**Technical Writing Sample #2 – LAS file preparation in RiSCAN PRO**

***Data Description.***

The data are 3D point clouds generated using a Terrestrial Laser Scanning (TLS) unit. This dataset is a legacy ground dataset collected by the USGS in 2014 over the surface rupture associated with the 1999 Hector Mine Earthquake ($M_w$ = 7.1). There are five RiSCAN projects total that contain scans for five geographically separate areas along the surface rupture. Each project has a folder of scans with multiple scan positions. Associated with each scan position are ≥1 “singlescans”, which are 3D snapshots of the landscape in the field-of-view of the TLS unit during data acquisition.

***Automatic Registration.***

This project used Version 2.14 of the Operating & Processing Software RiSCAN Pro for RIEGL 3D Laser Scanners. The scans associated with each of the five scan areas were automatically registered during creation of the RiSCAN project. However, the software’s “Automatic Registration” feature is a quick alignment feature that focuses on registering “tie point scans” with isolated positions within the point cloud. Consequently, vertical and lateral misalignments may persist farther away from the positions of the tie point scans, as seen in the left panel of Figure 1.

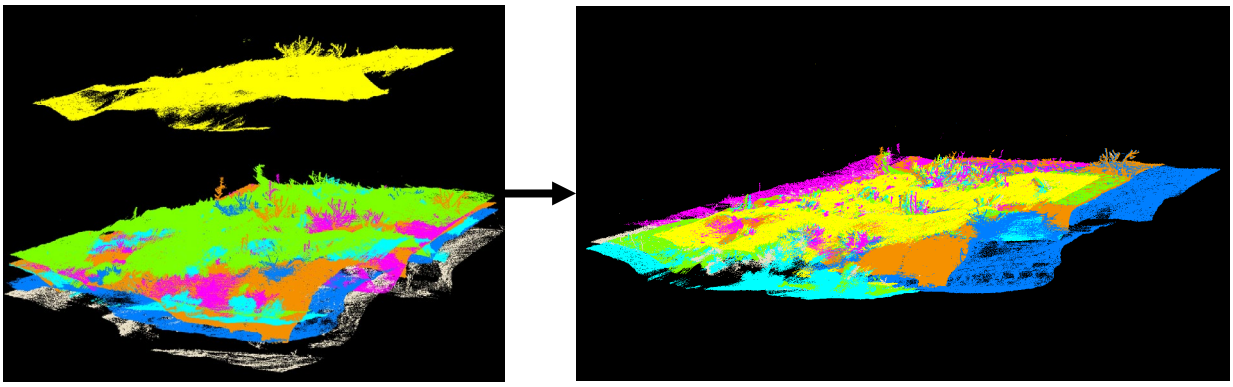
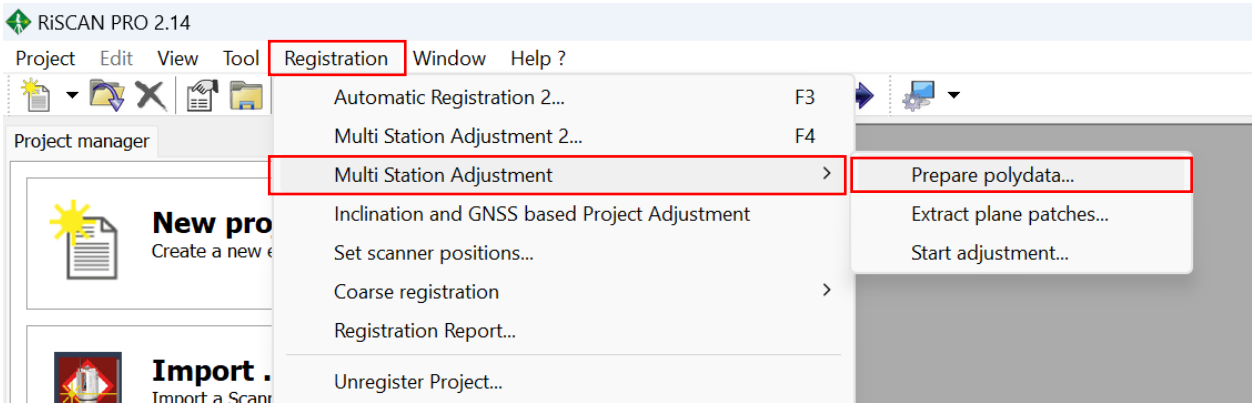


