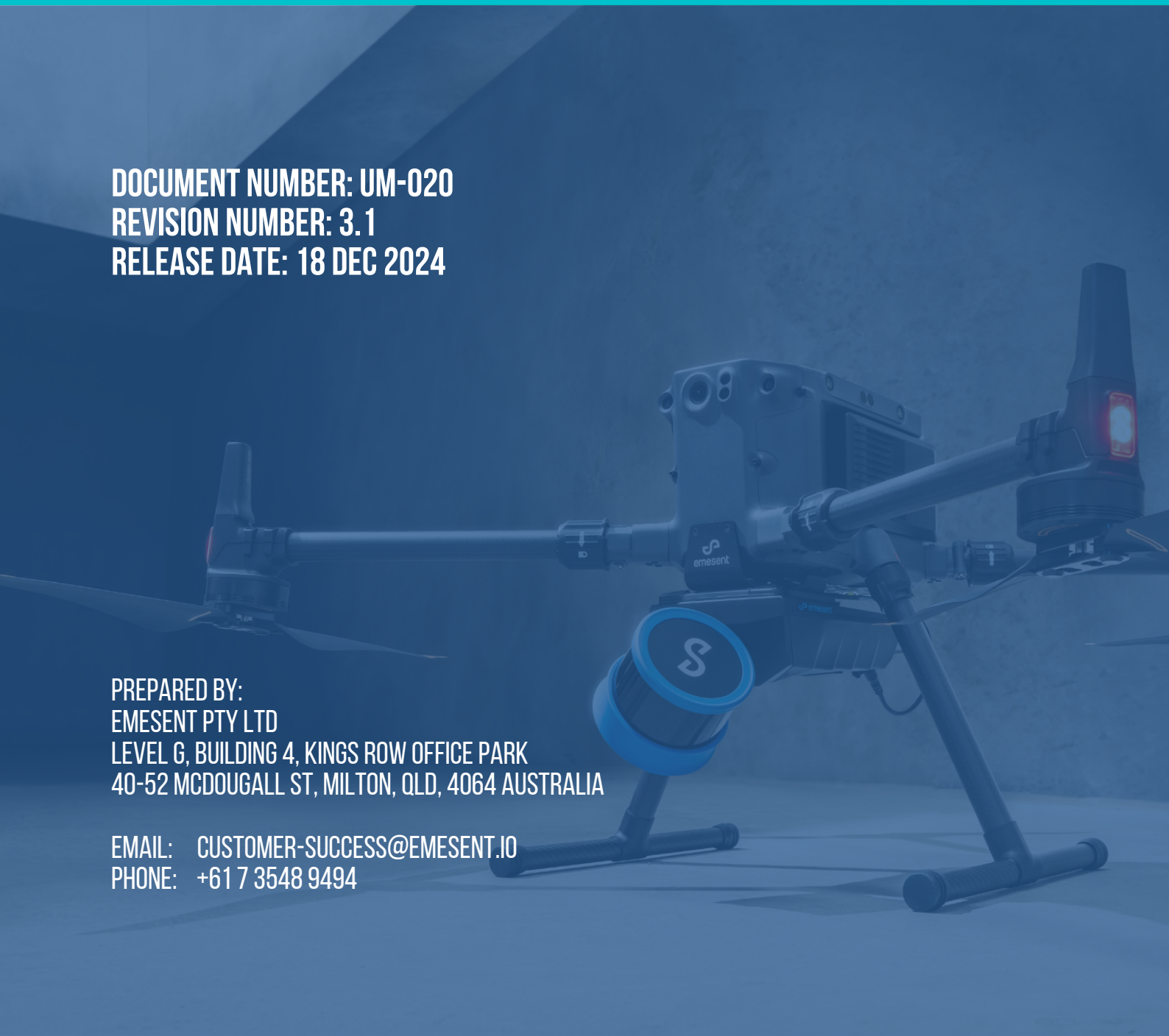
emesent

EMESENT AURA USER MANUAL



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Using this manual

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

Disclaimer and safety guidelines

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

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

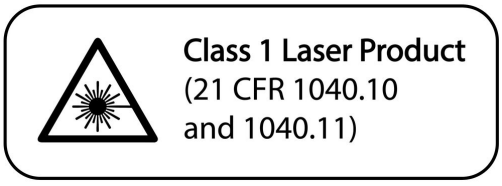
The use of Remotely Piloted Aircraft Systems (RPAS) may result in serious injury, death, or property damage if operated without proper training and due care. Before using an RPAS, you must ensure that you are suitably qualified, have received all necessary training, and read all relevant instructions,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

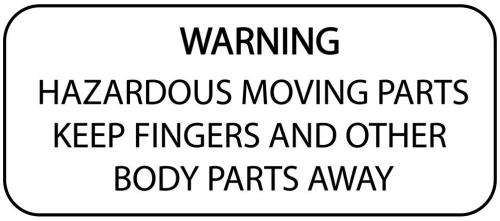
Warnings

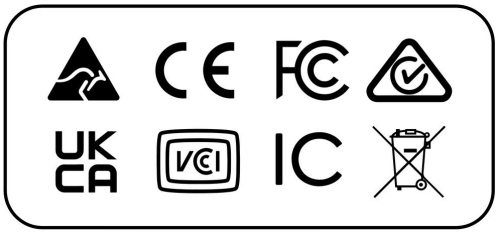
- This document is legally privileged, confidential under applicable law and is intended only for the use of the individual or entity to whom it is addressed. If you have received this transmission in error, you are hereby notified that any use, dissemination, distribution or reproduction is strictly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

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

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







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Welcome to Emesent Aura!

Emesent Aura is an integrated processing and visualization software that allows you to process, view, and analyze your point clouds in one platform for more accurate insights and improved decision-making.

This easy-to-use software allows you to:

- **Process your raw Hovermap data**
  - Convert your raw Hovermap data into a highly detailed, accurate point cloud.
  - Create customized profiles (or apply one-off processing settings without saving a profile) or use the existing profiles to easily process your scans.
- **View your point clouds**
  - Quickly load, view, and manipulate large point clouds using multi-frame rendering.
  - Work on a point cloud while you are processing a scan.
  - Work on multiple point clouds simultaneously and easily toggle between them.
  - Create screenshots of areas of interest.
- **Analyze and manipulate your point clouds**
  - Analyze your data, including taking point info, angle, or distance measurements.
  - Manipulate your point cloud using various 3D tools, including selection, translation and rotation, axis locking, and measurement tools.
  - Clean your point cloud using the statistical outlier removal (SOR), decimate by distance (DBD), and moving object filters.
- **Set and forget automated filtering**
  - The automated filters provide a simple and streamlined workflow for eliminating noise, stray points, outliers, and moving objects during processing.
- **Georeference your data**
  - Georeference a scan using RTK data from via the M300/M350, Backpack RTK, or Vehicle RTK .
  - Automatically georeference and correct your point clouds using Emesent's Automated Ground Control solution.
  - Validate your target alignment with a GCP accuracy report.

- **Merge your point clouds**
  - Merge multiple datasets manually using the rotation or translation tools.
- **Colorize your point clouds**
  - Augment your point cloud with real-world color, providing more context, clarity, and realism to your model for visualization and analysis.
  - The addition of the GoPro Max 360 camera accessory enables you to colorize your point cloud for vehicle and backpack scans (in addition to handheld and drone). Also, you can now achieve 360 panoramic colorization for backpack and handheld scans without painting the environment (i.e., moving the camera up and down for panoramic capture).
- **Export your data**
  - Export your point clouds to multiple file formats.
- **Extract images from 360 video**
  - Extract data from the GoPro MAX as 360 images. These images can be imported into third-party tools such as Pointerra, Cintoo, and Trimble Business Center.
- **Filter moving objects**
  - Accelerates the removal of unwanted moving objects such as people or vehicles from a generated point.
- **Reproject your point cloud**
  - Reproject your point cloud during export into specific coordinate systems, ensuring an accurate representation of real-world locations.
- **Change Detection and Convergence Monitoring**
  - This solution integrates the rapid data capture capabilities of the Hovermap with Aura's intuitive processing and analysis to help you manage and monitor your excavation projects. Tailored for underground environments and enclosed spaces, swiftly capture current excavation profiles with the Hovermap and seamlessly process, align, and visualize changes in Aura.

1.1 License 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.

1.2 System requirements

We recommend the following system requirements for Emesent Aura.

- **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
- **OS/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

Important
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).

2. Getting Started with Emesent Aura

2.1 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).

2.2 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 Technical Support Services if you have any issues.

2.3 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 Technical Support Services for more information on how to upgrade your license.

> **Warning**
> 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.

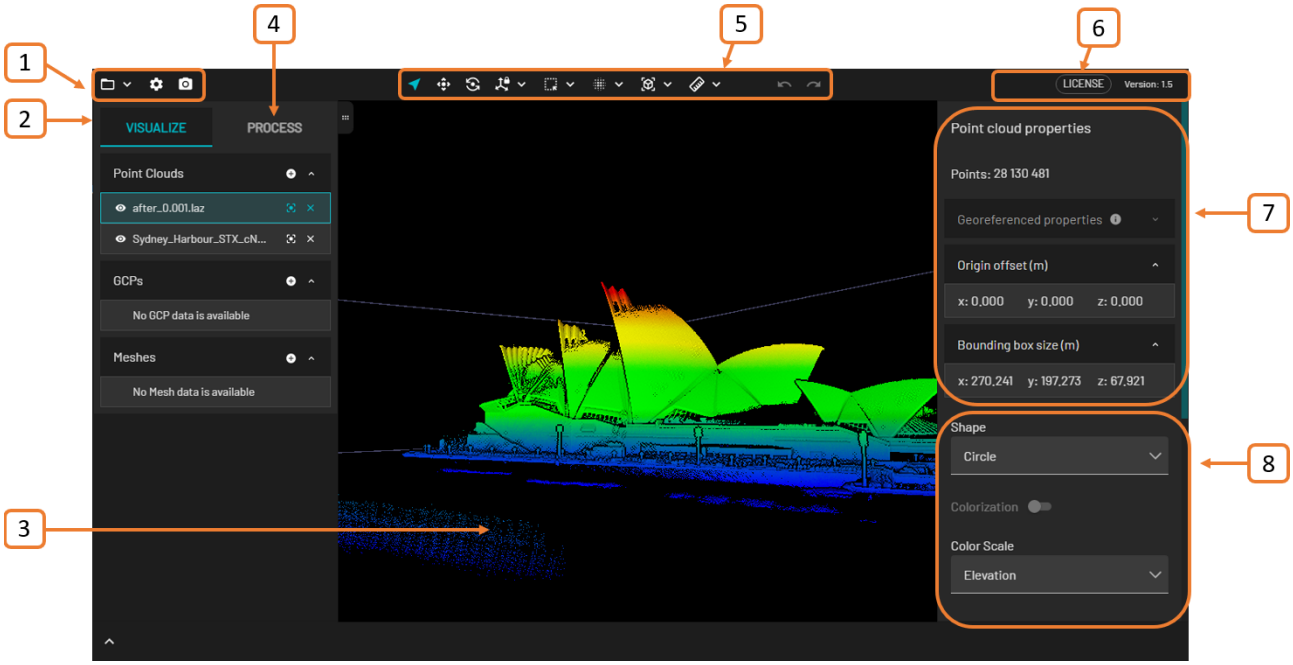


Figure 1 Emesent Aura UI

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.

2.4 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.

2.5 Step 5: Open a point cloud

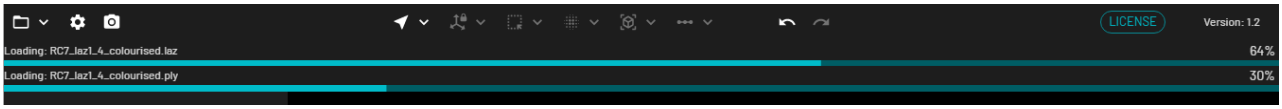
There are three ways to open files in Emesent Aura.

- 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 Technical Support Services 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.

2.6 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 two point clouds that share a single coordinate system. 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 go to Extract 360 Images Workflow section.
    - **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.

2.7 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.

2.8 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.

2.9 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.

2.10 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.

3. Emesent Aura UI

3.1 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.

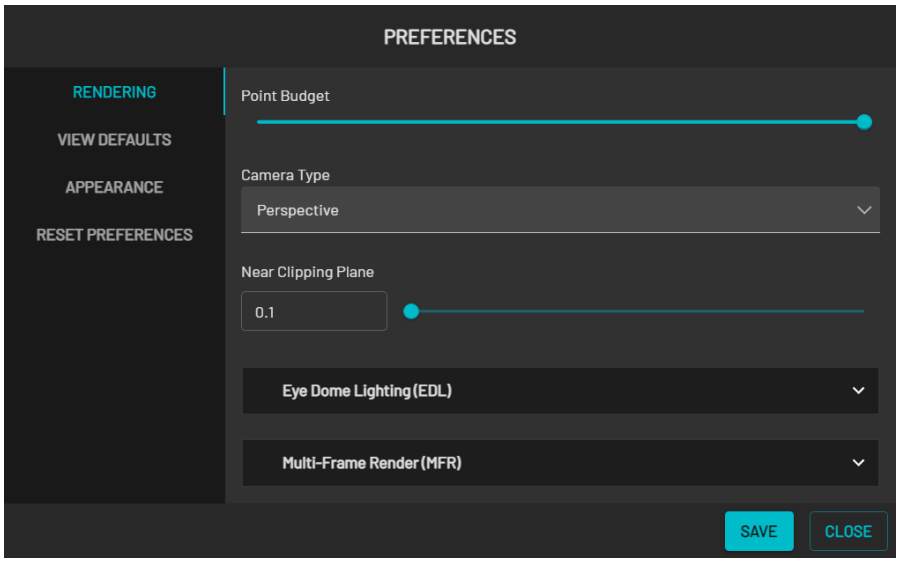
3.1.1 Project Menu

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

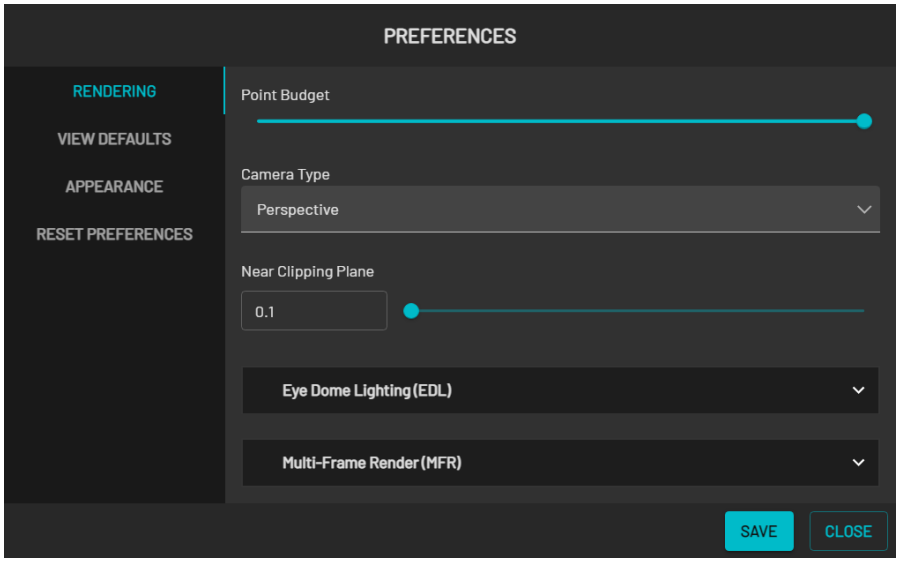
Table 1 Project Menu Options

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.

3.1.2 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* **Tips** • 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.

3.1.3 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.

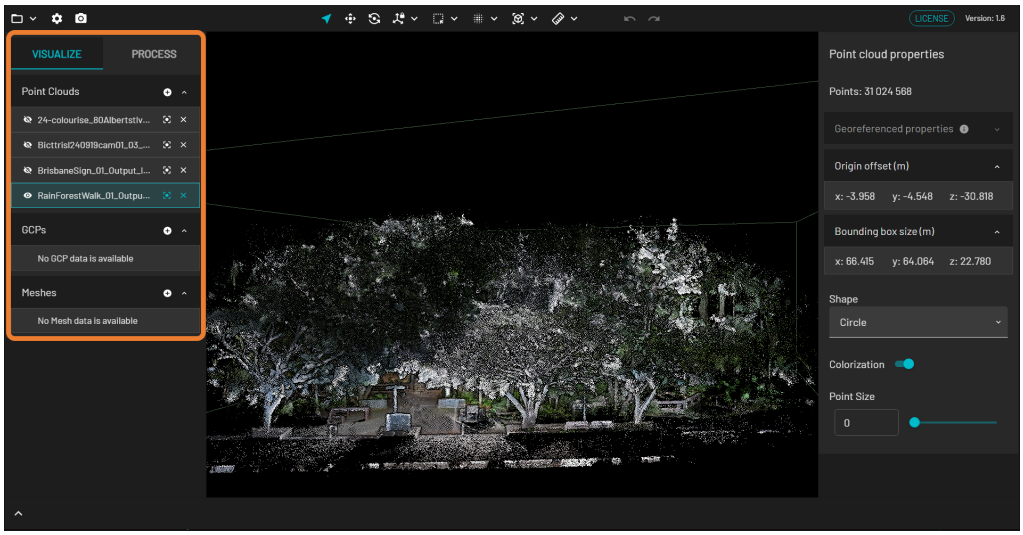
If you have **Multi-Frame Rendering** enabled, a high-quality screenshot will be produced. All settings, such as GCP landmarks, will appear in the screenshot.

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

3.2 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.



3.2.1 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

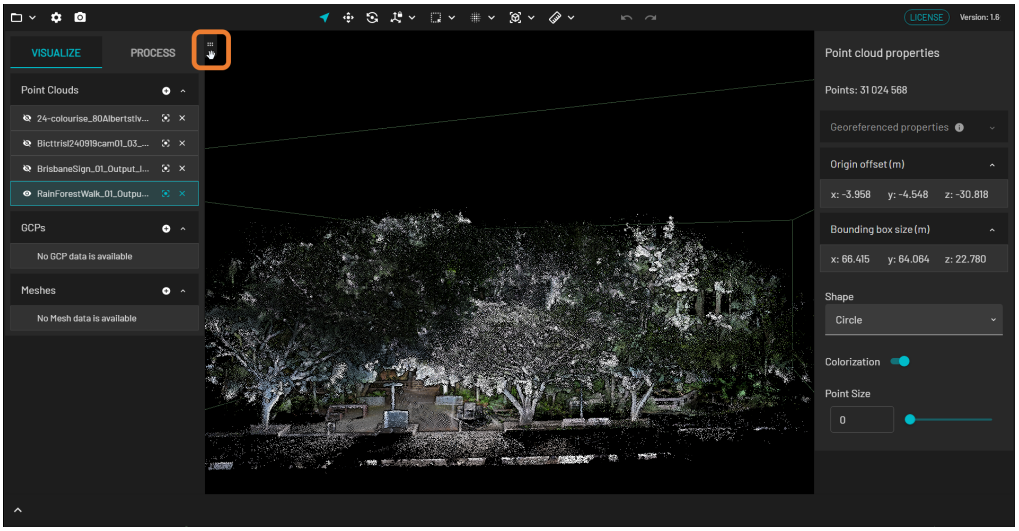
> PLY is a standard mesh file format, which also serves as a supported format for point cloud data. Currently, Emesent Aura does not offer the capability to generate PLY files; it only supports the loading of third-party generated mesh PLY files.
> Also, interaction for imported meshes is fairly limited.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

Table 3 Options

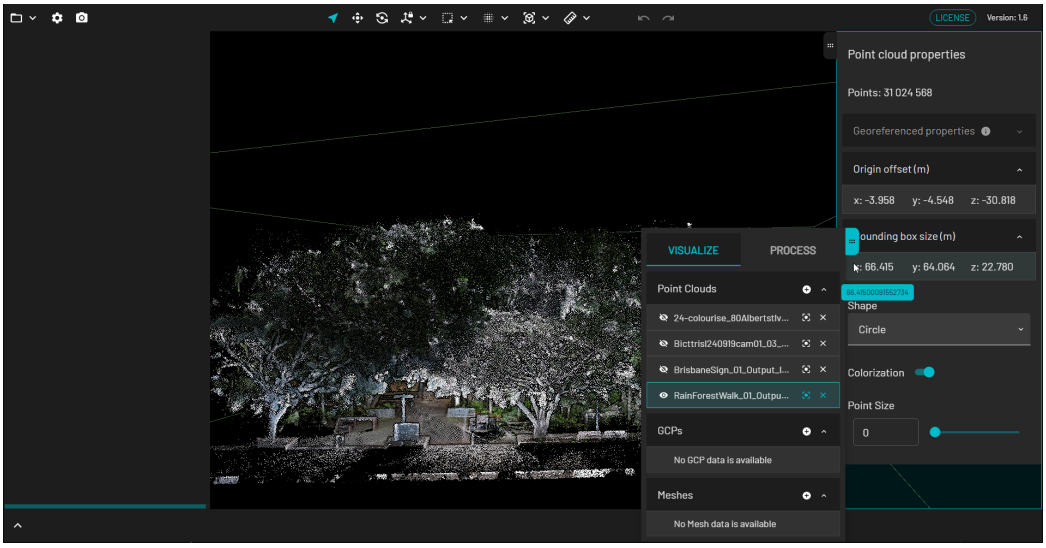
Button	Name	Action
	Display	Shows the file the in viewport. You can display multiple files at the same time.
	Hide	Hides the file in the viewport.
	Remove	Removes the file from Emesent Aura.
	Focus	Allows you to focus on *this particular file* in the viewport.

