



COGS Scanning Project, 2020-21



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Executive Summary

The Applied Geomatics Research Group (AGRG) of NSCC's Annapolis Valley Campus scanned, processed, and developed 3-D point clouds and meshes in order to develop various viewing applications for the new residence building at NSCC's Center of Geographic Sciences (COGS) in Lawrencetown. Scans were performed on three different dates at different stages of construction, first with the Matterport Pro2 3D camera and Teledyne Optech Polaris Terrestrial Laser Scanner (TLS), and later with only the Matterport. Polaris TLS data was processed by AGRG, and Matterport camera data through Matterport's cloud processing service, then downloaded for delivery and development. Several challenges were encountered during the scanning phase as a result of this being an active construction site. Ideally there would not have been people on site and no extra materials or debris would have been in the rooms were scanning. However, every effort was made to acquire high quality scans during these dates. An augmented reality (AR) mobile application was developed using the Unity Editor, and a virtual reality (VR) desktop PC application was developed using the Unreal Engine Editor. These software were developed for use with the Matterport 3D mesh and point cloud data in AR and VR respectively. The AR application allows the user to view an area from any of the three Matterport scans on a mobile device by pointing the camera at the same scanned area in the residence building. We attempted to push this AR application onto Apple iPhone and iPad devices for demonstration purposes. Unfortunately, the only Mac equipment available to us at AVC was too old to enable the operating system to be upgraded to allow for the AR application software to be loaded and thus push the app to the mobile devices. The VR application, with the use of a VR (Oculus Rift and HTC Vive) headset and a compatible desktop, allows the user to view any of the three Matterport scans, as well as the choice to view the 3D mesh or the 3D point cloud for a given scan. This allows the user to view the finished wall and shower of a room or to see what is behind the drywall by toggling through earlier scans. This has a practical application for the Building Information Management (BIM) application to be able to see the utilities hidden behind the drywall. User guides for both of these pieces of software can be found at the end of this report. This project has successfully demonstrated how scanning technology can be integrated into a VR environment to support BIM applications.

Table of Contents

Executive Summary	ii
Table of Contents	iii
Table of Figures	iv
List of Tables	iv
1 Introduction	1
1.1 Project Description	1
2 Methods	4
2.1 Hardware	4
2.2 Software & Development	9
3 Results	12
3.1 AR Platform	13
3.2 VR Platform	14
4 Conclusion	18
5 Acknowledgements	19
6 References	20
7 Bibliography: Links to Resources for the Reader	21
8 Appendix 1: AR App User Guide	22
9 Appendix 2: VR App User Guide	23

Table of Figures

Figure 1 Maximum extent of scanned areas highlighted in blue, actual areas scanned vary scan-by-scan. Areas referred to within the report as the “North” and “South” areas of the building are labelled as such. 2

Figure 2 Example of the stage of construction on the third floor during visit on July 13, 2020. 3

Figure 3 Matterport Pro2 3D Camera sensor body showing the angles of the three sets of cameras. 5

Figure 4 Matterport Pro installed on a tripod to conduct a 360° scan. 5

Figure 5 Example of the near infrared light pattern projected by the MatterPort. A – Example of the broad structure from light pattern. B – Example of how the light pattern is influenced by far and near objects. 6

Figure 6 Research Assistant Jesse Siegel, operating the Matterport scan for Scan 3 of the North area of the building, after the installation of drywall and painting. 7

Figure 7 Polaris TLS standalone unit, not mounted on a tripod in this figure, but normally would be for operations. 8

Figure 8 Screen capture of cross-section of aligned North section Polaris point cloud scans taken from CloudCompare. In this shot, we can see an electrical outlet and its cabling routed to the ceiling before it was covered by drywall. 9

Figure 9 Screen capture of example alignment from the South area of the building. 10

Figure 10 Example Unity editor window for the AR Android app. 11

Figure 11 Example screen capture of Unreal editor window with VR app open, displaying the mesh from Scan 3. 12

Figure 12 Side-by-side comparison of meshes of the same area from scan 2 (A) and scan 1 (B) taken from within the AR app. 13

Figure 13 Side-by-side comparison of meshes of the same area from scan 1 (A) on August 26th, 2020 and scan 2 (B) on November 23rd, 2020 taken from within the VR app. 14

Figure 14 Side-by side comparison of meshes taken from within the VR app, making an example of its use to find electrical component routing behind drywall. Scan 1 is in frame A, and Scan 3 in frame B. ... 15

Figure 15 Example of point clouds in the VR environment. A - Matterport point cloud Aug. 24, 20220. B - Polaris point cloud Aug. 24 single scan. C - Matterport point cloud Sept. 14. D - Matterport point cloud Nov. 23, 2020. 16

Figure 16 Example of final point clouds, pre and post drywall. A - Matterport point cloud with exposed wiring. B – Matterport scan after drywall has been put on and crack filled with the shower installed. ... 17

Figure 17 Fall 2020 aerial photo update of building construction. 18

List of Tables

Table 1 Table of 3D scans, the dates on which they took place, and descriptions of the state of the building on those days the Matterport was used to scan. 3

1 Introduction

With the recent advances in 3-D scanning technology utilizing laser scanners, or other technology such as structure from light, this project offered an opportunity to demonstrate how various phases of the construction project can be captured, aligned and integrated into a virtual reality or GIS system for Building Information Modeling (BIM).

1.1 Project Description

For a period of time over the last year, the Nova Scotia Community College (NSCC) Center of Geographic Sciences (COGS) campus located in Lawrencetown, NS has had a new building under construction meant for eventual use as both student residence and an educational setting. As a part of this project, we at AGRG have been responsible for making 3D scans and collecting data on the various stages of construction. Firstly, when the building's exterior walls were finished, and the interior wall studs were in place. Secondly, after the plumbing and electrical work has been put into place. Third, after the installation of the drywall, and finally, after the painting is finished and much of the ceiling tiles have been put into place. These scans were done on two different areas within the building, one at the North side and one at the South side of the building on the second floor. A reference to these locations can be found in *Figure 1*, and information regarding the dates and building condition of the scans can be found in *Table 1*. Once these scans were complete and processed appropriately, the data were ingested into internally developed mobile-based Augmented Reality (AR) and desktop PC-based Virtual Reality (VR) environments to be used for the visualization of the various steps of construction. This concept is meant to allow the user to "see into the walls" and be able to look at the location of electrical and plumbing utilities once they have become hidden by insulation and drywall. This workflow relates to an infrastructure and building construction planning process known as Building Information Modeling (BIM). According to Autodesk, maker of some of the world's most popular computer-aided design (CAD) software, the process of BIM involves creating a set of models for planning, designing, building, and the operation and maintenance phases of a project. This scanning project in particular plays into the operation and maintenance phase of the "as built" project, offering BIM data to save the user the headache of looking up old schematics and plans for construction when repairs and modifications are made to those rooms in the building that have been scanned.

