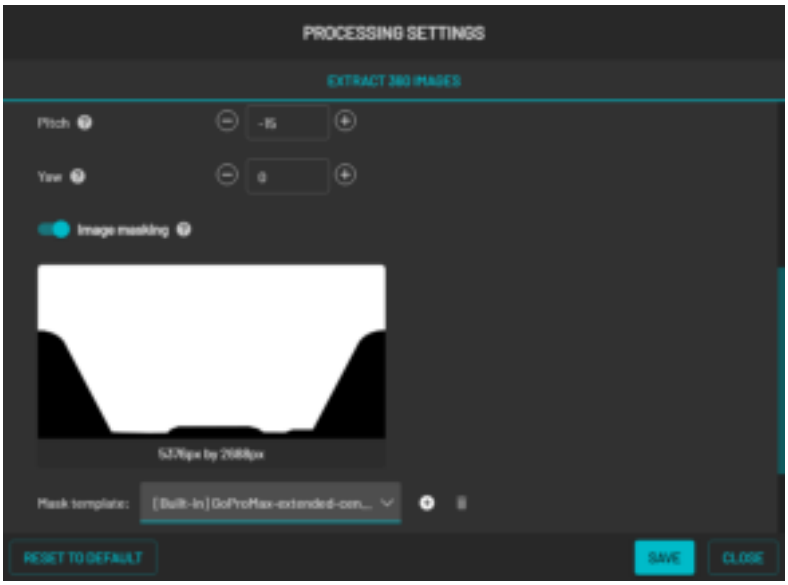


Table 8 Processing Settings - Extract 360 Images

Field	Data
Video Time Range	Sets the start and end time when frames are extracted from the video. The time represents the actual elapsed video time, not the number of seconds to trim from the end of the total video duration. Setting the **Video end time** to **0** will include everything after the start time.
Frame extract interval	Uses the maximum time, distance, and angle to determine the number of video frames to skip between image extractions, keeping only the necessary images. **Time:** It is recommended to turn this setting off to avoid repetitive extractions when the camera is not moving. The recommended range is between **1** to **20**. **Distance:** Extracts images based on the distance the camera travels to avoid repetitive images when standing still. The recommended settings are **1** to **2** for small, confined spaces and **5** to **10** for moving capture in open spaces. **Angle:** Extracts images based on changes to the camera angle. The recommended settings are **10** to **15 degrees** when using a perspective camera and **45** to **90** degrees when using a 360 camera.
Camera orientation override	Allows you to configure the camera's orientation settings manually. • **Roll:** Configure the rotation around the front-to-back axis. • **Pitch:** Configure the rotation around the side-to-side axis. • **Yaw:** Configure the rotation around the side axis.
Image Masking	This allows you to hide unwanted features from all your extracted frames. Choose from the available mask templates depending on the accessory/ platform you are using. To create your own, Refer to the Creating a Custom Mask section for instructions.

4.3.3.6 Output Tab

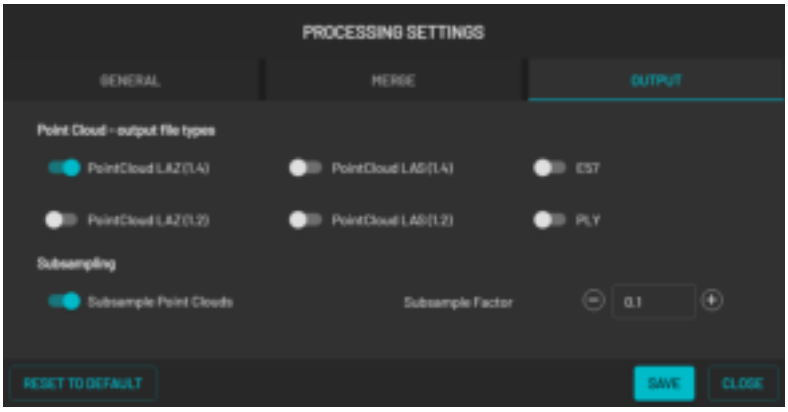


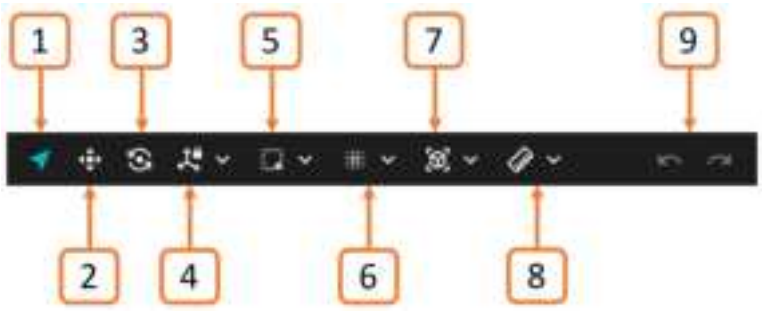
Table 9 Processing Settings - Output Tab

Field	Data
Point Cloud - output file types	• **PointCloud LAZ (1.4):** Output a point cloud in compressed LAS 1.4 format *Default: On* • **PointCloud LAS (1.4):** Output a point cloud in uncompressed LAS 1.4 format. *Default: Off* • **E57:** Output a point cloud in an E57 format. *Default: Off* • **PointCloud LAZ (1.2):** Output a point cloud in compressed LAS 1.2 format. *Default: Off* • **PointCloud LAS (1.2):** Output a point cloud in uncompressed LAS 1.2 format. *Default: Off* • **PLY:** Output a point cloud in PLY format. You can select more than one option.

Field	Data
Subsampling	• **Subsample Point Clouds:** Generate a subsampled point cloud for each of the selected options above. *Default: On* • **Subsample Factor:** The fraction of the points in the point cloud to sample. For example, 0.10 will output 10% of the points. *Default: 0.10*
Reset to Default	Reset all settings to the default.

4.4 Main Toolbar

The Main Toolbar contains several tools for navigating and interacting with your point cloud. It can be docked to the top or bottom of the viewport (or it can be a floating panel). These tools are grouped based on usage. The icon displayed in the toolbar indicates the tool that has been selected for that group.



1. Navigate
2. Translate
3. Rotate
4. Axis Lock tools
5. Selection tools
6. Cleaning filters
7. 3D View menu
8. Measurement tools
9. Undo / Redo

The Undo/Redo function is only currently available for certain tools. If you need to make any major changes, we recommend that you first save your file using the **Save** or **Save as** options in the **Project Menu**.

Table 10 Main Toolbar

Button	Action
Navigate	
	**Navigate:** Move around the point cloud, as opposed to *shifting* it. Left-click your mouse to choose the center of rotation. This point will be shown by a white ball. Double-click your mouse to lock the rotation on an exact point. The ball will turn orange. Double-click again to unlock.
Translate	
	**Translate:** Move your point cloud along different axes. Click on the arrow to choose which axis. Select the square to translate along *multiple* axes.
Rotate	
	**Rotate:** Click on the desired axis to rotate your point cloud around that axis.
Axis Lock Rotates your point cloud around the selected axis. Right-click and drag to translate along the locked axis. Double-click your mouse to lock the axis on an exact point. The ball will turn orange. You can change the axis while the ball is orange, and the new axis will rotate around the same point. Double-click again to release.	
	**X Axis Lock:** Locks the point cloud rotation to the X axis, which is represented by a red line.
	**Y Axis Lock:** Locks the point cloud rotation to the Y axis, which is represented by a green line.

Button	Action
	**Z Axis Lock:** Locks the point cloud rotation to the Z axis, which is represented by a blue line.
Selection tools	
	**Select Points:** Select and deselect points within the square selection box. This function is good for point cloud cleaning, as well as for selecting targets in the GCP workflow. Right-click your mouse, or press the **Esc** key to remove the selection. Not available when working with meshes.
	**Select Area:** Select a 2D region (often represented as a polygon) in the point cloud to encompass multiple points within that defined area. Right-click your mouse, or press the **Esc** key, to remove the selection. Not available when working with meshes.
	**Select Volume:** Define a 3D region or volume in the point cloud and select all points falling within that defined volume. When this tool is selected, the color of the point cloud changes to grayscale and a 3D bounding box becomes available. Drag the arrows in the bounding box to select all points within that volume. This selection tool is useful for tasks such as object extraction or isolating specific structures in the point cloud.

Button	Action
	**Delete selection:** Deletes any points you have selected. • Not available when working with meshes. • Be careful, as there is no undo function available for this action. Be sure that you want these points deleted before you do so.
Cleaning Filters	
	**Decimate by distance filter:** Subsamples the point cloud by specifying the minimum distance allowed between points (measured in meters). You can either select or delete the points. This tool is useful when you want to thin out your point cloud to make it easier to navigate. The smaller the point cloud, the more responsive it will be. You may have to experiment with the settings to achieve the desired result. There are three input parameters: • **Minimum distance:** Select the minimum distance between points. *Default setting: 0.01 (1 cm)* • **Point decimated:** Specify whether the points should be deleted or selected. *Default setting: Delete* • **Invert:** Inverts the selection calculated by the DBD algorithm. Not available when working with meshes.

Button	Action
	**Classic SOR:** Removes stray points in a dense point cloud. This filter works out the average distance of each point from its neighboring points. It then rejects the points that are farther than the average distance. All points outside of this distance are considered outliers and can be removed from the dataset. You may have to experiment with the settings to achieve the desired result. **Denoise SOR:** Removes noise in a dense point cloud. This filter analyzes the point cloud to identify points that are likely to be noise or outliers. Points that significantly deviate from the expected parameters are considered outliers and are removed from the dataset. **Adaptive SOR:** Adaptively removes outliers while considering variations in point density and noise levels across different regions of the point cloud dataset. This filter can be particularly useful in cases where the point cloud has varying levels of detail. The available parameters vary depending on the SOR type. • **Nearest neighbor:** The number of neighboring points required to calculate the average distance for a given point. *Default setting: 6* • **Alpha:** If Adaptive SOR is selected, this setting controls the adaptability of the filter to local point density variations. A higher value leads to more adaptive thresholding and can be useful for handling data with varying point density. A lower value might make the filter less sensitive to density changes and provide a more uniform filtering behavior. • **Log Scale:** If Denoise SOR is selected, this setting emphasizes details in regions with lower point density and reduce the impact of regions with high point density. It allows the filter to treat points with different magnitudes more uniformly, enhancing the denoising process by effectively dealing with variations in the dataset.

Button	Action
	• **nSigma:** If Classic SOR is selected, this option will calculate the mean distance from *every* point to its neighboring points. The result is a normal distribution. You can use decimal values here. The lower the number you choose, the more points will be trimmed from your dataset. *Default setting: 1* • **Point outlying:** Choose whether the outlying points will be deleted or just selected. • **Invert:** Select or delete everything in the point cloud *except* for the statistical outlying points. Not available when working with meshes.
	**Moving object filter:** Removes points over 5 second intervals and keeps fixed points in the environment. Identifying moving objects within a point cloud is done by estimating statistical scores for points based on their temporal and spatial relationship to their neighborhood. These scores provide a quantitative measure of the likelihood that a point belongs to a moving object, enabling the Moving Object filter to differentiate between dynamic and static elements in the point cloud. Refer to the Moving Object Filtering section for more information.
3D view menu	
	**Focus:** Fits the point cloud to your screen.
	**Front:** Shows the front view of the point cloud.
	**Top:** Shows the top view of the point cloud.
	**Right:** Shows the view from the right of the point cloud.
	**Left:** Shows the view from the left of the point cloud.

Button	Action
	**Back:** Shows the back view of the point cloud.
	**Bottom:** Shows the view from the bottom of the point cloud.
Measurement tools	
	**Point measurement:** Click anywhere in your point cloud to show coordinates for a single point. Click again to clear your selection.
	**Line measurement:** Select any two points to show the distance between them and the coordinates for each point. Click a third point to reset the tool and take another measurement.
	**Angle measurement:** Select three points to measure the angle between them. Shows coordinates for each point.

Button	Action
Undo / Redo	
	The undo/redo actions are currently limited to the following actions: • Translate • Rotate • Point size, point bias, point shape • Color scale selector • Colorization filter • Fill color • Scalar gradient, with associated Scalar Filter upper/lower limit and scalar range changes The undo and redo functions are not currently available for delete actions, DBD and SOR filters, so be careful when performing these actions. Further functionality will be explored in future releases.

4.5 Context Panel

The Context Panel enables you to make further modifications to your processed point cloud or GCP data. The available settings vary depending on the selected file in the **Visualize** tab. The Context panel can be docked to the left or right of the screen or made as a floating panel. Refer to the docking instructions found in the Visualize Tab section for more information.

> There is no associated **Context** panel for meshes.

4.5.1 Point Clouds

There are two panels available when you select a point cloud. These panels can either be docked together or displayed separately.

4.5.1.1 Point Cloud Visualization

These settings help customize the point cloud's appearance to suit specific analysis requirements or highlight crucial details for better understanding and interpretation of the dataset.

Table 11 Context Panel - Point Clouds

Field	Data
Shape	• **Square:** Each point is shown as a square. • **Circle:** Each point is shown as a circle.
Colorization	If toggled on, no **Color Scale** or **Scalar Gradient** is available, as colorization overrides these options. If you can't toggle on colorization, this means that you have a file that hasn't been colorized.
Color Scale	The color scale specifies filtering settings for the following scalar fields: • **Solid:** A solid color, with no gradient. Choose this option for better contrast between selected points and the rest of the point cloud. This option can also provide more contrast against the background. • **Elevation:** Shows the elevation of each point in the point cloud. The color scale goes from blue (low elevation) to red (high elevation). • **Position:** Colors your point cloud on all three axes (X, Y, and Z). The X axis is blue, the Y axis is red, and the Z axis is green. • **Classification:** Colors your point cloud based on classifications, objects that have been identified (such as pipes) will be shown in randomized color selections. Currently, classification can not be generated by Aura. • **Intensity:** Shows the intensity of each point in the point cloud. This is particularly useful for detecting targets in your point cloud. • **Time:** Shows the time that each point was collected during the scan. • **Ring:** Shows primary colors, one for each of the Hovermap lasers. This option can be used for calibration, to check that all lasers are present in the scan data.

Field	Data
	• **Range:** Shows the distance of each point from Hovermap. • **Return:** Shows the laser strength and return order. This can be used for troubleshooting and point cloud cleaning. Emesent Aura can detect the contents of the point cloud file and apply the appropriate color scale filter. Only the appropriate filters will appear in the dropdown list. For example, the **Ring** option will only be available for Emesent scans, as it detects information from Hovermap. If you have imported a third-party scan, the **Ring** option will not be available.
Point Size	Controls the size of each point. If the point size is set to 0, the points will appear as pixels (instead of the shape chosen in the **Shape** field). *Default setting: 1*
Scalar Gradient	This option gives you a range of color ramps to choose from. It is available on all attributes except when **Classification**, **Position**, or **Solid** color scale is selected.
Scalar Filter	The option is available when the **Intensity**, **Time, Elevation**, **Return**, or **Range** color scale is selected. A histogram chart allows you to visualize the intensity, time, or range distribution of your data. You can move the stops at each end of the graph to control how the color is presented, and specify histogram min. and max. values with an input value.
Scalar Range	The **Scalar Range** is the slider that sits below the graph. You can adjust the upper and lower stops to show a specific range of data. For example, if you only want to see points with an intensity between 100 and 200, you can adjust the stops to show only that range of data.

4.5.1.2 Point cloud properties

If the selected point cloud is georeferenced, this panel displays the number of points and other important information such as transformations, scaling, and offsets applied to ensure accurate spatial representation.

Table 12 Context Panel - Point Clouds

Information	Description
Points	The number of points in the point cloud dataset (total number of points if multiple point clouds are selected).
Projection Information	Provides details about how the point cloud data is represented spatially.
Coordinates	The geographic coordinates indicating its global position.
Transformations	Shows the scaling factor and the offsets applied to coordinates.

Information	Description
Origin offset	The translation or displacement applied to the point cloud data's origin.
Bounding box	The dimensions of the bounding box around the point cloud data in each direction (X, Y, Z axis).

4.5.2 Ground Control Points

The Context panel for GCPs contains tools to help you georeference your point cloud.

4.5.2.1 Edit Constellation

A constellation is a set of coordinates that represent the real-world locations of the targets that were used during scanning. Emesent Aura attempts to automatically match targets of the appropriate size and intensity to locations within this constellation. This list allows you to choose which potential target identified in the point cloud is associated with which landmark in your constellation.

