TERRESTRIAL LIDAR CAPABILITIES FOR 3D DATA ACQUISITION (INDOOR AND OUTDOOR) IN THE CONTEXT OF CADASTRAL MODELLING: A comparative analysis for apartment units

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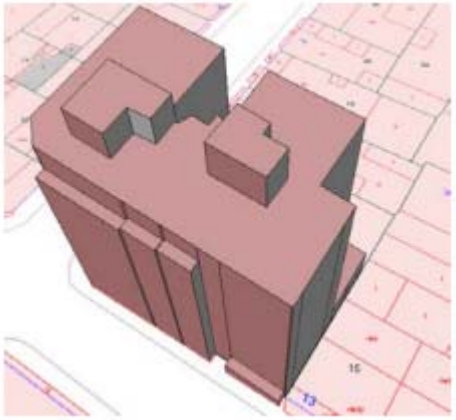
Do we need 3D “survey” data to build 3D cadastre model of apartment units?

- No
- We can used 2D data and simply extrude a constant H (height) or the value of an attribute
  - X,Y coordinates or the building footprint
- Ex: Spain, use parallelogram
  - sub parcels having a volumetric attribute floors placed over the ground floor.
- Ex. Portugal, CGA shape grammar



Extracted from Olivares Garcia 2011

Which are the 3D data used to build 3D cadastre model of apartment units?

- Floor height
  - Based on Earth surface or local surface
- Number of floors
- Vertical elevation of the Earth surface
- Vertical elevation (orthometric or ellipsoidal altitude) of all the floors
- Z coordinates of all the points delimitating the units
  - Indoor/outdoor, private and common
- *Volume of the legal 3D units*

What are the current survey instruments used to collect 3D cadastral data?

	Quebec Land Surveyors	
Survey instruments	**Today**	**In 10 years**
Distancemeter (laser rangefinder)	84%	78%
Measuring tape	76%	65%
Total station	71%	61%
GNSS/GPS	29%	39%
Terrestrial LiDAR (laser scanner)	8%	47%
Stereo-photography	2%	6%
Videogrammetry	0%	12%

Sept 2013, 49 participants
on about 250 land surveyors (20%)

Objective

- Identify the capabilities of terrestrial LiDAR instruments to survey apartment units to produce 2D plans and 3D models
  - Under the current specifications of the Quebec land administration authority

Methodology

- Compare with traditional survey instruments
- Survey two apartment units with both instruments
- Establish a list of comparing criteria
- Produce the 2D plans and 3D models based on the same specifications
  - Quebec land administration authority
- and compare…

Survey instruments

- Distancemeter
  - PCE-LDM 50
  - Precision of 5 mm

Survey instruments

- Terrestrial LiDAR (laser scanner)

	Callidus CP3200	FARO Focus 3D (Trimble TX5)
Year of commercialisation	1997 to 2006	2010 to now
Spec Field of view (H:V)	360:140	360:305
Spec Distance range	0.6 to 120 m	0 to 32 m
Spec Precision (distance of 50 m.)	5 mm	2 mm

Study sites

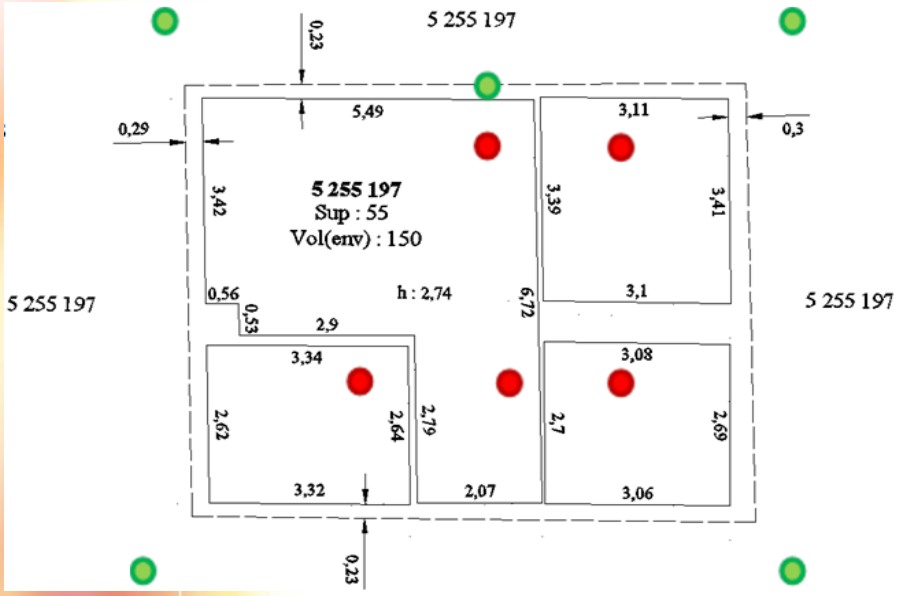
Site A

Site B

	Site A	Site B
Number of co-owners	2	2
Number of floors	2	2
Number of walls	16	49
Instrument	Callidus	Faro
Survey resolution	2 to 20 cm	2 to 20 cm
Number of scans	18	10
Number of surveyed points	562 544	24 350 000

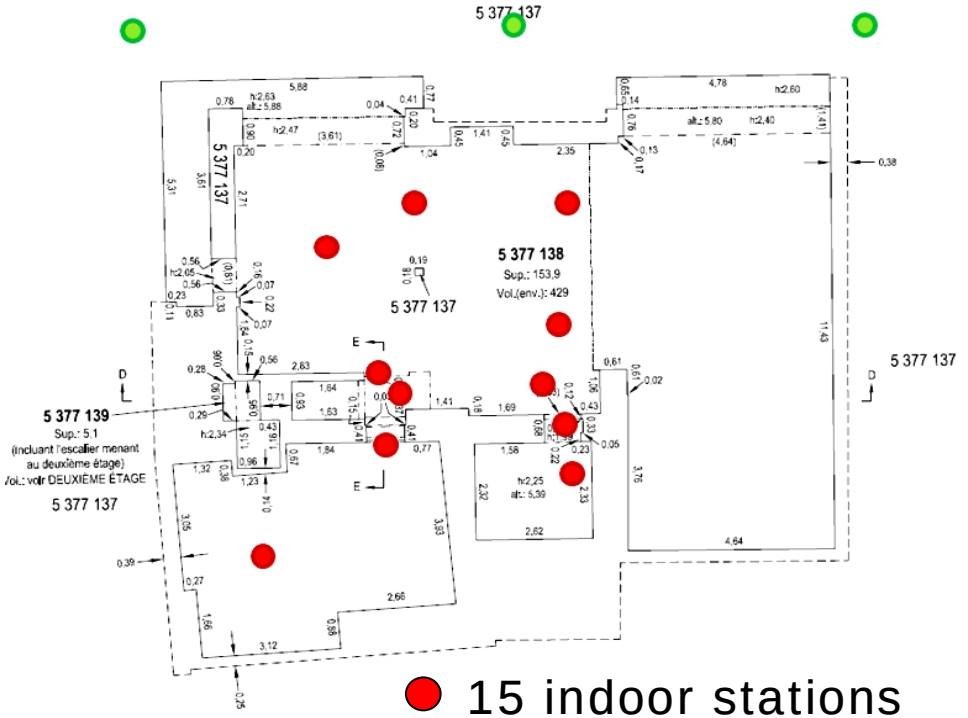
Study sites

Site A (1st floor)



