

## Plane-based Registration (C2C Registration)

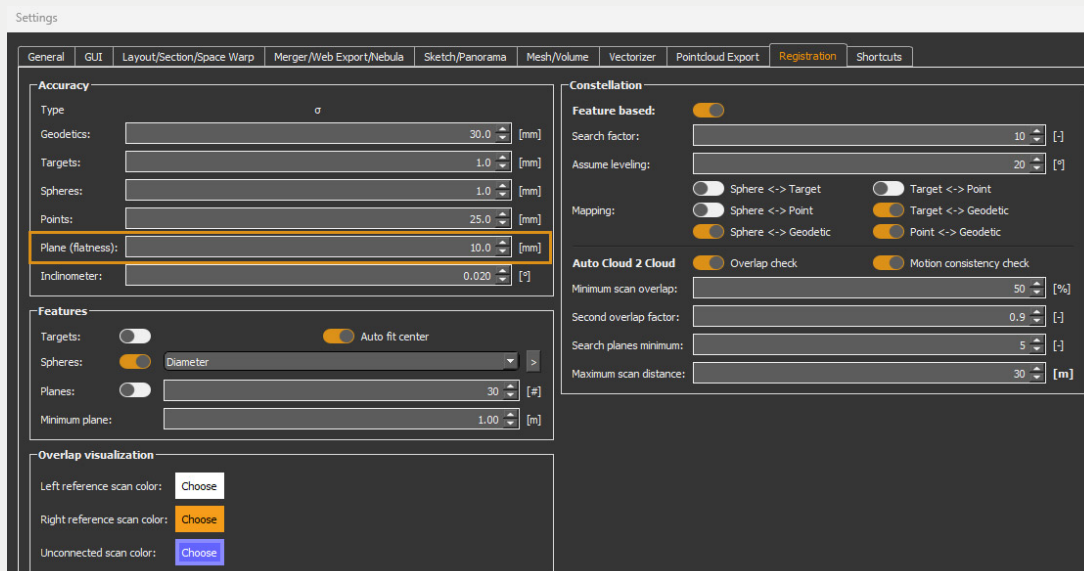
### 1. When it works best

The PointCab Origins “Cloud2Cloud” registration matches scans based on plane patchlets (little planes) and is, in the technical sense, a feature-based registration. It furthermore decides which scans to connect with each other based on the information you provide for the scans. Therefore, there are a few things to check before you try to register your project with our C2C. If the following conditions are not met, you will probably receive no or a bad result with the registration. **So please make sure to check these points, before using the registration:**

- It's an indoor project with up to 20 scans, where a lot of planes can be found (independent in all 3 axes).
- The amount of identical planes in different scans is high (a doorframe scan to a scan in the room works a lot better, then a scan from room A to another scan in room B).
- The scan names to scan connections are alphanumerically sorted (scans are sorted by name and the ones next to each other in name are assumed to have a connection and are getting checked if they are connected).
- The distance between two different scans is less than 5 meters.

### 2. Necessary presets and different setting options

Go to File > Settings and the Registration tab. Here you can set the default for the a-priori accuracies of the features (targets, spheres, points, planes), as well as the possible geodetic points (references). By default, the a-priori accuracy for planes is set to 10mm. This can be changed in case the scan measurements are inaccurate or the distance to said planes is larger than a few meters.

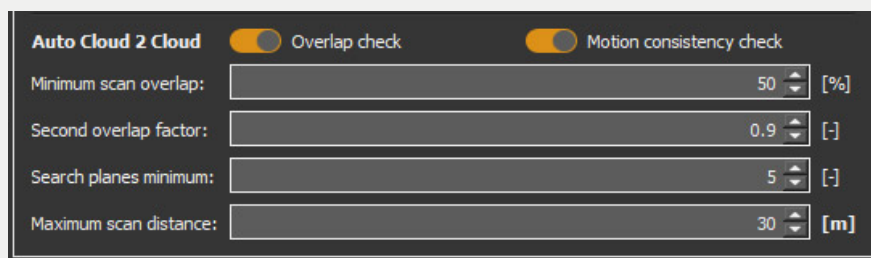


Under **Features**, you can set whether to search for targets, spheres and/or planes. The default settings will determine the maximum number of planes to be searched in a scan, as well as minimum area a plane should have in order to be extracted. These settings are automatically applied in every new project.