> A landmark can have multiple GCP targets associated with it to provide redundancy and improve accuracy.

Setting	Description
1. Show/Hide Landmark	Toggles between showing or hiding the selected landmark from the Viewport.
2. Show/Hide Target	Toggles between showing or hiding the selected target from the Viewport.
3. Expand/Collapse	Toggles between showing just the landmark or the landmark and its associated targets. This is useful if you have a long list of coordinates.
4. Focus	Zooms in on the selected target on the Viewport.
5. Remove Target	Removes the selected target from the constellation and moves it to the Inactive Targets list. This can be useful in situations where the target was incorrectly identified during the initial georeferencing process. Refer to the GCP Workflow section for more information on matching targets to the correct landmark.
6. Deactivate Landmark	Removes the selected landmark and its associated target(s) from the constellation. It is important to exercise caution when using this function to ensure that you are removing the correct landmark and that it will not adversely affect the overall accuracy and alignment of the point cloud. When prompted, click **Deactivate** to confirm the removal.
7. Save Constellation	Saves the changes you made to the constellation file.
8. Quick Save	This option is only available when running the GCP processing workflow. If you use the **Quick Save** option, the saved file will overwrite the **constellation.yaml** file that was originally produced during processing. This is important, as Emesent Aura will look for this file to run the next steps in the process. If you open an existing GCP project, the Quick Save option will not be available.

4.5.2.2 Inactive Landmarks

This list contains identified landmarks that have not yet been matched to any target in the constellation. When aligning point cloud data to a known coordinate system using GCPs, Aura will detect landmarks within the point cloud but they may not be suitable as GCP targets. You can choose to delete these landmarks before GCP data processing. If not, these will be listed as inactive landmarks in the Context panel so you can add them to the constellation if required.

Setting	Description
1. Show/Hide Inactive Landmark	Toggles between showing or hiding the selected landmark from the Viewport.
2. Focus	Toggles between showing or hiding the selected inactive landmark from the Viewport.
3. Add to Constellation	Moves the selected inactive landmark to the Edit Constellation list. You can then assign a target to the newly added landmark by dragging the target to the field below it.

4.5.2.3 Inactive Targets

This list contains identified targets that have not yet been matched to any landmark in the constellation. Any targets left in the **Inactive targets** list will be disregarded when reprocessing the point cloud.

Setting	Description
1. Show/Hide Inactive Targets	Toggles between showing or hiding the selected inactive target from the Viewport.
2. Add Target	Creates a new target. Select an area of points and click the **Add Target** button to create a new target.
3. Trash Target	Deletes the selected inactive target. It is important to exercise caution when deleting a target as you will not be able to recover it once deleted. When prompted, click Delete to confirm deletion.

4.6 Viewport

Use the Viewport to navigate and manipulate your point cloud. The Viewport also shows live X/Y/Z mouse coordinates. Press the **F1 key** in Aura at any time to access Help and see the full range of mouse actions and keyboard shortcuts available to you.

> The bounding box shows the extent of your point cloud. You cannot interact with the bounding box but you can hide it by unselecting the the point cloud on the from the **Visualize** tab.

5. Working with Point Clouds

5.1 Processing Profiles

A profile is a group of processing settings that allow you to optimize processing for specific environments and situations. Emesent Aura has several built-in profiles available for processing, georeferencing, merging, and colorization. These built-in profiles will give good results in most situations.

If the built-in profiles don't cater to your needs, Emesent Aura also allows you to create and save custom profiles.

5.1.1 Built-in Profiles

The following built-in profiles are available.

Workflow	Profiles
Process	**Standard:** We recommend that you use this profile for most processing operations. Sometimes this profile won't give you an outcome that you are happy with. If your point cloud output includes ghosting, copies of objects, or overlapping objects, or if the trajectory file significantly diverges from known information about the actual trajectory (for example, where a dataset from a closed loop scan is processed and the trajectory file shows the start and end points are a significant distance apart), we recommend that you try one of the other three built-in profiles. The default georeferencing mode for this profile is set to None. **Low Features:** Use this profile for environments with relatively few geometric features. It includes adjustments to window size and iterations. This profile can improve point clouds from some environments, but it can also result in worse point clouds from others. **Auto SLAM** eliminates the need to switch to the "Low Features" profile in most scenarios. **More Iterations:** This profile is designed for environments that are more challenging for the SLAM algorithm to handle. It increases the number of iterations.
	Forest: This profile is designed for environments that are largely or exclusively natural terrain and vegetation. It includes adjustments to the way that global registration is performed. **ST-X:** This profile contains the recommended intensity and range filtering settings as the ST-X LiDAR has a greater range and is more sensitive than older hardware. **Disable Feature Matching:** This profile is recommended when scanning featureless or repeating environments such as multi-story building car parks.
GCP	**Standard:** The default profile for a GCP workflow. This profile will cater to the most common georeferencing jobs. **ST-X:** This profile contains the recommended settings for detecting targets when georeferencing the point cloud.

Workflow	Profiles
Merge	**Standard:** The default profile for a merge process. This profile will cater to the most common merge jobs. **Outdoor Indoor:** This profile can give better results when merging datasets that have overlaps between outdoor and indoor environments. **Complex Building:** This profile can give better results when merging datasets from complex building structures, such as buildings with multiple levels or with multiple similar rooms. **Terrain:** This profile can produce better results when merging datasets from outdoor environments with large open areas.
Colorization	**Standard:** This default profile provides a set of configuration parameters that should suit most colorization requirements. It achieves a good balance of output quality vs processing time for most datasets. **Quick:** This profile delivers a faster output at the cost of quality. This option is useful when reviewing results in the field. Only one video frame every 5 seconds is used to colorize the points, which may result in gaps or poor colorization. **Quality:** This profile increases the quality of the colorized point cloud at the cost of increased processing time. It uses 10 frames every second (instead of two, which is standard), and decreases the visibility voxel scale from 250 mm to 100 mm. **Driving:** This profile is useful when colorizing scans done at higher speeds (for example, driving scans). It uses 10 frames per second (instead of two, which is standard) to ensure sufficient coverage at high speed.
Extract 360 Images	**Telescopic mount extended:** This profile provides orientation parameters for extracting images on a 360 camera captured with the telescopic mount fully extended. **Telescopic mount retracted:** This profile provides orientation parameters for extracting images on a 360 camera captured with the telescopic mount retracted. **360-camera mount calibrated:** This profile provides parameters for extracting images on a 360 camera captured with the calibrated 360-camera mount.

5.1.2 Custom Profiles

When you make changes to a built-in processing profile in Emesent Aura, a temporary custom profile is created. You can choose to save this custom profile to save time in setting up processing jobs for common or known environments. Once saved, it becomes available for selection in the **Profiles** dropdown list.

> If you choose not to save the custom profile, it is automatically removed when the application is closed.

To create a new processing profile:

1. Go to the **Process** tab then click **Process Scan**.
2. Select the workflow to create a new profile for then click the **Add Profile** icon.
3. In the **Create Profile** dialog box, enter a name for the new profile then click **Create**.

4. Click **Processing Settings** then customize the settings for the new profile.
5. Click **Save**. Your new profile should now be available in the dropdown list.

To save a custom profile:

1. Go to the **Process** tab then click **Process Scan**.
2. Select a workflow then select from one of the available built-in profiles.

3. Click **Processing Settings** then edit the settings of the built-in profile.
4. Click **Save** to go back to the main panel. The selected profile changes to the newly created “Custom” profile.
5. Click **Save Profile**.

6. In the **Create Profile** dialog box, enter a name for the new profile then click **Create**. Your new profile should now be available in the dropdown list.

5.2 Output Folders

Point cloud processing (SLAM) involves a sequential series of stages, usually Odometry, Atlas, and Global.

These files are stored in the following folders:

Folder	Description
IntermediateFiles	Contains the intermediate results, which are not intended for direct user interaction. A subfolder is created for each processing stage (e.g., "offline_odom").
Output	Contains the final output artefacts associated with the processing workflow.

5.3 Process Workflow

To create a point cloud from your raw Hovermap data, you need to process the scan in Emesent Aura.

> If you are planning to georeference your scan, you may skip this process as point cloud processing is also performed when using the GCP workflow. Refer to the GCP Workflow section for more information.

> Because of Aura's significant processing requirements for generating a point cloud from Hovermap data, we recommend your laptop is connected to a power outlet during Step 5: Processing.

The basic process for generating a point cloud is as follows.

5.3.1 Step 1: Retrieve your scan data

Follow the Hovermap workflow to capture your scan data. Once you have completed your scan, insert a USB flash drive into Hovermap to download the data. The status LEDs will change to a light flashing blue while the scan is being transferred.

> To retrieve data, the USB flash drive must be formatted in an exFAT file format.

Once the transfer is complete, the status LEDs will return to a slow pulsing Emesent blue. You can now remove the USB flash drive.

5.3.2 Step 2: Copy the data to your computer

Copy the data from the USB flash drive to a local drive on your computer so that you can begin processing.

> ⚠ Scans from a Hovermap that use Emesent Cortex version 3.3 (or later) can only be processed in Aura 1.7 (or later).

> ⚠ For scans from a Hovermap that use Emesent Cortex version 3.3 (or later), it is essential to ensure that both `metadata.yaml` and `platform_configuration.yaml` files are included in the same folder as your scan files. These files contain crucial information required for processing the point cloud data.

5.3.3 Step 3: Configure your processing job

1. Open Emesent Aura. Make sure you have an active **SLAM** license.
2. In the **Process** tab, click **Process Scan**.
3. In the **Configure New Scan Job** panel, select the **Process** workflow.
4. Click **Add Dataset.**
5. Browse for the folder that contains the raw point cloud dataset to be processed. Select that folder.

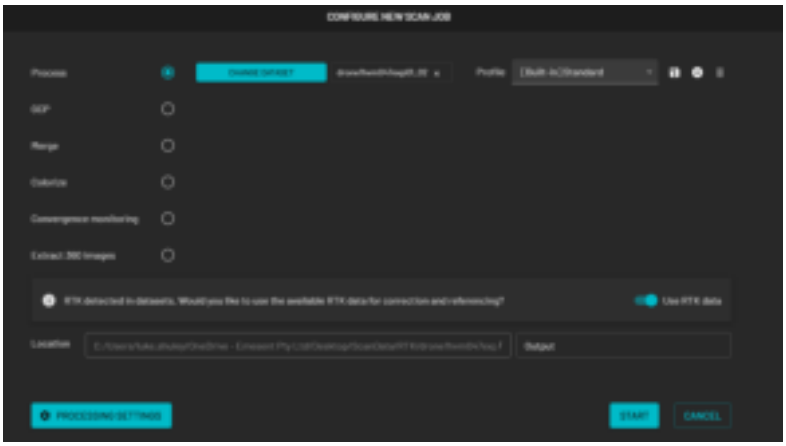
6. In the **Location** field, enter the preferred name for the output folder. Emesent Aura will create this folder, which stores all the processed results and data, as a child directory within the raw scan folder.

7. Select the processing profile to use. Refer to the Processing Profiles section for more information about which profiles to use and how to create a custom profile.

5.3.4 Step 4: (Optional) Use RTK Data

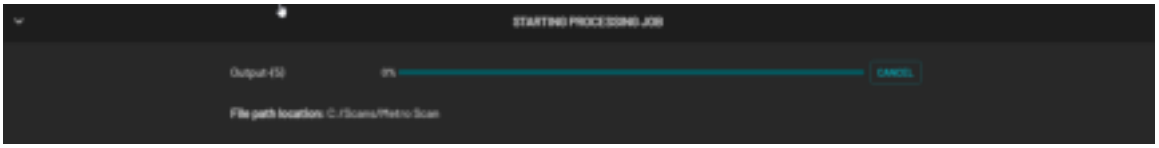
1. If RTK data is detected in your dataset, toggle on **Use RTK data** to use the real-time corrections provided by the RTK system to improve the georeferencing accuracy of the point cloud data.

More information on processing and reprojecting a georeferenced scan is provided in Reprojecting your Point Cloud section.



5.3.5 Step 5: Processing

1. Click **Start** to begin processing. The **Configure New Scan Job** panel is replaced with the **Starting Processing Job** panel and shows a progress bar showing how far along you are in your processing job. In addition to the progress bar, the elapsed time of the processing job is shown to the right.
   The directory file path below the progress bar provides a way to identify the dataset source. This is useful if simultaneously processing multiple jobs with the same output folder name. Copying the file path and pasting it on your computer's file explorer allows you to access the completed files without having to wait for the processing job to be completed.



2. The processing job will proceed through the local and global processing phases and finally generate the output processing files. You can load and interact with other point clouds while processing in the background.
   Refer to the Output Files section for more information on where the generated files are stored once the processing is completed.

> The **Retry** button becomes available if a failure occurs during processing. Click this button to attempt to process the current job from the last successful stage.

3. The resulting point cloud is added to the child directory created within the raw scan folder.

5.3.6 Step 6: View your point cloud

1. Once your processing job has finished, the bottom panel displays the generated files.

2. Click **View** beside each generated file to load them into the Viewport for analysis or further editing. The following main files are generated:

   - Full point cloud
     The point cloud with the complete set of data points. The output file type varies depending on the profile used in generating the point cloud. The filename includes the output folder name with the output file type appended to it.
     For example: *Output_laz1_4.laz* where the output file type is PointCloud LAZ (1.4) and the file is located in the “Output” folder.
   - Subsampled point cloud
     The point cloud containing a subset of points from the original point cloud dataset (based on **Subsample Factor** value in **Processing Settings**). This output is only generated if **Subsample Point Clouds** is enabled in the **Output** tab of the **Processing Settings** panel.
   - Trajectory file
     The data file containing the recorded movement or path of the Hovermap as it acquired the point cloud data.

5.4 Cleaning your Point Cloud

Every user will clean their point clouds slightly differently. We recommend the following process.

5.4.1 Step 1: Copy your point cloud file

Start by making a copy of your original point cloud file. This will be the file you work on in Emesent Aura.

5.4.2 Step 2: Open in Emesent Aura

Open the copy file in Emesent Aura. You can do this in one of three ways:

- In the top-left menu, click the **Project Menu** icon then select **Open** in the menu that displays.
- Drag and drop your file directly into the viewport.
- Go to the **Visualize** tab then click **Add** next to your chosen section.

5.4.3 Step 3: Make your point cloud visible

To ensure you can easily see all points for cleaning purposes, we recommend doing the following.

1. Change the point cloud to a solid color:
    a. Select the point cloud to display its Context panel.
    b. In the **Color Scale** field, click **Solid**.
    c. In the **Fill Color** section, choose a color for your point cloud that contrasts with sepia (which is the default selection color).
    Note: When you change the color of the point cloud, the color of the bounding box automatically changes at the same time. This is useful if you have multiple point clouds open. It allows you to see the extent of each point cloud (assuming they are different colors).
2. Change the background color to a solid color:
    a. In the top-left corner, click **Preferences**.
    b. In the **Preferences** dialog box, go to the **Appearance** tab.
    c. In the **Background** section, select **Solid**.

d. Choose a color that stands out against the point cloud color. We recommend that you avoid using a black background for clean-up, as it can make points easier to miss (especially if you are working with a colorized point cloud)

e. Click **Save**.

3. Change your point size so that the points are easily seen:

a. Go to the point cloud panel.

b. In the **Point Size** field, set the value to **1** or greater.

5.4.4 Step 4: Start with a small area

We recommend that you clean only small areas of your point cloud at a time (particularly if you are cleaning using filters). If you clean the whole point cloud at once, you may accidentally remove features that you did not intend to, and there is currently no undo function for deletion.

1. Select a small area of your point cloud. If this area is on the edges of your point cloud, make sure that it includes at least a portion of the main point cloud, not just the peripheral points. The reason for this is so that Aura has a better idea of the mean distance between *all* the points, not just the peripheral ones. If you only select the points on the edges, this could skew your filtering.

> When you choose an area, a selection will be created that extends back through the point cloud. This means that your selection includes points that are behind your visible selection, which may not be your intention. If you have opted for perspective mode in your global preferences, the selection's shape will expand as it moves further into the distance. On the other hand, if you have chosen orthographic mode, the shape will remain the same throughout the point cloud.

