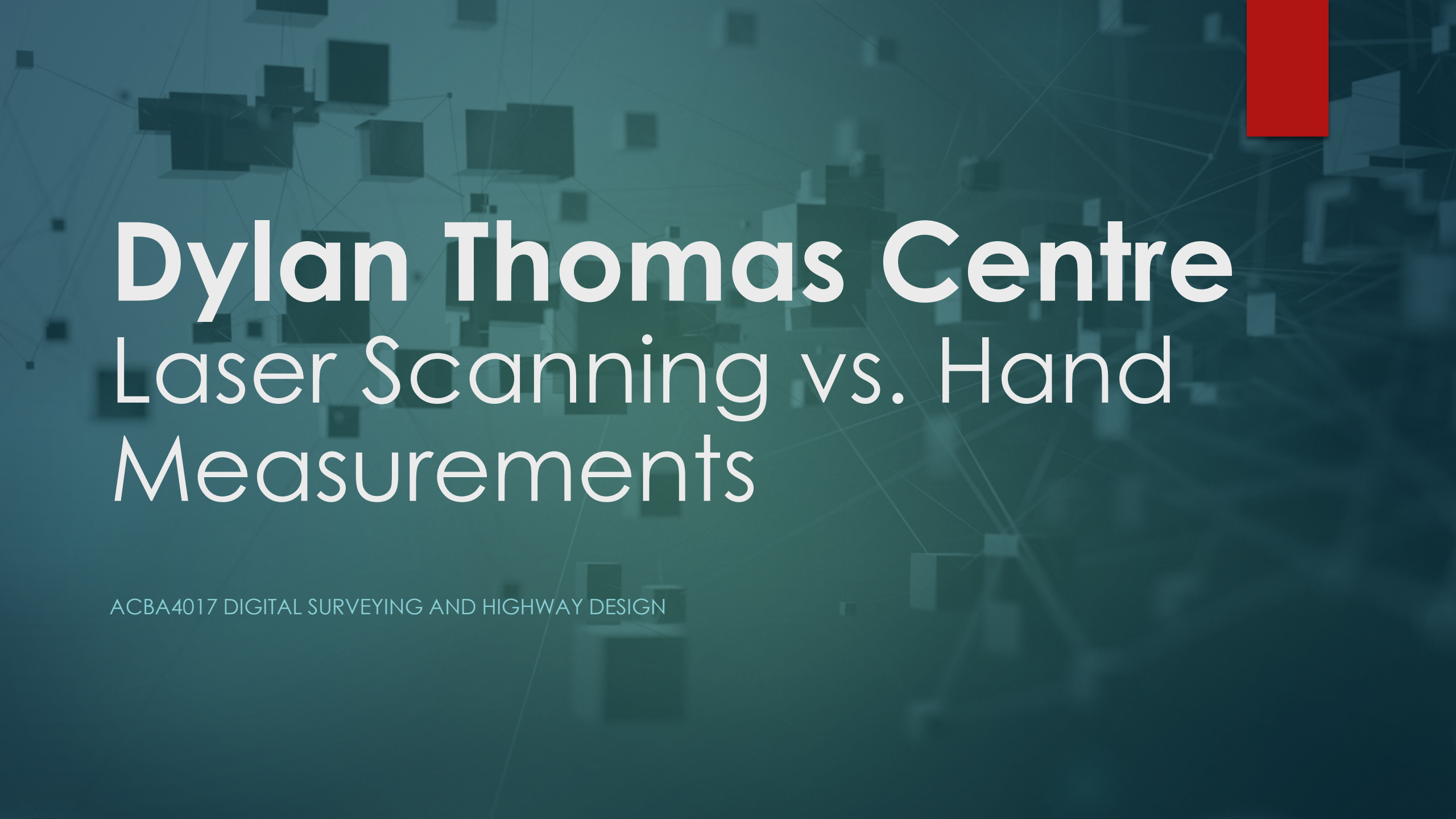




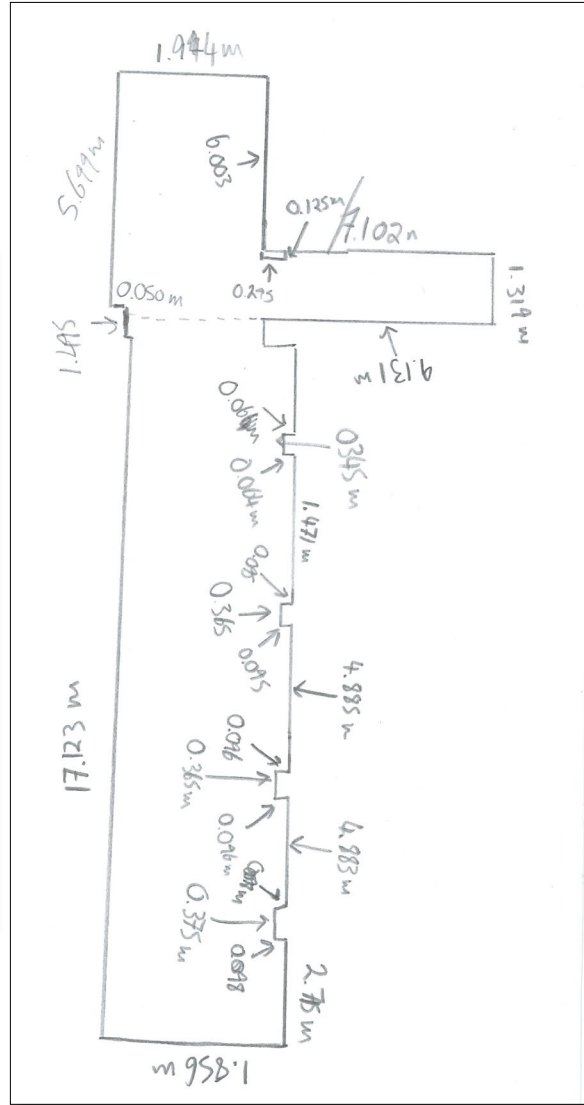
Dylan Thomas Centre

Laser Scanning vs. Hand Measurements

ACBA4017 DIGITAL SURVEYING AND HIGHWAY DESIGN

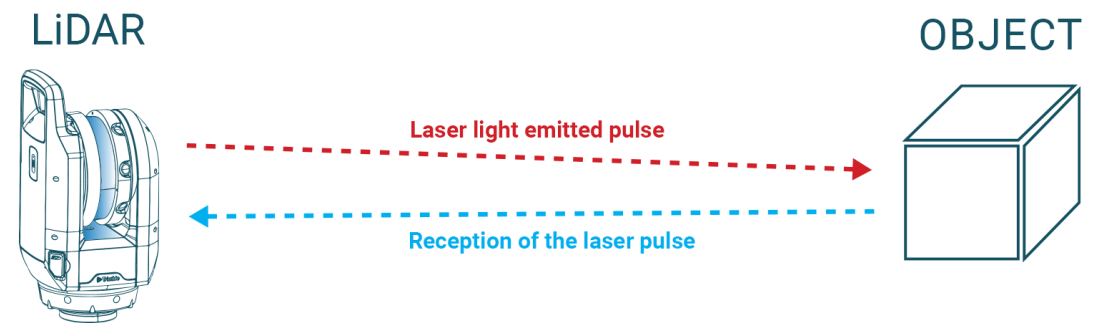
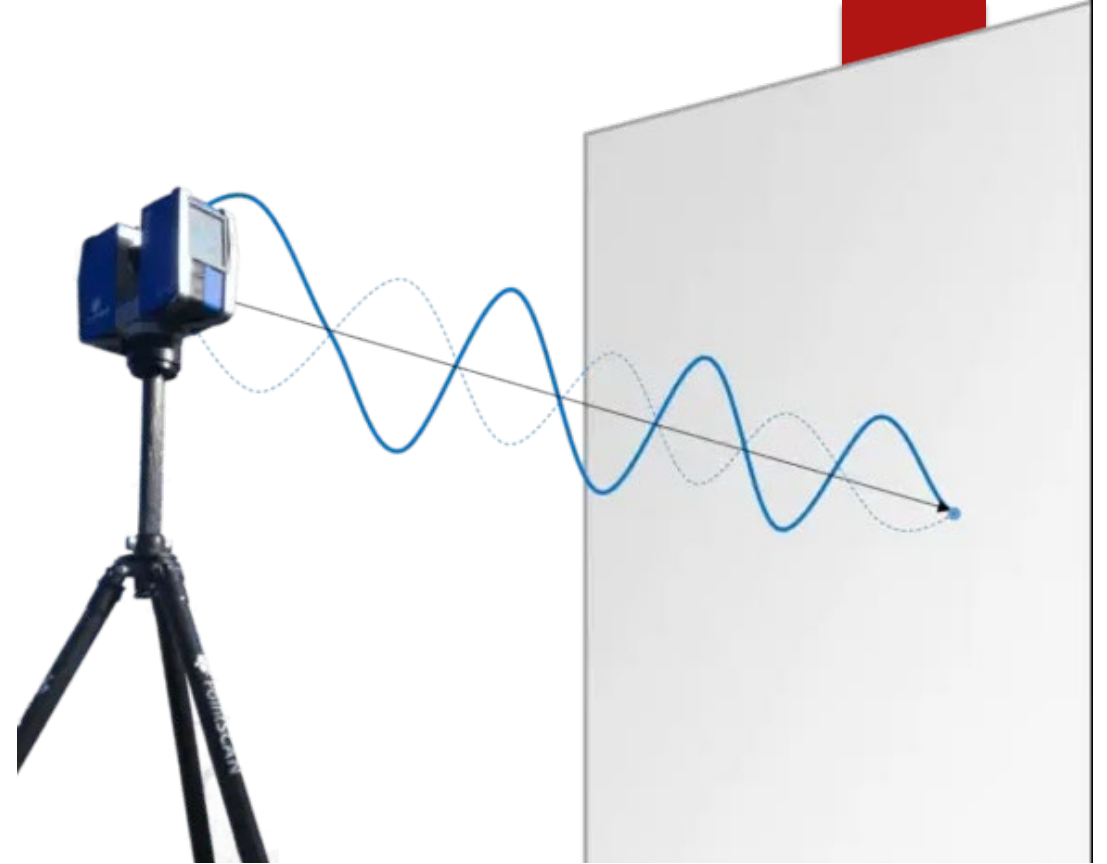
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- [illegible]