3.2.2 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.

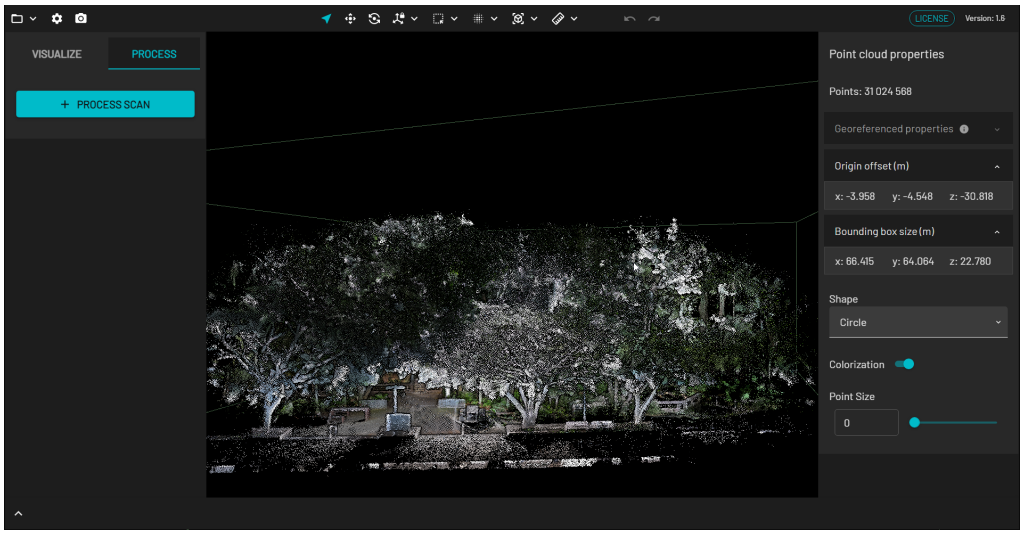


Alternatively, you can make the panel float anywhere on the screen.

3.3 Process Tab

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

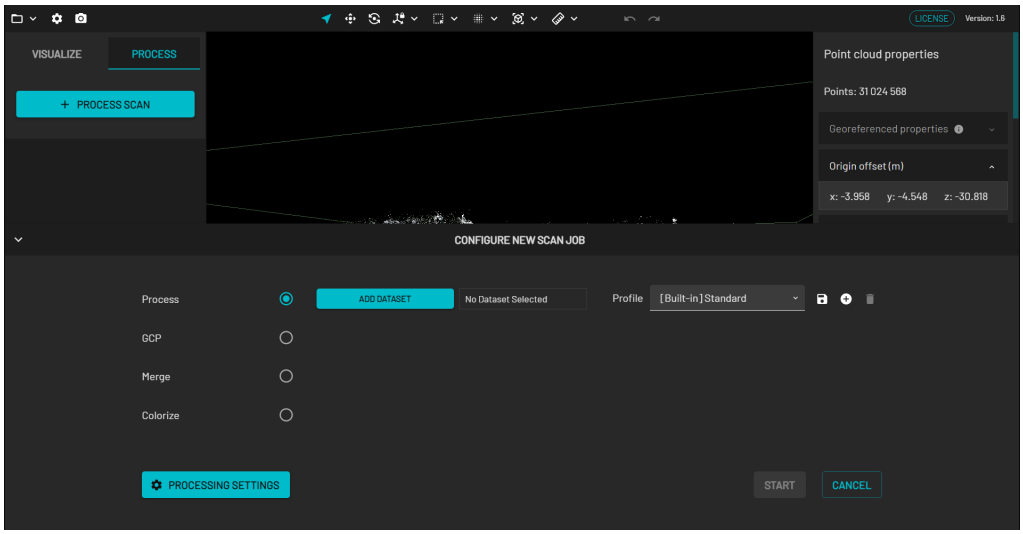
> Refer to the Visualize Tab section for docking instructions or making the panel float on the screen.



3.3.1 Configure New Scan Job Panel

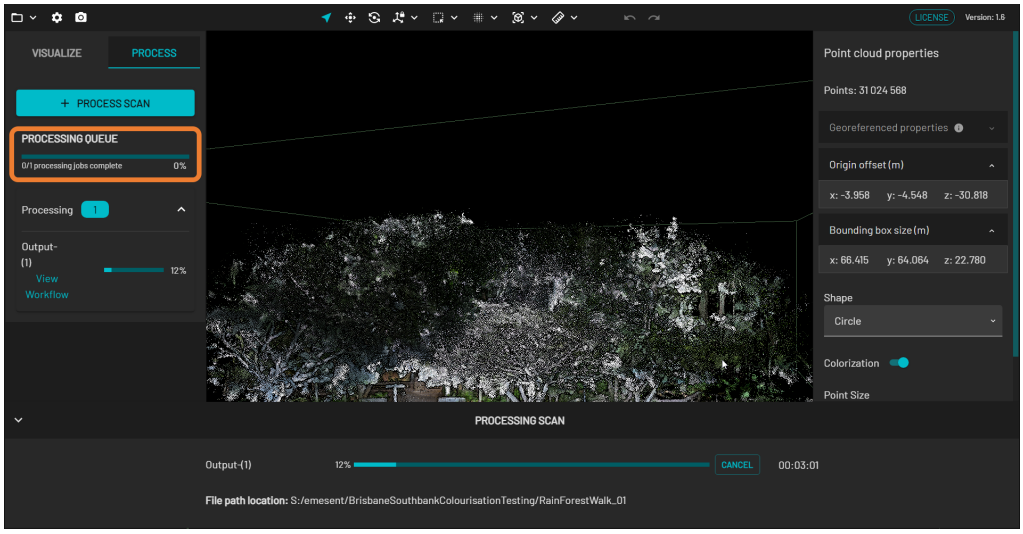
Clicking on **Process Scan** displays the **Configure New Scan Job** panel, which allows you to process a point cloud or GCP data. Once processed, enhance your scans using the **Merge** or **Colorize** features. You can then load these processed scans for editing in the **Visualize** tab.

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



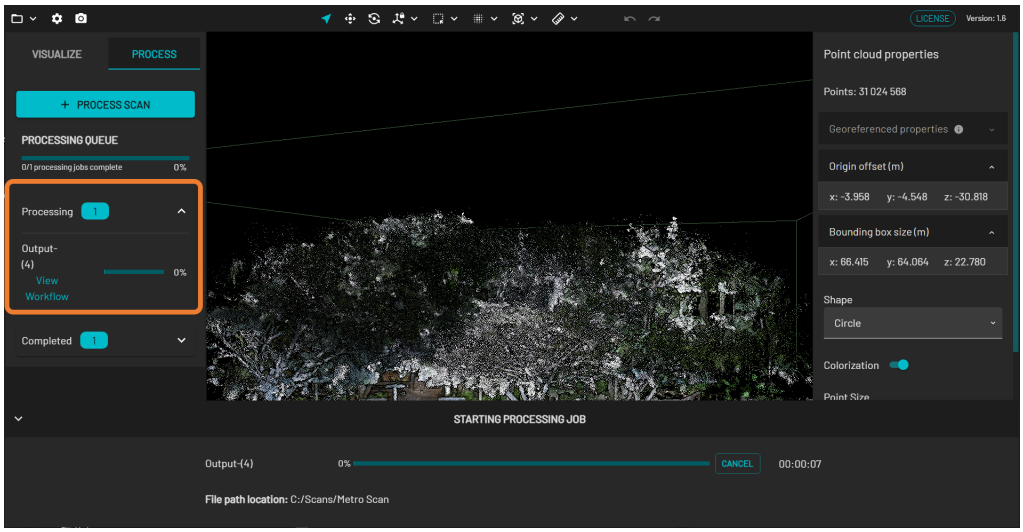
3.3.2 Processing Queue

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.



3.3.2.1 Processing

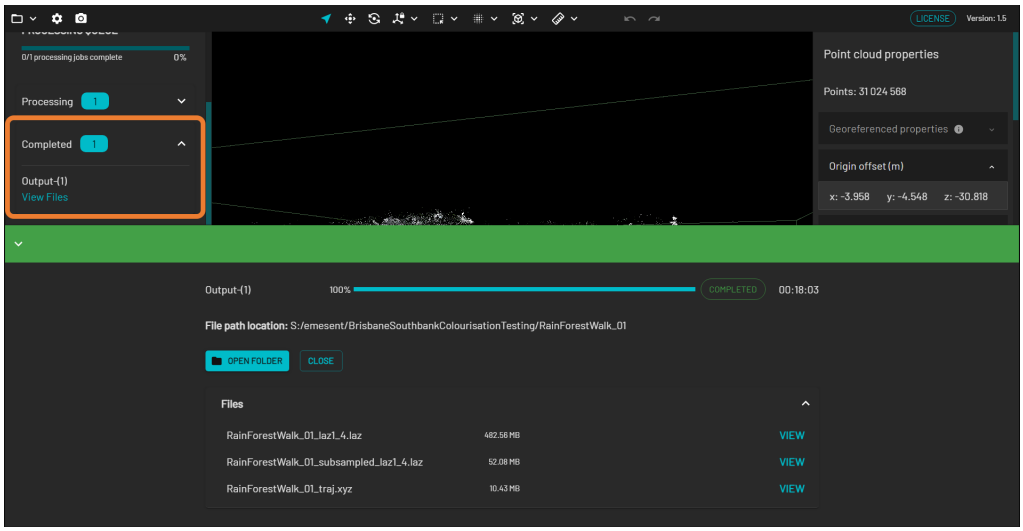
All current and pending workflows are shown in the **Processing** section. Each workflow shows the folder name where the output files are saved. Clicking on **View Workflow** displays the progress of that particular workflow at the bottom.



3.3.2.2 Completed

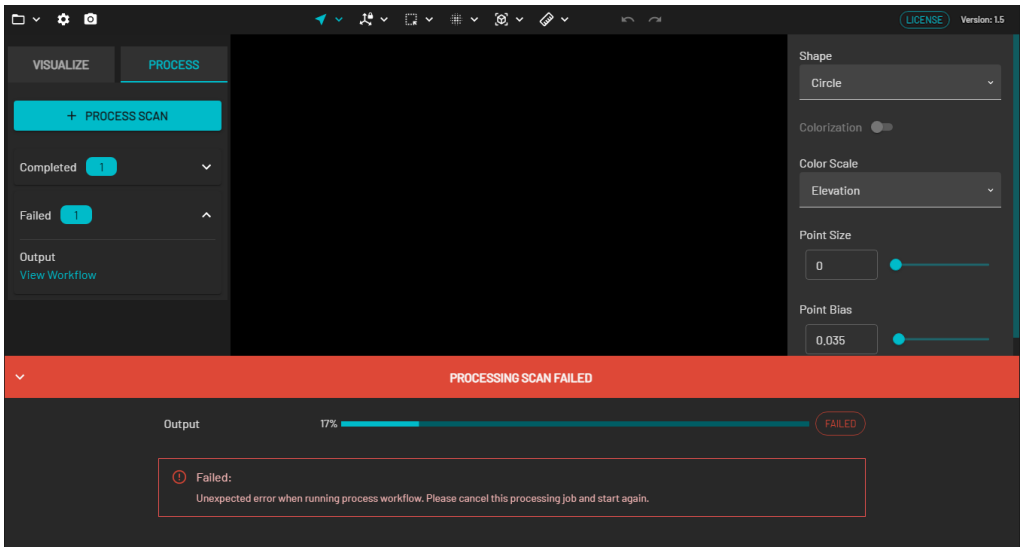
Once the processing is finished, the workflow is moved to the **Completed** section.

- 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.



3.3.2.3 Failed

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



3.3.3 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.

3.3.3.1 General Tab

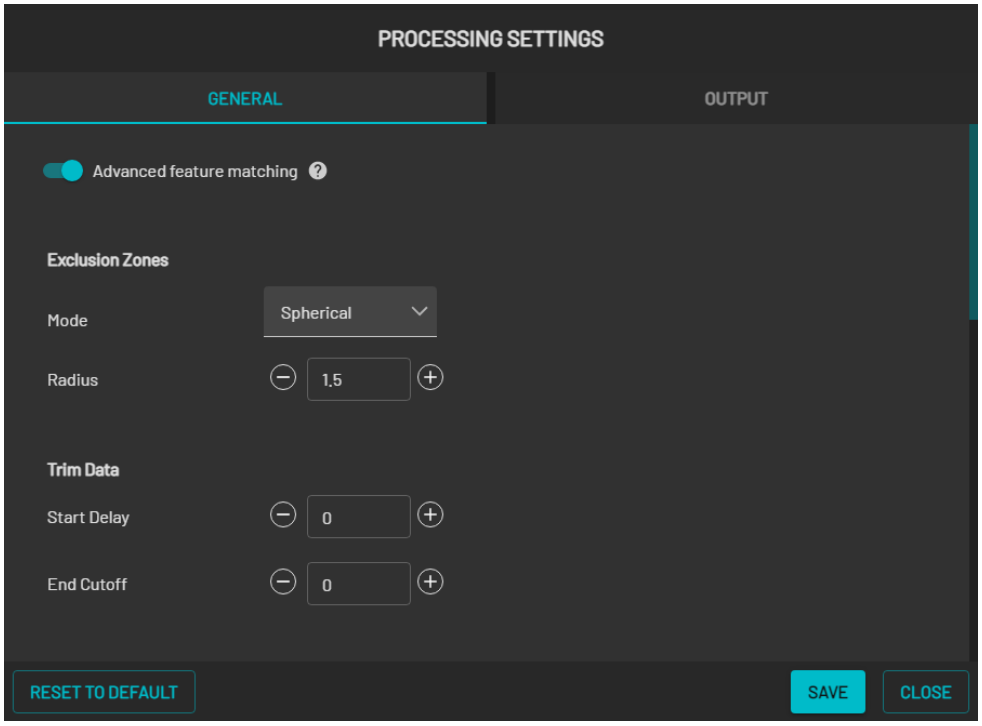


Table 4 Processing Settings - General Tab

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.

Field	Data

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:
	
	• **Spherical:** Sets the minimum distance that points must be from the LiDAR sensor *in any direction* before they are accepted for processing.
	  ◦ **Radius:** Measured in meters.
	  Default setting: 1.5 m
	• **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.

Field	Data

	• **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.

	• **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 Technical Support Services.	
Local mapping	

Field	Data
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* • **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*
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*

Field	Data
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*
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*

3.3.3.2 GCP Tab

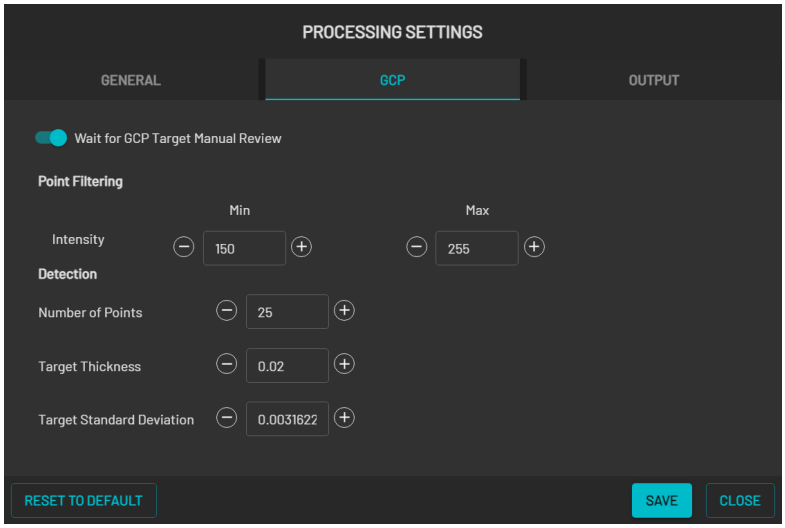


Table 5 Processing Settings - GCP Tab

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.

3.3.3.3 Merge Tab

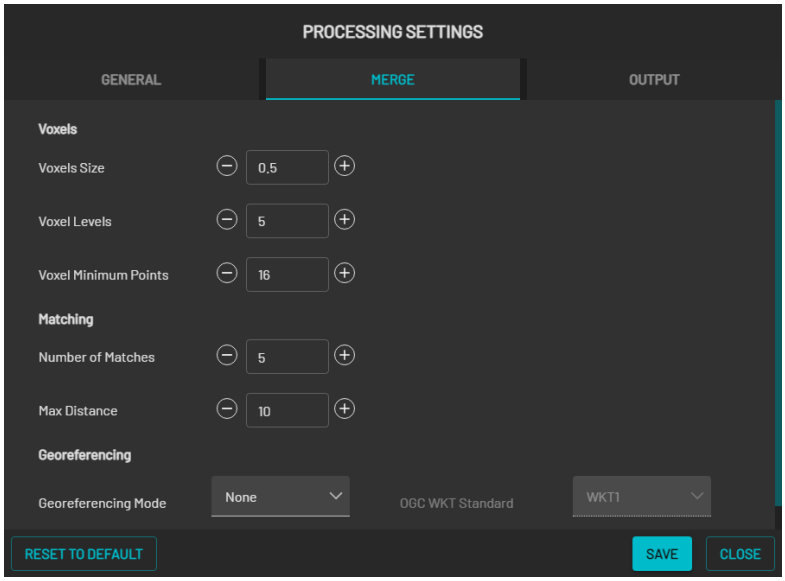


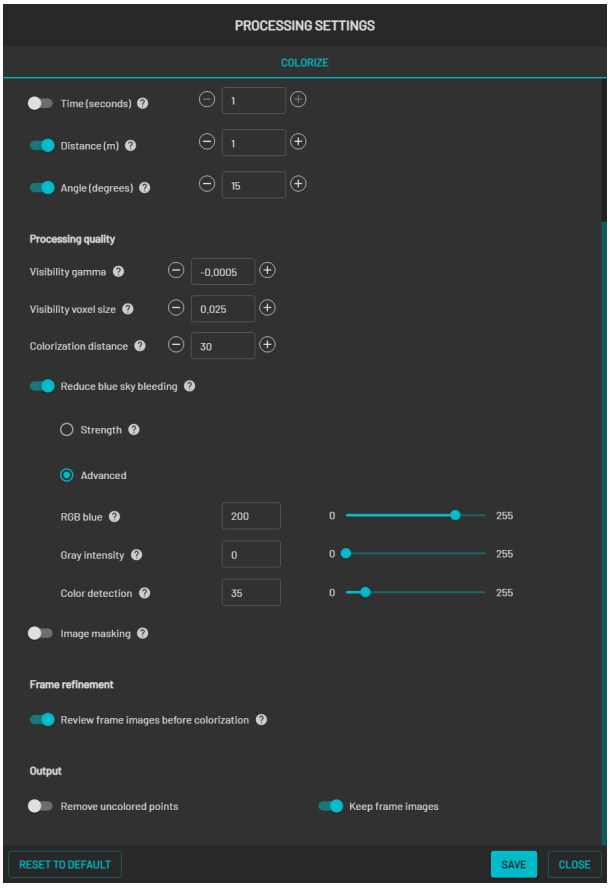
Table 6 Processing Settings - Merge Tab

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.