2. To find points that may have been selected further into the distance, you can either:
   - Navigate to the other side of your point cloud to check that nothing else has been selected.
   - Use the near clipping plane, which will allow you to see through areas of your point cloud. To do this, go to the **Preferences** menu and change the value in the **Near Clipping Plane** field. Experiment with what works best for you.
3. Refine your selection as follows:
   - **To add points:** Shift + select
   - **To remove points:** Ctrl + select
   - **To invert your selection:** Alt + select

5.4.5 Step 5: Use the SOR filter

We recommend using the SOR filter for your first clean before you do your manual point removal. This is a good way to clean up the edges of your scan, where there is usually quite a bit of noise.

The SOR filter allows you to remove stray points and noise in a dense point cloud. This filter works out the average distance of each point from its neighboring points. It then rejects the points that are farther than the average distance. All points outside this distance are considered outliers and can be removed from the dataset. You may have to experiment with the settings to achieve the desired result.

> Automated filtering can be integrated into the processing workflow. To do this, go to **Processing Settings**. In the **Point Filtering** section of the **General** tab, enable the cleaning filter(s) to be automatically applied during processing.

> The bounding box, which shows the furthest extent of the points in your point cloud, does not automatically adjust when trimming points. Save the point cloud first then reload it to see the adjusted bounding box.

1. Once you have selected your area for cleaning, go to the **Main Toolbar**.

> If no selection is made, the filter is applied on the entire point cloud that is currently selected. The filter is disabled if multiple point clouds are selected in the **Visualize** tab.

2. Click the **Cleaning Filters** icon then select **SOR filter**.
3. In the **Statistical Outlier Removal** dialog box, select the SOR filter to use. Refer to the Main Toolbar section for more information on the different SOR filters and their associated settings.
4. Once you have configured the settings for the selected SOR filter, click **OK**.

5. Points selected for clean-up will change to a sepia color. If you are happy with the selection, proceed to delete these points.
6. Run the SOR filter in the same area until you are happy with the result.

> The DBD filter is not suitable for point cloud clean-up. It is more suitable for meshing, as you're effectively just subsampling the point cloud by running this filter. Currently, meshing is not supported within Emesent Aura.

5.4.6 Step 6: Do a manual clean-up

Once you have finished using the filters for your initial clean-up, you can then do a manual clean-up. Go to the Main Toolbar section for more information about each tool.

> The Selection Tools in the Main Toolbar work across multiple point clouds. If you have two point clouds selected at the same time, you can select points in both. To select/unselect multiple files, hold down the **Ctrl** key then click on each file you want to select or unselect.

5.4.7 Step 7: Save

From the **Project Menu**, click **Save** to save the changes to the existing file. Use **Save As** to create a copy of your point cloud with a different name, location, or file format.

5.5 GCP Workflow

The Emesent Knowledge Base article Working with Point Clouds - GCP Workflow walks you through the entire GCP workflow step-by-step, and links to the complementary video Best Practice for Automated Ground Control Points.

5.6 Merge Workflow

Aura's Merge workflow uses a SLAM-based algorithm to non-rigidly align multiple datasets into a single, seamless point cloud output. Merging multiple point clouds improves efficiency, accuracy, and usability especially for complex, multi-scan projects. It also ensures consistent alignment of scan data, resulting in a high-quality deliverable.

Aura supports merging a combination of georeferenced and non-georeferenced scans. Each scan must be individually processed before merging.

The merge process outputs individual `.laz` files for each scan. These files are aligned using the SLAM algorithm and georeferenced if applicable. The individual `.laz` files can then be combined within Aura to produce a unified point cloud.

The following steps outline the merge workflow in Aura.

5.6.1 Prepare for the Merge

5.6.1.1 Ensure Overlap

During capture you need to include a reasonable amount of overlap between scans to provide sufficient information for alignment. A rough guide is to have one-third of each dataset overlap with the next.

> You can merge vehicle RTK, backpack RTK, and non-RTK scans together. RTK scans will help improve the alignment of non-RTK scans in areas where they overlap.

5.6.1.2 Consider System Resources

Although there is no strict limit to the number of files you can align, processing demand will increase with each added dataset. Avoid merging point cloud files that add up to more than your available RAM. Use subsampled point clouds to reduce computational load.

5.6.1.3 Scan Requirements for Merging

Before merging, each scan must be processed in Aura:

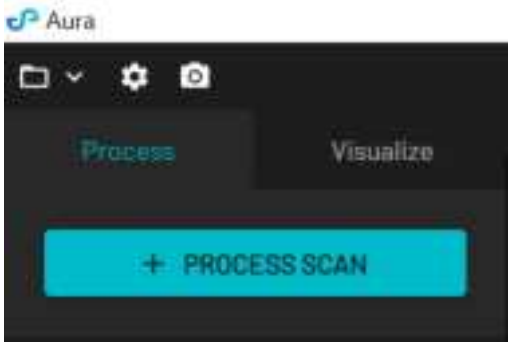
- **Georeferenced Scans (RTK)**:
  - Must be processed with the correct device under **Georeferencing mode** in **Processing Settings**.
  - **Set the base coordinate reference system** to match the **coordinate system used for RTK corrections**.
  - **Georeferencing** must be **Enabled** in Processing Settings.
- **Non-georeferenced scans**:
  - Must have **Georeferencing mode** set to **None** in the Processing Settings.
- **Drone RTK and GCP scans**:
  - Can be merged, but **georeferencing will not be retained**. Set georeferencing to **None** before merging.
- **Scans processed in Aura versions earlier than 1.10**:

    - May default to **GPS** for non-georeferenced scans. Reprocess these scans in Aura 1.10 or later with georeferencing set to **None**.

- **Mixed scanner models**:
    - Merging scans captured using different Hovermap models (e.g. ST and ST-X) is supported, but ensure compatible firmware and Aura versions were used.

5.6.2 Step 1. Configure Your Merge Job

1. **Open** Emesent Aura and **click Process Scan** in the top-left corner.



2. **Select** the **Merge** workflow in the **Configure New Scan Job** panel.

3. **Click Add Datasets**, then **click Add** next to *Add dataset folder*. (e.g. ScanJob123)

```
ScanJob123/
├── Output/
```

> ⚠ Do not select the **Output** folder. Ensure you select the main scan folder.

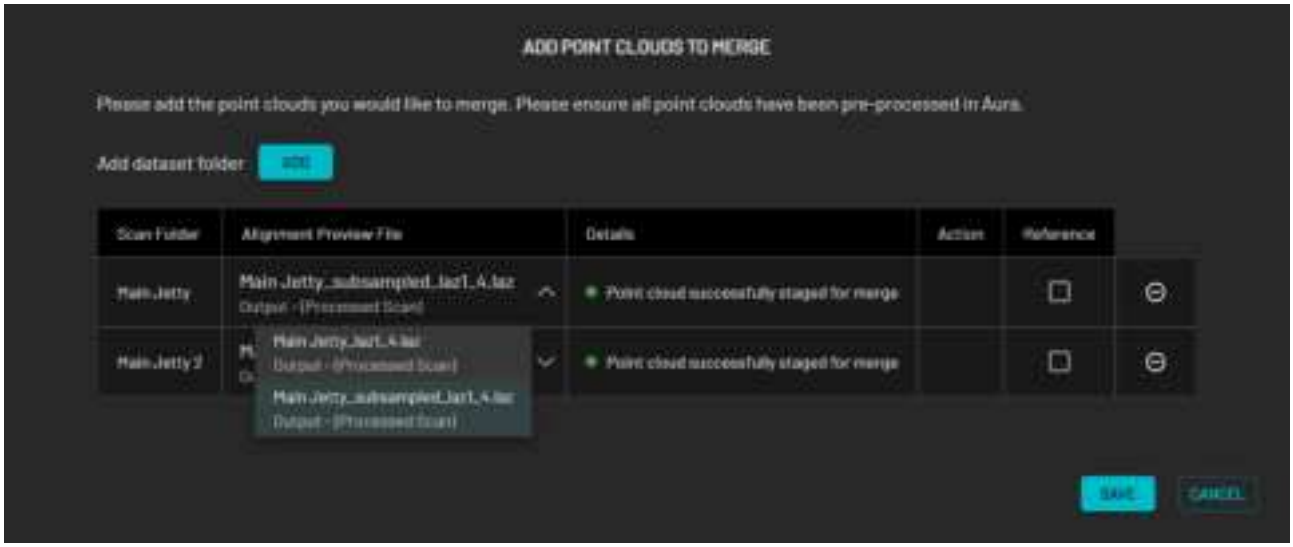
4. **Wait** for Aura to automatically detect and list the available files.

5. **Repeat** steps 3–4 to add all scans you want to merge.

5.6.3 Step 2: Choose an Alignment Base for Preview

For all merge types (Non-georeferenced scans, RTK, RTK + Non-RTK):

- In the **Alignment Preview File** column, select any scan to use as the alignment base.
- This file is used for preview purposes only and does not affect the final output. If available, Aura will default to a subsampled version.



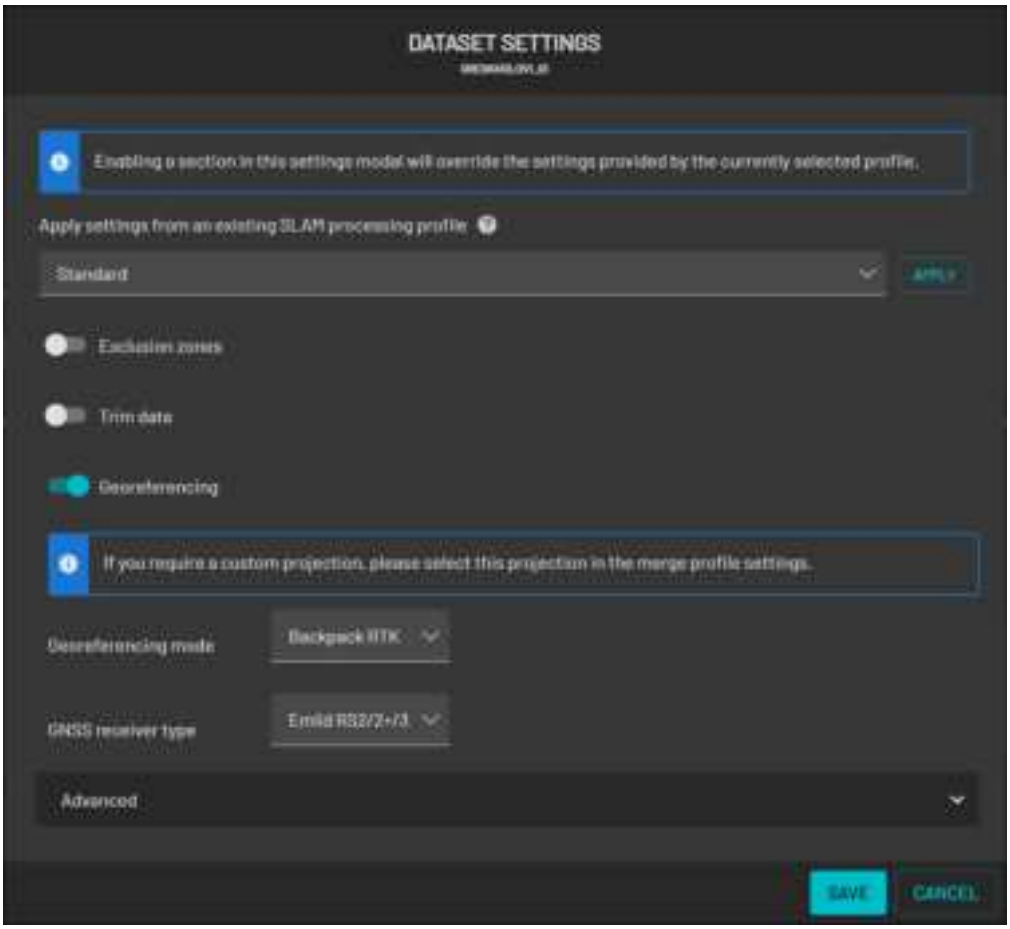
5.6.4 Step 3: Configure Apply Overrides (Optional)

For all merge types (Non-georeferenced scans, RTK, RTK + Non-RTK):

- Configure scan-specific settings, such as defining **exclusion zones** or **trim data**.

For RTK Merges and RTK + Non-RTK Merges:

1. Verify that RTK scans have their **georeferencing method** and **GNSS receiver type** correctly assigned. Aura will apply these automatically.



5.6.5 Step 4: Select a Reference Scan (Optional)

For Non-georeferenced scans (Non-RTK) Merges:

- You can choose one scan to act as the reference scan. This scan will be locked in place, and all other scans will align to it.

> ⚠ If a reference scan is **not selected**, Aura will perform **pairwise alignment** between all point clouds. This increases computational complexity and may extend processing time.

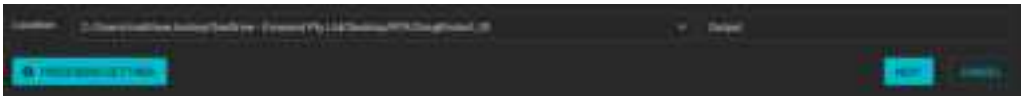
For RTK Merges and RTK + Non-RTK Merges:

- Reference scans are supported for merges involving RTK scans. **Proceed to Step 5.**

5.6.6 Step 5: Configure Processing Settings

For all merge types (Non-georeferenced scans, RTK, RTK + Non-RTK):

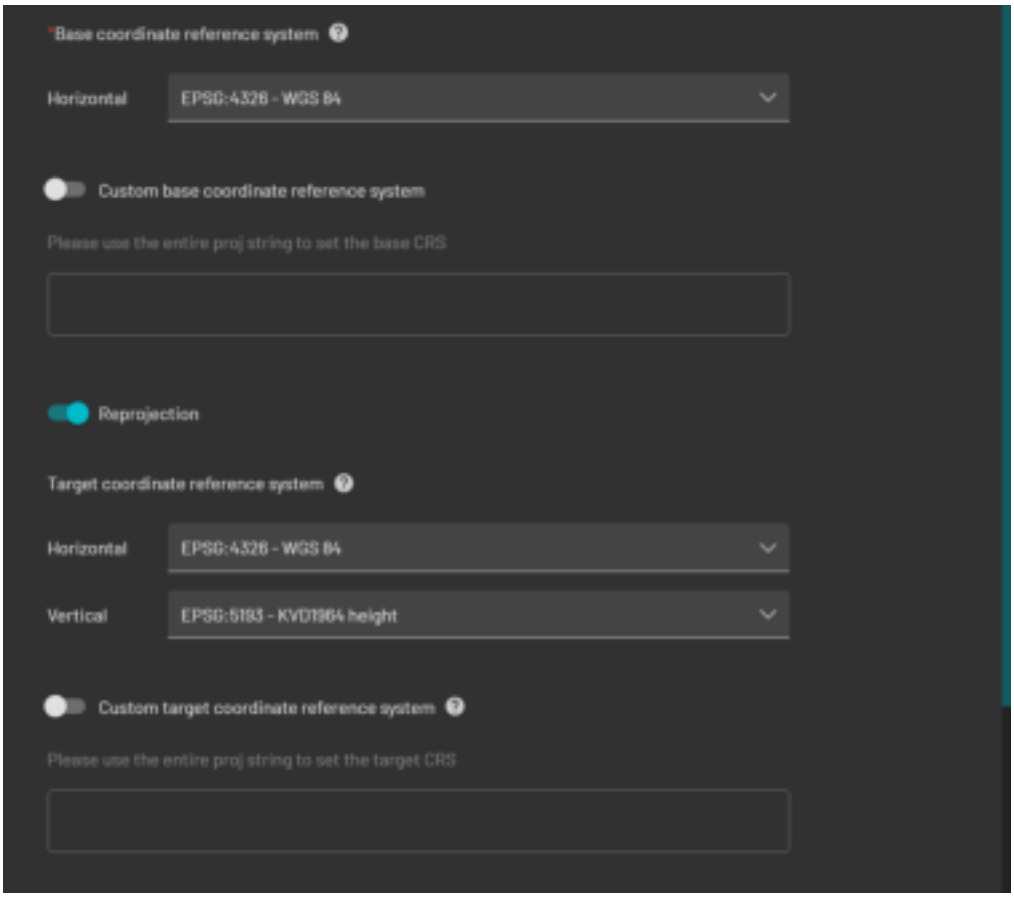
1. **Define** the location and name for the merged output.