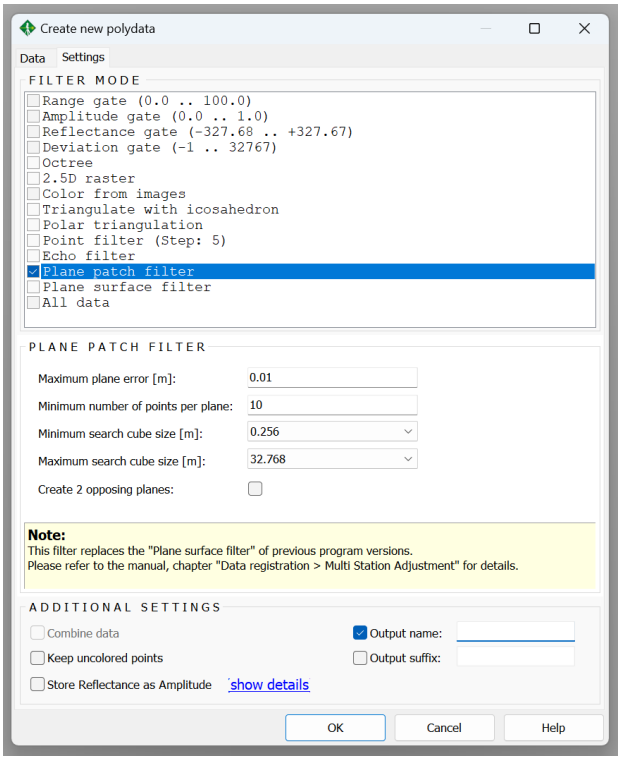
**Figure 1.** Even after RiSCAN Pro’s Automatic Registration process, extreme vertical misalignment between different scans of the same area persists (left). RiSCAN Pro’s Multi Station Adjustment tool provides iterative corrections to achieve alignment (right).

***Prepare data for Multi Station Adjustment.***

RiSCAN Pro has a “Multi Station Adjustment” (MSA) feature to further refine point cloud alignment. To begin, click: Registration > Multi Station Adjustment > Prepare polydata.




A new window will pop up with two tabs: “Data” and “Settings”. Under the “Data” tab, put a check next to the scans that need to be filtered. Under the “Settings” Tab, select the “Plane patch filter” as the filter mode.




This filter has the following user-defined parameters:

(1) Maximum plane error [m]: The filter’s algorithm will repeat until it meets this threshold for the standard deviation of residuals between the plane and the points used to create the plane.
(2) Minimum number of points per plane: Every best-fitting plane will use at least this number of points (number must be ≥3).
(3) Minimum search cube size [m]: This number is the minimum size of the cube used to bound the best-fitting plane.
(4) Maximum search cube size [m]: This number is the maximum size of the cube used to bound the best-fitting plane.

The values selected for these parameters will depend on the density of the point cloud, and the scale of the features of interest within the point cloud.

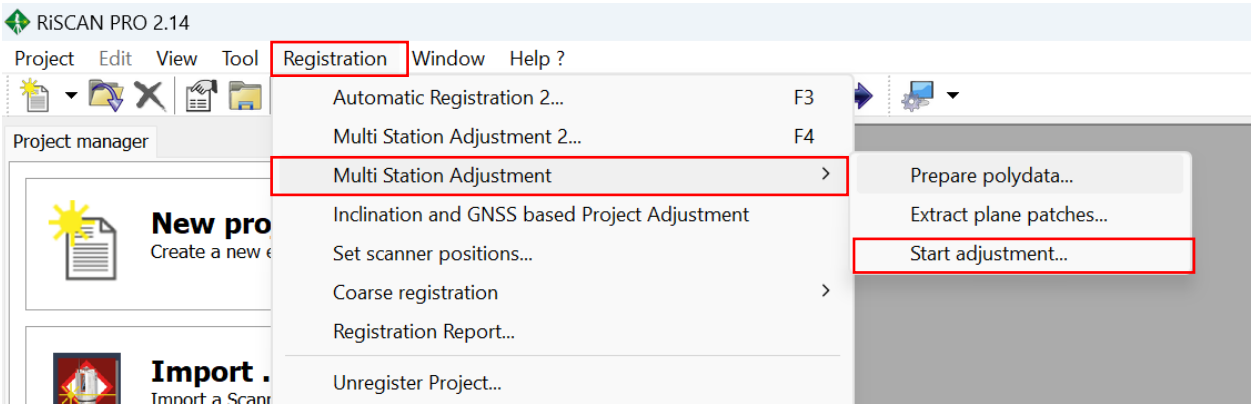
To create the plane patches, the algorithm will divide the point cloud into search cubes of an equal size, and then it will calculate the plane of best fit for the points within each search cube using the least-squares method. If the standard deviation of the normal distances between each point in the search cube and the best-fit plane exceeds the user-defined “Maximum Plane Error”, then this “parent” search cube is divided into 8 smaller “child” cubes, where each child cube has ½ the edge length of the parent cube, and the fitting procedure is restarted. The search cube division and plane-fitting process will repeat until:

1. The algorithm finds a valid plane, upon which it is added to the list of plane patches in the filtered point cloud, or
2. The number of points in the search cube falls below the “Minimum number of points per plane”, or
3. The cube size (defined by its edge length) falls below the “Minimum search cube size”.