3.3.3.4 Colorize Tab



Colorization of point cloud outputs in E57 format is not supported in this version of Emesent Aura.

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:** 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.

Field	Data
Processing Quality	• **Visibility Gamma:** Adjusts the visibility of points in the point cloud. Values closer to zero will detect more points, which may lead to more points being colorized at the risk of additional noise in the colorized point cloud. The recommended range is between **0.0001** and **0.001**. • **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.

Field	Data
	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.
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.

3.3.3.5 Extract 360 Images Tab

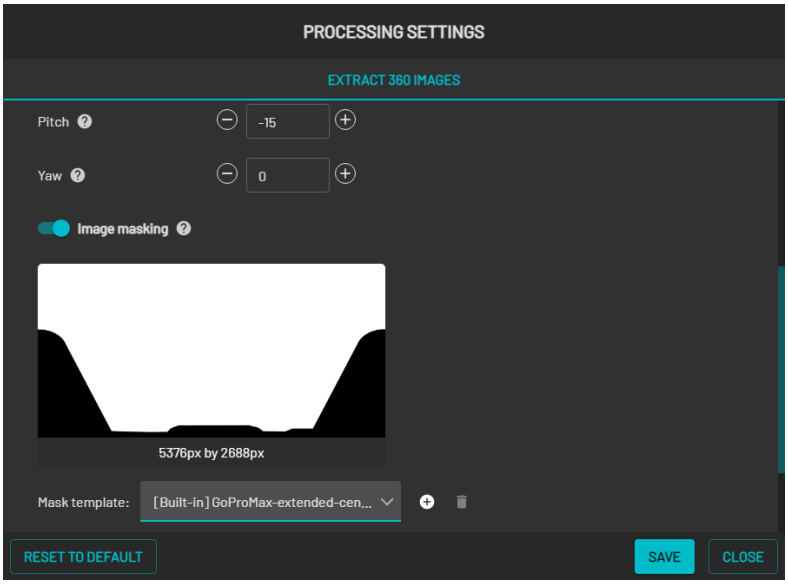


Table 8 Processing Settings - Extract 360 Images

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.

Field	Data
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.

3.3.3.6 Output Tab

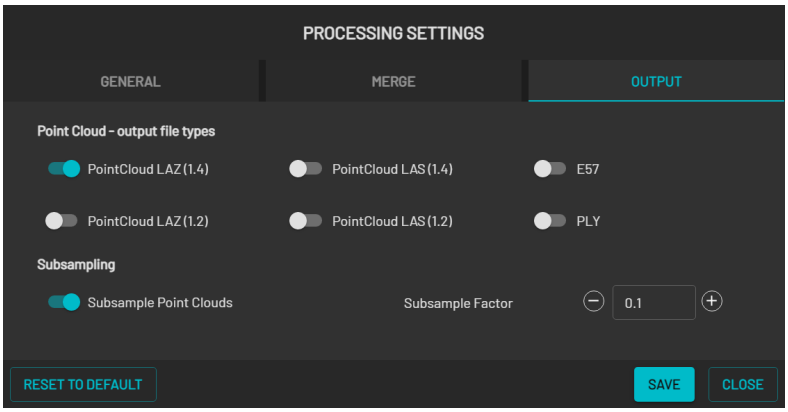
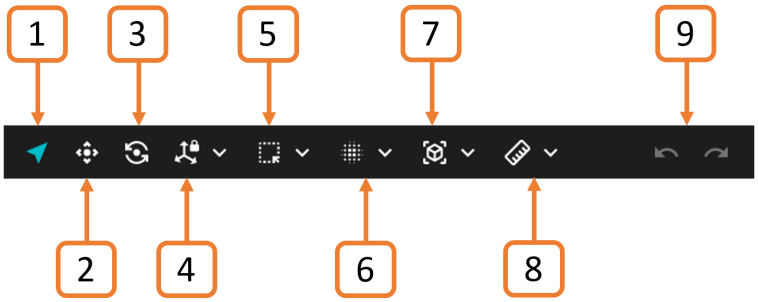


Table 9 Processing Settings - Output Tab

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. ℹ You can select more than one option.
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.

3.4 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

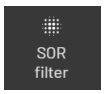
Warning
The Undo/Redo function is only currently available for certain tools. If you need to make any major changes, we recommend that you first save your file using the **Save** or **Save as** options in the **Project Menu**.

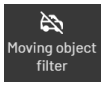
Table 10 Main Toolbar

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 **Warning:** 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.

3.5 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.

3.5.1 Point Clouds

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

3.5.1.1 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.

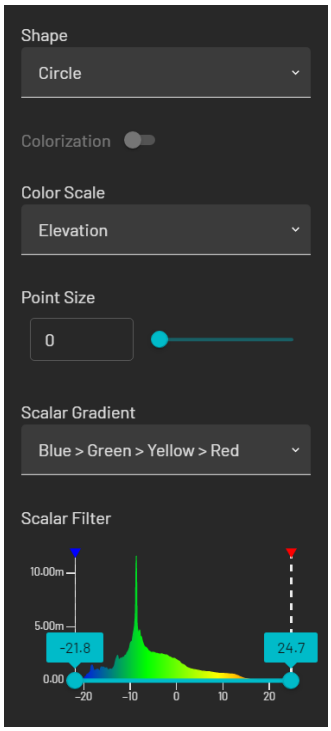


Table 11 Context Panel - Point Clouds

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. Colorized files contain configuration settings that tell Emesent Aura whether this is an option.
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 for 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 appears that allows you to visualize the distribution of intensity, time, or range in your data. You can move the stops at each end of the graph to control the way the color is presented.
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.

3.5.1.2 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.

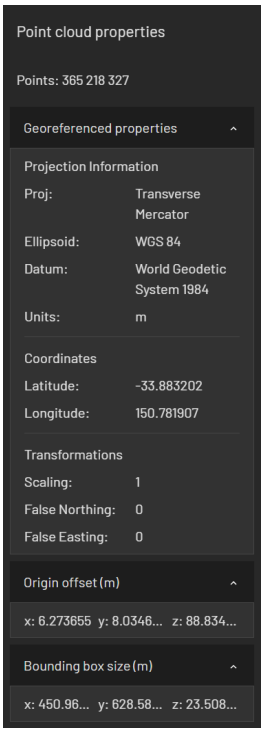


Table 12 Context Panel - Point Clouds

Information	Description
Points	The number of points in the point cloud dataset (total number of points if multiple point clouds are selected).
Project Information	Displays the map projection used, the mathematical model, and the reference framework used to represent the Earth's shape and orientation. The measurement unit applied to coordinates and dimensions are also provided.
Coordinates	The geographic coordinates indicating its global position.

Information	Description
Transformations	Shows the scaling factor and the offsets applied to coordinates to ensure positive values and prevent negative coordinates.
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).

3.5.2 Ground Control Points

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

3.5.2.1 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.

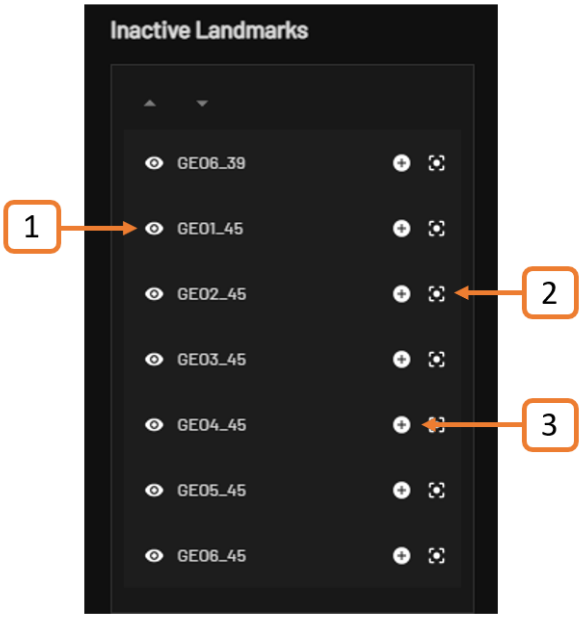
> A landmark can have multiple GCP targets associated with it to provide redundancy and improve accuracy.

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.

Setting	Description
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.

3.5.2.2 Inactive Landmarks

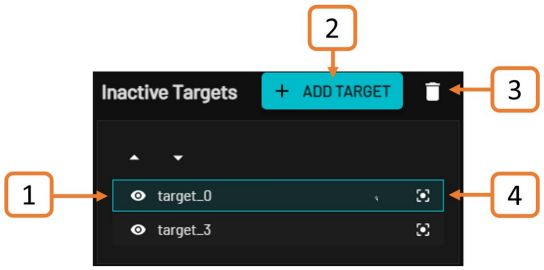
This list contains identified landmarks that have not yet been matched to any target in the constellation. When aligning point cloud data to a known coordinate system using GCPs, Aura will detect landmarks within the point cloud but they may not be suitable as GCP targets. You can choose to delete these 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.

3.5.2.3 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.

3.6 Viewport

Use the Viewport to navigate and manipulate your point cloud. 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.

4. Working with Point Clouds

4.1 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.

4.1.1 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. **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. **More Iterations:** This profile is designed for environments that are more challenging for the SLAM algorithm to handle. It increases the number of iterations.

Workflow	Profiles
	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.
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.

Workflow	Profiles
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 default profile provides a set of configuration parameters for extracting images on a 360 video captured with the telescopic mount fully extended.

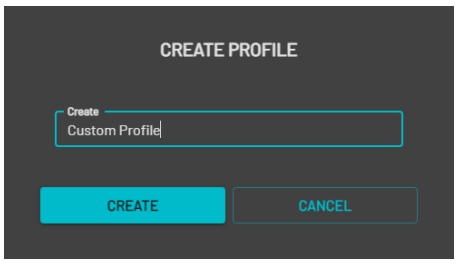
4.1.2 Custom Profiles

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.

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

To create a new processing profile:

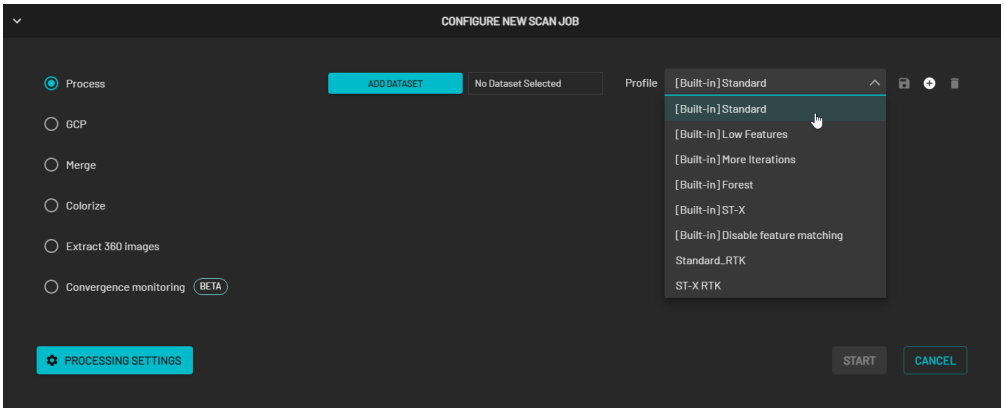
1. Go to the **Process** tab then click **Process Scan**.
2. Select the workflow to create a new profile for then click the **Add Profile** icon.
3. In the **Create Profile** dialog box, enter a name for the new profile then click **Create**.



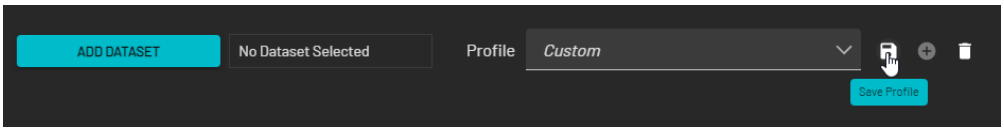
4. Click **Processing Settings** then customize the settings for the new profile.
5. Click **Save**. Your new profile should now be available in the dropdown list.

To save a custom profile:

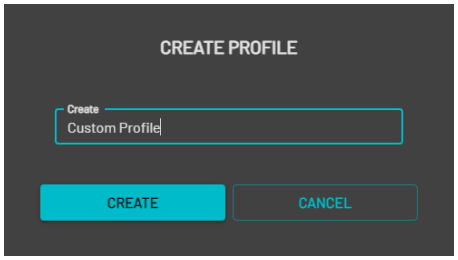
1. Go to the **Process** tab then click **Process Scan**.
2. Select a workflow then select from one of the available built-in profiles.



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.



4.2 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.

4.3 Process Workflow

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

> **Note**
> 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.

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

4.3.1 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.

4.3.2 Step 2: Copy the data to your computer

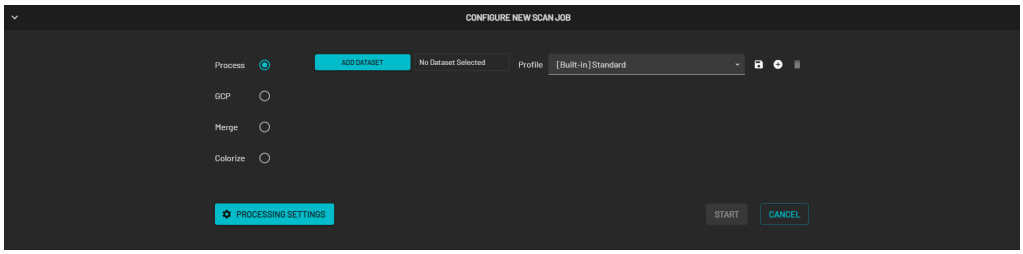
Copy the data from the USB flash drive to a local drive on your computer so that you can begin processing.

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

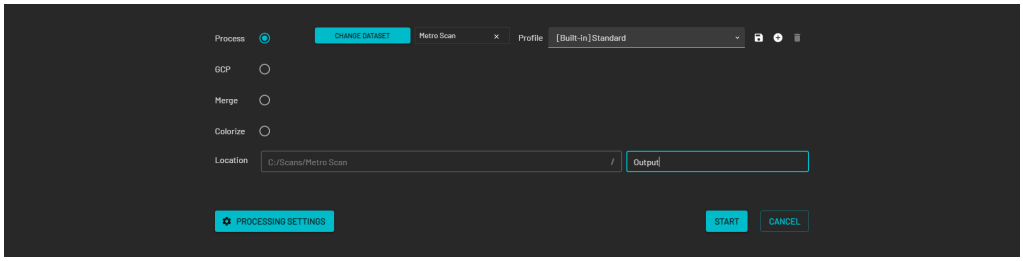
For scans from a Hovermap that use Emesent Cortex version 3.3 (or later), it is essential to ensure that both `metadata.yaml` and `platform_configuration.yaml` files are included in the same folder as your scan files. These files contain crucial information required for processing the point cloud data.

4.3.3 Step 3: Configure your processing job

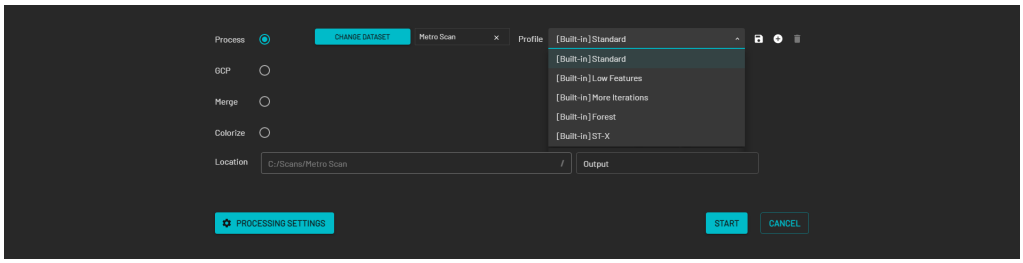
1. Open Emesent Aura. Make sure you have an active **SLAM** license.
2. In the **Process** tab, click **Process Scan**.
3. In the **Configure New Scan Job** panel, select the **Process** workflow.
4. Click **Add Dataset.**
5. Browse for the folder that contains the raw point cloud dataset to be processed.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



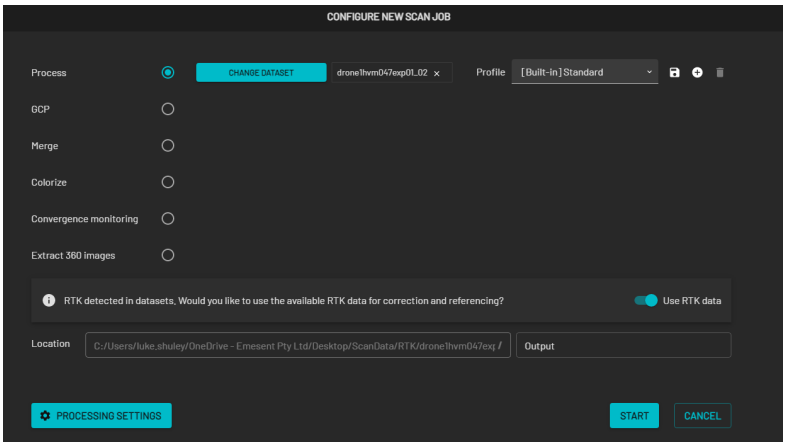
7. Select the processing profile to use. Refer to the Processing Profiles section for more information about which profiles to use and how to create a custom profile.



4.3.4 Step 4: (Optional) Use RTK Data

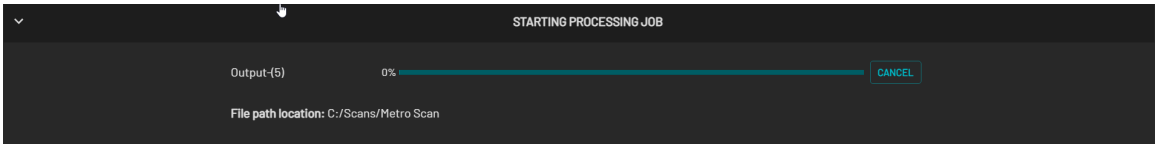
1. If RTK data is detected in your dataset, toggle on **Use RTK data** to use the real-time corrections provided by the RTK system to improve the georeferencing accuracy of the point cloud data.

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



4.3.5 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.

4.3.6 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.

4.4 Cleaning your Point Cloud

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

4.4.1 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.

4.4.2 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.

4.4.3 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.

4.4.4 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

4.4.5 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.

4.4.6 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.

4.4.7 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.

4.5 GCP Workflow

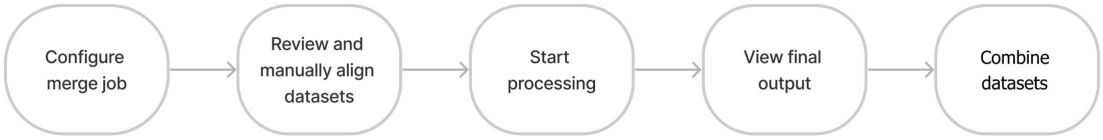
The Emesent Knowledge Base article Working with Point Clouds - GCP Workflow walks you through the entire GCP workflow step-by-step, and links to the complementary video Best Practice for Automated Ground Control Points.