1. Adjust any desired settings using the general merge or output options, as outlined in the ***Aura User Manual*, Section 3.3 – Process Tab.**

For RTK Merges and RTK + Non-RTK Merges:

1. Set processing settings:
    a. Set the **Base Coordinate Reference System** to match the original horizontal CRS used during scan acquisition (e.g. EPSG:4326 – WGS 84).
    b. To manually enter a full PROJ string, enable **Custom base CRS**.
    c. Enable **Reprojection** (optional) if you want to transform the output into a different coordinate system. Define the **Target Coordinate Reference System** by selecting the desired horizontal and vertical CRS values.


*Base coordinate reference system
Horizontal
EPSG:4326 - WGS 84
Custom base coordinate reference system
Please use the entire proj string to set the base CRS
Reprojection
Target coordinate reference system
Horizontal
EPSG:4326 - WGS 84
Vertical
EPSG:5183 - KVD1964 height
Custom target coordinate reference system
Please use the entire proj string to set the target CRS

5.6.7 Step 6: Proceed to Alignment

For Non-georeferenced scans (Non-RTK) Merges:

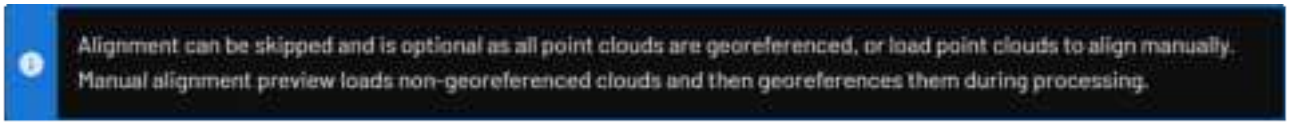
- Proceed to **Step 7: Review and Manually Align**.

For RTK Merges and RTK + Non-RTK Merges:

- Proceed to **Step 7: Review and Manually Align**.

For RTK Merges

- If setup is correct, Aura will notify you that no manual alignment is necessary and you can skip manual alignment and start processing.



5.6.8 Step 7. Review and Manually Align (If Required)

Aura's SLAM algorithm relies on overlapping features between scans to perform a merge. When georeferencing is unavailable or inconsistent across datasets, manual alignment is required to provide an initial position estimate. This reduces drift and improves the overall quality of the merged point cloud.

Manual alignment is required in the following scenarios:

- Merging scans without georeferencing (e.g. Non-RTK)
- Merging georeferenced and non-georeferenced scans together (e.g. RTK + Non-RTK)

Aura will attempt to merge scans even if they are misaligned, either horizontally or vertically. This can result in a skewed or inaccurate final output. Always verify alignment before continuing.

1. **Click Load Scans** to load all selected point clouds into the viewer.
   - Each scan is automatically assigned a unique color to assist with differentiation and alignment.
   - To add or remove datasets from the current merge job you can click **Edit Point Clouds Selected**.

2. **Align scans manually** using the **Translate** and **Rotate** tools. Start with **Top View** to position and rotate scans horizontally, then switch to **Front View** to adjust them vertically.

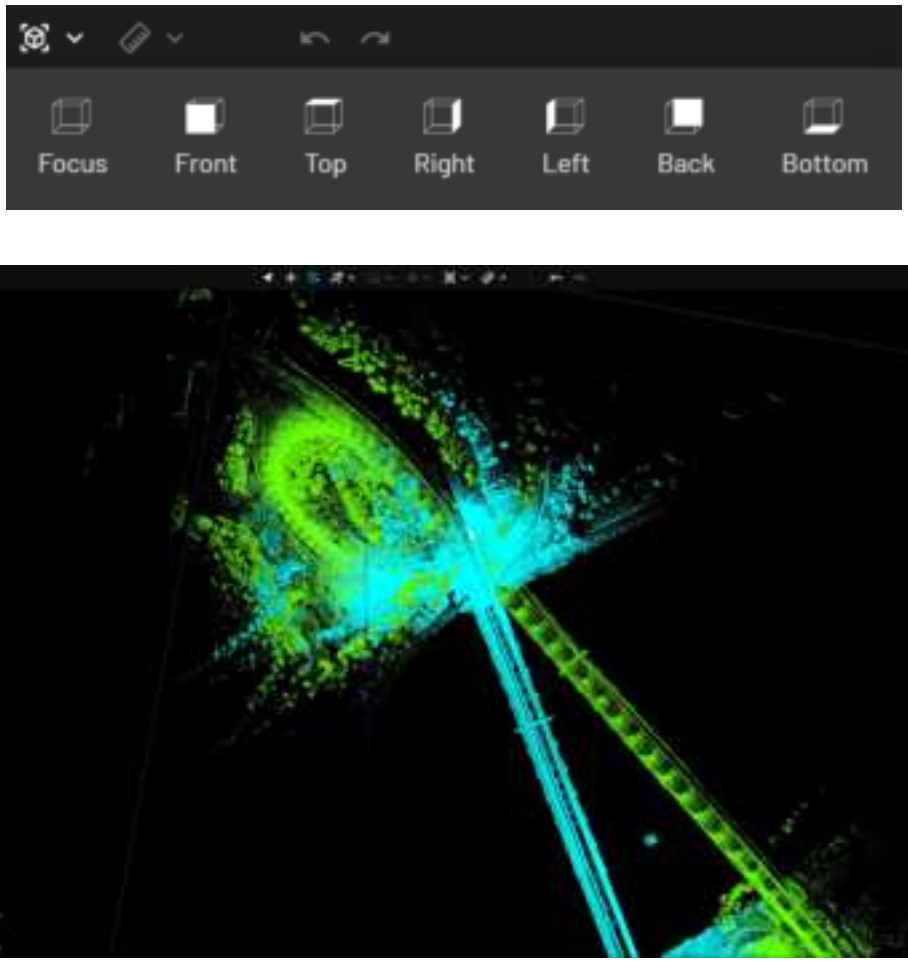


Figure 2 Align horizontally using the Translate and Rotate tools.

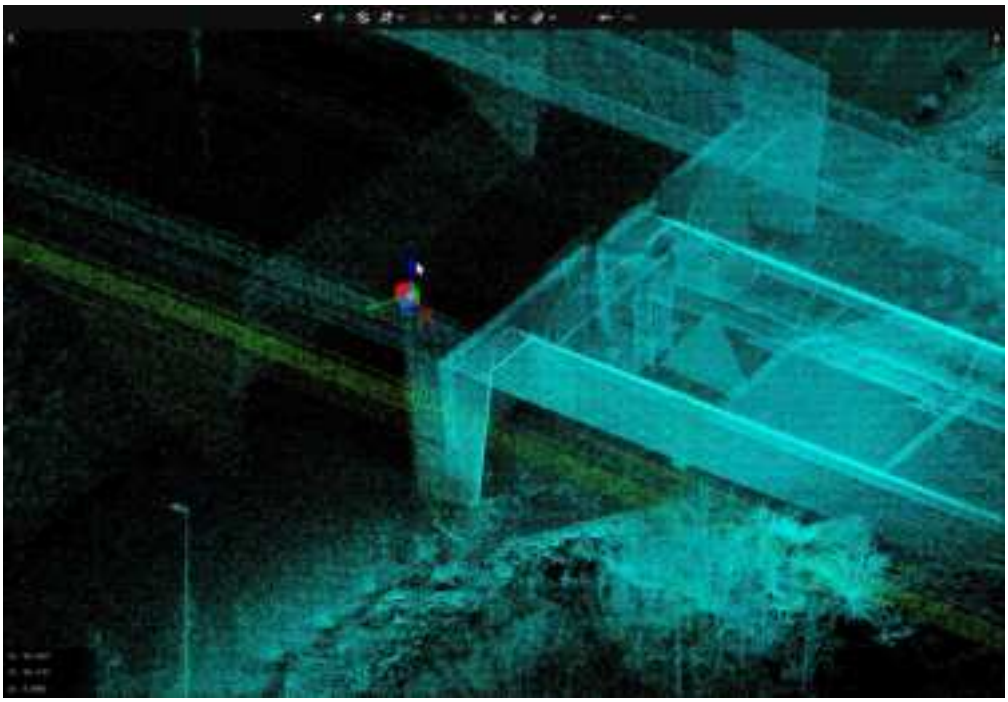


Figure 3 Align Vertically using Translate

Click Reload Scans in the **Configure New Scan Job** panel to reset a scan's position.

You are now ready to begin processing.

1. Click **Start** to begin the merge.

> **Start button not visible**
> If the **Start** button is hidden, click the **Configure New Scan Job** panel at the bottom of the window to reopen the **Processing Scan** panel and access the **Start** button.

5.6.9 Step 9. View and Combine Your Datasets

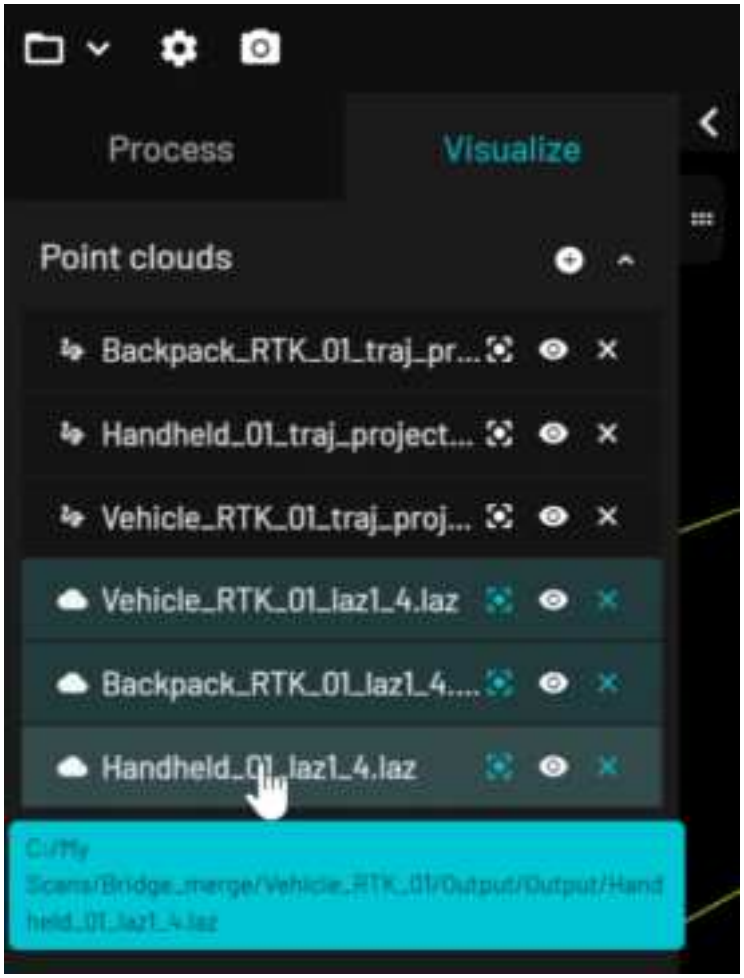
Once processing is complete, Aura outputs a `.laz` file for each scan. These files are stored in the directory specified in Step 1. They are aligned using the SLAM algorithm and georeferenced, if applicable.

You can now combine these individual `.laz` files within Aura to produce a unified point cloud. The outputs are grouped and displayed in the **Merge Complete** panel.

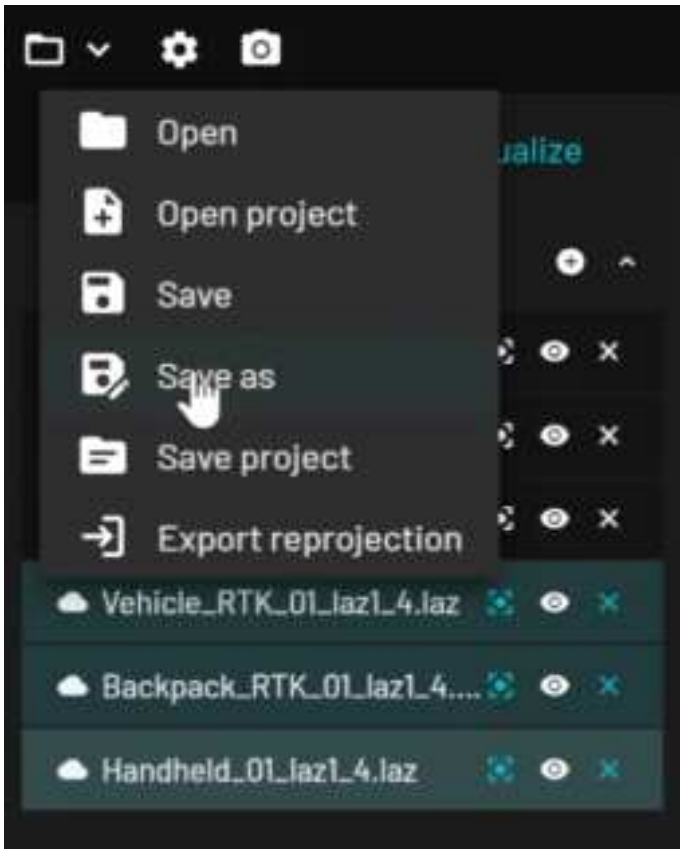
1. **Click View** under the **Merge Complete** panel to inspect each output dataset individually.

2. **Minimise** the **Merge Complete** panel to access the **Visualize** tab.

3. **(Optional) Adjust** the color of each point cloud in the **Visualize** tab to compare and validate the alignment and quality of the merged scans.
4. **Select** multiple datasets by holding **Shift** and **clicking** on each desired dataset.

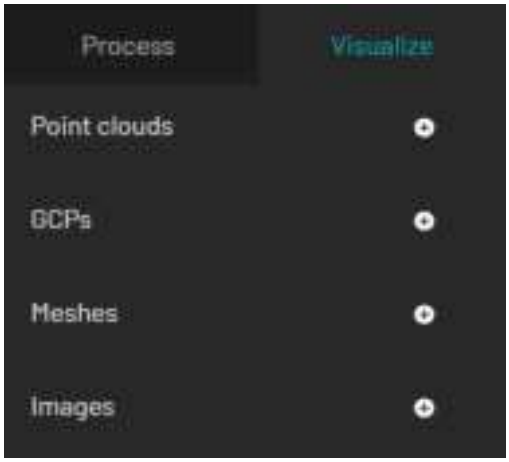


5. **Open** the **Project** menu and **select Save As** to save the combined dataset as a single point cloud.



5.6.10 To combine datasets at a later time:

1. **Navigate** to the **Visualize** tab.
2. **Click Add** to load previously processed `.laz` files.

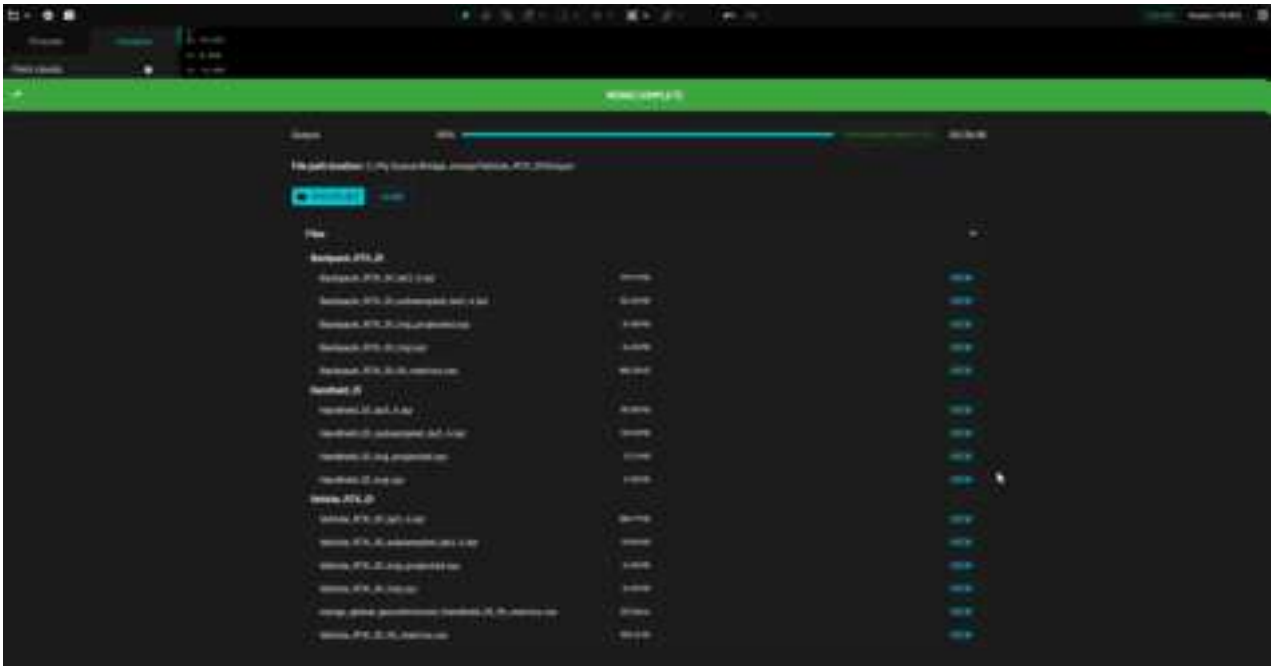


3. **Repeat** steps 3–5 above to compare, validate, and save the combined dataset.

