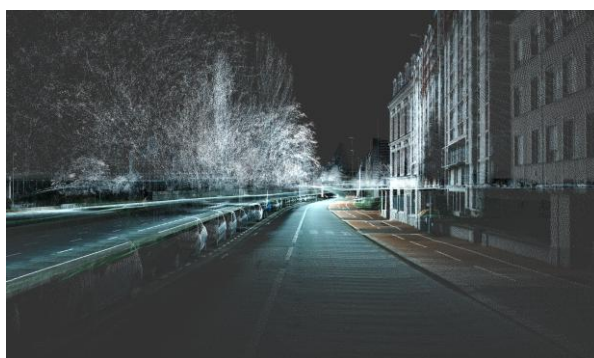
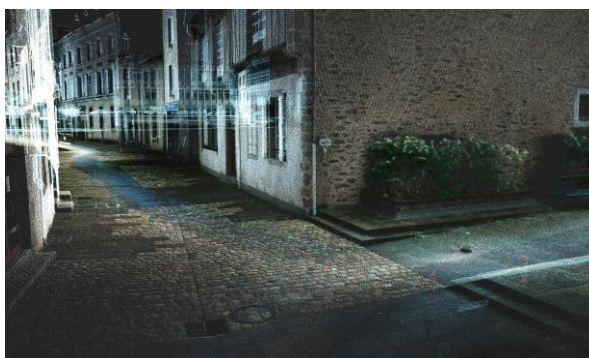
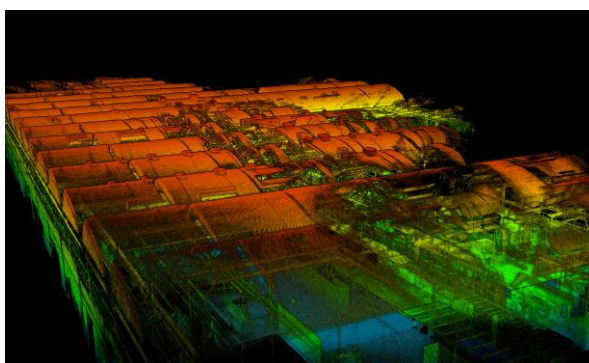


PPiMMS 2.0

User Manual



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Support Email
Support.ppimms@viametris.com

Support Phone
+33 243 497 791

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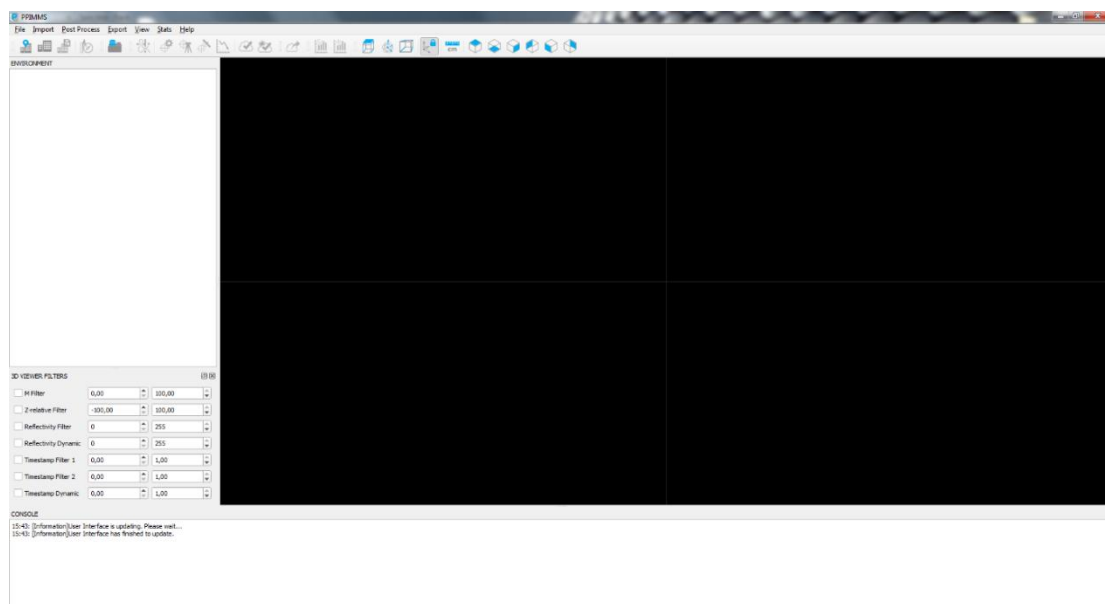
1 INTRODUCTION & PRELIMINARY

Mobile scanning system is efficient surveying equipment. Such system works if we are able to calculate an accurate trajectory from which the measurement will be output.

PPiMMS is a software dedicated to mobile scanning dataset post-processing in order to calculate trajectory of systems in different conditions.

Initially developed for the VIAMETRIS systems (iMS2D and iMS3D), this software is now able to handle different kind of systems and sensors. This manual presents the workflow to get the final result.

The main window of PPiMMS is as following:



The Main window gathers:

- The Tree View environment at the top left: this window displays the status of the process
- The 3D window at the center: used to display the point cloud
- The console: it informs the user at any step of the process at the bottom
- The 3D viewer filter window

2 DATA MANAGEMENT

PPiMMS manages datasets in an internal database. Then, it means that the user cannot import several times the same acquisition dataset.

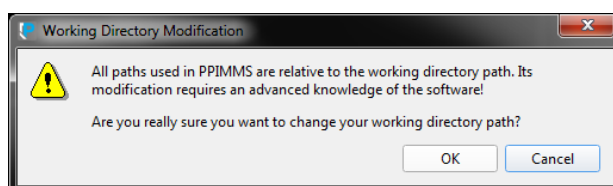
2.1 SUPPORTED SYSTEMS

PPiMMS is the post-processing software to handle raw data of systems provided by VIAMETRIS. The current systems supported by the current PPiMMS version are:

- vMS3D road scanner
- bMS3D backpack scanner for multiple usages
- MS-96 Modular Mobile Scanner

2.2 WORKING DIRECTORY

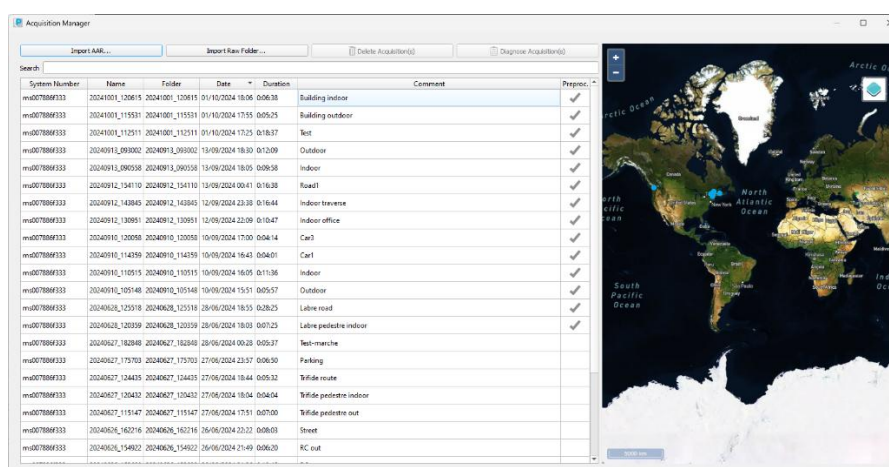
Once PPiMMS is installed on the working station, the user will be asked to set up the working directory path at the first launch. This working directory will contain all the datasets (Acquisitions Directory) and the projects at any step of the process (Projects Directory). This Working Directory can be changed at any time but the user is no more able to open an existing acquisition or process result if the user changes the Working Directory the acquisition is located in.



PPiMMS can handle several kinds of dataset. To be able to identify which kind of system and what kind of data PPiMMS is supposed to find in the dataset, the software uses a specific VEC file ("*.vec") which represents the ID of the systems. This file contains the type of systems, the sensors names and the calibration.

PPiMMS 2.0 WILL NOT PROCESS ANY DATASET WITHOUT A VEC FILE

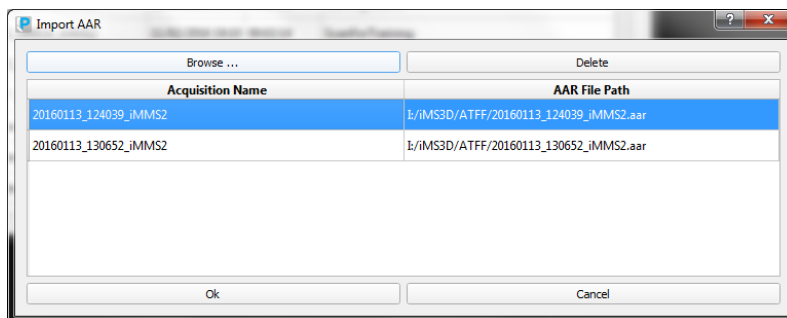
2.3 ACQUISITION MANAGER



The user is able to manage the acquisitions in the current Working Directory. It is possible to:

- Import AAR files (VIAMETRIS Systems)
- Import folders containing a dataset
- Delete imported acquisition

The user is able to select several acquisitions at once to import them at the same time. For the dataset including GNSS data, PPiMMS locates each of them on the map on the right.



Then the acquisition is imported to the Working Directory:

Name	Date	Duration	Comment
1_190934_iMMS2	11/02/2016 19:10	00:02:14	ScanForTraining
3_113532_iMMS2	13/01/2016 11:36	01:04:05	Aiguille
7_082606_iMMS2			
rawData			
nsnet_Floor34_raw			4 South Africa tour
nsnet_Floor2_raw			second floor during South
_Floor2_raw	22/11/2015 10:00	00:00:00	

The user is able to delete the acquisition from the Working Directory using the same window.

3 CREATE PROJECTS AND ENVIRONMENTS

As mentioned previously in chapter 2, the user is not able to import several times the same raw dataset but he is able to create several projects/environments based on the same dataset. It means that the user can apply different parameters and different process strategies at once.

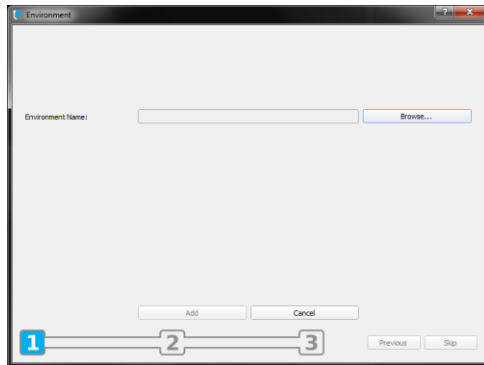
3.1 NEW ENVIRONMENT/PROJECT

Once acquisition is imported, the user needs to create the environment and the corresponding project.