How Laser Scanners Work

- ▶ Laser Scanners fire out laser pulses that are then reflected off surfaces back into the device.
- ▶ The device measures the time it takes for these laser pulses to be reflected back.



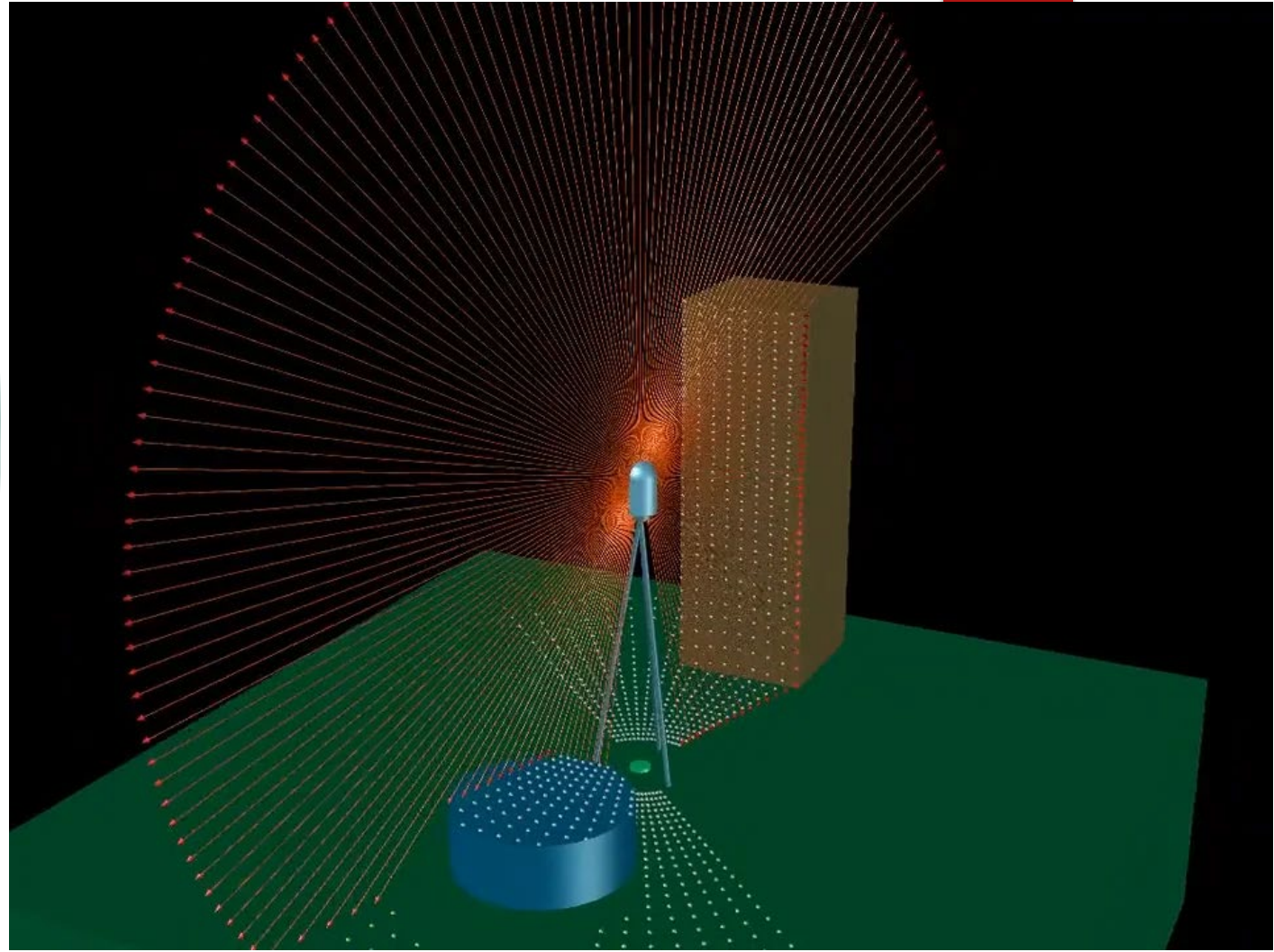
Laser pulse travelling at speed of light