5.6.11 (RTK Only) View the Combined Accuracy Report

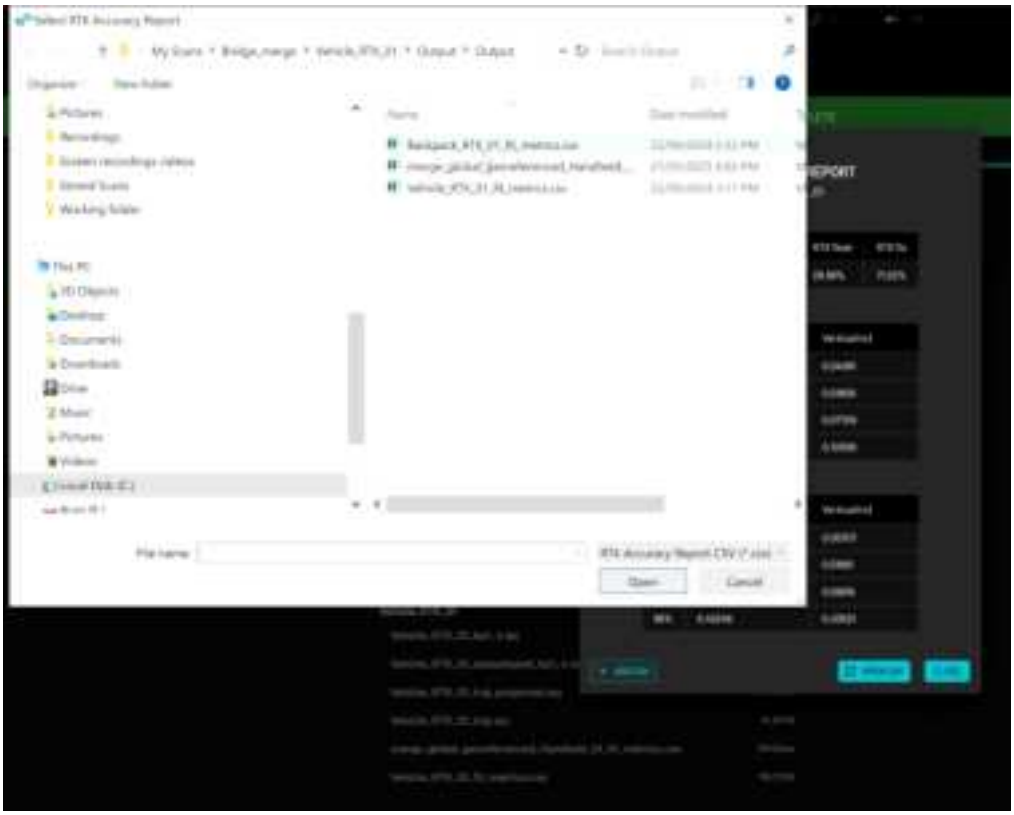
After processing an RTK merge, each scan generates a `.csv` accuracy report. These reports are stored in the output folder of each individual scan. To load multiple reports into Aura and generate a combined accuracy report, follow the steps below.

1. **Open** the **Merge Complete** menu in Aura.
    - This appears automatically after processing, or can be accessed by clicking the **Merge Complete** bar.

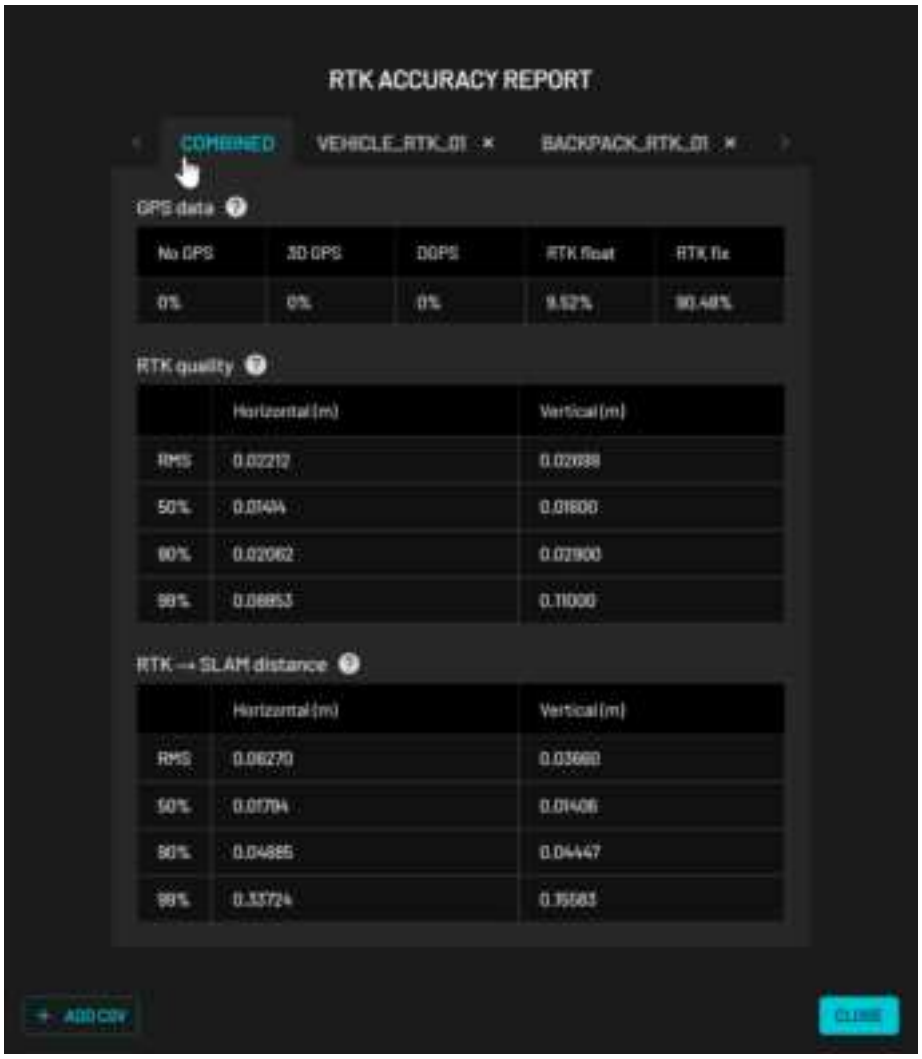


2. **Click View** on the right-hand side of any `metrics.csv` accuracy report to open it.

3. **Click + CSV** in the report window to open Windows Explorer, then **navigate** to and **select** any additional `.csv` accuracy reports to include.



4. **Select** the **Combined Report** tab to view the merged accuracy data.


RTK ACCURACY REPORT
COMBINED
VEHICLE_RTK_01
BACKPACK_RTK_01
GPS data
No GPS
3D GPS
DGPS
RTK float
RTK fix
0%
0%
0%
9.52%
90.48%
RTK quality
Horizontal (m)
Vertical (m)
RMS
0.02212
0.02088
50%
0.0149
0.01800
80%
0.02962
0.02900
99%
0.08853
0.11000
RTK → SLAM distance
Horizontal (m)
Vertical (m)
RMS
0.06270
0.03660
50%
0.01704
0.01406
80%
0.04886
0.04447
99%
0.33724
0.35583
ADD CSV
CLOSE

5.6.12 Colorize and/or Extract 360 images (Optional)

After merging, you can colorize your point clouds using camera imagery by following the instructions in the **Aura User Manual - Colorization Workflow.**

5.6.13 Merge Compatibility Summary

Scan Type	Merge Supported	Georeferencing Retained After Merge
Vehicle and Backpack RTK	✓	✓
Drone RTK	✓	✗
GCP	✓	✗

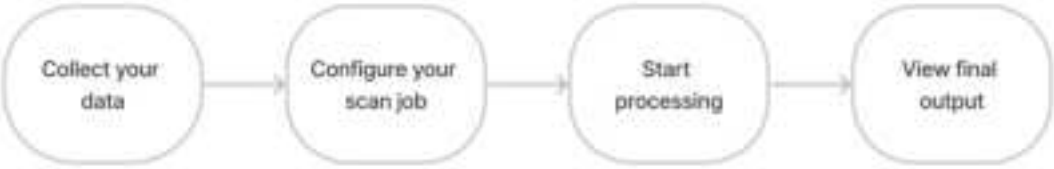
5.6.14 Troubleshooting

Issue	Cause	Solution
Merged RTK scans aren't georeferenced	Apply Overrides wasn't used	Select a georeferencing mode using **Apply Overrides** before merging scans.
RTK scans still require manual alignment	Georeferenced scan not set as the preview file	Select the RTK scan as the **Alignment Preview File** (satellite icon).
Aura isn't detecting my scan files	Wrong folder selected or scans not processed	Select the **offload folder** with `.bag` files, not the Output folder

5.7 Colorization Workflow

Emesent's colorization feature allows you to augment your point clouds with true color, providing additional context for visualization and analysis. Colorization works by merging Hovermap's LiDAR scan data with video recorded by a GoPro that has been mounted to Hovermap.

The basic process for colorization is as follows.



5.7.1 Step 1: Collect your data

1. Go to Working with colorization for more information on how to set up your Hovermap and GoPro for colorization and colorization-specific scanning techniques.
2. Check that you have everything necessary to create a colorized point cloud:
    - An updated license dongle with a valid **Colorization** license.
    - Your Hovermap scan folder (containing raw data from Hovermap).
    - A GoPro video file (an MP4 file contained within the scan folder).

5.7.2 Step 2: Configure your scan job

1. Open Emesent Aura. Make sure you have an active **Colorize** license.
2. In the **Process** tab, click **Process Scan**.
3. In the **Configure New Scan Job** panel, select the **Colorize** workflow.

4. Click **Add Dataset.**

> ⚠ To colorize a dataset, the serial number of the camera used to create the dataset must match the serial number in the Hovermap calibration file.

In the dialog box that displays, browse for the folder that contains the point cloud to be colorized. Ensure the scan has been processed and the **.mp4** file or **.360** file is in the same directory. If the video file is detected, it will appear in the **Video file(s)** column (multiple video files will appear if detected depending on the scan duration).

5. If there are multiple output folders in the selected scan folder, click the arrow beside the output folder then select from the list.

In addition, in the **Scan File** column, the non-georeferenced output is selected by default. If you want to colorize a georeferenced point cloud, click the arrow beside the scan file then select the file labeled **Scan Processed with Landmarks**.

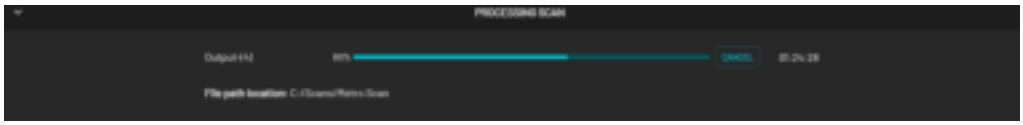
6. Once you have selected the point cloud to colorize. click **Save**.
7. In the **Location** field, enter the preferred name for the output folder. Emesent Aura will create this folder, which stores all the processed results and data, as a child directory within the raw point cloud folder.

8. Select the processing profile to use. Refer to the Processing Profiles section for more information about which profiles to use and how to create a custom profile.

9. Define colorization settings - refer to the Creating a Custom Mask section for instructions on creating your own image mask.

5.7.3 Step 3: Start processing

1. Click **Start** to begin processing. The panel will show a progress bar showing how far along you are in your processing job. In addition to the progress bar, the elapsed time of the processing job is shown to the right.



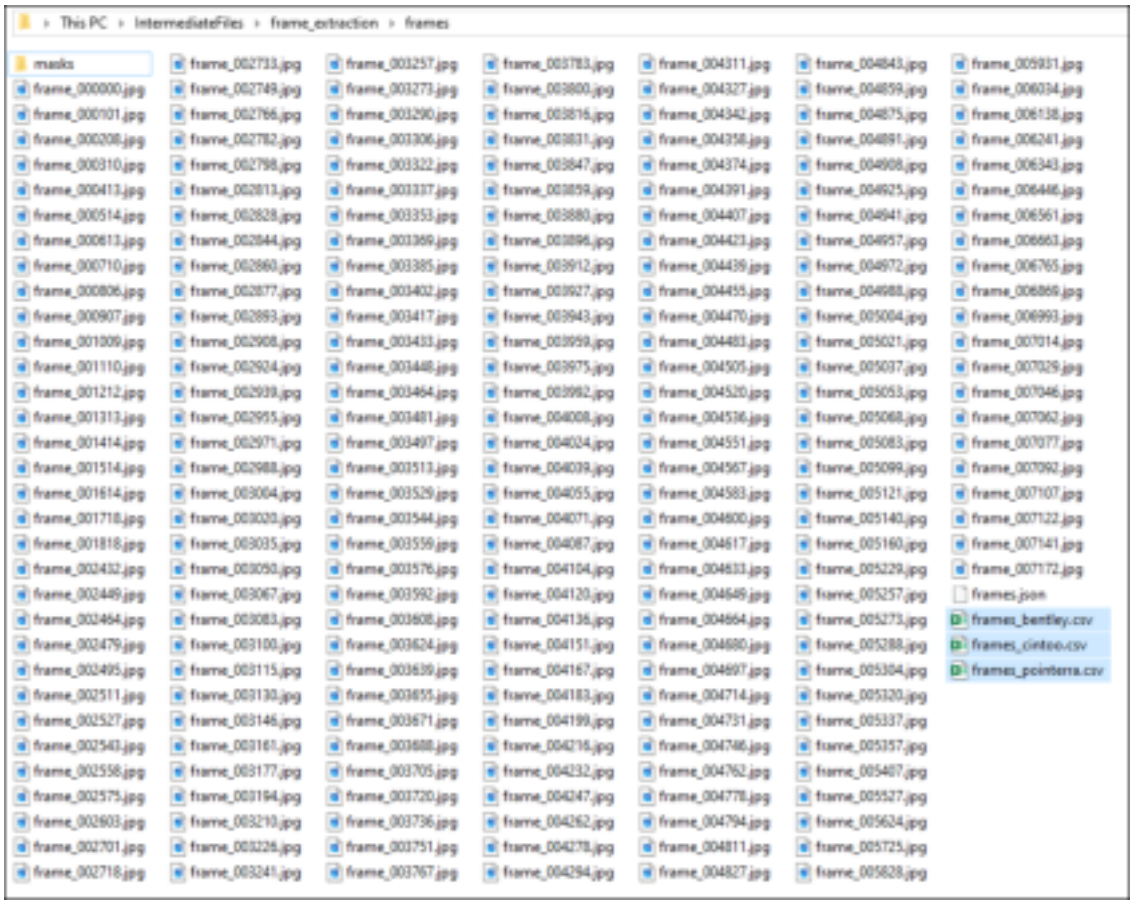
2. When prompted, click **Review Frames**.

3. In the file explorer window, manually delete any unwanted frames from your video.
4. Once the unwanted frames are removed, return to Emesent Aura and click **Resume**.

> If a failure occurs during processing, the **Retry** buttons becomes available. Click this button to attempt to process the current job from the last successful stage.