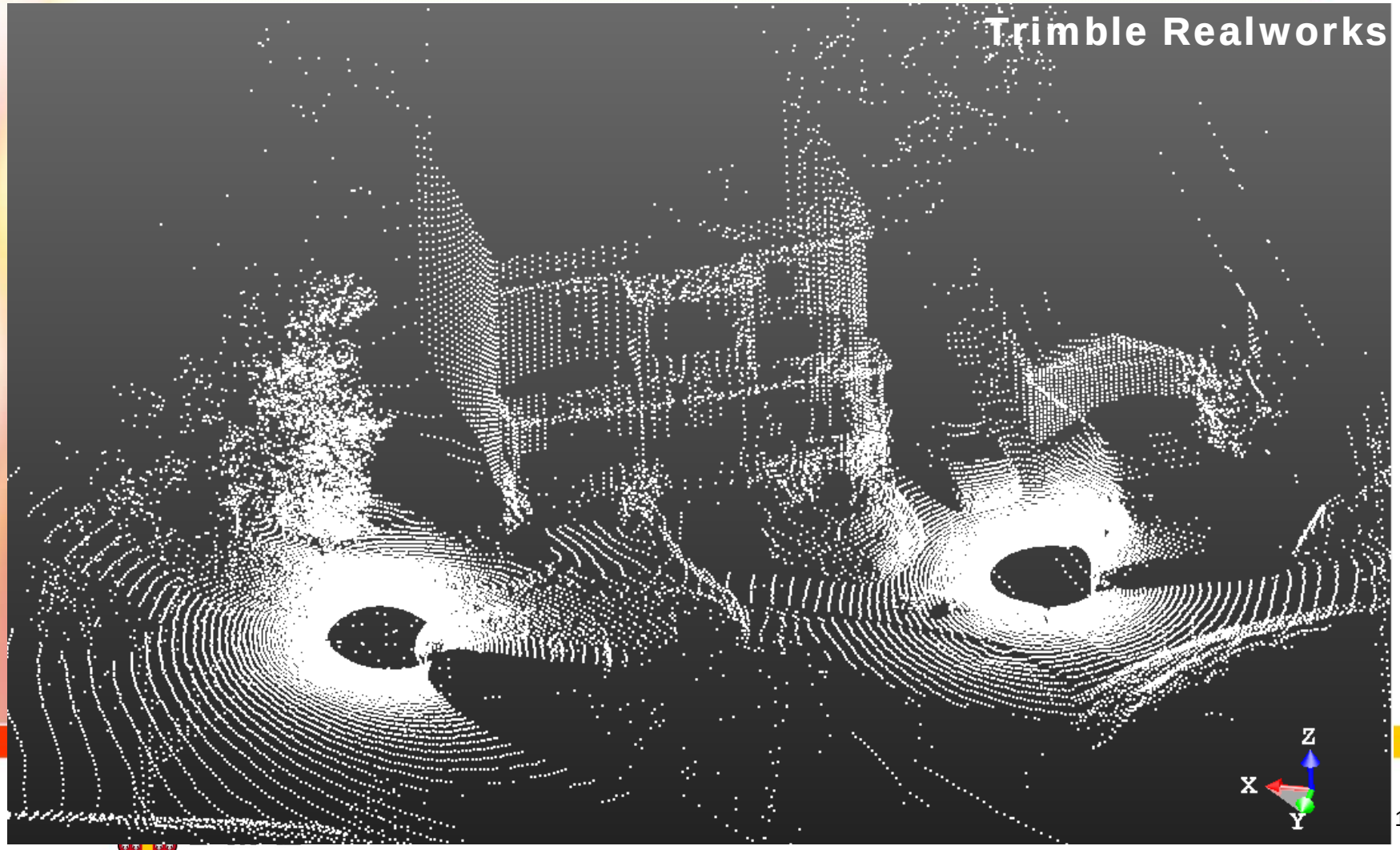
- 10 indoor stations
- 5 outdoor stations

Site B (1st floor)

