Chapter Four

Results and Analysis

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4-1 Introduction

In this chapter, photographs of the Palestine Polytechnic University mosque were taken using a drone, These images have been added to the program Agisoft Photoscsan, a three-dimensional model of the mosque was produced from all sides.

In 2017 ,Palestine Polytechnic University had laser scanner TX5 with characteristic :High accuracy, High resolution, High speed, Intuitive control via the built in touchscreen display, High mobility due to its small size, light weight, and the integrated quick charge battery, Photorealistic 3D color scans due to the integrated color camera, Integrated dual axis compensator to automatically level the captured scan data and Integrated compass and altimeter to give the scans an orientation and a height information. This project is aimed as training for use in the most proper and practical application.

Figure (4-1): First test model for Palestine Polytechnic University Mosque

4-2 Field Work Using By Agisoft Photo Scan Software

4-2-1 Agisoft PhotoScan

Agisoft PhotoScan is a stand-alone software product that performs photogrammetric processing of digital images and generates 3D spatial data to be used in GIS applications, cultural heritage documentation, and visual effects production as well as for indirect measurements of objects of various scales.

Agisoft PhotoScan is an advanced image-based 3D modeling .Based on the latest multi-view 3D reconstruction technology, it operates with arbitrary images and is efficient in both controlled and uncontrolled conditions. Photos can be taken from any position, providing that the object to be reconstructed is visible on at least two photos. Both image alignment and 3D model reconstruction are fully automated.

4-2-2 Procedure

Step 1_ Add Photos

To add photos select Add Photos... command from the Workflow menu or click Add Photo. In the Add Photos dialog browse the source folder and select files to be processed. Click Open button.

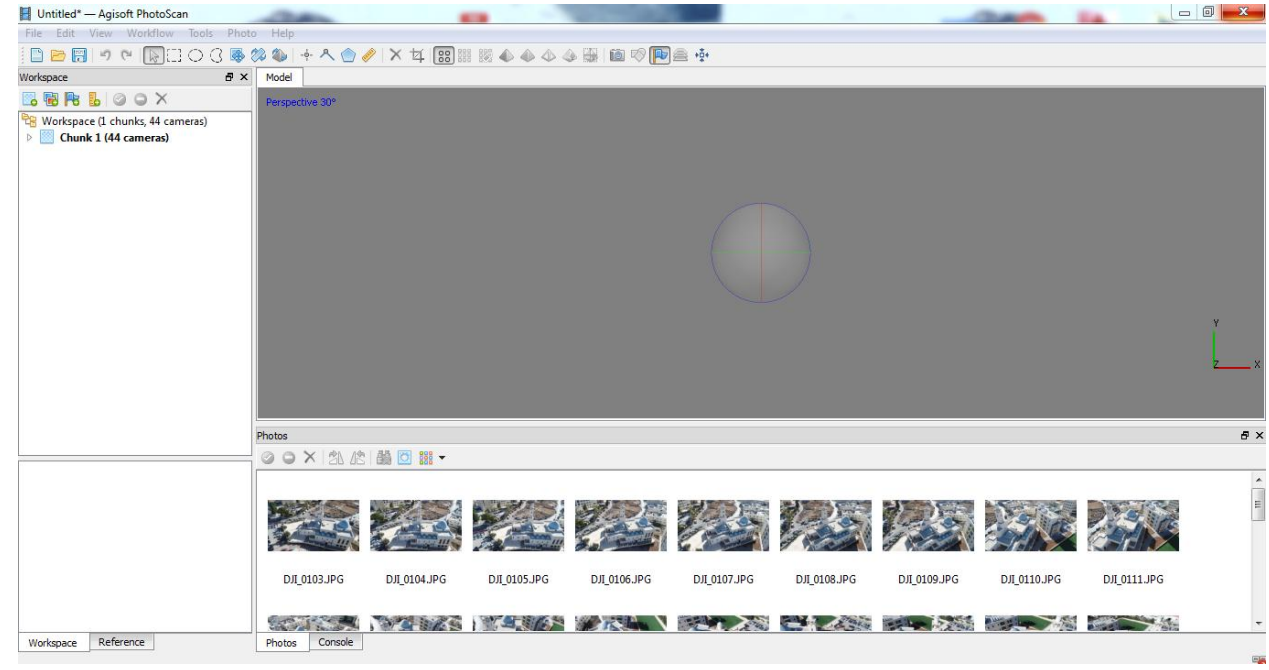

Figure (4-2): Adding photo for first test model by Agisoft photoscan

Step 2_Mask Photos

To achieve good reconstruction results it is necessary to mask all irrelevant elements on the source photos.

Step 3_Align Photos

At this stage PhotoScan refines the camera position for each photo and builds the point cloud model. Select Align Photos command from the Workflow menu.

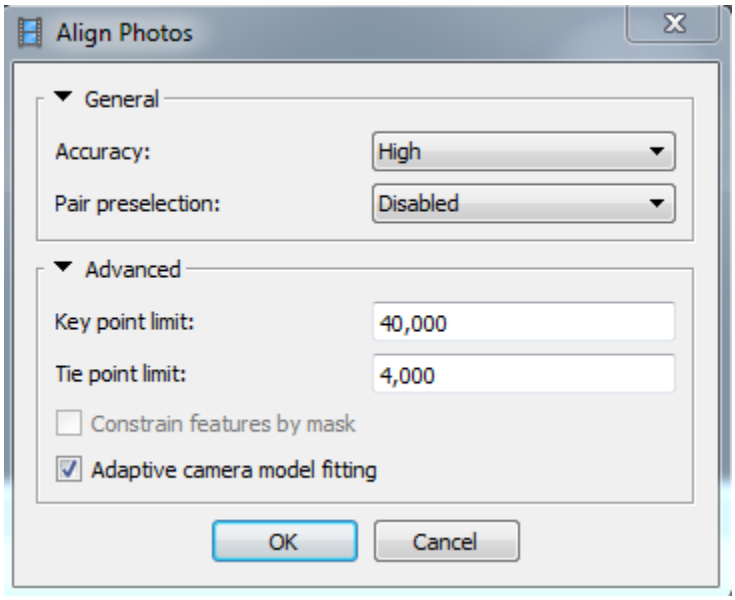

Figure (4-3): Aligning photo for first test model by Agisoft photoscan

Set the following recommended values for the parameters in the Align Photos dialog:

Accuracy: High (higher accuracy setting helps to obtain more accurate camera position estimates. Lower accuracy setting can be used to get the rough camera positions in the shorter time).

Constrain features by mask: Enabled (if the mask covers any moving objects including clouds) or Disabled (if all masked area was static during shooting).

Key point limit: 40000

Tie point limit: 4000

This step is optional since PhotoScan automatically calculates bounding box dimensions and location. But it is recommended to check if any correction is needed, because geometry reconstruction step deals only with the point cloud inside the volume.

After photo alignment is finished, refine bounding box position and orientation to fit the object:

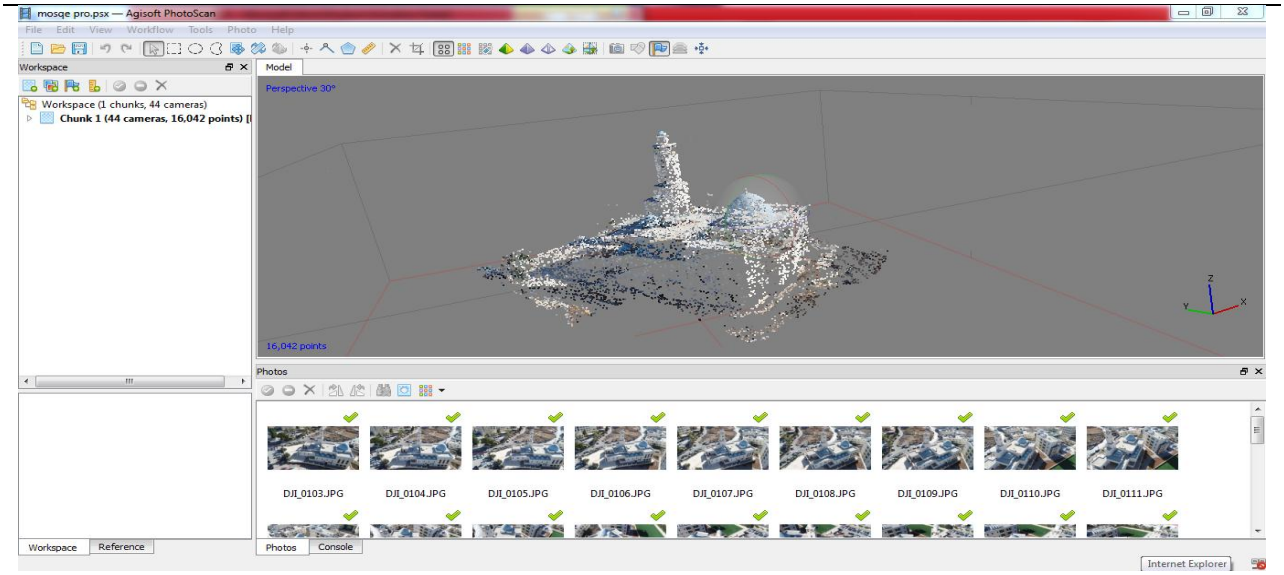

Figure (4-4): Aligning photo for first test model by Agisoft photoscan

Step 4_Build Dense Point Cloud

Dense Point Cloud Based on the estimated camera positions the program calculates depth information for each camera to be combined into a single dense point cloud. Select Build Dense Cloud command from the Workflow menu.

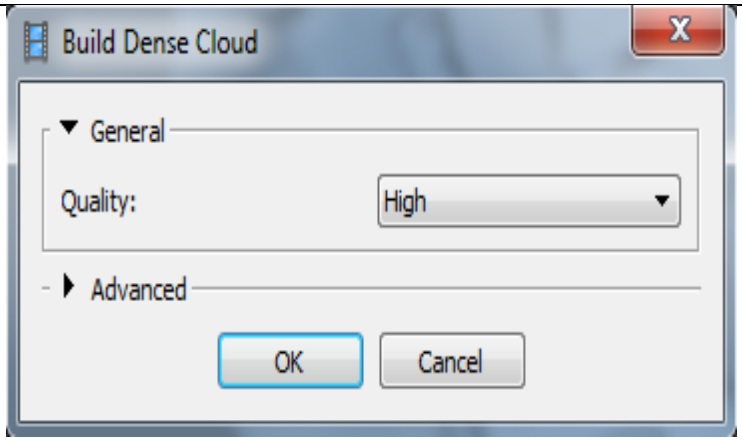

Figure (4-5): Building Dense Point Cloud for first test model by Agisoft photosca

Set the following recommended values for the parameters in the Build Dense Cloud dialog:

Quality: High

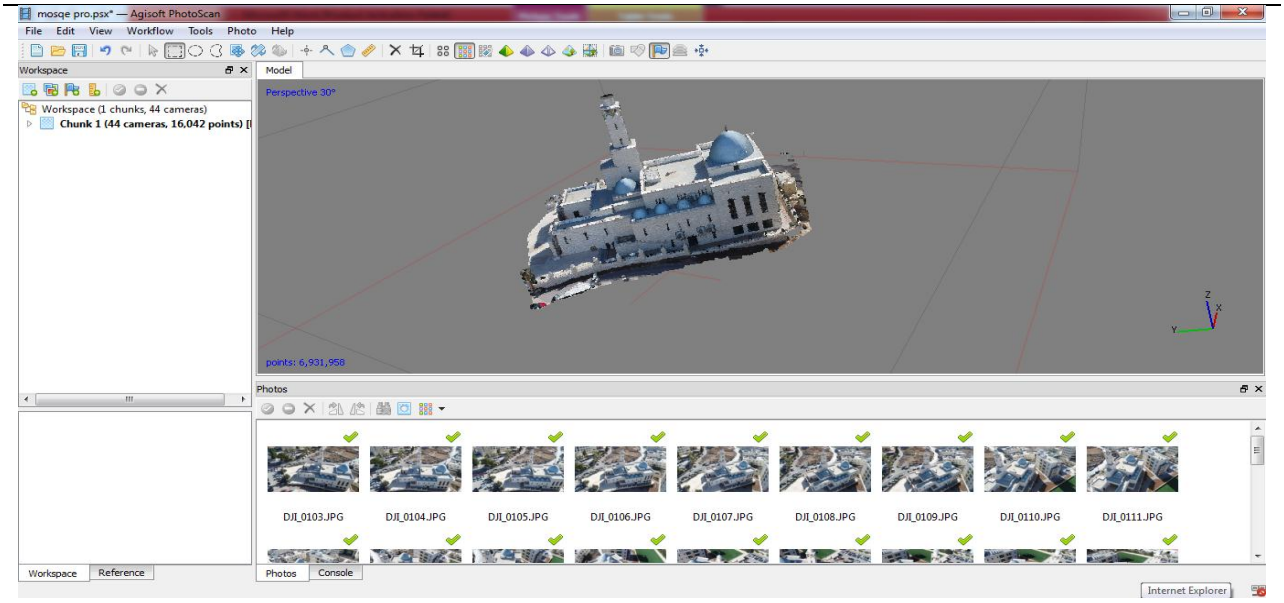

Figure (4-6): Building Dense Point Cloud for first test model by Agisoft photoscan

Points from the dense cloud can be removed with the help of selection tools and Delete/Crop instruments located on the Toolbar.

Step 5_Build Mesh

After dense point cloud has been reconstructed it is possible to generate polygonal mesh model based on the dense cloud data.

Select Build Mesh command from the Workflow menu.

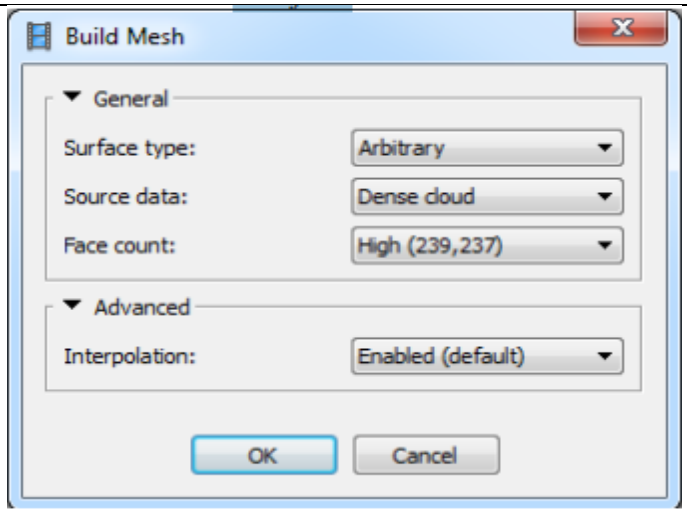

Figure (4-7): Building Mesh for first test model by Agisoft photoscan

Set the following recommended values for the parameters in the Build Mesh dialog:

Surface type: Arbitrary

Source data: Dense cloud

Polygon count: High

Interpolation: Enabled

Click OK button to start geometry reconstruction.

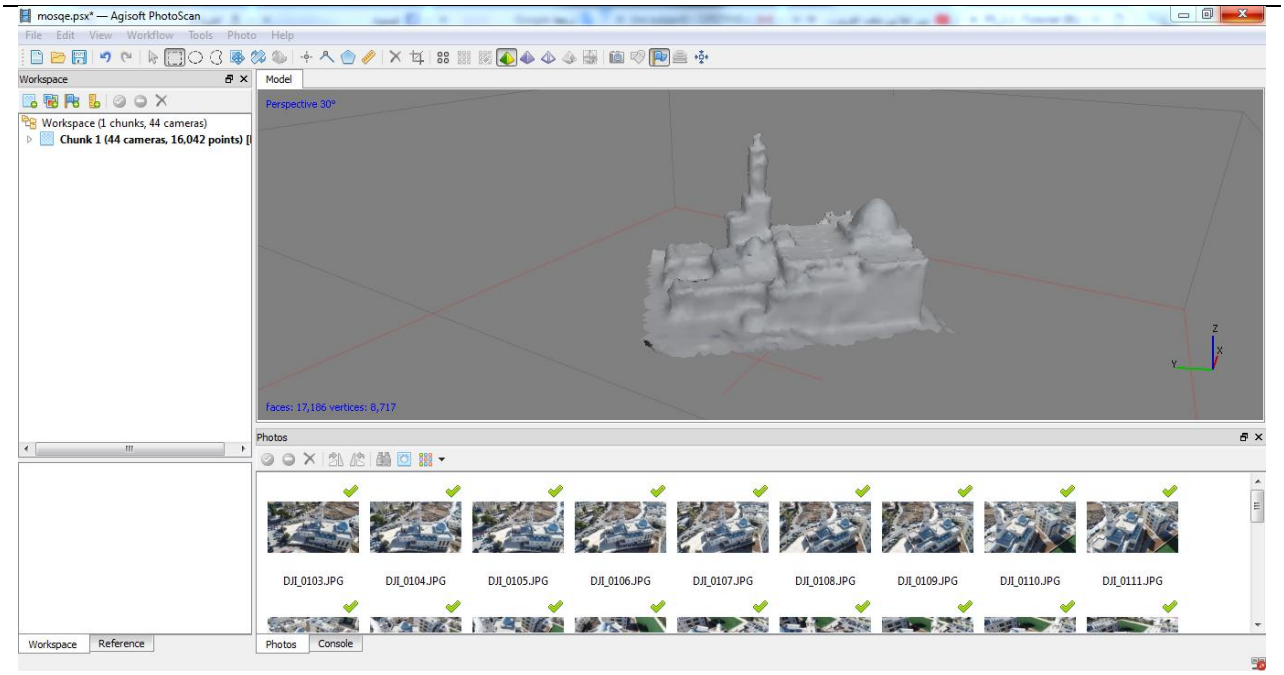

Figure (4-8): Building Mesh for first test model by Agisoft photoscan

Step 6_Build Texture

This step could be skipped if untextured model is sufficient as the final result.

Select Build Texture command from the Workflow menu.

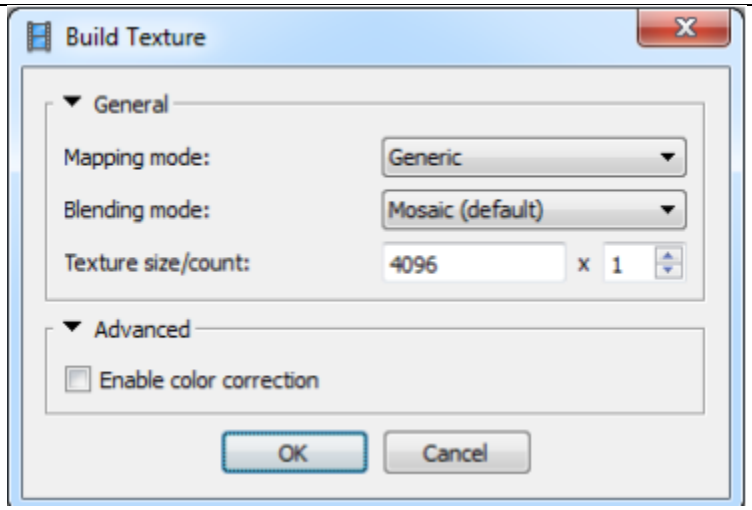

Figure (4-9): Building Texture for first test model by Agisoft photoscan

Set the following recommended values for the parameters in the Build Texture dialog:

Mapping mode: Generic

Blending mode: Mosaic

Texture size/count: 4096 x 1 (width & height of the texture atlas in pixels and determines the number of files for texture to be exported to. Exporting texture to several files allows to archive greater resolution of the final model texture, while export of high resolution texture to a single file can fail due to RAM limitations)

Enable color correction: disabled

Click OK button to start building texture.

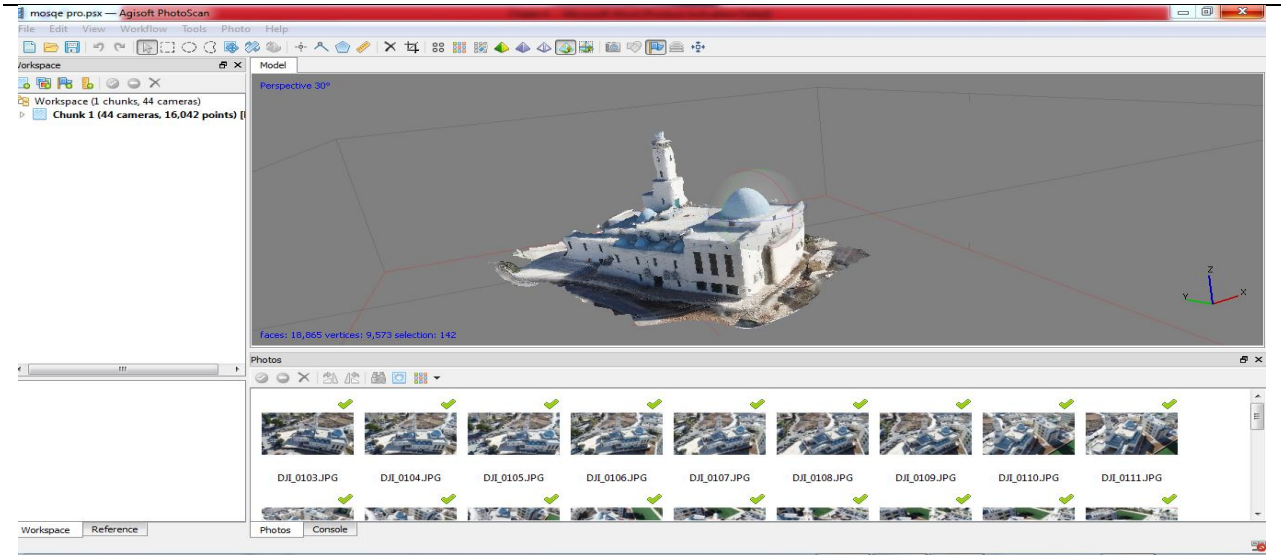

Figure (4-10): Building Texture for first test model by Agisoft photoscan

Step_5: Tilted Model

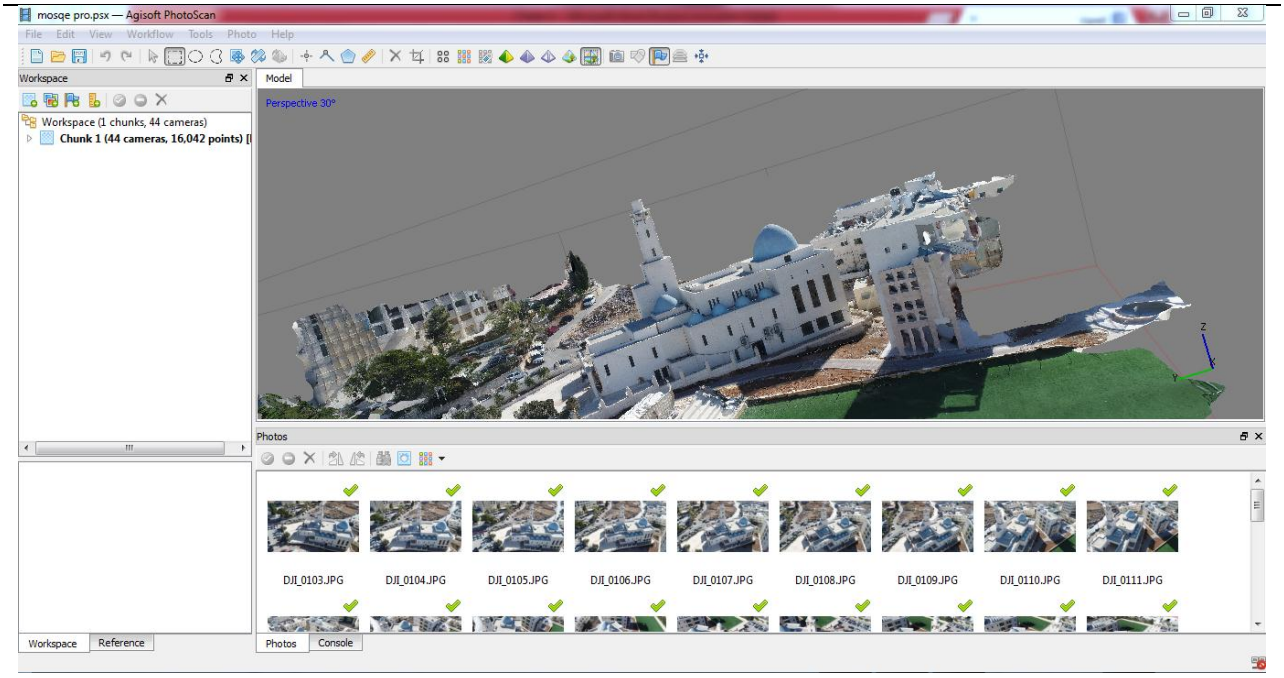

Figure (4-11): Tilted Model for first test model by Agisoft photoscan

4-3 Field Work Using By PointCap Software

4-3-1 Introduction:

Our target-based registration is a manufacturer-independent solution for rapid and exact referencing and registration of terrestrial laser scanning data.This also enables you to merge scans from different terrestrial laser scanners in one joint project.