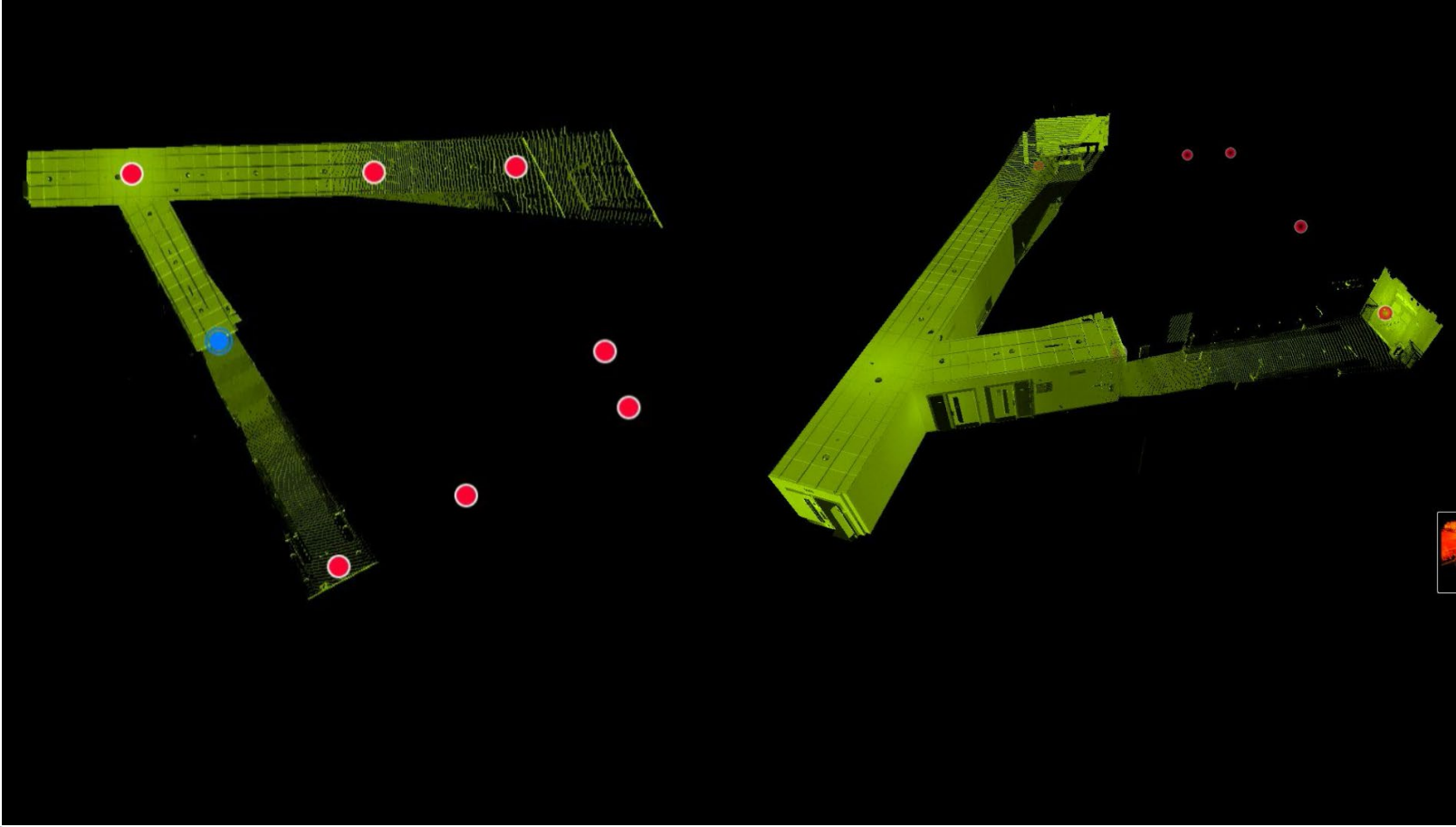
$$distance = \frac{c \times t}{2}$$

The speed of light is known and invariant

How Laser Scanners Work

- ▶ The device also knows the angle at which it emitted these laser pulse received the reflected pulse back.
- ▶ With these two measurements it can generate a point representing a physical object.
- ▶ By emitting millions of laser pulses these points can start to accurately 3D model an environment – creating a *point cloud*.
- ▶ This is also broadly known as LiDAR [Light Detection and Ranging]





Scan and Stitch – Tripod Scanners

Scans from the Tripod mounted scanner (RTC360) are stitched together to create a unified point cloud.