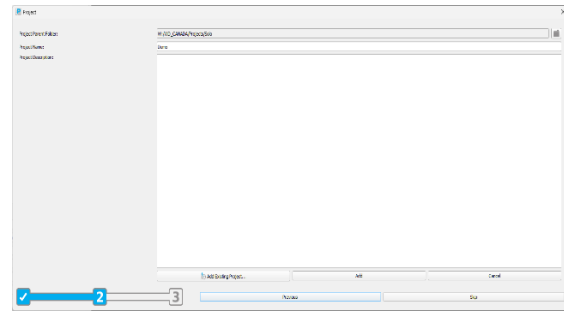
- One environment can contain several projects
- One project could contain one or several acquisitions



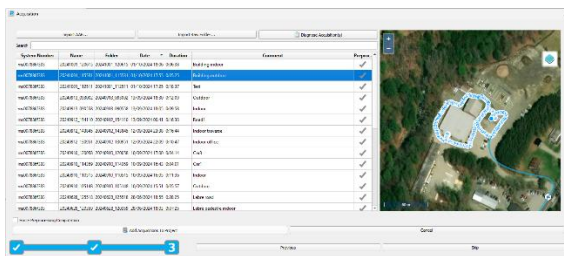
The following windows will open:



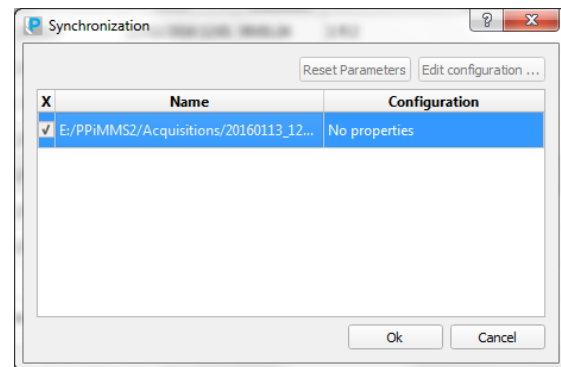
Step 1:
The user writes the name of the environment
then clicks on *[Add]*



Step 2:
The user gives the name of the project and click
on *[Add]*

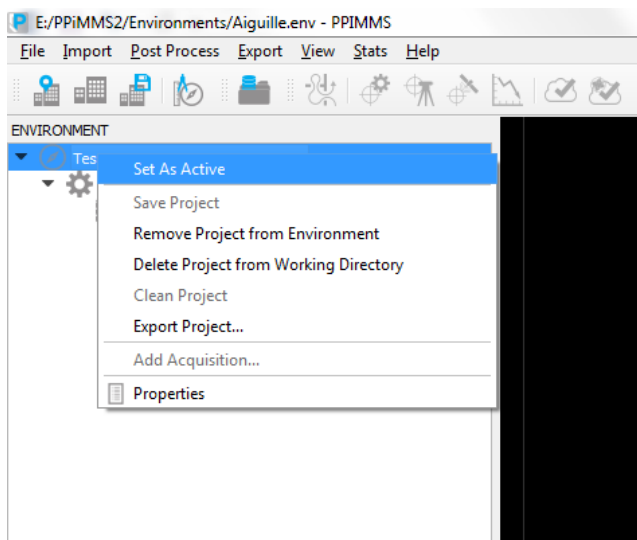


Step 3:
The user clicks on the required acquisition
dataset and clicks on *[Add Acquisition to
Project]*



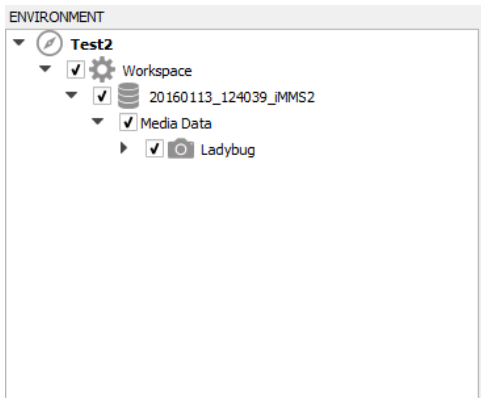
Step 4:
The user clicks on *[Ok]*

Once this is done, the project is created and needs to be activated to be viewed and to be processed:



Right click on the project name and click
on *[Set As Active]*

3.2 WORKSPACE DESCRIPTION

		The project contains a workspace and one or several results validated by the user
		The Workspace is the part of the project where any data is processed
		The Dataset gathers all the sensors
		Pictures list giving all the pictures grabbed during the scan

PPiMMS keeps most of your parameters in memory. The user is also able to share configuration files to other users by saving properties of every processing steps. Those configurations are saved into *.json files.

3.3 PROJECTION MANAGEMENT WITHIN PPiMMS

By default, the internal coordinates reference system is local. Then, Data in PPiMMS is projected into reference frame using EPSG code convention¹. It is described below in both chapters 5.1 and 5.3.2.

The operator is asked to enter a valid EPSG code upon the first geo-localized constraint, either it is Navigation constraint or GCP.

CAUTION#1. Grid transformation is not available in PPiMMS. PPiMMS works in modern Ellipsoid (for instance WGS84, RGF93, etc.).

CAUTION#2. All the acquisitions in a project use the same projection.

CAUTION#3. PPiMMS does not include altitude grids, so coordinates with respect to the geoid needs to be handled separately.

¹ <http://epsg.io/>

4 ODOMETRIC TRAJECTORY COMPUTATION

The odometric trajectory is the base of the post-process. Indeed, PPiMMS works on elastic trajectory to be able to manipulate it and to reduce drifts. We assume that the odometric trajectory is drifted but should not have discontinuities or jump.

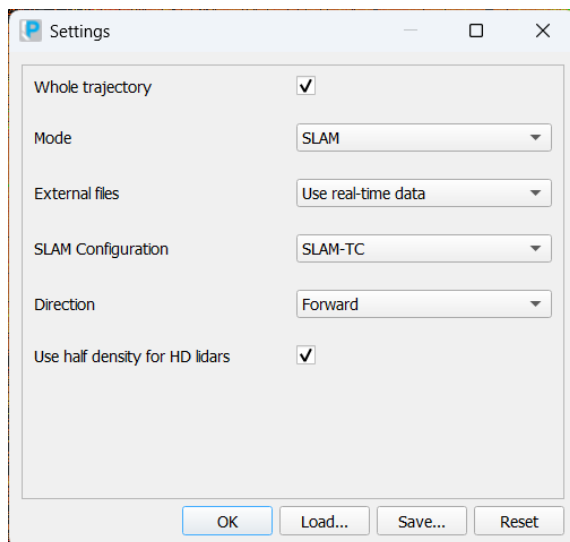
Depending on the system which is considered, the Odometric trajectory comes from different sources:

- 1- SLAM technology (3D LiDAR-based SLAM)
- 2- IMU velocity vectors (3D velocities get from inertial navigation system - INS) from **Post-Processed** data.
- 3- Attitude correction

PPiMMS is designed to choose automatically, with respect to the VEC identification file, which process is the most appropriate. The user can change those settings if requested.

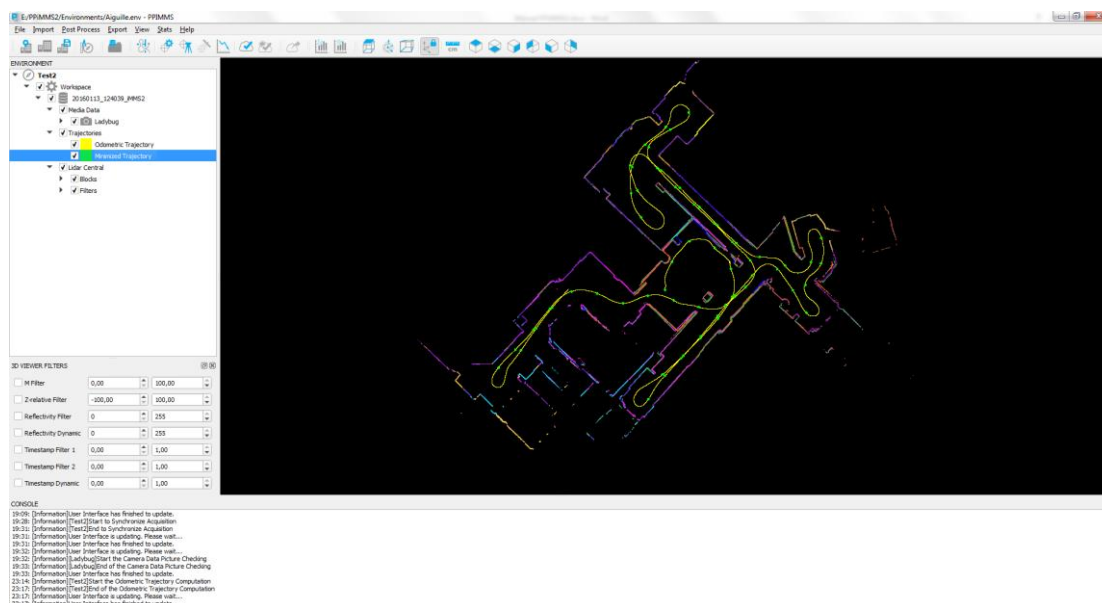


To launch the process, click on *[Post Process → Odometric Trajectory Computation...]* then click on *[ok]*.



- By checking **Whole Trajectory**, the process will be launched on the entire dataset. Unchecking means that the user can recalculate some blocks and apply different parameters
- **Mode**: depending on the system type, the user can select the most appropriate one. Parameters below will change with respect to the selected mode. The *Attitude correction* mode will only import Roll & Pitch data from an external post-processed file.
- **SLAM Configuration**:
 - *[Simple/Double/Triple]* resolution mode stand for accumulation grid SLAM
 - *[SLAMF]* stands for Feature-based algorithm
 - *[SLAM-TC]* stands for Tight-coupled SLAM-IMU algorithm, the most accurate version
- **Direction** stands for which direction the algorithms will be processed, *[forward]* is from past to future or *[backward]* is from end to beginning
- **Use Estimation** is useful if the user wants to recalculate the odometric trajectory, by using the previous result as a priori knowledge.
- **SLAM Aiding** proposes several aiding methods. The one selected is the best one by default.

Then, the 3D viewer displays the trajectory (Yellow line) and points with different colors for every block. One block represents a distance of movement: for instance, the iMS3D block is set to 5 meters.



Actually, two trajectories are displayed at the same time: the green line which is called “Minimized Trajectory” is at this step equal to the “Odometric Trajectory” because no other step has been processed yet. But throughout the process, the minimized trajectory will change.

5 CONSTRAINTS



Once the Odometric Trajectory is computed, the goal is to remove drifts by finding the gap between several paths. This step is called the loop Closure process.