The efficient search for target marks and spheres, and the search for assignment between the individual scanner positions, combined with optimized equalization and a detailed log make this solution an integral constituent part of the laser scanning evaluation. With the possibility to use natural point correspondences, even an inexperienced user is able to register projects for terrestrial laser scans without target marks and spheres.

With the PointCab software, the processing of high-resolution point clouds is easy as can be is the entry-level solution for the efficient processing of point clouds to create detailed 2D ground plans and façade views.

The PointCab software is compatible with all current CAD systems and is therefore used in many areas such as architecture, building industry, geodesy, civil engineering, monument protection and facility management.With the practical functions for measurement, the simple web export, and the alignment tools, getting started is child's play.

4-3-2 Applications:

Our software is used in a wide variety of industries. Here are examples of how the Point Cab software can help you with your applications.

1. Architecture: building footprints and sections, floor plans, facade plans, interior wall documentation, staircases
2. Monument protection: elevations, ceiling paintings
3. Surveying: site plans, inventory plans, site maps, roof cadastres, pit cuts, terrain profiles, tunnel sections, cross sections, road profiles
4. Factory planning: pipeline documentation, set-up and machine layout plans, cuts through production and factory halls, sections for static considerations
5. Forensics: Basis for simulations, trajectory analyzes, accident documentation.

4-3-3 Registration:

Our target-based registration is a vendor-independent solution for fast and accurate referencing and registration of terrestrial laser scanning data. This allows you to combine scans from different terrestrial laser scanners in a single project.

The efficient search of targets and bullets and the search for a match between the individual scanner positions as well as an optimized adjustment with detailed protocol make this solution an integral part of the laser scanning evaluation. With the ability to use natural point correspondence even the untrained user is able to register terrestrial laser scanning projects without targets and bullets.

4-3-4 Target based registration for surveyors

1. Required preferences:

Select File > Settings and Registration tab. Here you can set preferences for a-priori accuracy of features (checkerboard targets, spheres, points) as well as your potential geodetic points (references). The relation of accuracies is decisive. Please respect that points generally provide significantly worse accuracies than checkerboard targets and spheres. If geodetic points are set via GPS, you can assume an accuracy of 30mm, for example.

Furthermore, you can determine if checkerboard targets and/or types of spheres shall be searched. These settings are automatically applied in each new project.

In the Sketch/Panorama tab, you deactivate the settings Colorized panorama to load scan views as reflectivity image more quickly later.

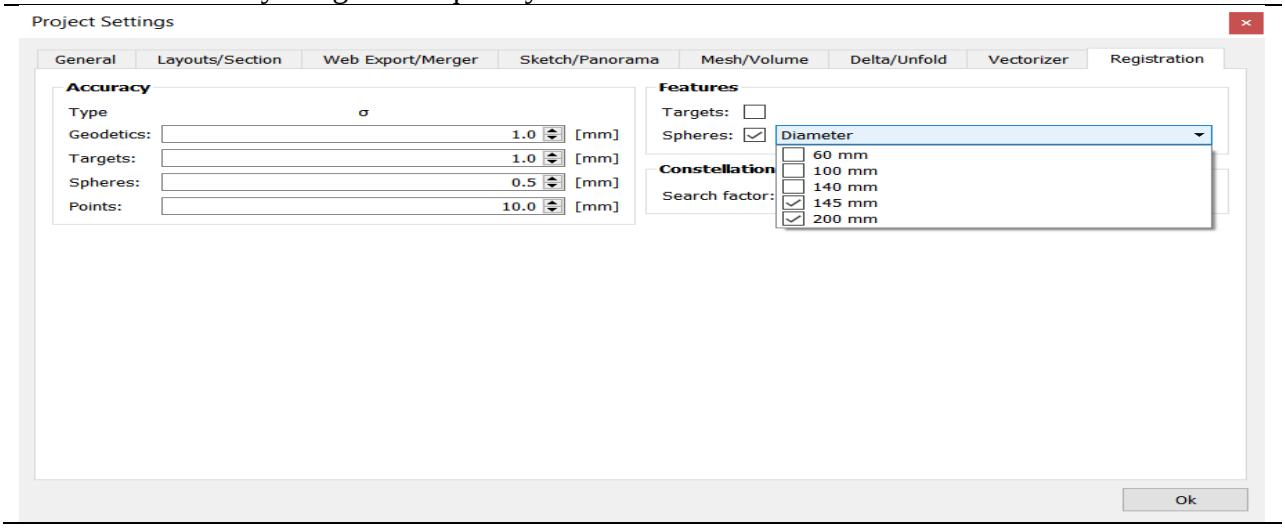

Figure (4-12): Required preferences

2. Create a project and import scans

Start a new PointCab project by selecting New > Advanced Importer. Enter a project name and save the project at a place of your choice. The Advanced Importer opens automatically.

Open your folder with FARO scans in RAW format using Windows Explorer or a comparable file browser. Select all scan folders together and drag and drop them to the free area in the Advanced Importer.

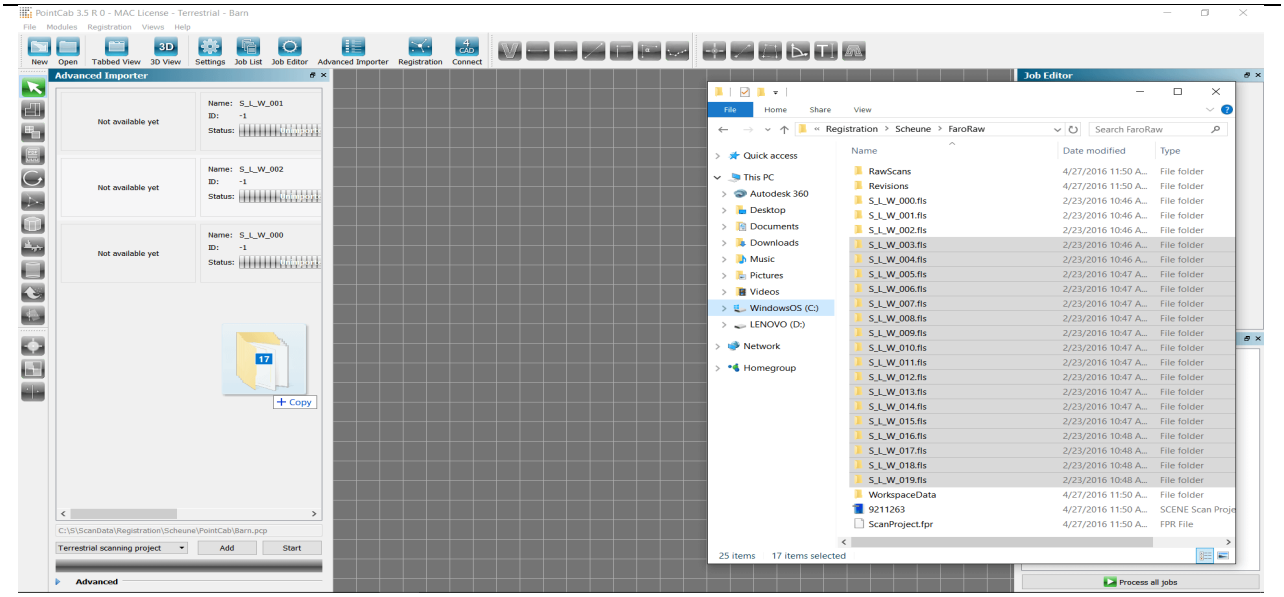

Figure (4-13): Create a project and import scans

Select “No” for the question if the scans are already registered. Now, all imported scans are listed automatically. As may be the case, add more scans in the same way. Then, start the import by selecting Start. The import may take some time depending on the number of scans, data type, scan volume as well as computer resources.

2. Registration Editor:

After import, the *Registration Editor* opens automatically; the *Advanced Importer* is closed. Make sure that *Job List* and *Job Editor* are displayed on the right (*main toolbar* or *menu Views* …)

The Registration Editor consists of 3 sections. The upper section incldes a dual view of two scans and allows to easily select corresponding points. Scans can be shifted manually for left or right side in the list box.

If you don’t need corresponding points, you can minimize or totally hide the right side by clicking and dragging into the intermediate area between both views. The dual view includes two hidden lists “Scans” and “Checkerboards & Spheres …” which can be made visible by clicking on the triangle.

The *Scan List* includes all available scans; the *Feature List* contains all available checkerboard targets, spheres etc. (currently empty).

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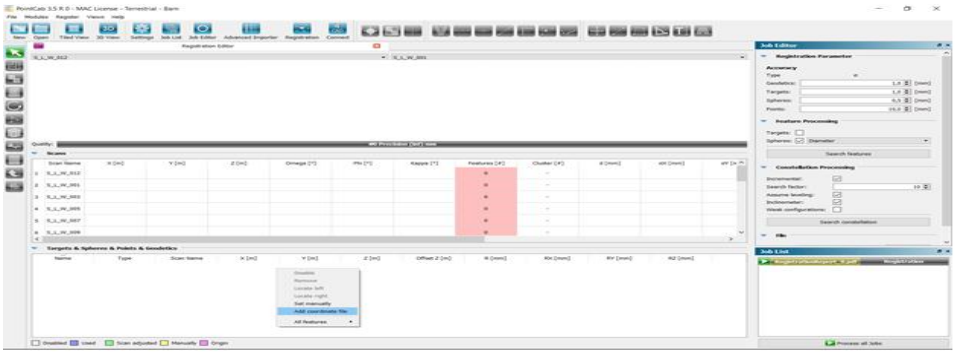


Figure (4-14): Registration Editor

The Job List shows a selected job "Registration". The Job Editor contains settings for registration. If not, simply click once on the job "Registration" in the Job List for selection. Now, you can individually adjust the settings for accuracies of features and feature search for this project.

If you have used external geodetic points in your project and if you want to import them, right-click into the Feature List and select "Load Coordinate File" in the context menu. The corresponding file formats are displayed; you can import your coordinate file that will be displayed in the list.

4. Automatic feature detection

Start the registration job in the Job List. You will receive a message that some scans don't have enough features and that they can be searched automatically. Confirm with "Yes". A job for feature search is created for each scan in the Job List and automatically started.

The Scan List contains the column "Features" that shows the number of features in each scan. If only two or less features are found, the entry is red. If three or four features are found, is yellow, otherwise green.

When the search in all scans is realized, you can open a scan in the upper view and set it using the tools "sphere" or "checkerboard". You save a lot of time since you can continue working simultaneously. For large projects, we recommend to check all scans visually and to remeasure features manually if needed.

You can open a scan in the scan list by right-clicking in the appearing context menu. In the context menu, you can activate / deactivate or set a scan as origin (as long as no geodetic points

are used).After the search process is finished, make sure that at least 3 features are found in each scan.

5. Search constellations automatically

Start the registration job in the Job List again. As the case may be, PointCab displays the same message if a scan doesn't contain at least 3 features. Otherwise, a constellation detection is performed and attributions between the scans are searched. If you have not set any geodetic points and any scan as origin, the first scan is automatically set as origin.

As a result of the search, the features are automatically renamed. If constellations can be found for all scans, a positive feedback appears and figure 0 appears in the column "group" for all scans. Otherwise, single scans or entire groups of scans could each exist in an own group. That means the groups could not be connected.

Check the scans regarding the features that should connect the groups, premeasure the missing features and restart the registration job. Perform this process as long as all scans are connected.

6. Optimize registration

Now, all scans are preregistered, highlighted in blue in the scan list and orientation data of scans exists.In the 3D view, which can be opened in the main toolbar, you can see the scan positions as well as geodetic points if available.

In the feature list, you see the initial residuals for each feature, that is the deviation of each feature from the average value of all three-dimensional coordinates of the features. The color shows how large the residuals are in relation to their a-priori accuracy. Red residuals show big deviations. Check them and delete the corresponding features if needed, and start again with step 5.

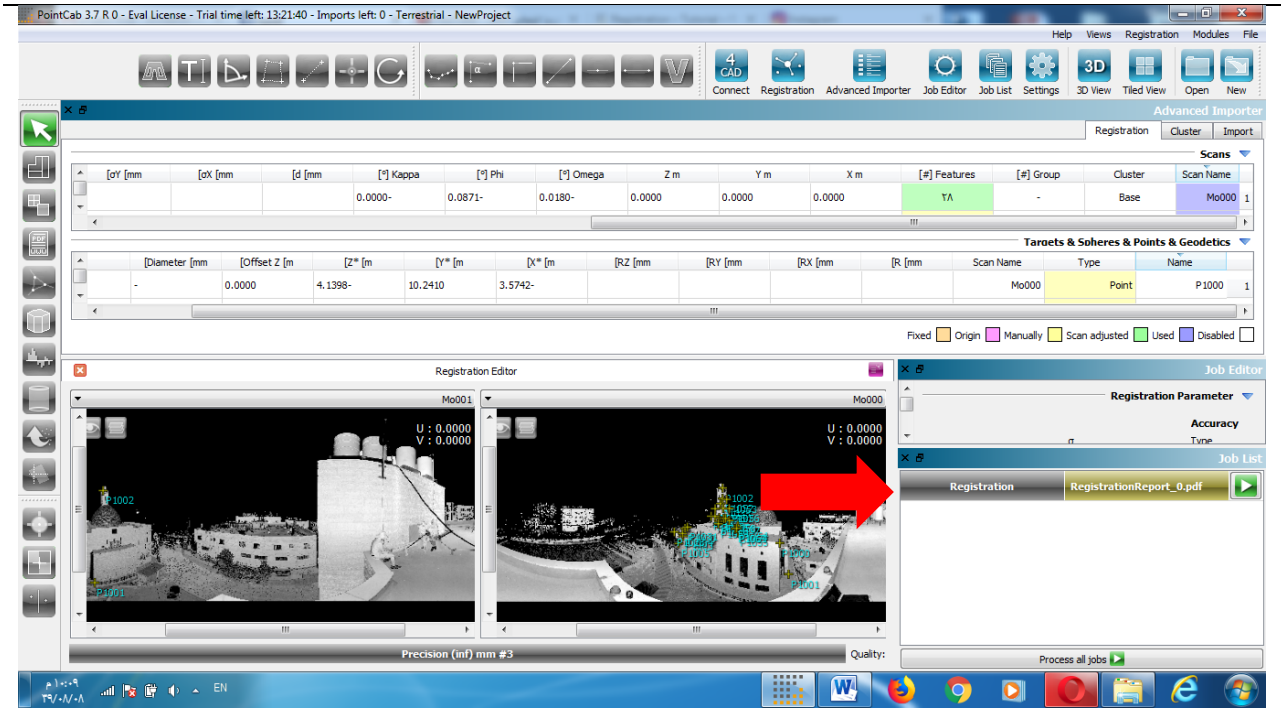


Figure (4-15): Optimize registration

Start the registration job again.

Now, PointCab performs a global optimization and tries to attribute more features. Scan positions are optimized and the residuals' square sum is minimized (Least Square Adjustment).

After adjustment is finished, all scans are green (origin scan is magenta). Check the residuals again. If required, delete the corresponding features, deactivate the option "incremental" and start again with step 5.

7. Finish registration and generate report

If desired, you can rename the log file in the File tab in the Job Editor. Restart the registration job to generate the report and to finish registration. The registration editor is closed and three default views are created automatically.

If a PDF viewer is installed, please open the report by double-clicking on the registration job. There, you find detailed information about the processed registration including accuracy specifications, a visualization of the feature graph, a detailed list of residuals as well as an accuracy analysis regarding the relative accuracy between scans (see Quality Matrix).

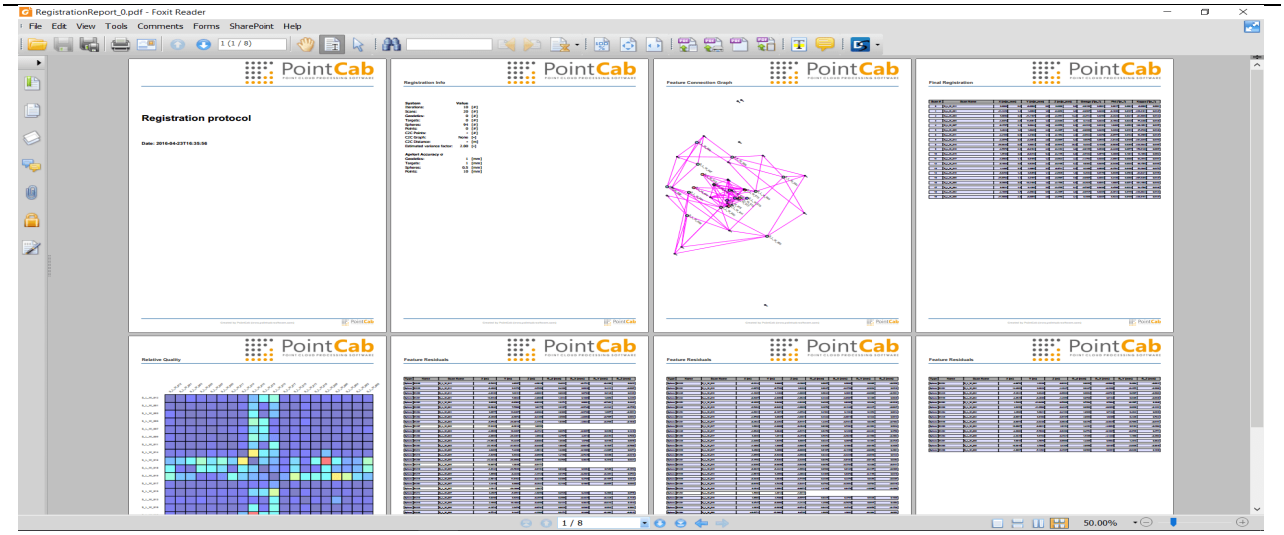


Figure (4-16): Finish registration and generate report

4-3-5 Point Cloud Export

With the Point Cloud Export module, you can export specific sections of your point cloud. Due to filters, you reduce the size of your point cloud output additionally.PointCab allows point cloud export into AutoCAD RCP format.

Select the tool “Export point cloud” and select the zone in the standard top view. Edit the selected zone by defining the upper and the lower border.

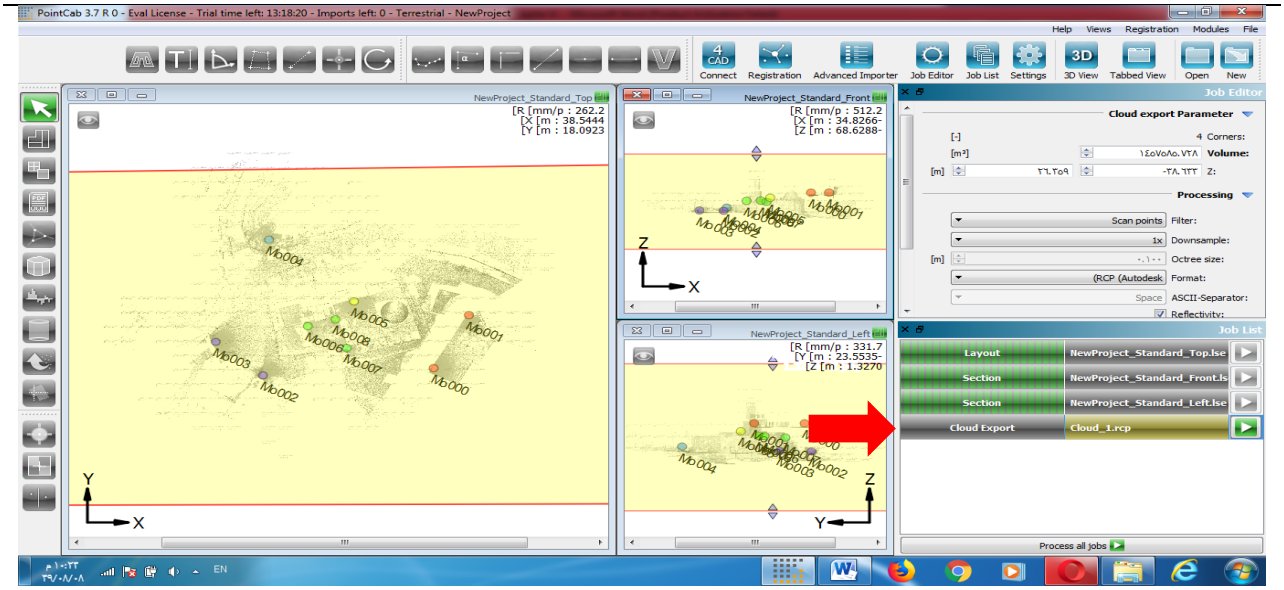


Figure (4-17): Point Cloud Export for Palestine Polytechnic University Mosque

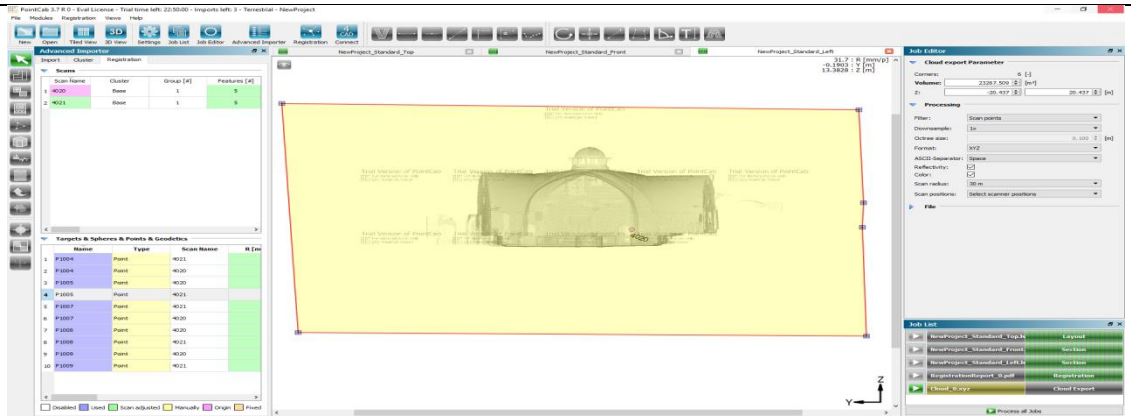


Figure (4-18): Point Cloud Export for Al-Hammam Al-Turkey

[2] Filter options:

Scan points: The number of scan points is reduced additionally by the chosen factor. If you choose the factor "2x", just each second scan point is used.