4.6 Merge Workflow

The primary purpose of the Merge workflow is to align multiple point cloud datasets together so that they share a common coordinate system, which is useful for change detection or correcting the edges of your datasets (where Hovermap's accuracy naturally drops off). This function ensures that the points from different datasets are correctly positioned relative to each other.

You need to include a reasonable amount of overlap between scans to provide sufficient information for alignment. The exact amount of overlap varies, depending on the environment and individual dataset trajectories. However, a rough guide is to have one-third of each dataset overlap with the next.

> When working with multiple datasets, it is important to consider the demand on system resources. As you align additional datasets, the demand will increase accordingly.



The basic process for merging is as follows.

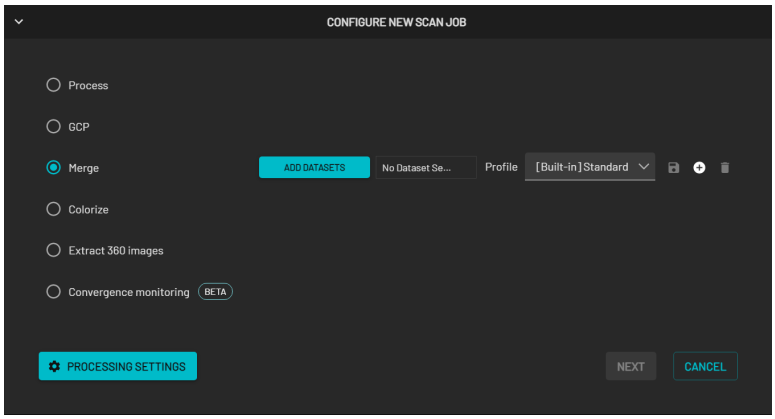
4.6.1 Step 1: Configure your merge job

> **Merge** doesn't support georeferenced or reprojected data, so make sure that scans you process for merging had the **Georeferencing** mode set to **NONE**.

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 **Merge** workflow.

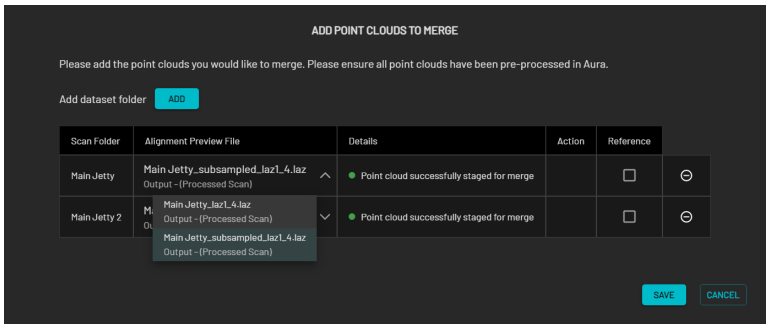
4. Click **Add Datasets**.



5. In the dialog box that displays, click **Add** then browse for the the point clouds you want to align. Make sure all the point clouds have been pre-processed in Aura.

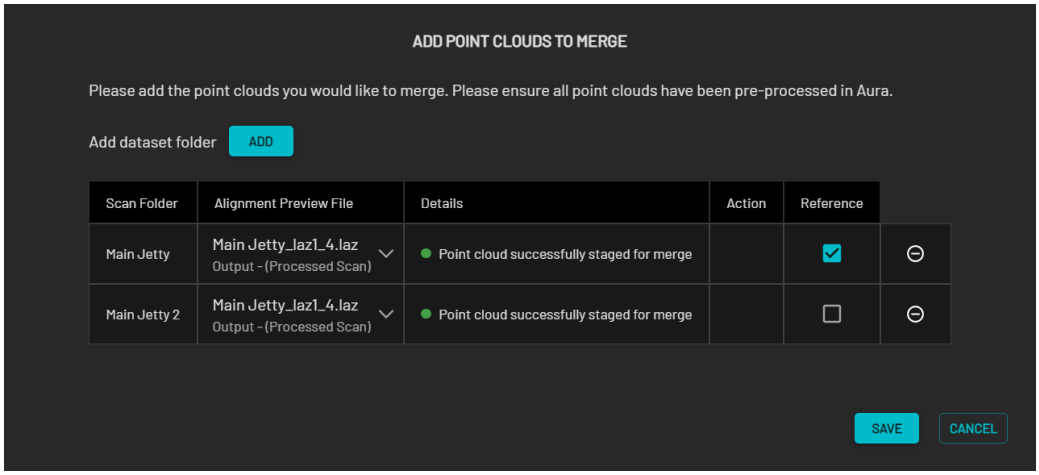
> There is no strict limit to the number of files you can align. You can work out your limit based on the size of your point cloud files and your RAM. Avoid merging point cloud files that add up to more than the sum of your RAM. You should also account for the amount of RAM your system requires to run.

6. In the **Alignment Preview File** column, select the scan file to use for alignment.

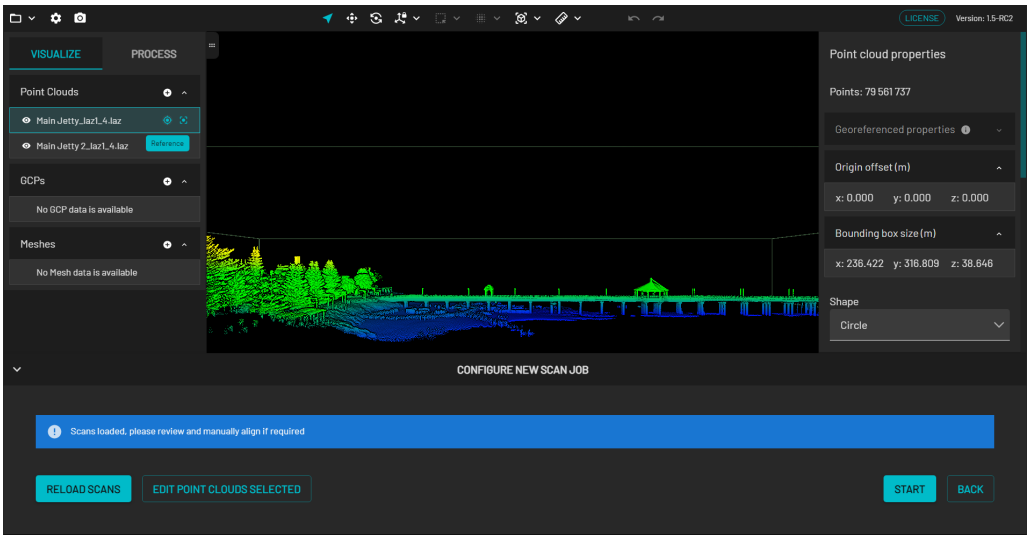


> **Tip:** Merging is done on the full point cloud regardless of the selected **Alignment Preview File**. To make the alignment process more practical, it is recommended to use only the subsampled files to lower the computational resources needed, especially for large datasets. In addition, the reduced set of points on a subsampled file allows you to focus on key features or points of interest, which can facilitate more accurate alignment, leading to higher-quality merged point clouds.

7. Select the reference scan file. The reference scan file provides a fixed frame of reference for aligning the other point clouds. Selecting a reference scan establishes a coordinate system that other scans can be transformed into, ensuring proper alignment between them.

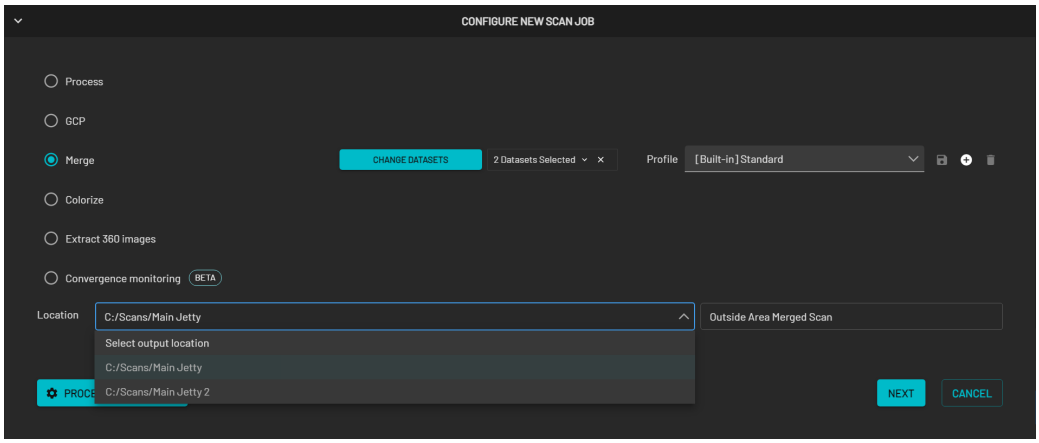


A target icon beside the point cloud file in the Visualize tab indicates a referenced scan file.



> If a reference scan file is not selected, Emesent Aura will perform the alignment between all point clouds leading to increased computational complexity and processing time.

8. Once you have added all the point clouds to merge, click **Save**.
9. In the **Location** field, enter the preferred name for the output folder. Also, select the location where this folder will be created.



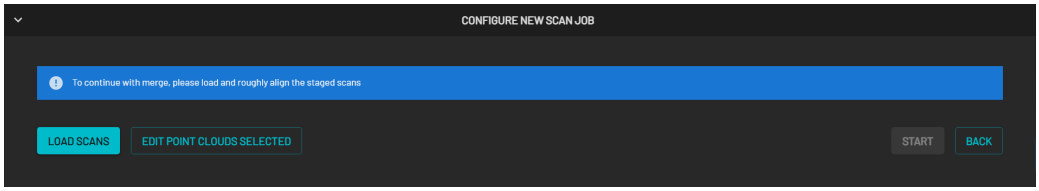
10. Choose your merge profile. Refer to the Processing Profiles section for more information on which profile to choose. Click **Next**.

4.6.2 Step 2: Review and manually align your datasets

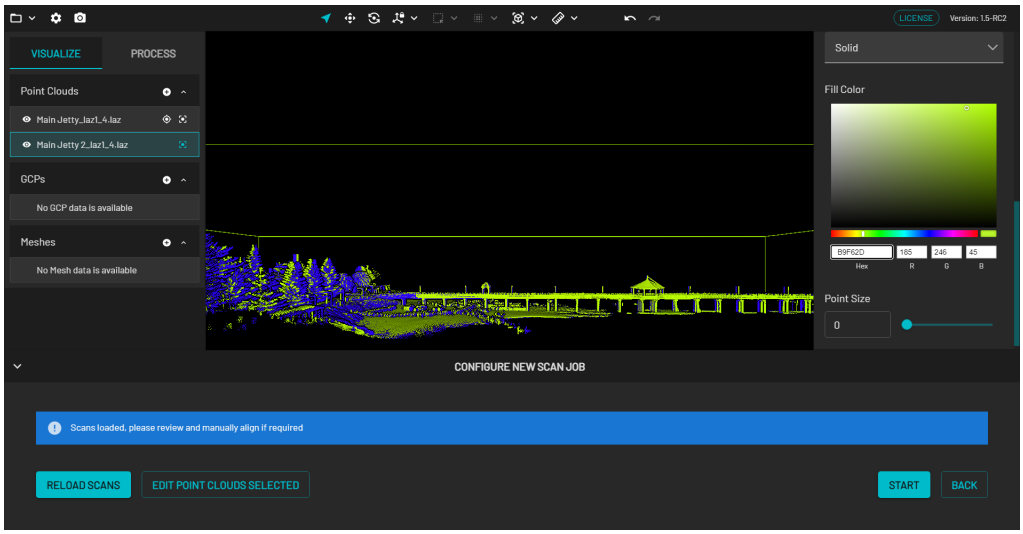
To manually align your point clouds:

1. Click **Load Scans** to start your review. All scans will load at the same time.

> To add or remove a dataset from the current merging job, click **Edit Point Clouds Selected**.



2. Set a unique color for each point cloud to easily differentiate and identify individual point clouds in the merged dataset. To do this, select your point cloud in the **Visualize** tab then go to the Context panel. Under **Color Scale**, select **Solid** from the dropdown list. In the **Fill color** section that appears, select a color from the color palette or choose a custom color by specifying the RGB or Hex values.



3. Once you have set the colors for all point clouds, go to the **Visualize** tab then select your point clouds. Press **Shift** to select more than one point cloud.

   a. In the **Main Toolbar**, set the view to **Top** then go back to the **Visualize** tab and select only your second point cloud.

   b. In the **Main Toolbar**, use the **Translate** tool to drag the second point cloud and align it with your reference point cloud on a common point.

   c. In the **Main Toolbar**, use the **Rotate** tool to further improve the alignment. Repeat as necessary to achieve a reasonable alignment when viewed from above.

   d. Select all your point clouds again then go to the Main Toolbar and set the view to **Front**.

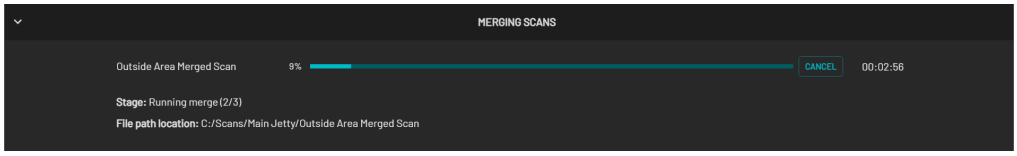
   e. In the **Main Toolbar**, use the **Translate** tool to drag your second point cloud up or down to align it with your reference point cloud.

> Click **Reload Scans** to discard all your changes and reload the original datasets.

> It is important that you make sure your Z axis is correct before you continue processing. You will need to do this manually. Your point clouds will attempt to merge even if they are at different heights, skewing your final dataset in the process.

4.6.3 Step 3: Start processing

1. Click **Start** to begin processing. The **Configure New Scan Job** panel is replaced with the **Processing Scan** 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.



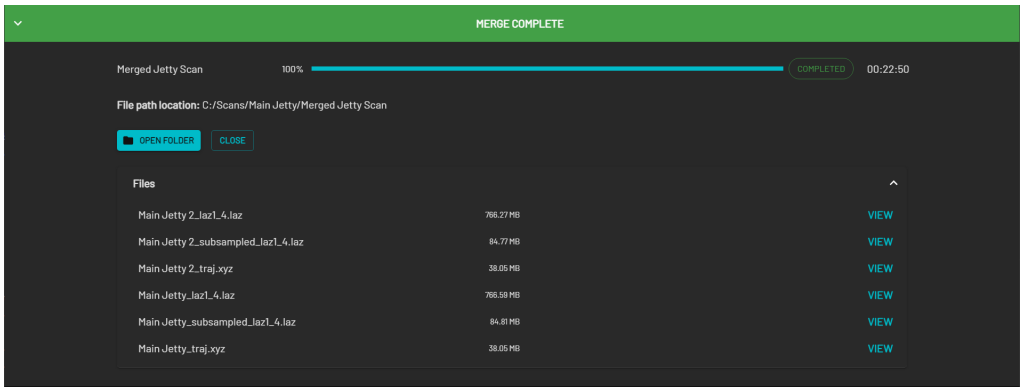
> If a failure occurs during processing, the **Retry** buttons becomes available. Click this button to attempt to process the current job from the last successful stage.

4.6.4 Step 4: View your final output

> The Merge workflow does not combine multiple point cloud datasets into a single, larger dataset. Refer to the next step for instructions on combining datasets.

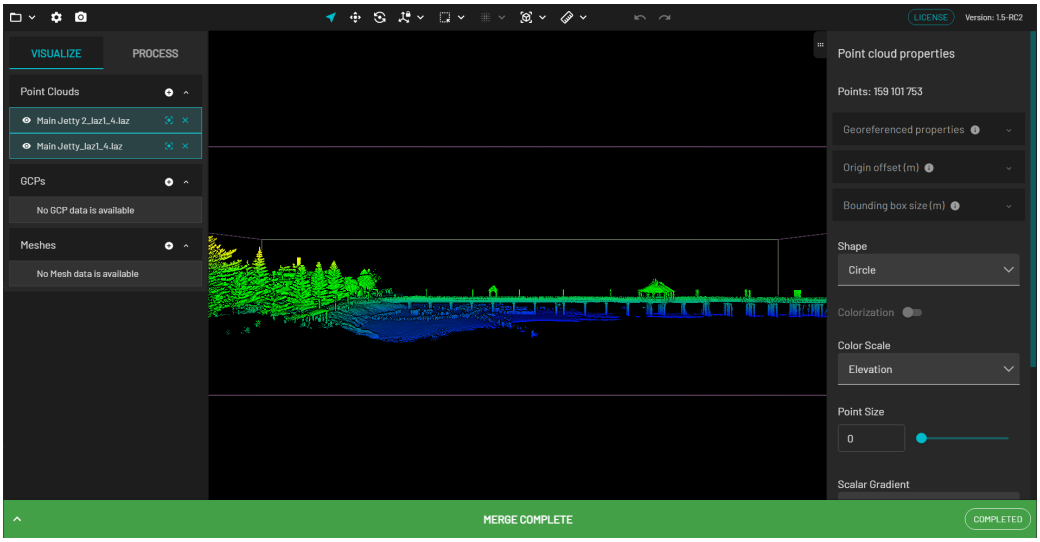
1. Once processing has been completed, you will get a **Merge Complete** notification and the generated files are displayed. Each output will have a **View** option, which displays the generated point cloud (**.laz**) or trajectory (**.xyz**) in the Viewport.
2. Once loaded into the Viewport, you can then interact with your point cloud.

3. Click **Close** to remove the completed scan information from the processing space.

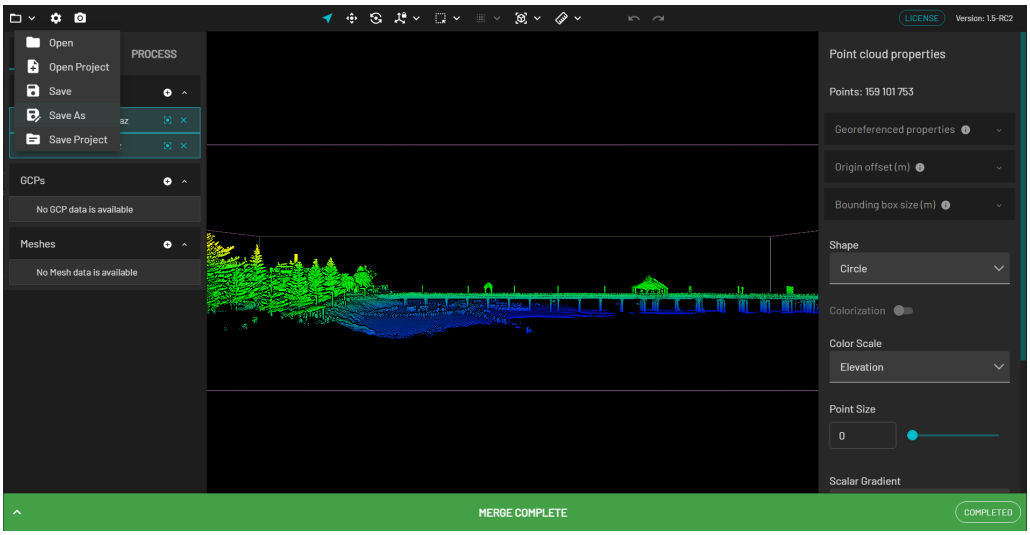


4.6.5 Step 5: Combine your datasets

1. Click **View** for each dataset you want to combine to load them in the **Point Clouds** section of the **Visualize** tab.
2. Hold down the **Shift** key then select the datasets you wish to combine.



3. Once selected, click the **Project Menu** icon then select **Save As**.



> If you wish to do this at a later time, simply go to the to the **Visualize** then click **Add** next to the **Point Clouds** section.