In the **Automatic cloud 2 cloud section** you can select two options: “Overlap check” and “Motion consistency check”. *We advise you to turn both options on.*

Generally speaking, the C2C registration consists of 2 steps. In the first step Origins checks sequentially by name if the scans have an overlap that is considered satisfactory to proceed with further registration (that’s the “Overlap check”). After the scans are paired, we need to check for triple connections for the already found scan pairs. Make sure that the option “consistency check” is activated, . If Origins finds a third scan coupled with the pair it performs a consistency check to verify the connection is feasible.



### Further explanation

The **“Overlap check”** option is a necessity for the automatic C2C. If there are no scans connected, this option tries to find connected scans via the extracted planes and a closest point estimation afterwards to calculate the overlap between 2 scans.

If the option **“Motion consistency check”** is selected, the registration will automatically check if the found connection between 3 scans is correct by loop closure and other means. This yields more accurate results but can also lead to less results found. This option won’t work without preprocessing with the “Overlap check” option or manually created scan groups.

**Minimum scan overlap** – the minimum percentage two scans should overlap to be considered for the automatic C2C registration.

**Second overlap factor** – a factor which determines if a match between scans will be considered for registration. Example: There are multiple possible matches for two scans. The first match is calculated at a 70% certainty, the second match at 60%. With a second overlap factor of 0.9, the second best match has to be lower than 63% to discard and therefore, validate the first match. Since the second best match is 60%, the registration will proceed with the first match and discard the second match.

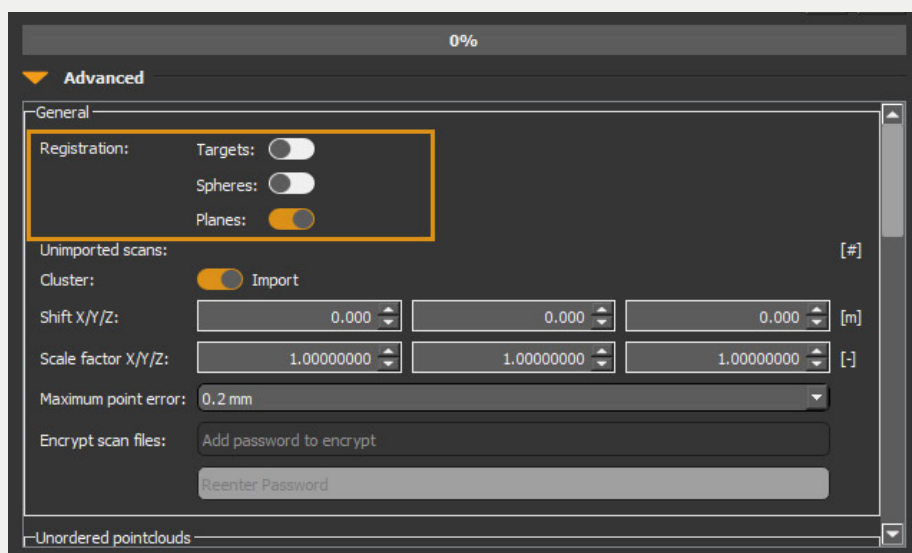
**Search planes minimum** – only important if planes have already been extracted, before the automatic search has started. Default is set to 5, which means that the automatic search will skip all scans where 5 or more planes have been extracted already.

**Maximum scan distance** – the maximum distance from the scan position where planes will be searched

### 3. Create a project and import scans

Open a new PointCab project with New > **Advanced Importer**. Name and save it in the location of your choice. This will automatically open the Advanced Importer. Open the folder containing the scans in raw format on your computer. Select all scan folders and drag and drop them into the free area of the Advanced Importer. Select „No“ when asked if the scans are already registered.

Select the **“Import”** tab and click on the arrow next to Advanced settings down in the left corner. Make sure to turn on the **“Planes”** option. If you missed this step, don’t fret. The feature extraction can be done in a later step, once the scans are imported. However, it’s more convenient to do it right away.