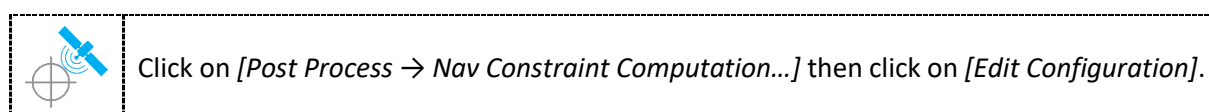
Another way to reduce the gap between two paths is to include GNSS information to influence the position.

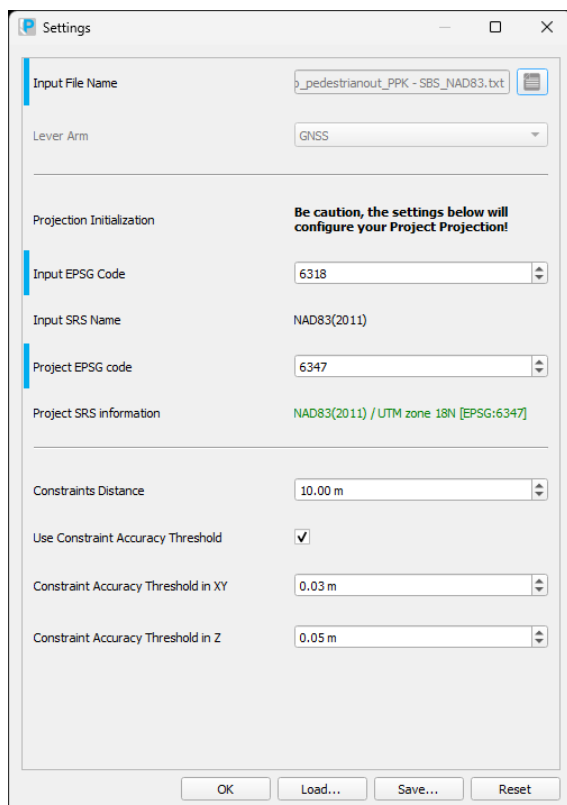
Finally, the third category is User Constraints that are manual click to include relative gap correction or Absolute point coordinates.

It is advised to start with Navigation constraint before calculating Loop Constraint as the process can be accelerated and more efficient.

5.1 NAVIGATION CONSTRAINT (WITH GNSS RECEIVER)

In systems that include GNSS receiver, the dataset could contain global position data. Ideally, the global position will be associated to confidence score that the algorithm will use to filter worth point.





- **Input File Name** is the file the user can select to provide post processed data
- **Lever Arm** is to select what is the reference point for which the points are referred to. It is automatically deduced from std files.
- **Input EPSG Code** is the geographic coordinate system (datum) of the file, with coordinates in degree² or directly projected SRS. If the Input SRS already represents a projected system, this will be used in the Project SRS without transformation.
- **Project EPSG code** designs the projection system the user can use accordingly the area of work. Please refer to the following [link](#) to get the right EPSG code³
- **Constraint Distance (m)** is the minimum step between two constraints
- **Constraint Accuracy Thresholds XY (m)** represent the 2D X-Y accuracy threshold above which the GNSS point is not accepted
- **Constraint Accuracy Thresholds Z (m)** represent the height accuracy threshold above which the GNSS point is not accepted

Whereas the user wants to use post processed data, it means that the user will use a third-party software to calculate these GNSS points. The result will be a file which needs to respect the format that PPiMMS is waiting for.

VIAMETRIS wrote dedicated manual for users using [GrafNav® Novatel]⁴ or [SBG-Systems® Qinertia]⁵. Similar process can be done in other third-party software, we have no restriction regarding GNSS post-processing software.

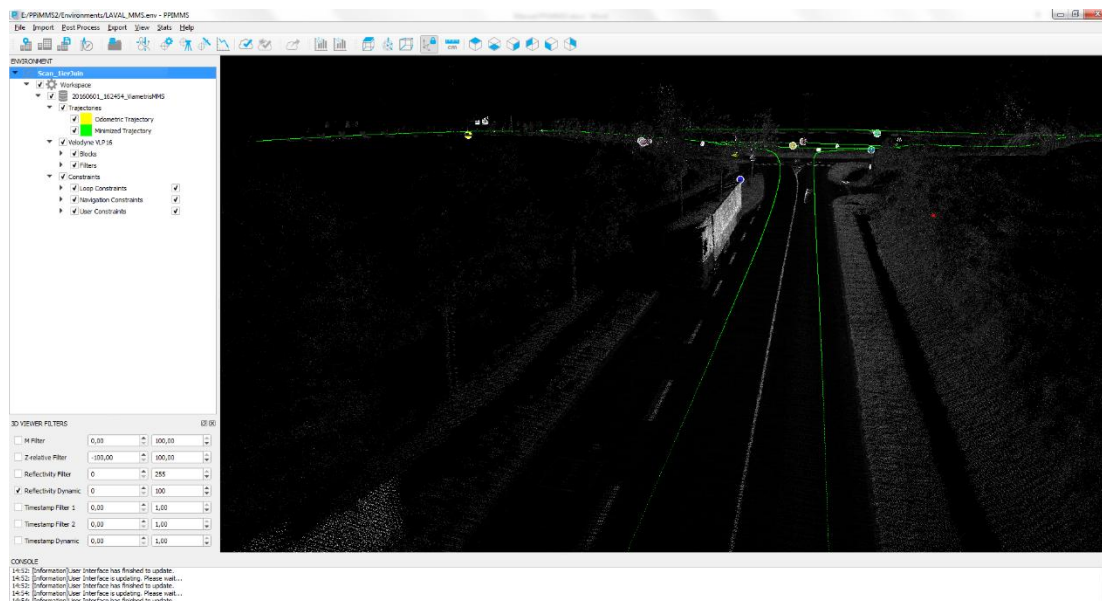
CAUTION#4. The datum of the external file (geographic coordinate in degree) must be similar to the datum of the projection (in meter)

² EPSG code for input file are for instance: WGS84 (code 4326), ETRS89 (code 4258) or RGF93 (code 4171)

³ <http://spatialreference.org/>

⁴ <http://www.novatel.com/products/software/grafnav/>

⁵ <http://www.sbg-systems.com/products/qinertia-ins-gnss-post-processing-software/>



Then, PPiMMS Tree view displays a new kind of data which are “Constraints”. “Navigation Constraints” displays a set of constraints which have been calculated automatically.

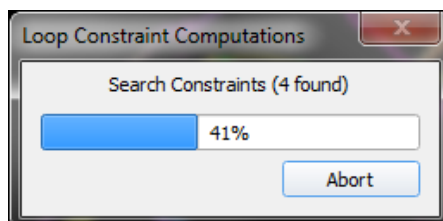
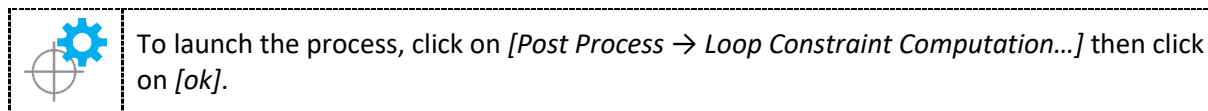
CAUTION#5. *Grid transformation is not available in PPiMMS.*

To handle potential systematic shift between Navigation result and existing traverse that the user would consider as the reference, the user can set a global shift parameter to the navigation constraints in order to fit the reference traverse.



The user is able to set a 3D shift (x,y,z). This shift is applied to every navigation constraint.

5.2 LOOP CLOSURE



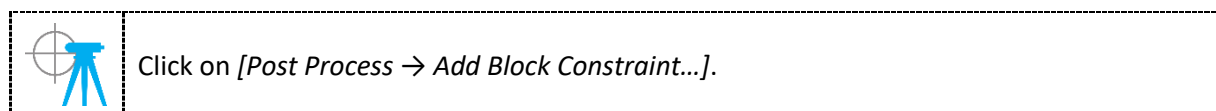
Under “Constraints” category in the tree view, “Loop Constraints” displays a set of constraints which have been calculated automatically using the blocks to detect loops and to set common points.



Now, the user observes the difference between the green and yellow trajectories which is indeed due to the drift correction influenced by the loop closure processing.

5.3 USER CONSTRAINT

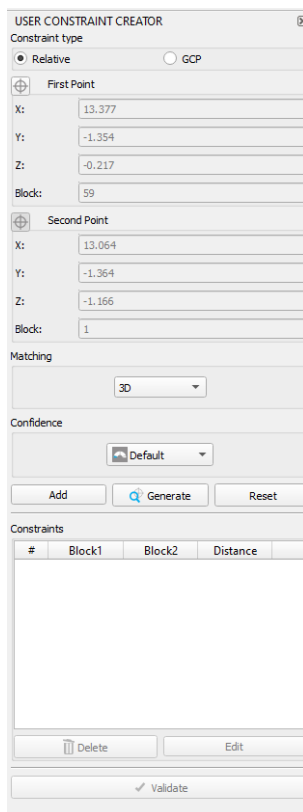
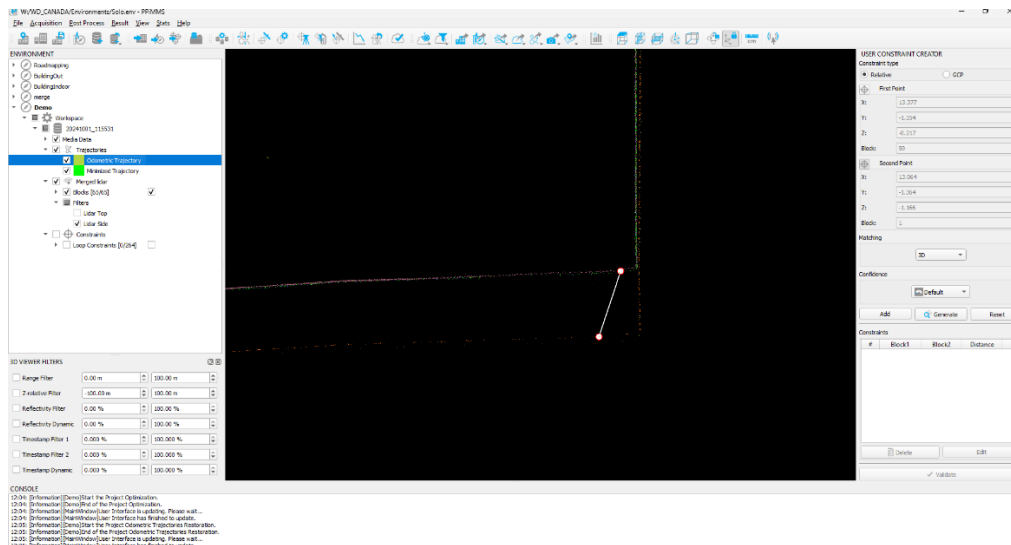
The user constraints are necessary to correct the automatic result, or very useful to change the reference system and to control absolute drift of the system.