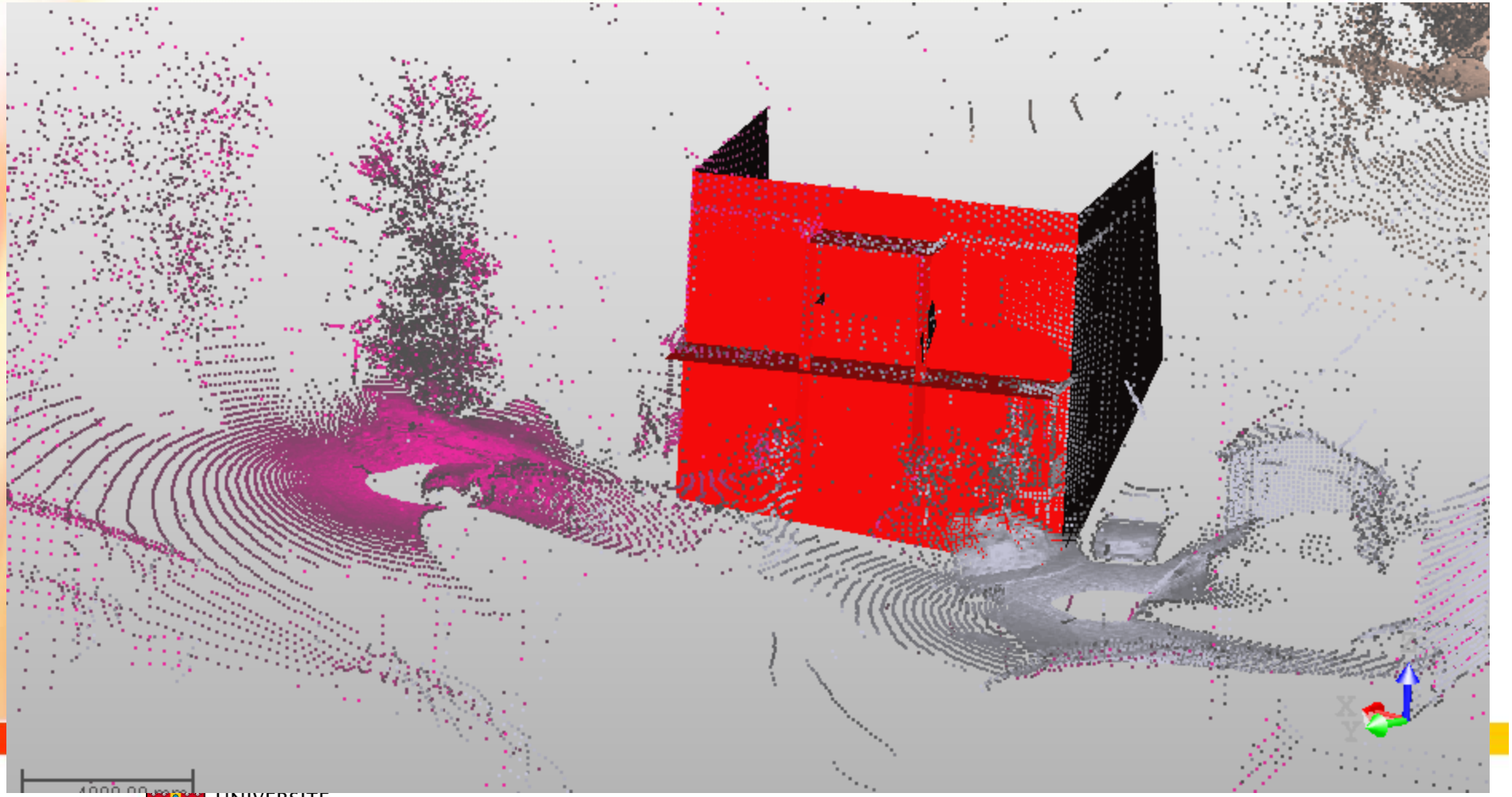


- 15 indoor stations
- 3 outdoor stations

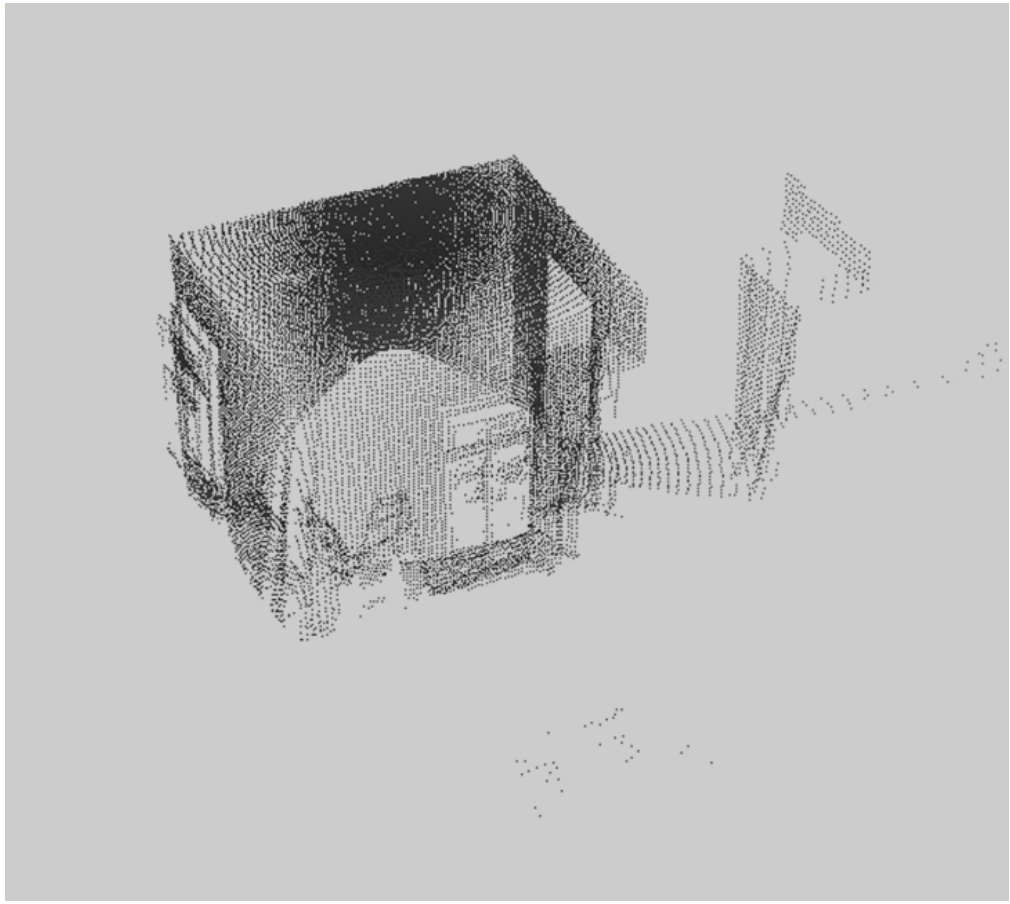
Site 1 – Example of points cloud