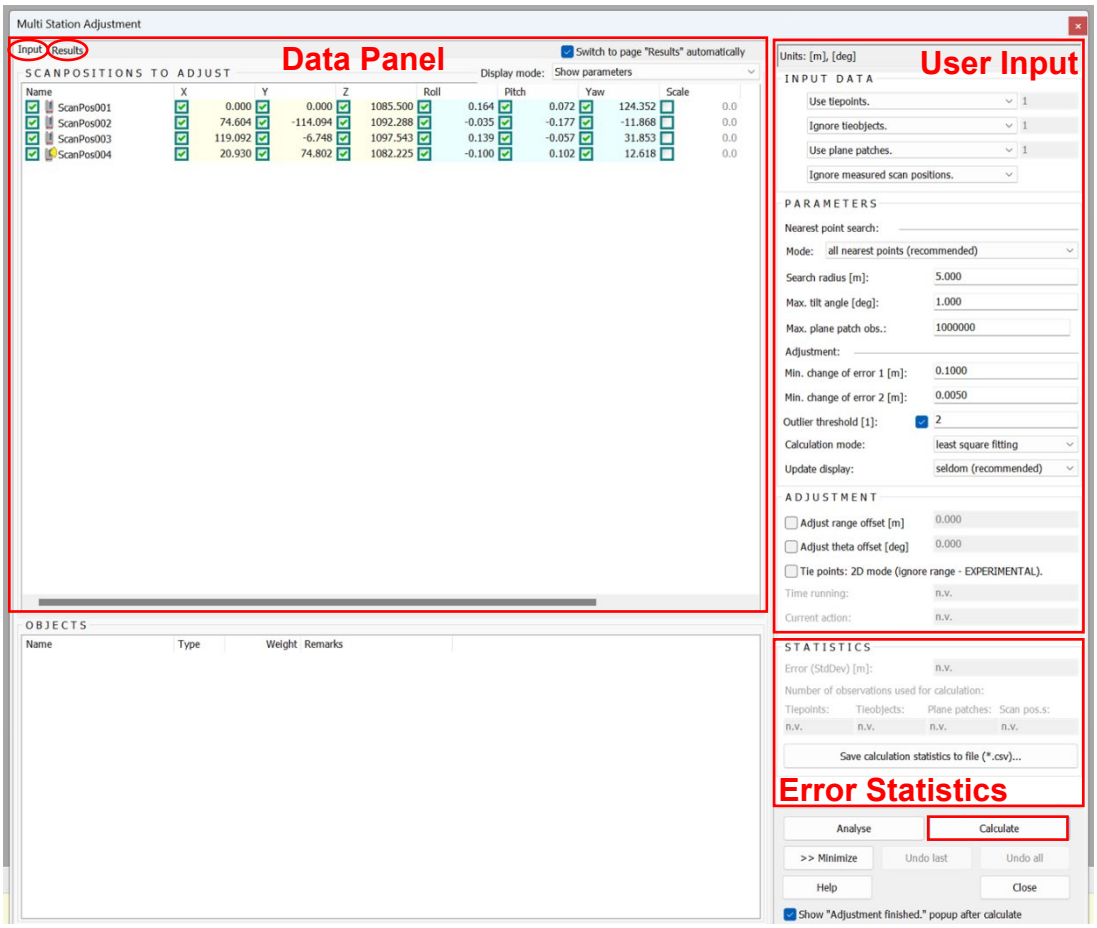
For each valid plane, the center point in the cube and the normal vector of the plane are stored in a new, filtered point cloud.

***Start Adjustment.***

To start the tool, click: Registration > Multi Station Adjustment > Start adjustment.




A new window will appear with three panels. In the “Data” panel, under the “Input” tab, put a check next to all the scans that were filtered in the previous step. The adjustment process requires locking the position and orientation of one of the scan positions. All other scans will be aligned to this locked scan position. By convention, the position and orientation of the first scan (which is the scan used to create the local coordinate system when the RiSCAN project is initialized) is locked. To lock a scan position, select it, right-click, and choose “Lock Position and Orientation”.




Navigate to the “Results” tab, which will display the results of the adjustment. In the “User Input” panel, in the “Input Data” section, select “Use plane patches”, and then select “Ignore” for all other options. In the “Parameters” section, select “all nearest points (recommended)” for “Mode”. The MSA algorithm identifies corresponding points in different scans based on their proximity to one another. The “Search radius [m]” parameter limits how far the algorithm searches for corresponding points. Once the algorithm finds a potential corresponding plane, it compares the normal vectors associated with each plane. If the angle between the normal vectors exceeds the “Maximum tilt angle [deg]” threshold, the algorithm discards the planes as potential matches, and the search process restarts.

To start the Multi Station Adjustment, click “Calculate”. Once the tool completes its run, assess the quality of the adjustment using the information populated in the “Statistics” section of the panel. The error is the standard deviation of the average normal distance calculated between all corresponding planes for each scan. The algorithm stops once the error is equal to “Minimum change of error 2”. The “Search radius [m]”, “Minimum change of error 1 [m]”, and “Minimum change of error 2 [m]” can be modified between executions of the adjustment process to further refine the alignment until it is satisfactory.