Walk and Scan – Handheld Scanners

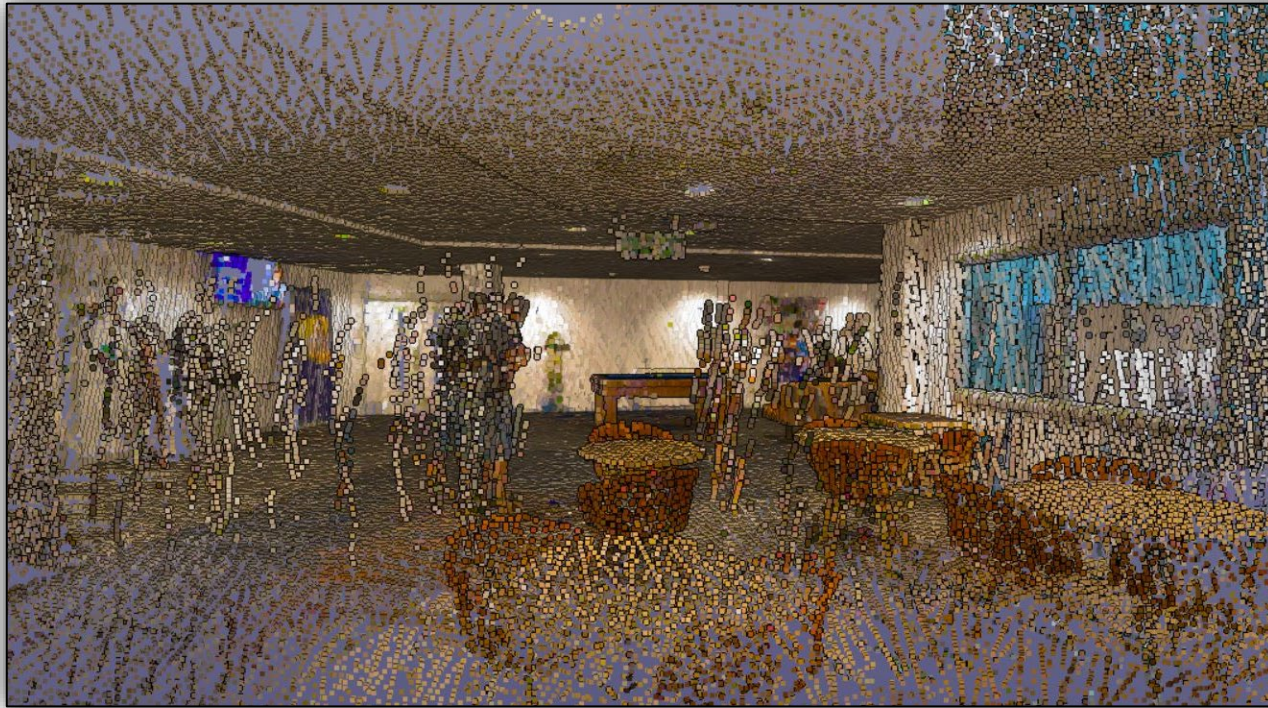
Handheld Scanners (BLK2GO) simultaneously track position and collect data.

A unified point cloud is generated, and alignment cannot be corrected or refined.



Speed of Capture vs. Data Quality

Handheld scanner (**BLK2GO**) enables rapid data capture with trade-off of point density, visual quality and accuracy compared to the tripod mounted scanner (**RTC360**).



Speed of Capture vs. Data Quality

Handheld scanner (**BLK2GO**) enables rapid data capture with the trade-off being lower point density, visual quality and accuracy compared to the tripod mounted scanner (**RTC360**).



Finalised Dylan Thomas Centre Dataset

297 scans with RTC360 capturing all accessible areas of the DTC.

All scan positions and alignments refined and optimized. Extensive data cleansing completed.

Raw point cloud of 9.3 billion points down sampled to a 10mm spacing to create a point cloud of 185 million points (~50x smaller)



Raw Dylan Thomas Centre Dataset

Raw data needed considerable processing to correct alignment errors and clean out 'noisy' data – particularly noise from reflective surfaces and windows.

35-40 hours on site scanning
~40 hours processing



Exterior

Link-Quality Matrix #1 -

	DTC- 2nd floor landing 001	DTC- Setup 001	DTC- Setup 005	DTC- Setup 002	DTC- Setup 003	DTC- Setup 007	DTC- Setup 006	DTC- Setup 008	DTC- Setup 009	DTC- Setup 010	DTC- Auditorium top 001	DTC- Setup 011	DTC- Setup 018	DTC- Setup 012	DTC- Setup 013	DTC- Setup 015	DTC- Setup 014	DTC- Setup 016	DTC- Setup 017	DTC- Setup 019	DTC- Setup 020	DTC- Setup 022 (2nd Floor Stairs B	DTC- Setup 023	DTC- Setup 097	DTC- Setup 021
DTC- 2nd floor landing 001	■	■																							
DTC- Setup 001	■	■																							
DTC- Setup 005	■		■																						
DTC- Setup 002		■		■																					
DTC- Setup 003			■		■																				
DTC- Setup 007				■		■																			
DTC- Setup 006			■				■																		
DTC- Setup 008					■			■	■																
DTC- Setup 009						■			■		■														
DTC- Setup 010							■			■	■														
DTC- Auditorium top 001								■																	
DTC- Setup 011									■			■													
DTC- Setup 018										■			■												
DTC- Setup 012											■			■	■										
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DTC- Setup 022 (2nd Floor Stairs B																				■					
DTC- Setup 023																					■				
DTC- Setup 097																								■	
DTC- Setup 021																									■

