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Refining The Scan to BIM Workflow for Further Automation and Visualisation

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Learning Objectives

- Learn how to process raw scanned data to produce a point cloud using Autodesk ReCap Pro
- Learn how to incorporate ClearEdge3D EdgeWise for automated point cloud geometry extraction, further automating the modelling process in Autodesk Revit
- Learn how to combine point cloud data and design models using Autodesk Navisworks and ReCap Pro for contextual visualisation
- Learn how to utilise Autodesk Navisworks to render and create panoramic virtual reality to convey realistic design visualisation

Description

As-built capture and modelling is the process of deriving measurements and dimensions of a constructed entity such as buildings and thereafter modelling the constructed entity based on the derived measurements to represent its completed state. This is required for effective operation and maintenance of the constructed entity. In the past, this task has been purely manual, cumbersome and inaccurate. With the progression in design and technology, this task has been made easier with the combination of laser scanners and BIM technologies, commonly known as The Scan to BIM Workflow. This workflow has made the process of as-built capture automated and quicker, but still requires the modelling process to be done manually by tracing off the derived point cloud to obtain the as-built model. But what if we could further automate the traditional Scan to BIM Workflow in the modelling phase as well as provide a realistic level of visualisation?. In this session we will be applying the Refined Scan to BIM Workflow which incorporates automated point cloud extraction technology ClearEdge3D EdgeWise with BIM technologies such as Autodesk ReCap Pro, Revit and Navisworks to further automate the modelling phase of the workflow and provide realistic visualisation.

Speaker

Shuaib Yunos is a BIM Technical Specialist in Civil Infrastructure & Mining at Baker Baynes, South Africa. Being a qualified Civil Design Technologist as well as an Autodesk Certified Instructor, Shuaib has shared his BIM and Civil Engineering design expertise to help many companies & consultants across the world design more efficiently, intelligently, and economically.

Shuaib has presented at many global events and professional bodies such as the South African Institute of Civil Engineers (SAICE), the South African Geotech Conference, BIM Harambee Africa, Autodesk University Africa, as well as being selected to present at the African Smart Cities Summit and Autodesk University Las Vegas in 2018.

Shuaib is a champion of BIM for Civil Infrastructure in Africa and abroad, with the hope to spur on digital transformation within the Civil Infrastructure Industry as well as inspire fellow design professionals to give off their best and have fun while doing it.

An Overview of The Refined Scan to BIM Workflow

The Refined Scan to BIM Workflow incorporates laser scanning, point cloud extraction technology and BIM intelligent tools to further automate the modelling process and provide realistic visualisation to convey design intent. This workflow can be applied across Architecture, Engineering and Construction (AEC) & Product Design and Manufacturing (PDM) industries, with this session demonstrating its application to remodel and space plan an office, with an overview of the process summarised below:

Scan

A laser scanner had been used to capture the as-built state of the office in order to derive dimensions and available area. The laser scanner used was the Leica BLK360 in conjunction with the Autodesk ReCap Pro app on an iPad. This workflow provided faster registration in the field as the scan progressed. Any suitable scanner may be used to capture the as-built state of the building, with the scan data processed and indexed on the Autodesk ReCap Pro Desktop application.

Process

Once the laser scanning of the building is complete, the scanned data derived needs to be processed, registered and indexed. This is done using Autodesk ReCap Pro on the desktop. This will result in a .RCP file which then can be imported into Autodesk software such as Infraworks, Civil 3D, Revit, AutoCAD and Inventor. For buildings, this .RCP file will be imported to Revit for intelligent modelling, but before that can occur, we will automatically extract the CAD geometry from the .RCP file.

Extract

Once the processing of the scanned data is complete and a .RCP file is derived from Autodesk ReCap Pro, the .RCP file is imported into ClearEdge3D EdgeWise for automatic point cloud geometry extraction. This reduces the modelling time by 50 – 70%, further automating and streamlining the modelling phase in Autodesk Revit. Once the automated geometry extraction process is complete, the geometry can be exported to a .RVT file which can be imported into Autodesk Revit for detailed design and modelling.

Model & Visualise

The extracted geometry from ClearEdge3D EdgeWise is imported into Autodesk Revit and modified and modelled accordingly. This affords the modeller/designer a base to work from, with the geometry elements extracted intelligently to Autodesk Revit families and modelled to requirements and specification. This leads to the model completed at a much quicker rate, a process normally purely manual in nature.

Once the Autodesk Revit Model is complete, the model can then be imported into Autodesk Navisworks. This provides the option to save the model as a .NWD file in Autodesk Navisworks, which can then be overlayed relative to the point cloud in Autodesk ReCap Pro for enhanced photo-realistic visualisation and verification. Autodesk Navisworks also provides the functionality to create panoramic virtual reality by utilising the Autodesk Cloud Rendering feature, which then can be shared with others to view in a browser or a Virtual Reality Headset.

Construct
The design model of the building is then constructed.

As – Built
Upon completion of construction, the as – built (as constructed state) of the building needs to be captured and modelled. This can be done by either scanning the as – built state and overlaying the point cloud on the design model, where adjustments are made to represent the final constructed state, or by scanning and extracting the point cloud geometry and applying the necessary finishes to represent the as – built state. We will be using the second option, to demonstrate the power of point cloud geometry extraction technology.

Figures 1 and 2 below depict The Refined Scan to BIM Workflow, with figure 1 illustrating the workflow applied across the AEC & PDM industries, whereas figure 2 illustrating the workflow applied and demonstrated in this session, highlighting the specific technologies adopted.

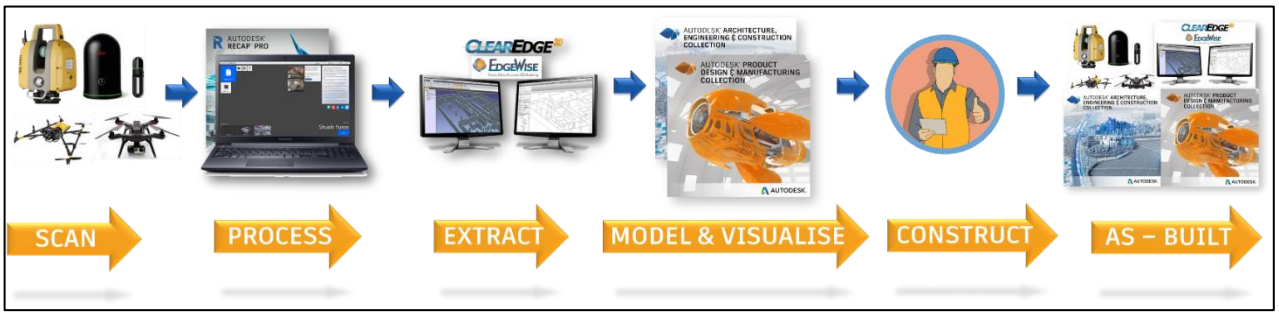

FIGURE 1: THE REFINED SCAN TO BIM WORKFLOW FOR FURTHER AUTOMATION AND VISUALISATION FOR AEC & PDM INDUSTRIES

FIGURE 2: THE REFINED SCAN TO BIM WORKFLOW FOR FURTHER AUTOMATION AND VISUALISATION FOR BUILDINGS

The Refined Scan to BIM Workflow

Scan

FIGURE 3: THE REFINED SCAN TO BIM WORKFLOW FOR FURTHER AUTOMATION AND VISUALISATION FOR BUILDINGS: SCAN PHASE

A laser scanner (whichever brand you prefer) is used to capture the as-built state of the office in order to derive dimensions and available area. In this case, the laser scanner used was the Leica BLK360 in conjunction with Autodesk ReCap Pro app for iPad. The process is as follows:

1. Autodesk ReCap Pro for iPad is downloaded on to the iPad from the Apple iStore. The required hardware and software system requirements for the Leica BLK360 & Autodesk ReCap Pro app for iPad can be accessed and viewed on the Autodesk Knowledge Network (AKN) and is tabulated below:

Hardware	ReCap Pro for mobile is a pairing of two specific platforms for optimum performance and ease of use: Leica BLK360 imaging laser scanner Apple® iPad® Pro tablet (10.5" or 12.9") While the iPad Pro can handle initial scan data formatting, registration, and inspection, most users will also require a Windows laptop or desktop computer for more advanced ReCap operations. Hardware and software requirements of this computer are specified in ReCap System Requirements.
Software	Apple iOS 10.0 or higher is required on the Apple iPad Pro. Apple iTunes® is required on both the Apple iPad Pro and the associated Windows laptop or desktop computer.

TABLE 1: SYSTEM REQUIREMENTS FOR AUTODESK RECAP PRO APP FOR IPAD

2. Once the Autodesk ReCap Pro for iPad is downloaded on to the iPad from the Apple iStore, we can then proceed to accessing the ReCap Pro App on the iPad. Upon start up, you will need to sign in using your Autodesk ID and password. This will require an internet connection in order to successfully sign in to the app.

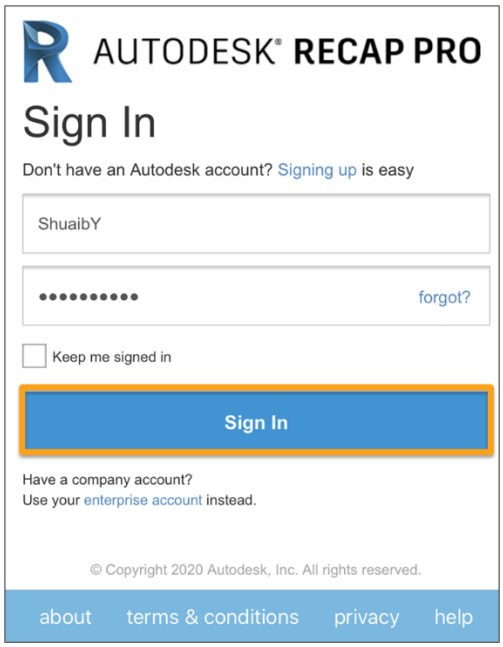

FIGURE 4: SIGNING IN ON THE AUTODESK RECAP PRO APP FOR MOBILE

3. Upon successful sign in to the Autodesk ReCap Pro app, we will need to connect the Leica BLK360 laser scanner to the iPad. This connection is achieved via WiFi. We will therefore need to disconnect from the internet connection we used to sign in to Autodesk ReCap Pro (you will still be signed in to the ReCap Pro app upon disconnecting from the internet) and connect to the Leica BLK360. The network name and password can be found on the clip of the battery compartment of the BLK360. Upon successful connection to the BLK360, you should see a tick next to the respective network as depicted below:

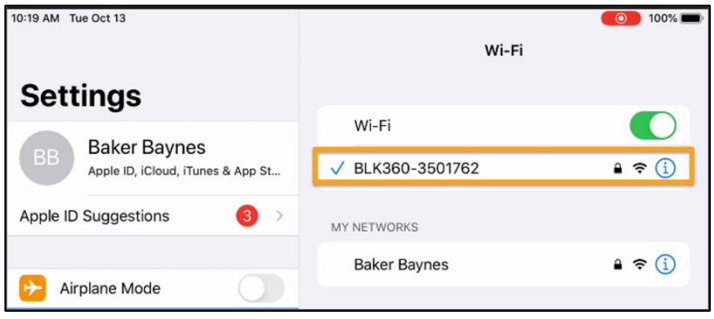

FIGURE 5: CONNECTING TO THE LEICA BLK360 SCANNER VIA WIFI USING THE IPAD PRO

4. Now that the connection is successful, we can now create a project on the ReCap Pro App. This is done by clicking on create a project and giving your project a name and clicking OK. In this case the project title is “BB New Office” as depicted below:

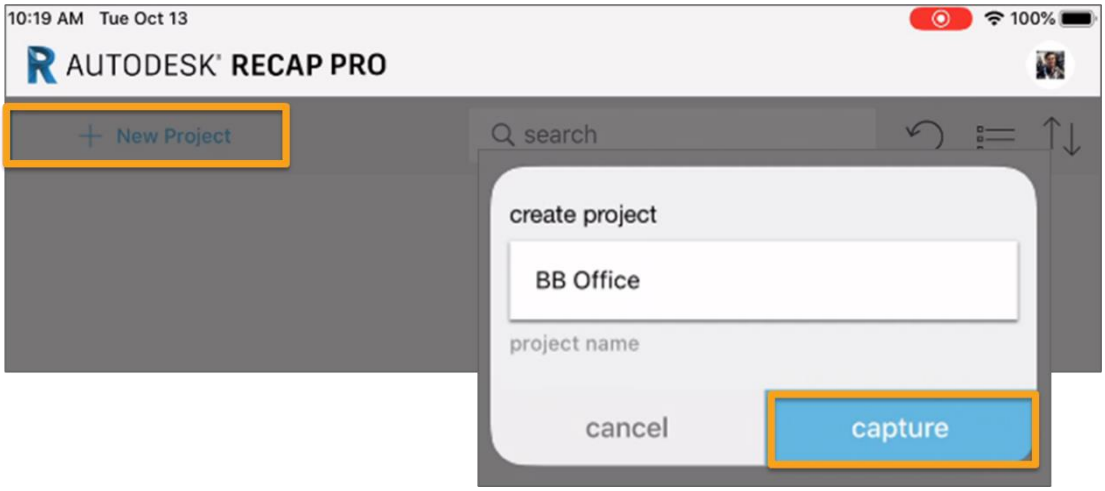

FIGURE 6: CREATING A PROJECT ON RECAP PRO APP FOR MOBILE

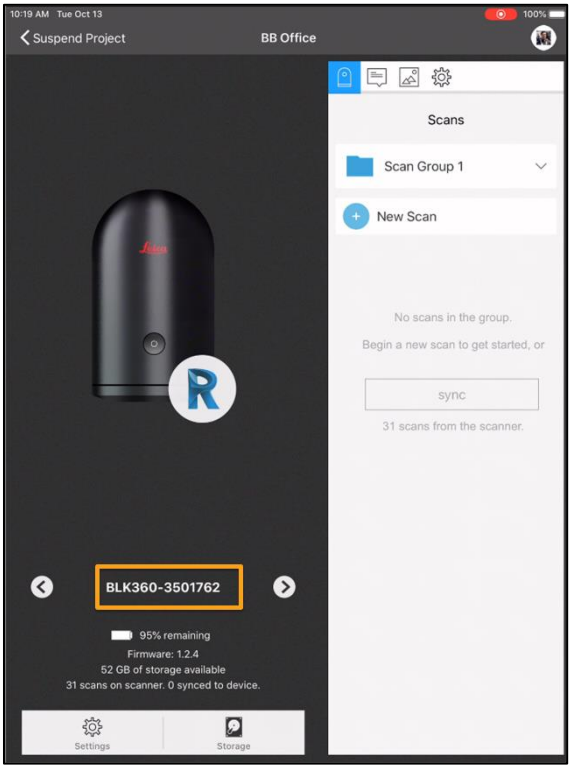

FIGURE 7: SEARCHING & SUCCESSFULLY CONNECTING TO THE LEICA BLK360 SCANNER

5. Once the project is created, we can then connect the BLK360 to the ReCap Pro App as well as adjust the settings as required. In this case, the scan setting used was medium as depicted below:

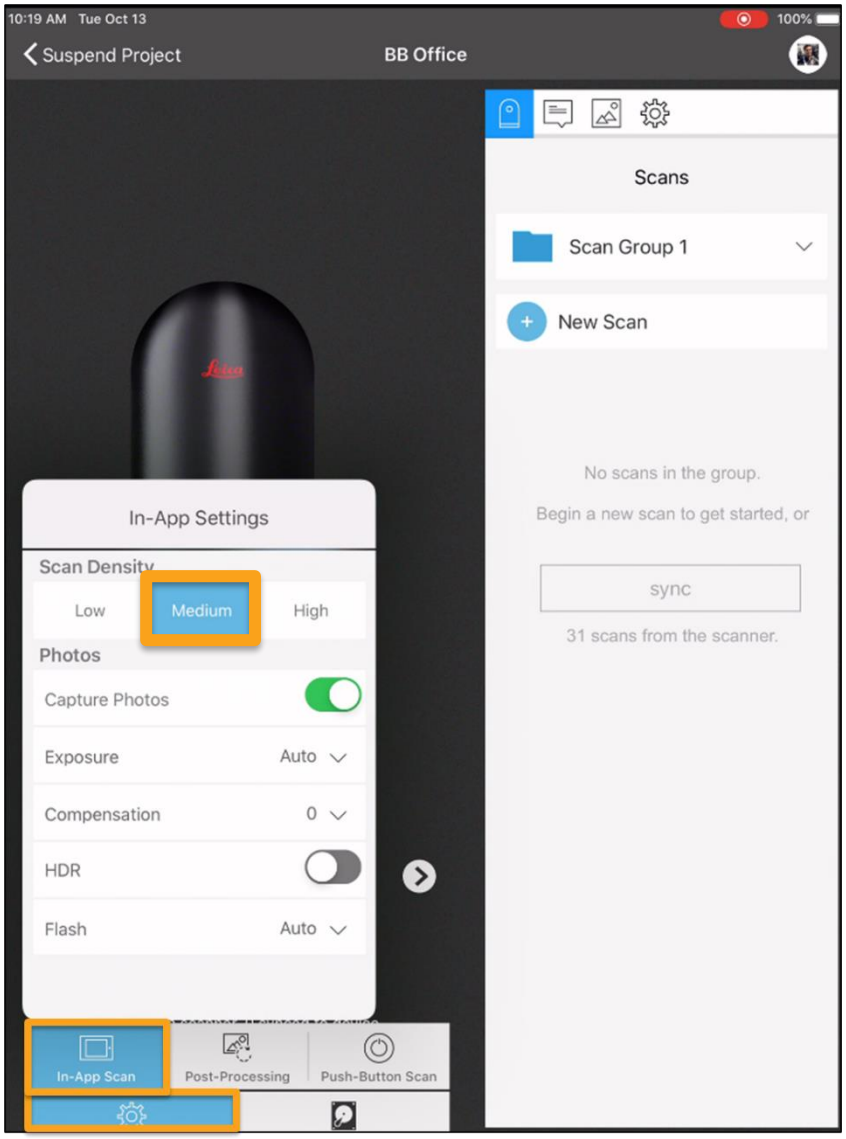

FIGURE 8: SETTING THE SCAN DENSITY

6. The scanning of the building can now commence. This is done by clicking on the “New Scan” option. This will result in the BLK360 starting with capturing the surrounding environment. Upon completion, the scanner indicator light will turn green and then can be placed at the next set up point, and then again clicking the New Scan button to

capture the next point. This process is repeated till you have captured the building area required as portrayed below:

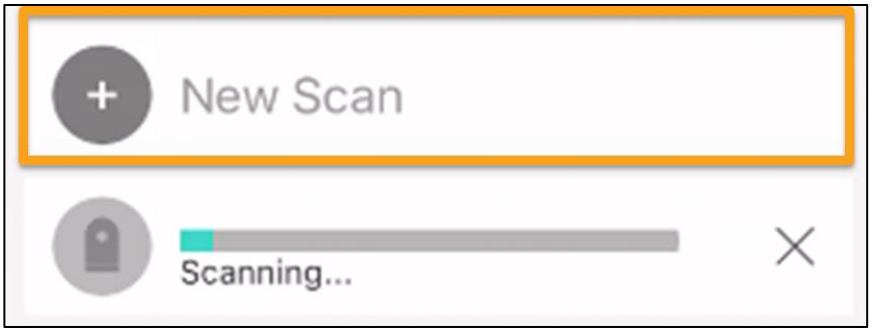

FIGURE 9: INITIATING THE SCANNING PROCESS

7. Now that the scanning is complete, the derived data will be transferred from the ReCap Pro app on the iPad to the ReCap Pro Desktop App which will be detailed under the Processing phase. The scans have been registered on the go in the field as depicted below:

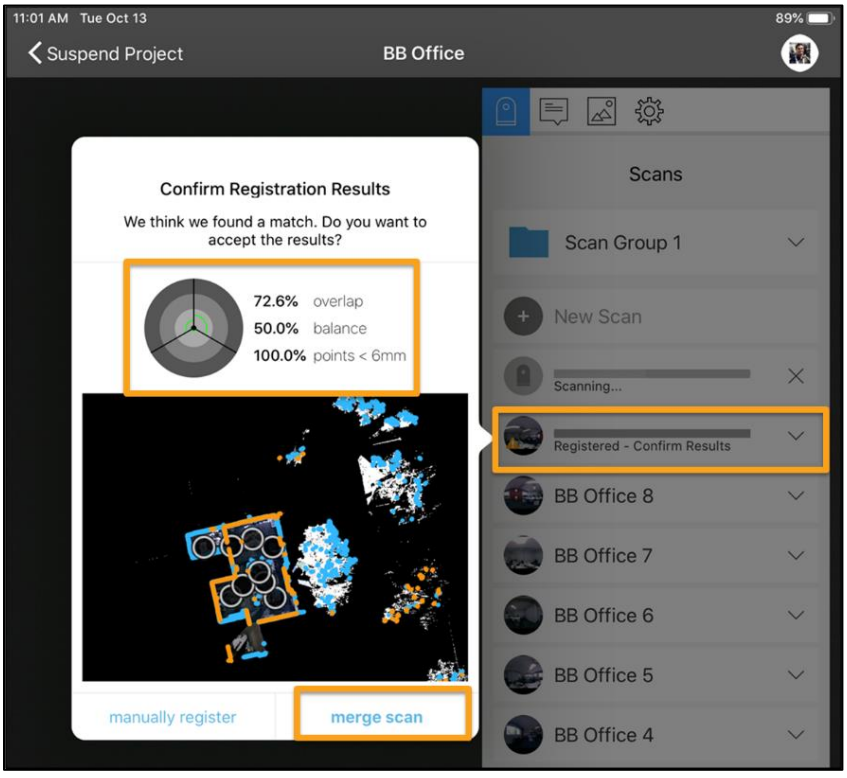

FIGURE 10: REVIEWING & REGISTERING THE SCANS ON THE GO

Process

FIGURE 11: THE REFINED SCAN TO BIM WORKFLOW FOR FURTHER AUTOMATION AND VISUALISATION FOR BUILDINGS: PROCESS PHASE

1. Now that the scanning is complete, the derived scan data is transferred from the ReCap Pro app on the iPad to the ReCap Pro Desktop App. This is done by opening the ReCap Pro on the desktop and creating a project, thereafter selecting the transfer from mobile option as depicted below. The iTunes App will also need to be open on the desktop prior to transferring the scan data.

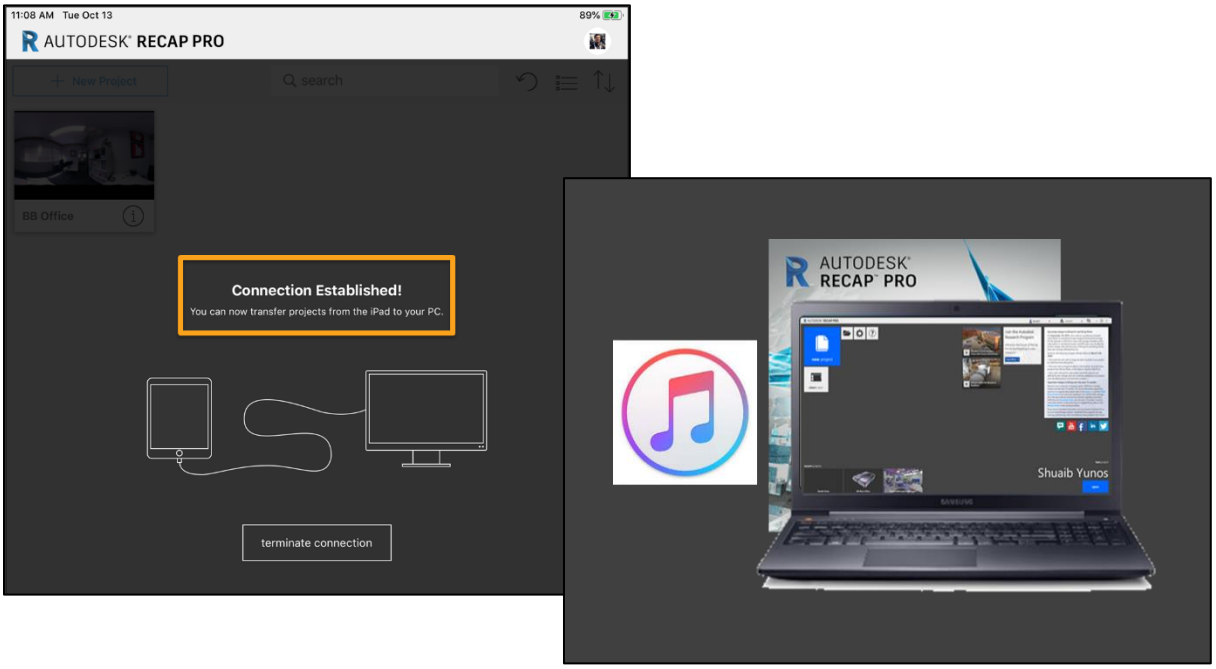

FIGURE 12: TRANSFERING THE SCAN DATA TO AUTODESK RECAP PRO DESKTOP APP FOR INDEXING

2. Once the data has been imported from the iPad, the scans can then be indexed as the registration of the scans were conducted as the scanning progressed on the iPad. If this has not been done during the progression of the scan, automatic registration will need to be selected for Autodesk ReCap Pro to automatically match/stitch the scans together. Should the software not be able to do this for certain scan files, manual registration will be required which involves matching of 3 common points between 2 scan files. More information pertaining to automatic and manual registration can be accessed at the link below:

   https://knowledge.autodesk.com/support/recap/learn-explore/caas/CloudHelp/cloudhelp/2018/ENU/Reality-Capture/files/GUID-9357DC21-386B-4EFB-8BA2-8F33FCED051B-htm.html

   In this case, the registration had been done as the scan progressed as mentioned previously.

3. Upon successful completion of the indexing of the scanned data, the consolidated, structured scan can be viewed, resulting in a .RCP file. This .RCP file can then be imported to ClearEdge3D EdgeWise for automated geometry extraction, taking us to the Extraction phase of the Workflow.

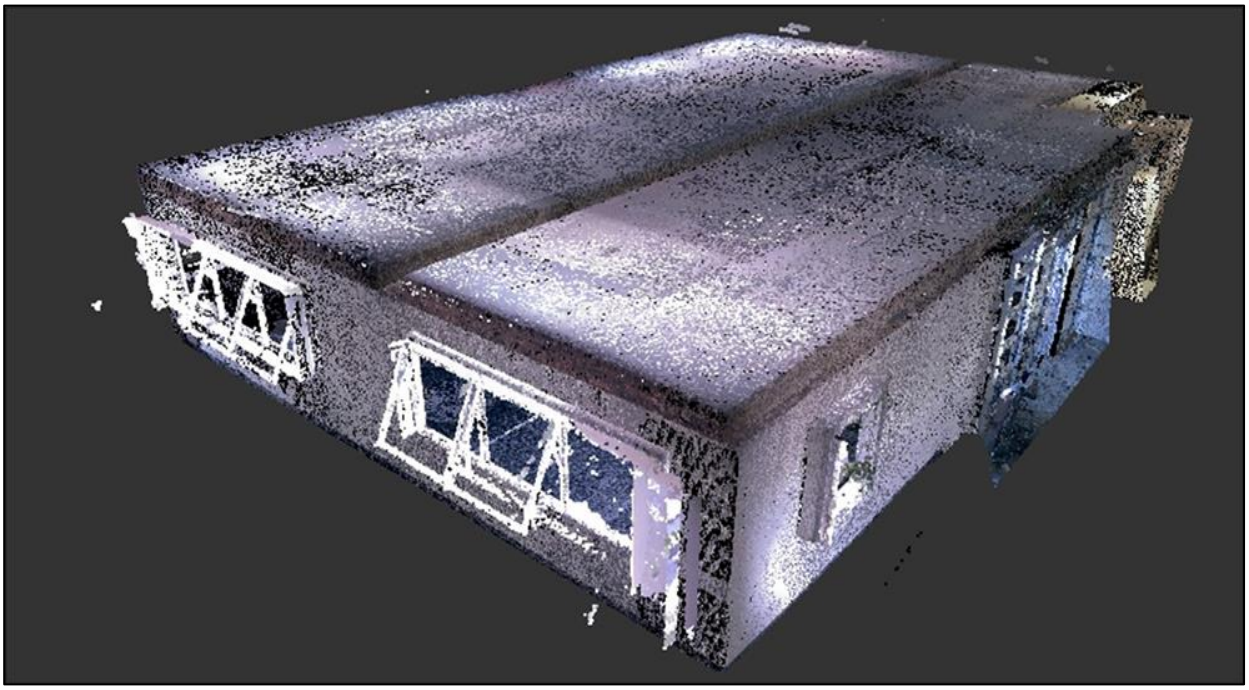

FIGURE 13: THE INDEXED SCAN AFTER THE PROCESSING IS COMPLETE AS A .RCP FILE

Extract

FIGURE 14: THE REFINED SCAN TO BIM WORKFLOW FOR FURTHER AUTOMATION AND VISUALISATION FOR BUILDINGS: EXTRACT PHASE

1. Now that the .RCP point cloud file is generated, we can import this file to ClearEdge3D EdgeWise for automated geometry extraction. This software can be applied across various disciplines, resulting in deriving geometry of elements in CAD format to further automate the modelling process. In this case, the software was used to extract the walls, columns and levels of the office space by clicking on the “Process Scans” option, the process depicted below:

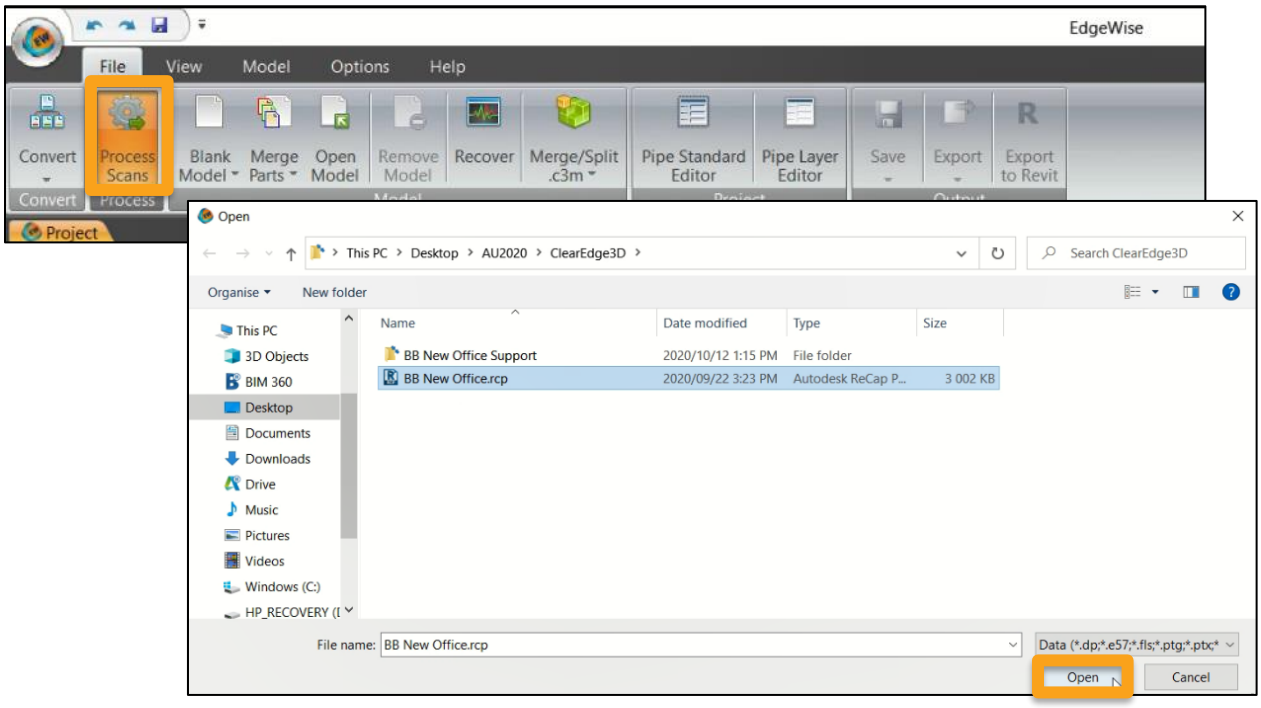

FIGURE 15: IMPORTING THE SCAN .RCP FILE IN TO CLEAREDGE3D EDGEWISE

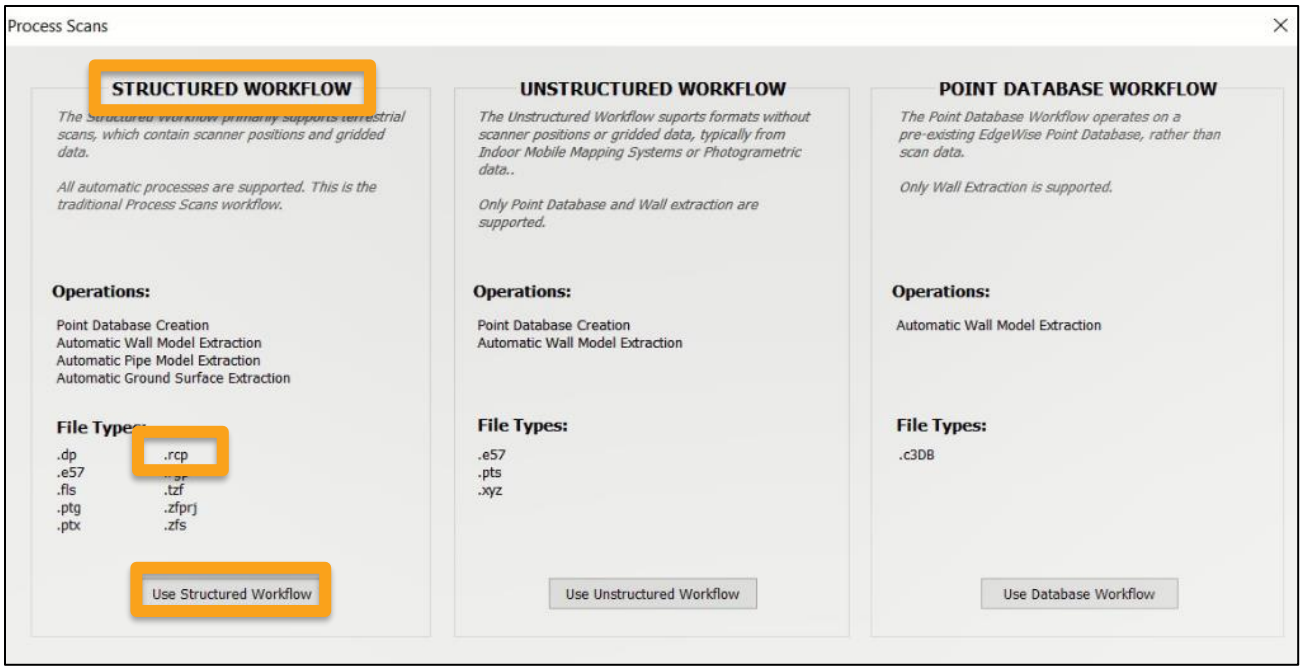

FIGURE 16: SELECTING THE STRUCTURED SCAN WORKFLOW SETTING IN CLEAREDGE3D EDGEWISE

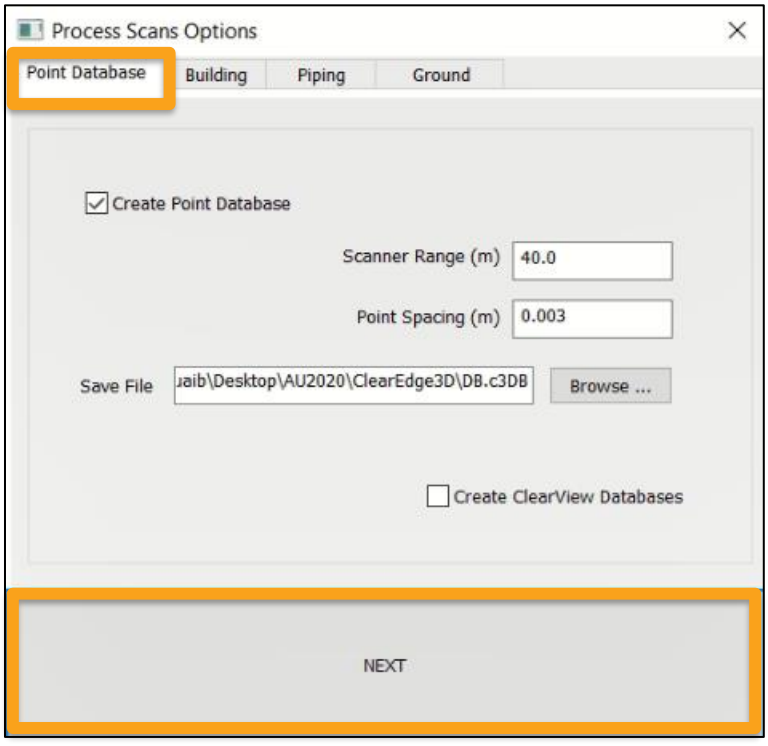

FIGURE 17: REVIEWING THE GEOMETRY EXTRACTION POINT DATABASE SETTING IN CLEAREDGE3D EDGEWISE

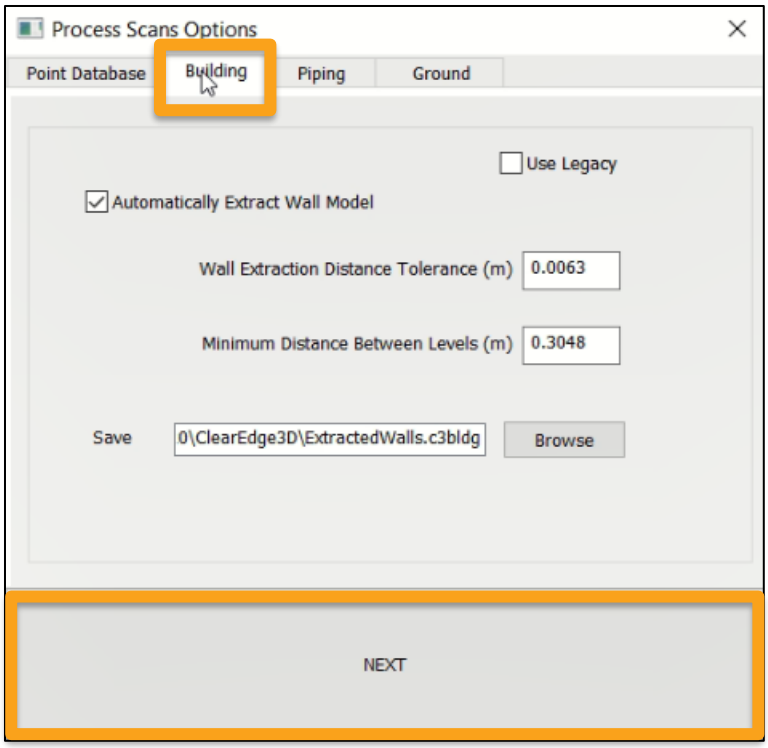

FIGURE 18: REVIEWING THE GEOMETRY EXTRACTION BUILDING WALLS SETTING IN CLEAREDGE3D EDGEWISE

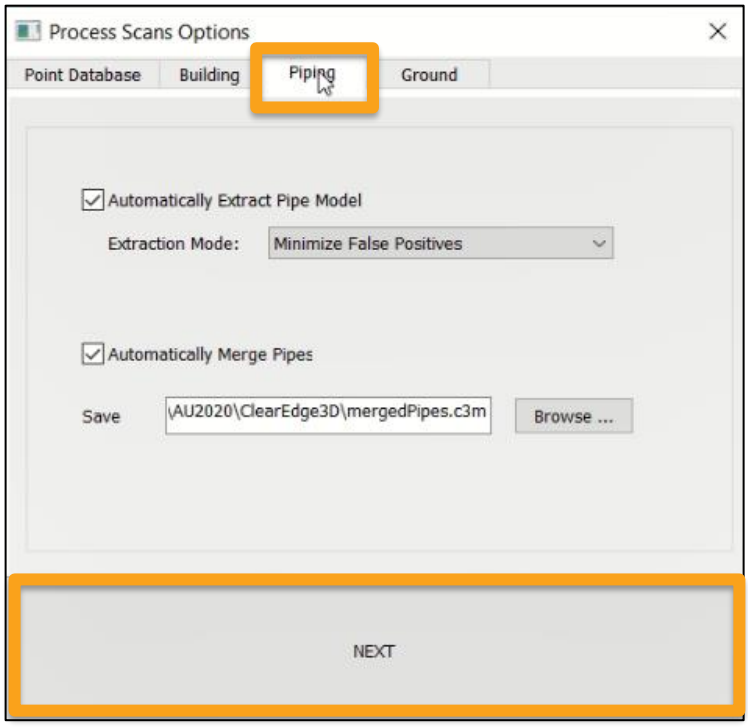

FIGURE 19: REVIEWING THE GEOMETRY EXTRACTION PIPE SETTING IN CLEAREDGE3D EDGEWISE

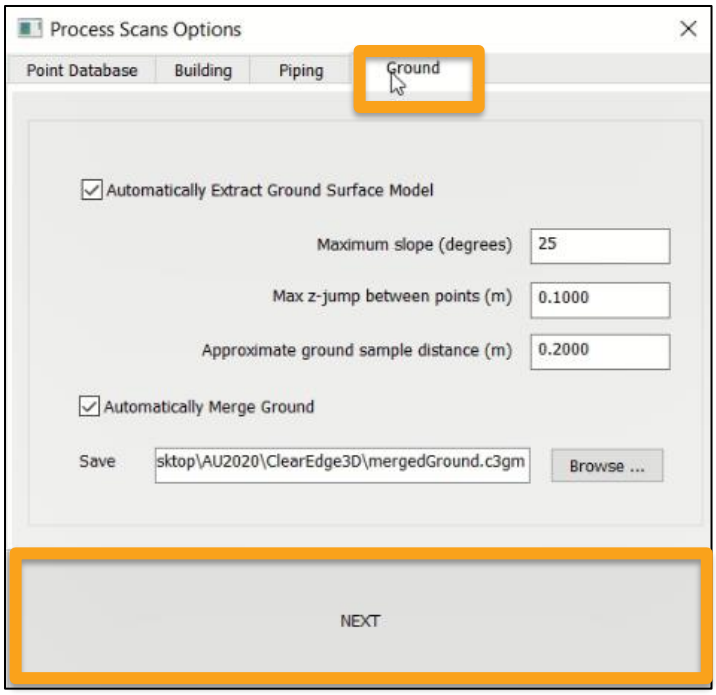

FIGURE 20: REVIEWING THE GEOMETRY EXTRACTION GROUND SETTING IN CLEAREDGE3D EDGEWISE

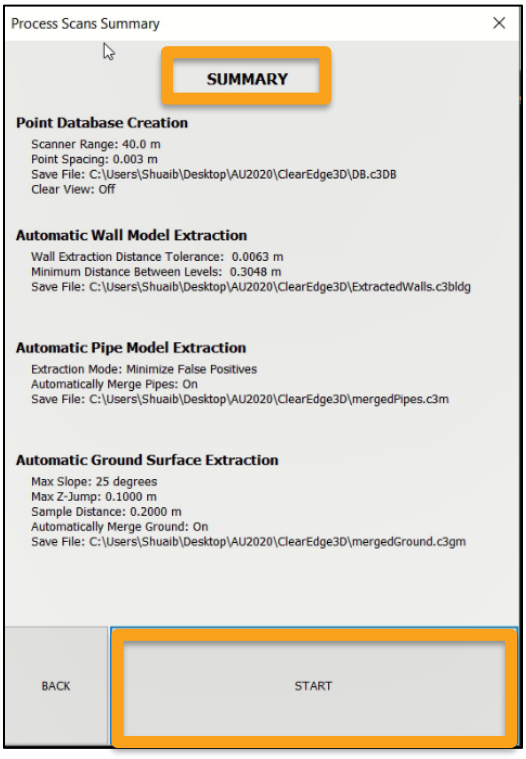

FIGURE 21: REVIEWING THE SUMMARY FOR ALL GEOMETRY EXTRACTION SETTINGS IN CLEAREDGE3D EDGEWISE

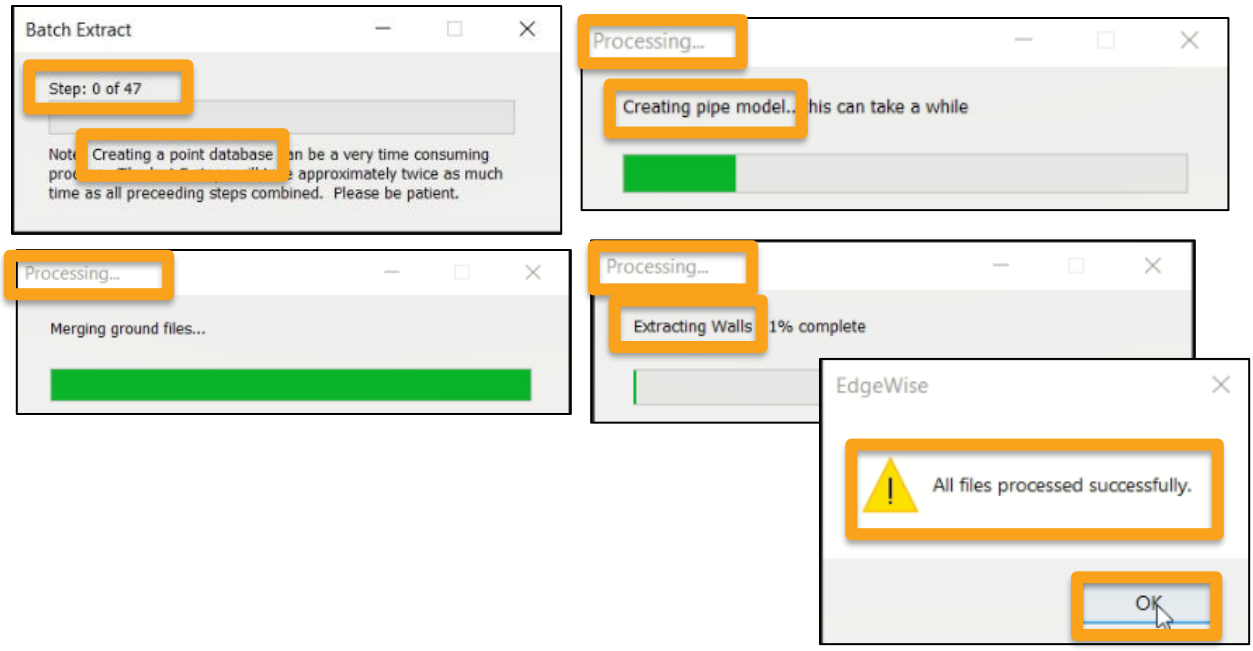

FIGURE 22: EXTRACTION PROCESS STAGES IN CLEAREDGE3D EDGEWISE

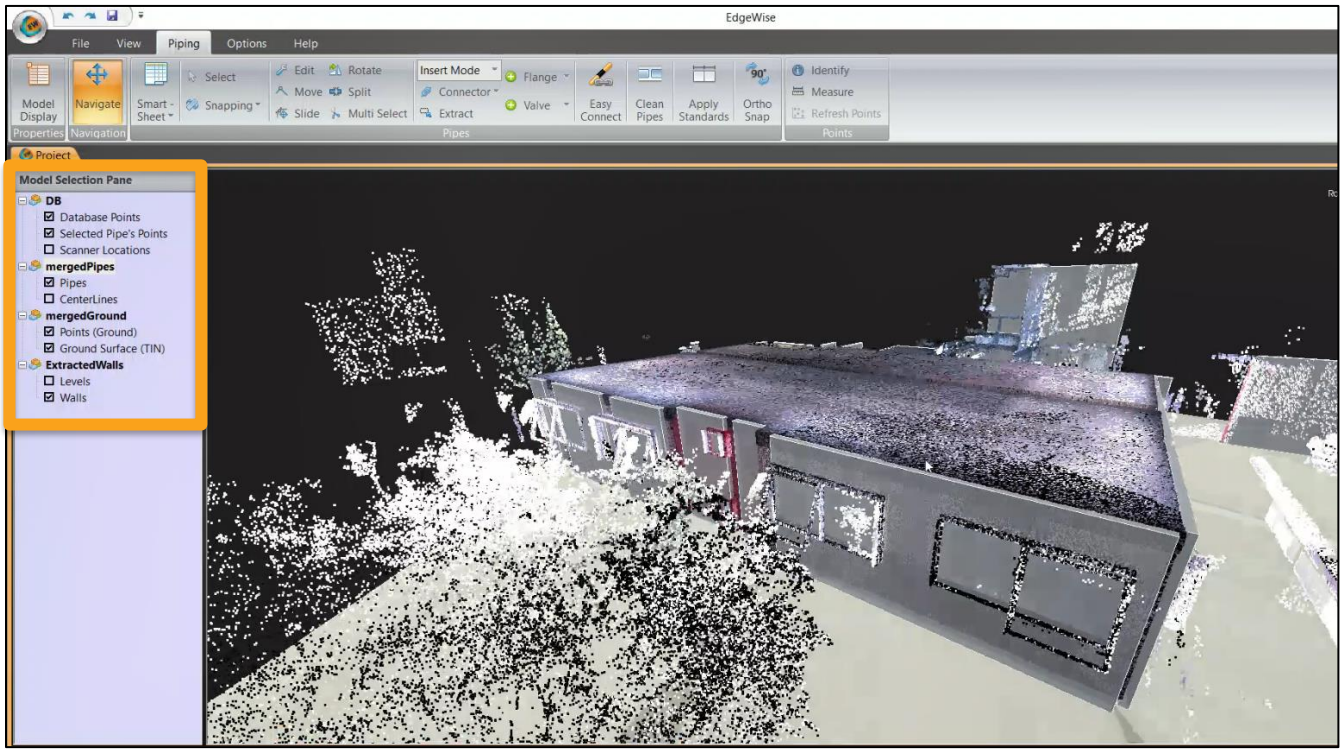

FIGURE 23: POINT CLOUD EXTRACTION UPON COMPLETION WITH ASSOCIATED DATABASES IN CLEAREDGE3D EDGEWISE

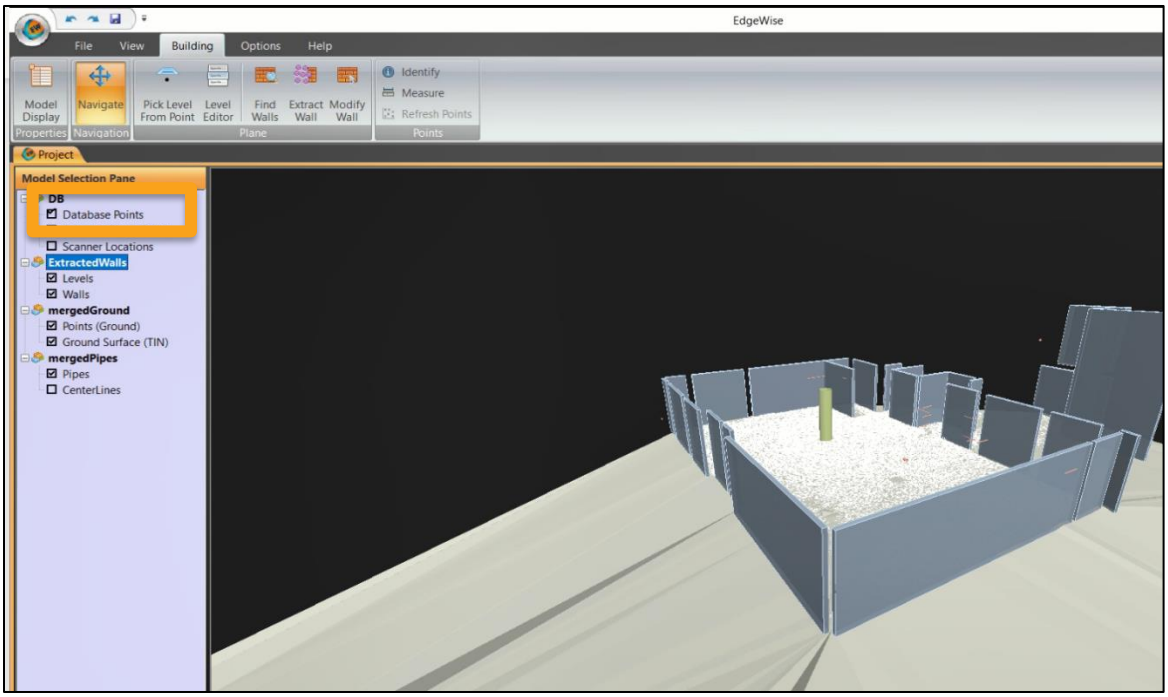

FIGURE 24: VIEWING THE EXTRACTED WALL GEOMETRY BY TOGGLING OFF THE DATABASE POINTS

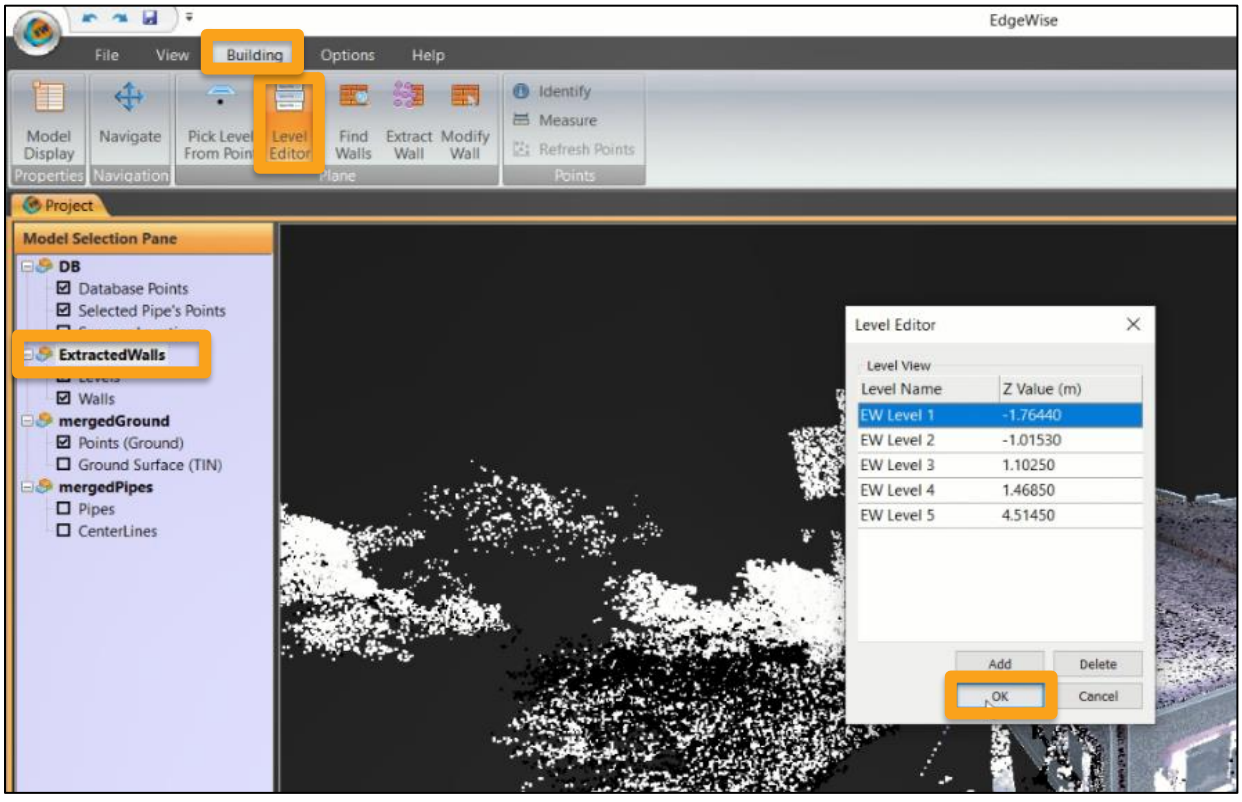

FIGURE 25: VIEWING & EDITING THE EXTRACTED BUILDING LEVELS USING THE LEVEL EDITOR

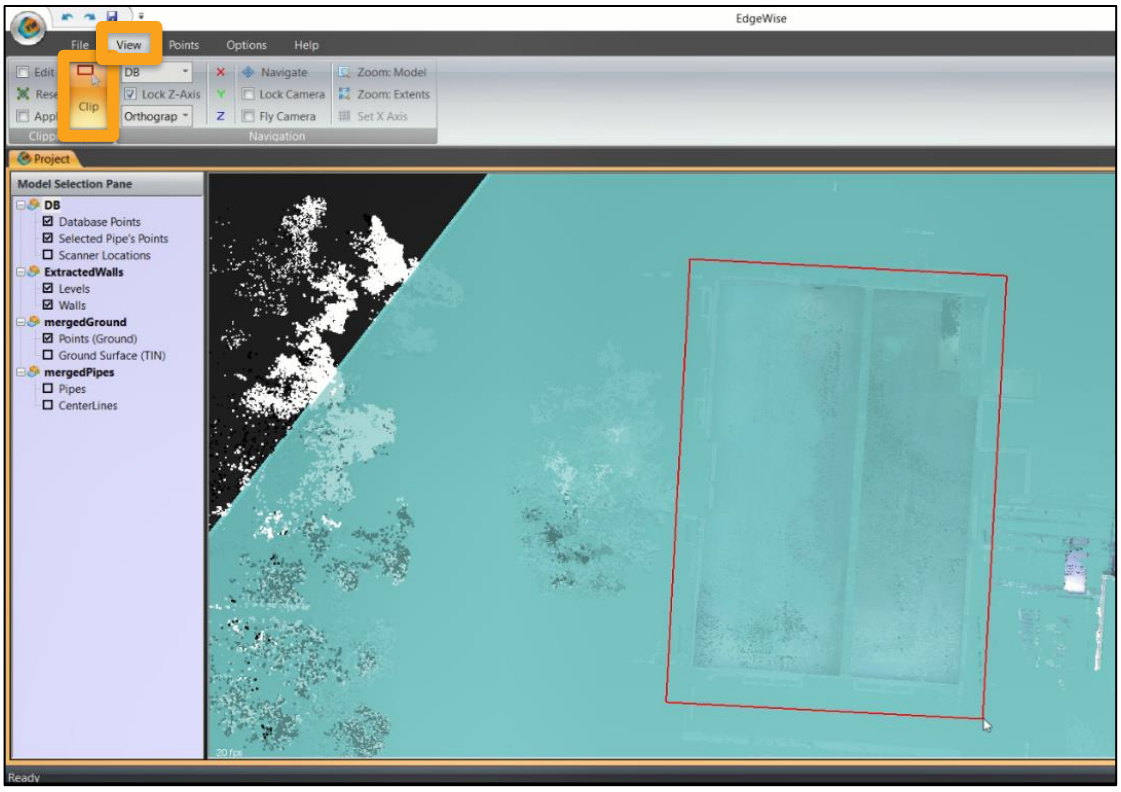

FIGURE 26: USING THE CLIP FUNCTION TO CROP THE EXTENTS OF THE POINT CLOUD FOR EASIER EDITING

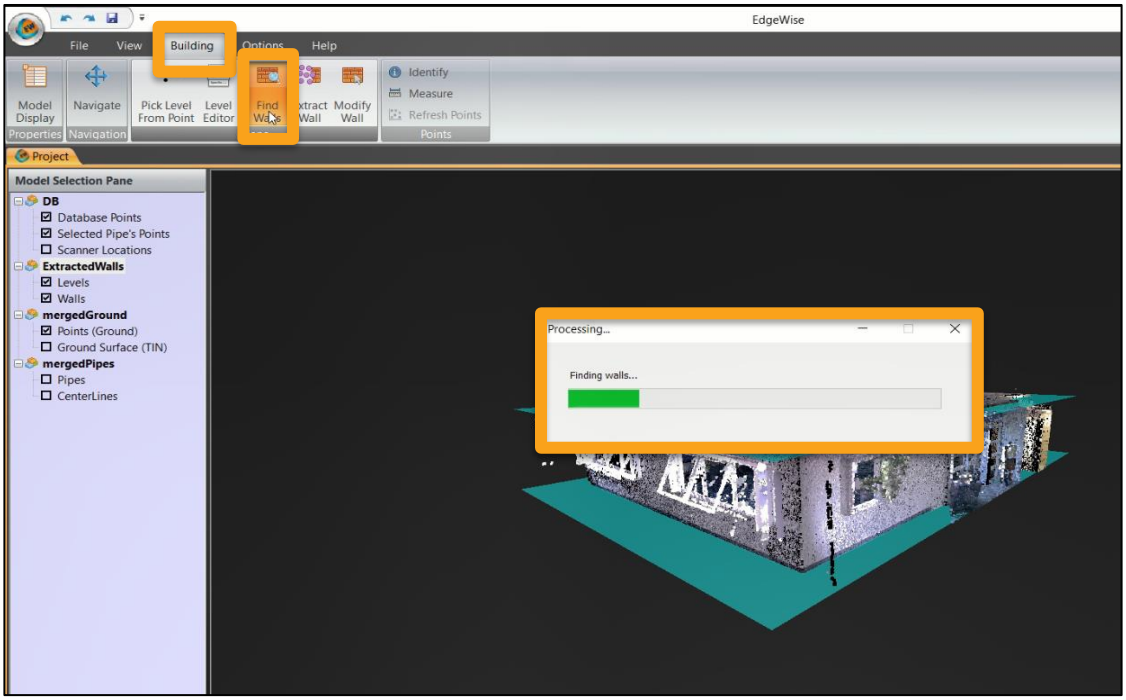