At the final stage of the project, the AR environment was meant to be demonstrated at the new COGS building to show how these data and technologies can be viewed and applied in the real world. A demonstration focused on the VR environment was done at the AGRG offices in Middleton.

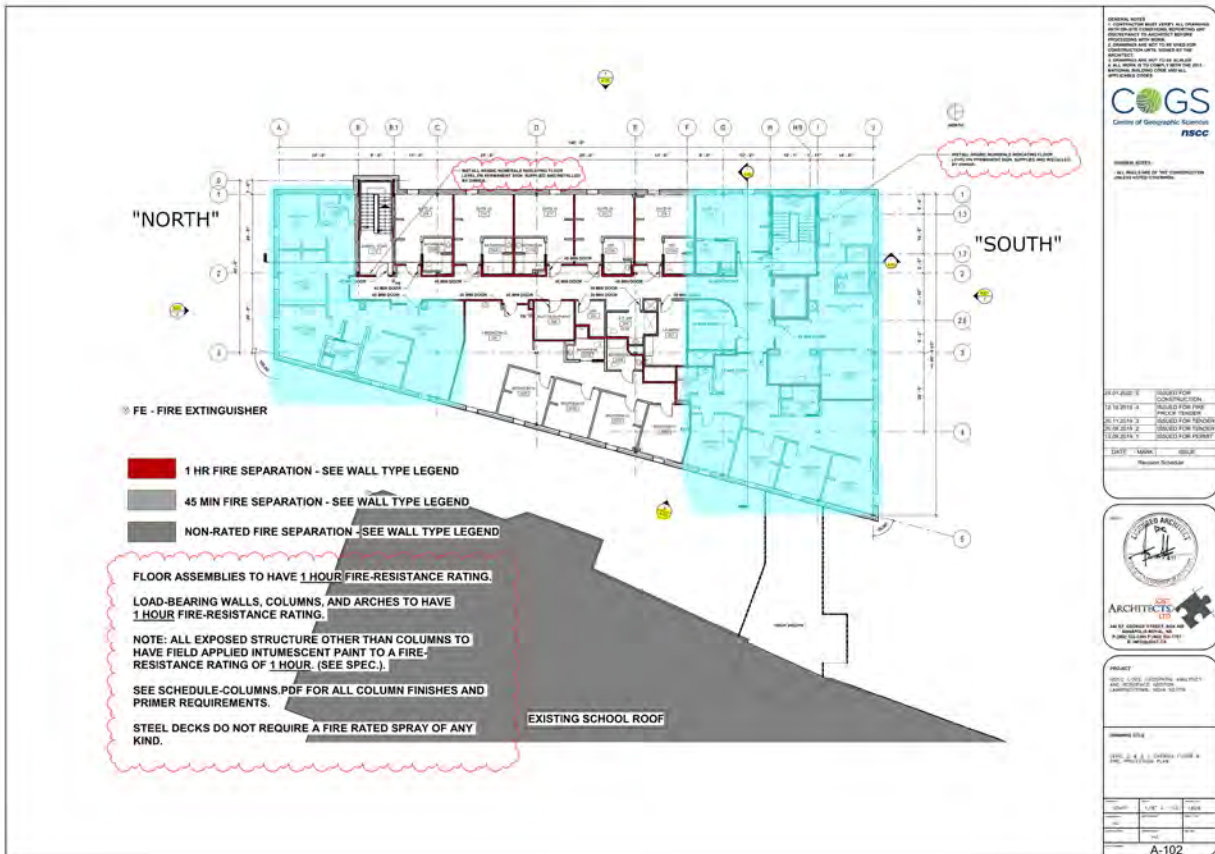


Figure 1 Maximum extent of scanned areas highlighted in blue, actual areas scanned vary scan-by-scan. Areas referred to within the report as the “North” and “South” areas of the building are labelled as such.

The site was initially visited on July 13th to interact with the project manager, facilities staff and general contractors on the site. At that stage of the project the third floor was more advanced than the second floor, which have identical layouts. The space was busy with contractors, the steel wall studs were up and in some cases insulation was in the walls (Figure 2). Communication between the project manager and staff at AGRG dictated that we conducted our scans when it was convenient for them, the dates of the scans can be seen in Table 1.



Figure 2 Example of the stage of construction on the third floor during visit on July 13, 2020.

Scan	Date	Description
Scan 1	August 26 th , 2020	Initial scan. Outer walls and wall studs up. Electrical work in place, plumbing started. Polaris scan performed on this day as well.
Scan 2	September 14 th , 2020	Second scan, after further refinements to electrical and plumbing. Drywall in place sporadically, insulation materials installed in places.
Scan 3	November 23 rd , 2020	Drywall up, painted. Some ceiling drop-tiles in place.

Table 1 Table of 3D scans, the dates on which they took place, and descriptions of the state of the building on those days the Matterport was used to scan.

2 Methods

We needed to conduct multiple scans to capture the “as built” environment at different stages of the construction. AGRG owns two pieces of equipment that were deemed suitable for this project. The first is the more user friendly and easier to operate Matterport Pro 2 which uses a technology known as structure from light to calculate the 3-D geometry. The second was the Polaris laser scanner from Teledyne Optech. Both systems have cameras to capture the conditions through photos which can be used to colourize the point clouds. Regardless of which technology is used, both required ideal conditions to accurately capture the data, which proved to be challenging at this active construction site. One of the criteria is that we cannot have people or objects moving within the field of view we are scanning during the scan. Secondly, it is ideal to have minimal extra materials around that clutter the site or obstruct the exposed walls and interior wiring and plumbing from being captured. Both of these conditions were encountered and had to be dealt with as best as possible during the scanning process. Since we were accessing an active construction site, we first conducted virtual training on worksite safety then ensured we wore safety boots (steel toed), safety glasses, and a safety vest, and masks until we began the scanning process.