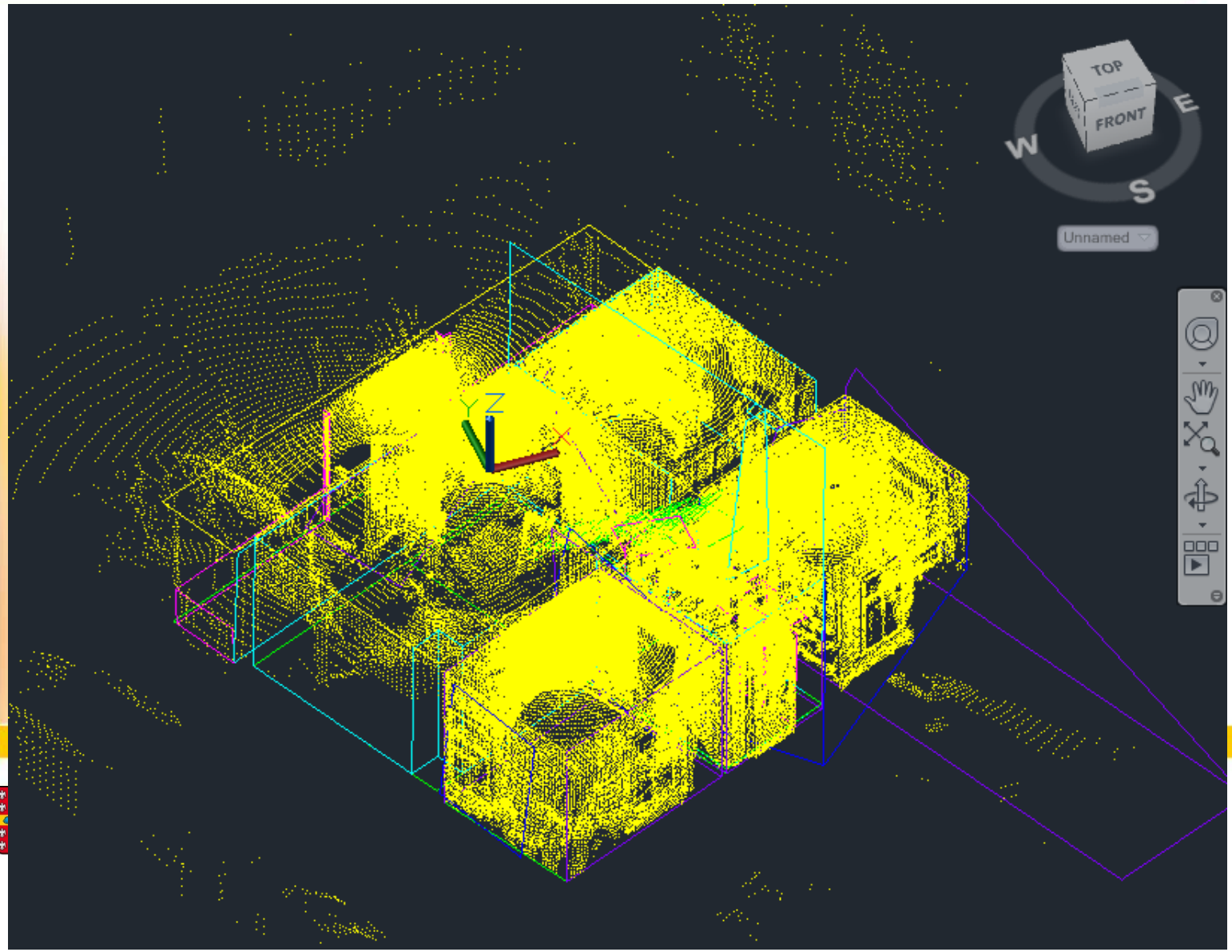
Site 1 – Scan #1 (Facade)



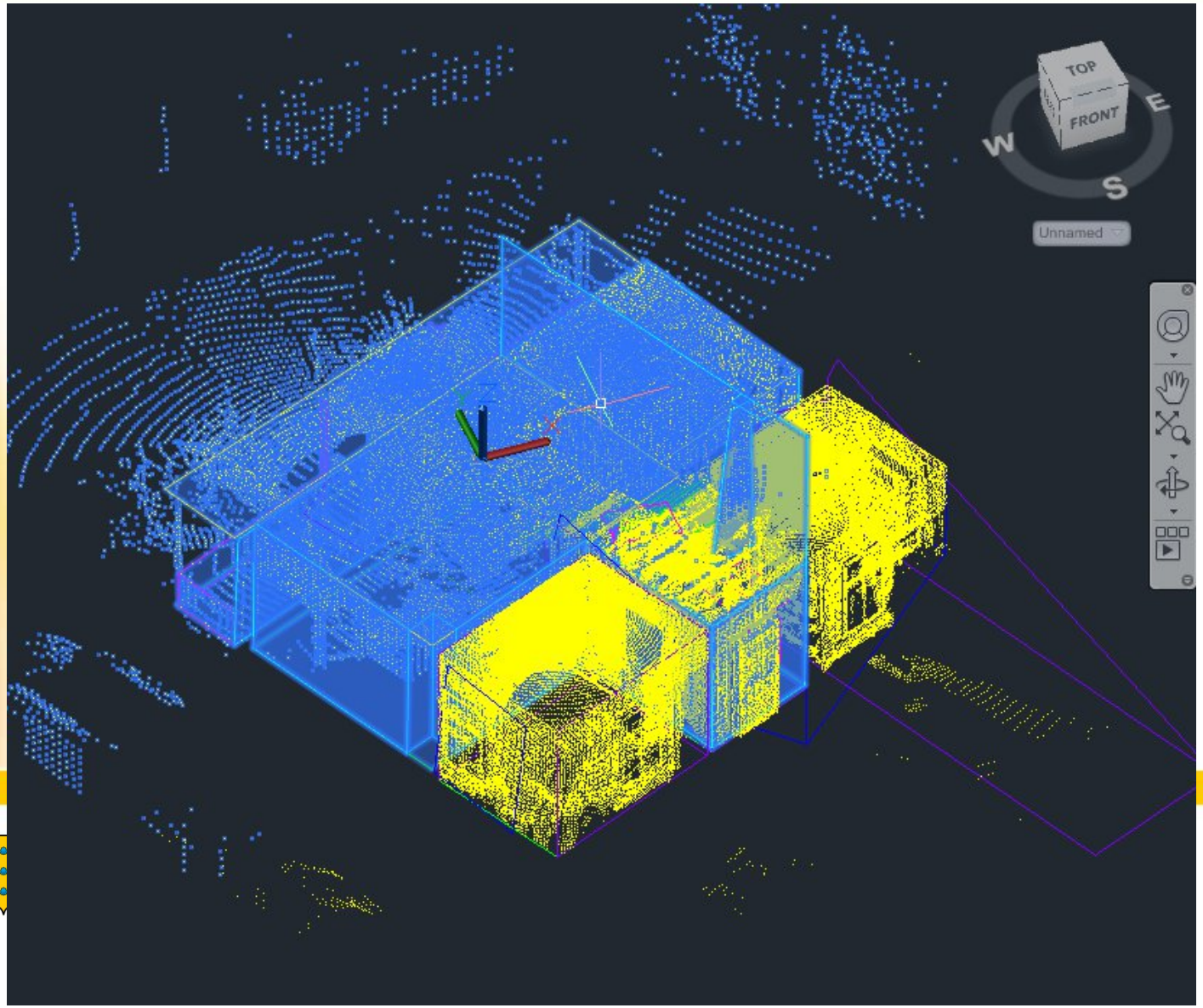
Site 1 – Scan #3 (inside)