Overall Quality

Error Results for Bundle 1

Setup Count: 297
 Link Count: 326

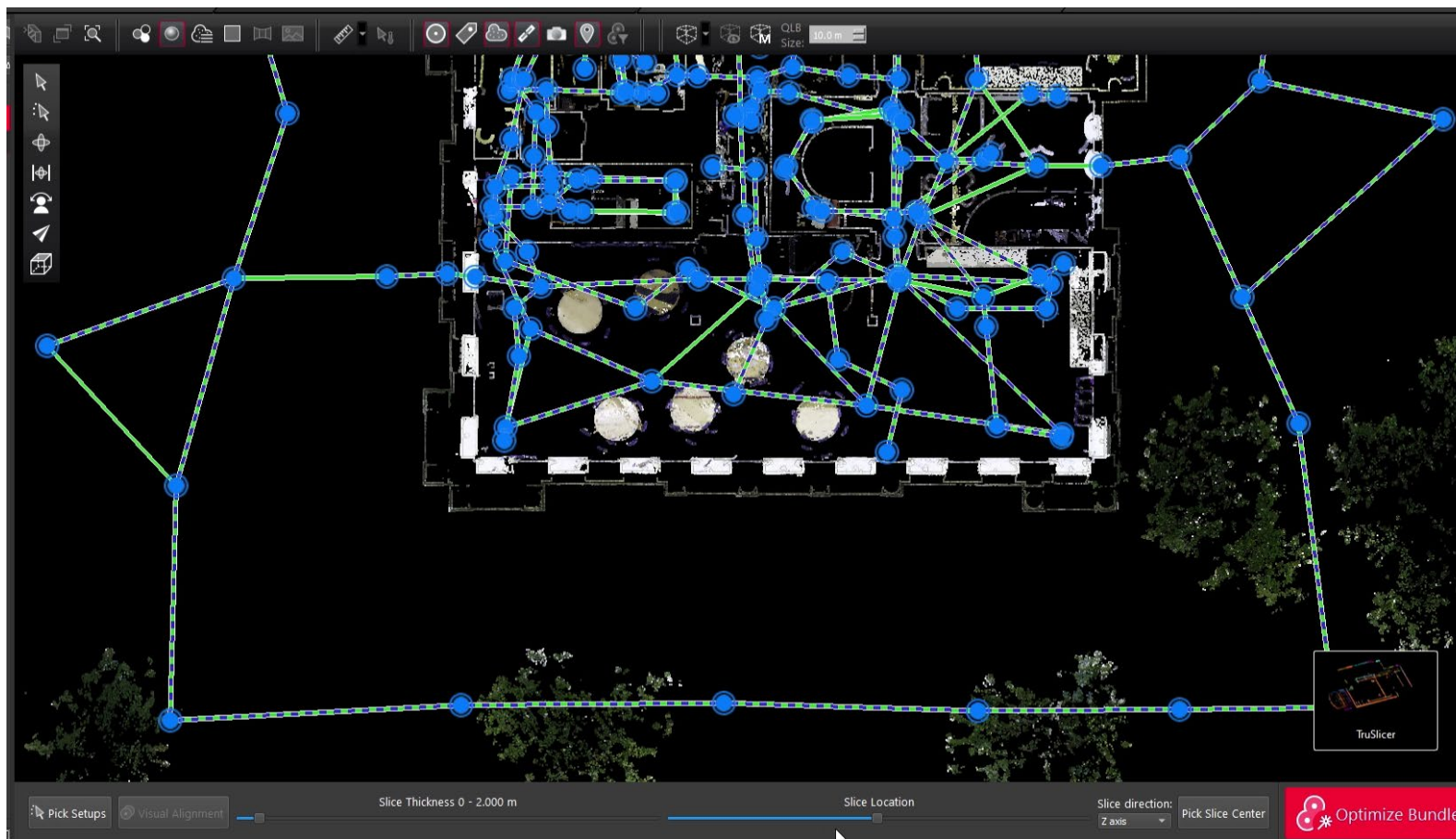
 Strength: 80 %
 Overlap: 69 %
 Global Bundle Error: 0.001 m

Bundle Error	
0.001 m	✓
Overlap	Strength
69 % ✓	80 % ✓
Cloud-to-Cloud	Target Error

Link Name	Setup 1	Setup 2	Overlap	Abs. Mean Error
Link 130	DTC- Setup 106	DTC- Setup 278	68 %	0.001 m
		Cloud to Cloud		0.001 m
		Target	Mean Target Error:	--

Link Name	Setup 1	Setup 2	Overlap	Abs. Mean Error
Link 132	DTC- Setup 107 (INTERNAL DTC door)	DTC- Setup 110	47 %	0.003 m
		Cloud to Cloud		0.003 m
		Target	Mean Target Error:	--

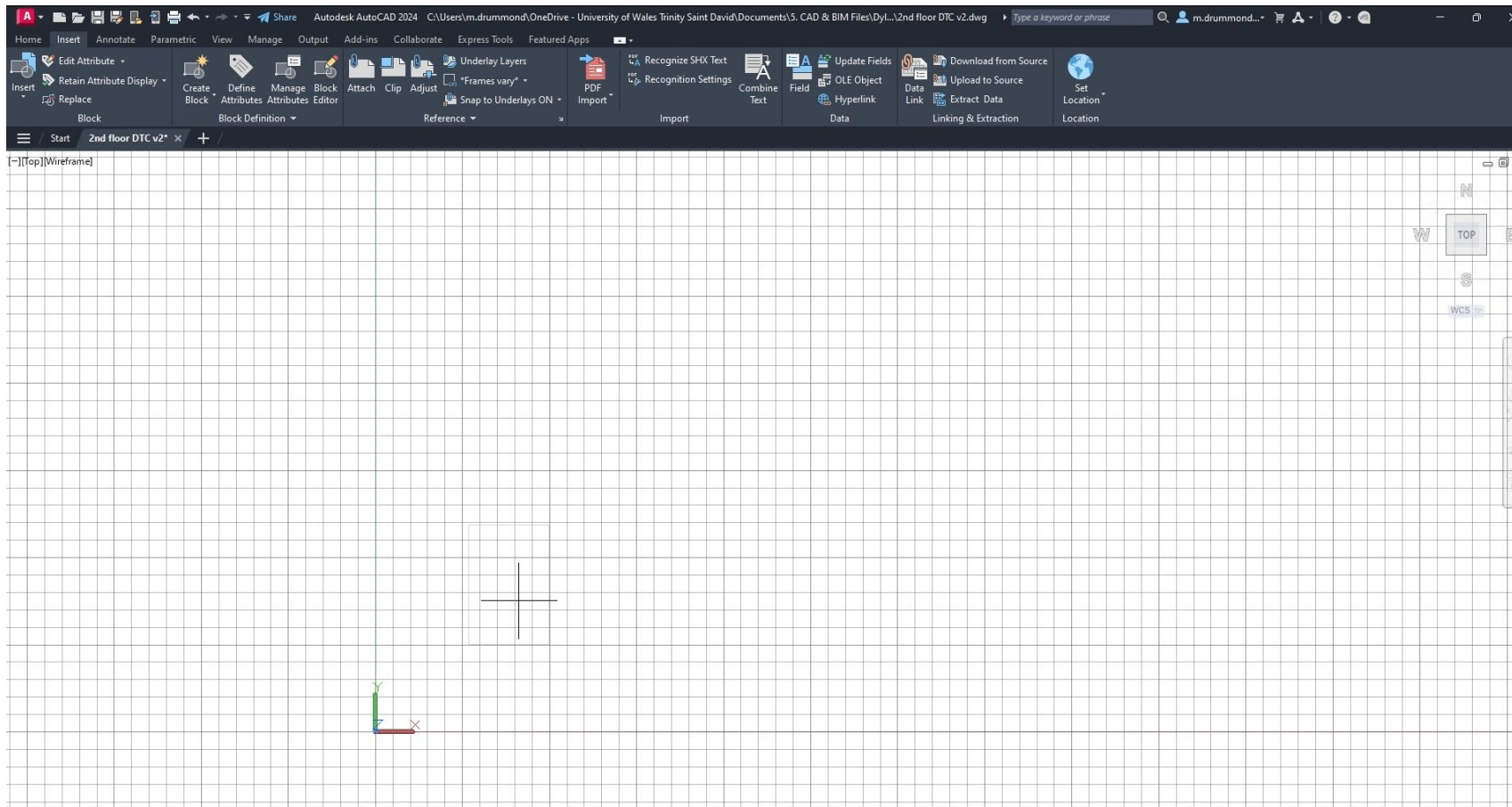
Link Name	Setup 1	Setup 2	Overlap	Abs. Mean Error
Link 133	DTC- Setup 108 (EXTERNALMain DTC door)	DTC- Setup 109	72 %	0.001 m
		Cloud to Cloud		0.001 m
		Target	Mean Target Error:	--