The Constraint Editor window then opens.

5.3.1 MANUAL RELATIVE CONSTRAINT

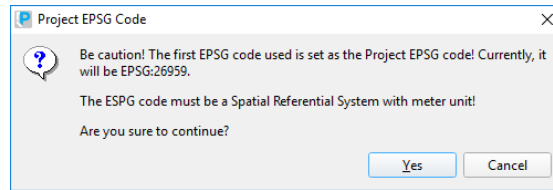
The relative constraint concerns two distinctive blocks the user detects obvious common part but that doesn't have the same position: we call this a drift.



- The user clicks the first point on the requested block and clicks on the similar point in another block (different color). Then, he clicks *[Add]*.
- Below, the list is updated and the user is able to click several couples to fill the list. Every point in the list is still editable or removable.
- The constraint can be set with different matching modes:
 - o *[3D]* mode means that PPiMMS minimizes the 3D distance between points.
 - o *[PLANIMETRIC]* means that PPiMMS minimizes the 2D (X-Y) distance without changing the Z of both points
 - o *[ALTIMETRIC]* means that PPiMMS minimizes the relative elevation (Z) between both points
- Once the user clicks on *[Validate]*, all the list of points will be added in a new constraint category called "User Constraints".
- The Confidence will set the manner the constraint will influence the result. *[Default]* means that the weight of the constraint will be similar to the automatic ones, while *[Full]* means that the constraint is doubtless and the constraint will be respected.

5.3.2 GROUND CONTROL POINT

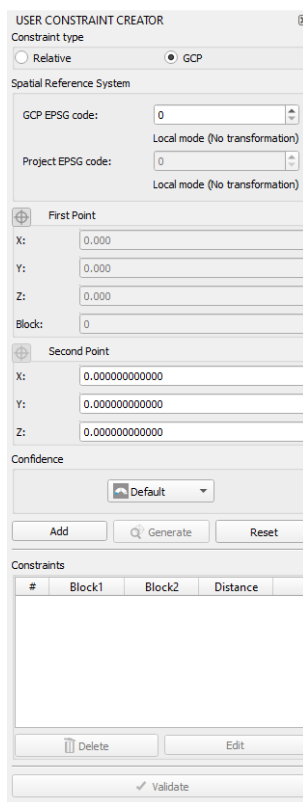
GCP mode is exactly the same principle but the second point is not a click but coordinates that the user knows from another source (Total Station, Static scanner, etc.). Those coordinates should be in meter (m) and always from a unique reference system. When the user will use EPSG code to specify the corresponding projection system, a warning message will appear as below:



The operator can choose the coordinates reference system of the input data by typing a valid EPSG code.

CAUTION#6. Grid transformation is not available in PPiMMS.

To activate this mode, the user selects the first parameter on the top of the window: *[GCP]*.



The "USER CONSTRAINT CREATOR" dialog box has several sections:

- Constraint type:** Radio buttons for "Relative" and "GCP" (selected).
- Spatial Reference System:**
 - GCP EPSG code: 0 (dropdown)
 - Local mode (No transformation)
 - Project EPSG code: 0 (dropdown)
 - Local mode (No transformation)
- First Point:**
 - X: 0.000
 - Y: 0.000
 - Z: 0.000
 - Block: 0
- Second Point:**
 - X: 0.000000000000
 - Y: 0.000000000000
 - Z: 0.000000000000
- Confidence:** A dropdown menu set to "Default".
- Buttons:** "Add", "Generate", and "Reset".
- Constraints Table:**

#	Block1	Block2	Distance
- Buttons at the bottom:** "Delete", "Edit", and "Validate" (with a checkmark icon).

- The user clicks the first point on the requested block.
- The user enters the coordinates of the control point. The user is required to enter the EPSG³ code of the corresponding point.
- The Confidence will set the manner the constraint will influence the result. *[Default]* means that the weight of the constraint will be similar to the automatic ones, while *[Full]* means that the constraint is doubtless and the constraint will be respected.
- Then, the user clicks *[Add]*
- Below, the list is updated and the user is able to click several couples to fill the list. Every point in the list is still editable or removable.
- Once the user clicks on *[Validate]*, all the list of points will be added in the same constraint category called "User Constraints". However, those GCP can be recognized in the tree view list as they are all between one block index (the one the user selected by clicking it) and the block '0' which is the reference block.

The user can use the external data import function in order to quickly open set of control points. This function is described below in the section 0.

Once inserted, those points can be selected when the user clicks one point in the 3D point cloud close to a control point.

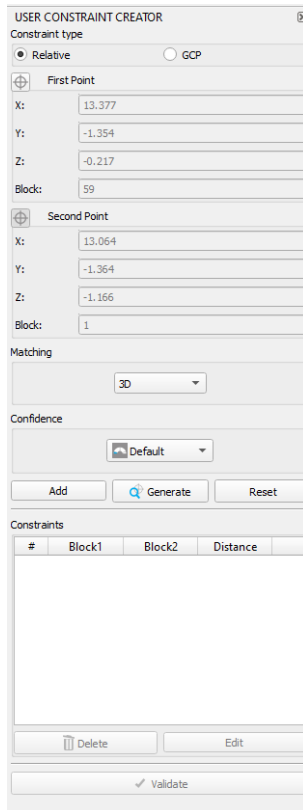
In case there is a GCP available near the point clicked in a block, the coordinates of this control point are filled in automatically in the "Second Point" field.

5.3.3 SEMI-AUTOMATIC CONSTRAINT

In certain case, it can be difficult to click similar constraints (for instance, when no corners or any kind of feature is available between two blocks).

This mode requires the user to roughly click only one couple of points on two different blocks.

Then, the user selects the confidence and clicks on *[Generate]*. The software tries to match those two blocks, helped by the clicked couple. The accuracy of the click is not required, the click is to designate which block should be matched.

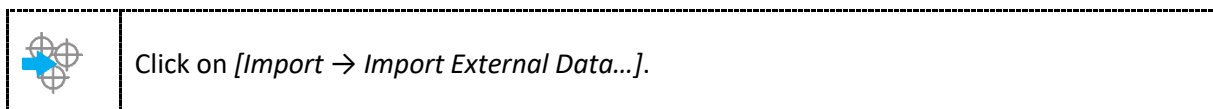


- The user clicks one point in the first block (in that case, this click is more or less to designate a block ID)
- Then, he selects the second block and clicks one point in it (for similar reason, a precise click is not required, the fine registration is calculated afterwards)
- The user changes the confidence if necessary.
- Then, the user clicks on *[Generate]*. This function will create couples of constraints automatically. This function is available only if MATCHING mode is set as *[3D]*.
- The user validates them or deletes them if they are not appropriate. This computation **CAN FIND ERRONEOUS MATCH. THE USER IS REQUESTED TO CHECK THE CONSTRAINTS BEFORE VALIDATING THEM.**

In case there is a Point cloud imported (see section 5.3.4), the operator can generate control points constraint using this *[Generate]* button. Once, the user has clicked a point in a block, he can click approximatively the same corresponding point in the external point cloud and click on *[Generate]* button to generate constraints using ICP algorithm to match the block and the control point cloud. The external point cloud will be considered as fix and the minimization will only influence the trajectory of the corresponding acquisition.

5.3.4 EXTERNAL DATA

The user is also able to import a file of control points:

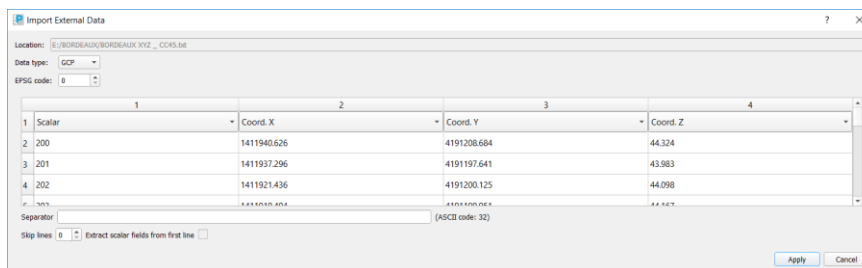


The user is requested to select a file and the path to find it.

PPiMMS is compatible with:

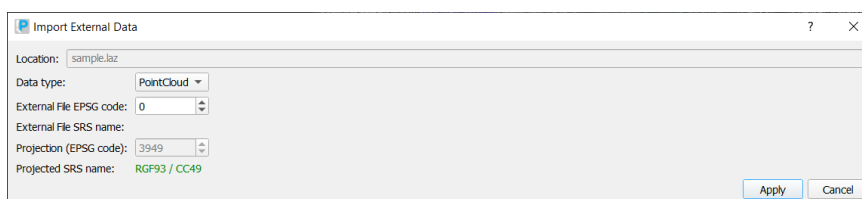
- TXT / CSV / XYZ → format used for Ground Control Points (GCP)

Then, a window opens, the user is then requested to select the separator character, the column id and the EPSG code to properly parse the file.

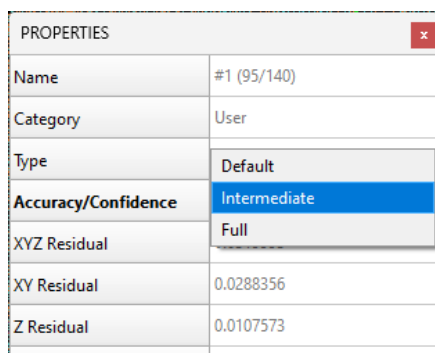


- LAS / LAZ → format used for Ground Control Point Cloud

A window will pop-up and the user can fill-in some parameters about the origins of the point cloud. The software imposes a limit of 25% of the maximum number of points. This number is set by the user, depending on the capacities of the graphic card and the dedicated GPU memory. The user can change this parameter by [Right click → Display → Maximum of displayed points]



5.3.5 CONFIDENCE PROPERTY



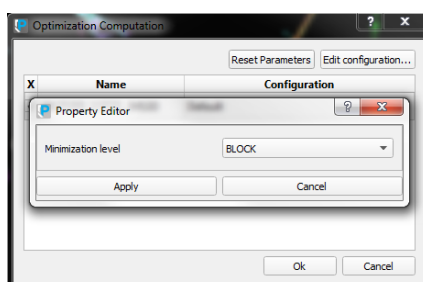
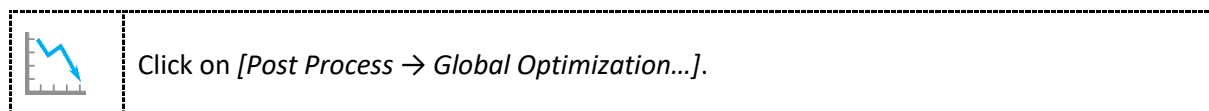
The user set constraint confidence during its creation in the constraint editor window.