FIGURE 27: USING THE FIND WALLS FUNCTION TO EXTRACT THE WALLS BASED ON EDITED/FINAL LEVELS

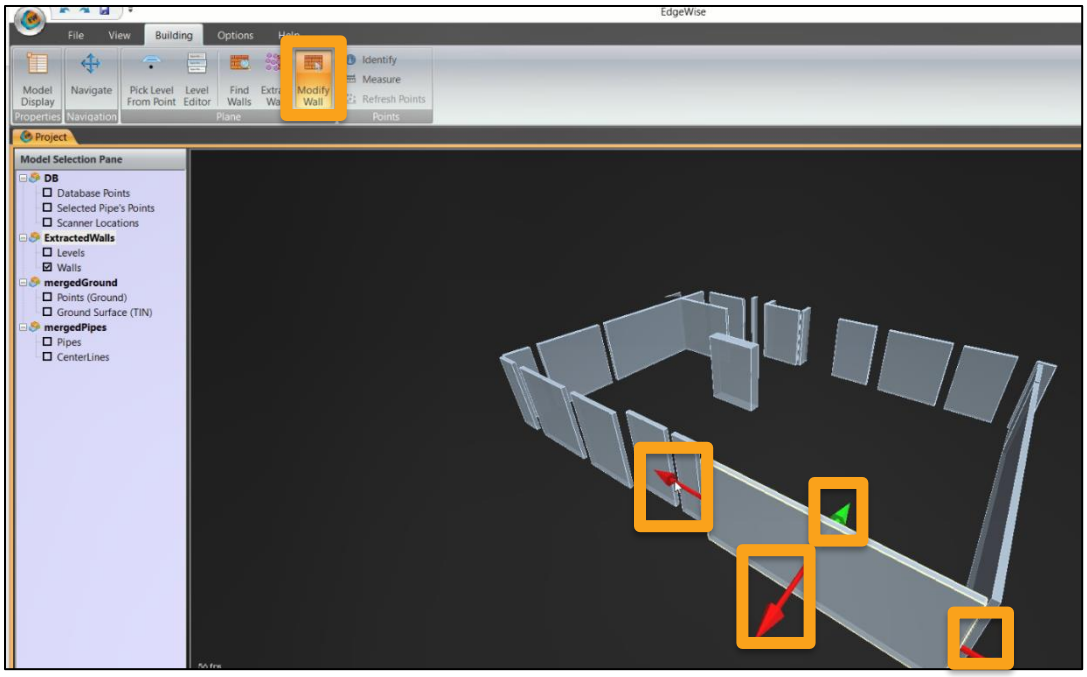

FIGURE 28: USING THE MODIFY WALLS FUNCTION TO EDIT WALL LENGTHS, POSITION & THICKNESS AS WELL AS DELETE WALLS

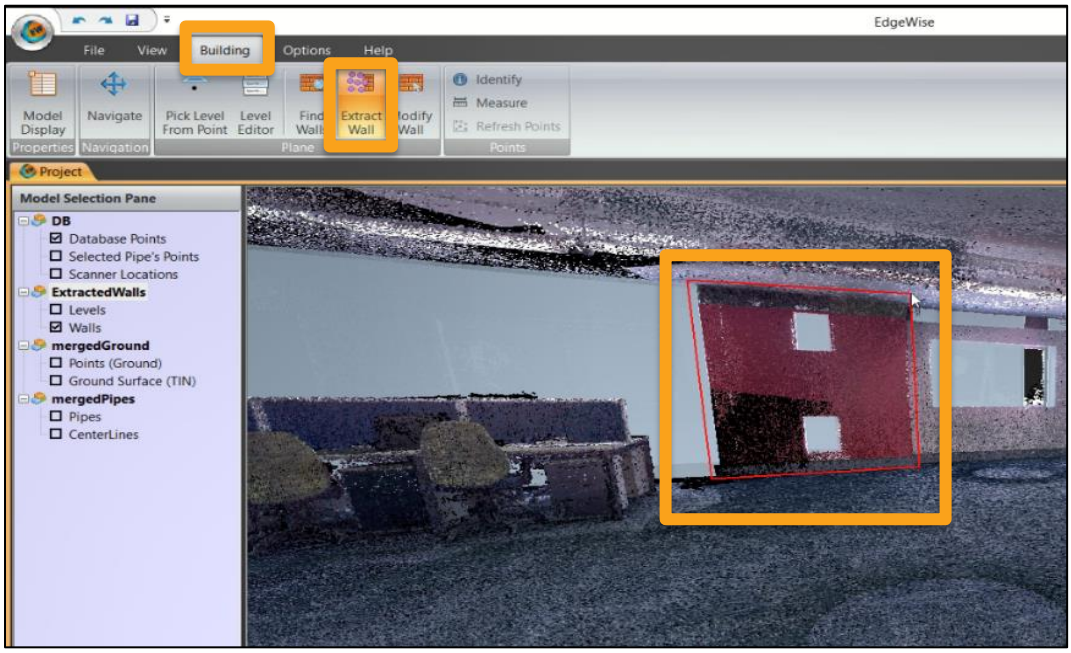

FIGURE 29: USING THE EXTRACT WALLS FUNCTION TO MANUALLY DEFINE WALLS THAT MAY HAVE NOT BEEN EXTRACTED

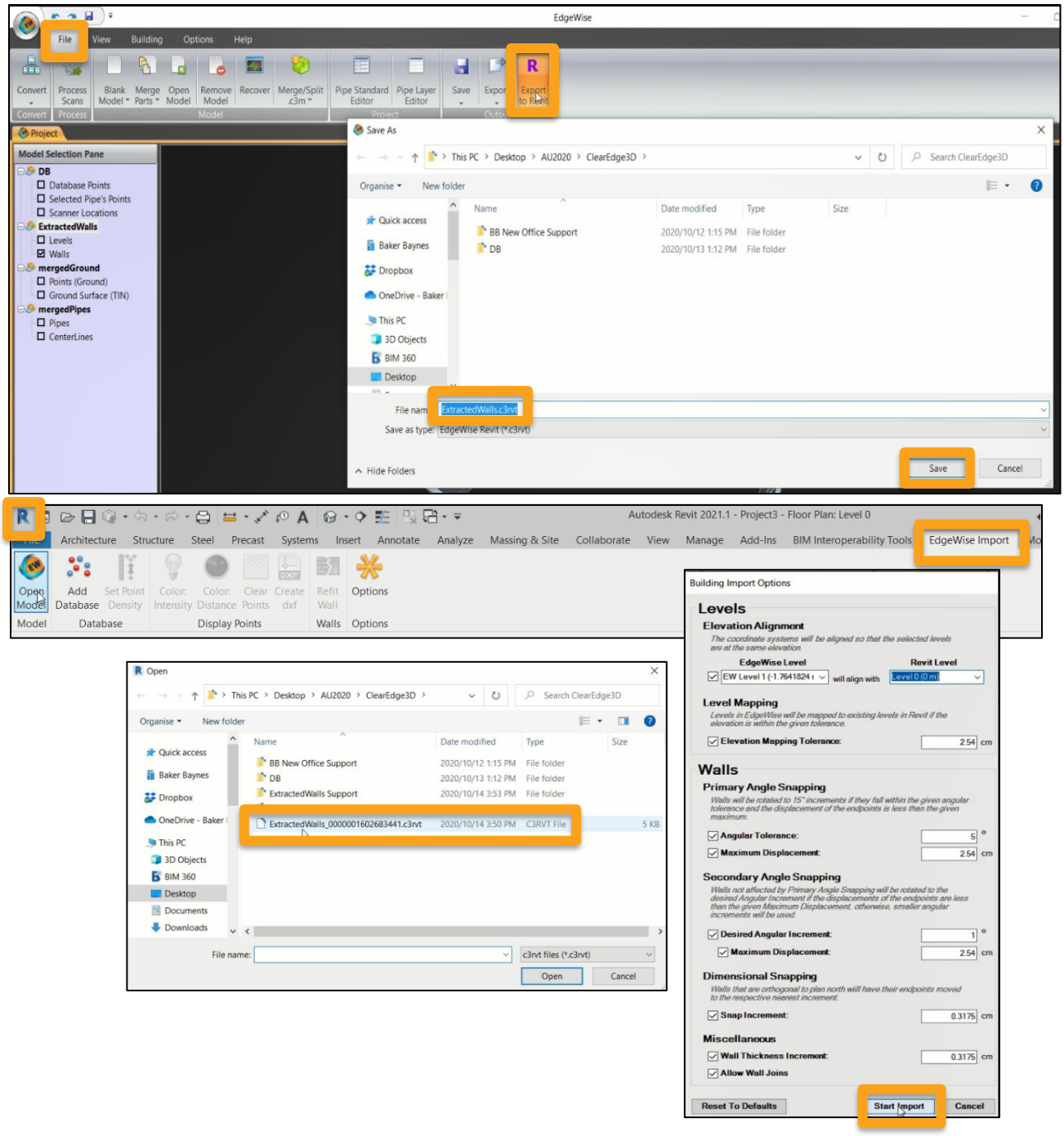

FIGURE 30: EXPORTING EXTRACTED GEOMETRY FROM CLEAREDGE3D EDGEWISE TO BE IMPORTED INTO AUTODESK REVIT

2. Once the extracted elements have been verified and modified where required, the extracted geometry is exported to a .RVT file which can then be imported into Autodesk Revit as intelligent families for detailed/final design, taking us to the Modelling phase of the workflow.

Model & Visualise

FIGURE 30: THE REFINED SCAN TO BIM WORKFLOW FOR FURTHER AUTOMATION AND VISUALISATION FOR BUILDINGS: MODEL & VISUALISE PHASE

1. Now that the geometry has been automatically extracted in the extraction phase, the exported .RVT file can be opened in Autodesk Revit and modified accordingly. The extracted geometry is depicted below:

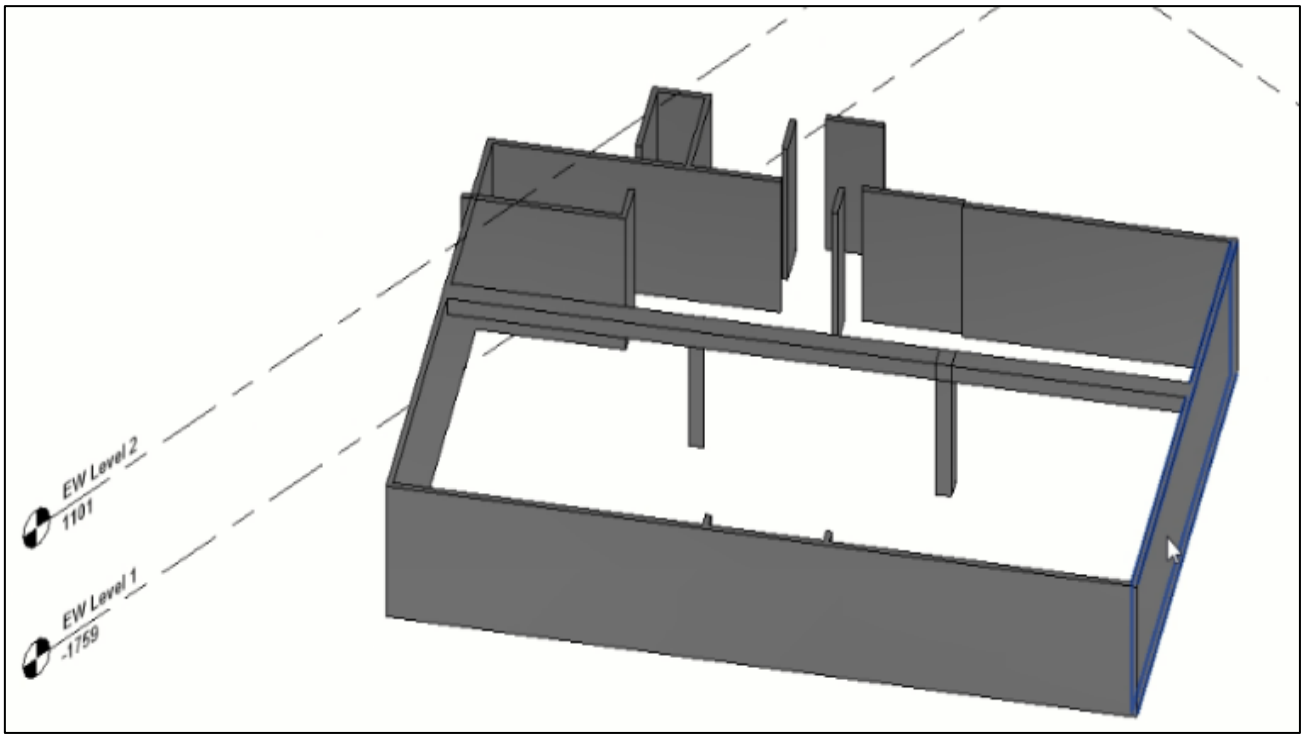

FIGURE 31: EXTRACTED POINT CLOUD GEOMETRY EXPORTED FROM CLEAREDGE3D EDGEWISE OPENED IN AUTODESK REVIT

2. Upon final modifications and edits, the final Revit BIM Model is obtained. In this case, the walls, doors, furniture and associated material textures have been added to derive the final office layout as can be seen below:

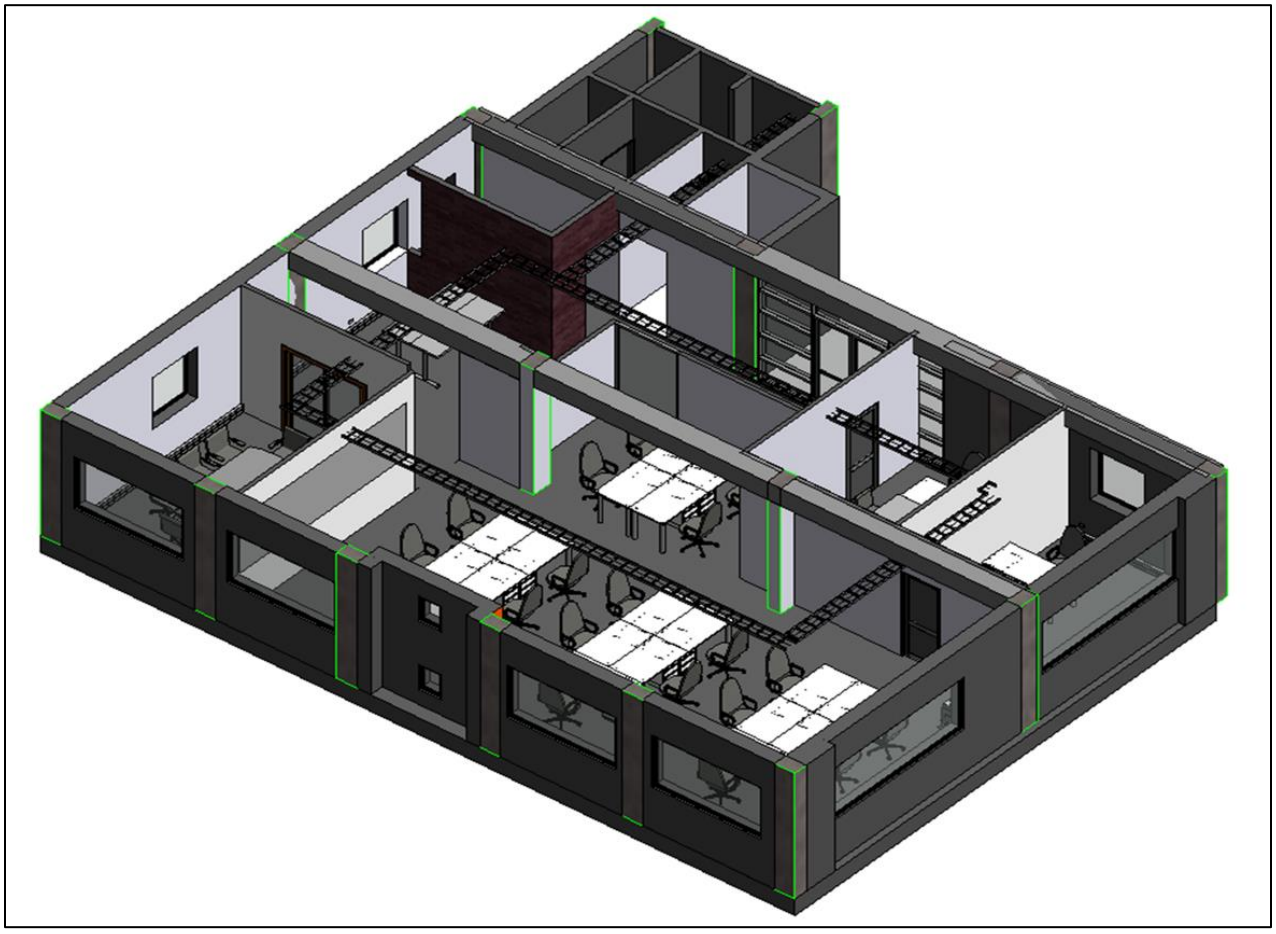

FIGURE 32: COMPLETED AUTODESK REVIT BIM DESIGN MODEL FOR CONSTRUCTION IN AUTODESK REVIT