Block filter: The number of scan points is thinned spatially and thus homogenized. If you select a block size of 0.05m, just one point is exported in a cube of this edge length. That's why almost all pieces of information are maintained in areas with low point density. In areas with high point density, redundant points are excluded.

Height points ("elevationt profile"): You get the grid-shaped DTM as a point cloud for the respective layout or sectional view. The number of points depends on the image resolution selected originally for the layout or section. A predefined scan radius is ignored during point cloud export.

[3] Output formats:

XYZ, LAS, LAZ, E57

RCP: Autodesk RCP format. Import data directly in AutoCAD without the need for Autodesk ReCap.

[4] Start processing the export in the Job List.

[5] Now, the generated point cloud file (Open by right-clicking: /projectname/projectname_Results/3D/).

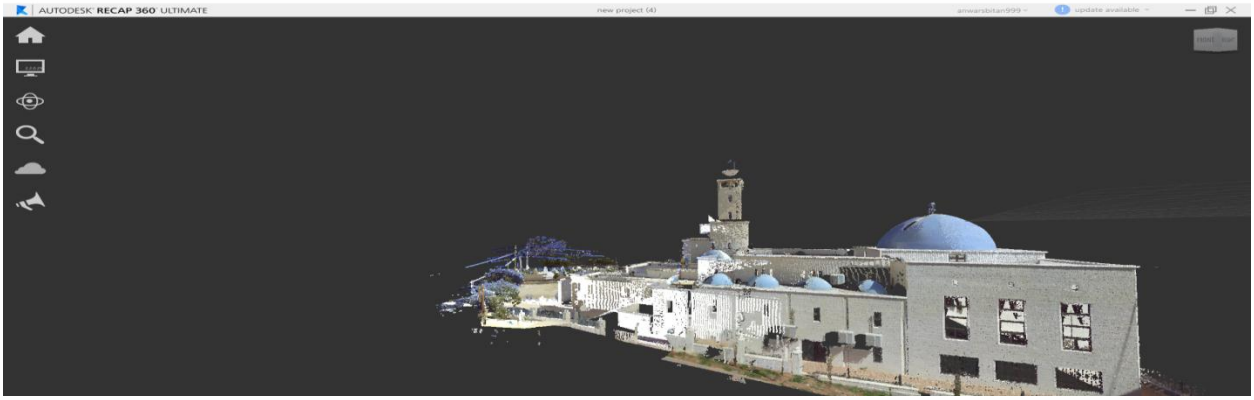


Figure (4-19): 3D Results for Palestine Polytechnic University Mosque

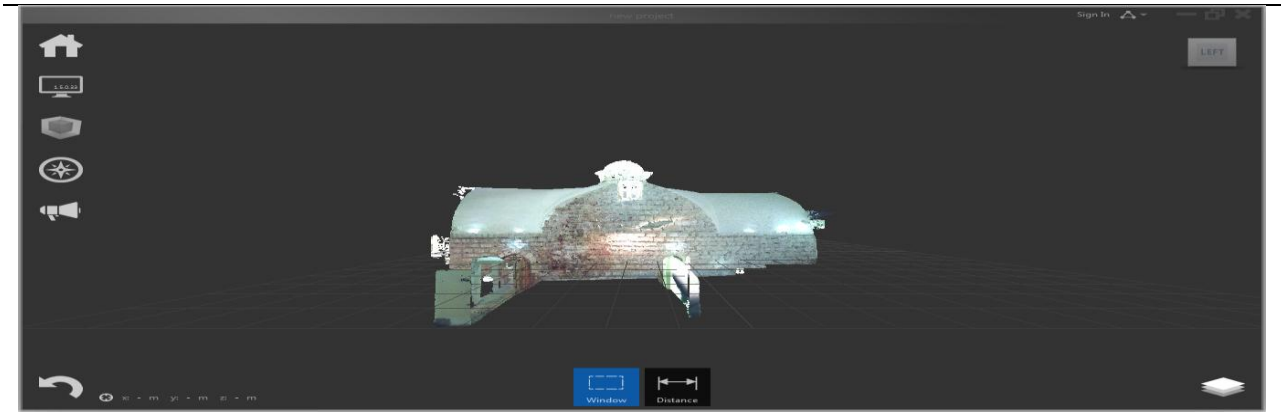


Figure (4-20): 3D Results for Al-Hammam Al-Turkey from outside

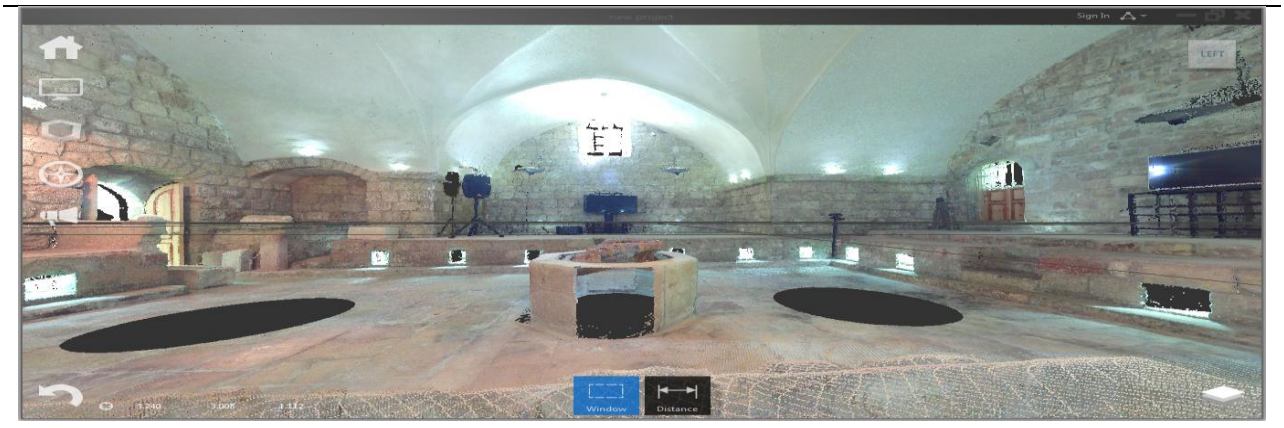


Figure (4-21): 3D Results for Al-Hammam Al-Turkey from inside

4-3-6Create a facade plan & Area model of a facade & Create Layout & 3D points

4-3-6-1 Sections: Create a facade plan

In order to do it activate Section tool ：

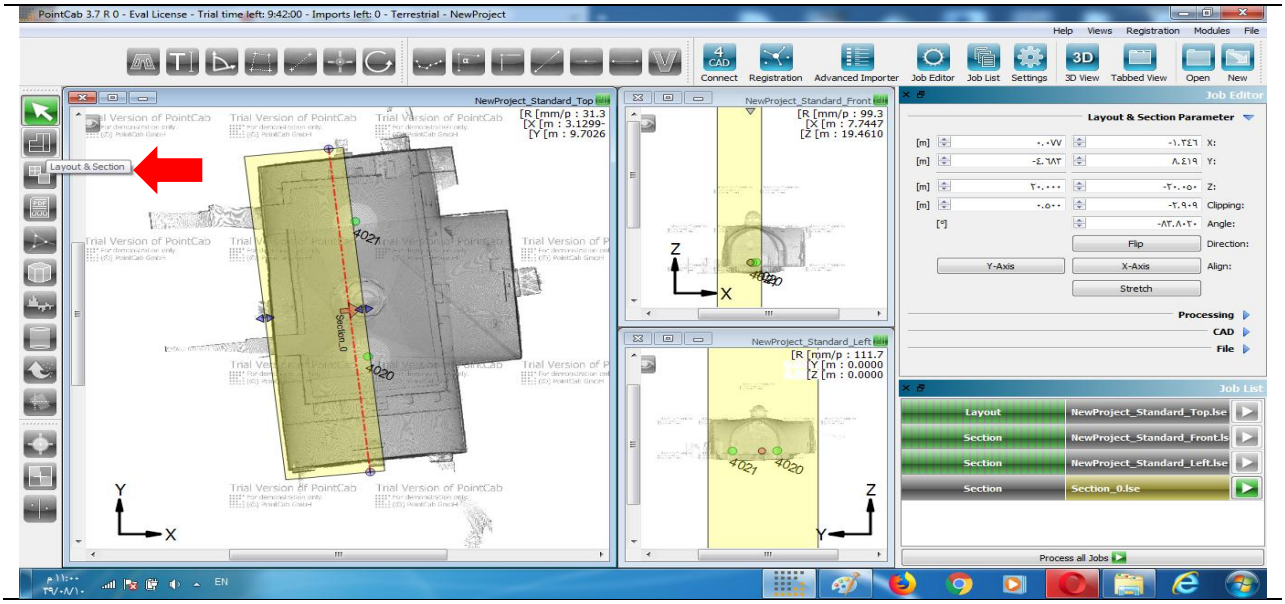


Figure (4-22): Activate Section tool

In order to define a facade you should choose for a start point we selected the left plan:

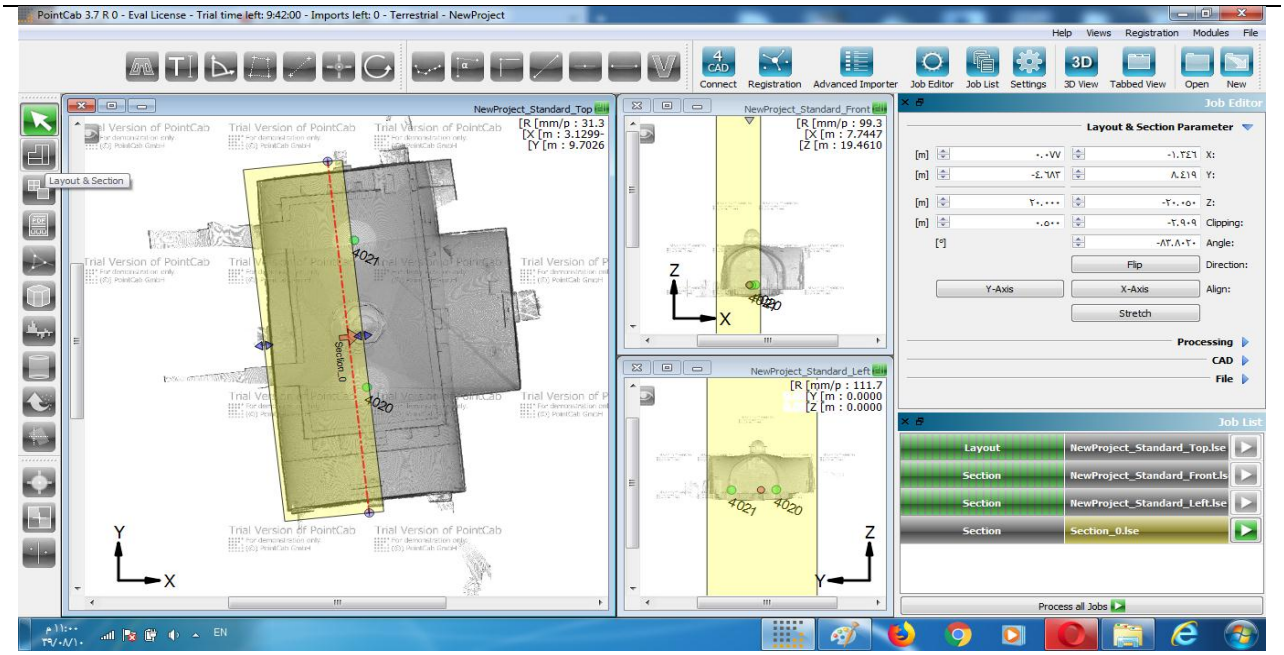


Figure (4-23): Select the left plan for Al-hmmam AL-Turkey to start

Now you can start processing :

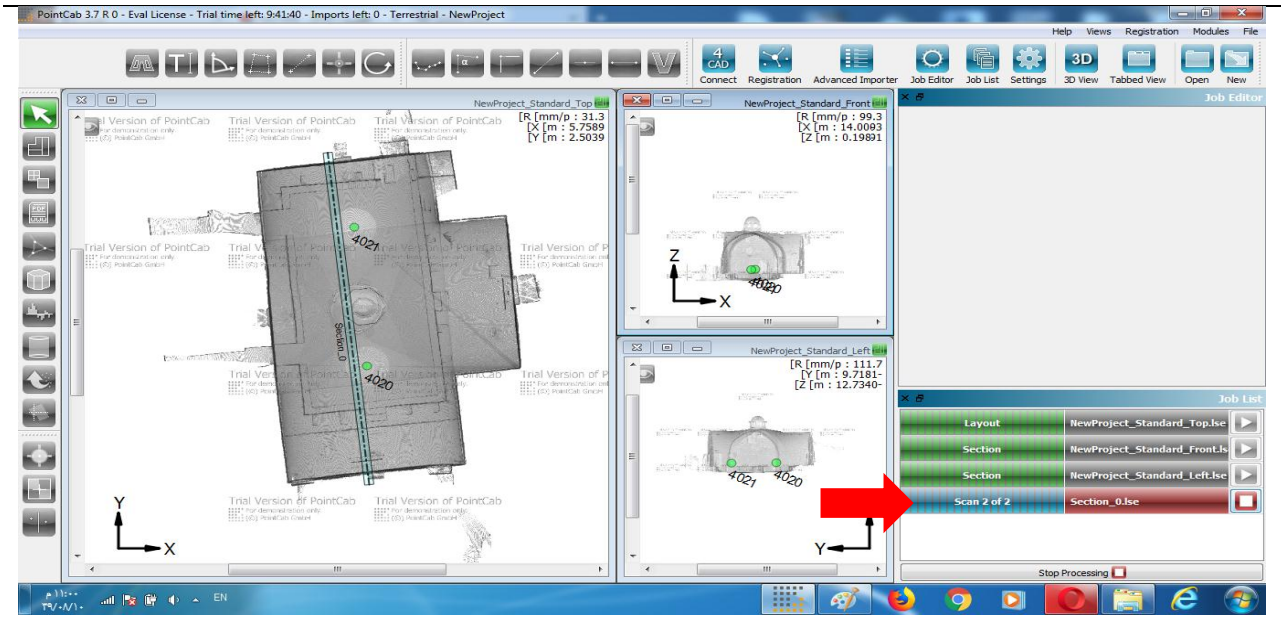


Figure (4-24): Start processing

After completion of the facade plan you can open the result by double clicking the Job in the Job List or right clicking –>Open .

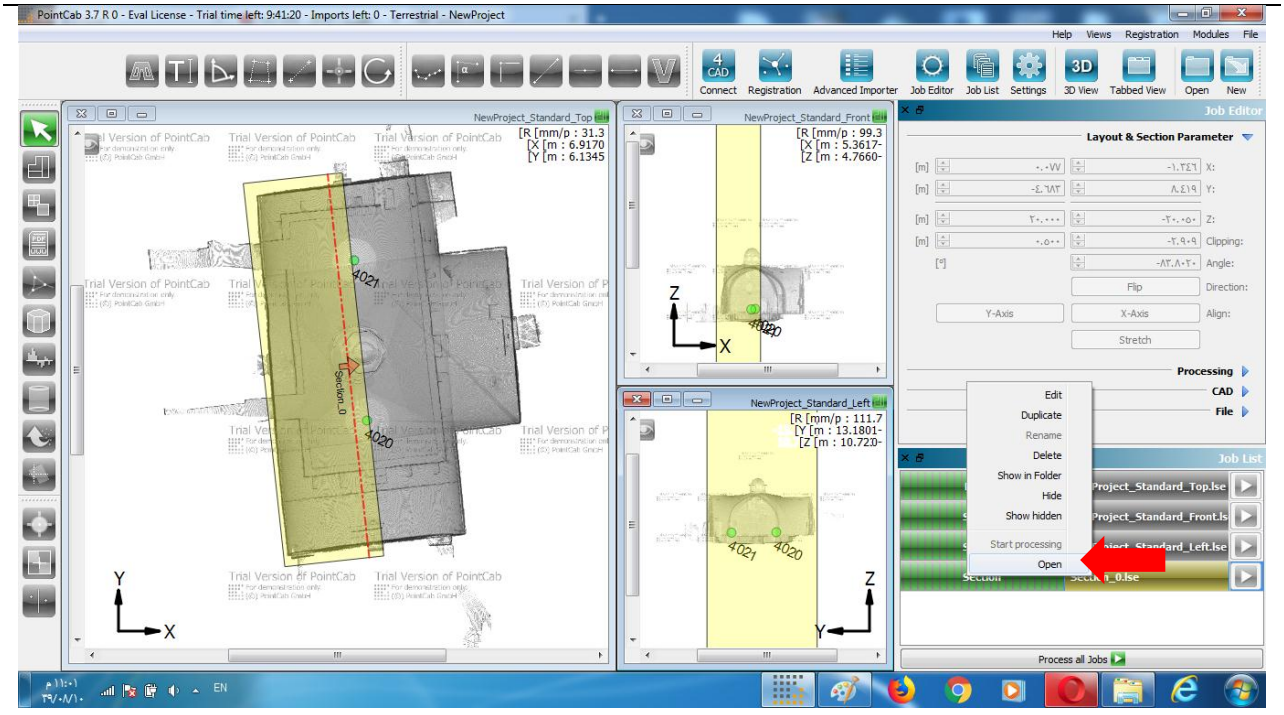


Figure (4-25): Show the result

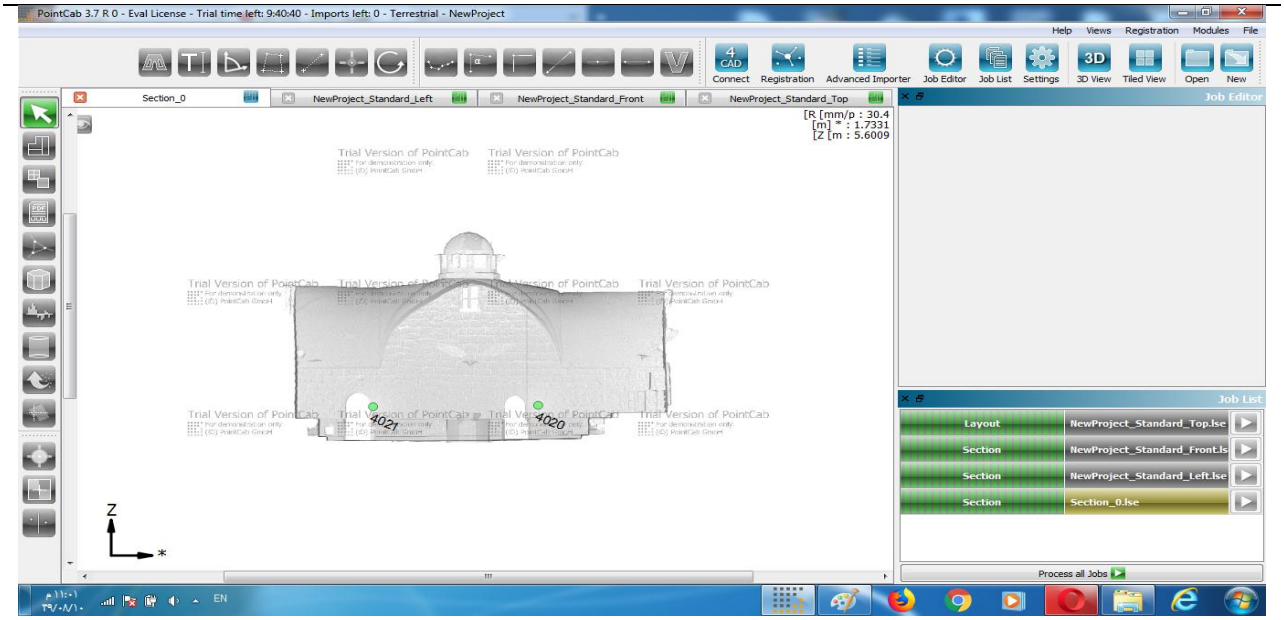


Figure (4-26): Facade plan in PointCab

4-3-6-2 Area model of a facade :

Activate the Mesh tool :

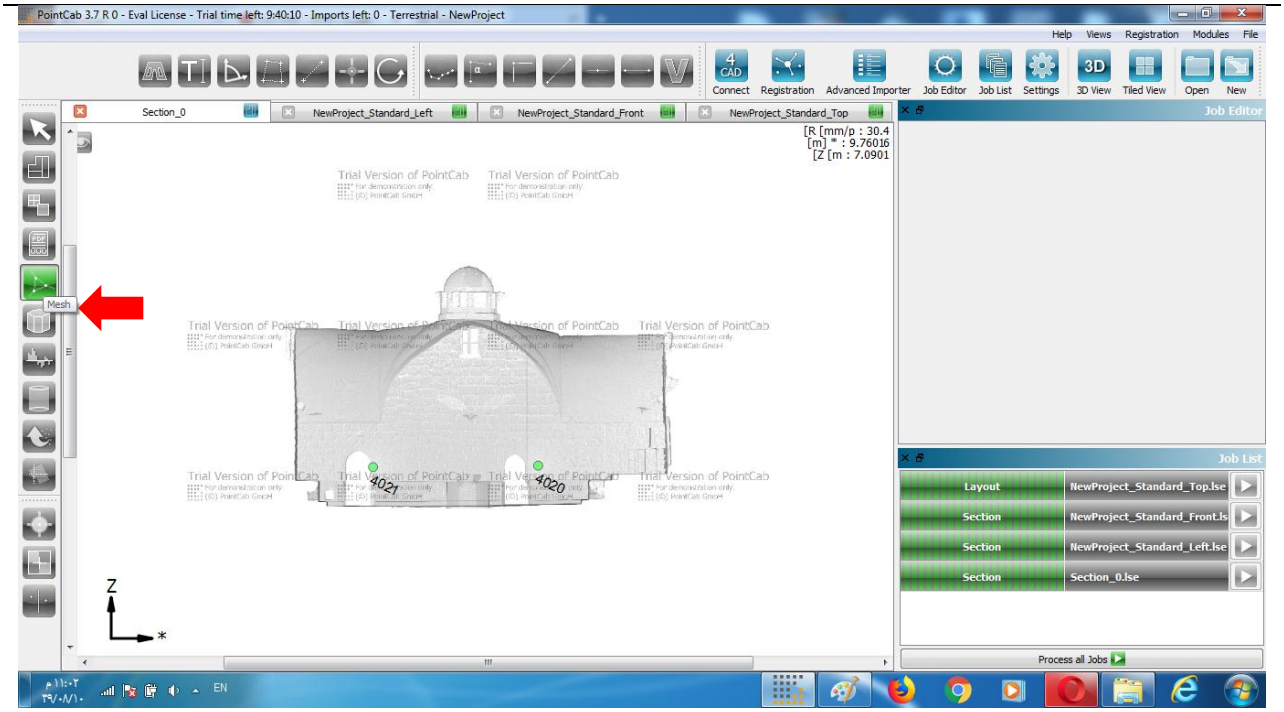


Figure (4-27): activate the Mesh tool

Select inner area of the facade :