2.1 Hardware

2.1.1 Matterport

For the 3D scanning portion of this project, we opted to use the Matterport Pro2 (henceforth referred to as *the Matterport*) tripod-mounted scanner. Common in the real estate industry, this device is very portable and user-friendly. The main technology leveraged for the Matterport’s 3D modelling capabilities is structured light, which will be discussed in detail in the content to follow. The unit also contains a built-in GPS receiver, used for simplifying sharing your publicly published scans on Google Street View, not for georeferencing. Its use will be hindered indoors and best integrated with scans that include building exteriors, though the unit’s utility for building exterior scans is limited compared to indoors due to high light levels interfering with the structured light sensors. As seen in Figure 3, the Matterport has three arrays of sensors facing in different directions that record data as the unit stops at different points between performing a 360-degree rotation about the Z-axis of the tripod for an individual scan (Figure 4).



Figure 3 Matterport Pro2 3D Camera sensor body showing the angles of the three sets of cameras.



Figure 4 Matterport Pro installed on a tripod to conduct a 360° scan.

Structured light is an active sensing technique that uses the projection of a known, consistent pattern of light of a given wavelength to extract information of the surface onto which it is projected. It is because we know the nature of the projections from the source, we can use the pattern made by its reflection from a surface to determine the nature of that surface. Measurements of shape of the objects

being scanned are the main pieces of information that the Matterport is extracting using an array of sensors that transmit and receive three different dot-based grids of near-infrared light (0.75–1.4 μm wavelength) (Figure 5). This distance and shape information is then paired with the photographs taken by the cameras located in the sensor array and taken into account when creating the final 3D models.

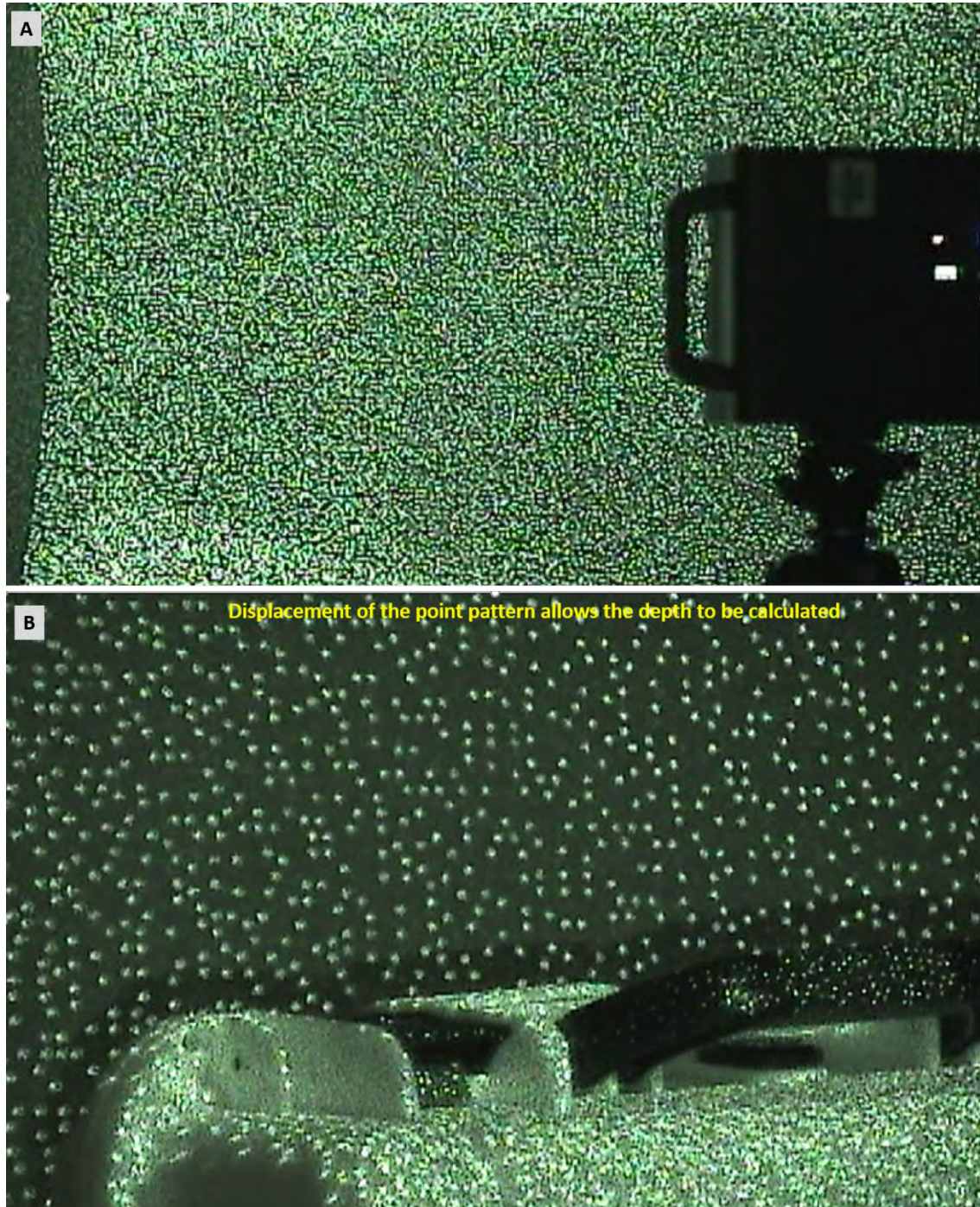


Figure 5 Example of the near infrared light pattern projected by the Matterport. A – Example of the broad structure from light pattern. B – Example of how the light pattern is influenced by far and near objects.

On the software side, the Matterport is very user-friendly, effective for quick and accurate scanning of an environment. The Matterport Capture app is available for iOS, with a beta version available for Android devices. After connecting to the Matterport with your phone or tablet, you'll want to create a "space", which will hold all your scans for a collection. Colleague Jesse Siegel can be seen in *Figure 5* operating a Matterport scan. Once the Matterport is set up on its tripod where you intend to start your collection, you can click the scan button. After the scan is finished, a notification sound will play and it is time to move the Matterport to the next position, making sure there is enough overlap between scans for alignment. As you go along, the app will align the scans for you automatically, giving warnings when there is not enough overlap between scans. This process is repeated until the area of interest has sufficient coverage. The last stage of the collection is to upload your "space" to Matterport's cloud for processing. In our case, we also purchase a MatterPak to gain access to the point cloud and 3D mesh datasets for the collections. Their use will be discussed in the sections to follow.