3. With the final design model completed in Autodesk Revit, we can now move on to the phase of the workflow focusing on Visualisation.

4. Now with the final design model complete, we have the options to portray and visualise the model in a highly photorealistic manner, as well as a panoramic virtual reality (VR). This is achieved by using Autodesk Navisworks and ReCap Pro.

5. For the photorealistic visualisation, the scanned data (.RCP file) will be opened in Autodesk Navisworks as portrayed below:

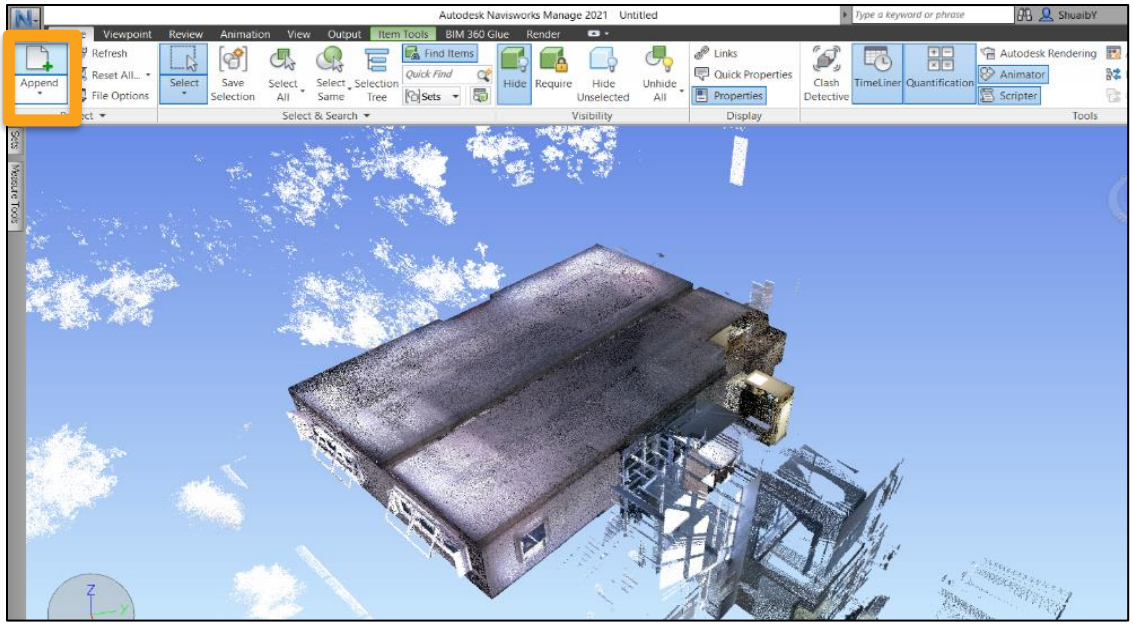

FIGURE 33: AUTODESK RECAP PRO .RCP FILE APPENDED IN TO AUTODESK NAVISWORKS

6. Once the point cloud is opened in Autodesk Navisworks, the Revit model will also be imported to Autodesk Navisworks, thus overlaying the Revit model relative to the scanned data. This is to confirm the correct positioning of both the scan data and design model, indicating the coordination is correct. If the model and scan data are not relative to each other (coordinated), the user will need to coordinate the files using targets in Autodesk ReCap Pro relative to the coordinate system used in Autodesk Revit. The second option which is not recommended or used as a last resort will be to move and position the model manually in Navisworks to the matching, correct location in the point cloud. In this case, the files were correctly coordinated as depicted below:

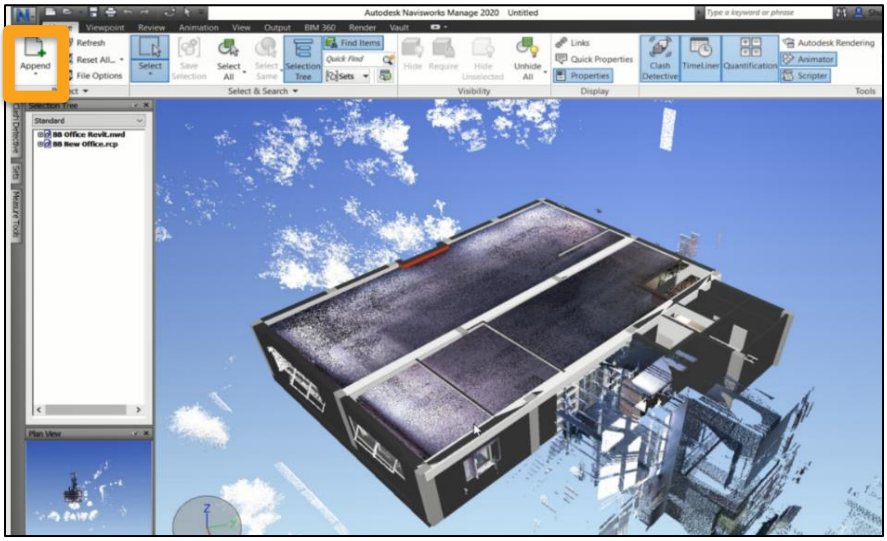

FIGURE 34: AUTODESK REVIT FILE APPENDED IN TO AUTODESK NAVISWORKS TO CHECK COORDINATION BETWEEN DESIGN MODEL & POINT CLOUD