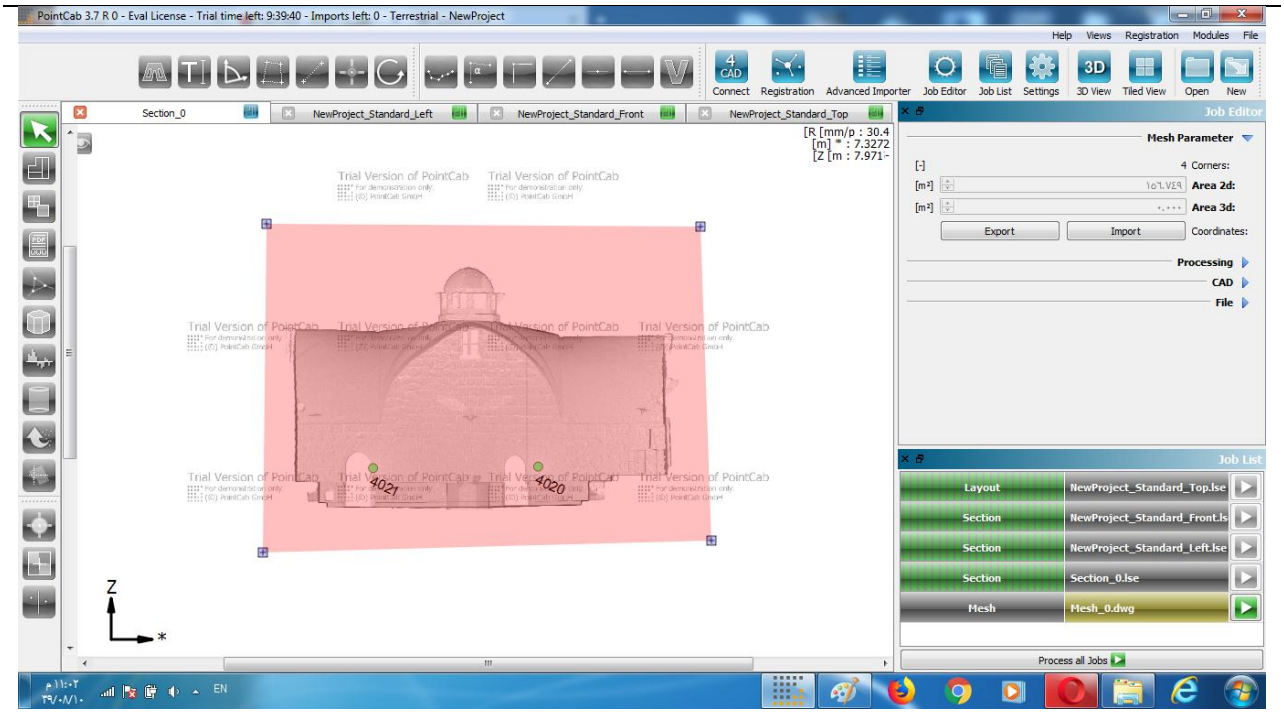


Figure (4-28): Select inner area of the façade

Now you can start processing :

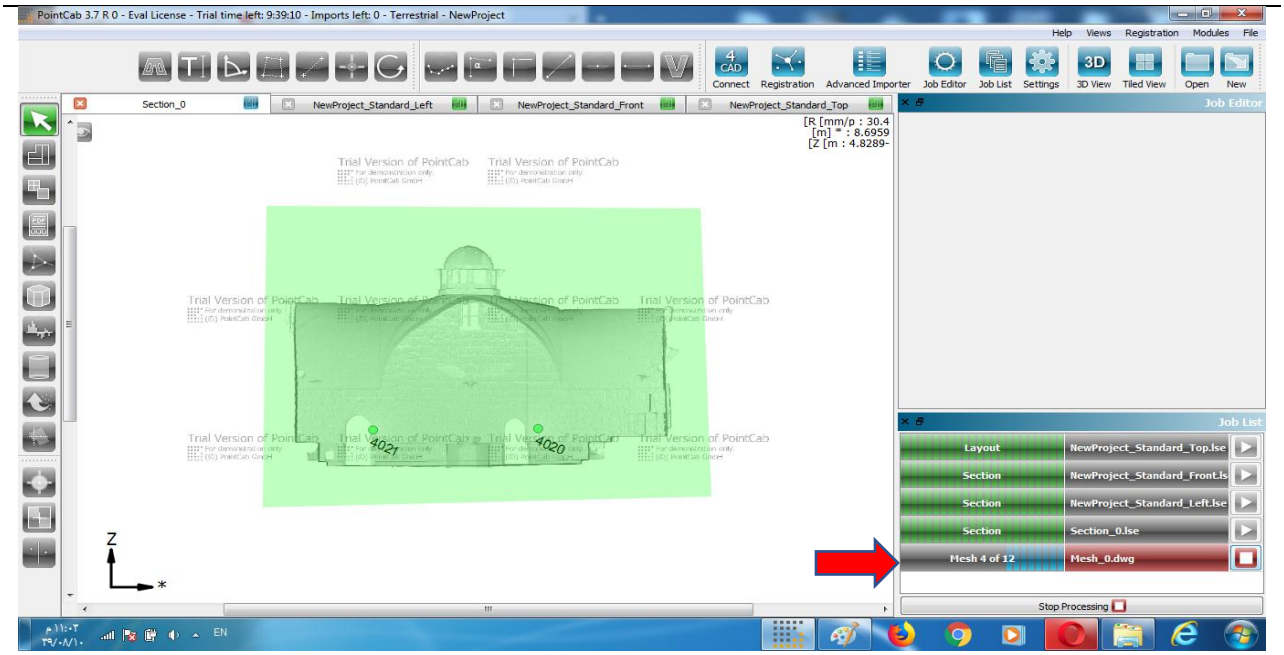


Figure (4-29): Start processing

After completing the processing, PointCab displays the mesh as an orthophoto:

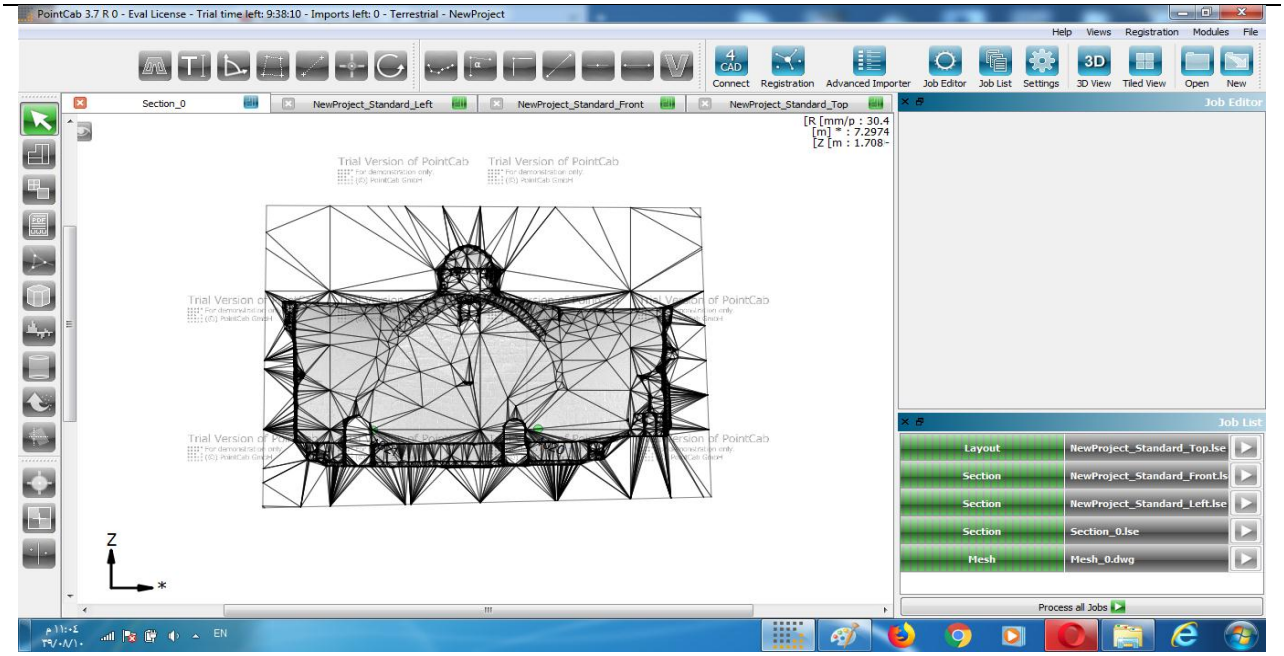


Figure (4-30): Mesh will be displayed

For further mesh analysis you can have a look on it in our 3D View. In order to start it open the Job:

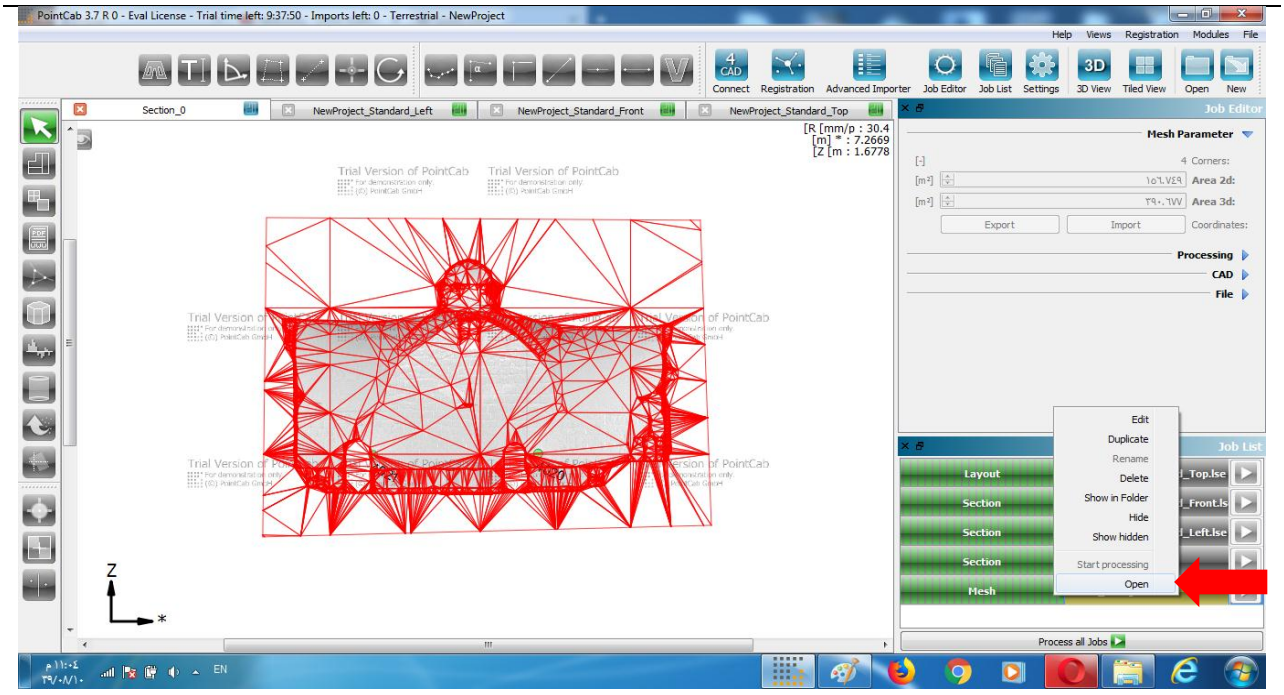


Figure (4-31): Open mesh in 3D View

3D opens in a new tab. Left click to have a look on your 3D area model :

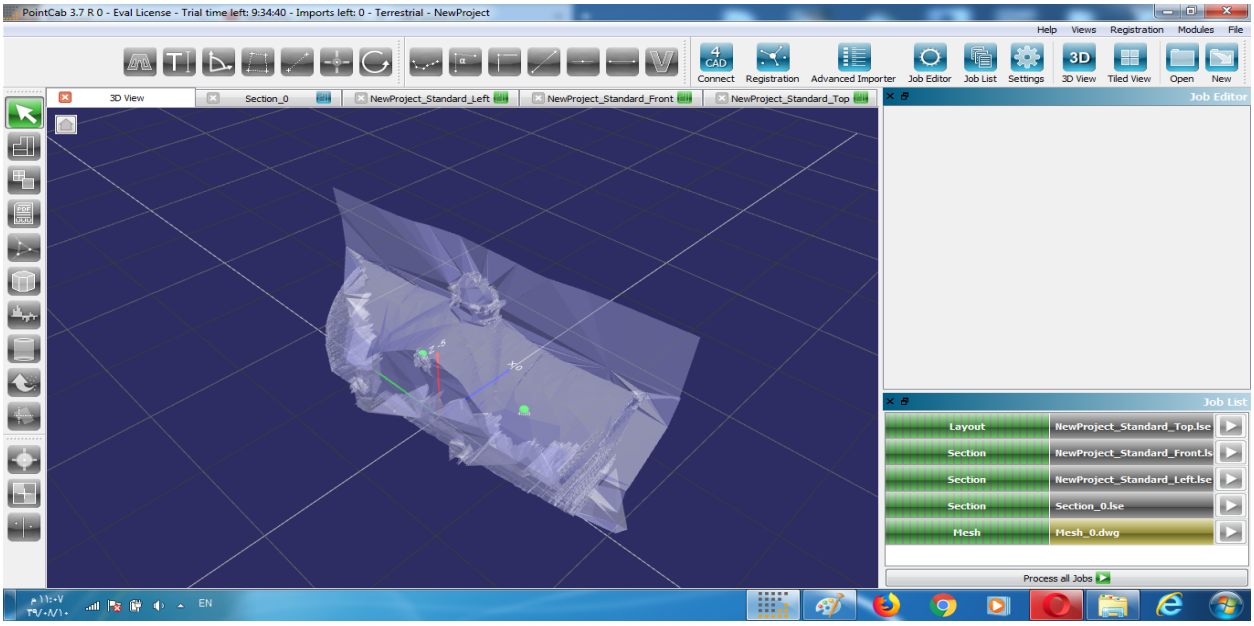


Figure (4-32): Mesh in 3D View

Finally you can open the results in your CAD Program. Right click the Job to open its storage path :

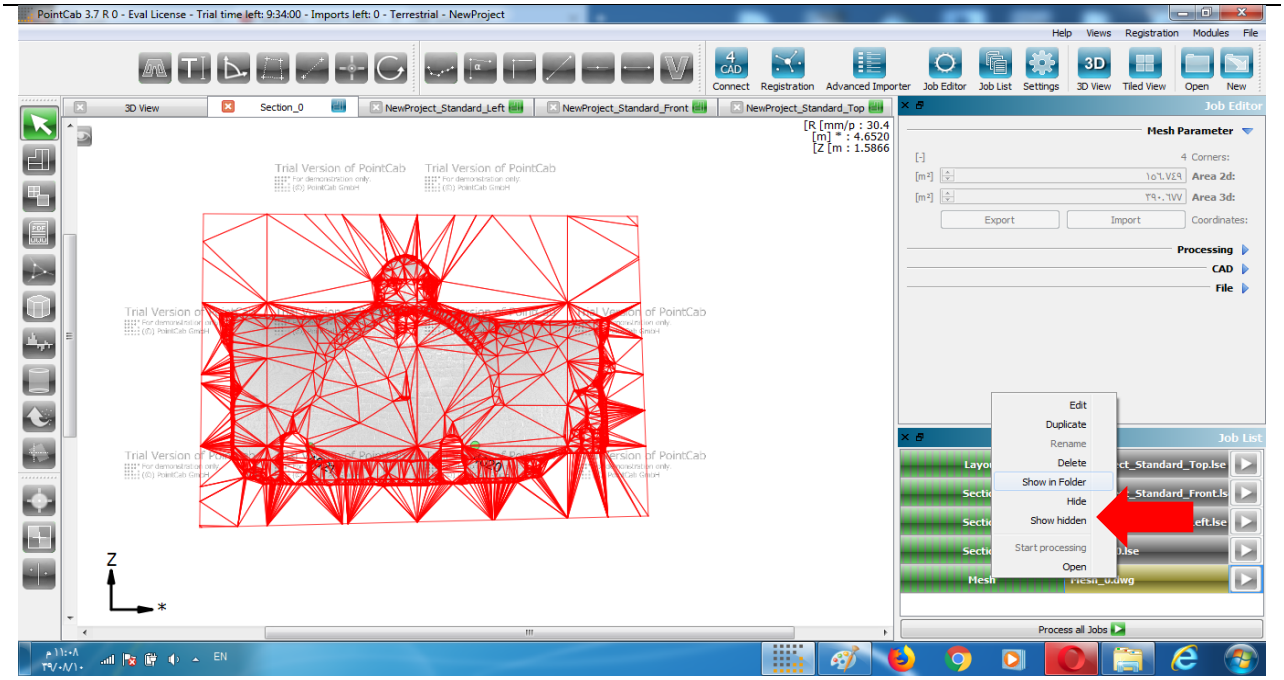


Figure (4-33): Show in Folder

Now select a CAD file :

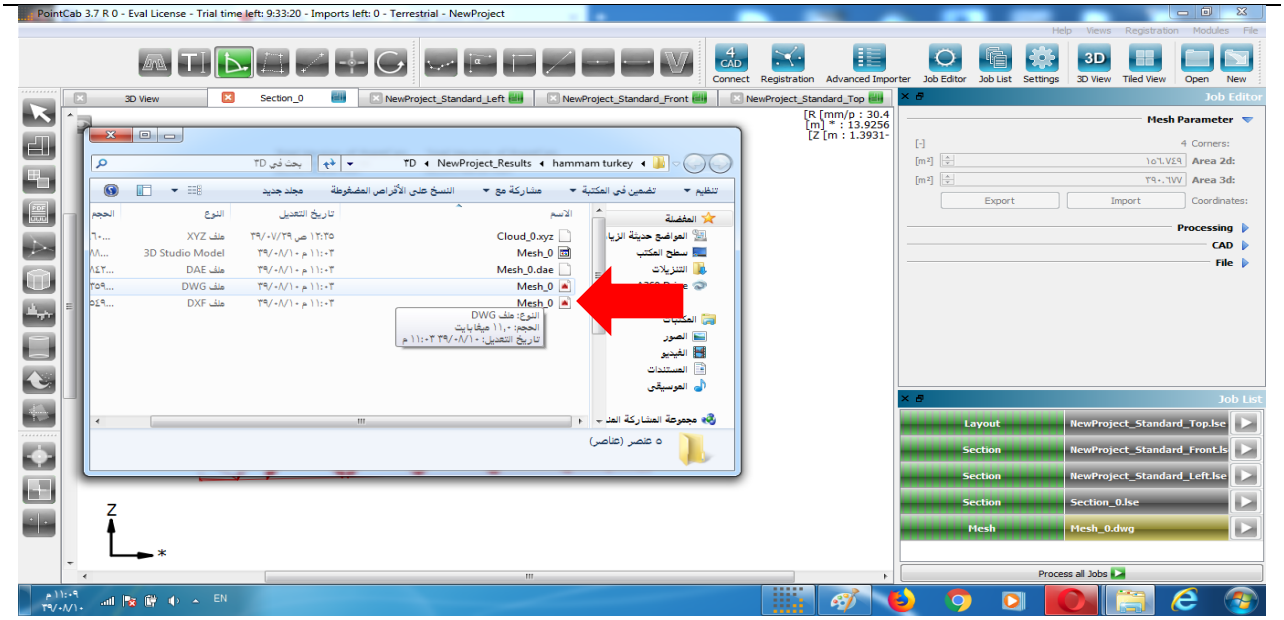


Figure (4-34): 3D area model as DWG

A facade model as DWG in TrueView :

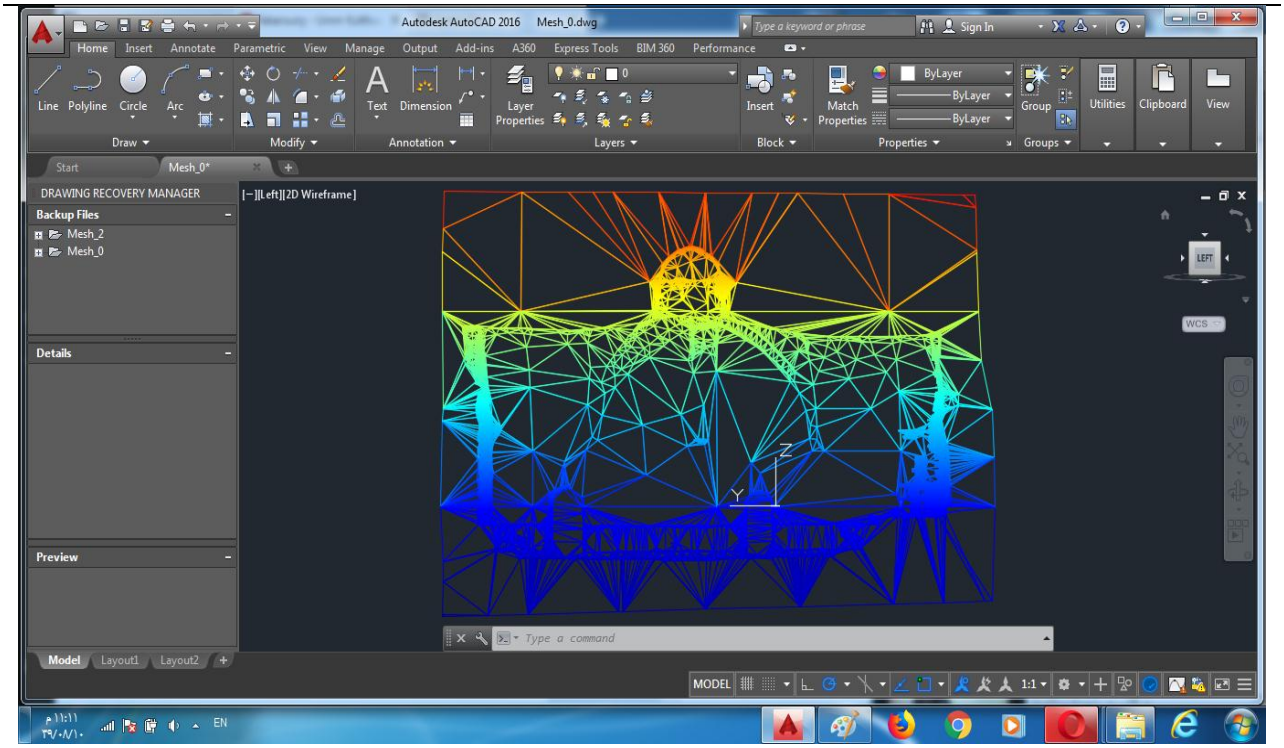


Figure (4-35): Facade model as DWG in True View

4-3-6-3 Create Layout:

Activate Layout tool:

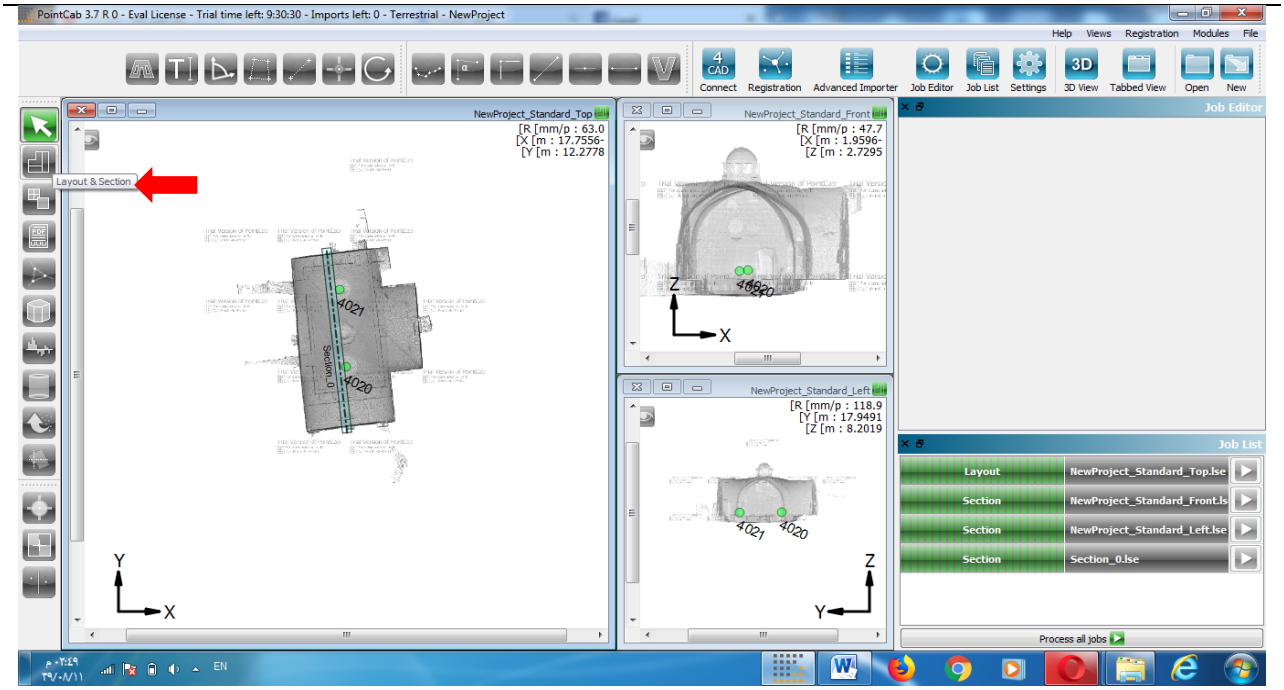


Figure (4-36): Activate Layout tool

For more precision switch to tabbed view by pressing F3 (or View–>Tabbed view)

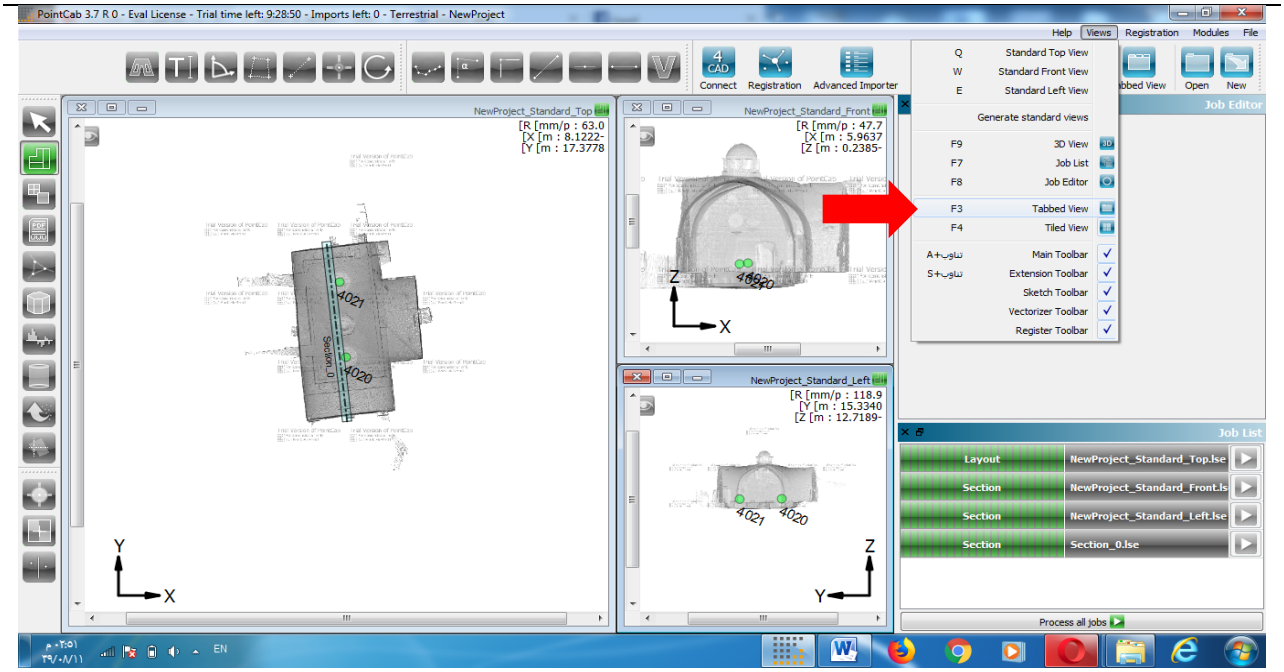


Figure (4-37): switch to tabbed view

Activate the front view:

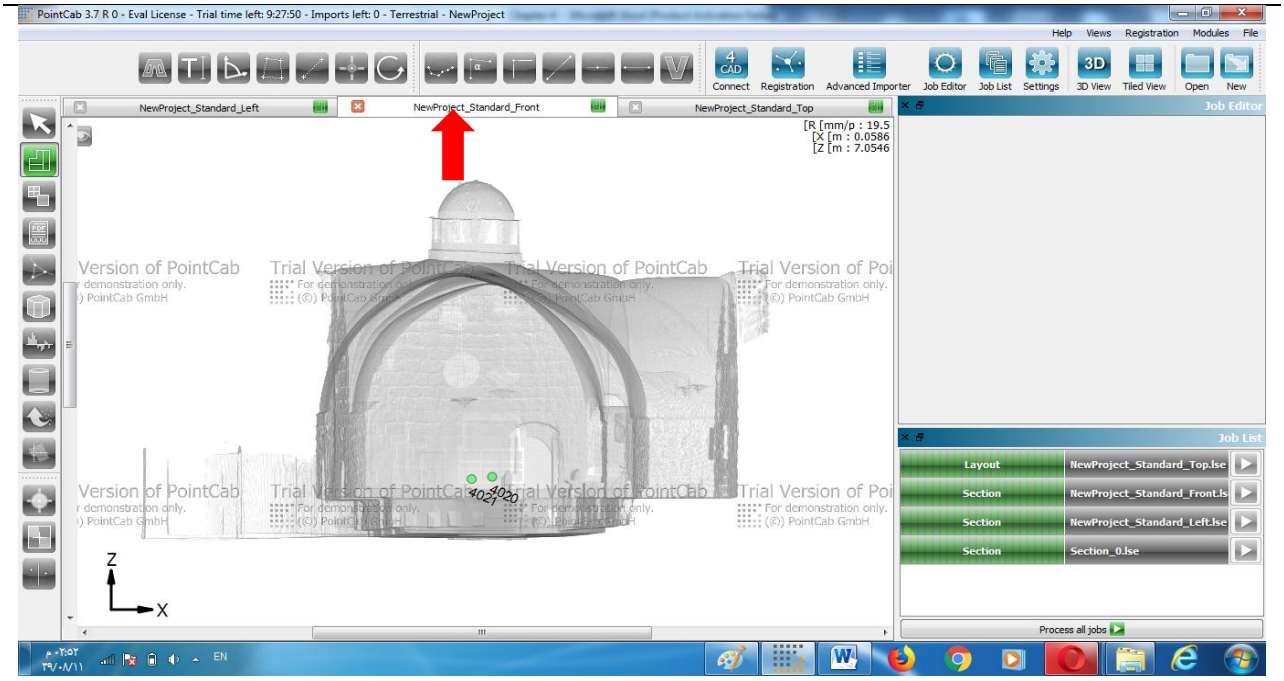


Figure (4-38): Activate the front view

Turn off scan positions by clicking the small icon or by pressing P key :

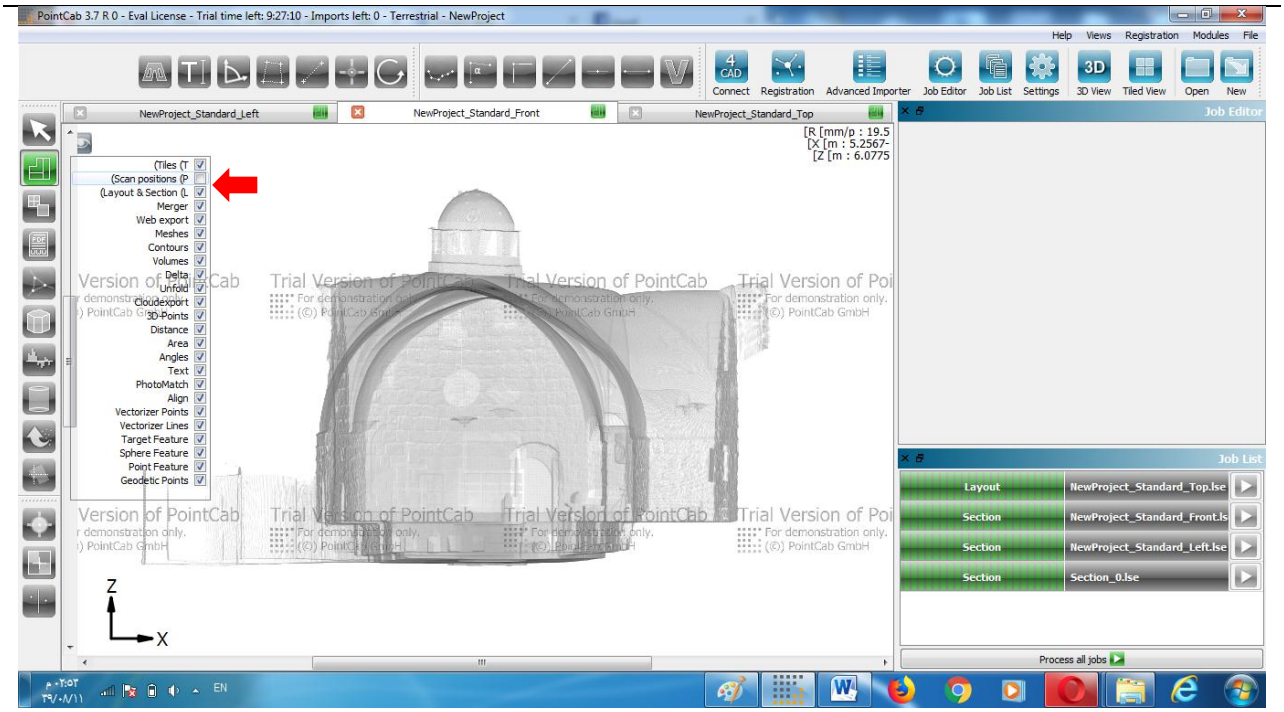


Figure (4-39): Turn off scan positions

Left-click start and end points of a section to define your layout:

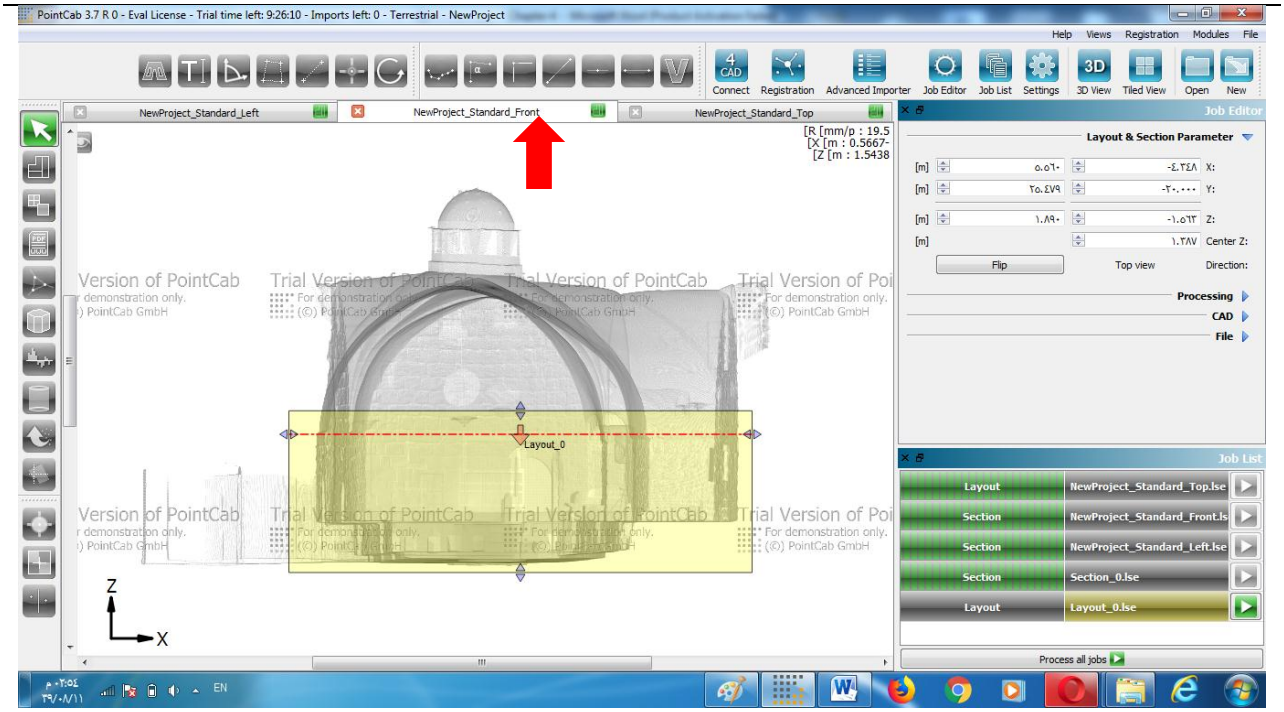


Figure (4-40): Activate the front view

Now activate the top view. Here you can sie the selected area:

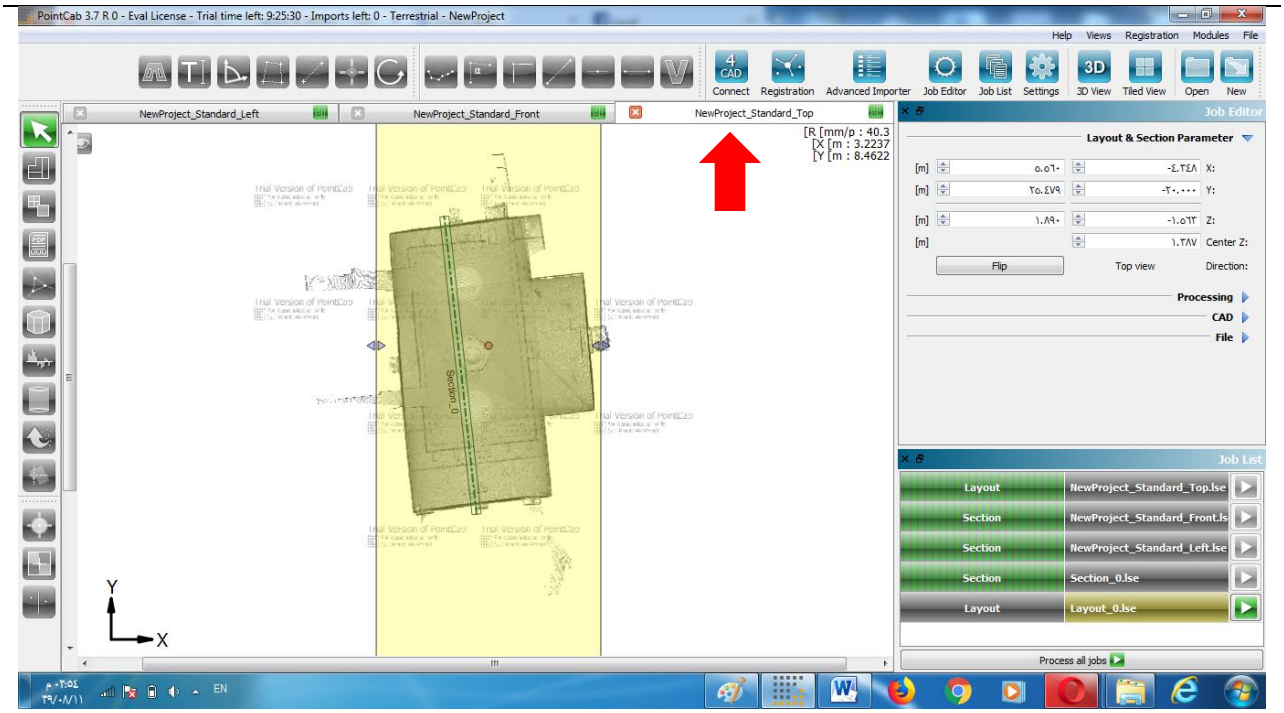


Figure (4-41): Activate the top view

Start calculation of your layout:

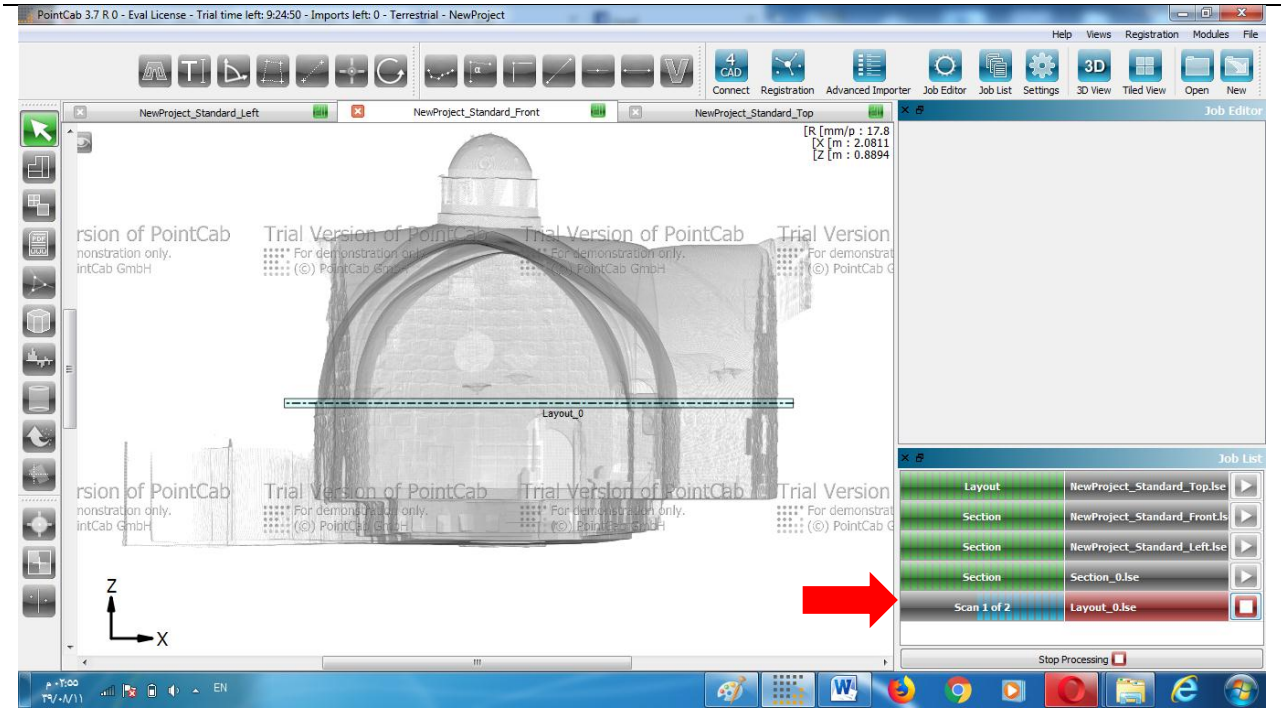


Figure (4-42): Start calculation of your layout

Right-click Job to open the layout as soon it turns green:

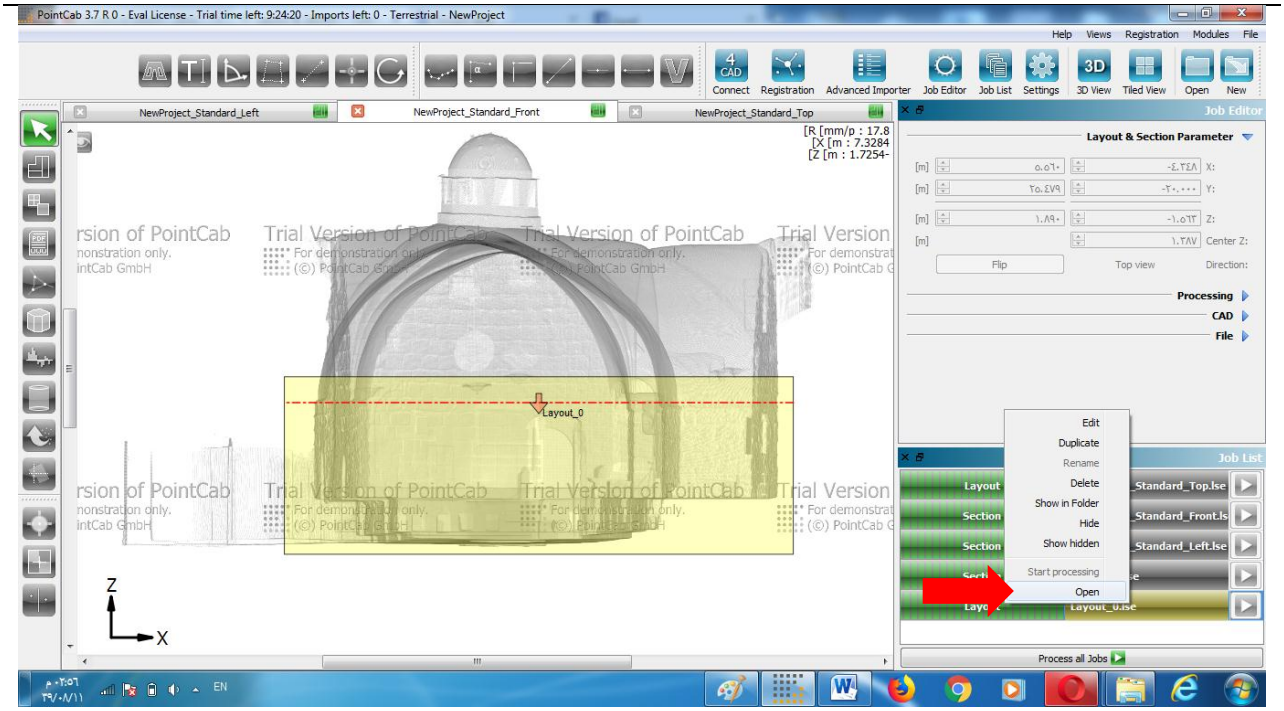


Figure (4-43): open the layout

Processed layout in PointCab :