Site 1 – Inside scan assembling

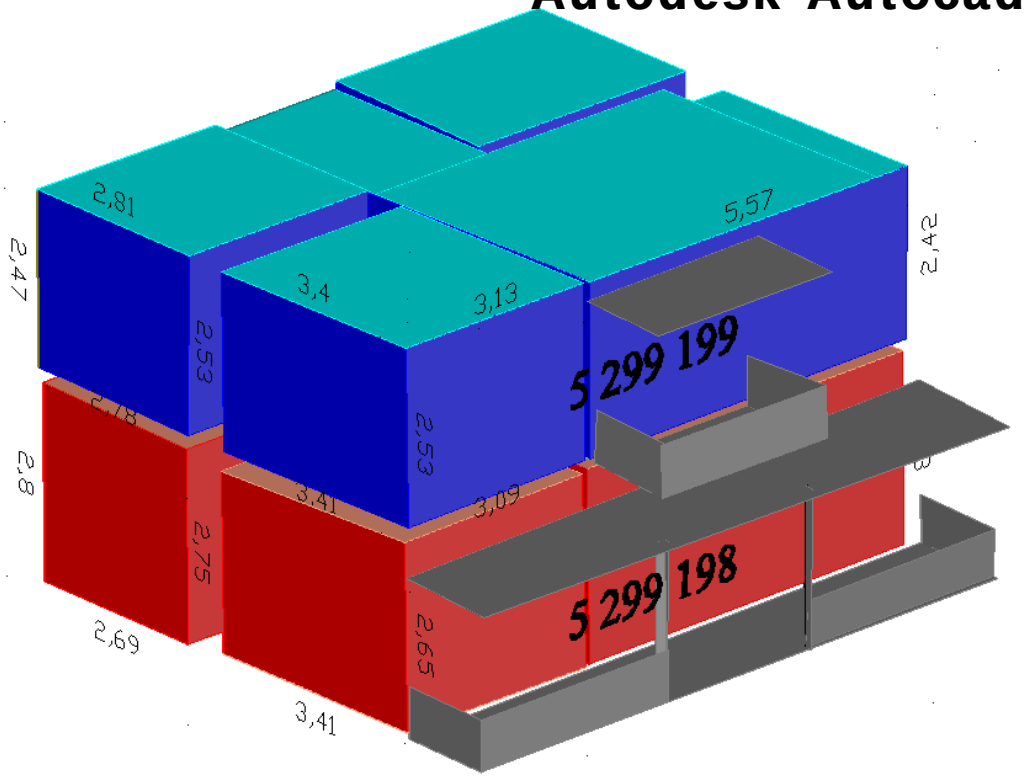


Site 1 – Inside scan assembling

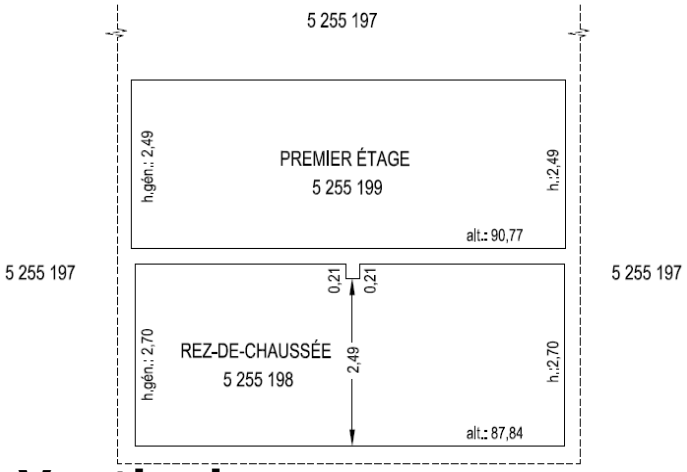


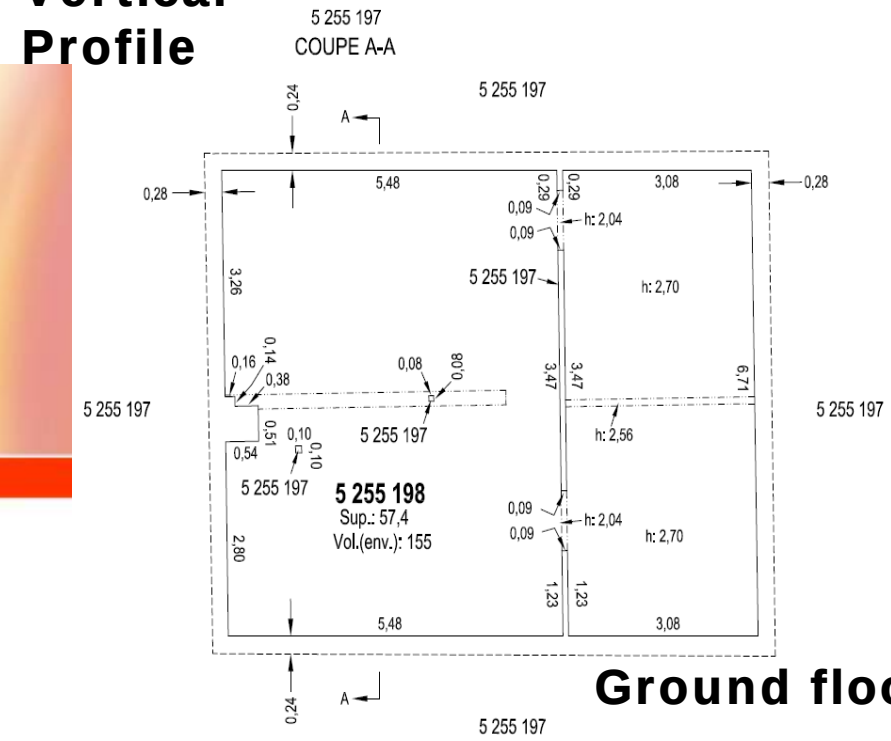
Site A

Autodesk-Autocad

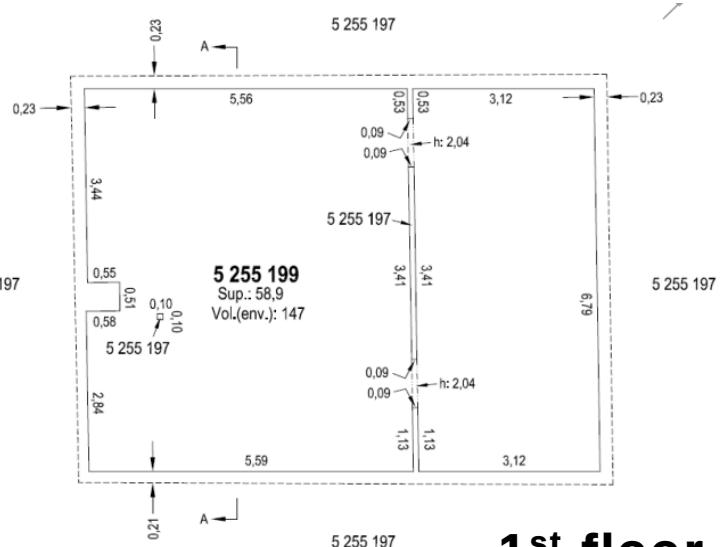


Vertical Profile





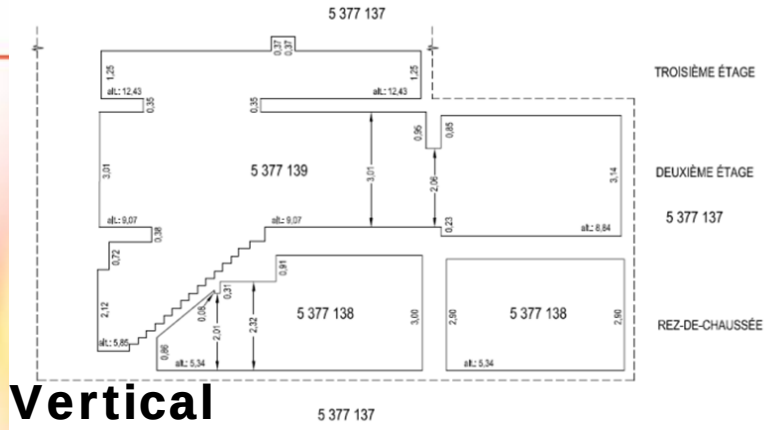
Ground floor



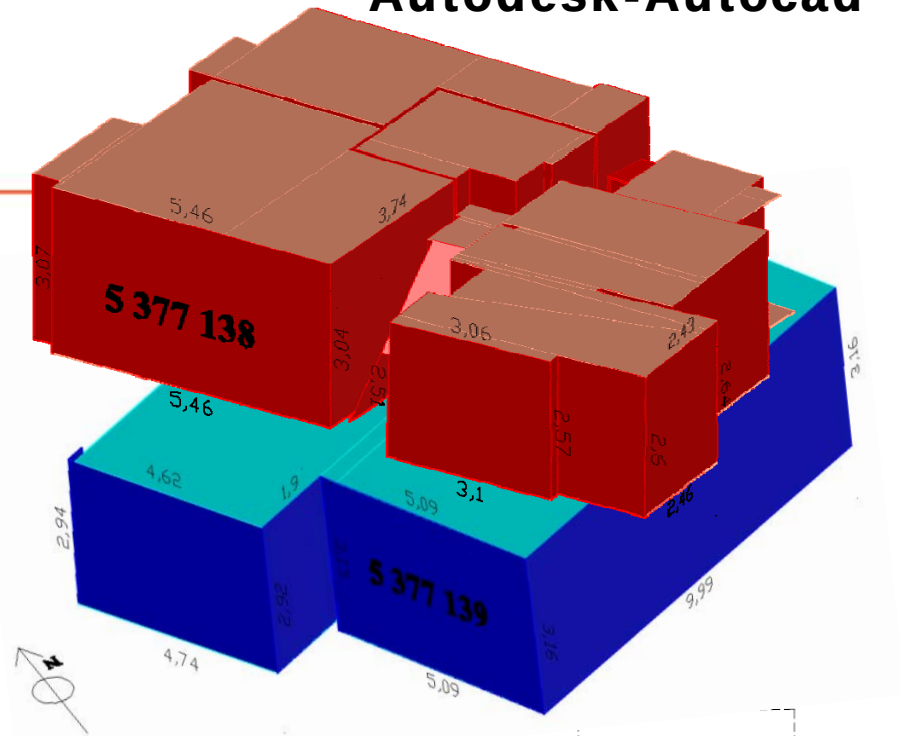
1st floor

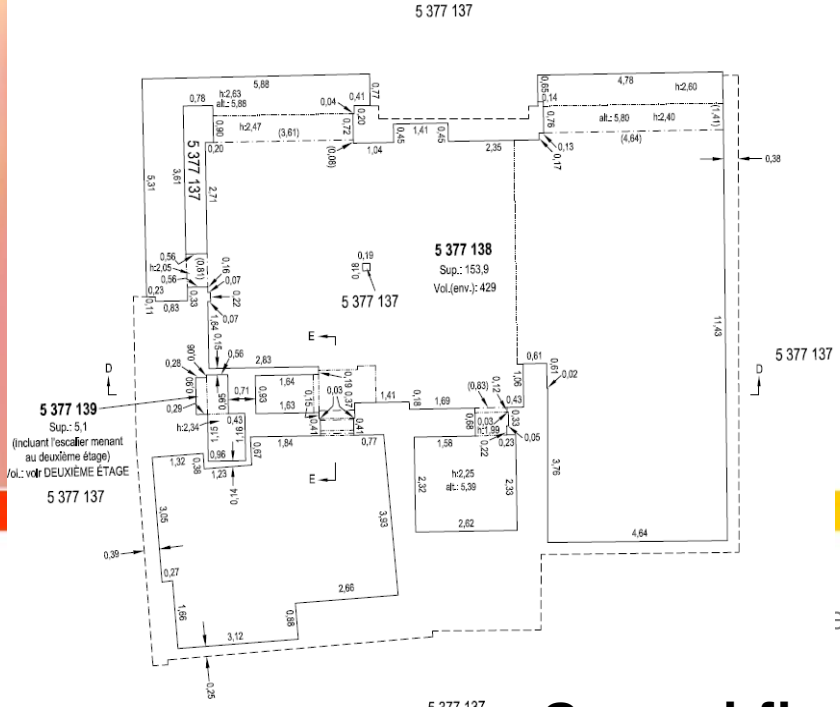
Site B

Autodesk-Autocad

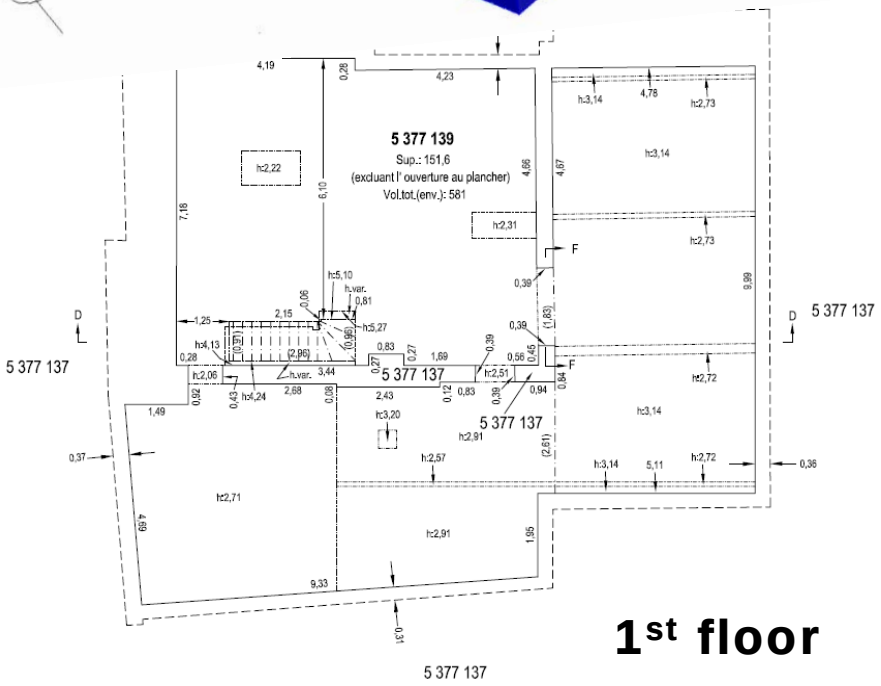


Vertical Profile





Ground floor



1st floor

Comparison

- Acquisition phase
  - Precisions were comparable (5 mm)