Figure 6 Research Assistant Jesse Siegel, operating the Matterport scan for Scan 3 of the North area of the building, after the installation of drywall and painting.

2.1.2 Teledyne Optech Polaris Terrestrial Laser Scanner (TLS)

In the early stages of the work, prior to settling on the use of the Matterport for the fulfillment of the project, the option of the Teledyne Optech Polaris TLS was explored. A much more capable, customizable, and expensive alternative option, the Polaris unit as seen in Figure 8 offers survey-grade point cloud data thanks to its use of lidar, tilt compensation sensor, digital compass, 80 megapixel cameras, and L1 GNSS receiver. Along with the greater potential quality of survey data versus using the Matterport comes a significant decrease in ease-of-use.



Figure 7 Polaris TLS standalone unit, not mounted on a tripod in this figure, but normally would be for operations.

The Polaris does not come with a simple one-click mobile app for operation, instead relying on the user to program the scan-specific settings using a touch-screen interface on the back of the unit. However, an app that replaces the function of this touchscreen is available for laptops and other mobile devices when it is not convenient or possible to access the unit for a scan. Data processing and storage is also the user's responsibility, no cloud transfers and processing for this technology. A USB hard drive or USB flash storage device is the preferred way to export data from the unit for simplicity's sake, with a suite of software known as ATLAScan used for processing of the data. A sample of this processed data can be seen in Figure 9, illustrating its potential for use in this project in identifying electrical utilities.

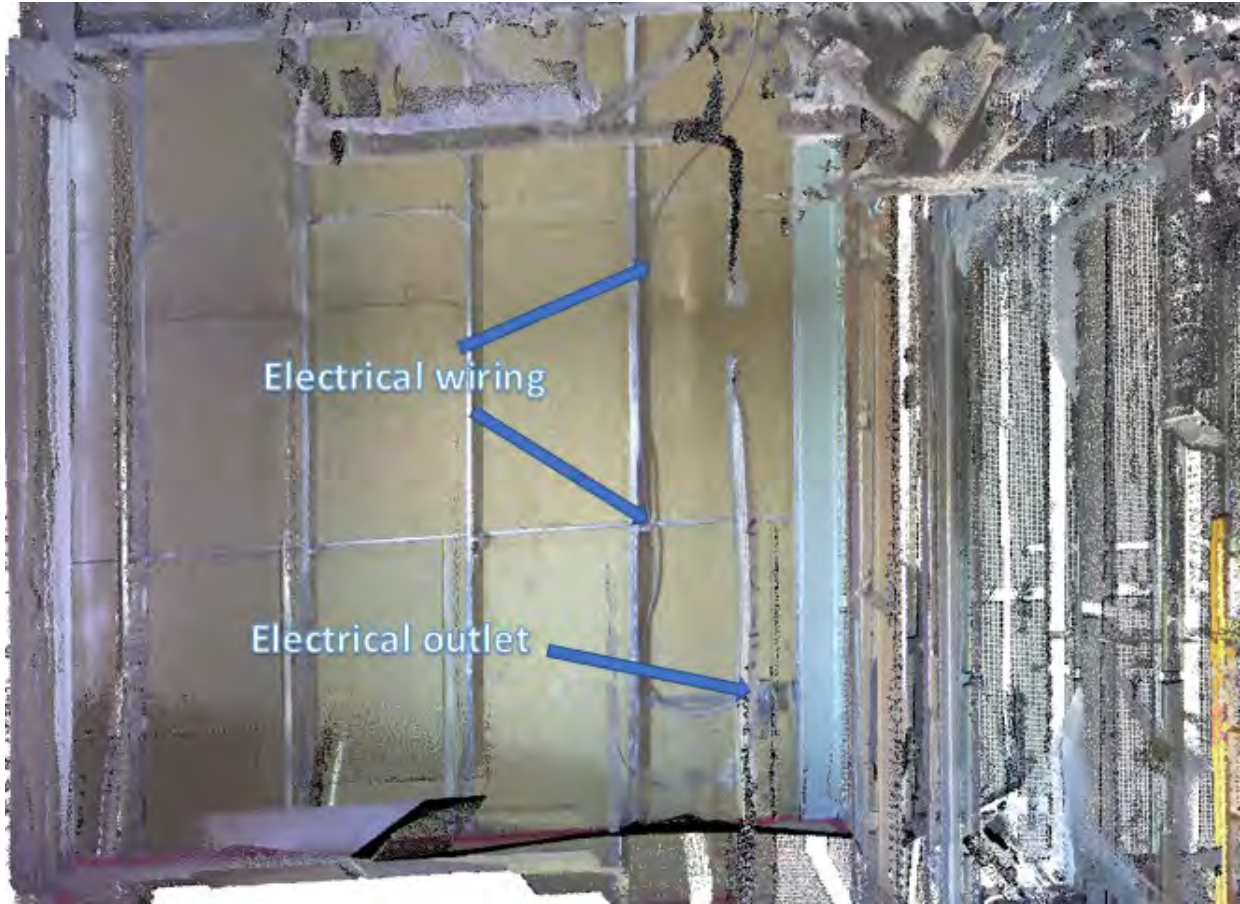


Figure 8 Screen capture of cross-section of aligned North section Polaris point cloud scans taken from CloudCompare. In this shot, we can see an electrical outlet and its cabling routed to the ceiling before it was covered by drywall.

2.2 Software & Development

2.2.1 CloudCompare

Because the purpose of this project is to have a comparison of the same two areas of the new residence building with multiple scans, they need to be aligned with one another so that they can be displayed together in the AR and VR applications. Being inside of a building rather than outside, georeferencing as a method of alignment was not the simplest or most efficient option. This led to the decision to use the open source 3D point cloud software CloudCompare.