However, if the user estimates that the confidence of certain constraints should be changed, it is possible to change it in the property window:

[Right click → Properties]

5.4 MINIMIZATION

When the user includes his own constraints, this is NECESSARY to update the new Minimized Trajectory which takes into account all the constraints. This function is called “Global Optimization”.

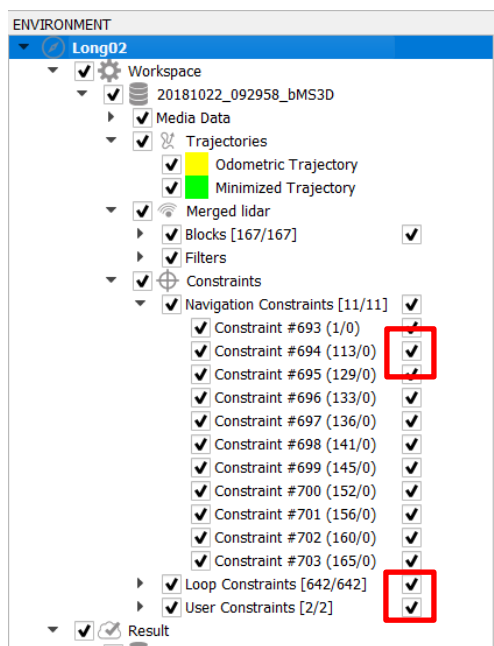


By clicking on *[Edit Configuration...]*, the user is able to optimize the trajectory at two different levels:

- 1- At a block level where every block is considered rigid
- 2- At a frame level where every LiDAR frame is considered Rigid and the block can be distorted internally.

This optimization will find the best trajectory that will reduce the error on every constraint, taking into account the odometric constraints, the loop constraints, the navigation constraints and GCP constraints, all of them weighted by their confidence. The quality of this minimized trajectory can be checked as explain in the section 5.6.

It is possible to select and unselect the constraints manually. The user can then use the checkboxes on the right in the Tree view:



- Unchecking one constraint will remove this constraint from the optimization.
- Unchecking one category of constraint will remove all the corresponding constraint from the optimization.
- Unchecking one or several block will automatically remove all the corresponding Odometric constraints of this trajectory section(s) and all the constraints relying on this section(s) from the optimization process. However, this action will break the continuity of the initial odometric trajectory. The optimization will be available only if this continuity can be recover through other constraints (loops/manual/Navigation/GCP).

5.5 RESTORE ODOMETRIC TRAJECTORY

It can be sometimes necessary to come back to the first original trajectory obtained after the function “Odometric Trajectory Computation”.

In order to do it, you can use the restore function which will cancel the effects of all your constraints.



Click on *[Post Process → Restore Odometric Trajectory...]*.

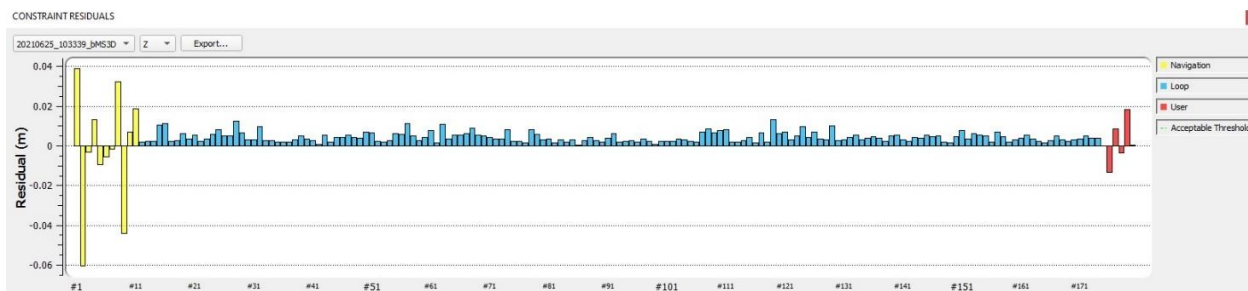
5.6 STATISTICS

Once optimized, the residual errors can be displayed by clicking on the graph:



Click on *[Stats → Constraint Residual Histogram...]*.

The user can check the quality of the constraints in order to validate the result.



Most of the constraints are displayed in this histogram but the odometric ones.

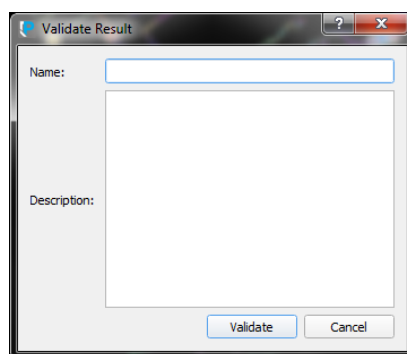
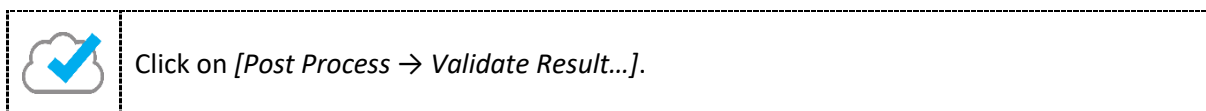
This window can display the histogram from any acquisition and from the inter-acquisition ones.

Also, the user can display those constraints by setting XYZ / XY or Z in order to show the distribution of the residual errors with respect to the axis.

6 VALIDATE A RESULT

The workspace is where the user can manipulate the trajectory, he can improve the result and remove the drifts by using several processes in PPiMMS.

Once the user decides that the result is coherent and respects the requested specifications, he can validate the result.

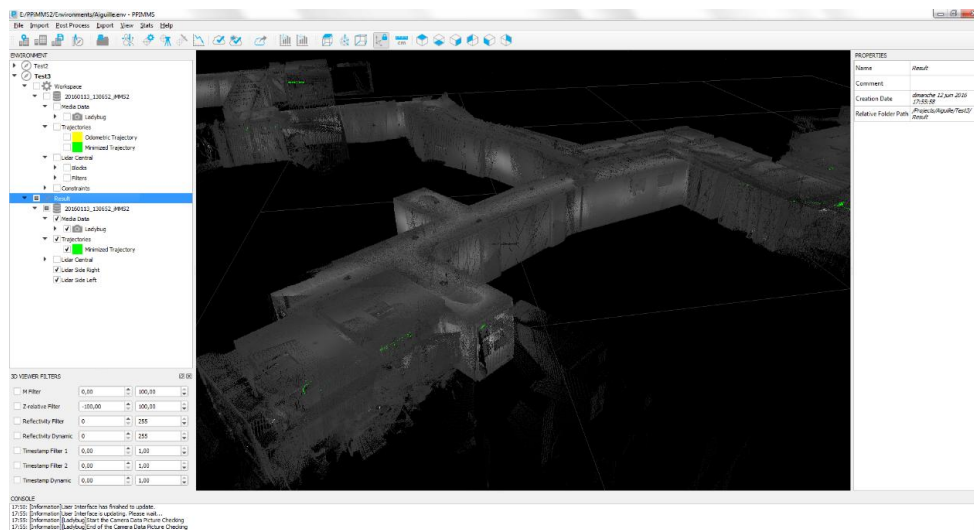


The user is requested to enter the name of this result and then to click on *[Validate]*.

This mode then saves the current trajectory (in green) in a Result. In the Tree view, there is new category under the Workspace.

The result name set during the validation can be changed.





7 MULTI-ACQUISITIONS (MERGING PROJECTS)

This section deals with the capability to merge different scans (continuous scans) into registered results using the VIAMETRIS workflow. Indeed, traditional registration algorithms would consider every continuous scan as rigid object while PPiMMS will consider them as elastic trajectories to match the point clouds and to optimize all the constraints.

Before this new functionality, the user was able to match different scans by using GCP presented in section 5.3.2. Now, PPiMMS allows users to match scans without absolute points.

Nothing differs between “single-acquisition” projects and “multi-acquisition” projects. The workflow still remains and the steps described above are strictly similar.

7.1 ADD ACQUISITIONS

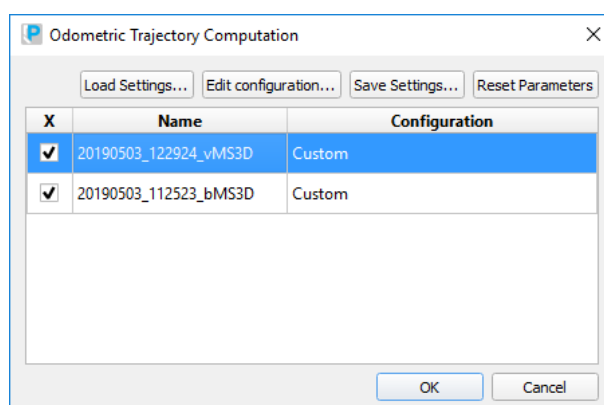
The user can add acquisitions to an existing project:



Right Click on [ProjectName → Add Acquisition...].

7.2 WORKFLOW

The steps described in previous chapters remains, the difference is in the parameter’s windows where the acquisitions are listed. This means that we can set different parameters for every acquisition:



7.3 IMPORT FROM RESULT

We advise PPiMMS users to not change the way they are working, i.e. one project per acquisition. Indeed, the user then works in projects that do not contains too much data for the PPiMMS 3D Engine. However, all those projects are supposed to be in the same environment in order to be merged.

The user creates one additional project to merge the acquisitions. To do so, the user imports results or workspaces from the other projects of the environment by selecting the function “Add Acquisition from result”.



Right Click on [ProjectName → Add Acquisition from Result...].

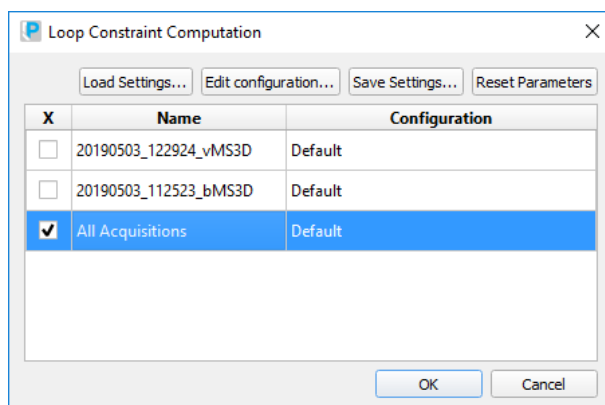
A window opens and the user can select the result he wants.