	Distancemeter	**LiDAR** (Faro;Callidus)
Survey duration	4h	4h ; 5.5h
Number of measures or scans	50	18 ; 10
Number of operators	1	1 ; 2
Estimated cost ($CDN)	400$	800$; 1500$

Comparison

- Modeling phase

	2D plan's production	
	Dist.meter	Faro;Callidus
Preprocessing time (Scan assembling)	1h	1h; 7.5h
Geometric modelling of all objects	4h	7h; 7h
Completeness (number of objects collected/required)	100% (49/49, 16/16)	100% (49/49); 160% (26/16)
Estimated cost ($CDN)	600$	1200$; 1800$

Comparison

- Modeling phase

	3D model's production	
	Dist.meter	Faro;Callidus
Preprocessing time (Scan assembling)	1h	1h; 19h
Geometric modelling of all objects	5h	1.5h; 15h
Completeness (number of objects collected/required)	125% (20/16)	150% (76/49) ; 400% (64/16)
Estimated cost ($CDN)	700$	600$; 5000$
TOTAL cost ($CDN)	1 700$	2 600$; 8 300$

Discussion – Acquisition phase

- Comparable results
  - Survey duration
    - BUT dependent on the scan speed, the number of scans and the view angle per scan
    - The objects obstruction and occlusion
- Dissimilar results
  - Cost (50% more expensive with LiDAR)

Discussion – Modelling phase

- To produce 2D maps
  - Need more software expertise for LiDAR
  - Cost (50% more expensive with LiDAR)
  - Duration (100% slower with LiDAR)
  - Completeness (10% more objects with LiDAR)

- To produce 3D models
  - Cost (10% less expensive with LiDAR)
  - Duration (100% faster with LiDAR)
  - Completeness (30% more objects for LiDAR)

Discussion

- To be considered:
  - Number of objects to model
  - Geometric complexity of the objects
    - LiDAR point cloud offers the possibility of producing more detailed 3D model (i.e. containing not only cadastral limits)
- Recent LiDAR technology like the Faro instrument obviously shows better results compare to older system like the Callidus
- Are these results comparable for city building (LiDAR acquisition and modeling)?

Discussion

- Two modes of acquisition
  - Object oriented (Distancemeter) vs Space oriented (LiDAR)
- The distinction between the boundary of the physical objects and the administrative limits is determined :
  - During the survey (on the field) = Distancemeter
  - During the modeling phase = LiDAR
- This distinction is important and result from the opinion of an expert
  - Where is the expert in those processes?
  - The LiDAR scans what he see... The Distancemeter measures what the human needs...

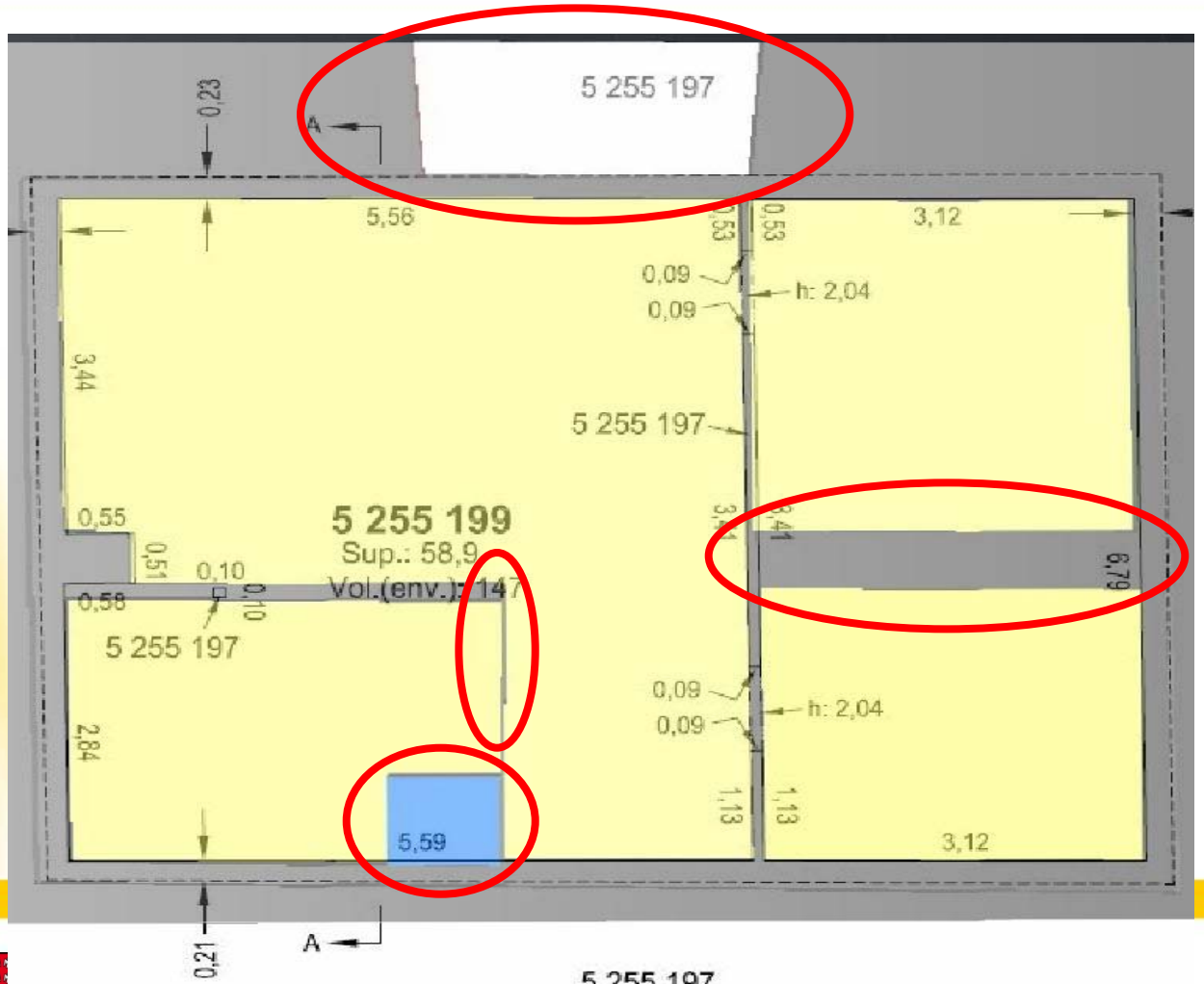
Next

- Need more tests
  - Have complex building
  - Focus on 3D modeling and quality control aspects (scan assembling, removing noise, surface reflection, etc)
  - Processing point clouds (have the good software)
- Procedural reports
  - How to collect data (which) , How to model data

Acknowledgement

- Groupe VRSB (M.Bédard; G.Langlois)
- Professional Association of Land Surveyors
- Trimble (D.Marcoux; D.Laflamme)
- S. Daniel (professor Ulaval)