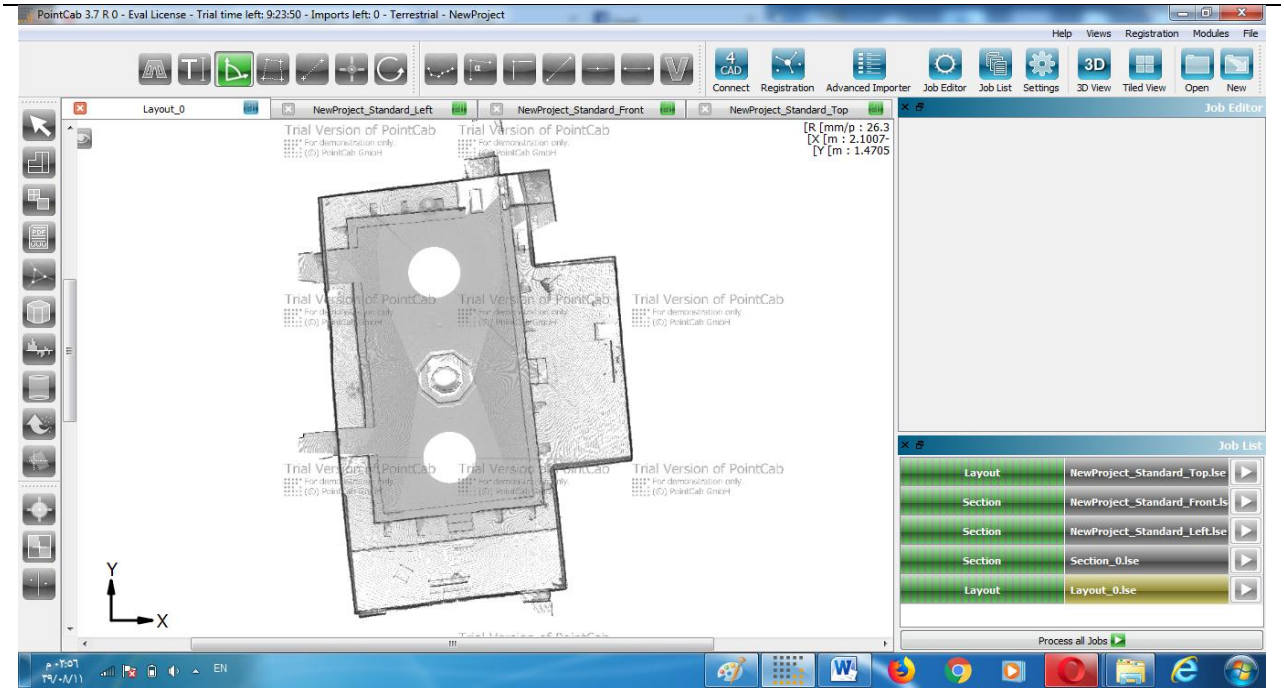


Figure (4-44): layout in PointCab

Alternatively you can open a folder containing your layout in DWG, DXF, DAE formats by right -click selected Job and click Show in folder :

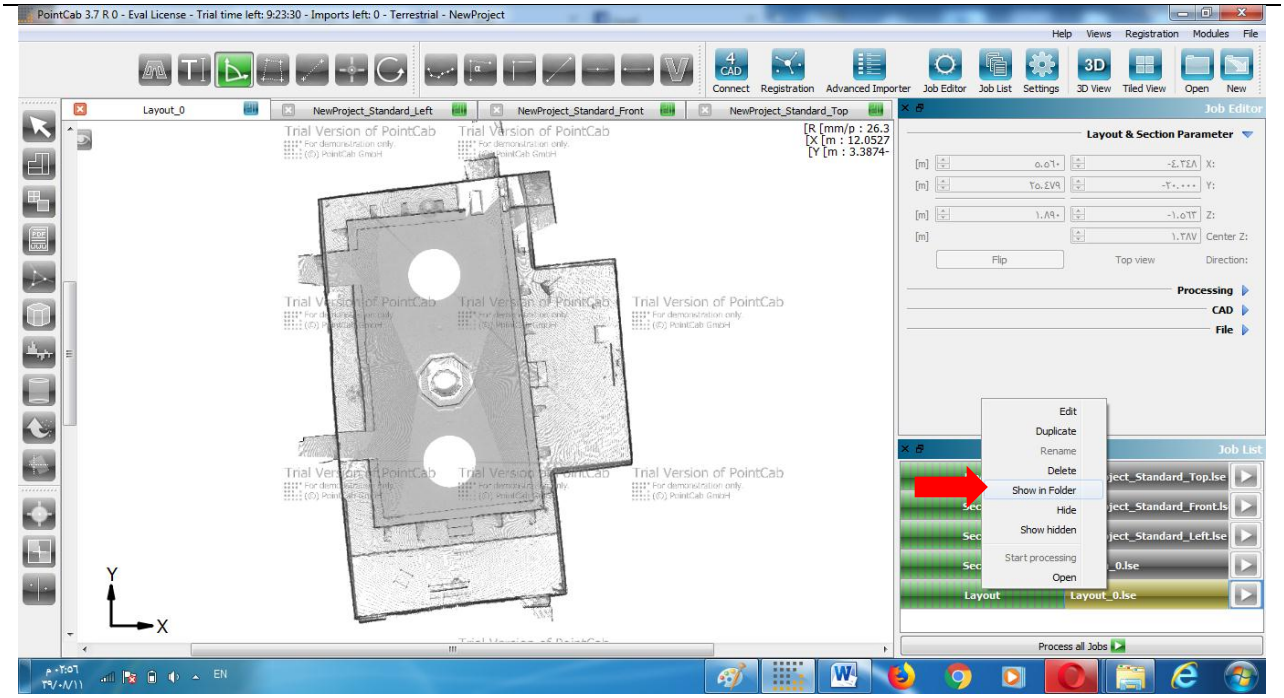


Figure (4-45): Show in folder

PointCab results in Windows Explorer:

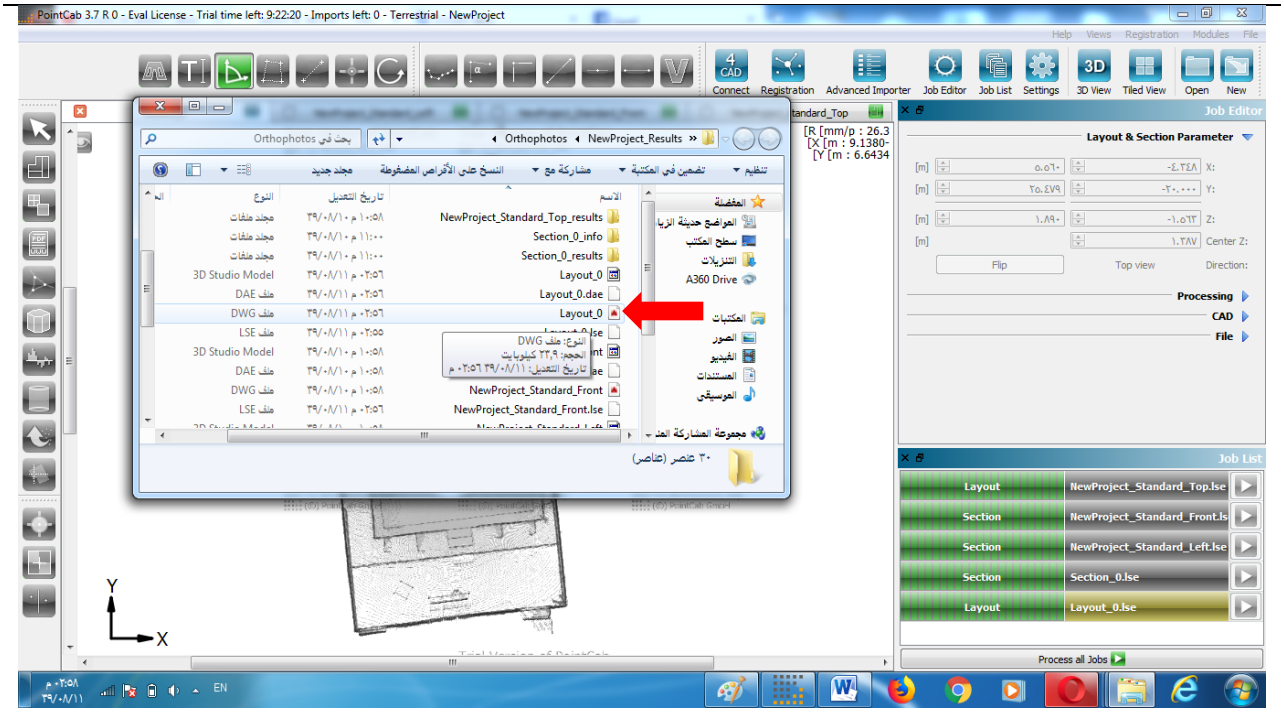


Figure (4-46): layout in PointCab

Double-click DWG file opens the layout in free program Autodesk DWG-True View:

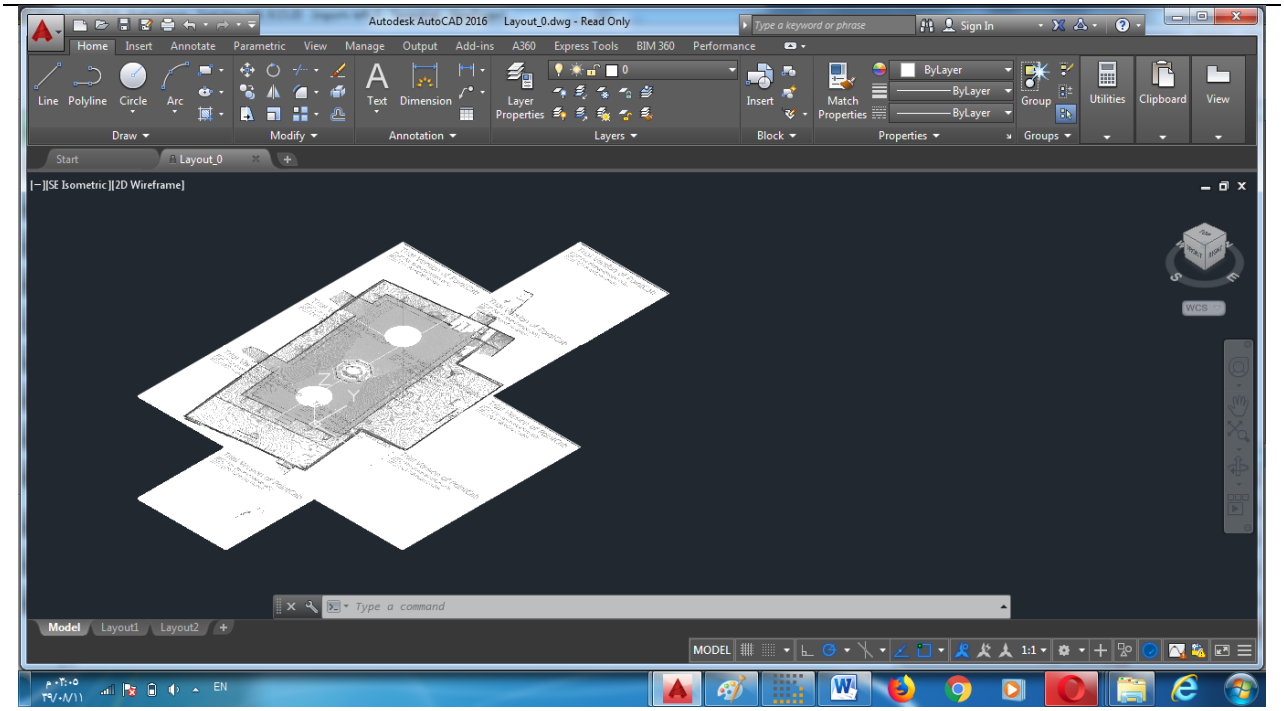


Figure (4-47): layout in Autocad

4-3-6-4 Export 3D-points

Export points to another system using export tool

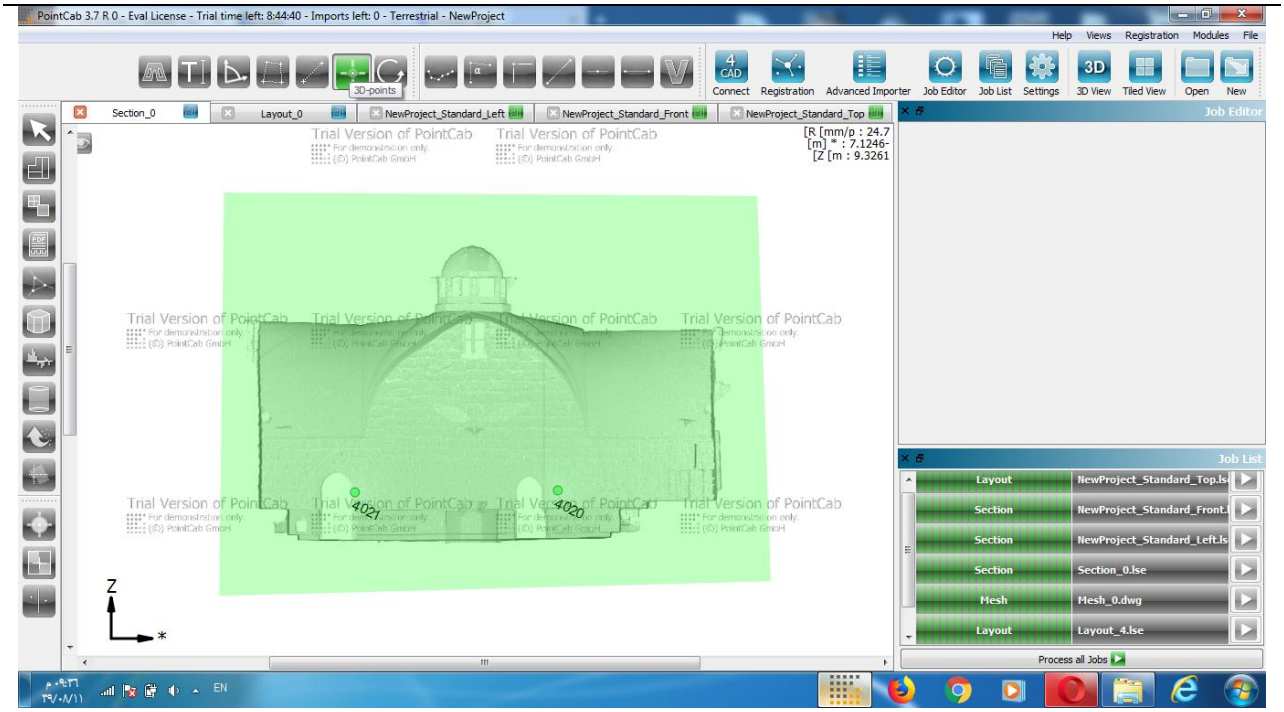


Figure (4-48): Activate the 3D Points tool

Click the required points on plan :

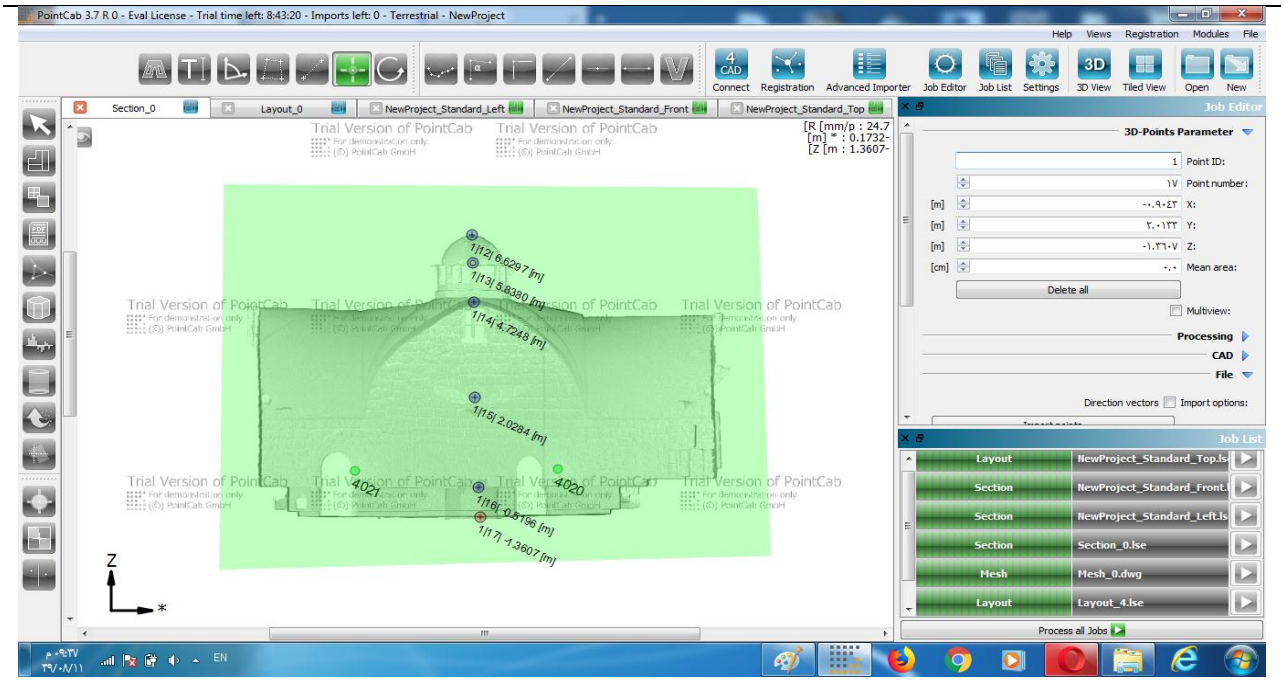


Figure (4-49): Mark Points

In Job Editor you can now export points :

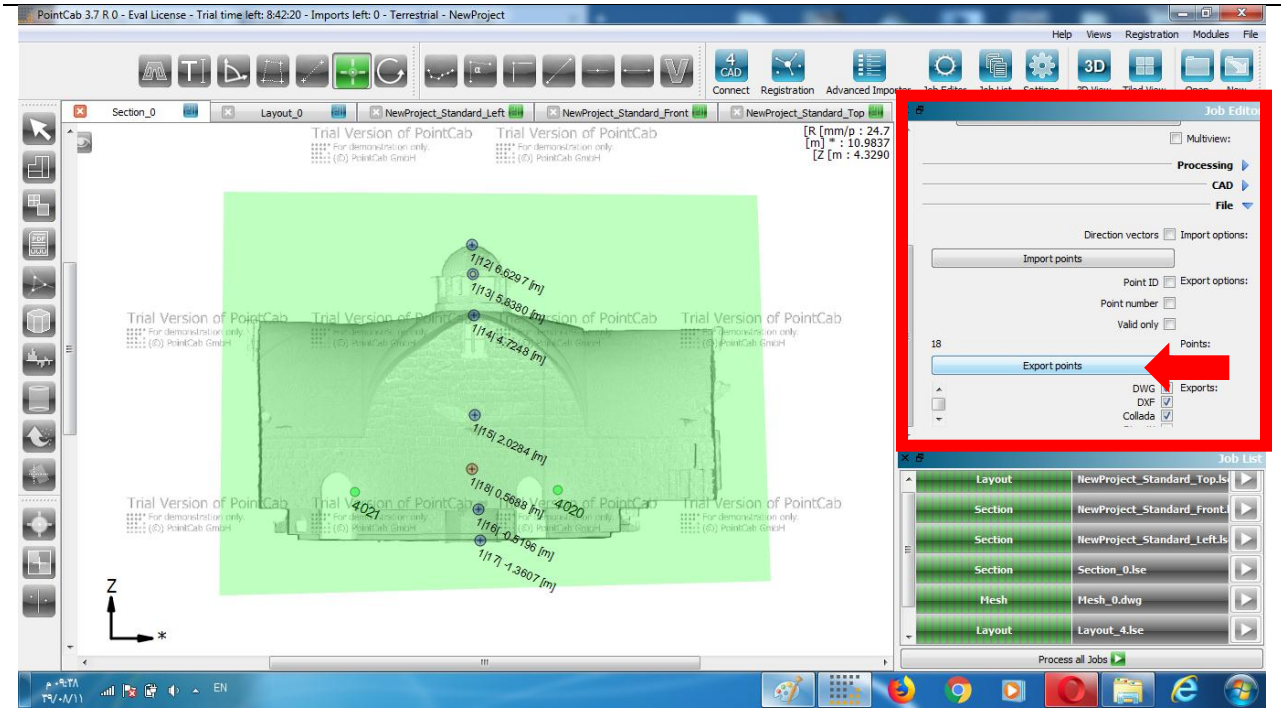


Figure (4-50): Export Points

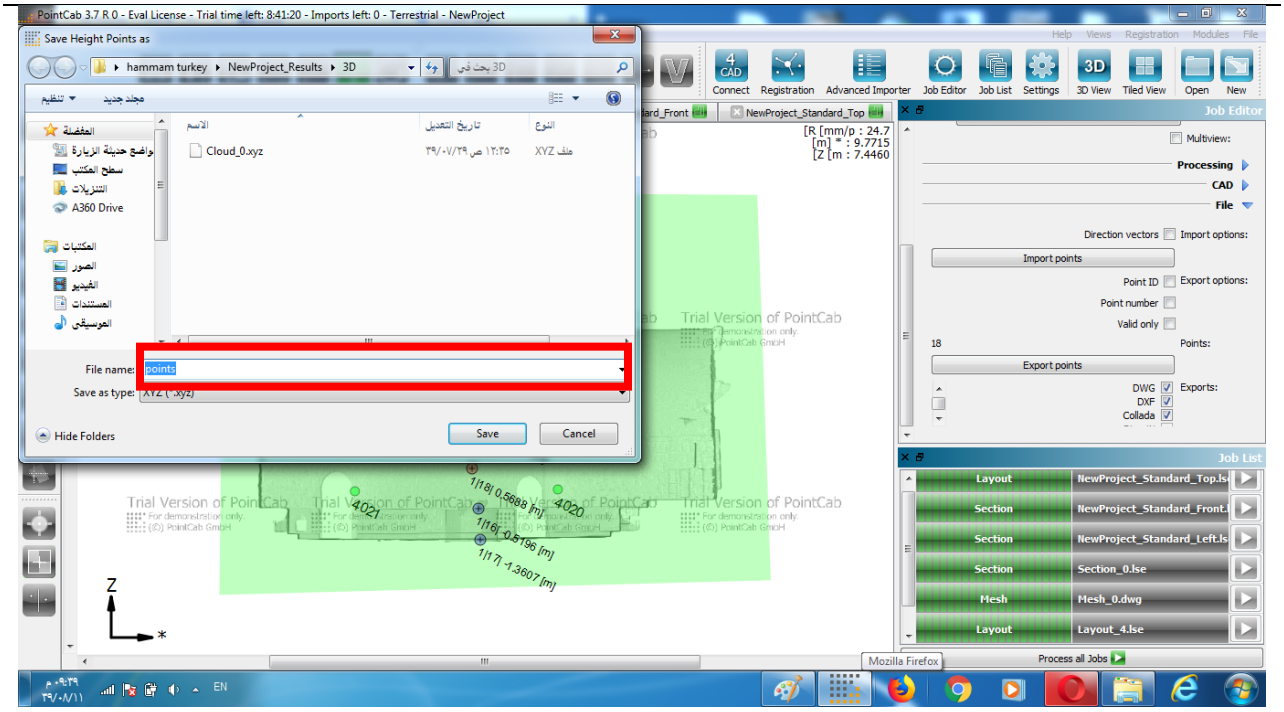


Figure (4-51): Name of file

The XYZ List will be saved under 3D in the folder Project_Results :