CloudCompare is a very versatile piece of software with many tools for processing, manipulating, and classifying 3D point clouds and meshes. The tool of interest to us for this specific use-case is the *Align* tool, for aligning one point cloud to another. Using the *Align* tool, point pairs are identified between two point clouds that represent one location in the real world as closely as possible. With a minimum of three

points, CloudCompare will apply a transformation matrix to one cloud in order to line it up with the reference point cloud chosen when loading the *Align* tool. The user will also see a RMS (or Root Mean Square) value, representing a model-based calculation of the error between the placement of the point cloud pair, decreasing as more and better alignment point pairs are added. After achieving a low, satisfying RMS value and applying the transformation, the ‘to align’ point cloud is shifted and the user can export the file, preserving the changes. Additionally, an *Align info* popup window will be displayed, giving the user the final RMS value and transformation matrix of the alignment that can be used to recreate the transformation. This can be seen as an example in Figure 10. In our case, we use this transformation matrix to repeat the alignment for the 3D meshes used in the AR application.

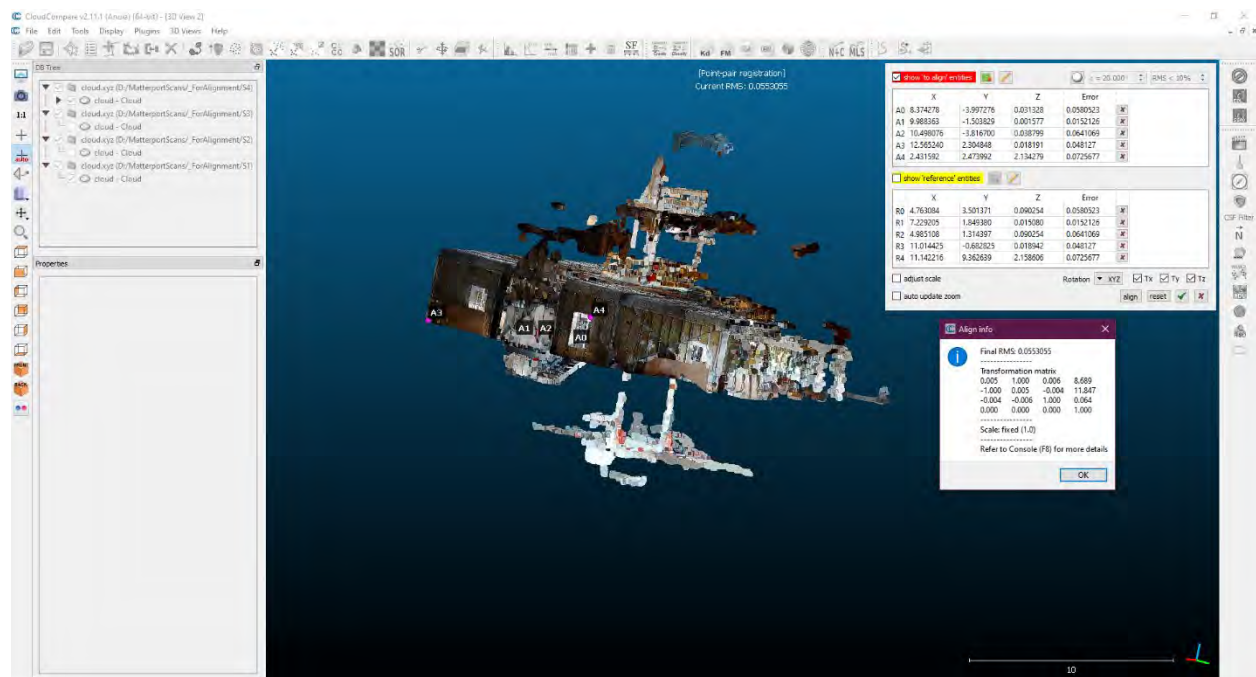


Figure 9 Screen capture of example alignment from the South area of the building.

2.2.2 Unity

For the development of the Augmented Reality application, Unity was chosen for its ease of use and familiarity to our main 3D visualizations developer, Jesse Siegel. Unity is a game engine and graphical project editor allowing for the user to create 2D, 3D, VR, and AR applications and demos for use across a variety of platforms with a robust suite of visualization and debugging tools. Much of the work done and changes made to the application can be seen in real-time in the main “game” window seen in Figure 11, greatly speeding up the development workflow versus coding from scratch using a graphics library such as OpenGL or Vulkan. The only real downside of going this route versus from-scratch coding is the less-

than-perfect performance optimization of applications, as the Unity libraries are written to work across many devices and not optimized for one in particular. An application developed from-scratch has the potential for much better optimization, given adequate skill of the developer, but on the lower-end with less graphically intense applications such as this AR app this won't be a limiting factor and is certainly worth the time-saved on development and the limited budget of this project.



Figure 10 Example Unity editor window for the AR Android app.

Unity, like other game engines, editors, and IDEs (integrated development environments), has its own built-in compilers, necessary to push the application into a state where it can be run as intended for the finished product. For testing, the application can be sent to the developer's phone once compilation is complete, saving the time needed if one had to export to a device and install manually.

2.2.3 Unreal Engine

Rather than using Unity for the development of both the AR and VR applications, the latest version of the Unreal Engine for PC was chosen for development of the VR application for its better support of 3D point cloud data types. Unity is capable of some basic work with point clouds, though much of its support comes from community developed add-ons, versus the LiDAR Point Cloud Plugin officially supported and well-documented by Unreal. Aside from having better point cloud support, the Unreal Engine Editor offers a similar graphical development environment to Unity, with customizable panels and layouts such as those seen in Figure 12 for the user to interact with different aspects of the application. Unreal also carries a

better reputation for visual fidelity, often picked as the go-to for big-time development studios wanting to make the most impressive experience they can offer, better able to take advantage of all the resources available to a device like the modern desktop PC with high RAM, CPU speed, and dedicated graphics cards. This also lends itself well to its use for displaying (rendering) point clouds, as it takes a great deal more computational resources to display tens or hundreds of millions of individual points from a point cloud on screen vs the hundreds of thousands of vertices for 3D geometries when displaying textured meshes.