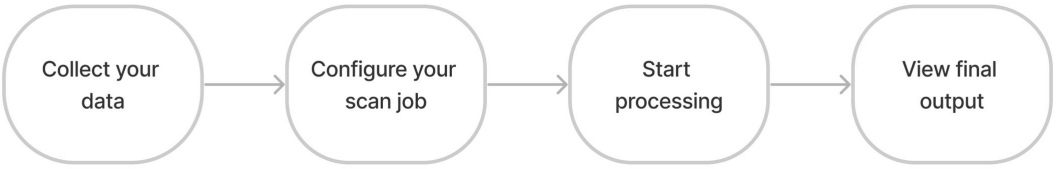
4.6.6 Step 6: Colorize your Merged Point Cloud (Optional)

From Emesent Aura version 1.5 or later, it is possible to colorize a merged point cloud. Refer to the Colorizing/Extracting 360 Images from a Merged Point Cloud section for instructions.

4.7 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.



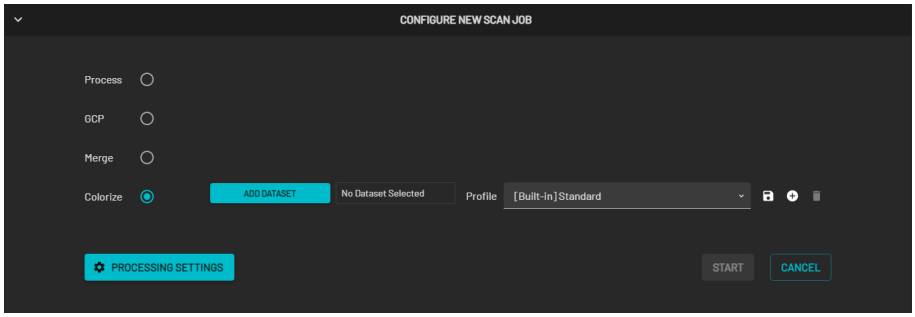
Reminder
Before you start, ensure that the **.mp4** (perspective camera) or **.360** file(s) are placed in the scan folder that contains the raw bag files. Open the video files after transferring using a suitable video playback software (e.g., VLC player which works for the .360 format) to ensure the file is not corrupted. This is a great opportunity to see which image mask to use.
Refer to the Creating a Custom Mask section for instructions on creating your own image mask.

4.7.1 Step 1: Collect your data

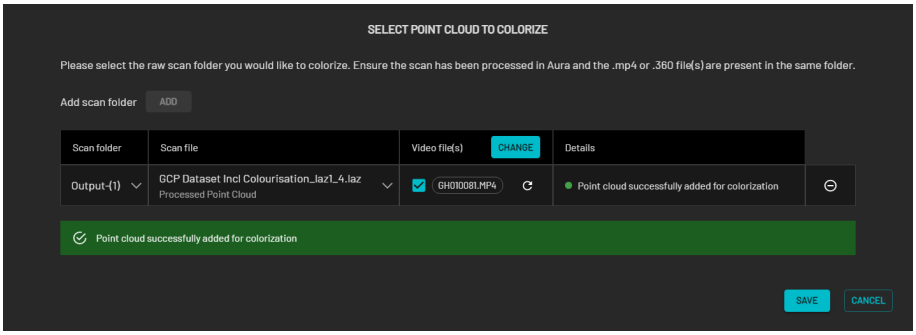
1. Go to Working with colorization for more information on how to set up your Hovermap and GoPro for colorization and colorization-specific scanning techniques.
2. Check that you have everything necessary to create a colorized point cloud:
   - An updated license dongle with a valid **Colorization**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

4.7.2 Step 2: Configure your scan job

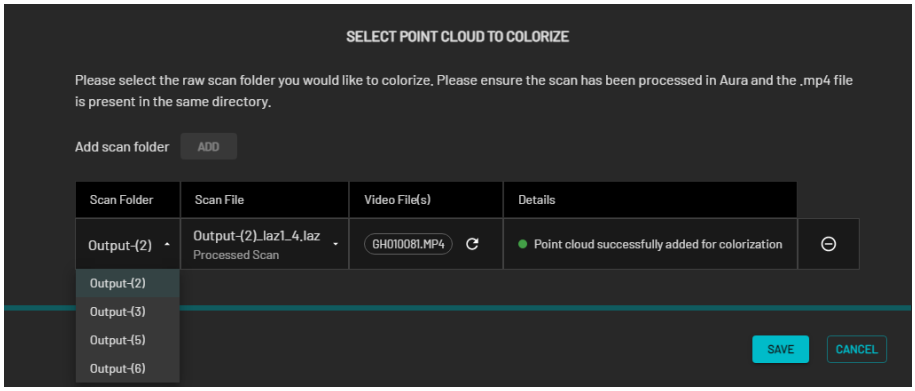
1. Open Emesent Aura. Make sure you have an active **Colorize** license.
2. In the **Process** tab, click **Process Scan**.
3. In the **Configure New Scan Job** panel, select the **Colorize** workflow.



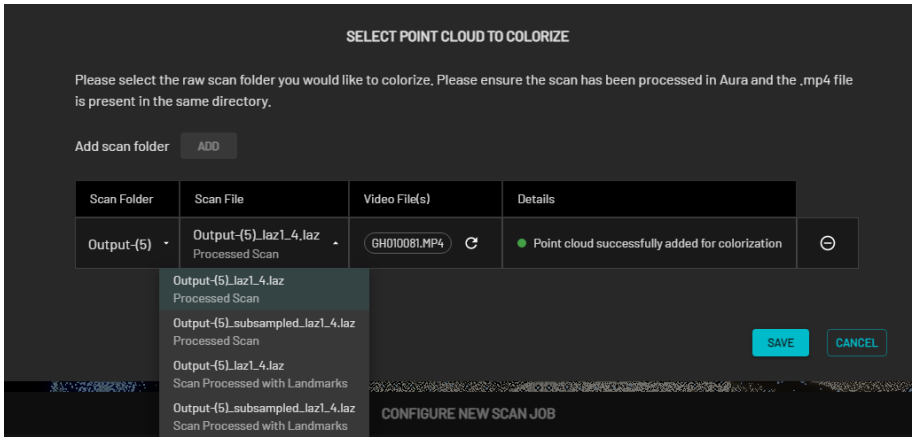
4. Click **Add Dataset.**
5. In the dialog box that displays, browse for the folder that contains the point cloud to be colorized. Ensure the scan has been processed and the **.mp4** file or **.360** file is in the same directory. If the video file is detected, it will appear in the **Video file(s)**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



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

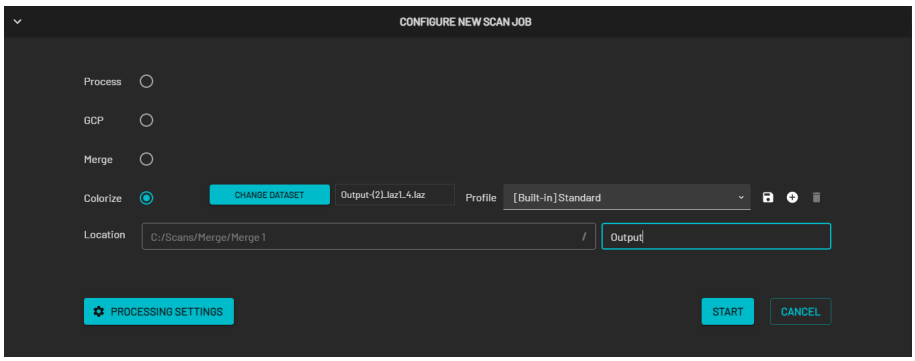


In addition, in the **Scan File** column, the non-georeferenced output is selected by default. If you want to colorize a georeferenced point cloud, click the arrow beside the scan file then select the file labeled **Scan Processed with Landmarks**.

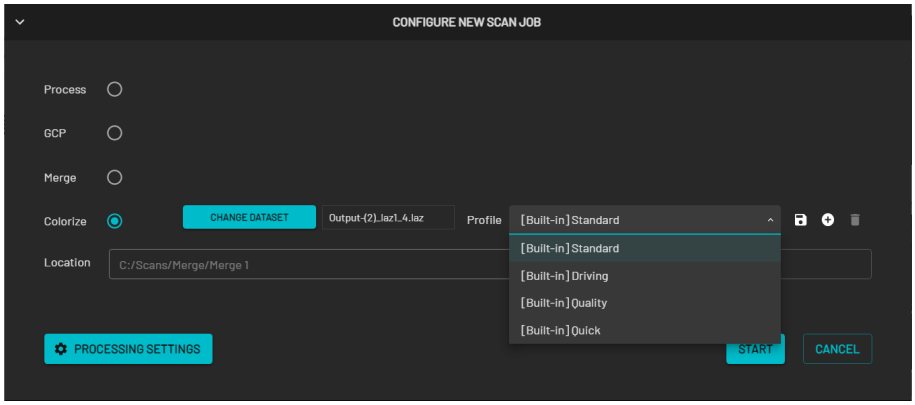


7. Once you have selected the point cloud to colorize. click **Save**.

8. 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.

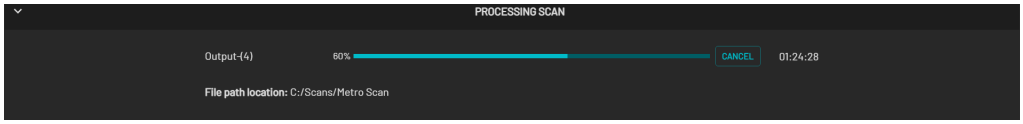


9. Select the processing profile to use. Refer to the Processing Profiles section for more information about which profiles to use and how to create a custom profile.

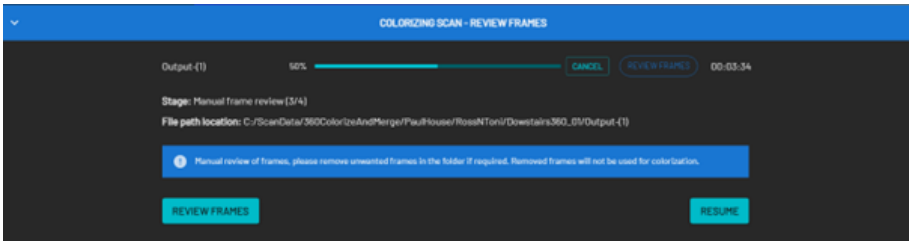


4.7.3 Step 3: Start processing

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**.

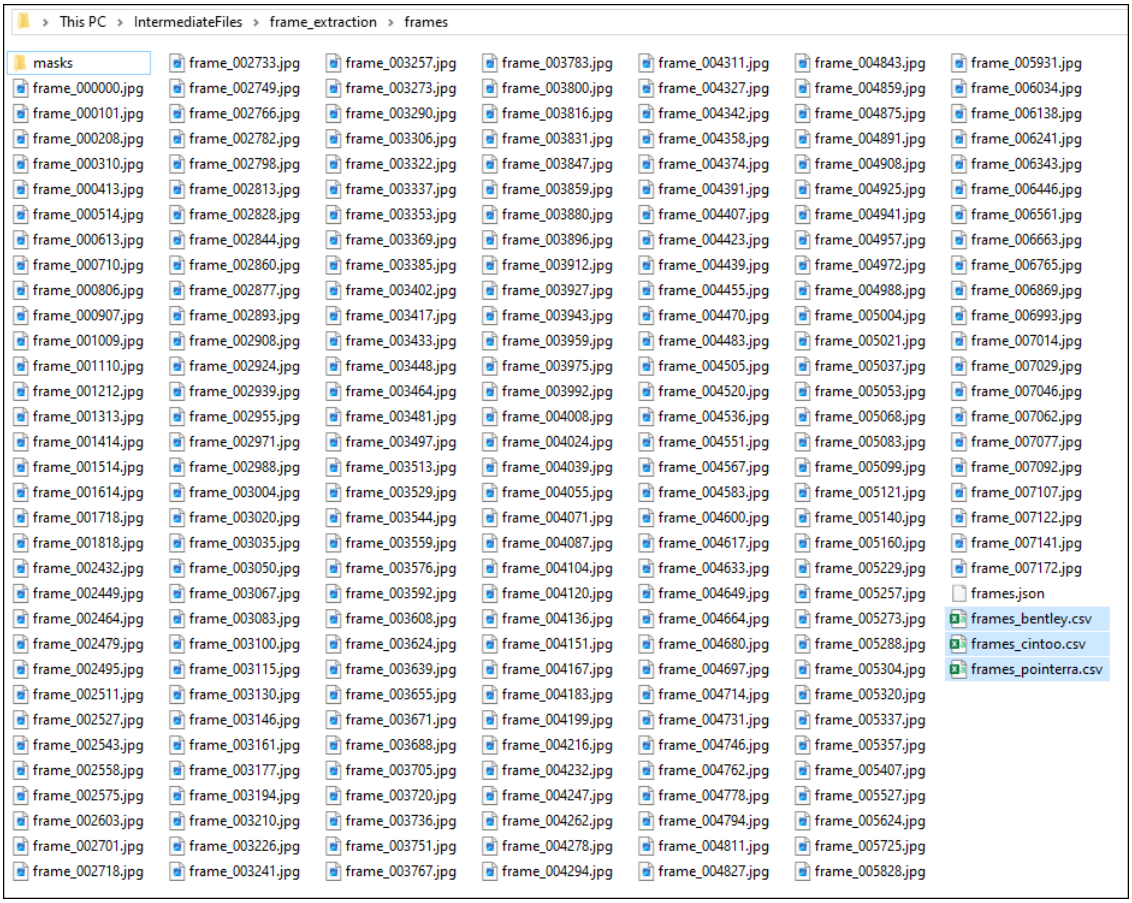
> **Note:** If a failure occurs during processing, the **Retry** buttons becomes available. Click this button to attempt to process the current job from the last successful stage.

4.7.4 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, and Bentley.



4.8 Extract 360 Images Workflow

Provide additional context to your point cloud by adding 360 contextual reality to your Hovermap point cloud scans. 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 to highlight areas of interest and enhance understanding for remote stakeholders or data users. Images are automatically registered and exported in Aura, ready for visualization.

Integration with third-party applications – such as Emesent partner Pointerra3D – allows the effortless display and sharing of visualizations via a simple streamlined workflow.

4.8.1 Step 1: Copy video files

Copy the **.360** video file(s) from the GoPro MAX into the same folder as your raw point cloud data.

4.8.2 Step 2: Process raw point cloud data

Before you can proceed with the image extraction, the raw point cloud data must be processed first. Refer to the Process Workflow for instructions on processing the point cloud.

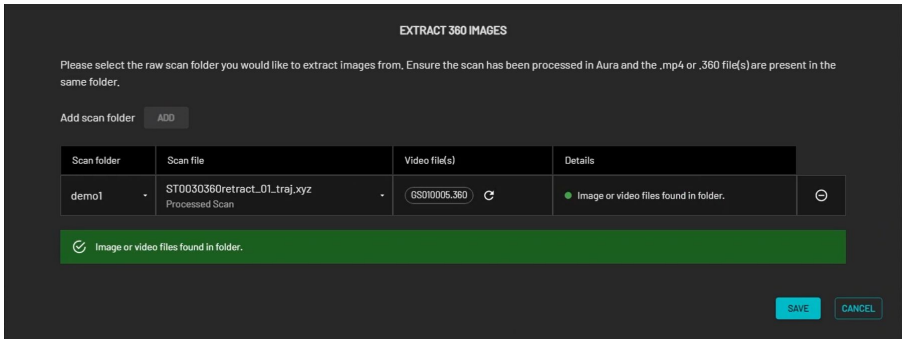
4.8.3 Step 3: Configure your processing job

Once the raw point cloud has been processed, you can proceed to extract the image from your 360 video.

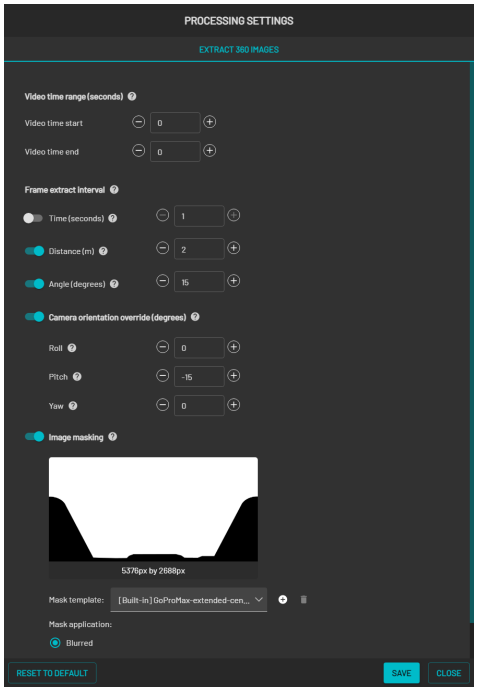
1. In the **Process** tab, click **Process Scan**.
2. In the **Configure New Scan Job** panel, select the **Extract 360 images** workflow.
3. Click **Add Dataset**.

4. In the panel that displays, navigate to the same folder used to process the raw point cloud data.

> To reiterate, the **.360** video file(s) should also be contained in the scan folder. If not, copy the video then click the **Refresh Video** button.



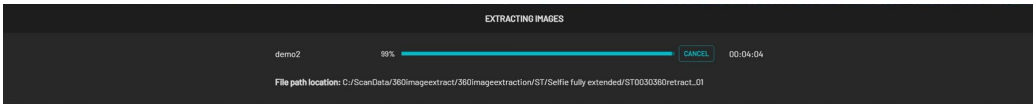
5. Click **Save** to return to the main panel.
6. Click **Processing Settings**. Configure the start and end times when the frames are extracted from the video and the camera orientation and image masking settings, as needed. Then, click **Save**.



> Refer to the Creating a Custom Mask section for instructions on creating your own image mask.

4.8.4 Step 4: Start processing

Click **Start** to begin processing. The **Extracting Images** panel shows a progress bar indicating how far along you are in your image extraction job. In addition to the progress bar, the elapsed time of the extraction 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 multiple jobs are simultaneously processed with the same output folder name. Copying the file path and pasting it on your computer's file explorer allows you to access the extracted files without waiting for the job to be completed.

4.8.5 Step 5: View your extracted images

You will get an indication once the extraction has been completed. Also, a button becomes available allowing you to navigate to the output folder, which contains the extracted images and 3 CSV reference files that can be uploaded to supported third-party applications.

> **Note:** It is recommended to review the images in Windows File Explorer before uploading and delete any that show recognizable people outside the masked areas. There is no need to alter CSV files.

4.8.6 Step 6: Colorize your Point Cloud (Optional)

From Emesent Aura version 1.5 or later, it is possible to colorize with GoPro Hero MAX. Refer to the Colorizing/Extracting 360 Images from a Merged Point Cloud section for instructions.

4.9 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.

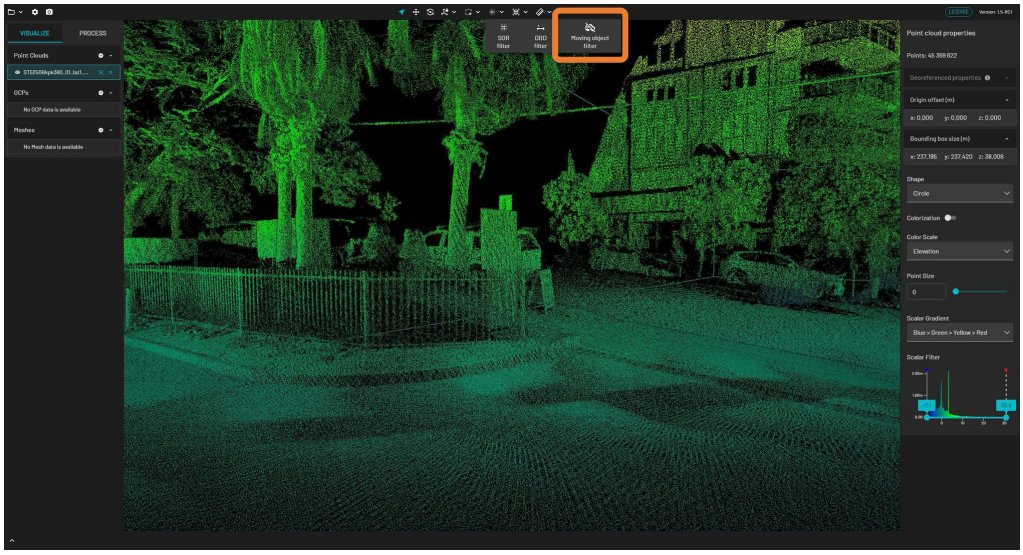
This feature can be applied to your point cloud as a cleaning filter or from the Processing Settings as part of Emesent Aura's processing workflow.