CAUTION#7. *The projection has to be the same for all the results to be merged*

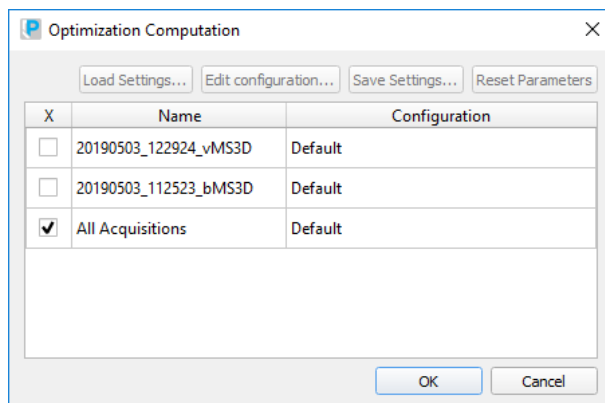
7.4 MULTI-ACQUISITION CONSTRAINTS

The most important advantage of MACQ project is the ability to constraint various scans in order to improve the global accuracy. The result, initially independent, will then be linked to others in order to adjust themselves.

The user can then create constraints (manual ones, semi-automatic ones, or from loop detection).



Those constraints will then be optimized in order to adjust all the scans to reduce all kind of drifts. Loop detection will be possible only if the scans are in the same coordinates system, either by using manual constraints, semi-automatic constraints or thanks to navigation constraints with similar projection system. Then the loop detection can be launched to merge several scans.



In case one more scan is added to the current project, launching the loop detection once more will only search, detect and create new constraints between the new scan and the first scans, but no more constraints will be created between the first scans.

7.5 ACQUISITION LOCK

In case one or several acquisitions in one project need to be fixed with respect to others that would “move” around, the user is able to lock some acquisitions in order to fix their positions. This means that during minimization steps, locked acquisitions will be considered freeze in the 3D space.



Click on *[Post Process → Lock Acquisition...]*.

Once locked, the computing function (odometric computation, Loop detection, minimization, ...) related to those acquisitions won't be possible.

Locked acquisitions are listed in the tree view with corresponding icon .

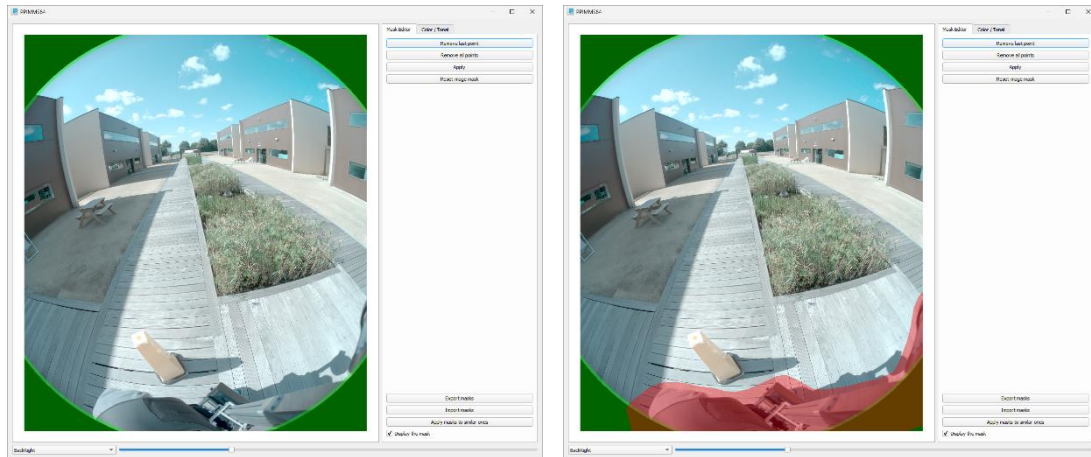
8 COLORIZATION

Once validated, a result can be colorized using the RGB data coming from a camera. It is preferable to check first, before launching the colorization process, that the mask applied to every image is correct and fits exactly the shape of the visible operator or vehicle in it.

In case the data comes from MS-96 system, there is a mask to generate for every camera and the user can then use the “Image Editor” function. This function is accessible from the tree view, by right-clicking on *MultiCams* in Media Data category.

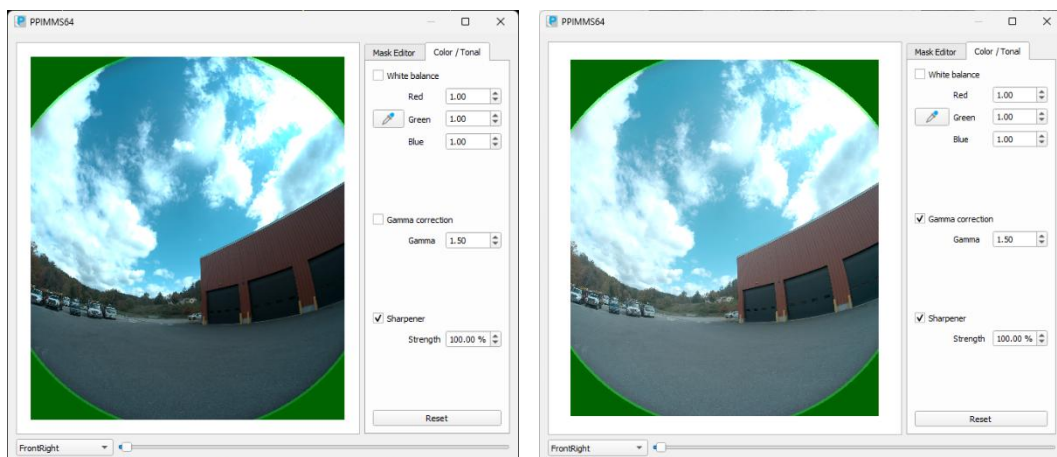
Right Click on *[MultiCams → Edit Mask/Color]*.

The images below show that the user can roughly draw a polygon around the object he wants to not use during the colorization process. The polygon is drawn by successive right-clicks around the object, once validated, this polygon is included to the mask.

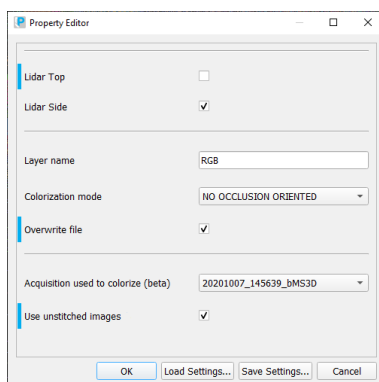


Moreover, using the same window, the 10-bits images acquired via MS-96 systems can be adjusted in terms of:

- White balance by clicking white point in the environment (using the pipette tool),
- tonal by setting gamma gain to enhance low light areas in images
- Image Sharpening function



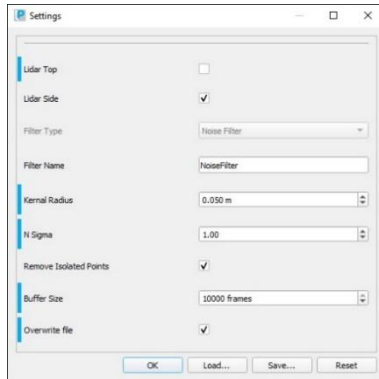
Once the user gets ideal correction and image quality, he can then launch the point cloud colorization process detailed below.



- The user selects which LiDAR sensor he wants to colorize
- The user can enter the name of the new RGB layer
- Several strategies are available including NO OCCLUSION ORIENTED; CONSISTENT ORIENTED or MIXTE strategy
- The user can check the box "Overwrite file" if the layer name is the same than an existing one
- In case of merging project, the user can colorize a point cloud from one scan using the camera from another scan (daylight/night conditions for instance)
- The user can colorize with the panoramic view (if available) or the independent camera images to remove stitching errors (much accurate but longer computation time)

9 NOISE FILTERING

PPiMMS now includes Noise Filtering. The filter is based on neighborhood and it measures the local standard deviation of neighbors based on local plan calculated from single value decomposition (SVD).

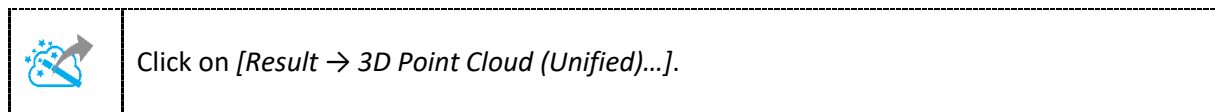


- The user selects which LiDAR sensor he wants to filter
- The user can enter the name of the new Filter layer
- The *Kernel Radius* is the radius size of the sphere in which the filter looks for neighbors
- *N Sigma* is the factor of std dev from the SVD plane
- The check box *Remove Isolated Points* is set to remove point out of neighbors
- *Buffer Size* is the number of frames we load in memory to compute the dataset

10 EXPORT

The Export functions are reachable once at least one result exists in the list of the tree view.

10.1 3D POINT CLOUD EXPORT (UNIFIED)



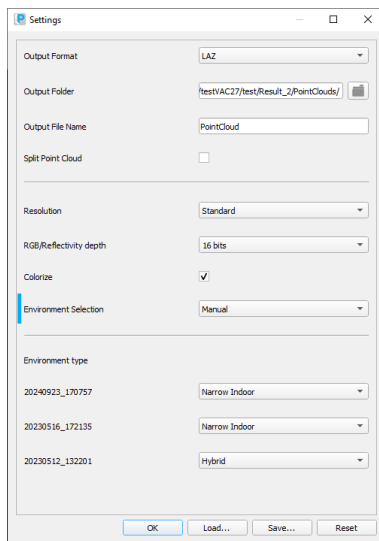
PPiMMS embeds advanced export function that ensure users the get the best result from its equipment.

This function will gather several filters and advanced algorithms for:

- Denoising the point cloud
- Smart decimation
- Point cloud colorization correction
- Merging several scans in one unique result

Those algorithms will depend on two main criterium: the kind of environment and the required resolution.

This new function of export is as simple as possible:



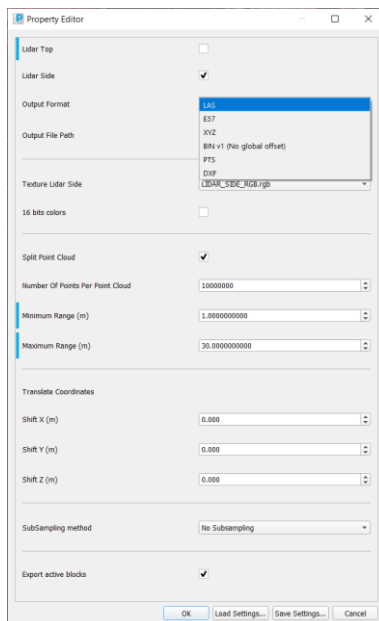
- The user selects the format of the output file
- The user can change the export path: by default, it will be exported on the Result folder
- The user can change the name file
- Resolution:
 - o [standard] point cloud decimation is 1pts/10mm
 - o [High] Point cloud decimation is 1pts/5mm
- Color and intensity can be encoded on 8bits or 16bits
- Result can be exported with or without color
- The user set automatic or manual environment selection:
 - o [NarrowIndoor] → maximum range is set to 10m and the denoising algorithm is less permissive
 - o [Hybrid] → maximum range is set to 30m and the denoising algorithm is balanced
 - o [LongRange] → maximum range is 50m and the denoising algorithm accepts isolated points

10.2 3D POINT CLOUD EXPORT (CUSTOM RAW DATA)



Click on [Result → 3D Point Cloud (Custom)...].