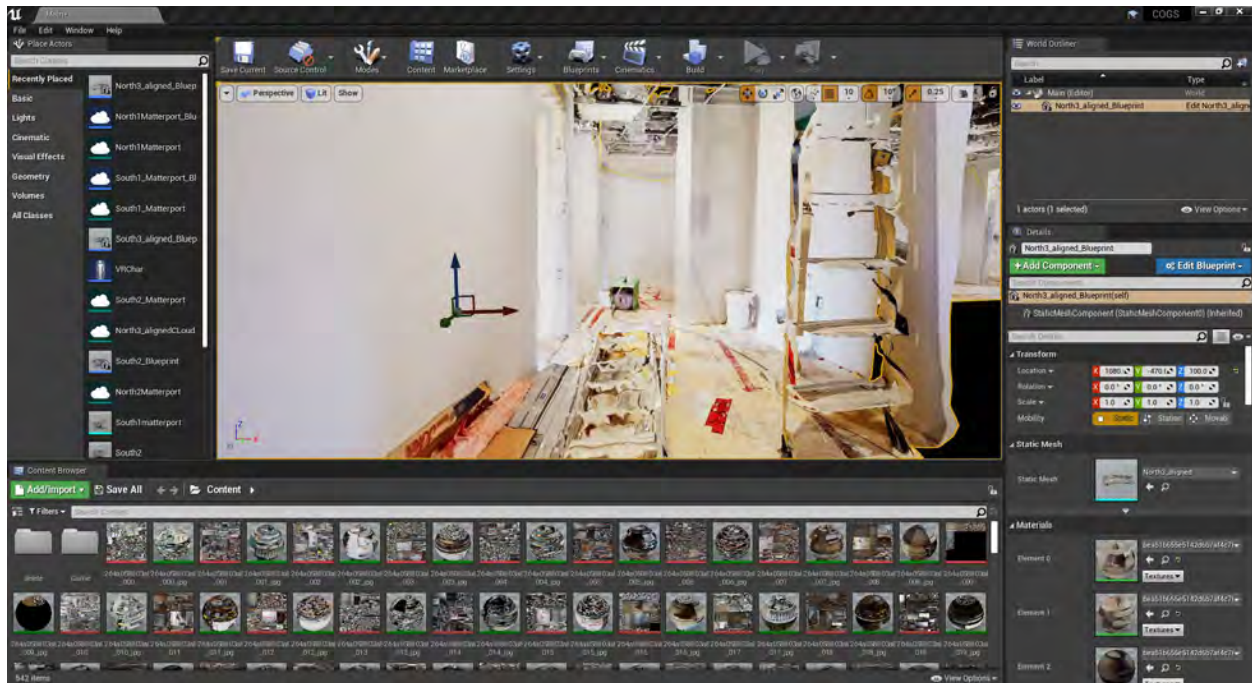


Figure 11 Example screen capture of Unreal editor window with VR app open, displaying the mesh from Scan 3.

3 Results

The multiple scans have all been processed to RGB coloured point clouds that have all been aligned and co-registered. The data have all been brought into both Unity and Unreal for visualization. Unfortunately, the Mac computers available at AVC are too old to support the latest iOS operating system that is required in order to push the augmented reality application to an iPhone or iPad tablet. As a result, we were not able to implement this augmented reality functionality because of this limitation in the technology available to us. In addition to the point clouds, models or meshes are also constructed from the scans. These are solid in nature and in some cases are better to visualize than the point cloud. However, in some cases objects in the models can appear stretched and have extra distortions not seen in the point cloud. An example of this situation can be seen in the following meshes (Figure 13).

3.1 AR Platform

Once the initial configuration of the AR app for iOS devices was configured through Unity, the project was exported to an Xcode project to be built and deployed to an iOS device. Once launched, the Unity splash screen presents itself during loading of assets, then the app presents itself for use. The controls for the app are located at the bottom of the screen, with one “button” for selecting each scan. One scan will be visible at a time, and as such only one button is selectable at a time. Using augmented reality technology, the phone’s rear (opposite side to the screen) camera(s) will observe what it is pointed at, displaying imagery from the selected scan that the app is most confident your phone is pointed at, with good accuracy. Exiting the app is as simple as pressing your phone’s home button.



Figure 12 Side-by-side comparison of meshes of the same area from scan 2 (A) and scan 1 (B) taken from within the AR app.

Tracking for the “reality” portion of the Augmented Reality is based on software-derived targets for matching to the final scan of the project, as it will resemble the finished building the closest. Short of adding in physical AR targets with patterns, QR codes, or the like, this was the best way to build the tracking system. So long as the building does not become cluttered with furniture and wall coverings, the

app's internal targets will be more than adequate for tracking. More information on installation and use can be found in *Appendix 1*. Note this component of the project was not implemented as a result of technological limitations of NSCC Mac equipment at AVC.

3.2 VR Platform

After compiling the working version of the app to an .exe file using Unreal Engine, the user can run the app through the VR software launcher supported by their headset. Testing was done mainly on the Oculus Rift system through Valve Corporation's SteamVR software, though the HTC Vive headset and Microsoft Mixed Reality-based headsets such as the Samsung Odyssey are also compatible with the application. Controls are intuitive thanks to the nature of VR technologies. Rotating your head will result in a 1:1 translation of your movement in the app. Look up, and the view in-app will turn upwards, look to the right, and the view in-app will turn to the right, and so-on. For the sake of safety, most of the movement of the virtual camera within the environment itself is done using the right thumb stick or touch pad on your headset's respective controller. This means the user can remain seated or stand in place and forgo the risk of walking into a wall or desk, or tripping over a cable in trying to navigate the environment. However, the user may walk around in the room they are using if they feel safe. Doing so will result in them moving around in the VR environment. Activation of the right "trigger" button will cycle through the available scans, starting with scan 1 on load, and incrementing by one scan per actuation and starting over at scan 1 after reaching the final scan. Examples of the VR application's use for comparing areas across scans can be found in Figure 14 and Figure 15. A more detailed explanation on how to use this software including installation can be found at the end of this report in *Appendix 2*.