4.9.1 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.

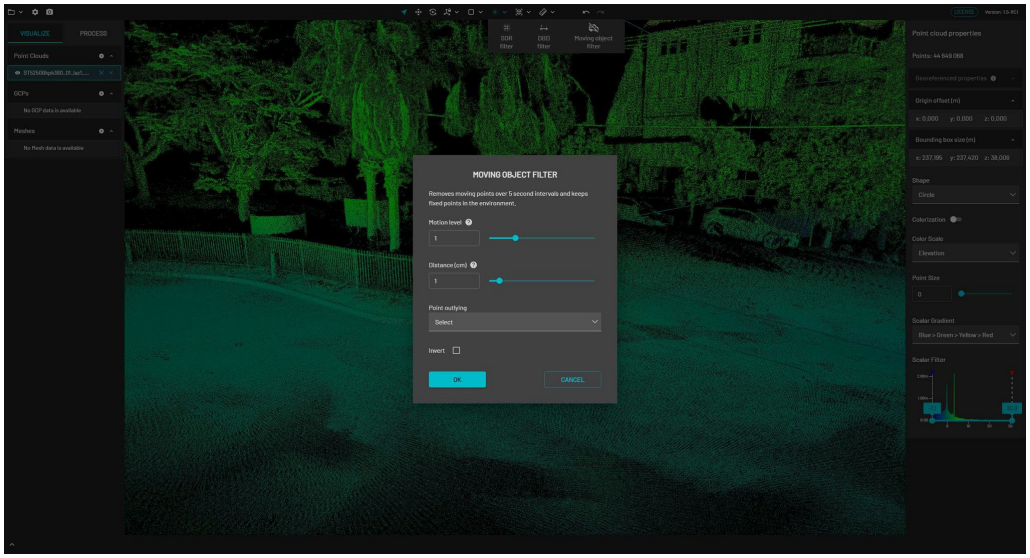
2. From the Main Toolbar, click the **Cleaning Filters** icon then select **Moving object filter**.



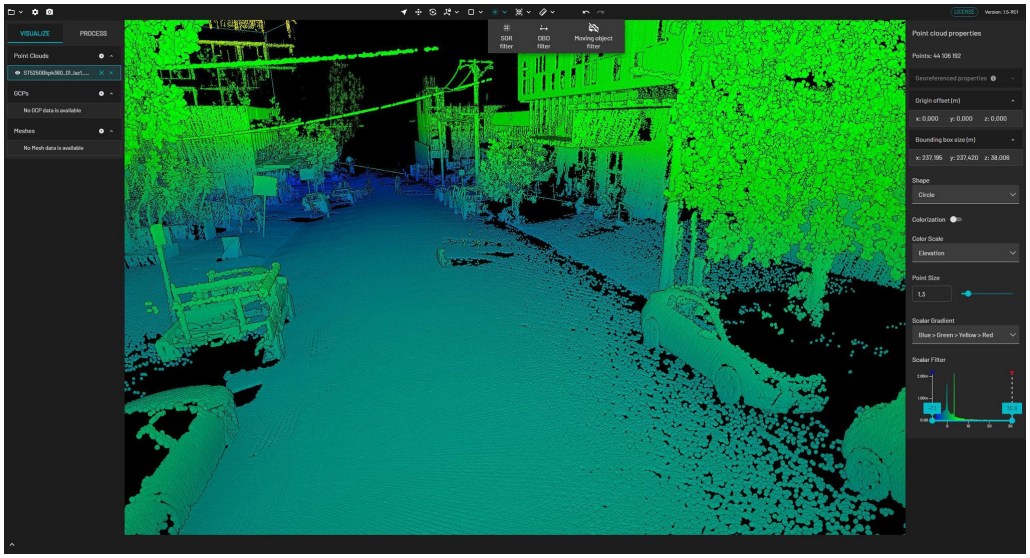
3. In the **Moving Object Filter** dialog box, configure the following parameters as required.

- **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.

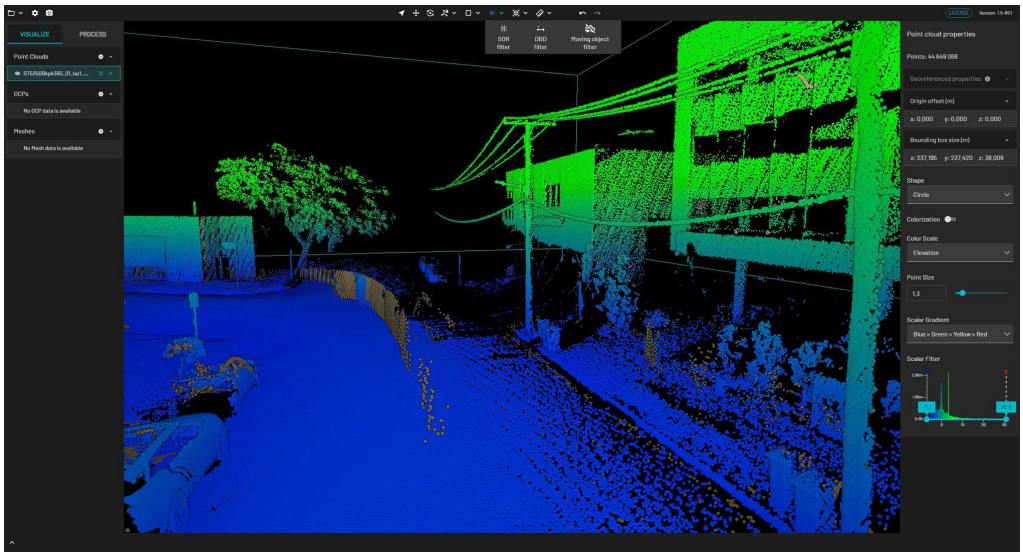


4. Under **Point outlying**, choose whether the outlying points will be deleted or just selected. If you choose **Select**, the selected points will show in sepia/gray color.



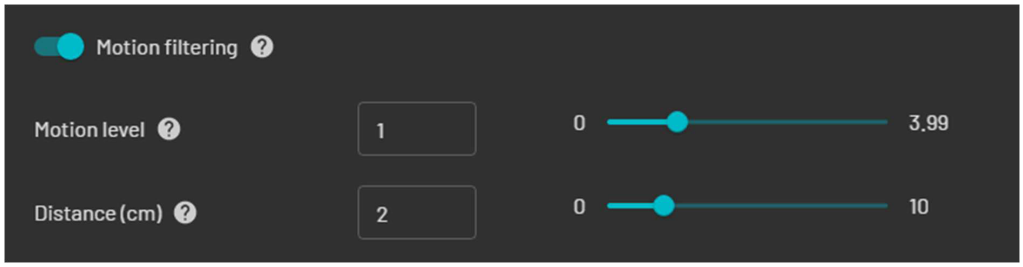
Once the points are selected, running the filter again will require the points to be cleared by pressing the **ESC** key. The algorithm only takes into account the whole cloud if no points are selected.

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



4.9.2 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.



Reminder

- 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.

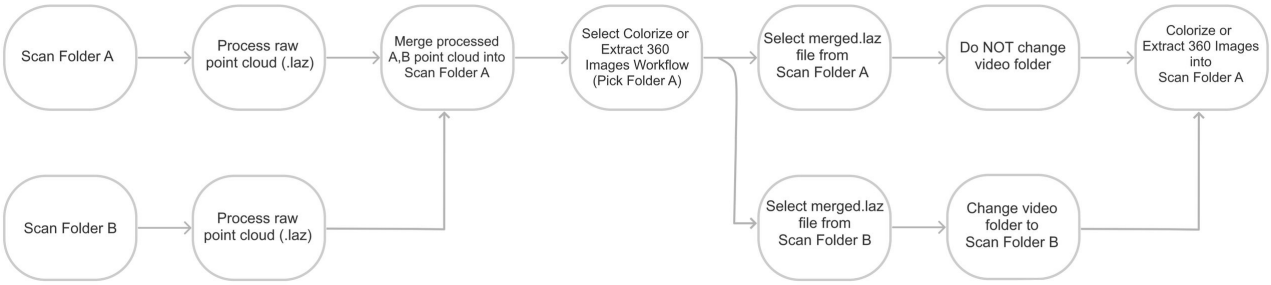
4.10 Colorizing/Extracting 360 Images from a Merged Point Cloud

The Colorization workflow includes the capability to colorize with the GoPro Hero MAX. The software comes with image masks, which remove objects such as drone components from appearing accidentally on the point cloud. During colorization, you can pause the workflow and review the frames used to colorize allowing you to delete any frames that cannot removed using the image mask.

> **Warning**
> It is important to ensure that the correct colorization calibration file matches the serial number of the camera when performing the colorization procedure. Not doing so can result in faulty output.

Special care must be taken when doing handheld colorization using the 360 camera. It is very easy to have the user accidentally appearing in the frames and “polluting” the final point cloud.

The image extract kit is NOT suitable for colorization. The extendable telescoping mount is not rigid enough to provide an accurate calibration which is necessary for colorization.



Reminder
Before you start, ensure that the **.mp4** (perspective camera) or **.360** file(s) are placed in the scan folder that contains the raw bag files. Open the video files after transferring using a suitable video playback software (e.g., VLC player which works for the .360 format) to ensure the file is not corrupted. This is a great opportunity to see which image mask to use.
Refer to the Creating a Custom Mask section for instructions on creating your own image mask.

4.10.1 Step 1: Process the individual point clouds

For more detailed information on processing point clouds, refer to the Process Workflow section.

1. In the **Process** tab, click **Process Scan**.
2. In the **Configure New Scan Job** panel, select the **Process** workflow.
3. Click **Add Dataset**.
4. Browse for the folder that contains the raw point cloud dataset to be processed. Select that folder.
5. Click **Start** to begin processing.
6. View your final output.
7. Repeat the same steps for the other raw scan data to be merged.

4.10.2 Step 2: Merge the processed point clouds

For more detailed information on merging point clouds, refer to the Merge Workflow section.

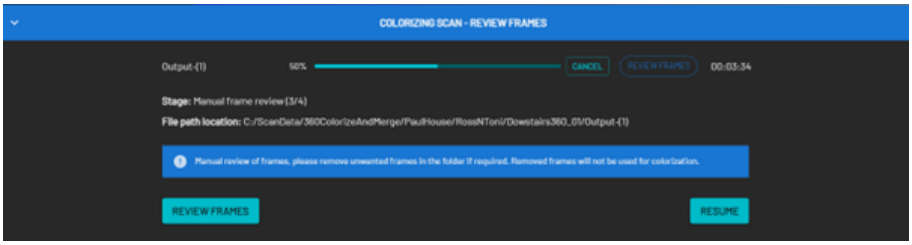
1. In the **Process** tab, click **Process Scan**.
2. In the **Configure New Scan Job** panel, select the **Merge** workflow.
3. Click **Add Datasets**.
4. In the dialog box that displays, click **Add** then browse for the the point clouds you want to align. Make sure all the point clouds have been pre-processed in Aura.
5. In the **Alignment Preview File** column, select the scan file to merge for each scan folder. Also, select the reference scan file, which provides a fixed frame of reference for aligning the other point clouds.
6. Once you have added all the point clouds to merge, click **Save**.

7. Manually align your point clouds when prompted. Click **Load Scans** to start your review. All scans will load at the same time.
8. Click **Start** to begin processing.
9. View your final output.

4.10.3 Step 3: Colorize the point cloud

For more detailed information on colorizing point clouds, refer to the Colorization Workflow section.

1. In the **Process** tab, click **Process Scan**.
2. In the **Configure New Scan Job** panel, select the **Colorize** workflow.
3. Click **Add Dataset.**
4. 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. Once you have loaded the merged point cloud and the corresponding video file, click **Save**.
6. Click **Start** to begin processing.
7. When prompted, click **Review Frames**.



8. In the file explorer window, manually delete any unwanted frames from your video.
9. Once the unwanted frames are removed, return to Emesent Aura and click **Resume**.
10. View your final output and check the results.
11. Repeat the same process for the other merged point clouds.

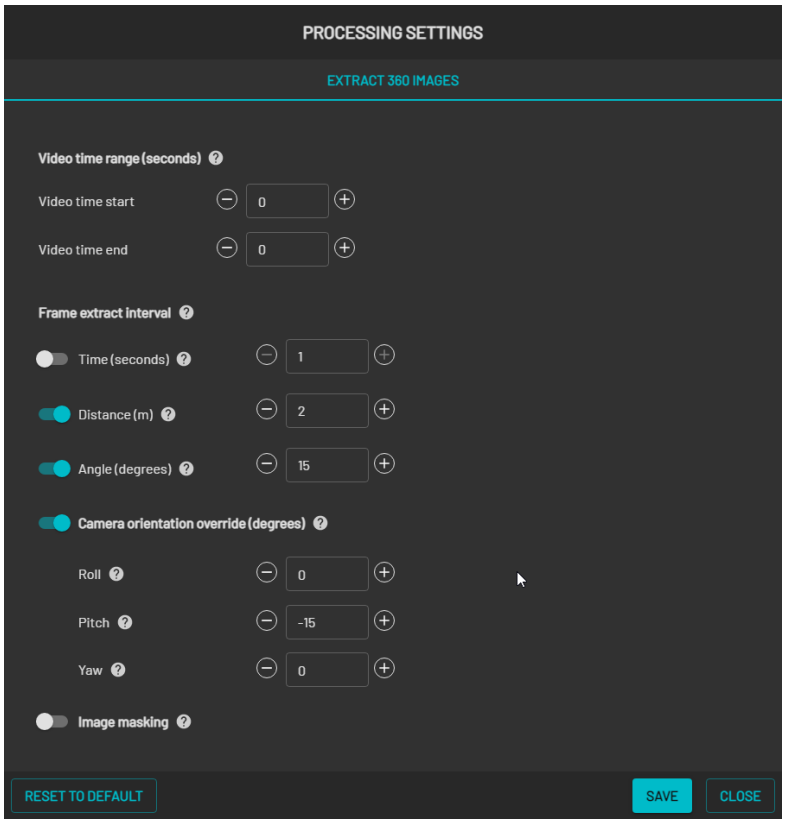
4.11 Creating a Custom Mask

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

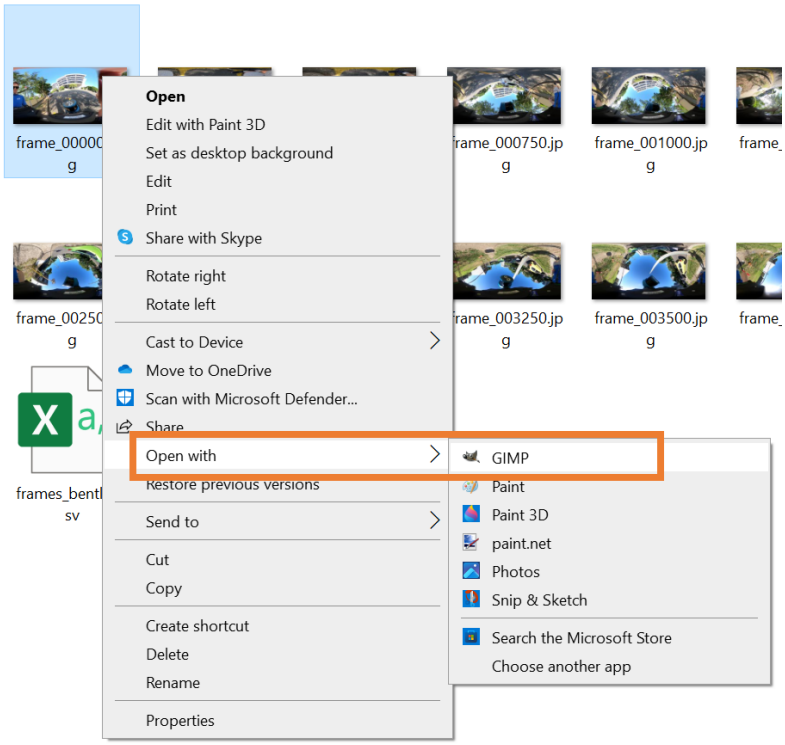
The following process is demonstrated using GIMP (a freely downloadable editing software). However, you can utilize any third-party image editing software, as the techniques discussed here are applicable across various platforms.

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

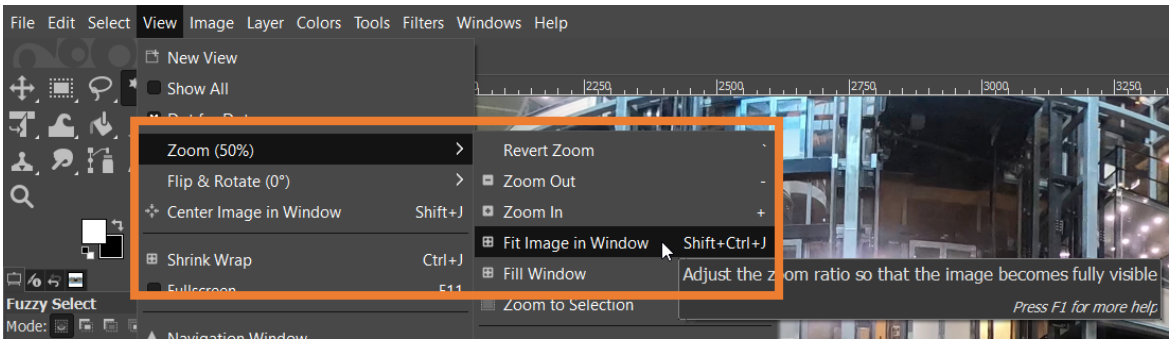


If you have a large video, running image extraction once on a small subset of data is recommended. You can achieve this by setting a high **Frame Extract Interval** (e.g. **Distance: 20** and **Angle: 90**) or specifying a low **Video time end** setting (e.g. **10 seconds**). For Aura 1.5 and earlier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

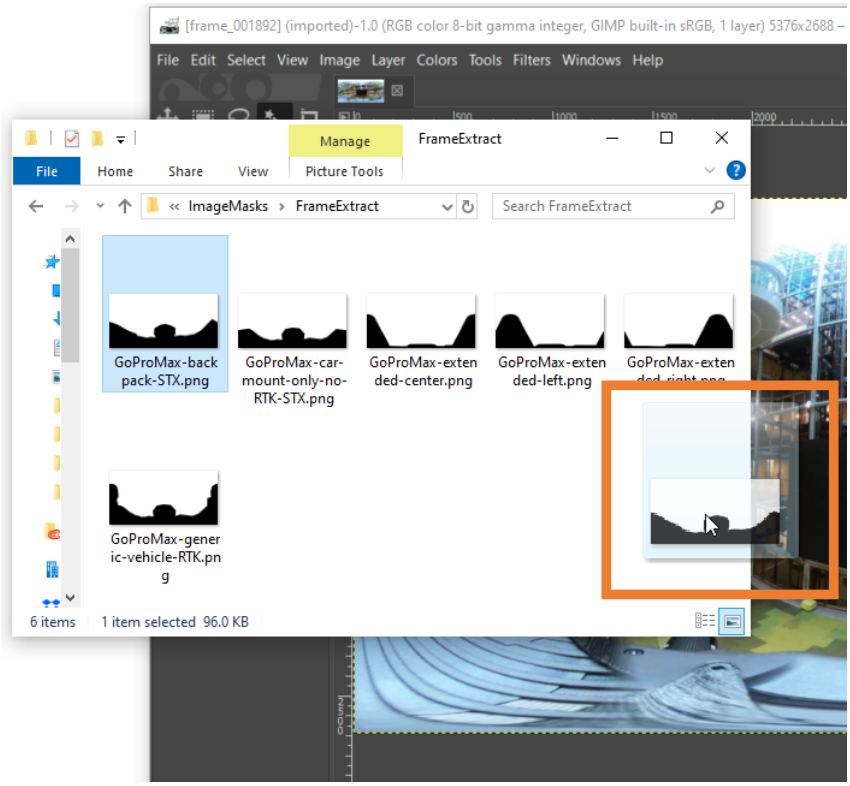
2. Navigate to the extracted frames folder once the frame extraction process is completed.
3. Select a frame you want to create a mask for and open it in GIMP.