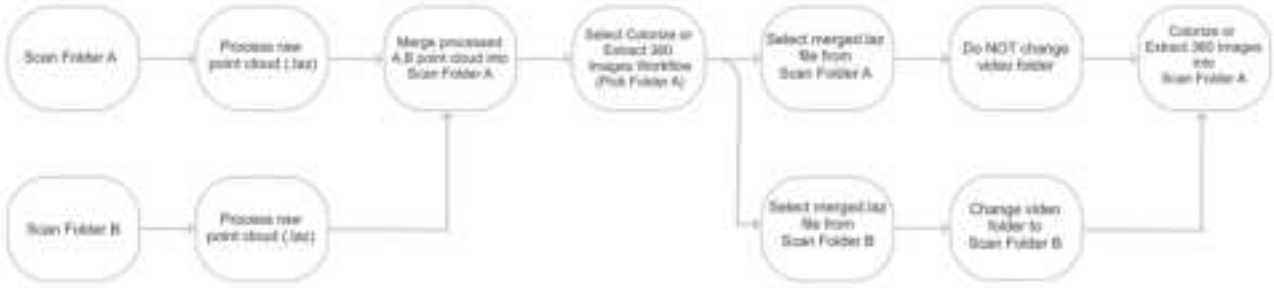
5.7.4 Step 4: View your final output

1. Once processing has been completed, click **Open folder** to view the output folder or **View** to display your colorized point cloud in the Viewport.
2. Click **Close** to remove the scan information from the processing space.
3. The image frames used during colorization can be exported with the colorized point cloud. You can find them in the **Intermediate files > frame_extraction > frames** folder. This folder also contains 3 CSV files with pose information in formats compatible with export to Pointerra, Cintoo, Bentley, and Prevu3D.



5.7.5 How do I colorize a Merged Point Cloud?

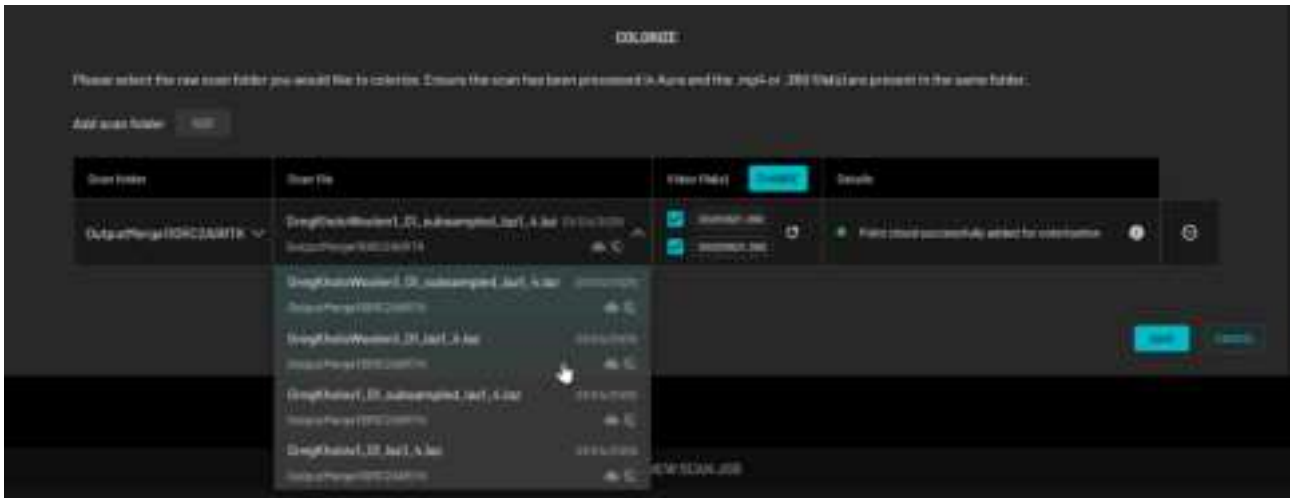
Colorizing a Merged dataset involves Merging the datasets first, then colorizing each individual scan as a separate Colorization processing job as illustrated in the diagram below.



Below are the steps to colorize a Merged dataset:

1. **Merge** the dataset by following the *Merge Workflow* before starting colorization.
2. **Select** the *Colorize* workflow in the Processing Tray.
3. **Add** the scan folder that contains the merged dataset output.
4. **Set** the merge output folder as your scan folder.

5. **Select** the first scan file to colorize.



6. **Select** the video files that correspond to the selected scan file.

7. **Save** the configuration.
8. **Adjust** processing settings as required by following the *Colorization Workflow Guide*.
9. **Start** processing.
10. **Repeat** steps 5–9 for each additional scan file, selecting the appropriate scan and video files for each.

5.8 Extract 360 Images Workflow

The plug-and-play 360-degree camera accessory for Hovermap, combined with seamless processing in Aura, enables the easy capture, registration, and export of 360 panoramic images.

Please refer to the Knowledge Base asset: 360 Panoramic Image Guide (includes video) for instructions.

5.9 Moving Object Filtering

Identifying moving objects within a point cloud is done by estimating statistical scores for points based on their temporal and spatial relationship to their neighborhood. These scores provide a quantitative measure of the likelihood that a point belongs to a moving object, enabling the Moving Object filter to differentiate between dynamic and static elements in the point cloud.

This feature can be applied to your point cloud as a cleaning filter or from the Processing Settings as part of Emesent Aura's processing workflow.

5.9.1 Using the Moving Object Filter

1. Load your point cloud using any of the following options:

- In the top-left menu, click the **Project Menu** icon then select **Open** from the popup menu.
- Drag and drop your file directly into the **Viewport**.
- Go to the **Visualize** tab then click **Add** next to the **Point Clouds** section.

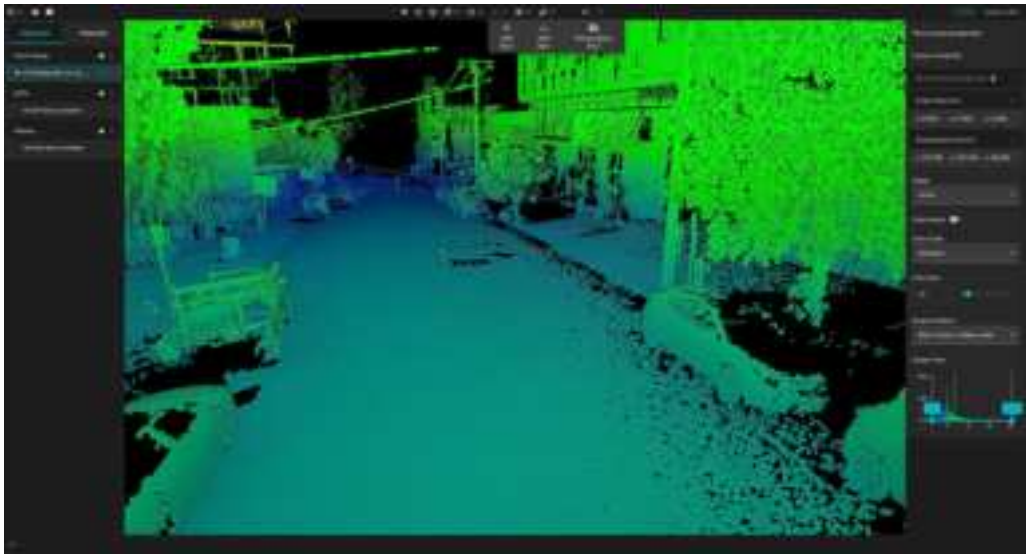
2. From the Main Toolbar, click the **Cleaning Filters** icon then select **Moving object filter**.

3. In the **Moving Object Filter** dialog box, configure the following parameters as required.

- **Motion level:** Detects movement over 5 second intervals. The higher the value, the lesser moving points are selected.

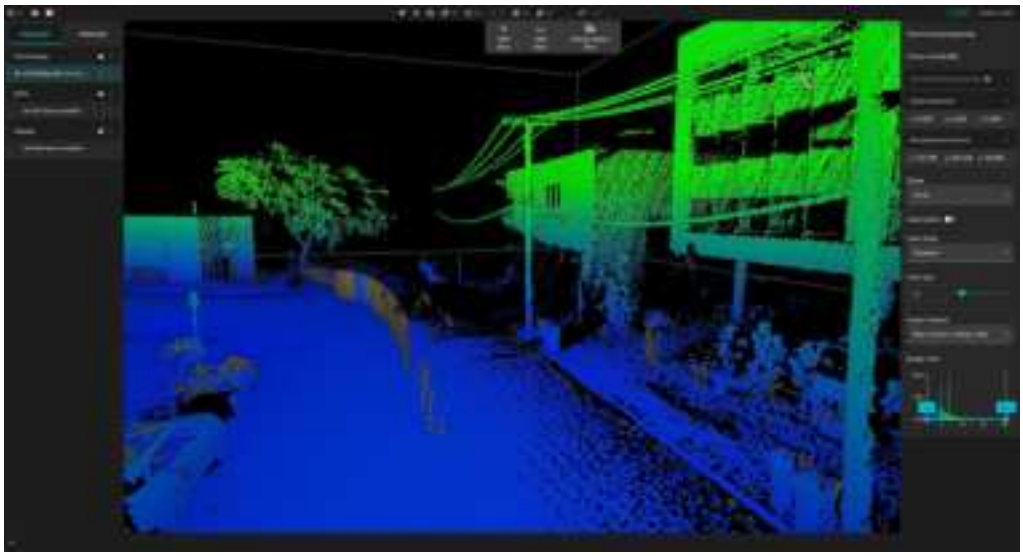
- **Distance:** The maximum distance for recovering fixed points. The higher the value, the more points are retained. A value of 1 to 2 cm is recommended for most scans.

4. Under **Point outlying**, choose whether the outlying points will be deleted or just selected. If you choose **Select**, the selected points will show in sepia/gray color.



Once the points are selected, running the filter again will require the points to be cleared by pressing the **ESC** key. The algorithm only takes into account the whole cloud if no points are selected.

5. Once satisfied with the selection, press the **DELETE** key on your keyboard to remove the points.



5.9.2 Applying Motion Filtering from Processing Settings

The filter can also be accessed by enabling **Motion filtering** from the **General** tab in **Processing Settings**. The filter will default to settings based on the profile and detected hardware in the raw scan directory.

- The filter is disabled by default to avoid accidentally removing some important features with default thresholds including GCP disks if they are not scanned well.
- An aggressive setting may lead to 'holes' on object surfaces in the resulting point cloud.

5.10 Creating a Custom Mask

When processing a dataset with 360 video for image extraction or colorization, one of the essential steps is applying a mask to the extracted frames. This is because there may be areas in the frame that you do not want to show. Emesent Aura comes with several pre-defined masks that you can use for this purpose but you can also create your custom mask in case none are suitable for your dataset.

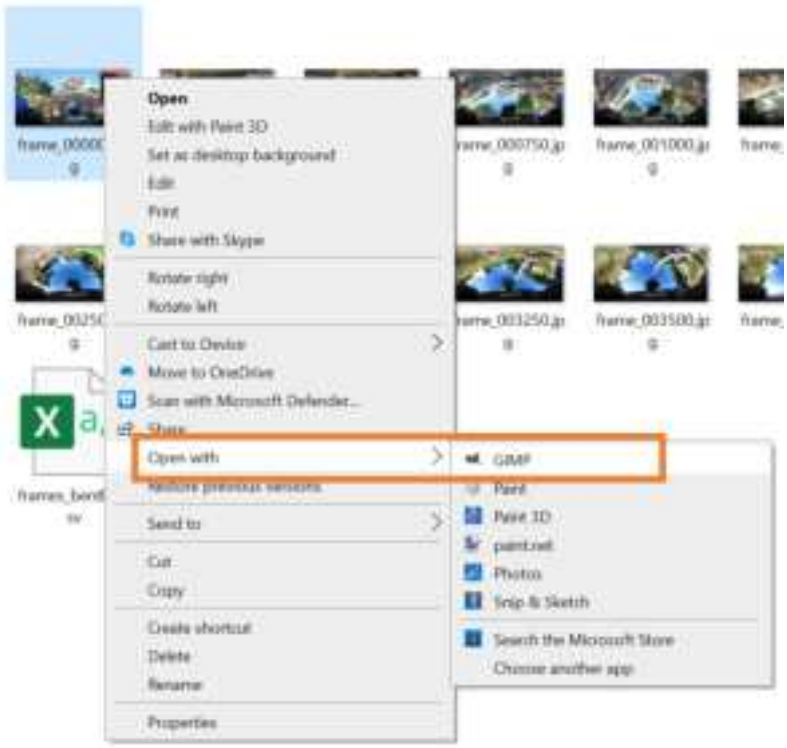
To create a custom mask

The following process is demonstrated using GIMP (a freely downloadable editing software). However, you can utilize any third-party image editing software, as the techniques discussed here are applicable across various platforms.

1. Run an **Extract 360 images** workflow with **Image masking** turned off.

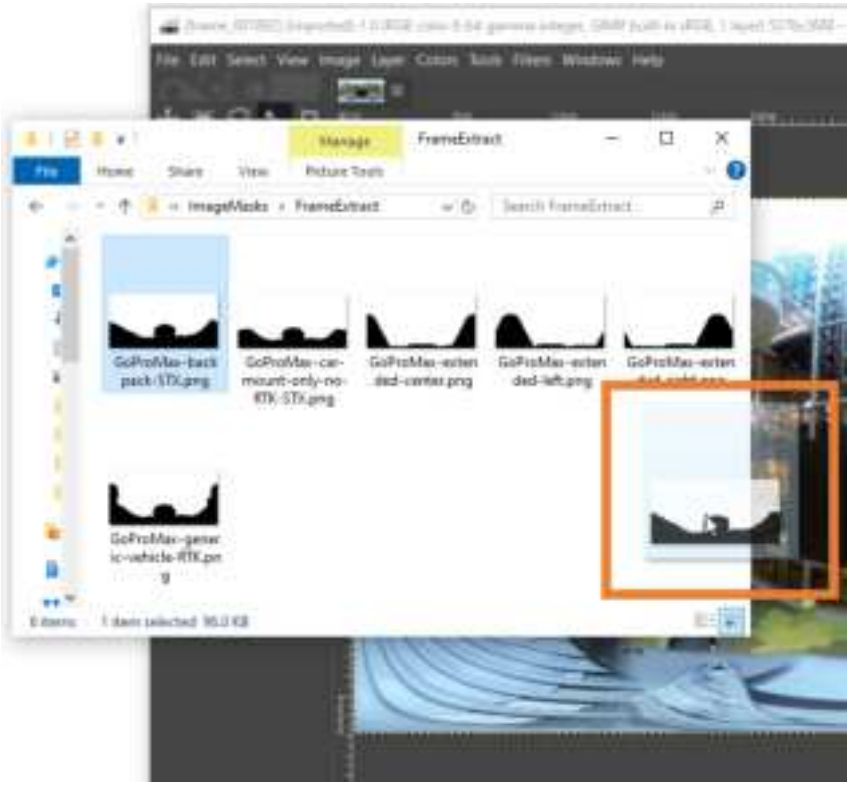
If you have a large video, running image extraction once on a small subset of data is recommended. You can achieve this by setting a high **Frame Extract Interval** (e.g. **Distance: 20** and **Angle: 90**) or specifying a low **Video time end** setting (e.g. **10 seconds**). For Aura 1.5 and earlier versions, you can also use a **Frame Interval** of **250**.

2. Navigate to the extracted frames folder once the frame extraction process is completed.
3. Select a frame you want to create a mask for and open it in GIMP.