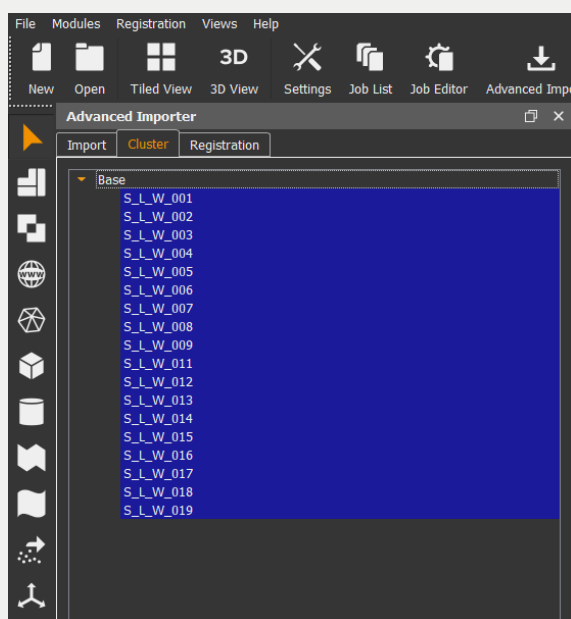


Start the import of the scans by clicking on „Start“. The import time may vary, depending on the number of scans, data type, scan size and your computer hardware.

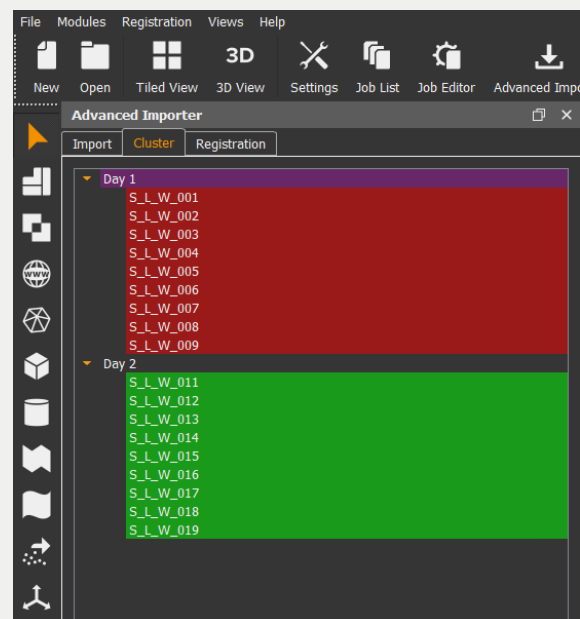
**Note:** For FARO scans, the colorization is done automatically. Provided your computer has enough CPU cores and memory, multiple scans will be imported simultaneously. We recommend storing the raw scan data as well as the Origins project on an SSD hard disk for fast imports.

## 4. Create cluster (optional)

After import, the registration editor opens automatically. For large projects, it is recommended to create the clusters before registration and sort the scans into the clusters. It simplifies and speeds up the iterative error-search process in the registration.