The user is able to set different parameters:

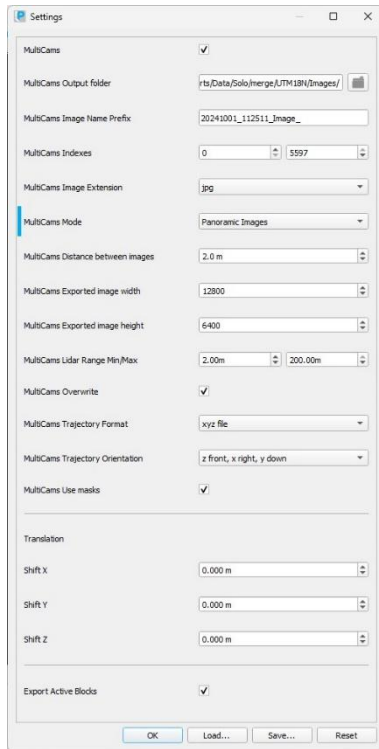


- The user can select which LiDAR he wants to export
- The user specifies the format of the file
- The user can change the export path: by default, it will be exported on the Result folder (Working Directory → Projects → ...)
- This is possible to colorize the result using the camera
- Color can be encoded on 16bits if necessary (for software compatibility issue)
- The user set up the range parameters to remove or to filter the points he requires
- It is possible to add absolute offsets in X, Y and Z to the overall result.

10.3 IMAGE EXPORT



Click on [Result → Export Images...].



- The path where the images will be exported
- The image name prefix
- The indexes of the first and last images exported
- The format of the images
- The mode of export [*Single Images*] or [*Panoramic Images*]
- Images size Width and Height.
- Point cloud Min and Max Range used to measure the range per pixel
- Position & Orientation of the images are exported w.r.t format file (see below the description of those file format)

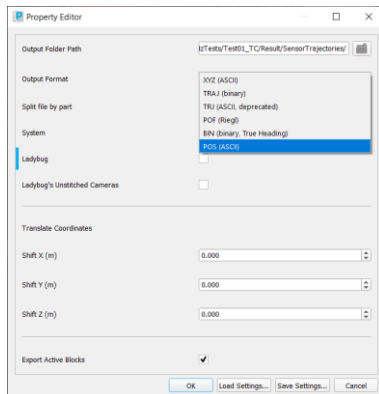
Images can be exported in E57 format in order to create virtual tour in third party software. The user will fill in the path of the E57 file containing the colorized point cloud. The resulting E57 file then combines Images and point cloud.

10.4 TRAJECTORIES



Click on [*Result → Sensor Trajectory...*].

Several options are available:



- The path of the output is required
- The format of the trajectory including XYZ (ASCII); TRAJ (BINARY); TRJ (Deprecated ASCII); BIN (SBGECOM Format to simulate TrueHeading); POS (Compatible with Third party software, including accuracy estimation)
- Select what the user wants to export (system will be trajectory of the reference center; the camera is available as well).
- Enter offset value for x, y and z if necessary
- Either export only trajectory from activated block or the entire trajectory

We assume below that we have the following coordinate system:

Position in the world coordinate system is given by the matrix T and the rotation Matrix R:

$$T = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}; R = \begin{bmatrix} R_{xx} & R_{xy} & R_{xz} \\ R_{yx} & R_{yy} & R_{yz} \\ R_{zx} & R_{zy} & R_{zz} \end{bmatrix} \text{ such as: } Tw = R.P + T$$

With P a point in system coordinate system and T_w the same point in world coordinate system.

The system coordinate system is as:

- Y is the front vector

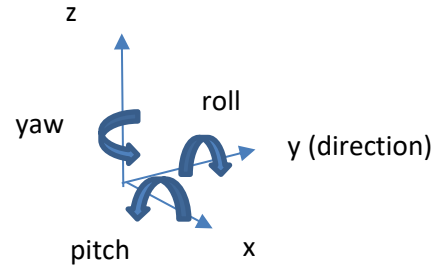
- Z is the up vector
- X looking right

EULER Angle:

$$R_{/y} = \begin{pmatrix} c3 & 0 & s3 \\ 0 & 1 & 0 \\ -s3 & 0 & c3 \end{pmatrix} \text{ avec } \begin{matrix} c3 = \cos(\text{roll}) \\ s3 = \sin(\text{roll}) \end{matrix}$$

$$R_{/x} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c2 & -s2 \\ 0 & s2 & c2 \end{pmatrix} \text{ avec } \begin{matrix} c2 = \cos(\text{pitch}) \\ s2 = \sin(\text{pitch}) \end{matrix}$$

$$R_{/z} = \begin{pmatrix} c1 & -s1 & 0 \\ s1 & c1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \text{ avec } \begin{matrix} c1 = \cos(\text{yaw}) \\ s1 = \sin(\text{yaw}) \end{matrix}$$



We can find back the rotation matrix using the following formulae:

$$R = R_{/z} \times R_{/x} \times R_{/y} = \begin{pmatrix} c1c3 - s1s2s3 & -s1c2 & c1s3 + s1s2c3 \\ s1c3 + c1s2s3 & c1c2 & s1s3 - c1s2c3 \\ -c2s3 & s2 & c2c3 \end{pmatrix} = \begin{pmatrix} R_{00} & R_{01} & R_{02} \\ R_{10} & R_{11} & R_{12} \\ R_{20} & R_{21} & R_{22} \end{pmatrix}$$

Similarly, from the rotation Matrix, we can find back the Euler angle:

$$\text{roll} = \text{atan}\left(-\frac{R_{20}}{R_{22}}\right) ; \text{pitch} = \text{atan}\left(\frac{R_{21}}{\sqrt{(R_{20}^2 + R_{22}^2)}}\right) ; \text{yaw} = \text{atan}\left(-\frac{R_{01}}{R_{11}}\right)$$

10.4.1 XYZ TRAJECTORY

The trajectory standard file for the camera will be a “*.xyz” file using the following structure:

Timestamp X Y Z R_{xx} R_{xy} R_{xz} R_{yx} R_{yy} R_{yz} R_{zx} R_{zy} R_{zz} 0 IndexIm {VIAMETRIS INTERNAL DATA}

Timestamp is the time of the data in second.

Each line of the file describes the position and the orientation of one image in the world coordinate system (X ; Y ; Z).

10.4.2 TRAJ (BINARY)

The TRAJ format is a binary format for internal use. Contact the support if you have requirements to use the binary file.

10.4.3 TRJ TRAJECTORY (DEPRECATED)

The TRJ format was used in PPiMMS 1.x to describe the trajectory. This file was mainly used for 2D trajectories. The best way to remove any ambiguity regarding the rotation matrix, it is recommended to use the XYZ trajectory format.

The TRJ file is in ASCII format and the structure is as following:

Timestamp, X, Y, Z, Yaw, Roll, Pitch, {VIAMETRIS INTERNAL DATA}

The Timestamp is the time of the data in millisecond.

10.4.4 BIN FOR TRUEHEADING

When trajectory is computed with SLAM and then registered to absolute coordinate frame using ground control points or navigation constraints, the trajectory is then an absolute trajectory from which we can deduce the system heading (w.r.t. the north).

However, INS/GNSS tight coupling algorithms available in post-processing software are usually not able to initialize when dynamic is too slow, without strong acceleration, or without kinematic profile to help. This is why, it is usually the reason why INS/GNSS systems requires double antenna for True Heading aiding.

In our case, this BIN file will be able to simulate True Heading data coming from virtual second antenna in order to activate tight coupling algorithms.

10.4.5 POS FILE

POS files are available for third party software compatibility. This file will respect the following structure:

Timestamp X Y Z Roll Pitch Yaw XAcc YAcc ZAcc RollAcc PitchAcc YawAcc

X, Y and Z are expressed in meter.

Roll, Pitch and Yaw are expressed in degree.

10.4.6 CSV FILE (VIA EXPORT IMAGES)

In « Export Images » window for MS-96 images only, it is possible to export CSV file with the following structure:

ImageName ; Timestamp ; x ; y ; z ; roll ; pitch ; yaw

X, Y and Z are expressed in meter.

Roll, Pitch and Yaw are expressed in degree.

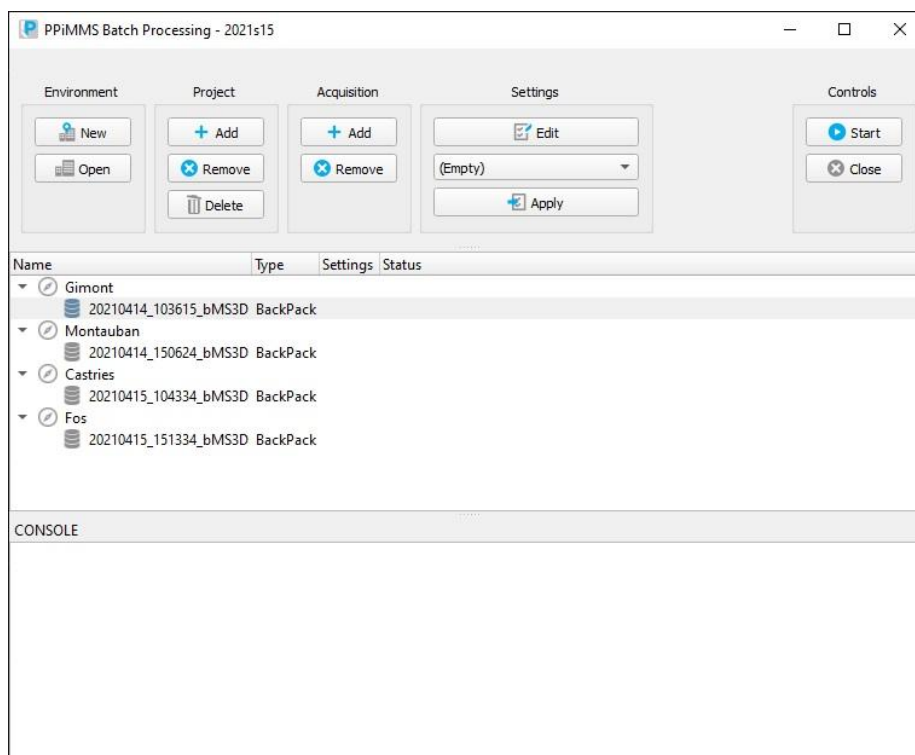
11 BATCH PROCESS



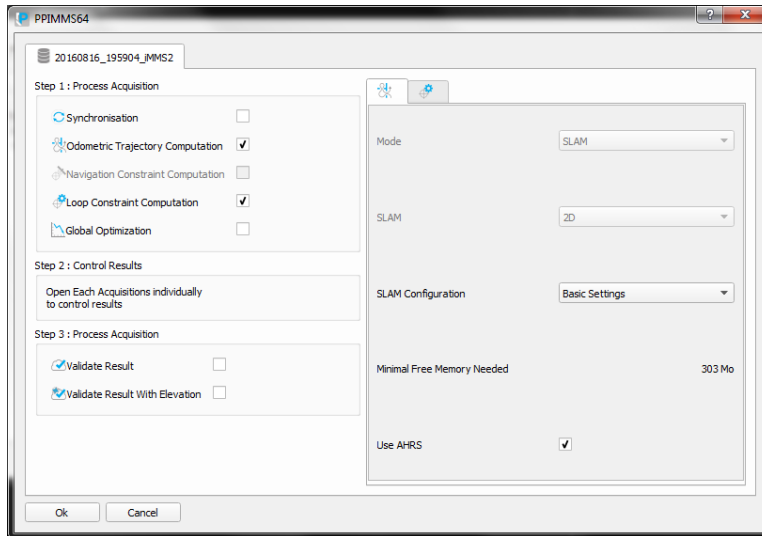
Click on *[Process → Batch Processing...]*.