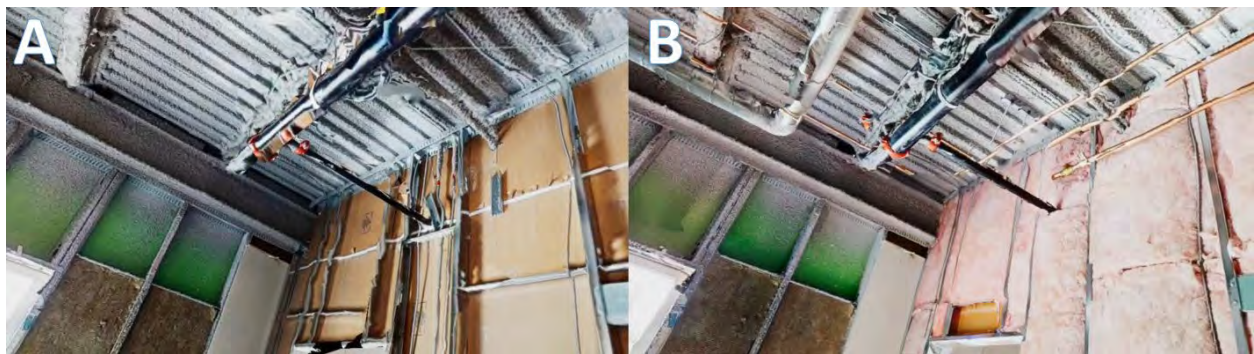


Figure 13 Side-by-side comparison of meshes of the same area from scan 1 (A) on August 26th, 2020 and scan 2 (B) on November 23rd, 2020 taken from within the VR app.



Figure 14 Side-by side comparison of meshes taken from within the VR app, making an example of its use to find electrical component routing behind drywall. Scan 1 is in frame A, and Scan 3 in frame B.

The point clouds as well as the meshes are available for display in the VR application. One of the main advantages of the Matterport over the Polaris is that during the scanning phase, the Matterport provides feedback on the amount of required overlap between scan locations. This helps insure you get a complete coverage of the area and with a minimum of shadow effects. In the case of the Polaris, one does not know how well the overlap is between scans or the problem with shadow until the data are processed and aligned back in the office.

An example of the four point clouds for a bedroom wall and shower unit demonstrate the various stages of construction and more importantly the location of electrical wiring and receptacles (Figure 15). As one can see from the various scans in Figure 15-B there is a stack of drywall that is obstructing the scan. Similarly, in Figure 15-C there are partial sheets of drywall leaning against the finished wall and shower further obstructing the surfaces from being completely scanned.

Although intermediate scans were captured during the project, Figure 16, highlights the proof of concept that this project was trying to demonstrate with scan pre and post drywall and shower installation.



Figure 15 Example of point clouds in the VR environment. A - Matterport point cloud Aug. 24, 20220. B - Polaris point cloud Aug. 24 single scan. C - Matterport point cloud Sept. 14. D - Matterport point cloud Nov. 23, 2020.

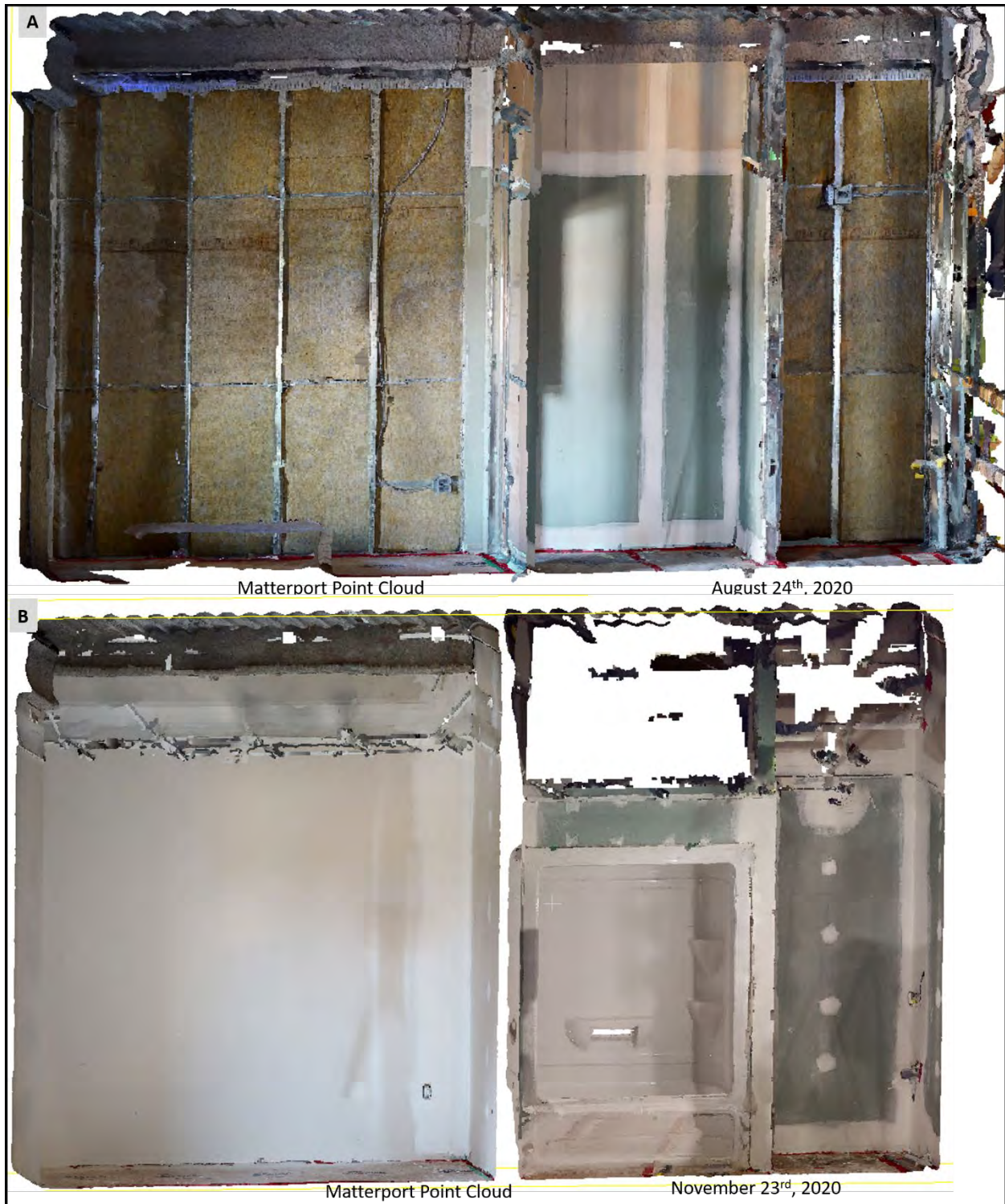


Figure 16 Example of final point clouds, pre and post drywall. A - Matterport point cloud with exposed wiring. B - Matterport scan after drywall has been put on and crack filled with the shower installed.