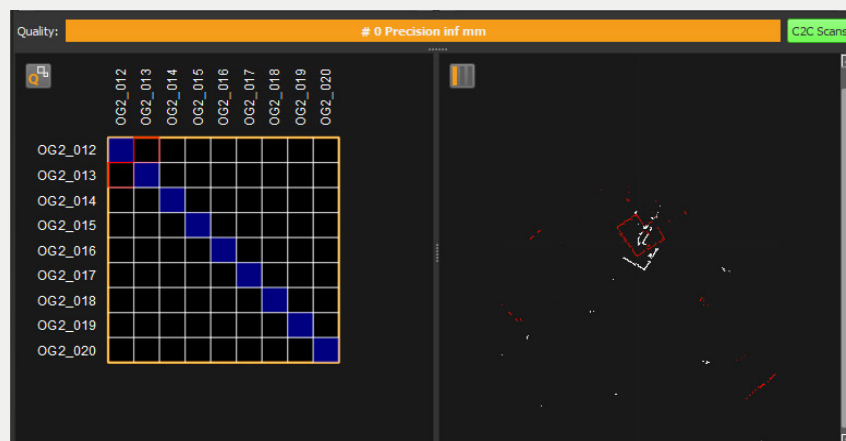


*before creating the clusters*



*after creating the clusters*

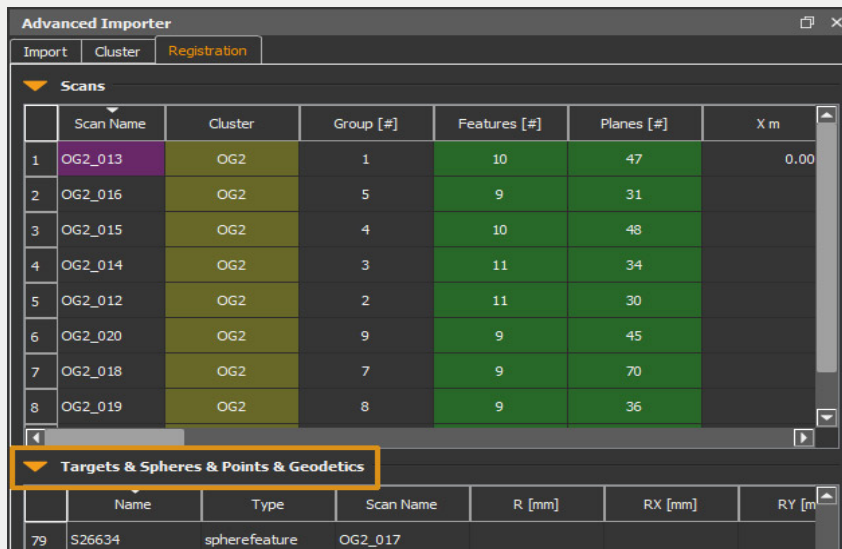
Scans in one cluster should overlap and connect. The constellation search (discussed in the next section) will prioritise matching all scans in the same cluster. This is a necessary condition that all scans are connected within the cluster in order to continue the registration process.



In the **Advanced Importer** under the Registration tab, all available scans are listed in the scan list. At this point all scans are in different groups. Upon performing the registration they will be in the same group. The origin scan is marked purple and has been assigned automatically. This can be changed by right clicking on the desired origin scan and selecting "Set scan as origin".

If the features were extracted during the import process, the number of features and planes will be shown next to the scan name. According to the number of features found, they will be displayed in green (more than 5), yellow (3 or 4 features) or red (less than 3).

All the extracted features as well as geodetic points (if available) are listed under the two further tabs which can be expanded by clicking on the arrow next to them.



The screenshot shows the 'Advanced Importer' window with the 'Registration' tab selected. It contains two main sections: 'Scans' and 'Targets & Spheres & Points & Geodetics'.

**Scans Table:**

	Scan Name	Cluster	Group [#]	Features [#]	Planes [#]	X m
1	OG2_013	OG2	1	10	47	0.00
2	OG2_016	OG2	5	9	31	
3	OG2_015	OG2	4	10	48	
4	OG2_014	OG2	3	11	34	
5	OG2_012	OG2	2	11	30	
6	OG2_020	OG2	9	9	45	
7	OG2_018	OG2	7	9	70	
8	OG2_019	OG2	8	9	36	

**Targets & Spheres & Points & Geodetics Table:**

	Name	Type	Scan Name	R [mm]	RX [mm]	RY [m]
79	S26634	spherefeature	OG2_017			

By selecting the „Registration“ job in the job list, you can adjust both the setting for the accuracy of the features, as well as for the feature search for this project if needed.

## 6. Feature search (optional)

*You may skip this step if the features have already been extracted during the scan import.*

Press on the registration job in the Job List. Activate the features to be extracted (only planes for C2C) and click on „search features“.

A message may appear which informs you that some scans do not have enough features. Confirm with „Yes“. Press on "Process all Jobs" in the job list in order to start the automatic feature search. After finishing the search, **make sure that at least 3 features were found in each scan.**

## 7. Search constellations automatically

Press on the "Registration" job in the Job List. Activate the auto Cloud2Cloud option Under "Constellation Processing". Click on „search constellations“.

The search automatically renames the features. If constellations could be found for all scans, a positive confirmation appears and the number 1 appears in the „Group“ column for all scans. Otherwise, individual scans or entire groups of scans can exist in their own group. This means that the groups could not be connected to each other.