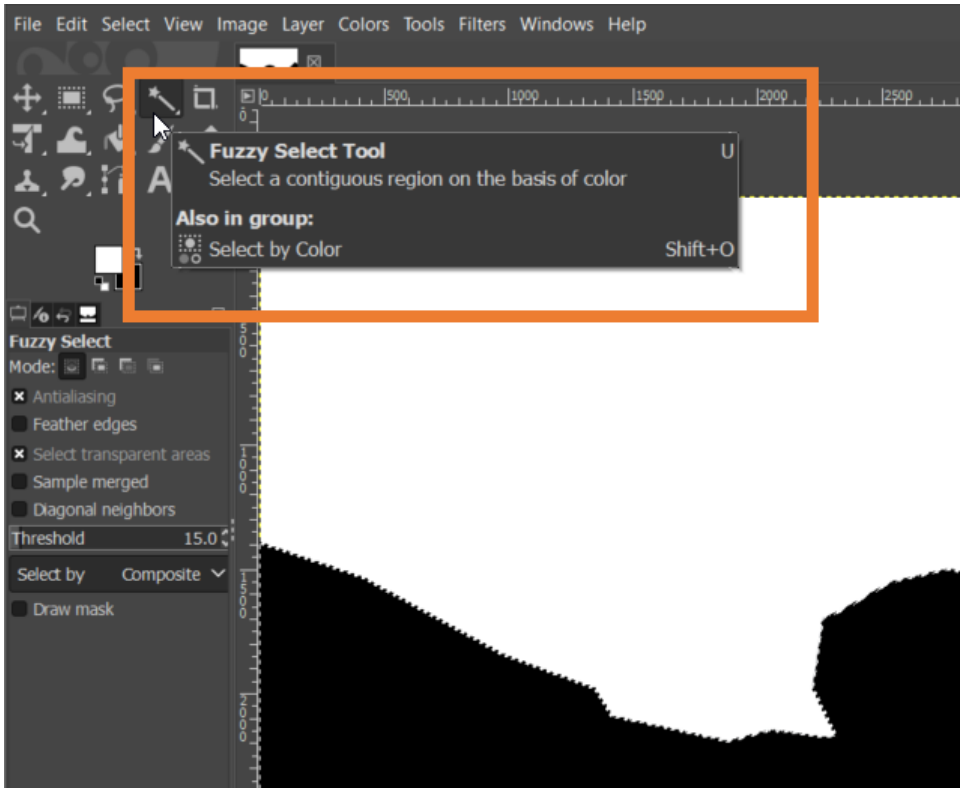
4. Adjust the display to ensure the image fits your screen properly.



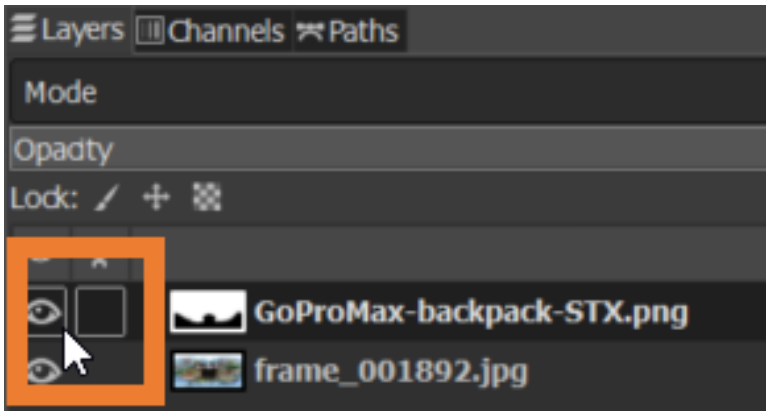
5. Start with an existing mask instead of creating one from scratch. Open the folder containing the predefined masks by navigating to **Program Files** > **Aura** > **Aura**> **Plugins** > **EmtProcessWorkflows** > **Content** > **ProcessWorkflows** > **ImageMasks**.
6. Select a suitable mask from either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



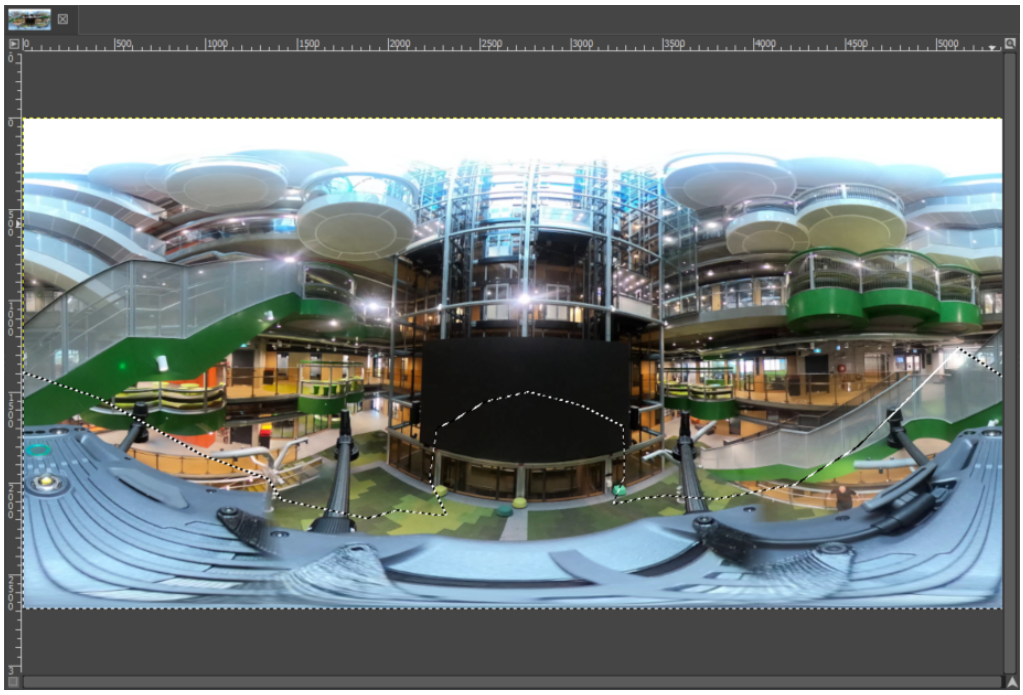
7. Use the **Fuzzy Select Tool** (aka **Magic Wand**) and click on the black area of the mask layer to select it.



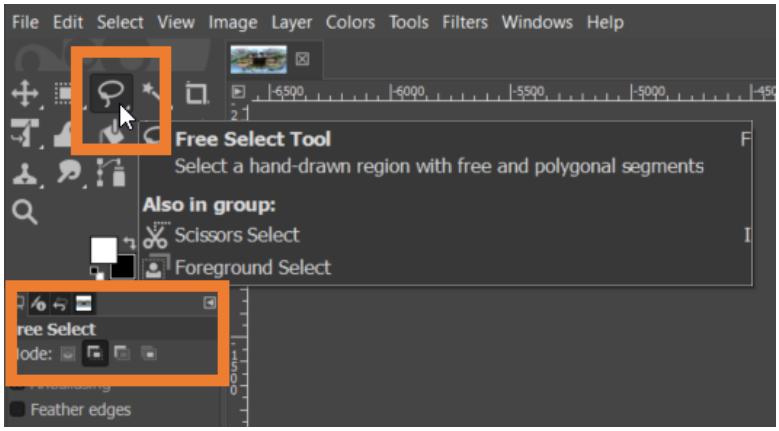
8. In the Layer panel on the right, every layer in the image appears as a thumbnail. The upper layer in the list is the first one visible. Click the **Eye** icon before the mask layer to hide the mask.



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



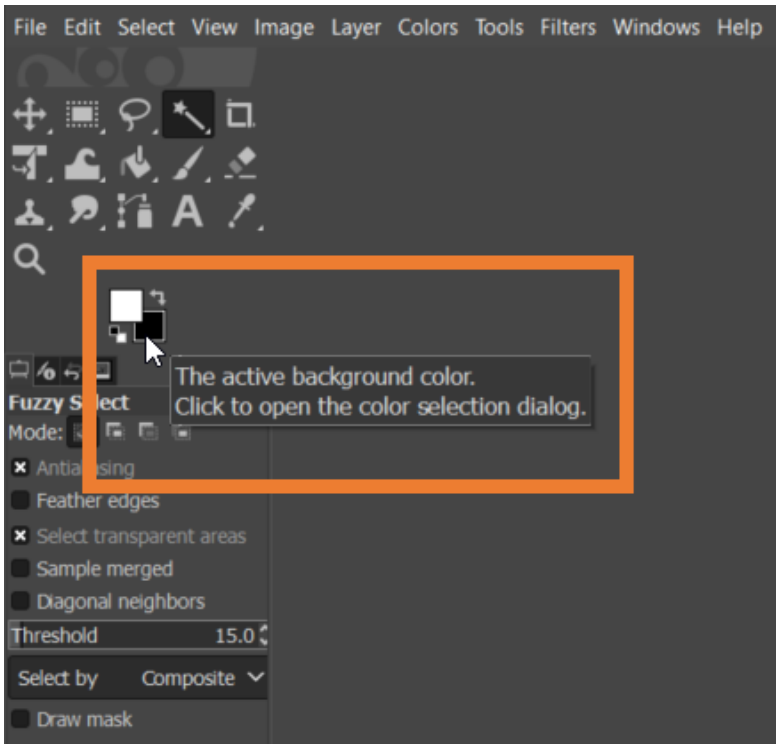
9. Use the **Free Select Tool** to add or refine areas to the mask as needed. Press the **Enter** key to add the area to the current selection.



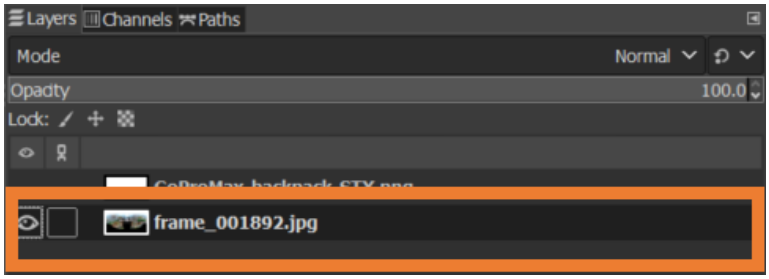
> **Note:** Make sure the **Mode** is set to **Add to the current selection**. You can do this by clicking on the second mode icon or pressing the **Shift** key while selecting.

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.

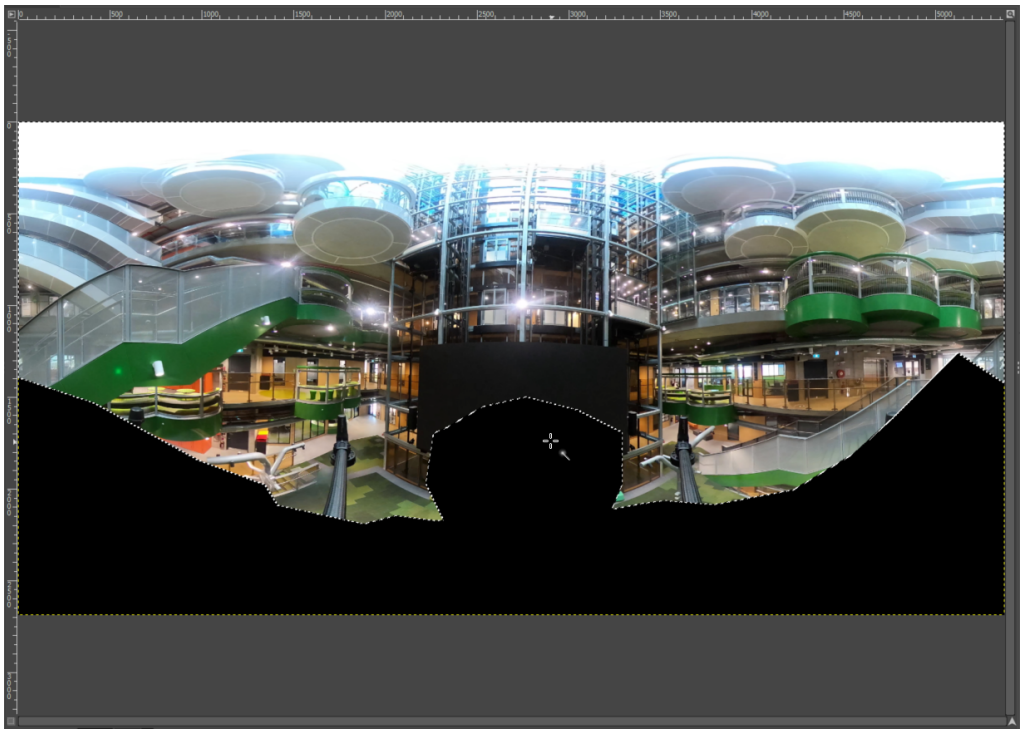
11. Ensure that the active background color is set to black.



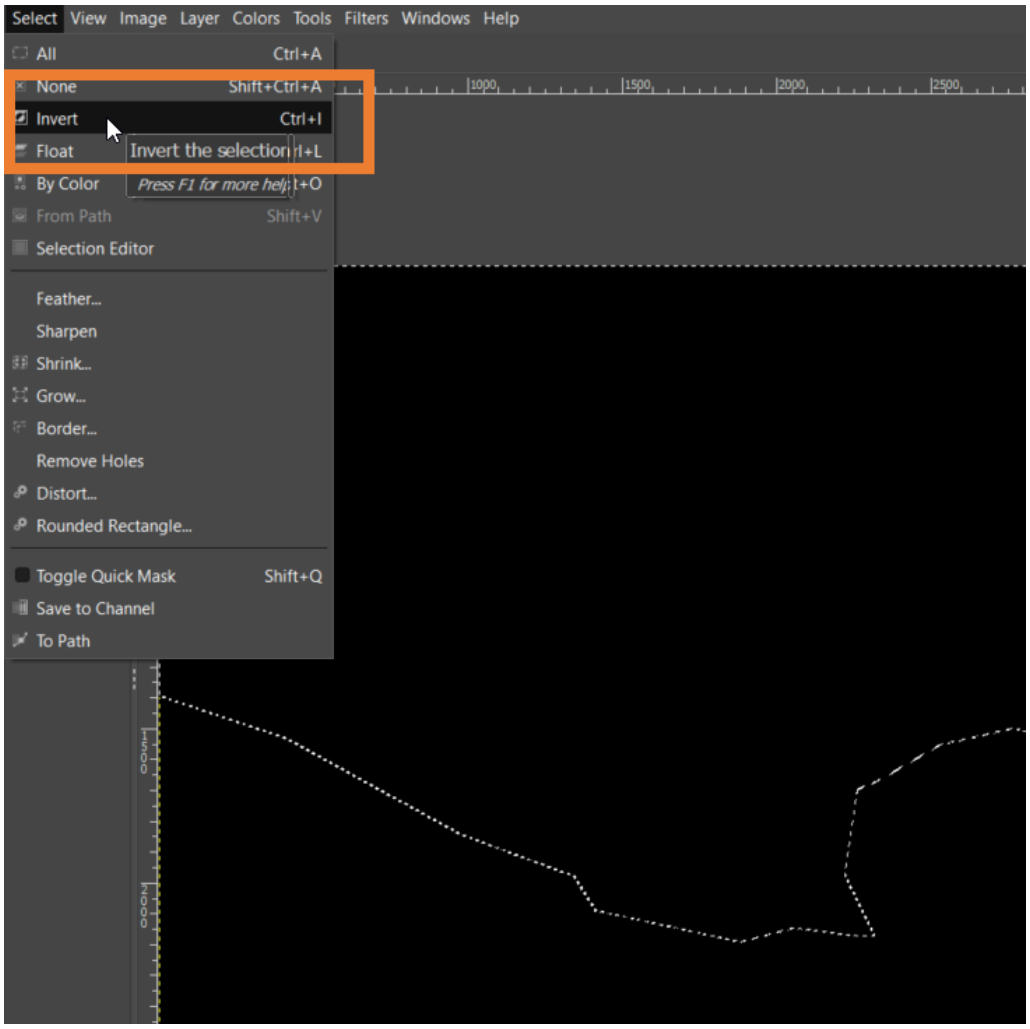
12. Once satisfied with the mask, go to the Layer panel and select the base layer containing the extracted image.



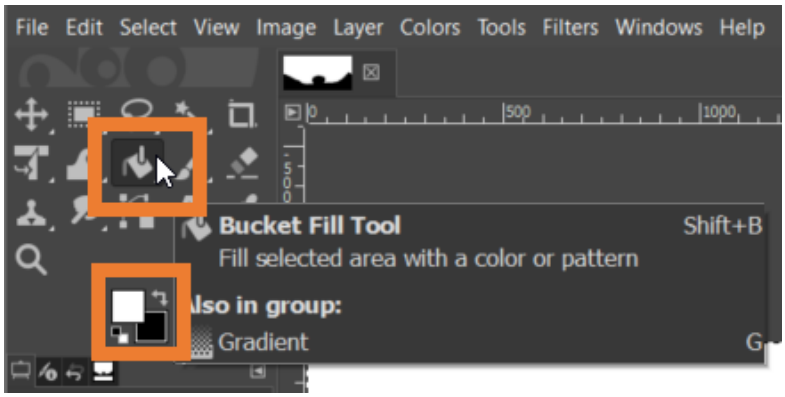
13. Press **Delete** on your keyboard.



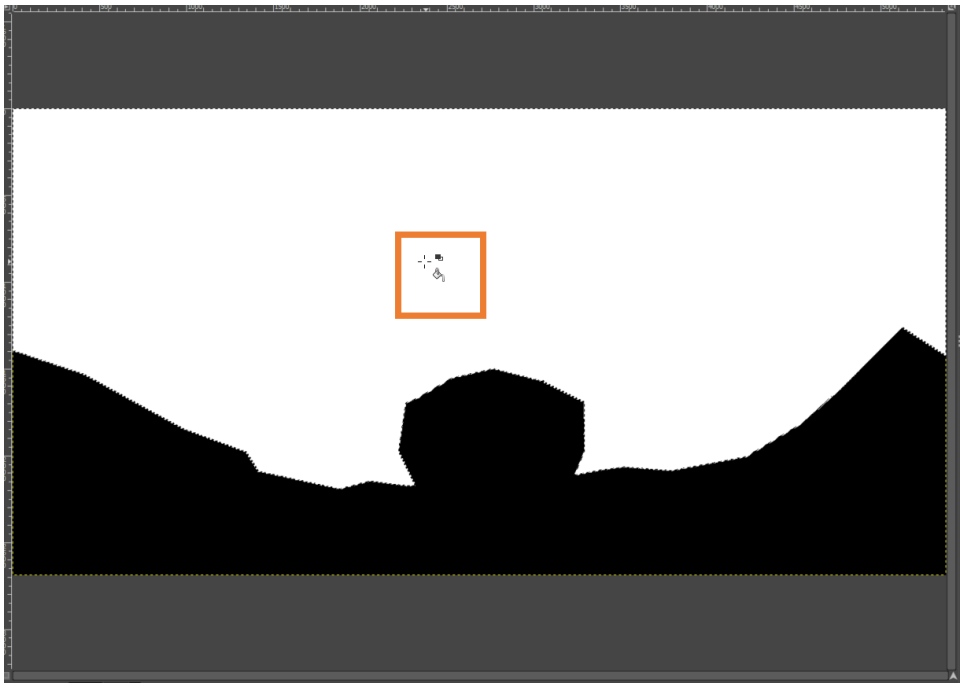
14. Go to **Select** > **Invert** then press **Delete** again. The entire image is now black.