4 Conclusion

Although this project had several challenges, including data collection at an active construction site, where our activity was not a high priority for the trades people, to conducting fieldwork during the pandemic, to the lack of modern Mac equipment to be able to push the augmented reality platform to an iPhone or iPad, the proof of concept of how this technology can be used to support BIM applications was accomplished. Both the Polaris high-end laser scanner was used as well as a more consumer grade Matterport structure from light system was used to scan a set of rooms in two locations of the building at three different stages of construction. Since it was an active construction site there were issues with extra material blocking areas that we needed to scan, but enough data were collected to be able to demonstrate the utility of 3-D scanning during construction to present this BIM application.

COGS staff have collected several drone flights to capture the exterior changes to the building during the project (Figure 17). A future effort could involve merging the drone-based colored point clouds with the interior scans to present a more unified fully integrated set of models.



Figure 17 Fall 2020 aerial photo update of building construction.

5 Acknowledgements

Thanks to site superintendent Scott Spidle & EllisDon construction for access to the job site.

Jesse Siegel for the entirety of the VR and AR software development.

Nathan Crowell, Dedipya Kodavati, Connor Dearing for assistance with the first scans, especially operation and data processing for the Polaris TLS.

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Polaris | Teledyne Optech. (2021). Teledyne Optech.
<https://www.teledyneoptech.com/en/products/static-3d-survey/polaris/>

7 Bibliography: Links to Resources for the Reader

Android ARCore

https://developers.google.com/ar/discover/supported-devices#google_play

Apple Augmented Reality support page

<https://www.apple.com/ca/augmented-reality/>

Apple Xcode

<https://developer.apple.com/xcode/>

HTC Vive

<https://www.vive.com/ca/>

Matterport

<https://matterport.com/>

Oculus Rift

<https://www.samsung.com/us/support/owners/product/hmd-odyssey-mixed-reality>

Polaris TLS

<https://www.teledyneoptech.com/en/products/static-3d-survey/polaris/>

Samsung Odyssey

<https://www.samsung.com/us/support/owners/product/hmd-odyssey-mixed-reality>

Teledyne Optech Polaris Terrestrial Laser Scanner

<https://www.teledyneoptech.com/en/products/static-3d-survey/polaris/>

Unity

<https://unity.com/>

Unreal Engine

<https://www.unrealengine.com/en-US/>

Valve Corporation Steam software

<https://store.steampowered.com/about/>

Valve Corporation Steam VR software

<https://store.steampowered.com/app/250820/SteamVR/>

Windows Mixed Reality for Steam VR

https://store.steampowered.com/app/719950/Windows_Mixed_Reality_for_SteamVR/

8 Appendix 1: AR App User Guide

The Augmented Reality mobile app supports Apple iOS devices, this includes the iPhone and iPad. Generally, anything released after the iPhone 6 running iOS 11 and sporting an A9 or newer-style processor should be supported. Check [this page](#) for a full list of supported devices.

Publishing the app to Apple’s official App Store is well outside the scope of this project and as a result, unfortunately, installation of the app takes a few more steps than opening the App Store and clicking “install”.

Quick-Start:

Install/Confirm Installation:

- Requirements:
 - An iMac or MacBook running OSX Catalina or higher, with the latest version of XCode installed.
 - An Apple Lightning to USB cable
 - An iPhone or iPad supporting ARKit
- To Install
 - Boot up your OSX device and start XCode.
 - Ensure your iOS device is powered on, up-to-date, and connected to your OSX device.
 - Load the provided iOS build into XCode, then build to your connected iOS device.
 - At this stage, the app should boot.

Use

After making your way to either the North or South sections of floor 2 of the new COGS Residence, open the application on your phone as you would any other app, and you will be greeted by the Unity splash screen. Aim your phone’s camera at the area you wish to view with the app. Assuming there are no obstacles that prevent the app from recognizing an area (new furniture, etc.), you will see on the screen what the app recognizes as the same area from Scan 1. Move your phone around as you please, and the view will change along with it.

The app interface is very simple. At the bottom of the screen there are buttons, one for each scan, with labels that reflect their purpose. Touch these buttons to display the scan you would like to see.

9 Appendix 2: VR App User Guide

This guide is written for a user with a very limited understanding of the subject. If you already own your own VR headset, many of these steps will be unnecessary and you can skip straight to launching the COGS VR application.

Quick-Start:

Install/Confirm Installation:

1. [Steam](#)
2. [SteamVR](#)
3. [Windows Mixed Reality for SteamVR](#) if using a WMR headset such as the Samsung Odyssey

Launch

1. Ensure your headset is connected and controllers are connected, following guides from the manufacturer.
2. Launch Steam and then SteamVR. If your headset requires it, launch Windows Mixed Reality for SteamVR.
3. Navigate to the folder you have placed the COGS VR application .exe, and double-click to run. Assuming everything has been set up correctly, you should see the app has launched to your headset.

Controls:

- Movement
 - You can move your head, and walk around to move within the environment if you have room barriers set up so that your headset warns you before you walk into an obstacle.
 - It is recommended for moving longer distances to use your right-handed controller's thumbstick (or touchpad on the Vive). Pressing forward will move the camera in the direction you are pointing your controller, **not** the direction you are looking in and **not** the direction you push the thumbstick.
- Viewing
 - The camera's view entirely depends on the direction your headset is facing. Turn your head to look at what you want to see, just as you would without the headset on.



- Changing displayed scan
 - At launch, the camera will be placed at the west end of the North section of the building with the 3D meshes for Scan 1, the first collected scan of the project, in view. The South end scans are placed a distance away from the North scans, relative to where you would expect them to be in the real world. In order to change which scan you are viewing, press the “trigger” on your right-handed controller, the button your pointer finger is most likely already resting on. One press changes the displayed scan up by one. Scan 1 will shift to Scan 2, etc. and once the last scan is reached, the display will return to Scan 1.
- Displaying point cloud
 - By default, for the sake of performance on lower-end hardware, the meshes will be displayed for all of the scans. The point cloud versions of the meshes created by the Matterport are included in the application and can be switched to display at any time using the “grip” button on your right-handed controller. You can find this button sitting near or under your middle finger and/or index finger. Alternatively, the spacebar on the keyboard attached to the device running the application can be used to switch between the two.