## 8. Check registration

At this point, all scans are pre-registered and have been assigned into groups and orientation data of the scans is available. Now, with the help of the matrix and correspondence view, we need to manually check if the matches and connections found by the automatic registration are indeed correct.

By clicking on a pair of scans in the quality matrix, we can observe that in our example one scan in the first group was matched incorrectly.



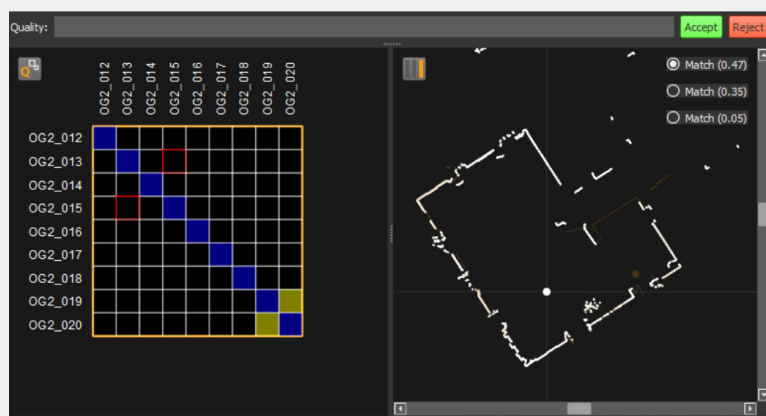
In order to find the scan that needs to be adjusted, click on the **bar symbol in the upper left corner** of the correspondence view in order to open the Scan2Scan view (click on the marked symbol until you reach the last bar) and on the main diagonal, check which scan does not match.

The reference scans are displayed in different colours and can also be identified by the scan name shown in the bar. The colors can be changed under Settings->Registration->Overlap Visualisation.



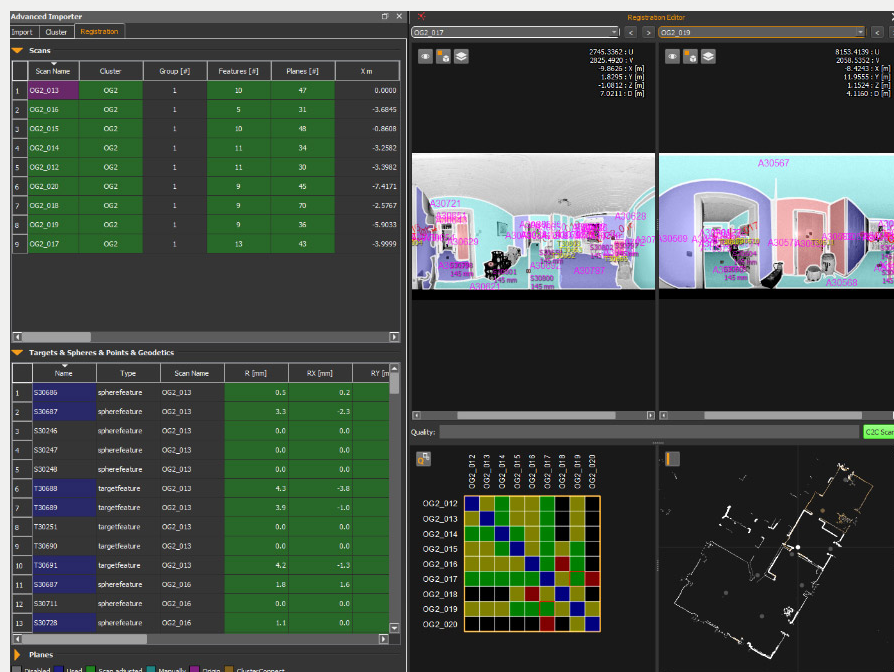
In this case, a manual plane-based C2C needs to be done between the two scans. Upon clicking on C2C Scans, a message will appear pointing out that the group will be dissolved. Click "Ok" and check the matches found. All other groups will remain unchanged.

Multiple matches can be found, **so select the correct one by clicking on each list item**. Once a correct match has been identified, click on "accept". The correspondent features have now been set to manual (the planes will be displayed in Cyan) and will not be changed during the automatic search for constellations, which we need to run again now.



When the first group is registered, we can proceed to check all other created groups. Once all the groups have been correctly registered, the last step is to connect the groups to each other. Choose a pair of scans where the groups can be connected, press on C2C Scan and choose the best match.