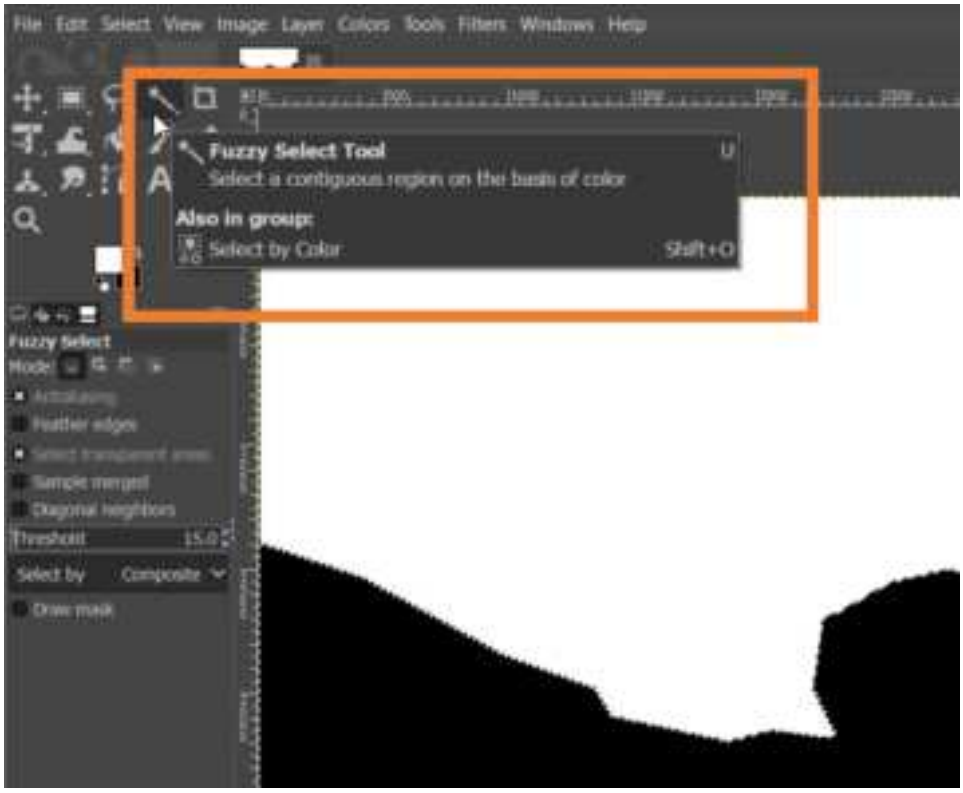


4. Adjust the display to ensure the image fits your screen properly.

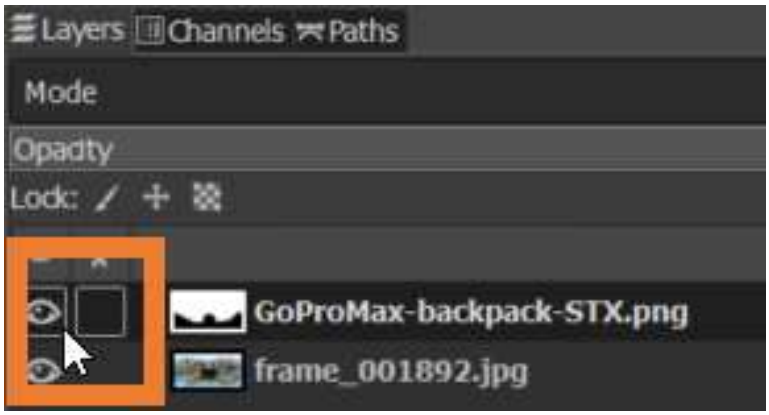
5. Start with an existing mask instead of creating one from scratch. Open the folder containing the predefined masks by navigating to **Program Files** > **Aura** > **Aura**> **Plugins** > **EmtProcessWorkflows** > **Content** > **ProcessWorkflows** > **ImageMasks**.
6. Select a suitable mask from either the **colourise** or **FrameExtract** folder then drag this mask onto your current image in GIMP. It will appear as a new layer.



7. Use the **Fuzzy Select Tool** (aka **Magic Wand**) and click on the black area of the mask layer to select it.

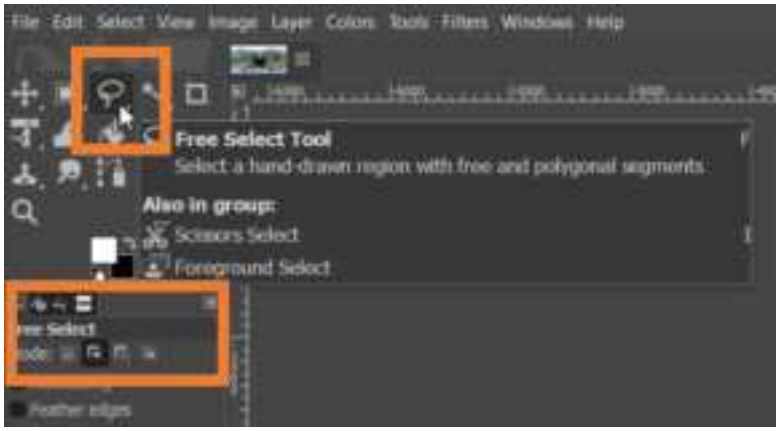


8. In the Layer panel on the right, every layer in the image appears as a thumbnail. The upper layer in the list is the first one visible. Click the **Eye** icon before the mask layer to hide the mask.



Notice that the selected mask area is visible on top of the image.

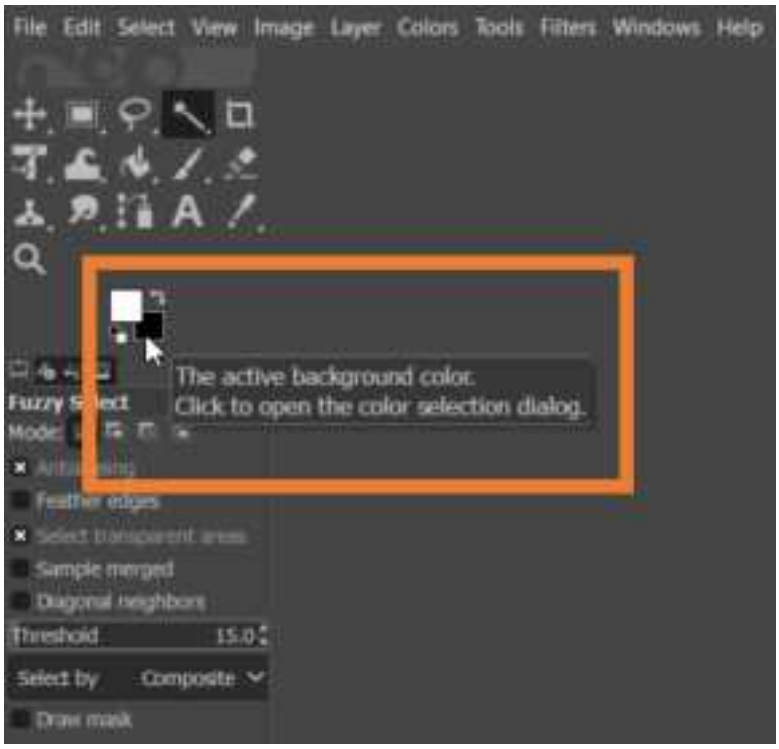
9. Use the **Free Select Tool** to add or refine areas to the mask as needed. Press the **Enter** key to add the area to the current selection.



> Make sure the **Mode** is set to **Add to the current selection**. You can do this by clicking on the second mode icon or pressing the **Shift** key while selecting.

10. Keep the frames folder handy and add more frames if necessary. Review each added frame, adjusting the mask to ensure proper coverage, especially around challenging areas like hands or cables.

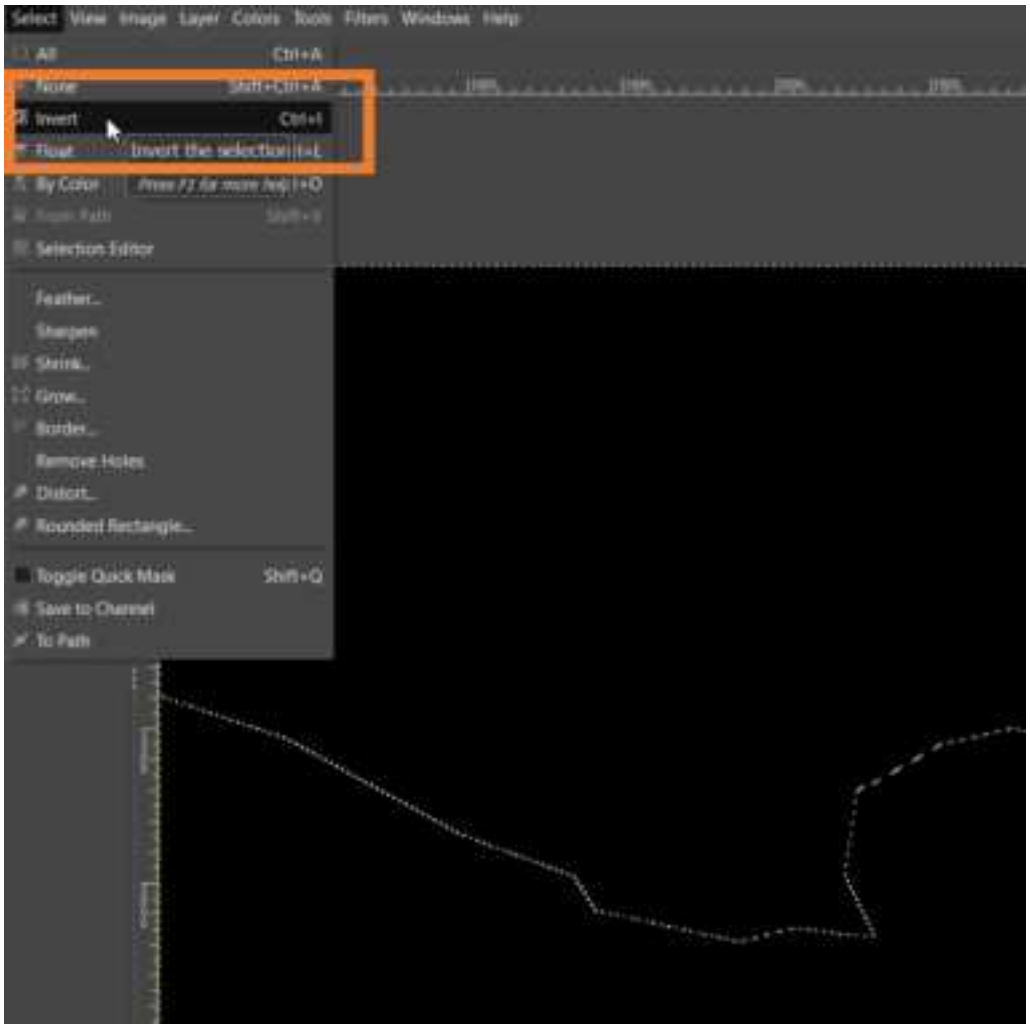
11. Ensure that the active background color is set to black.



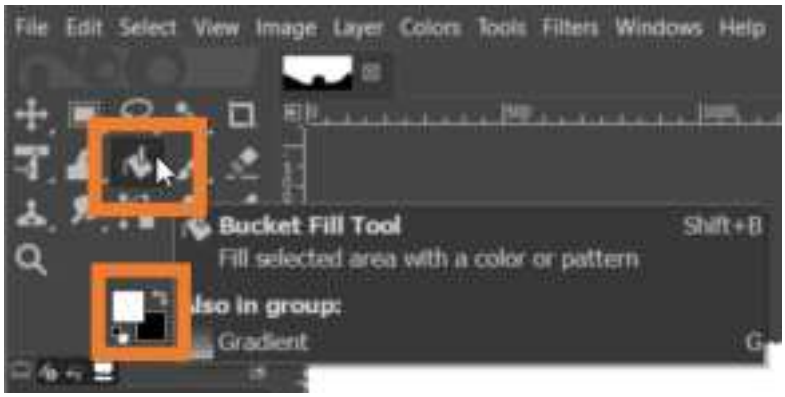
12. Once satisfied with the mask, go to the Layer panel and select the base layer containing the extracted image.

13. Press **Delete** on your keyboard.

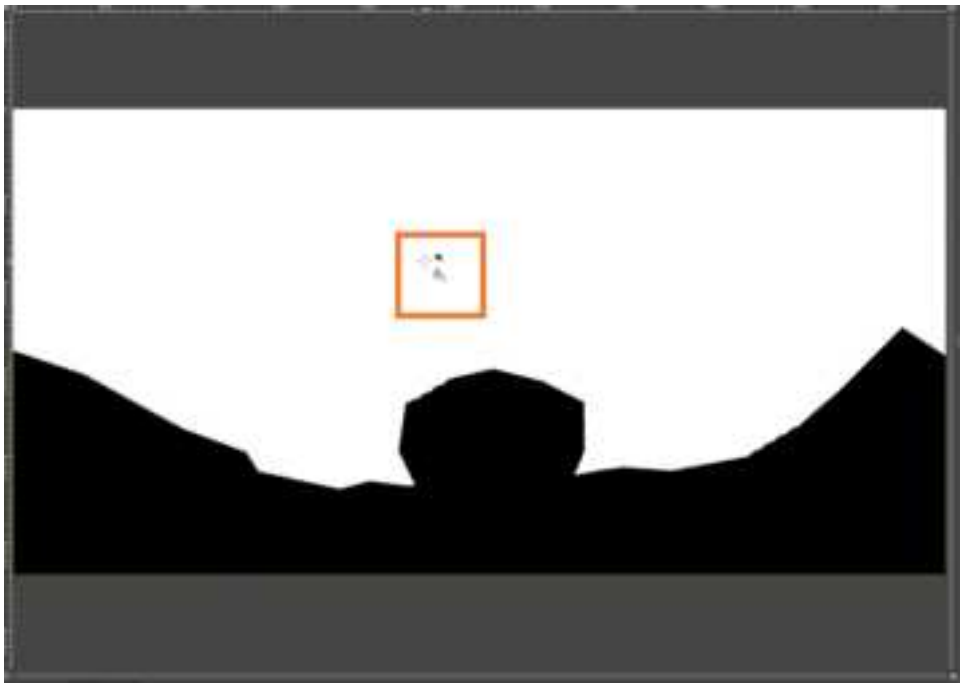
14. Go to **Select** > **Invert** then press **Delete** again. The entire image is now black.



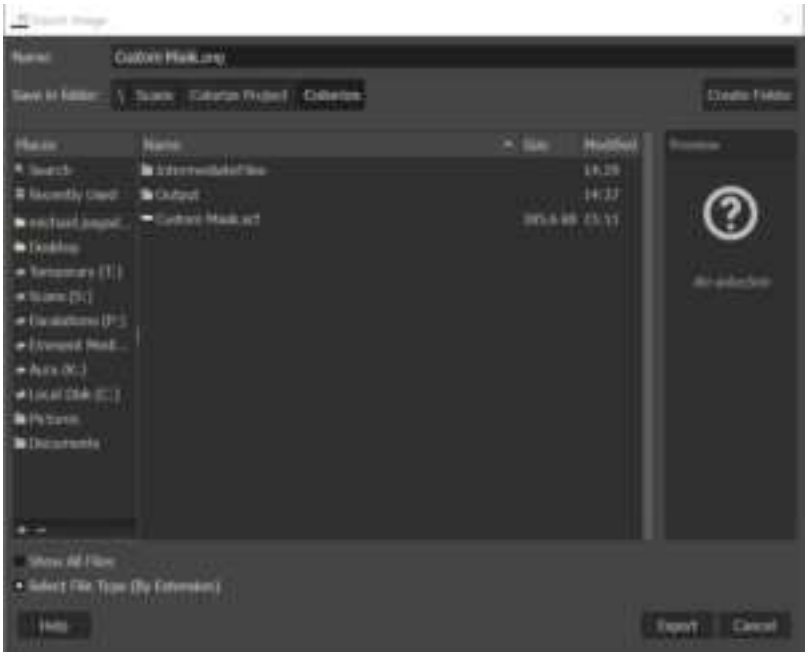
15. Click the **Bucket Fill Tool**. Ensure the active foreground color is white.



16. Click the top area to fill it with the active foreground color (white).



17. Go to **File** > **Export As**. Save the mask in PNG format to avoid the lossy compression issues associated with JPG files.