Example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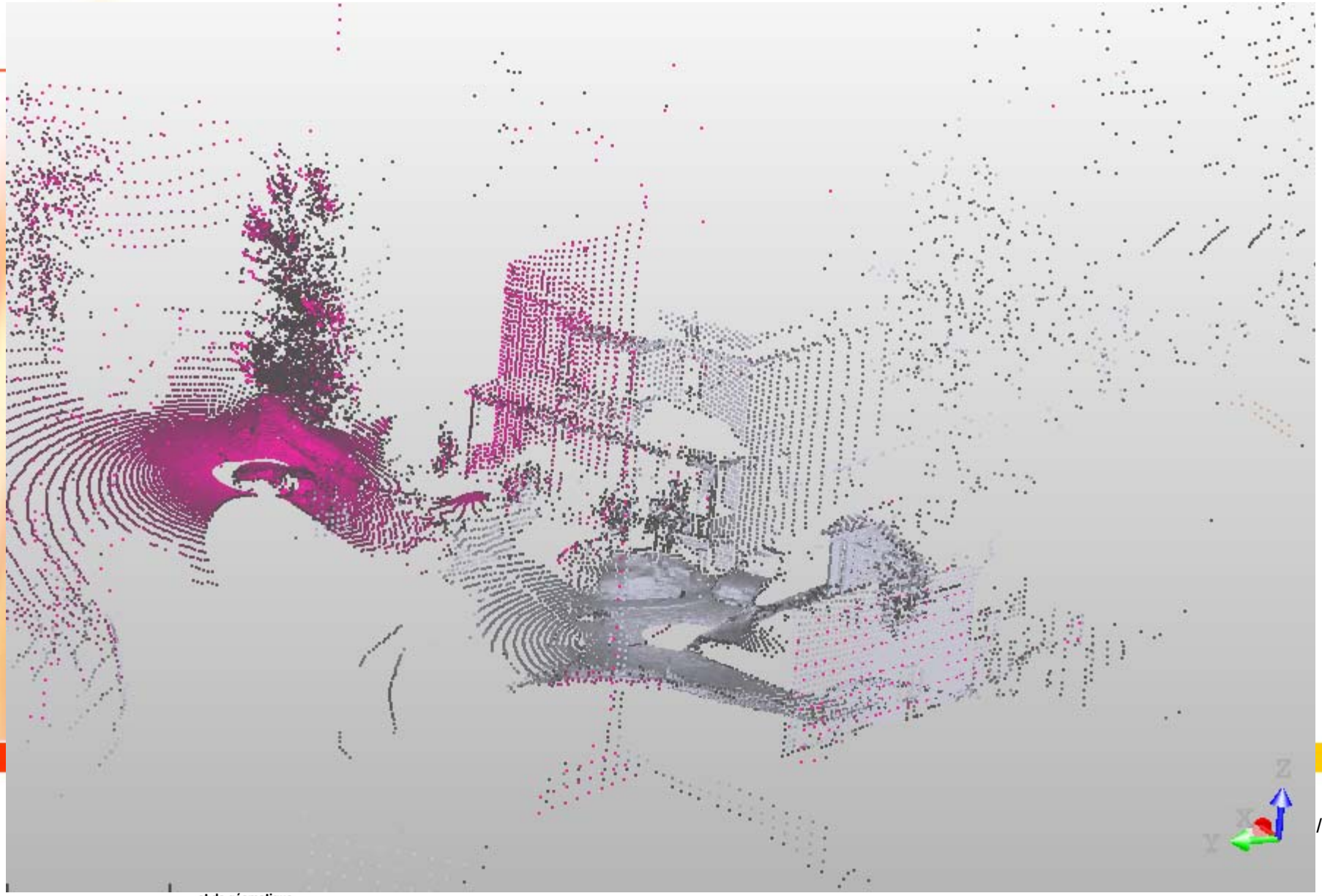
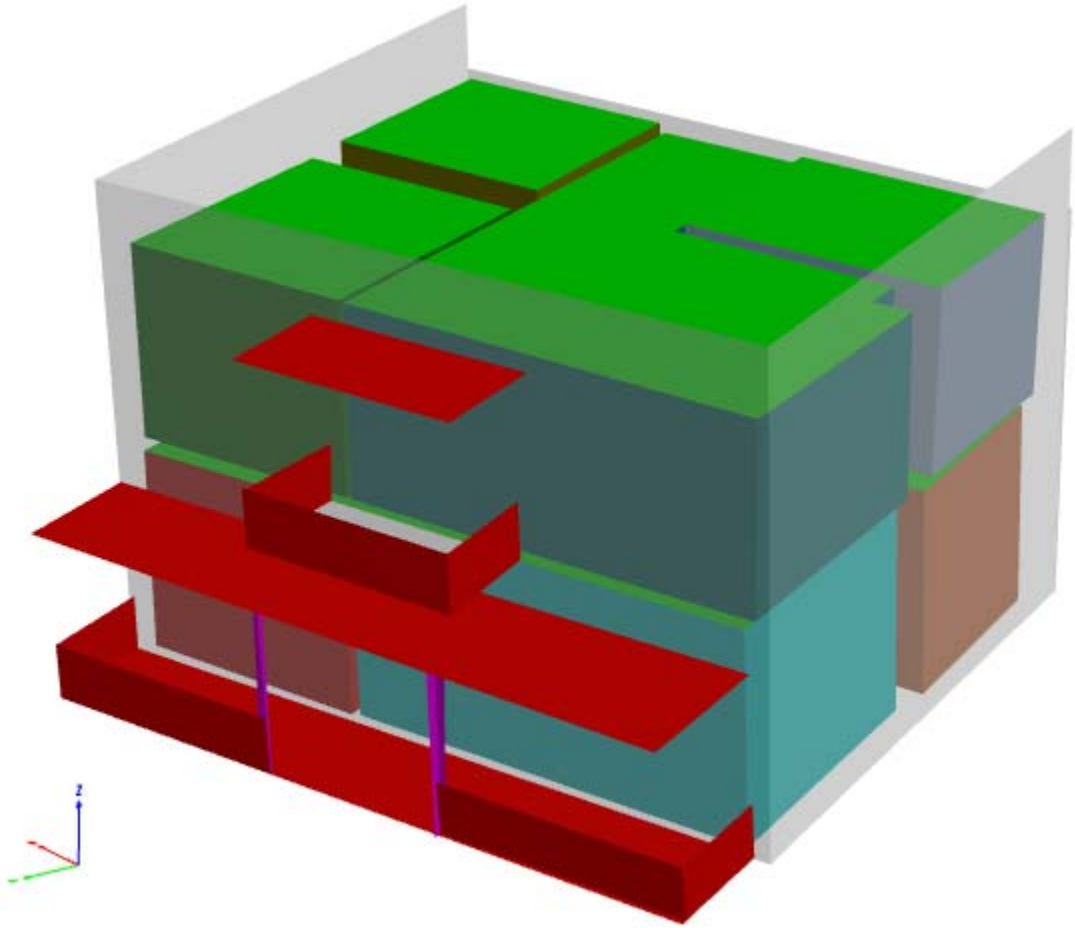