Once the scans are registered, all scans are assigned to one group (typically 1, or 0 if they are georeferenced). We can check the overlap in the correspondence view.



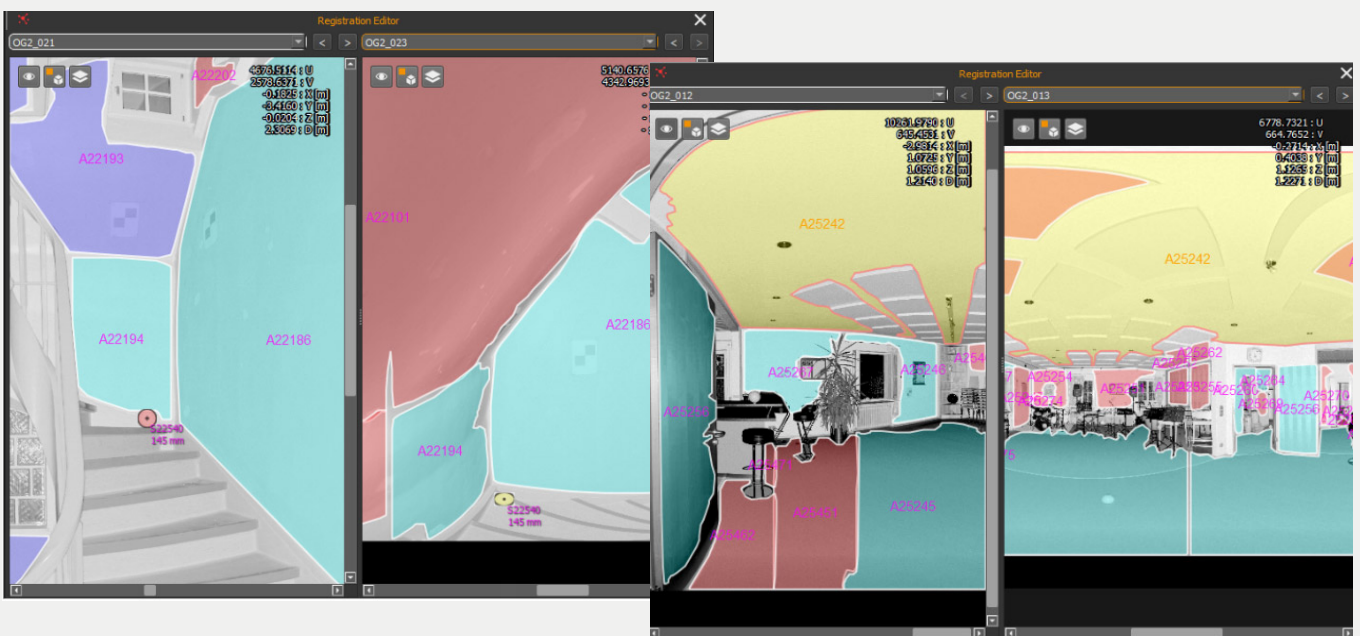


## 9. Troubleshooting: add features manually (optional)

Sometimes, no valid match can be found between two scans. In this case, manual feature correspondences can be added. There are two ways to do so:

1. Check the extracted planes and manually change the names of three common planes in both scans to be registered. When changing the name of a plane, it will automatically be set to "manual". The same has to be done in the second scan. This can be done either by changing the name, or by selecting the plane and pressing on the "M" key. The planes will be displayed in cyan. Perform the C2C again, the match will now be a 100%. Finish the procedure by clicking "Accept".
2. Use planes and features (either correspondence points or spheres/targets if available). Perform the same steps described above for planes and add at least one common feature. When extracting spheres or targets, press the "Alt" key when clicking on the feature in order to automatically assign the same name and mark the feature as "manual". Try to increase the accuracy by adding more correspondences.

**Tip:** When trying to find feature correspondences in two scans, press the "Alt" key and click on a feature. The feature will be highlighted in both scans.



## 10. Complete registration and create protocol

Under the "File" tab, in the Job Editor, you can rename the log file if necessary. Then start the registration job again to write the protocol and complete the registration.

The registration editor will close and the three default views are created automatically. The registration is complete.