Visual Alignment Check

Checking alignment quality by visually inspecting the alignment of internal and external window mullions by viewing a slice in plan view.

There are 23 links separating scan 50 on the 2nd floor mezzanine, and the external scan 153.



DTC 2nd floor in AutoCAD

The 2nd floor of the DTC was isolated and imported into AutoCAD.

A thin slice of the point cloud approx. 100mm above floor level is created.

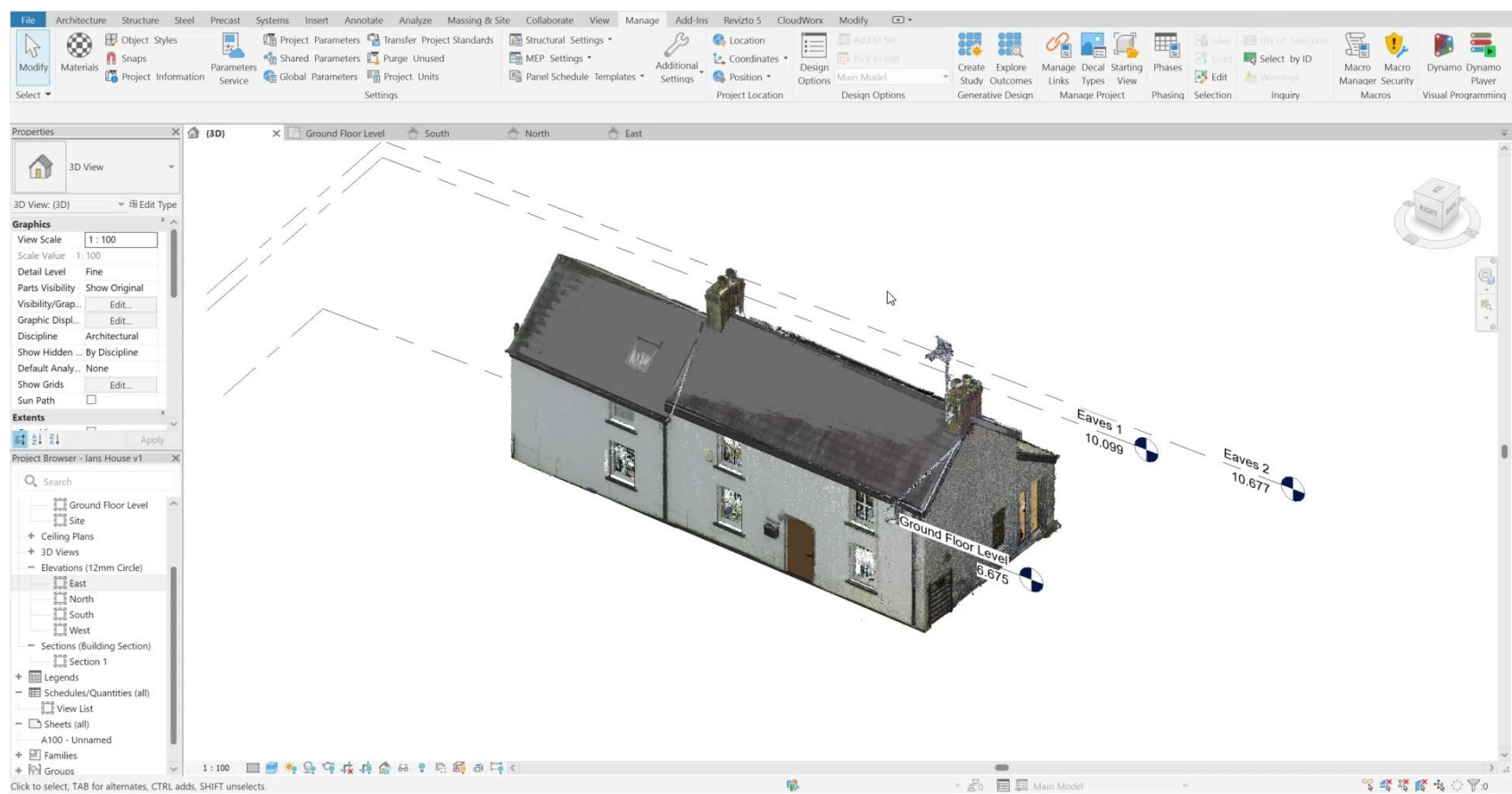
Using the Polyline tool walls and doors are draw.