7. With the coordination correct, the Point cloud can be switched off in Autodesk Navisworks, with the Revit Model saved as a .NWD file as depicted below:

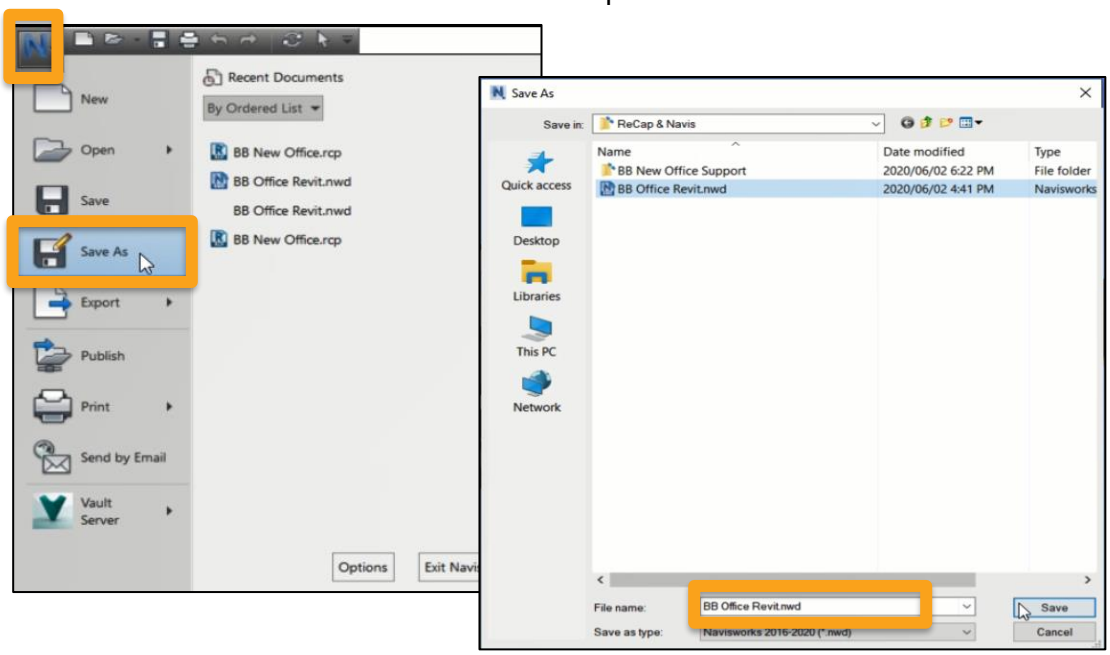

FIGURE 35: SAVING THE APPENDED REVIT FILE IN NAVISWORKS TO A .NWD FILE FORMAT

8. This .NWD file can now be attached to the point cloud in Autodesk ReCap Pro for photorealistic visualisation between photogrammetry and design model. This is done as follows:

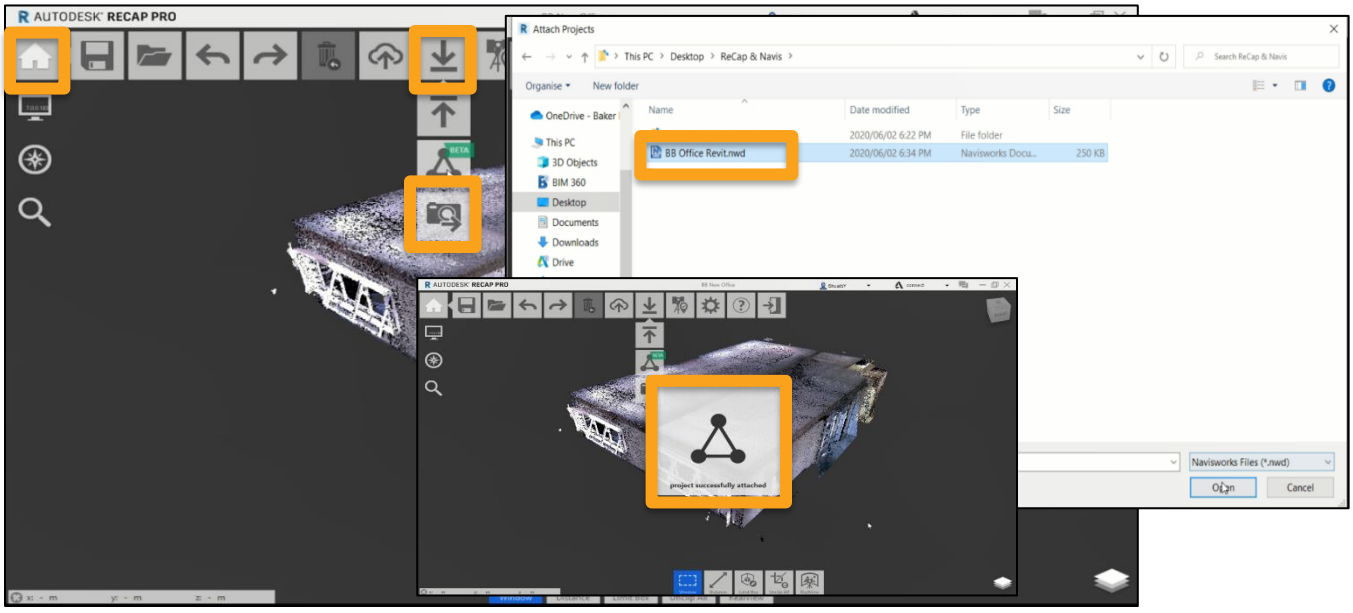

FIGURE 36: ATTACHING THE .NWD FILE TO THE POINT CLOUD IN AUTODESK RECAP PRO

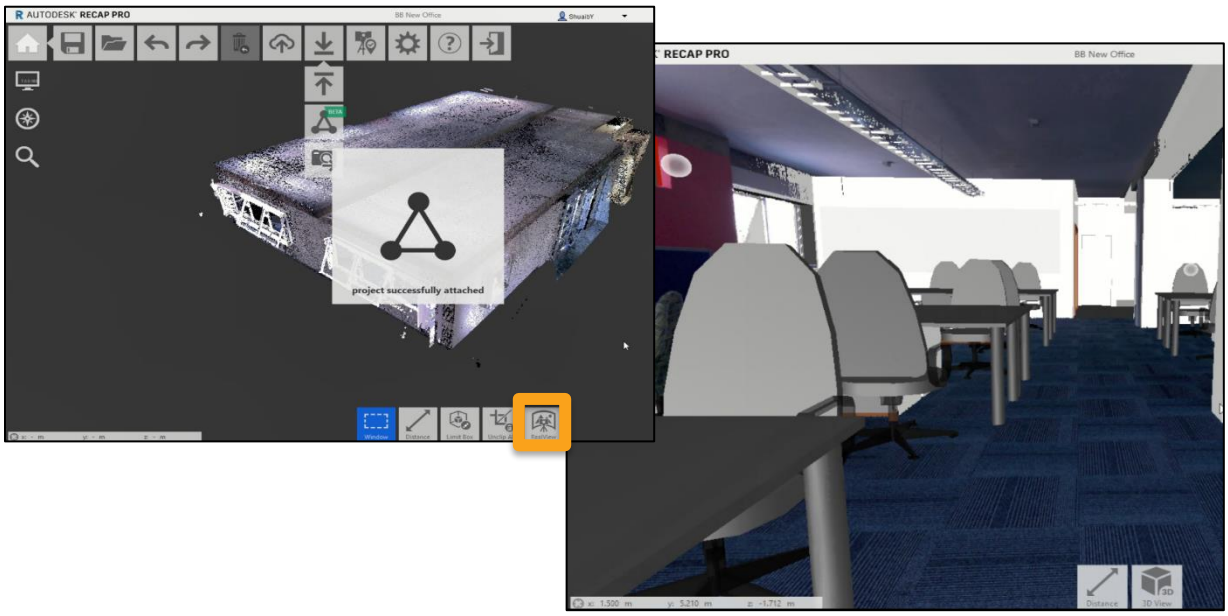

FIGURE 37: PREVIEIWING THE .NWD FILE ATTACHED TO THE POINT CLOUD IN AUTODESK RECAP PRO WHEN CLICKING ON THE REAL VIEW OPTION

9. With model now successfully attached, we can now create model snapshots which can be used in reports and presentations:

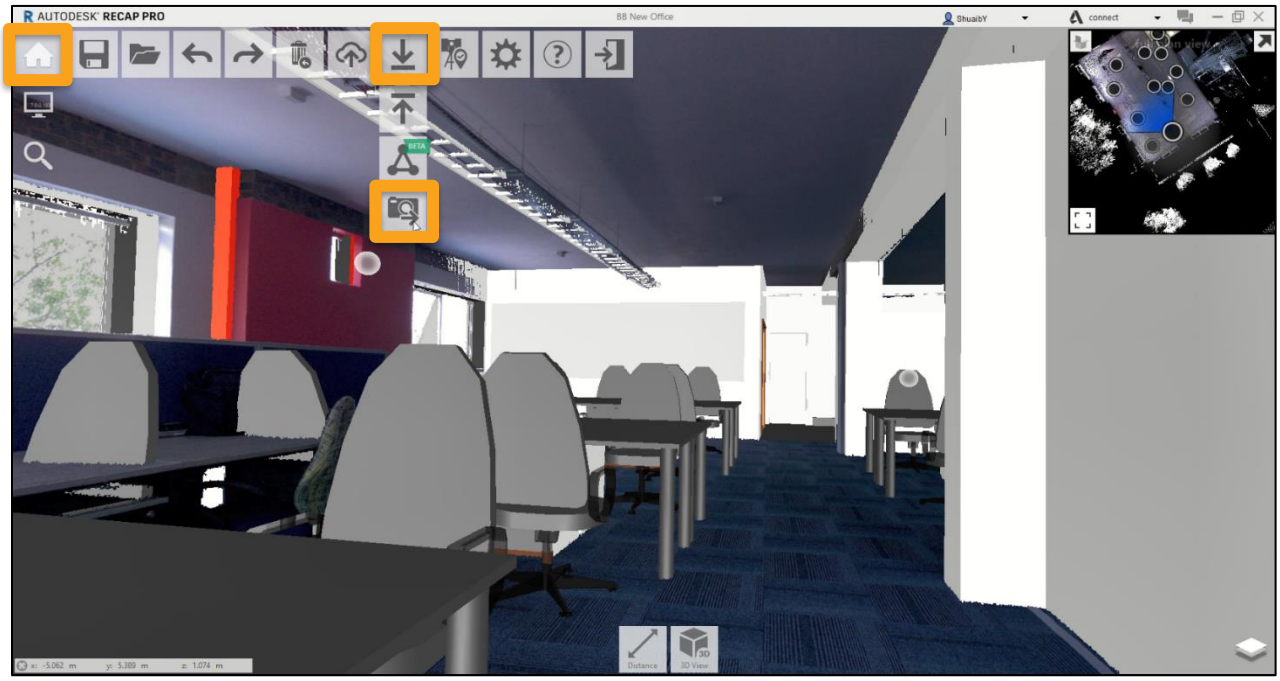

FIGURE 38: CREATING A SNAPSHOT IN AUTODESK RECAP PRO

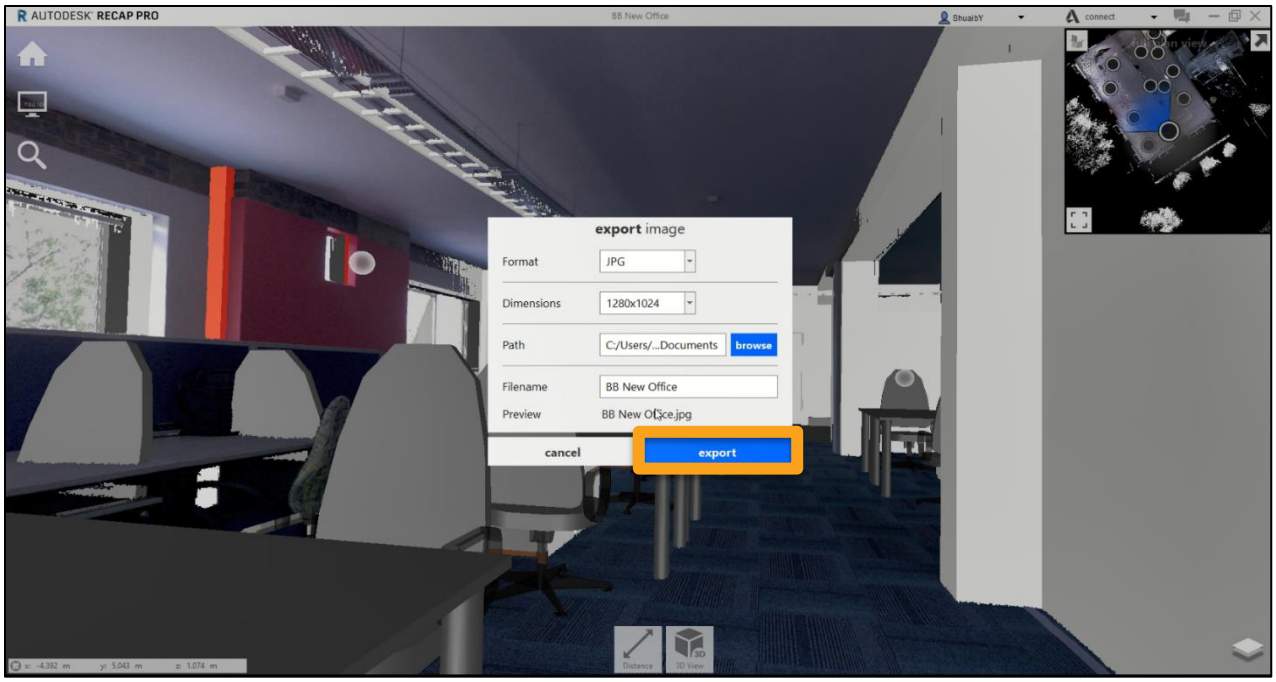

FIGURE 39: SPECIFYING IMAGE PROPERTIES IN AUTODESK RECAP PRO

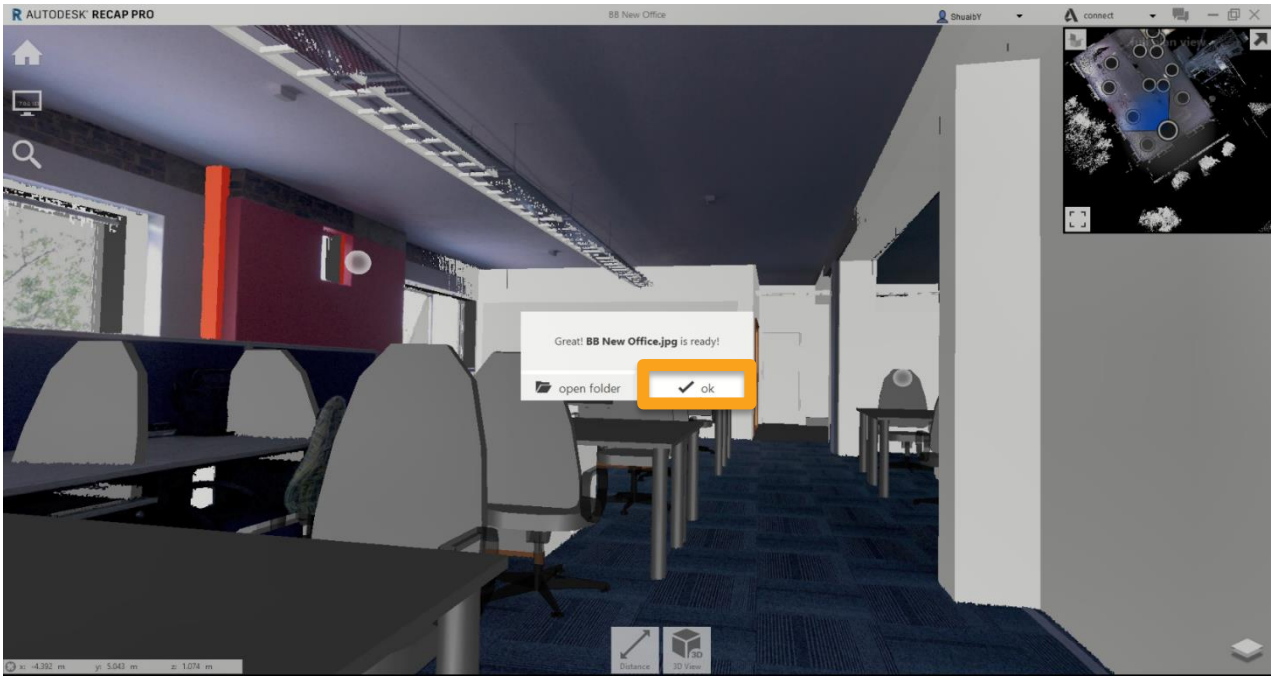

FIGURE 40: SNAPSHOT IMAGE SUCCESSFULLY CREATED AND SAVED TO DESIRED LOCATION

10. Should we want to create a small video annimation at key points of the design, we can create View States at key locations of your choice. Once all the View States have been created, we can then export these locations to video in Autodesk ReCap Pro. The software pieces these locations together based on parameters we specify as depicted below:

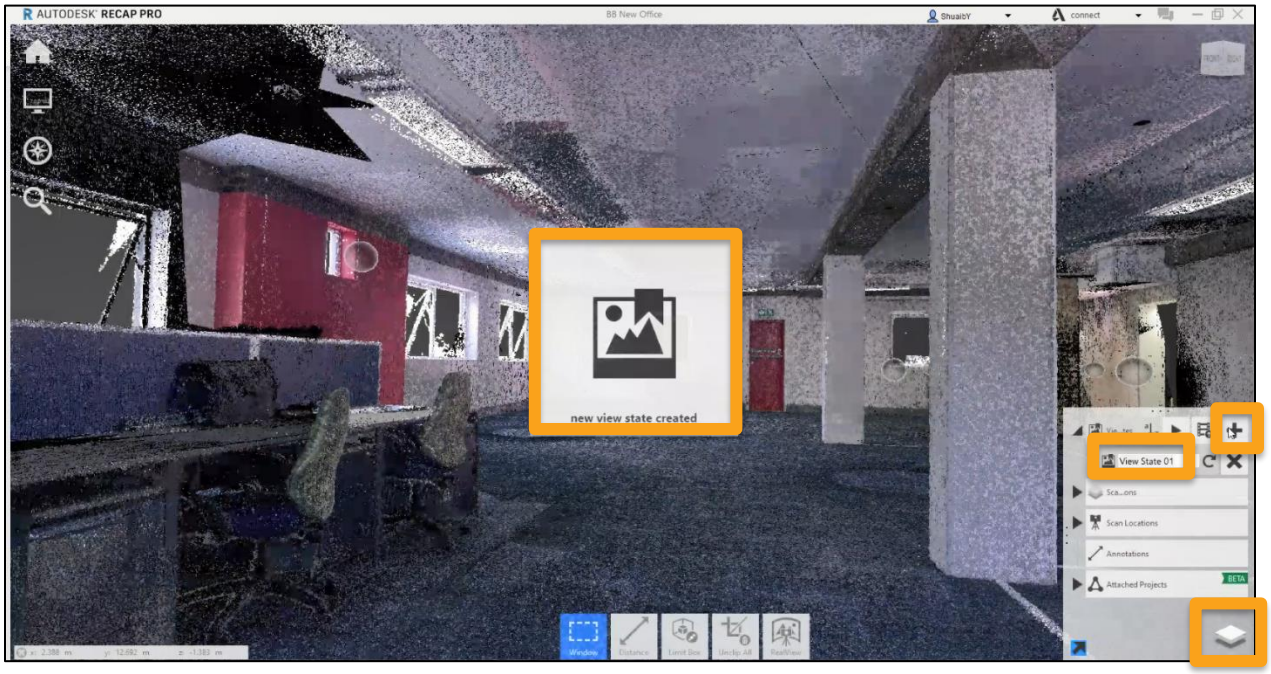

FIGURE 41: VIEW STATE CREATE AT LOCATION 1

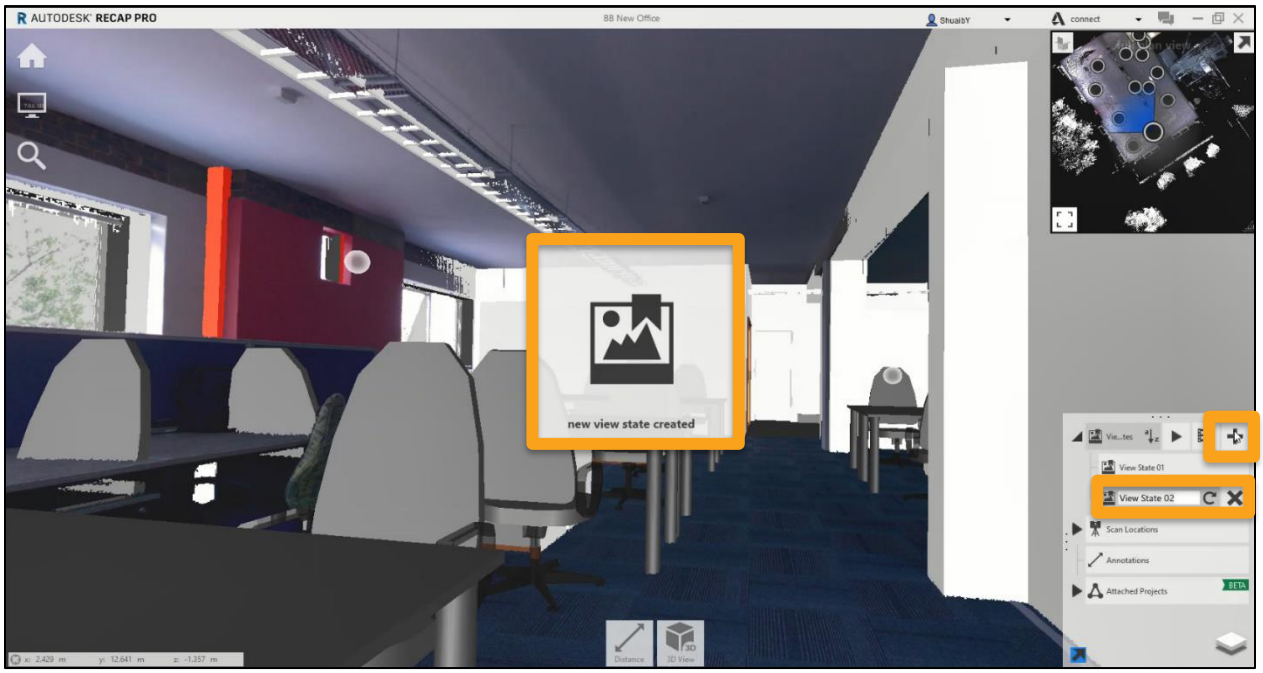

FIGURE 42: VIEW STATE CREATED AT LOCATION 2

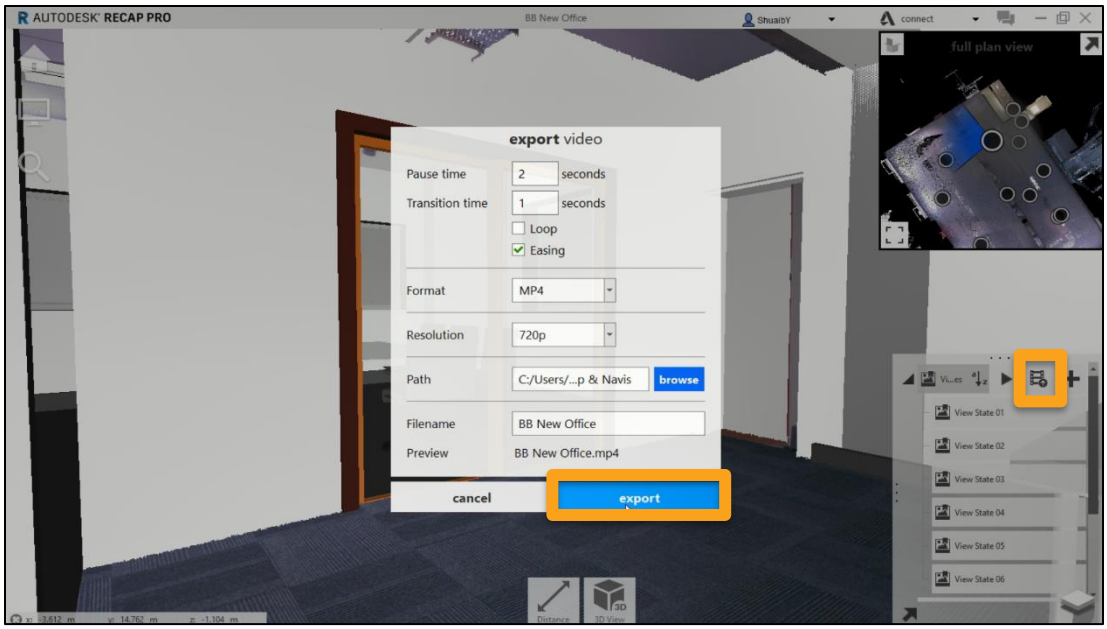

FIGURE 43: EXPORTING VIEW STATES TO VIDEO

11. When it comes to panoramic VR, this done in Autodesk Navisworks. This is achieved by opening the Autodesk Revit Model in Autodesk Navisworks and utilising the Autodesk Cloud Rendering service, which renders the design model in the cloud, as depicted below:

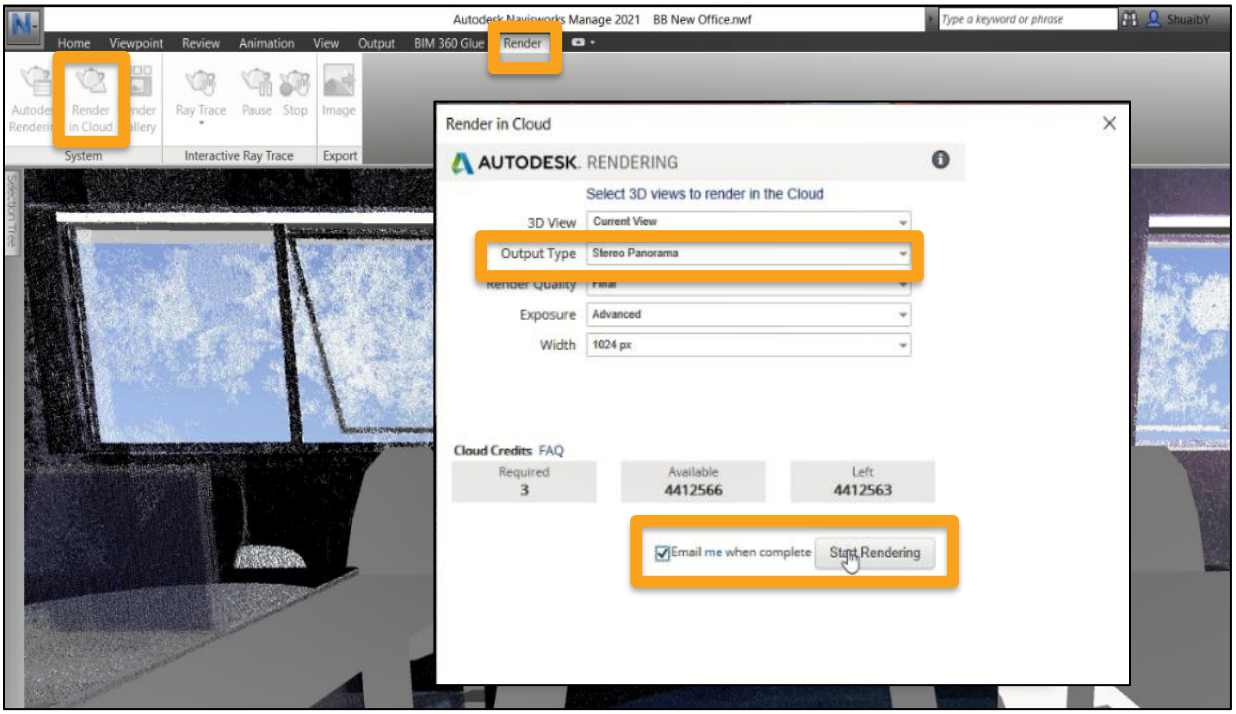

FIGURE 44: RENDERING USING THE AUTODESK RENDERING IN CLOUD SERVICE

12. We will then be notified via emailed as to when the cloud rendering has been successfully completed, allowing us to view the render in the render gallery.

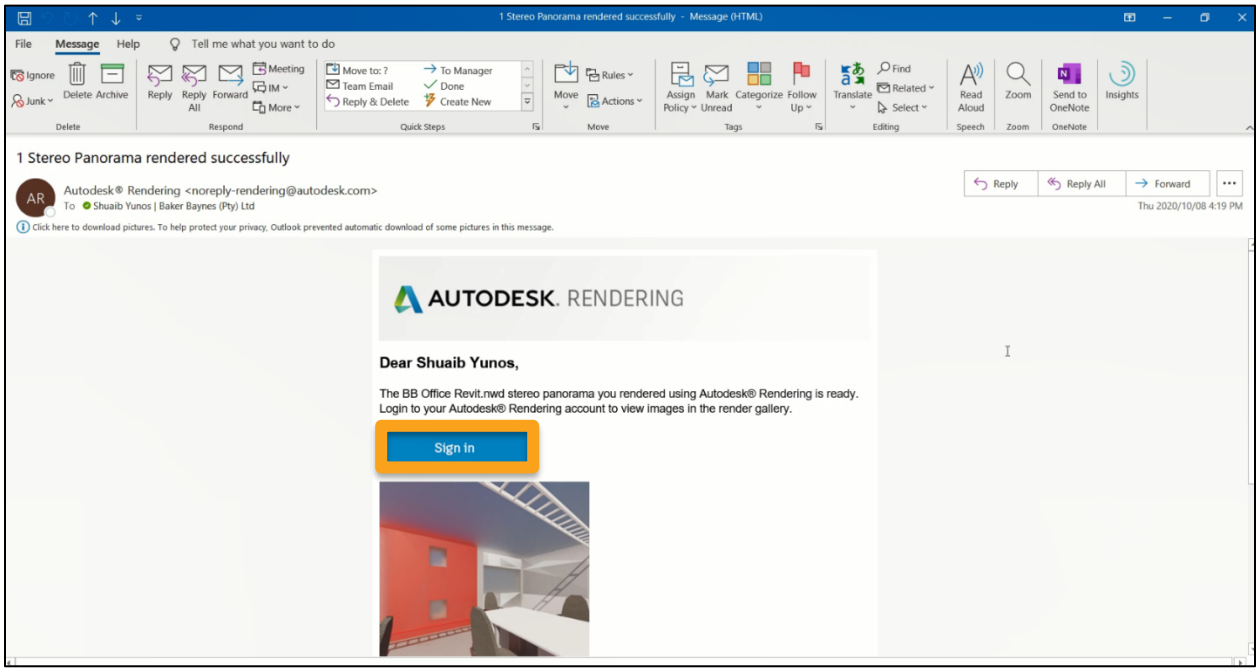

FIGURE 45: EMAIL NOTIFICATION UPON SUCCESSFUL COMPLETION OF CLOUD RENDERING

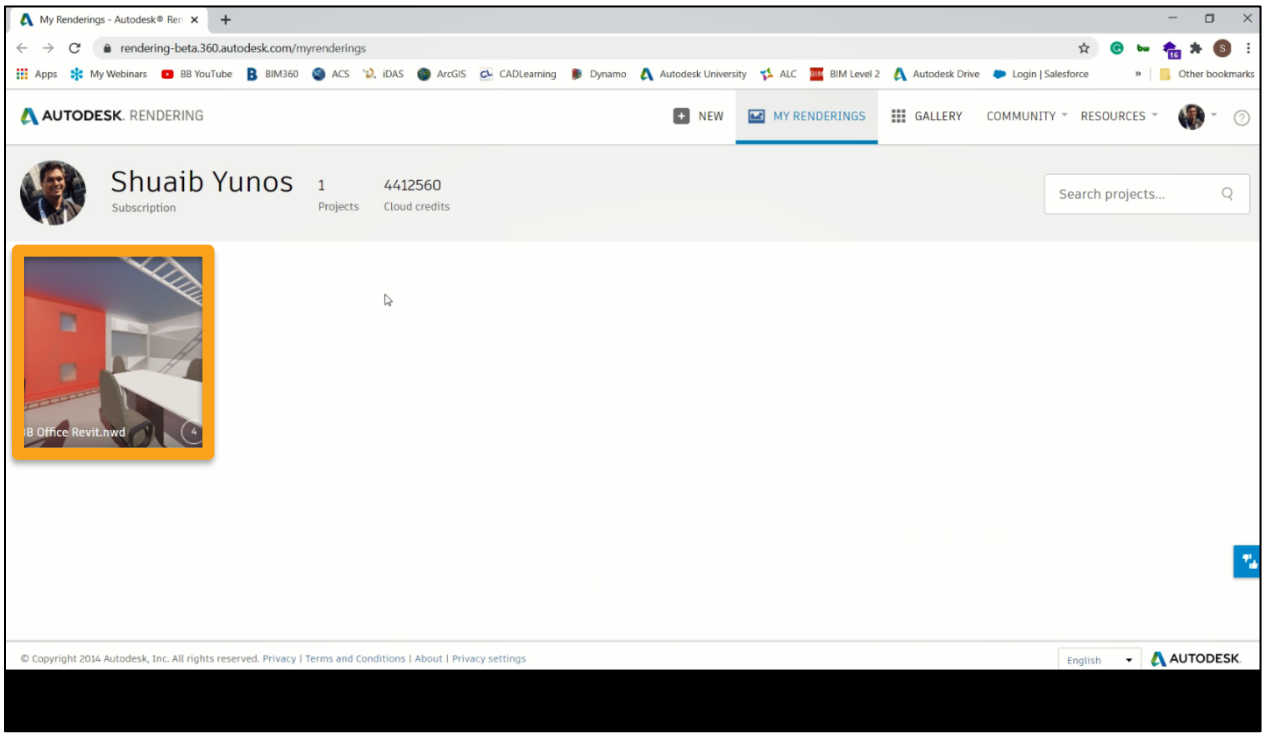

FIGURE 46: ACCESSING THE RENDER ONLINE AFTER SIGNING IN TO THE RENDER GALLERY

FIGURE 47: REVIEWING THE COMPLETED RENDER

13. Once we are happy with the render that we see, we can then share this render to whomever we need to. This is done via a link or QR code. The link will allow users to view the panoramic render in a browser as depicted below:

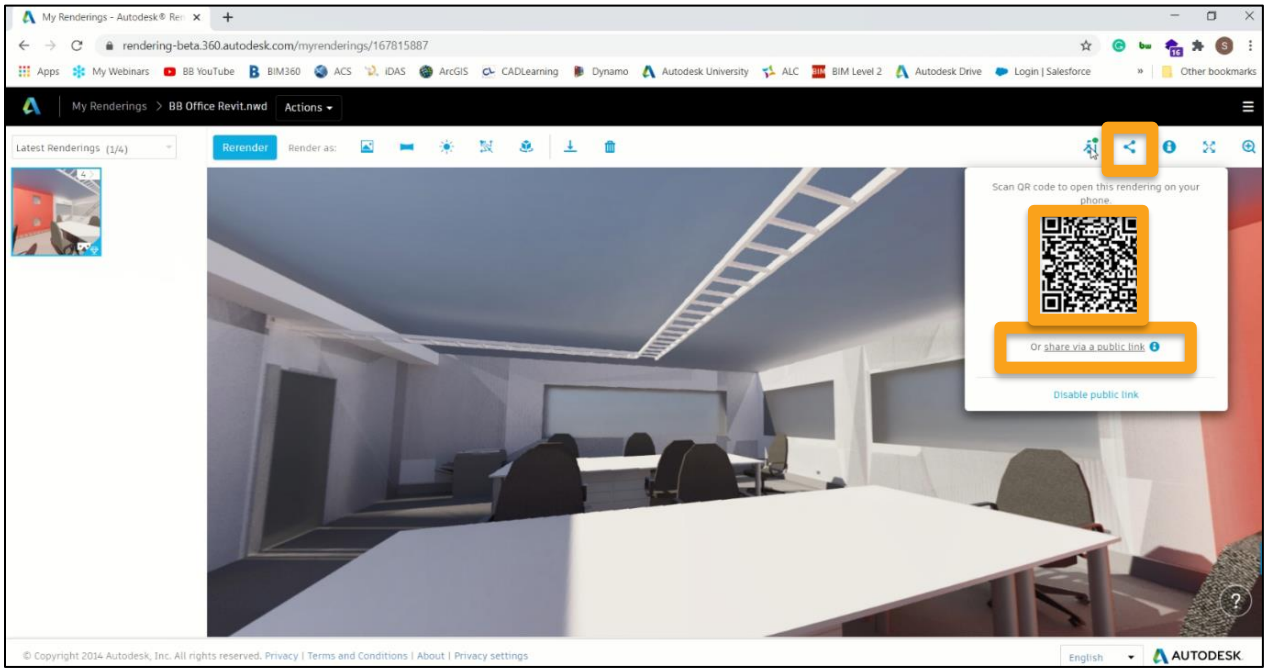

FIGURE 48: SHARING THE RENDER VIA LINK OR QR CODE WITH OTHERS

14. Should you have a VR headset, the QR code can be scanned using your phone and then placed in a VR headset for a more realistic VR experience. This is depicted below. You can also scan the QR code and have a look yourself!

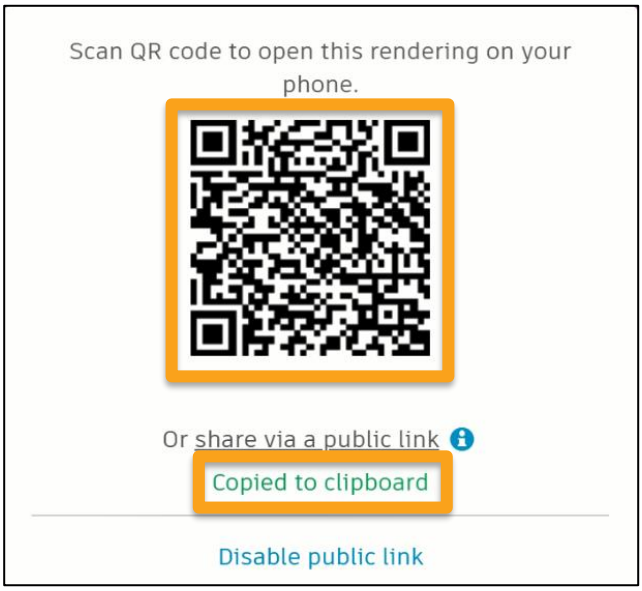

FIGURE 49: VIEWING THE RENDERED MODEL ON A VR HEADSET

Construct

FIGURE 50: THE REFINED SCAN TO BIM WORKFLOW FOR FURTHER AUTOMATION AND VISUALISATION FOR BUILDINGS: CONSTRUCTION PHASE

1. The office is then constructed as depicted below:

FIGURE 51: BEFORE CONSTRUCTION

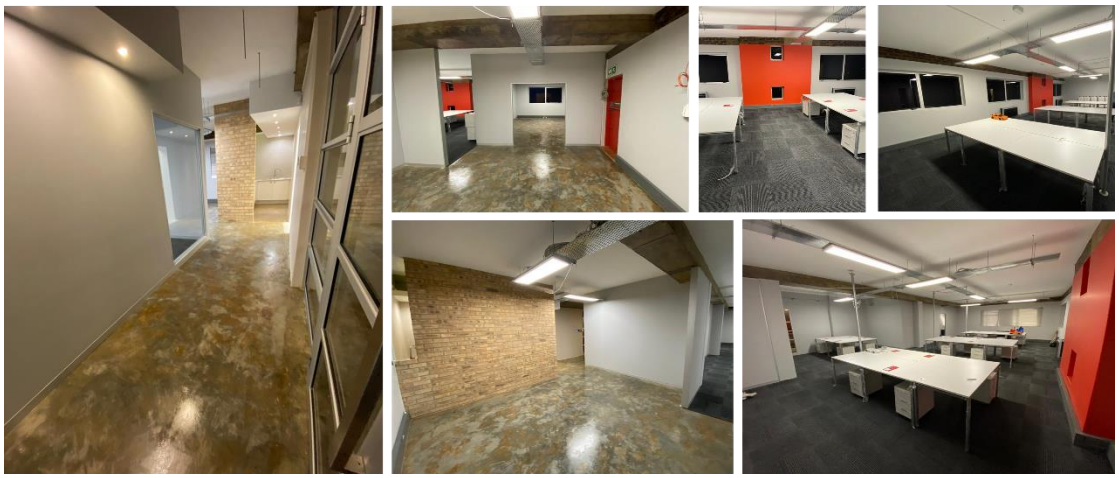

FIGURE 52: CONSTRUCTION COMPLETE

As – Built

FIGURE 53: THE REFINED SCAN TO BIM WORKFLOW FOR FURTHER AUTOMATION AND VISUALISATION FOR BUILDINGS: AS - BUILT PHASE

1. Now that the construction of the office is complete, we need to capture the as – built state of the building in order to produce the final design model of the constructed state to be handed over for effective operation and maintenance.

2. In order to capture the as – built measurements, the office will be scanned again using the laser scanner and then processed in Autodesk ReCap Pro to obtain a point cloud in a .RCP format as depicted below:

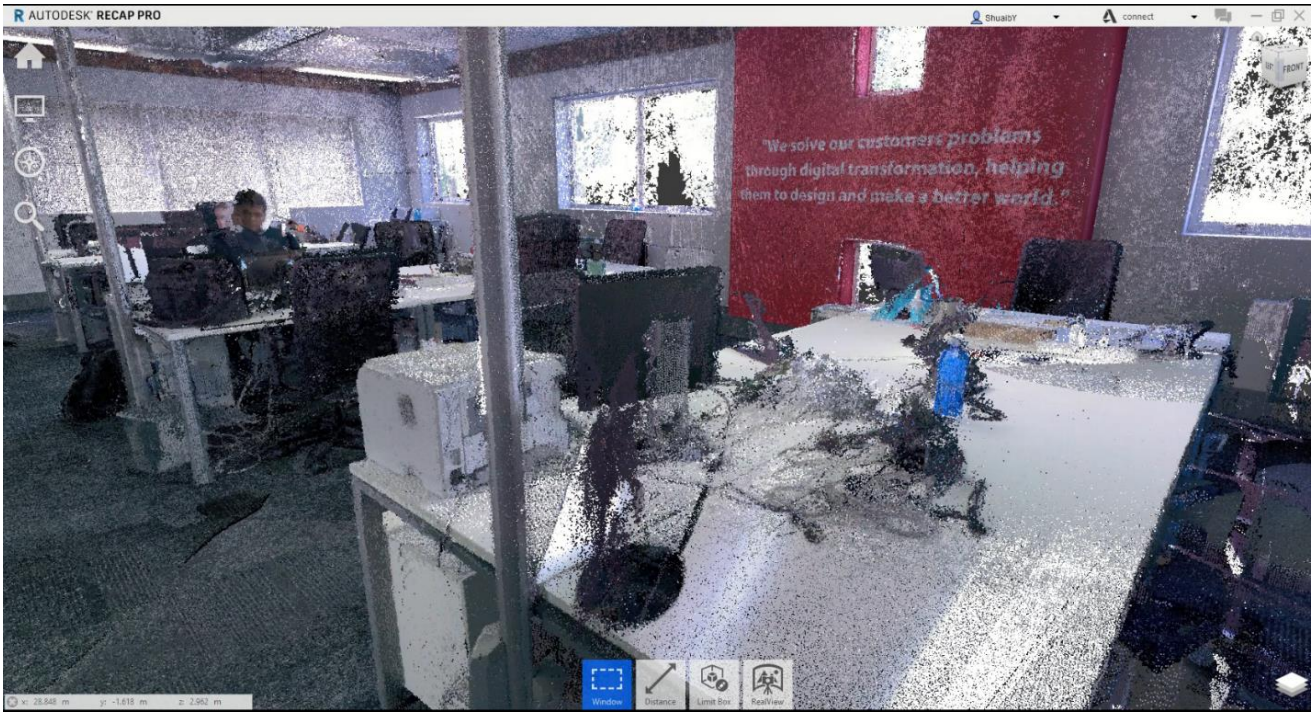

FIGURE 54: AS – BUILT POINT CLOUD IN AUTODESK RECAP PRO

3. The as – built model can then be verified by overlaying the point cloud over the Autodesk Revit model, with the model modified accordingly to match the point cloud as depicted below:

FIGURE 55: POINT CLOUD OVERLAYED ON DESIGN MODEL IN REVIT SHOWING DIFFERENCE BETWEEN DESIGN MODEL (WALL) & AS – BUILT POINT CLOUD THAT NEEDS TO BE ADJUSTED TO MATCH AS – BUILT STATE

4. Another way will be to apply ClearEdge3D EdgeWise to extract the as – built point cloud geometry, then exporting the extracted geometry to Autodesk Revit and then assigning finishes and other properties to produce the final as – built model as depicted below:

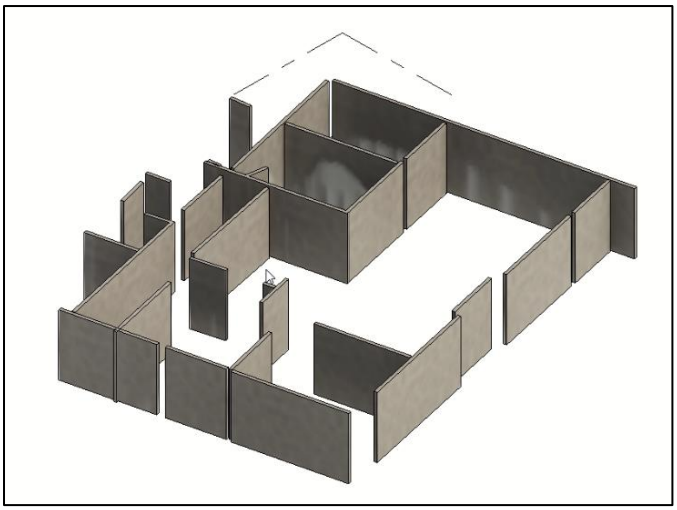

FIGURE 56: POINT CLOUD GEOMETRY EXTRACTED FROM AS – BUILT SCAN USING CLEAREDGE3D EDGEWISE TO BE MODIFIED IN REVIT TO MATCH AS – BUILT STATE

5. You can use whichever method described above, the result being the derivation of the final as – built model which can then be handed over as depicted below:

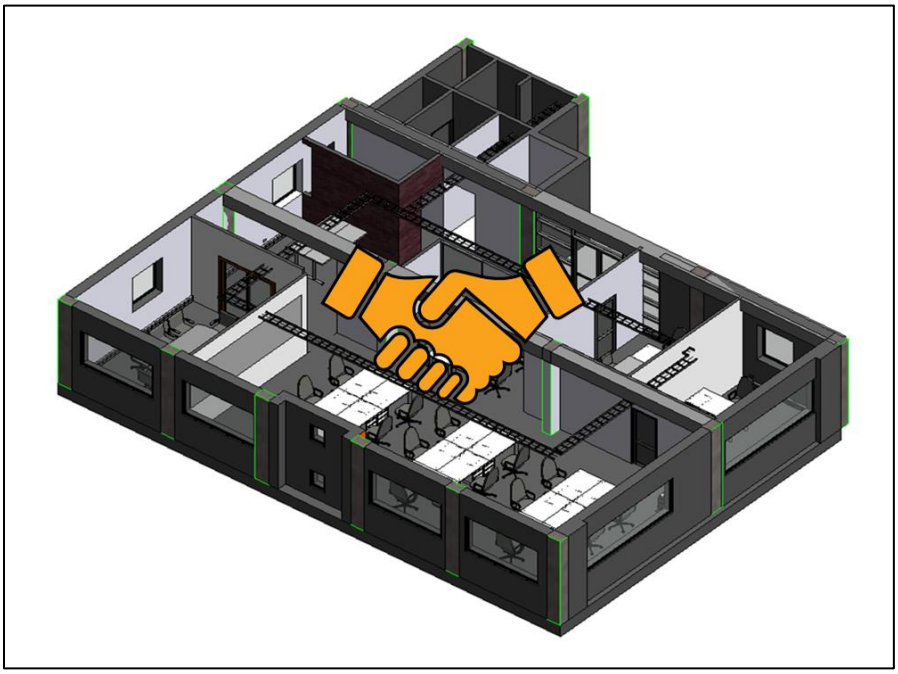

FIGURE 57: AS – BUILT MODEL COMPLETE & HANDED OVER

Conclusion

FIGURE 58: THE REFINED SCAN TO BIM WORKFLOW FOR FURTHER AUTOMATION AND VISUALISATION FOR BUILDINGS

The combination of Laser Scanning, Automated Point Cloud Geometry Extraction and BIM Technologies are definitely a gamechanger in the pursuit of intelligent, sustainable infrastructure. The implementation of this Refined Scan to BIM Workflow will result in time saving, increased efficiency, greater transparency and a highly, visually-rich portrayal of design intent along the project lifecycle.