The batch processing function allows the user to set-up the process workflow of one or several projects at once.

Clicking on this button, a window pops up and the user can select the project:



Project	The user can select the project he wants to process. The project can be an existing one or the user can create one selecting the acquisition.
Acquisition	The user can select the acquisition to add to project.
Settings	The user can edit and save settings in properties sheets in order to call them back later.
Start	The start button launches the process by following the user workflow. The processes will sequentially launch one by one.



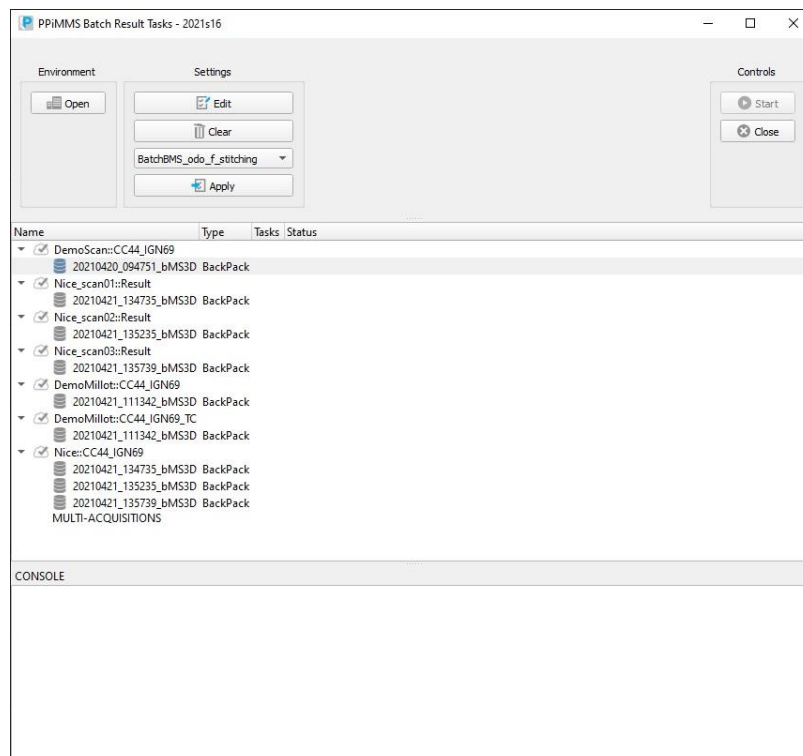
- On the left, the user selects the process steps
- On the right, every process step selected will create the corresponding tab. The user can customize the parameters as explained in the previous chapters.

12 BATCH RESULT TASKS

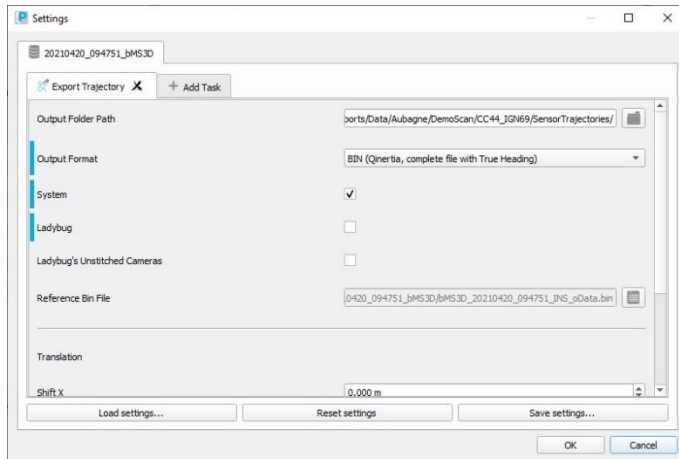


Click on *[Export → Batch Result Tasks...]*.

The Batch Result Tasks is developed in order to optimize the several tasks the user is usually doing once he validates a result, i.e. colorizing, exporting, point clouds and trajectories, images.



Environment	The user selects the environment from which he will be able to set the tasks to batch.
Settings	The user can edit and save settings in properties sheets in order to call them back later.
Start	The start button launches the process by following the user workflow. The processes will sequentially launch one by one.



- The user selects first the tab of the acquisition
- Then, by clicking on “+Add Task”, the user chooses which kind of task between Colorizing, Filtering, Point cloud export, trajectory export and image export
- The user can add as task as necessary.

13 3D VIEWER OPTIONS AND SETTINGS

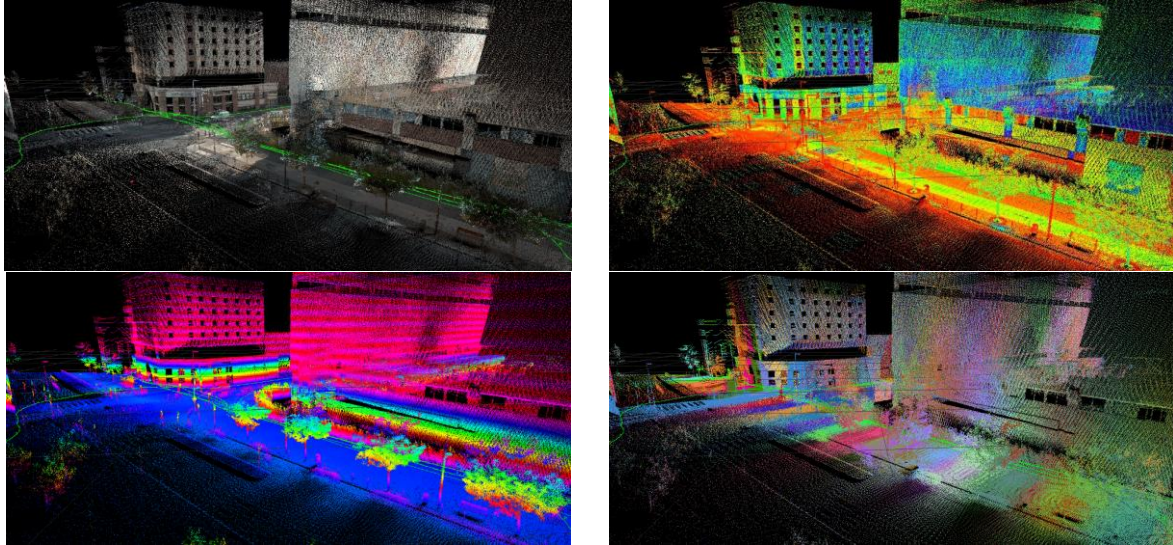
13.1 POINTS OF VIEW & TOOLS

	Orthographic Top View → This mode is useful to work and detect the gap between blocks
	Vertical Section Orthographic View → This mode automatically displays the vertical section with orthographic point of view. The user needs to click two points: those two points defines the section orientation and position, the first point is on the left of the window, the second on the right. By default, the section depth is set to 5cm. The user can set this value (Right click → Camera → Section Width). Keyboard shortcut to activate → ALT+LeftClick on the first point in the 3D view By pressing ALT+Scroll the section view moves <u>forward</u> or <u>backward</u> parallel to the current section. Keyboard shortcut to deactivate → ALT+RightClick in the 3D view come back to the previous view before activating the section.
	Horizontal Section Orthographic View → This mode displays an horizontal section by defining a constant z coordinate. This mode requires on click in the 3D view. Keyboard shortcut to quickly activate this mode is available → ALT+CAP+LeftClick in the 3D viewer by picking one point in the point cloud. ALT+Scroll will move the section at different constant height. ALT+RightClick comes back to the initial view mode
	Object-Centered View → Click on it and then click on a 3D point in the 3D Viewer: the user is able to move the point of view around this point – the user can activate this mode and select the center point by CTRL+LeftClick – he can deactivate this mode by CTRL+RightClick
	Perspective View → Standard navigation point of view in 3D
	Rotation lock → in order to block the left click and keep the ability to translate only
	Camera Roll Locker → The camera is released or not regarding the Roll: it means that the Z axis is maintained vertical or not during the navigation
	Measurement Tool → By clicking points in the 3D Viewer, the information is displayed on the Top right part of the window. Keyboard shortcut is CAP+LeftClick to pick the first point in the window, the user deactivates the tool by CAP+RightClick

13.2 POINT CLOUD LAYERS

Every point cloud can be displayed using color or B&W representation. The user can then display:

- RGB layer (only available for validated result and once the colorization has been calculated)
- Intensity of LiDAR in B&W
- Intensity of LiDAR in Colored-HSV
- Height of Point (color of point is function of relative Height)
- Range of Point (color of point is function of range)
- Timestamp of Point
- Block Index of Point



13.3 3D VIEWER SETTINGS

Display	The user can change: - the size of points, - the background color, - the maximum number of displayed points, and activate the High-performance mode (this mode is useful for systems with very long-range capabilities only)
Tools	Following check boxes are available: - <i>Grid</i> activates or deactivates the horizontal grid - <i>Selection helper</i> changes the color of point the user is selecting - <i>Disk</i> activates or deactivates the disk at the position of the pointer - <i>Disk Interpolation</i> activates or deactivates the capability to click where there is no point thanks to local interpolation
Camera	The user can change some 3D view parameters such as - Perspective/ortho view - ZFear / ZFar set the range limits to display points in front of the 3D view - Translation and rotation steps will change the way the 3D view moves at every mouse action
Reset settings	PPiMMS reset back to standard parameters