3D Modelling of Point Clouds

Point clouds can be import into most 3D modelling software (Autodesk Revit in this video)

Using a range of plan and section views a 3D architectural model can be created using the standard Revit modelling tools.

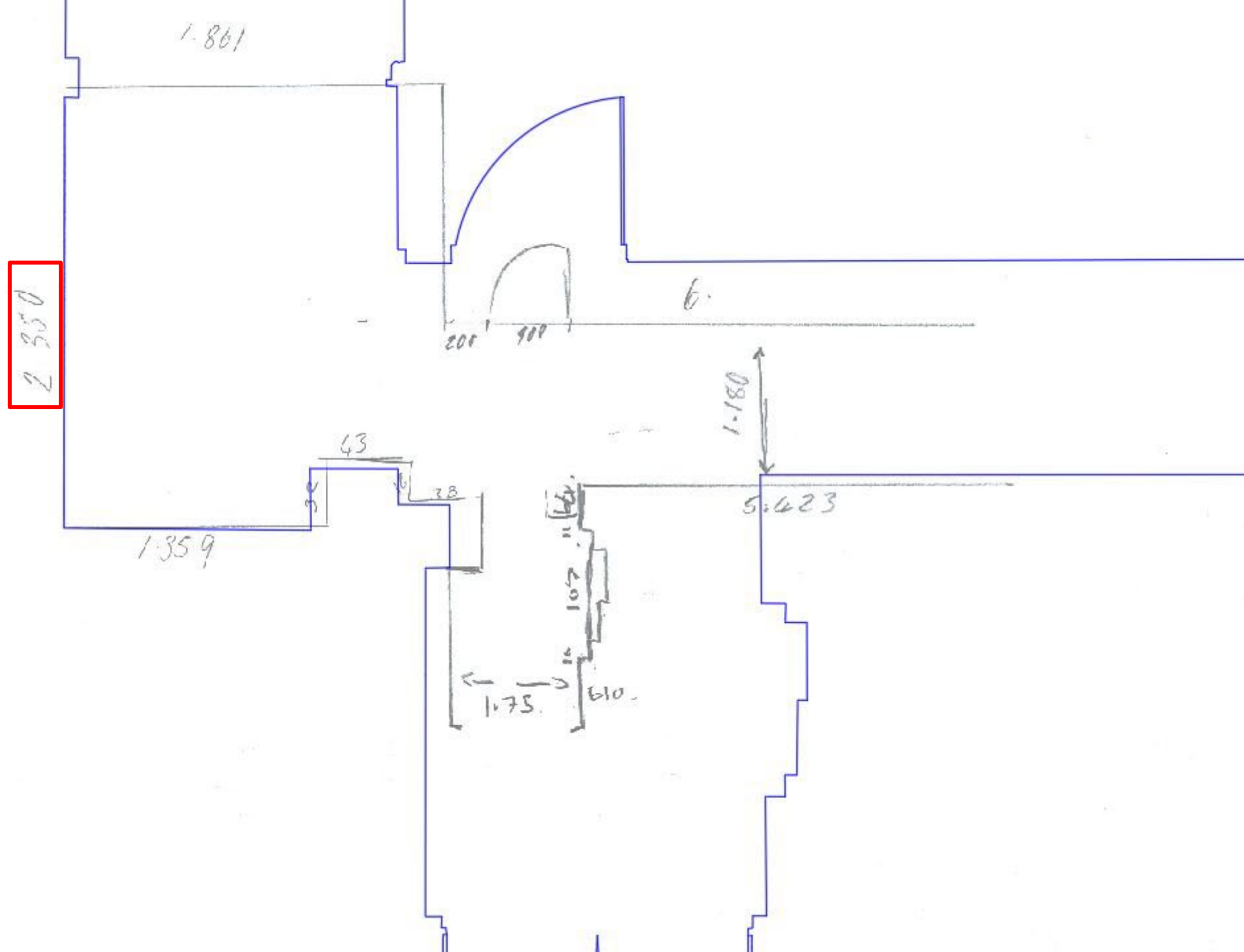


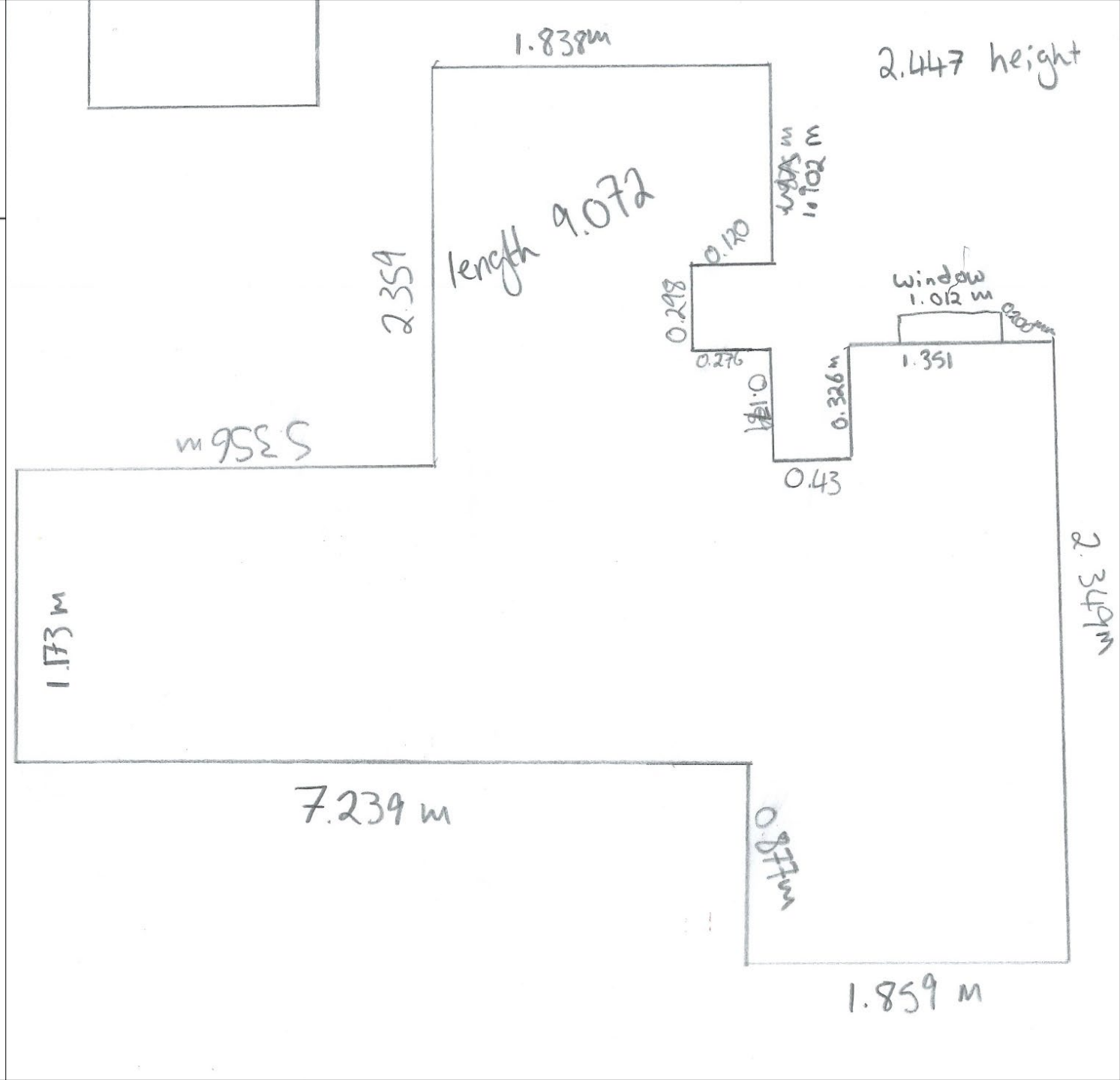
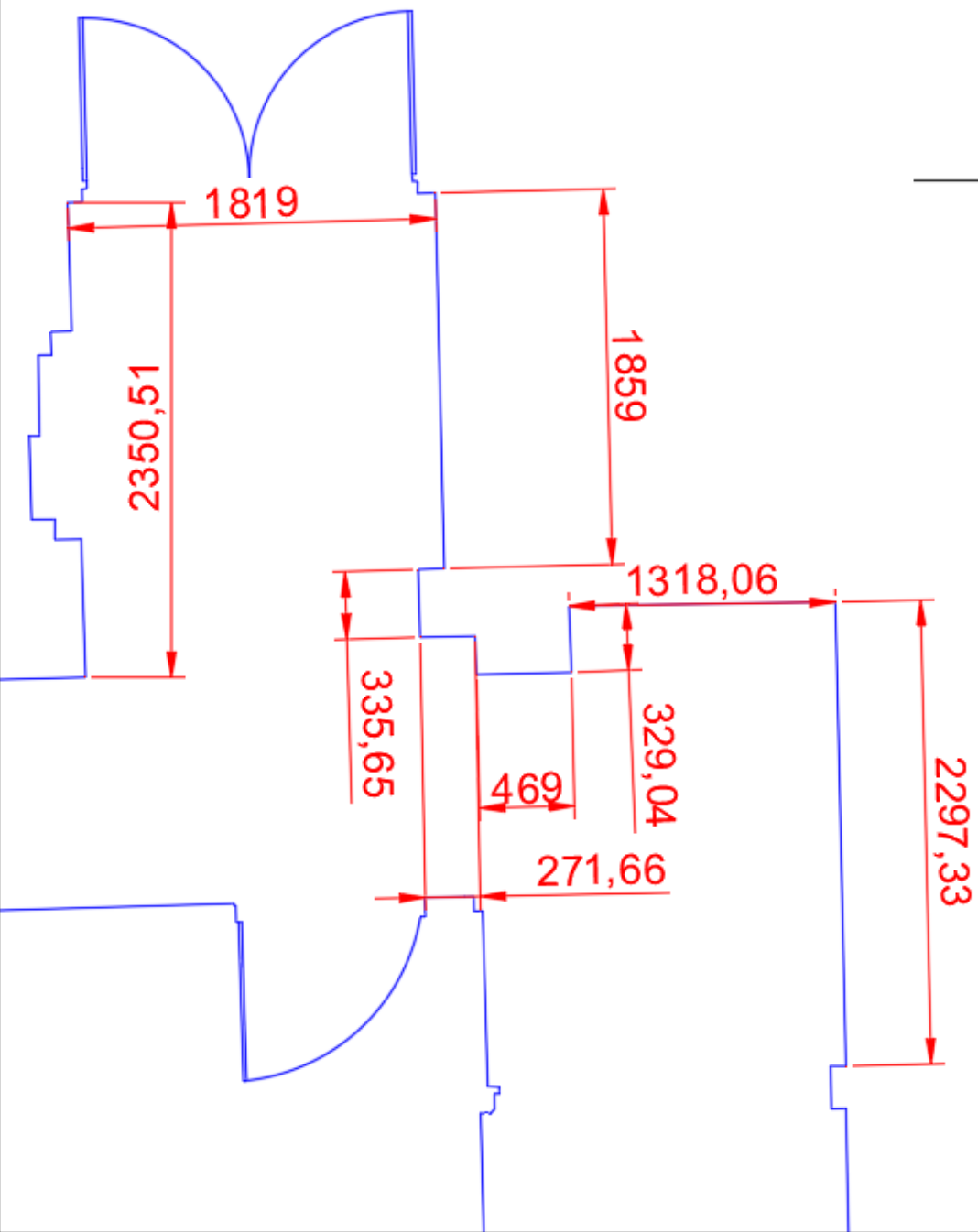
3D Modelling of Point Clouds

Annotated 2D plan, elevation and section views drawings can then be easily generated from the Revit model.

AutoCAD Point Cloud vs. Hand Measurements

- Hand measurements scanned and imported as TIFF into AutoCAD
- One measurement chosen to scale TIFF to a 1:1 and align with Scan derived drawing.







Reality Capture vs. Traditional Survey

A large and complex point cloud of a heritage building which has been 3D modelled in architectural modelling software (Autodesk Revit).

2D elevation drawings and floorplans can then be extracted from the 3D model.

A previous survey is shown to be inaccurate when compared against the laser scan derived data.

Overview

- ▶ Review of Laser Scanning Principles
- ▶ Appreciation of time required to scan and process a large building such as the Dylan Thomas Centre.
- ▶ Appreciation of the need to diligently review, clean and optimise alignment of scan data.
- ▶ Importance of both alignment quality report and visual quality inspection.
- ▶ Comparison of Scan derived floorplans and hand measured floorplans
- ▶ Lampeter project showcase