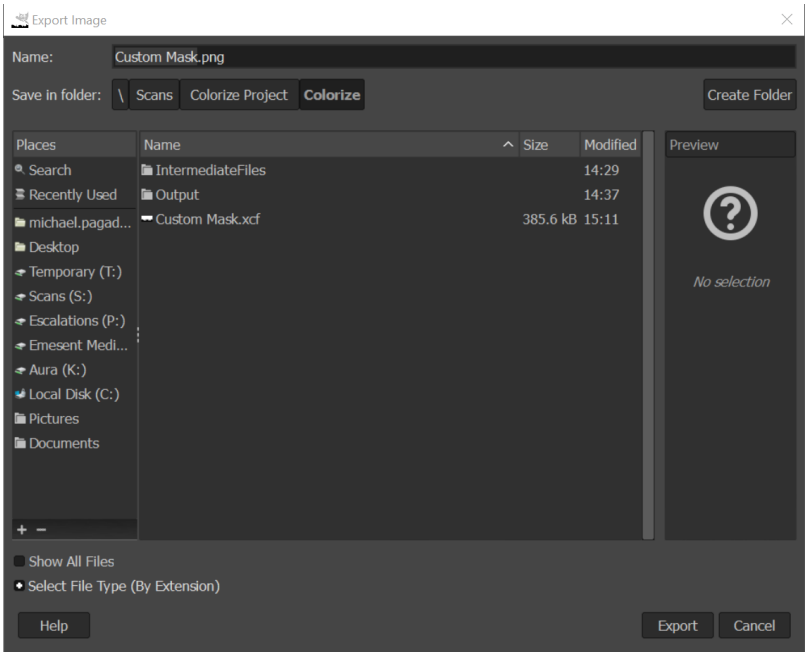
15. Click the **Bucket Fill Tool**. Ensure the active foreground color is white.



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.



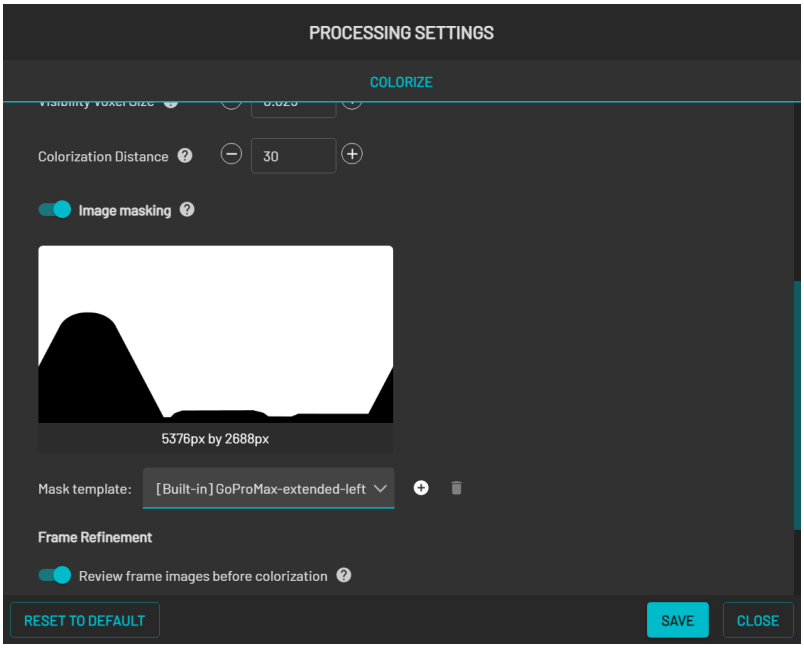
18. Click **Export**.

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

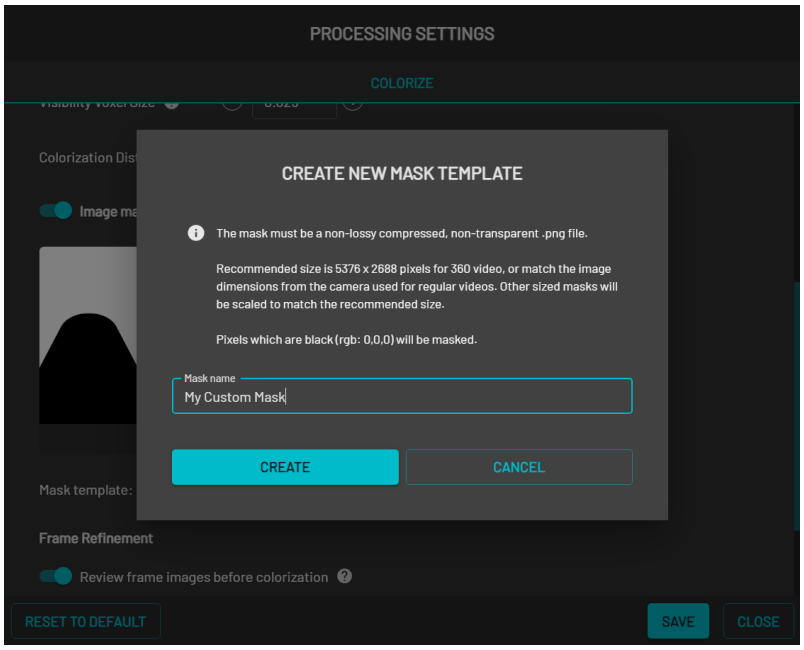
19. Close GIMP and return to the Emesent Aura.

To add the custom mask in Aura

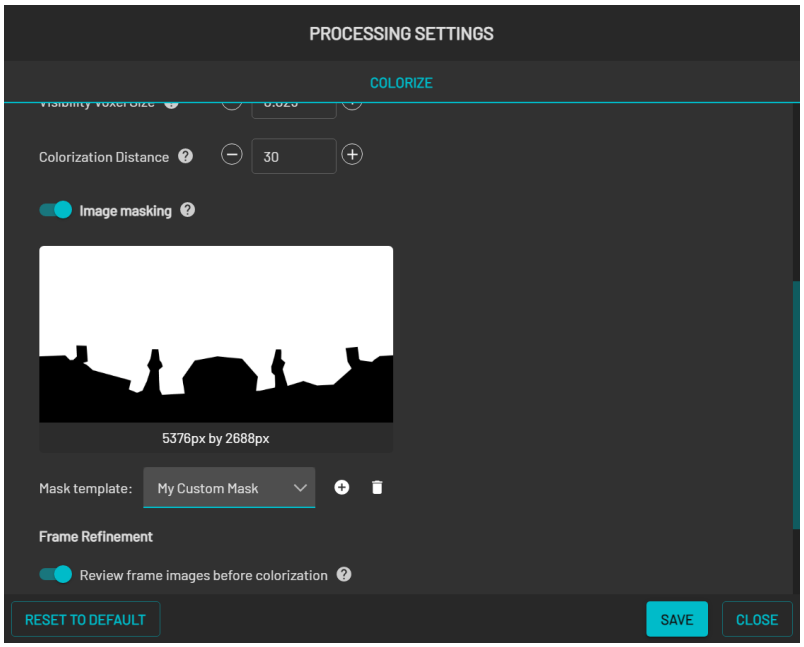
1. Run a **Colorize** or **Extract 360 images** workflow again.
2. Click **Processing Settings**.
3. In the **Colorize** or **Extract 360 images** tab, enable **Image masking**.



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.

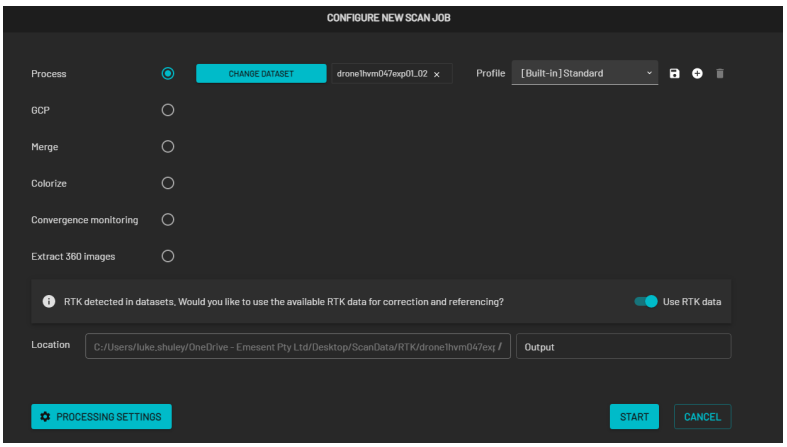


4.12 Reprojecting your Point Cloud

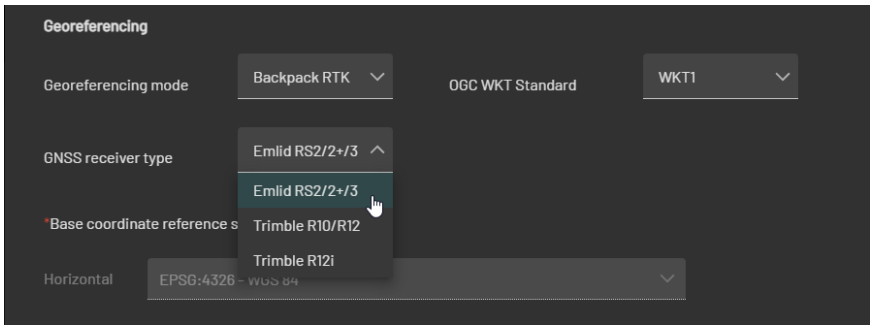
Reprojection in Emesent Aura is an automated workflow that allows for RTK scans to be processed with the correct coordinates by simply selecting the target coordinate reference system (horizontal) and converting from ellipsoidal height to orthometric height using a GEOID model (vertical). This can be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

4.12.1 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**.

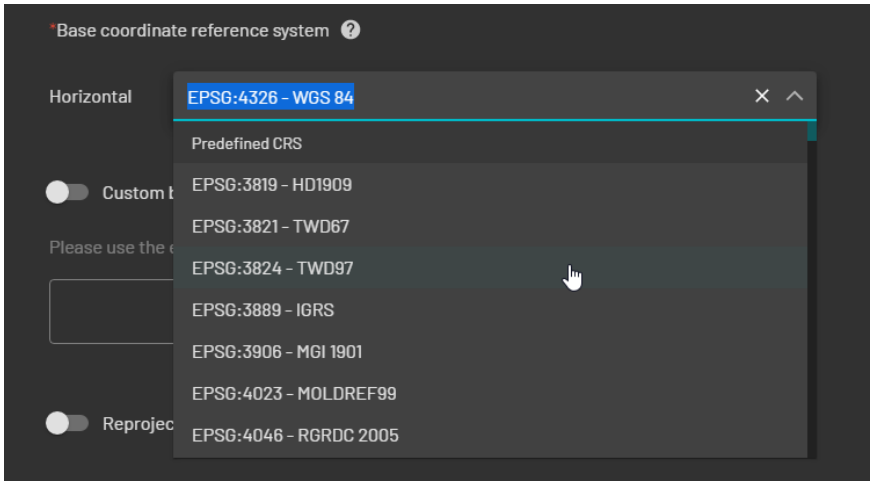


5. In the **Location** field, enter the preferred name for the output folder. A subfolder is created, which stores all the processed results and data.
6. Click **Processing Settings**. Under **Georeferencing** in the **General** tab, select the RTK device and GNSS receiver used to capture the RTK data.

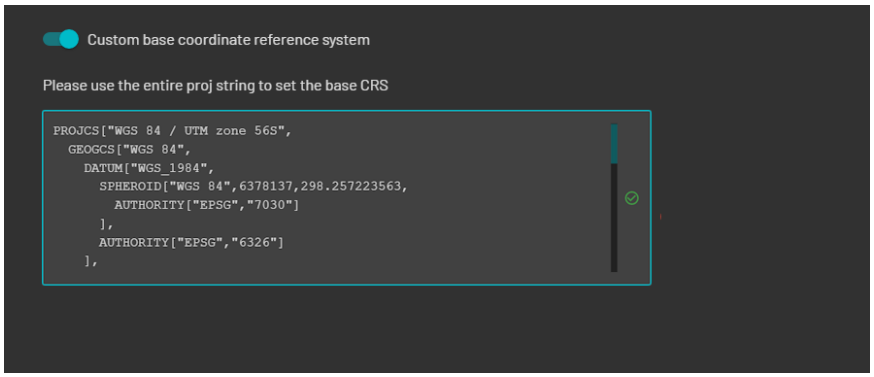


> For optimal results, ensure that the **Georeferencing mode** and **GNSS receiver type** match the hardware used during data collection. While the resulting point cloud remains usable, the accuracy may be affected.

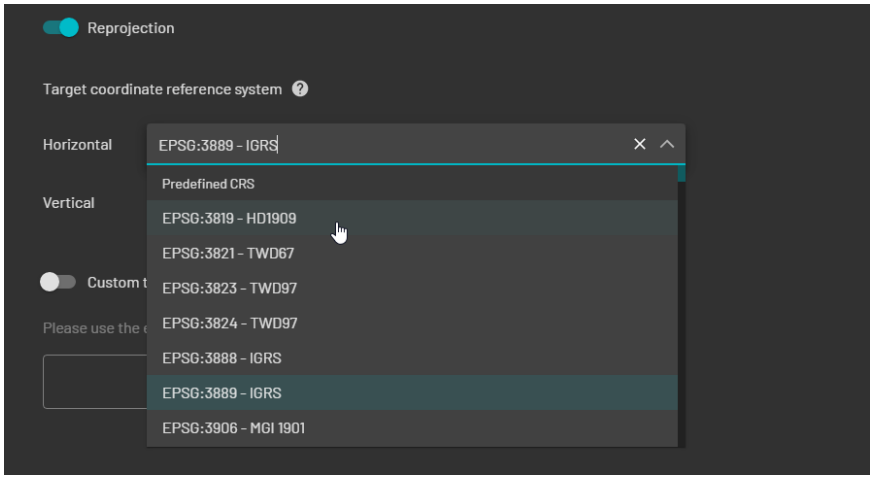
7. Under **Base coordinate reference system**, set the Coordinate Reference System in which the data was originally collected. This information is essential for accurate transformations and reprojections to the target CRS.



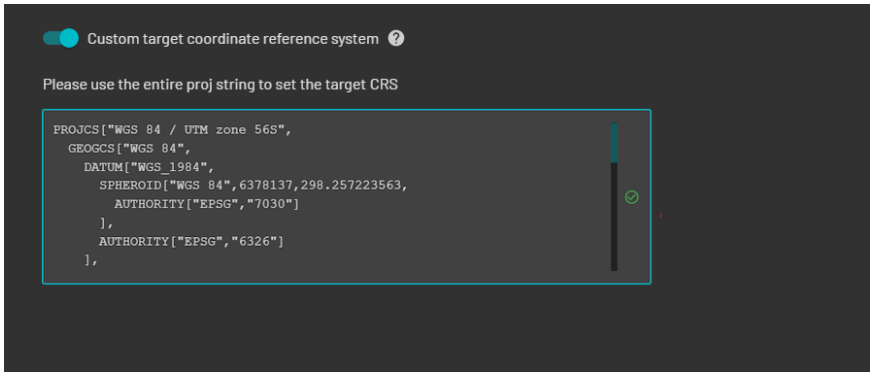
Alternatively, toggle on **Custom base coordinate reference system** to enter a project string that describes the desired geodetic coordinate reference system.



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.



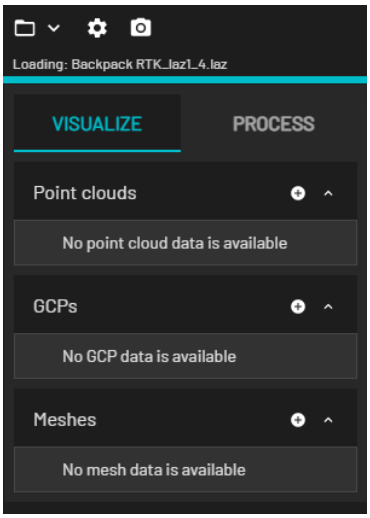
Alternatively, toggle on **Custom target coordinate reference system** to enter a project string that describes the desired target coordinate reference system.



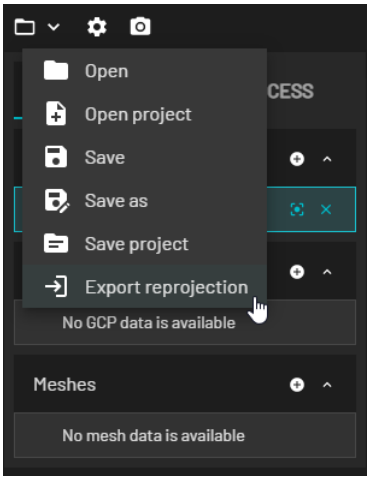
9. Click **Save**.

4.12.2 Reprojecting a Processed Point Cloud

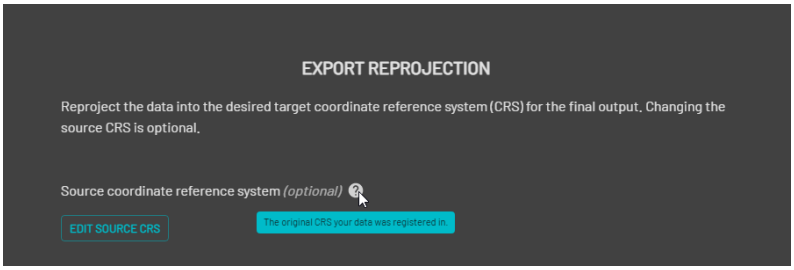
1. Open Emesent Aura and go to the **Visualize** tab.
2. Load the processed point cloud or trajectory you want to reproject.



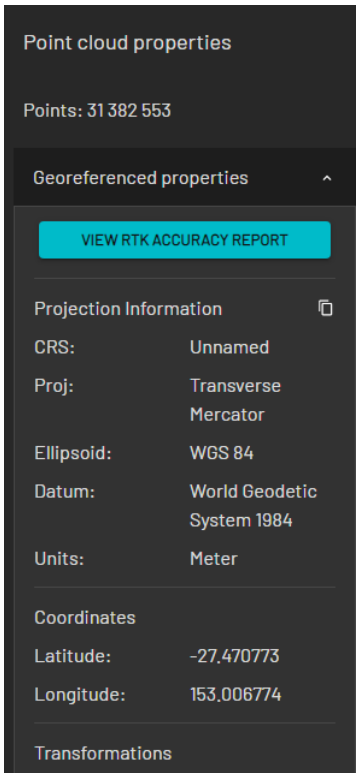
3. Click the **Project menu** icon then select **Export reprojection**.



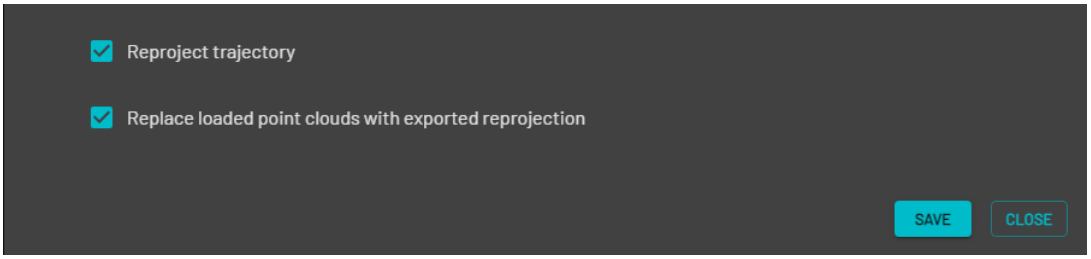
4. In the **Export Reprojection** dialog box, click **Edit Source CRS**. This step is optional as Emesent Aura automatically detects the CRS of the input data. However, editing may be necessary if the CRS is incorrect or you are working with data from multiple sources that require a specific CRS.



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.

5. 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.

6. Support

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

From here, you can:

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

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

Thank you!

emesent

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