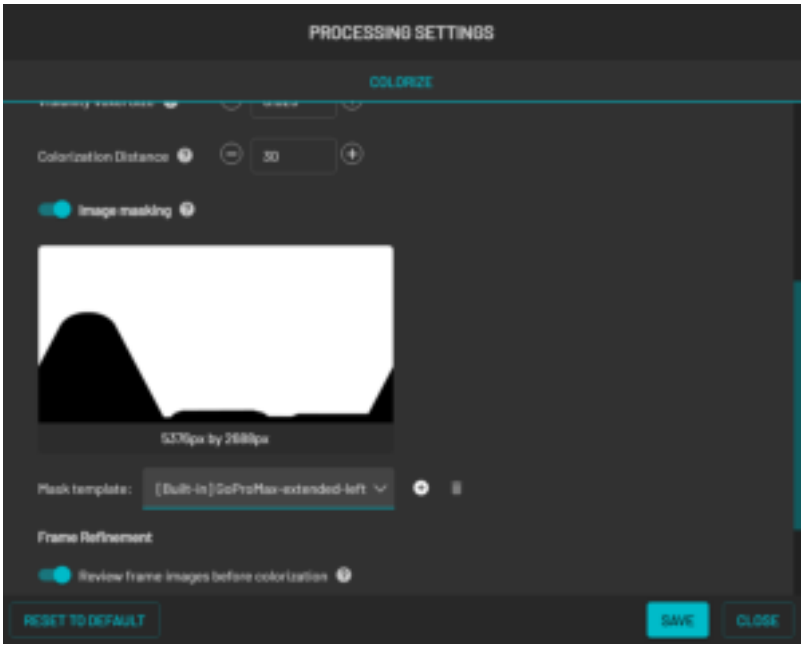
18. Click **Export**.

> If using Emesent Aura version 1.5 or earlier, change the pixel format to **8bpc RGB**.

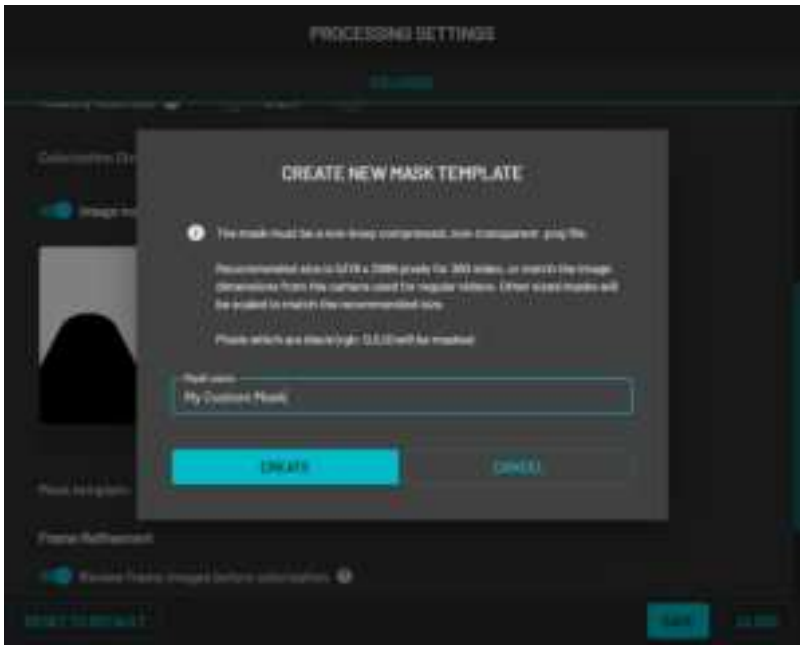
19. Close GIMP and return to the Emesent Aura.

To add the custom mask in Aura

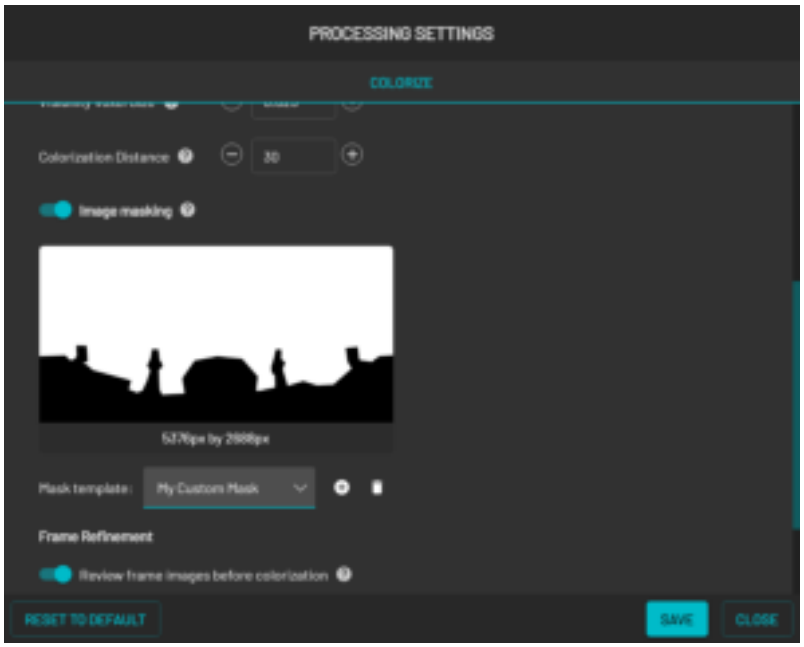
1. Run a **Colorize** or **Extract 360 images** workflow again.
2. Click **Processing Settings**.
3. In the **Colorize** or **Extract 360 images** tab, enable **Image masking**.



4. In **Mask template**, click the **+** icon.
5. Enter a name for the custom mask, click **Create** then browse for the newly created mask.



6. Click **Save** to finish adding the custom mask to Emesent Aura.



5.11 Reprojecting your Point Cloud

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

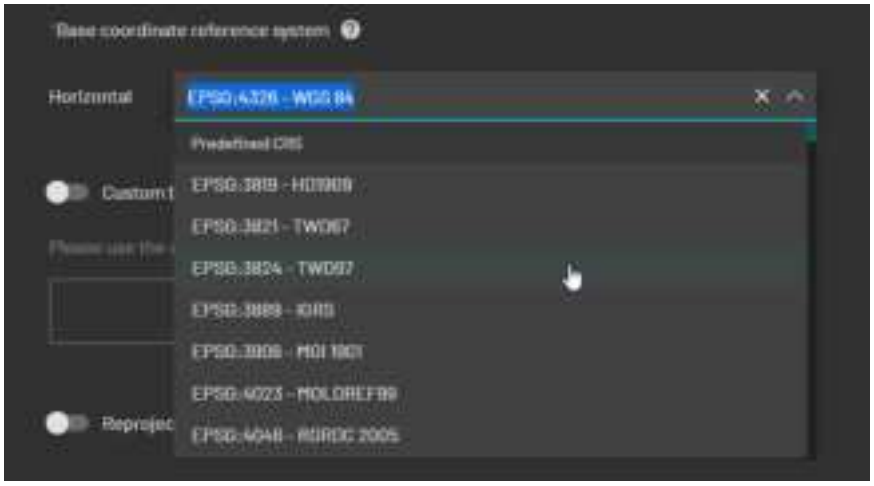
5.11.1 Processing and Reprojecting Raw Point Cloud Data

1. Open Emesent Aura and in the **Process** tab, click **Process Scan**.
2. In the **Configure New Scan Job** panel, select the **Process** workflow.
3. Click **Add Dataset** then browse for the folder that contains the raw RTK data to be processed. Select that folder.
4. You will be prompted once RTK data is detected in your dataset. Toggle on **Use RTK data**.

5. In the **Location** field, enter the preferred name for the output folder. A subfolder is created, which stores all the processed results and data.
6. Click **Processing Settings**. Under **Georeferencing** in the **General** tab, select the RTK device and GNSS receiver used to capture the RTK data.

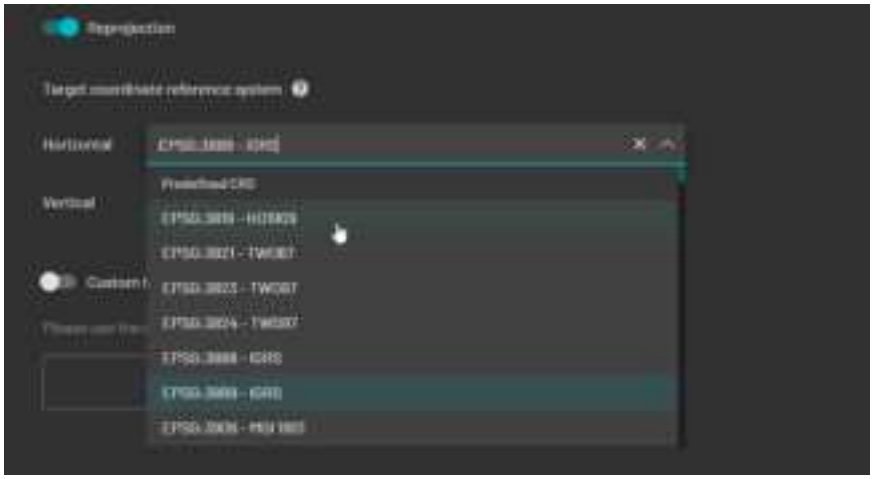
> ⚠ For optimal results, ensure that the **Georeferencing mode** and **GNSS receiver type** match the hardware used during data collection. While the resulting point cloud remains usable, the accuracy may be affected.

7. Under **Base coordinate reference system**, set the Coordinate Reference System in which the data was originally collected. This information is essential for accurate transformations and reprojections to the target CRS.



Alternatively, toggle on **Custom base coordinate reference system** to enter a project string that describes the desired geodetic coordinate reference system.

8. Toggle on **Reprojection** then select the appropriate **Horizontal** and **Vertical** coordinate reference systems.
    - **Horizontal:** Reproject to a different map projection or coordinate system.
    - **Vertical:** Convert from ellipsoidal height to orthometric height using a GEOID model.



Alternatively, toggle on **Custom target coordinate reference system** to enter a project string that describes the desired target coordinate reference system.

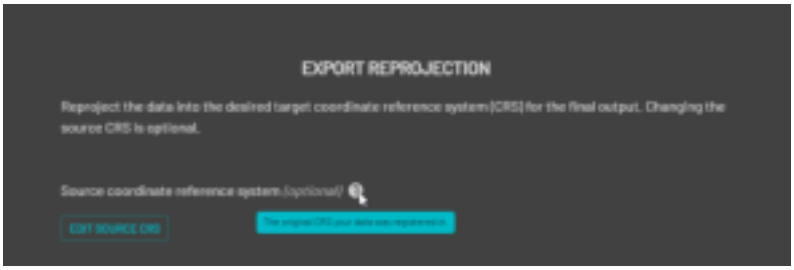
9. Click **Save**.

5.11.2 Reprojecting a Processed Point Cloud

1. Open Emesent Aura and go to the **Visualize** tab.
2. Load the processed point cloud or trajectory you want to reproject.

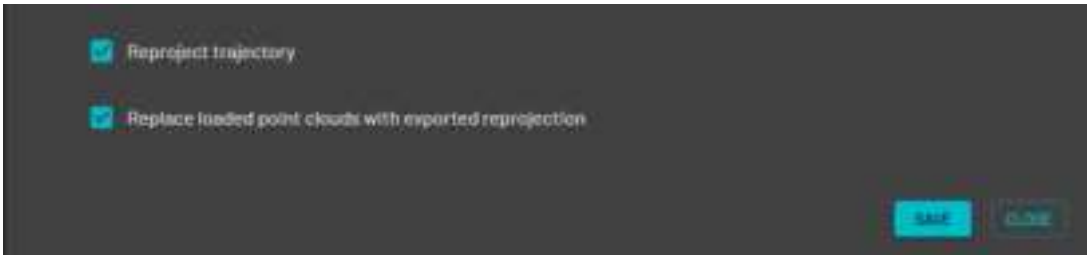
3. Click the **Project menu** icon then select **Export reprojection**.

4. In the **Export Reprojection** dialog box, click **Edit Source CRS**. This step is optional as Emesent Aura automatically detects the CRS of the input data. However, editing may be necessary if the CRS is incorrect or you are working with data from multiple sources that require a specific CRS.



Refer to the **Context Panel** on the right of the screen to see the projection information of the current point cloud.

5. Select the target **Horizontal** and **Vertical** coordinate reference systems or toggle on **Custom target coordinate reference system** to enter a project string that describes the target CRS.
6. Enable **Reproject trajectory** to apply reprojection to the trajectory data associated with the point cloud, ensuring that any movement or path data is aligned with the target CRS.
7. Enable **Replaced loaded point cloud with exported reprojection** to replace the currently loaded point cloud with the newly reprojected version.



8. Click **Save**. The results are saved in the same output folder as the original point cloud.

6. Glossary

Term	Definition
Constellation	A collection of targets and landmarks, and the way that they sit in relation to each other. A constellation is *associated* with the point cloud, but is separate from it.
EDL	Eye dome lighting. Improves depth perception by shading the outline of points, accentuating the shape of each object.
File formats supported	• **LAS:** Contains the point cloud. Industry-standard file format for LiDAR data. • **LAZ:** A compressed LAS file. • **E57:** A compact file format used for point cloud storage. Only E57 files generated by Emesent Aura are supported. • **SLAZ:** A Streaming LAZ file. Instead of loading the entire point cloud, Emesent Aura only streams images of the portion of the point cloud that you are looking at, "discarding" the rest. This is an optimized way of looking at scans, which means a faster loading time than the usual LAZ datasets. • **XYZ:** A widely-supported point cloud format. In the context of Emesent Aura, XYZ files appear in the **Entity panel** as a trajectory point cloud, showing Hovermap's path. • **PLY:** Standard mesh file format. • **YAML:** A configuration file attached to a LAS file. In the context of Emesent Aura, a YAML file is the constellation of GCPs. The file superimposes targets over your point cloud. The default name is *constellation.yaml*.
GCPs	Ground control points. GCPs are points with known geographical coordinates.

Term	Definition
Intensity	Measures how much of the emitted laser signal is returned. It is based mostly on the reflectivity of the object struck by the laser, but can also be affected other factors, such as the scan angle, surface composition, roughness and moisture content.
Landmark	The GPS coordinates entered in the CSV file. These are referred to as landmarks in Emesent Aura.
Mesh	A 3D model consisting of vertices, faces and edges.
Point cloud	A collection of individual points plotted in a 3D space.
Scalar field	Scalar fields give you a single, measurable value for each point in your point cloud. Because each value is associated with one point, it is possible to show the point cloud using a color gradient that is based on these measurable values. These values also allow you to apply filters to your point cloud.
SLAM	Simultaneous localization and mapping. SLAM technology runs in real-time to allow Hovermap ST to create a map of its environment, while at the same time working out its position, orientation, and speed within that environment.
Target	The reflective disc aligned to a GPS coordinate.
Transform	Records the orientation differences between point clouds after you have done a manual alignment. Emesent Aura works in the background to record this automatically. The transform then tells the processing job what to do to align the scans properly.
Translate	To move or shift the point cloud along an axis.
Units	All units in Emesent Aura are in meters.

7. Support

The Emesent Customer Support team is available to assist at every stage of your experience. For support, visit the Customer Portal.

The following services are available through the portal:

- Submit a support request for technical assistance, report an incident, or suggest a new feature
- Download firmware and software updates from the Software Downloads page
- Access user guides, training resources, tutorials, and troubleshooting content in the Knowledge Base
- Access guided training to take your skills further in Emesent Academy

> When submitting a request, provide as much detail as possible to assist the support team in resolving the issue efficiently.

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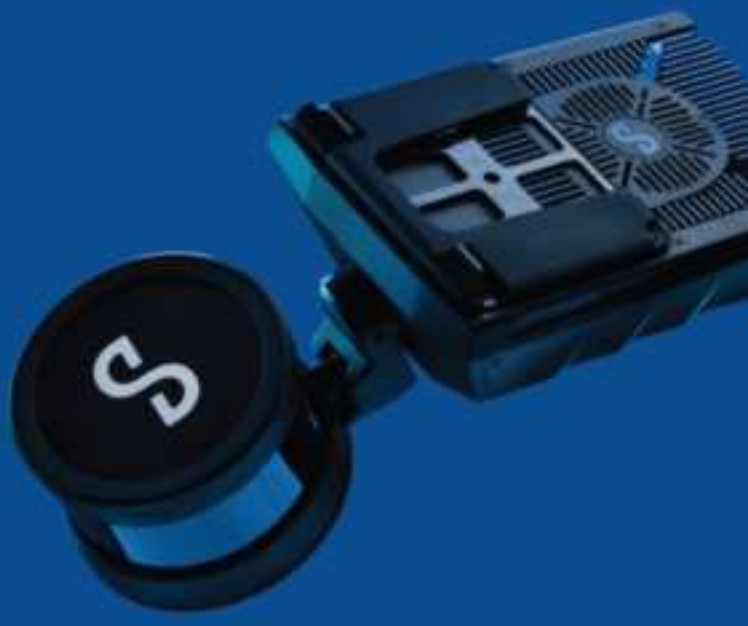

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