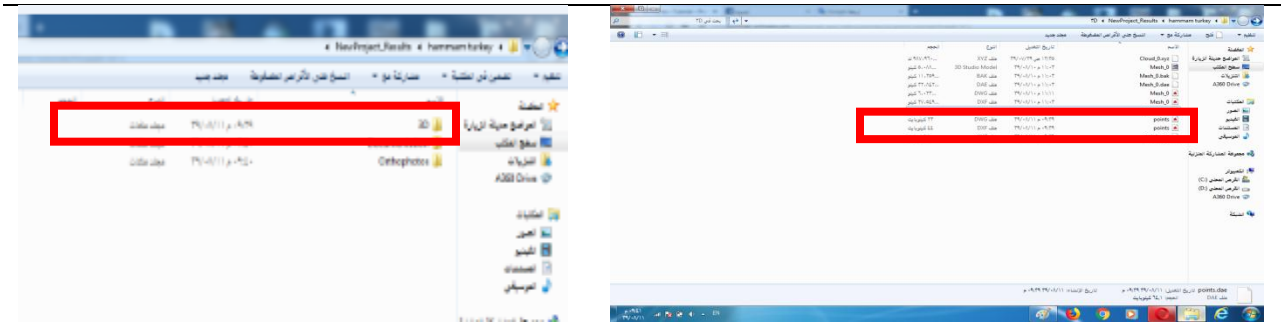


Figure (4-52): 3D Points will be saved in 3D Folder

The List of coordinates is in ASCII format and can be open as a text file in Editor:

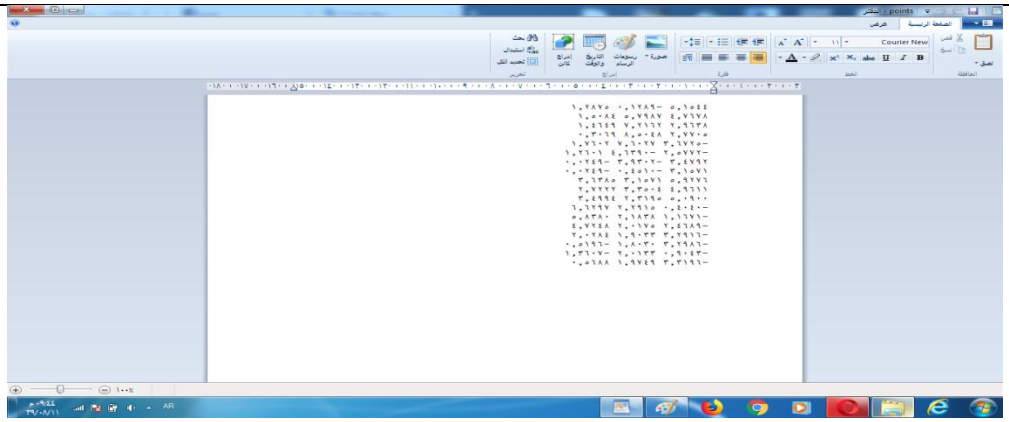


Figure (4-53): XYZ List of Points

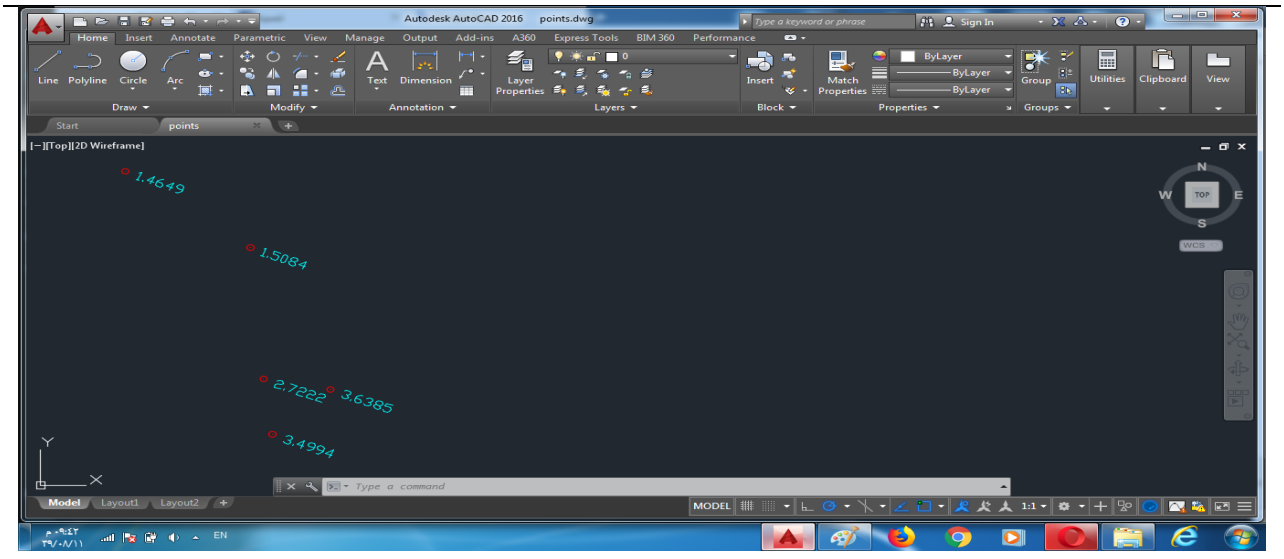


Figure (4-54): points in Autocad

4-3-7 Analyze facade deformations

To analyze the deformation of a facade due to our Delta tool

Activate our Delta tool

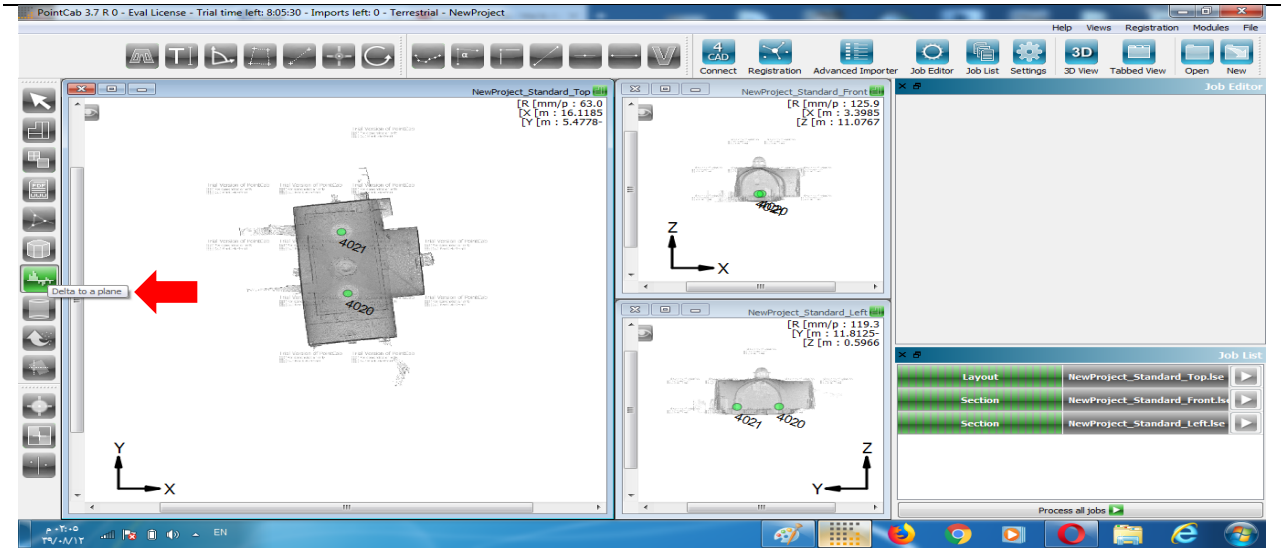


Figure (4-55): Activate our Delta tool

The area, which is highlighted in yellow, indicates the point clouds that are analyzed. You can adjust this area visually or by means of coordinates in the Job Editor:

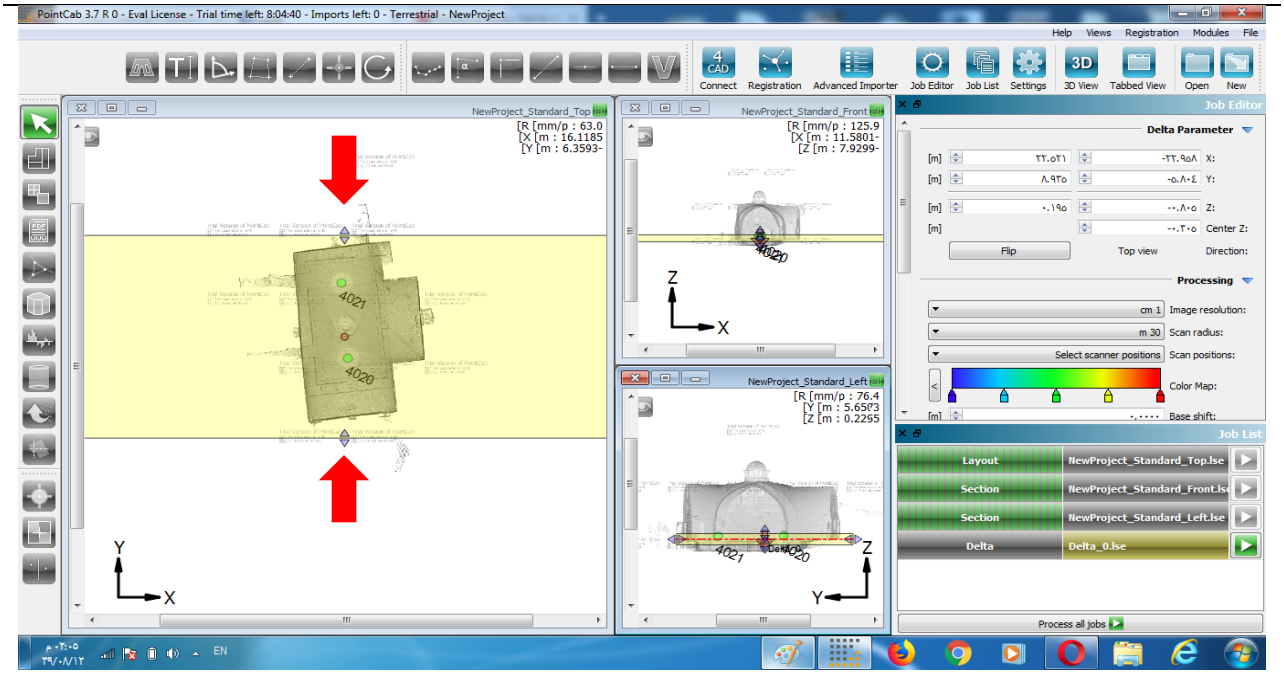


Figure (4-56): Limit the area to be analyzed

start processing

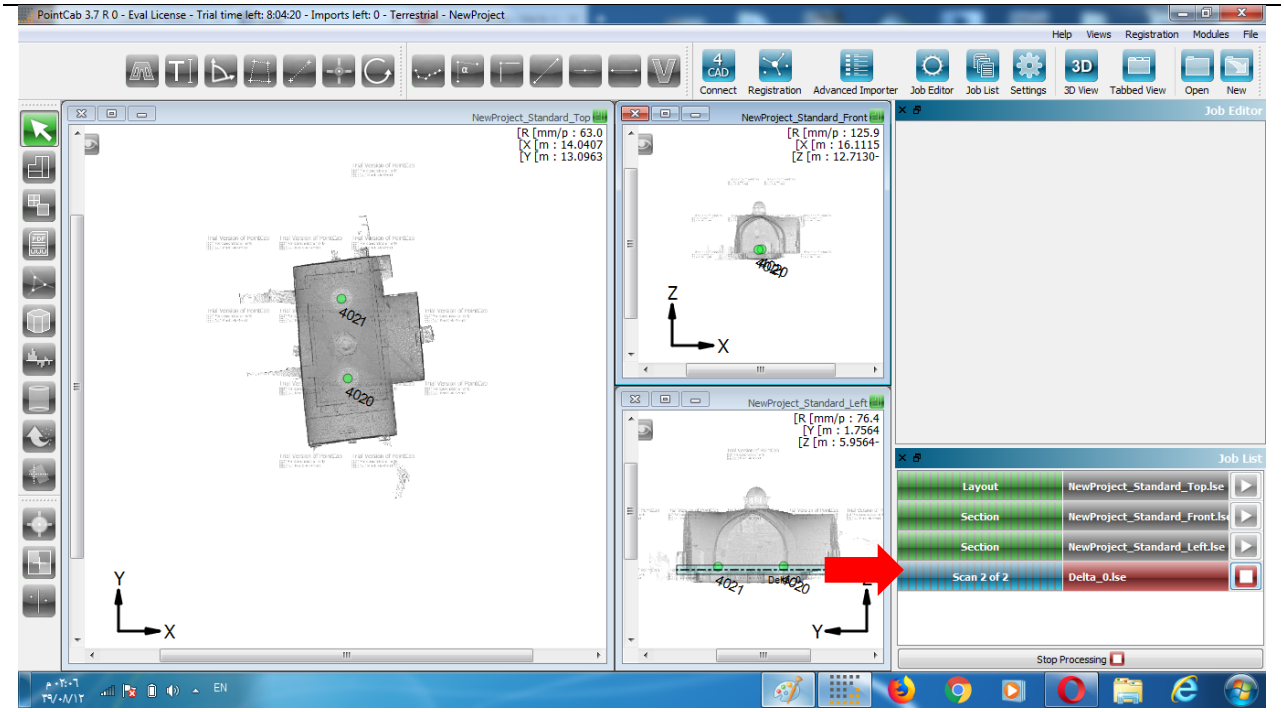


Figure (4-57): start processing

Double-click on the processed job to open the result of the Delta analysis in PointCab. You obtain the same result with the context menu and then with the option Open. You can open the context menu by right-clicking on the processed job.

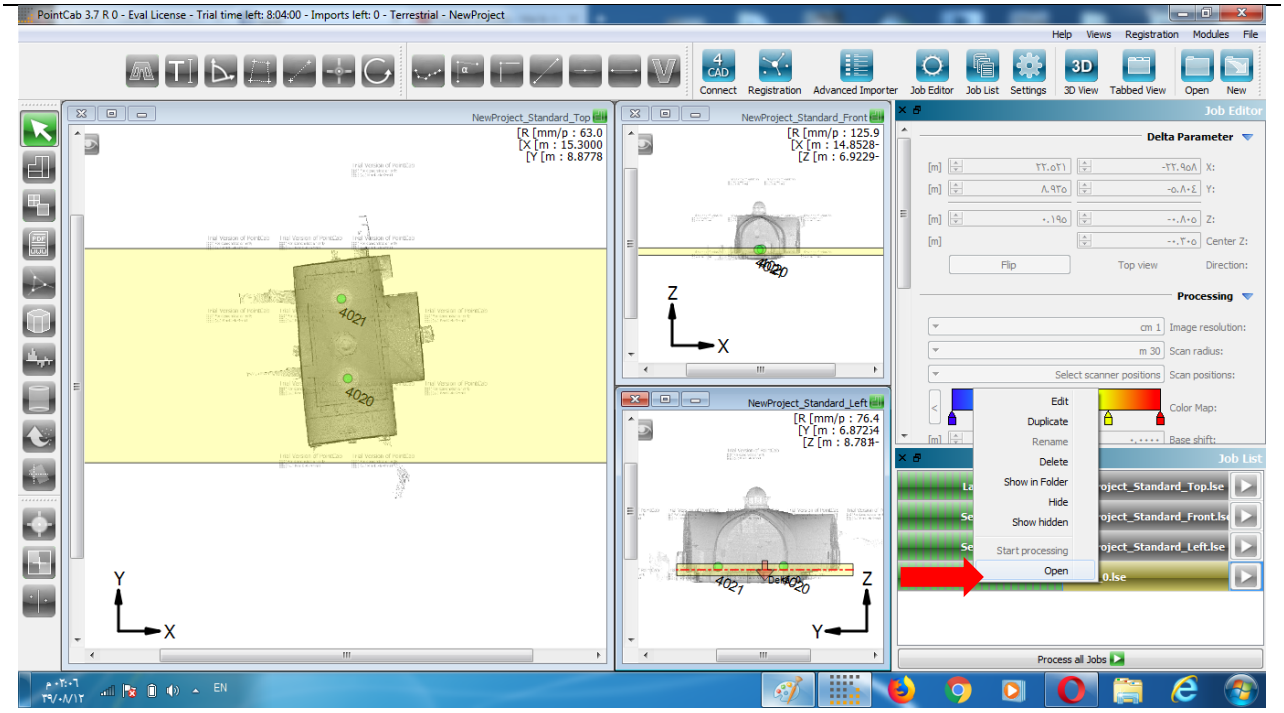


Figure (4-58): open the delta

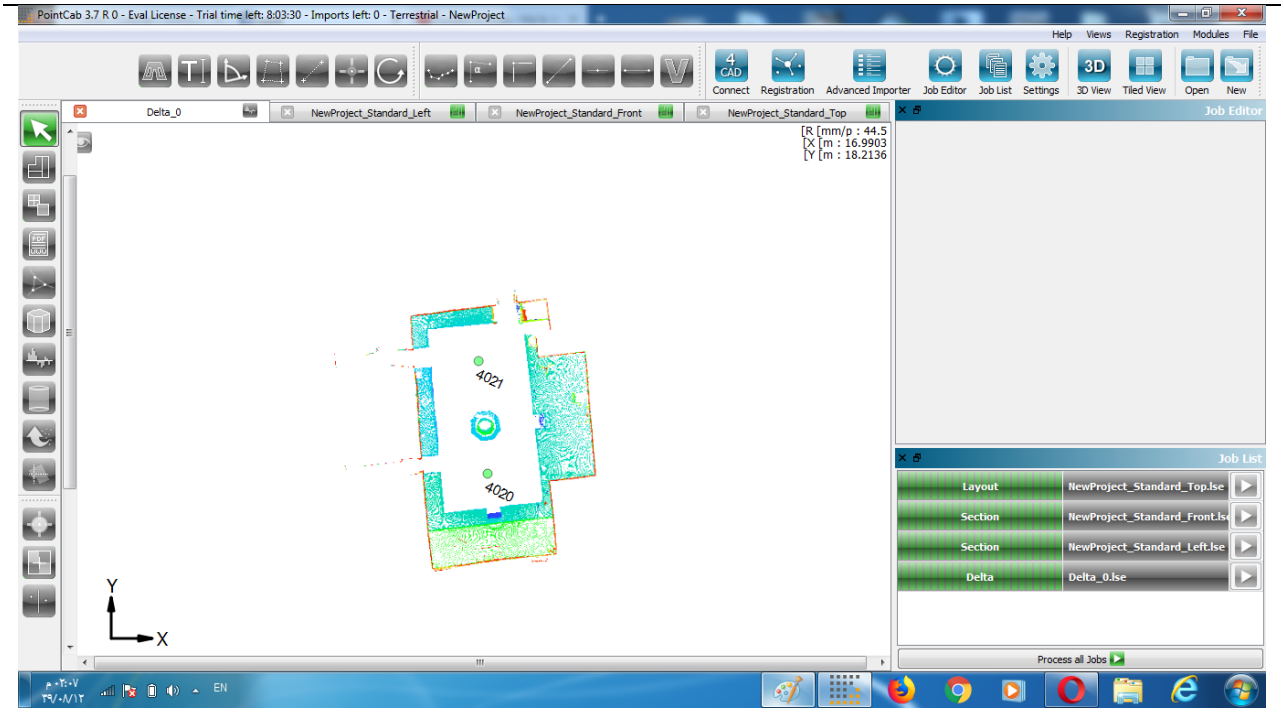


Figure (4-59): Delta analysis in PointCab

By using the context menu, you can display the results by clicking on Show in Folder:

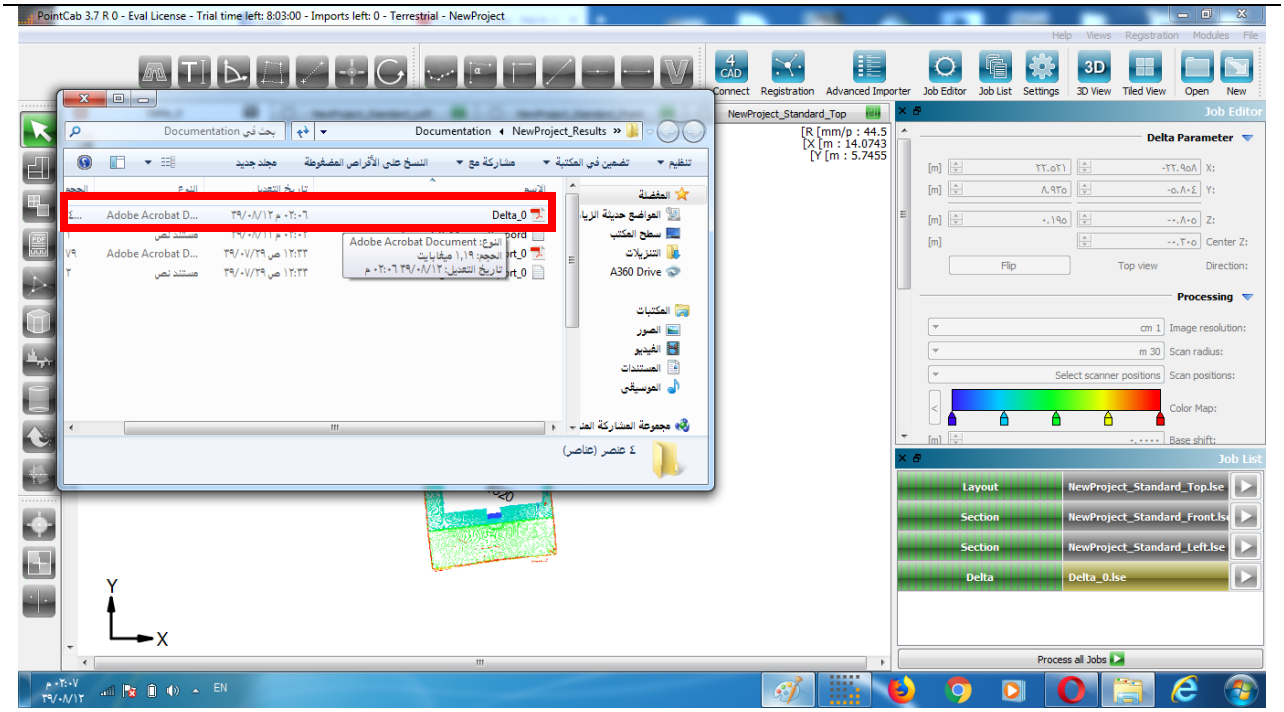


Figure (4-60): Show in Folder

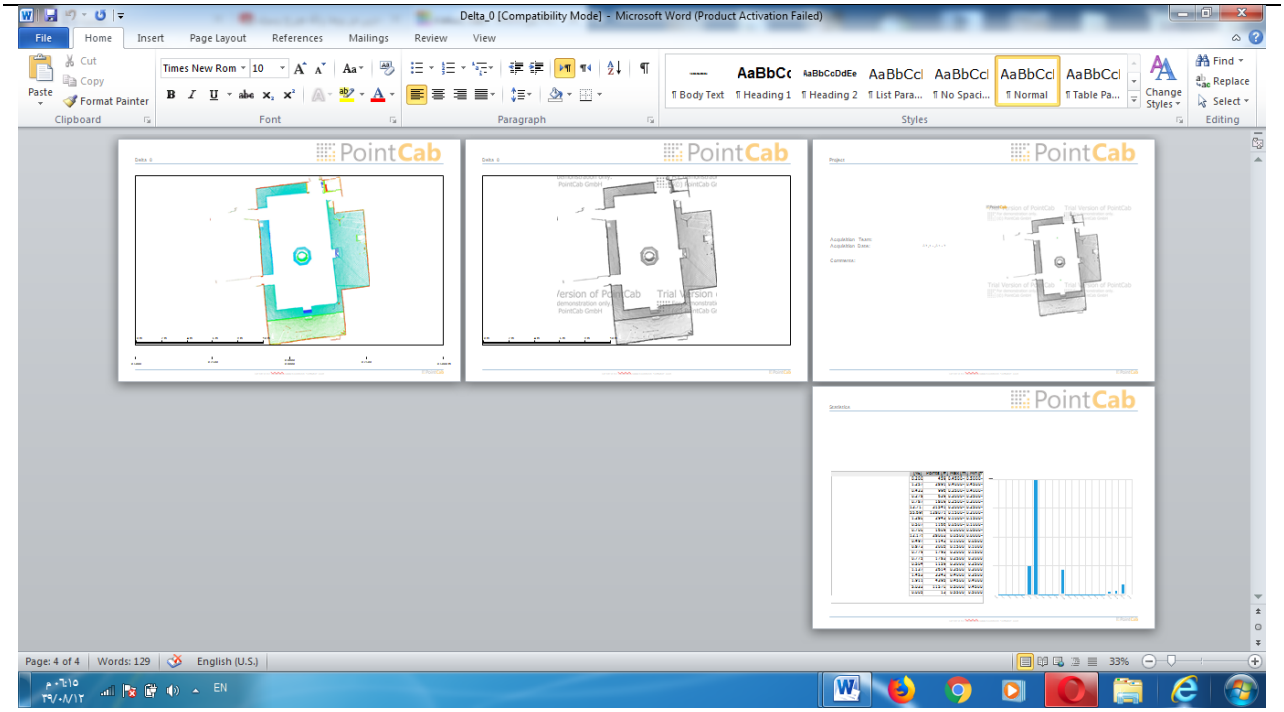


Figure (4-61): PDF protocol as documentation for the Delta analysis

You can open the DWG file in AutoCAD, for instance, and position it under your project. Here, the DWG is opened in Autodesk TrueView:

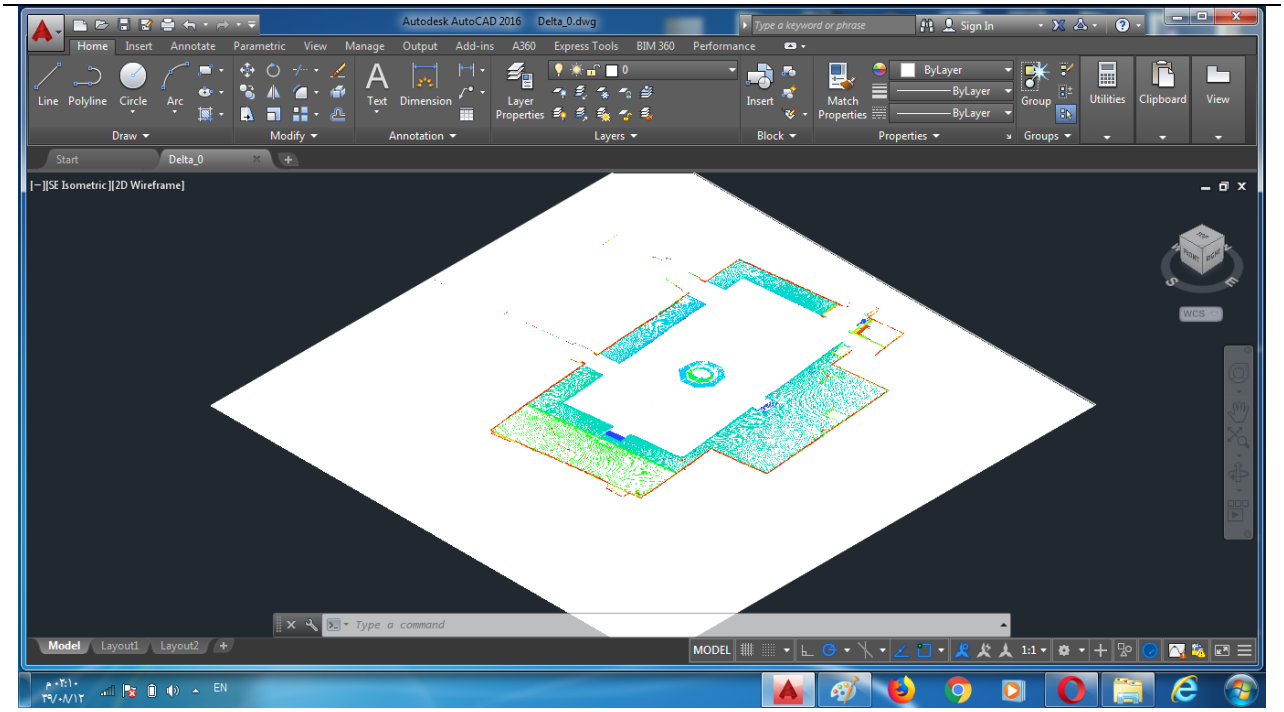


Figure (4-62): DWG of the Delta analysis in Autodesk True View

4-3-8 Volume of a foundation pit

The volume of a foundation pit can be calculated immediately using our Volume tool. Activate the Volume tool :

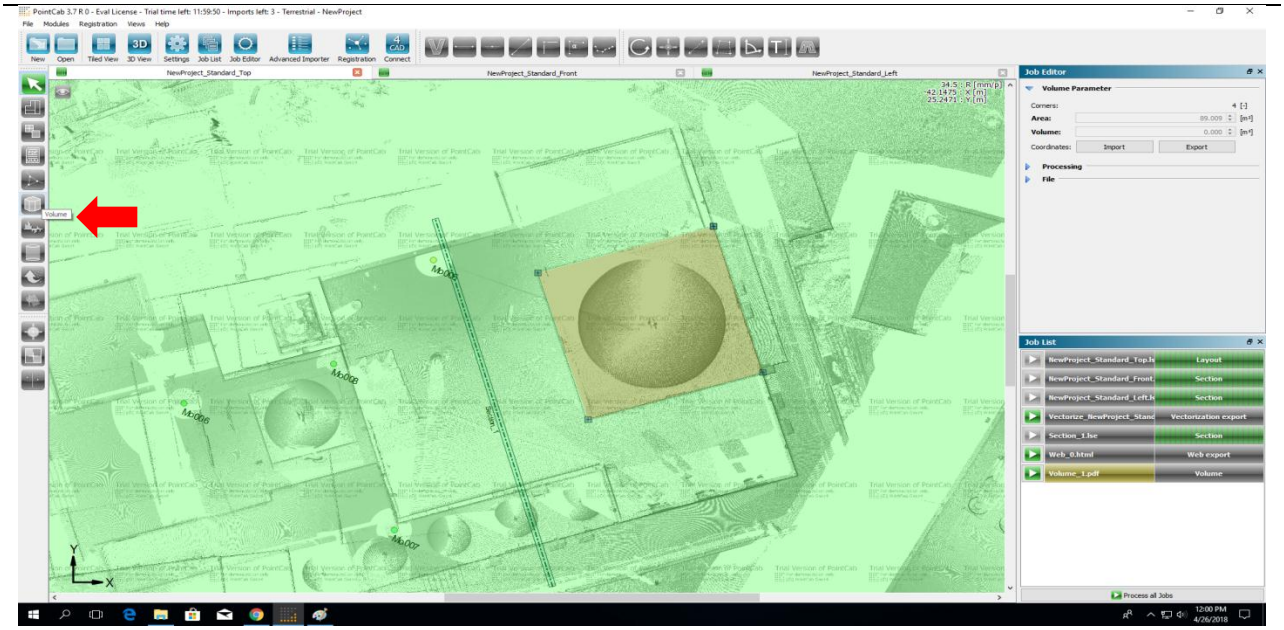


Figure (4-63): Activate the Volume tool

Select the foundation pit respectively the area to calculate the volume & Start processing:

Figure (4-64): Select area& Start processing

The result will be showed directly:

Figure (4-65): Volume calculation results

The result will be showed directly:

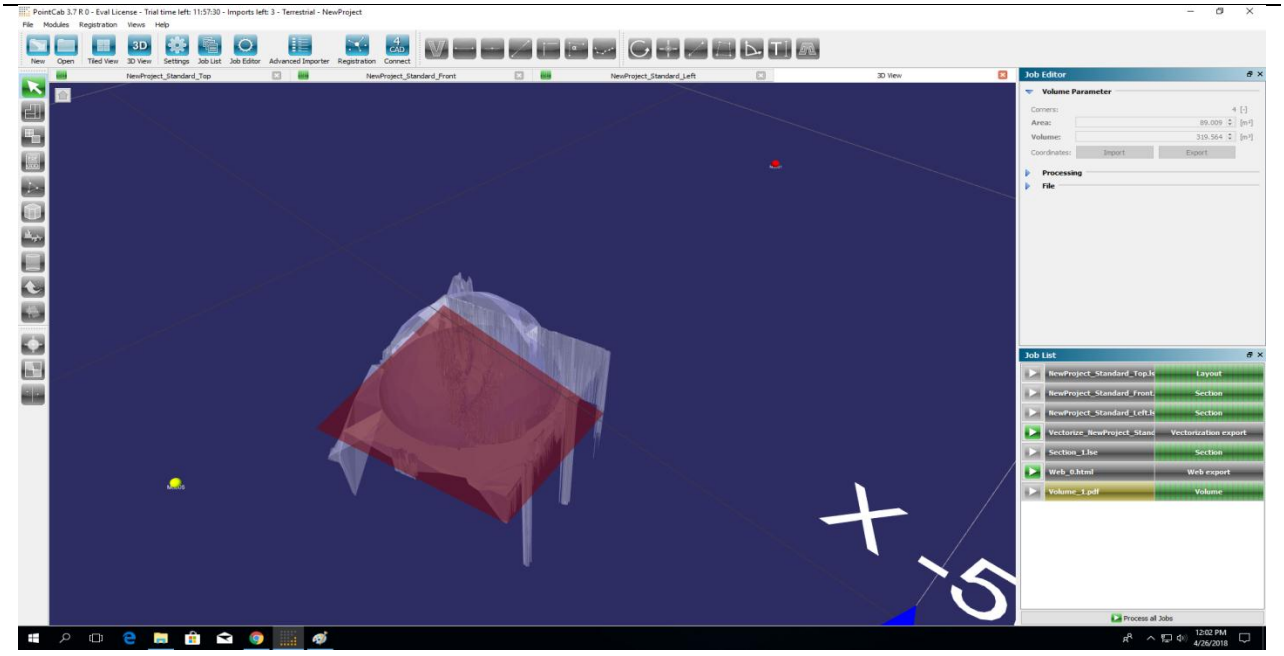


Figure (4-66): Volume in our 3D View

4-3-9 Correct resolution for your laser scanner:

In order to choose the correct resolution of the scanner, it is important not to lose sight of the task. Ultimately, laser scanning must always be economical. However, this is only guaranteed if the correct parameters are selected. One should ask the following questions:

-Is it outside or inside?

-What are the distances between the scanner and the object?

-How many scans will I do to avoid shading?

-Do I need a colored point cloud or is even a gray point cloud meaningful?

-How do I continue to process the scan data and, above all, with which software?

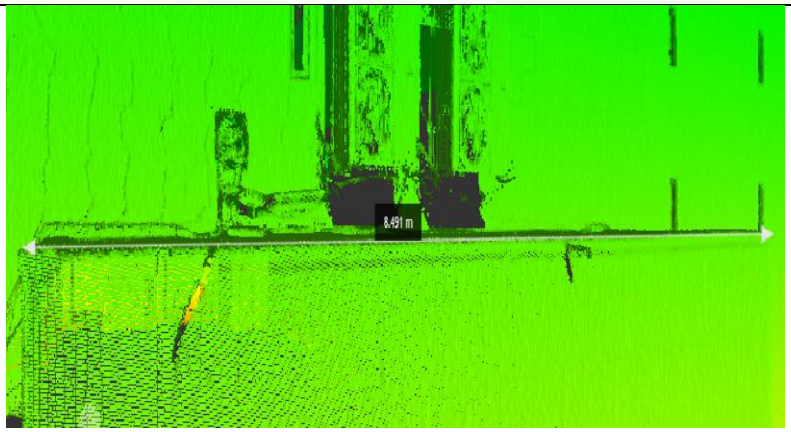
The farther the distances to the object the higher the resolution has to be chosen. For a simply clinkered house facade without ornamentation, e.g. a resolution of 1/4 and twice the quality is sufficient. Much more important than the resolution is to avoid shading by many laser scanner locations on a facade.

Measurements For mosque:

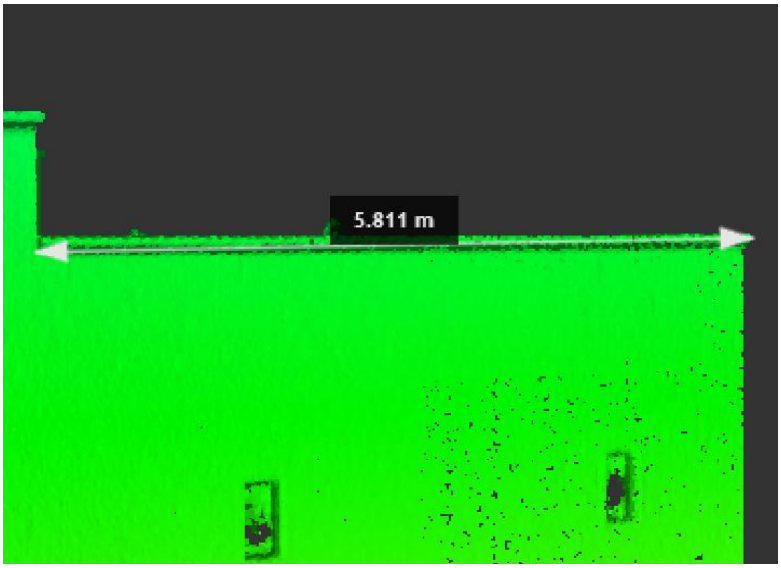
No.	Laser scanner RecapAutodesk	Reference	Accuracy	Relative Error
1	8.491	8.5	.009	1%
2	5.811	5.8	.011	1%
3	9.585	9.6	.015	1%
4	10.577	10.65	.073	1%
5	9.897	9.8	.097	1%
Average	8.8722	8.87	.041	.01
Max	10.577	10.65	0.097	.01
Min	5.811	5.8	0.009	.01
Standard devision	1.869552	1.879362	0.04111	0

Table (4.1): Compression Measurement for Palestine Polytechnic University Mosque

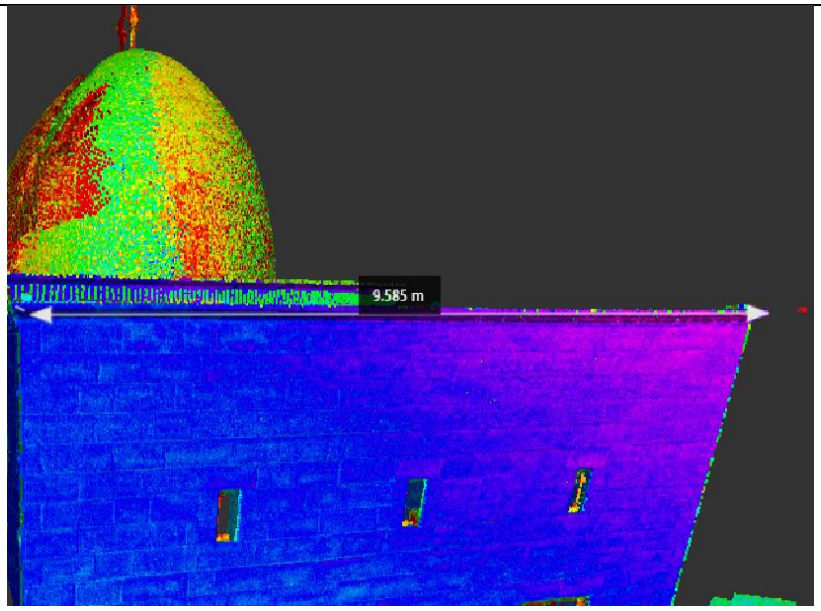
1



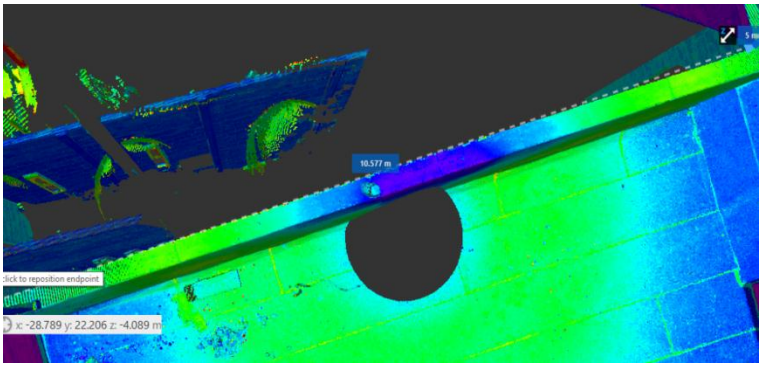
2



3



4



5

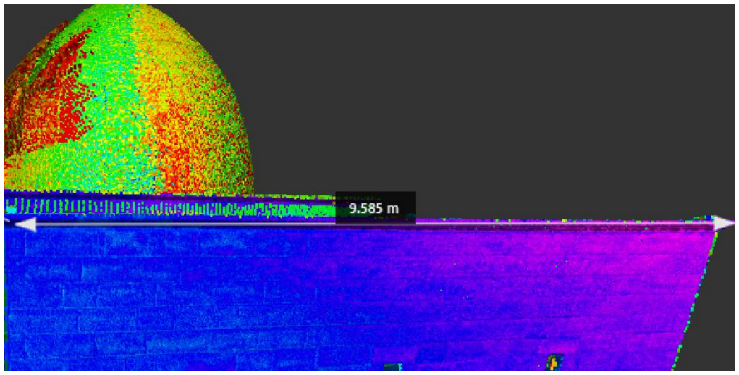


Figure (4-67): Trial Measurement for Palestine Polytechnic University Mosque

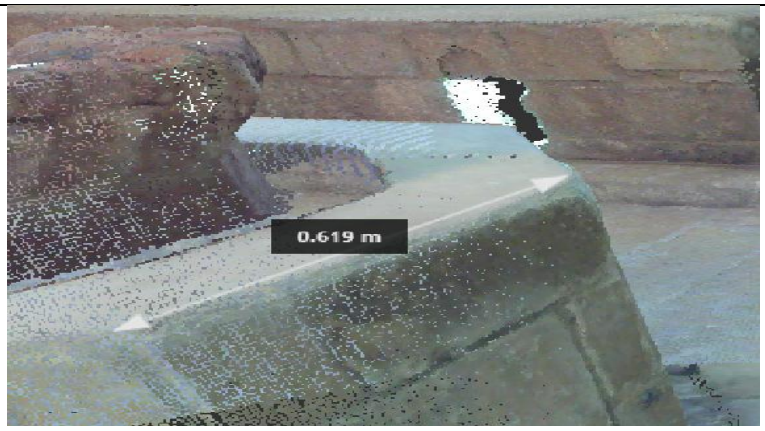
Figure (4-68): Test model for Al-Hammam AL-Turkey

Measurement for AL-Hammam AL- Turkey:

No.	Laser scanner Recap Autodesk	Reference	Accuracy	Relative Error
1	.619	.600	0.019	0.03167
2	3.725	4.00	0.275	0.06875
3	.898	1.00	0.102	0.102
Average	3.604333	3.666667	0.189	0.067473
Max	6.19	6	0.275	0.102
Min	0.898	1	0.102	0.03167
Standard	2.648063	2.516611478	0.086504	0.035182

Table (4-2): Compression Measurement for AL-Hammam AL- Turkey

1



2

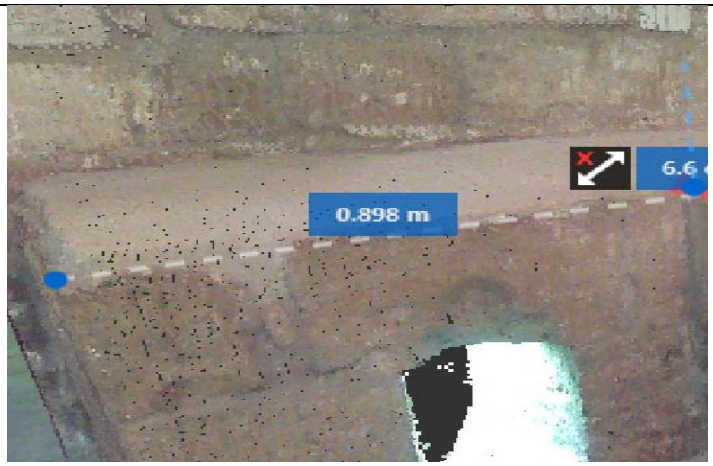
3	

Figure (4-69): Trial Measurement AL-Hammam AL- Turkey