Data acquisition procedure

- to walls, ceilings, floors, stairs



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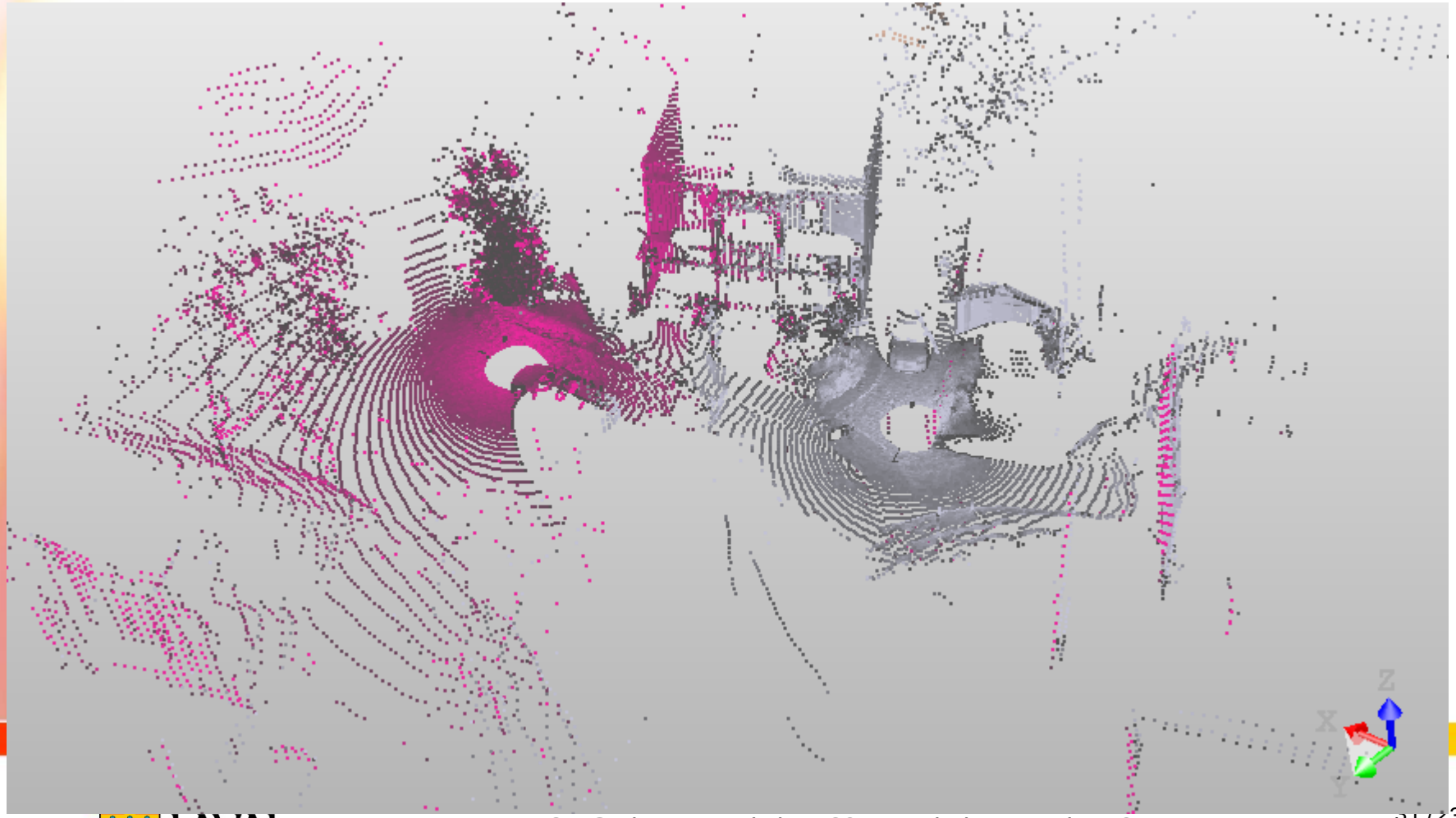
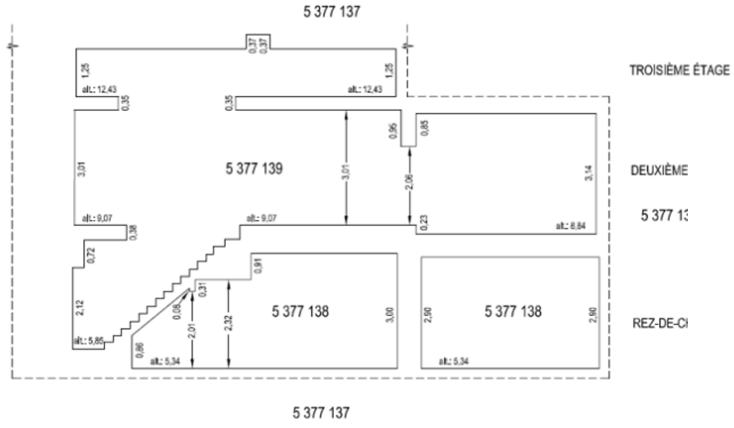
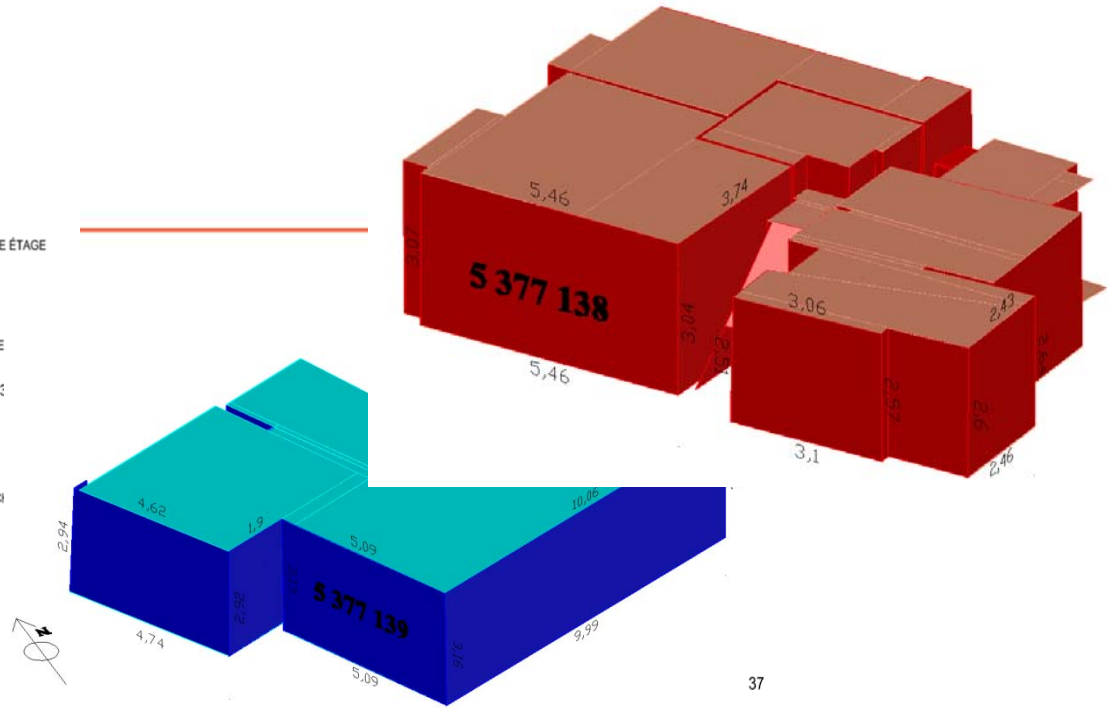
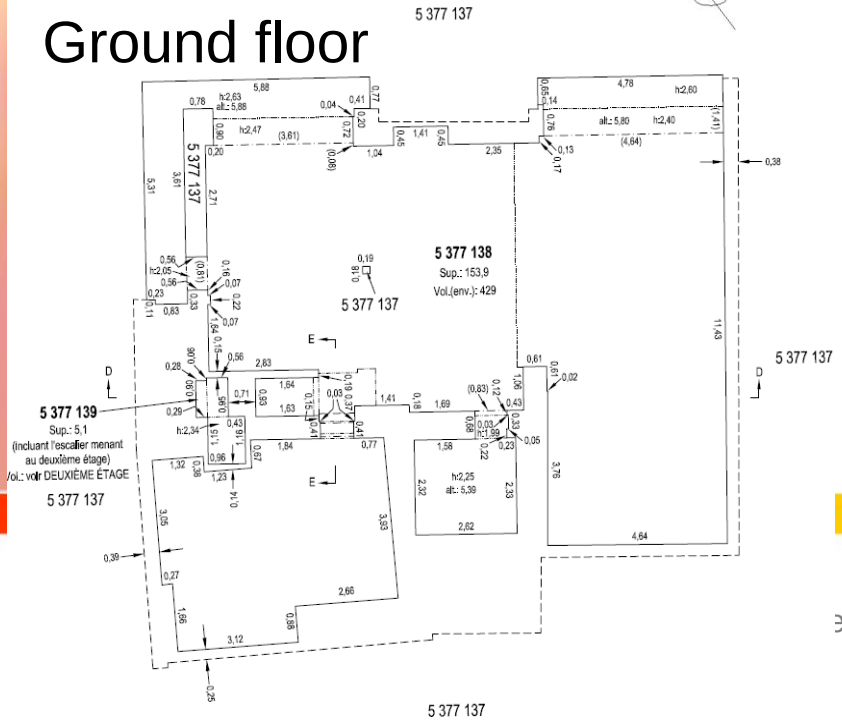


Site B

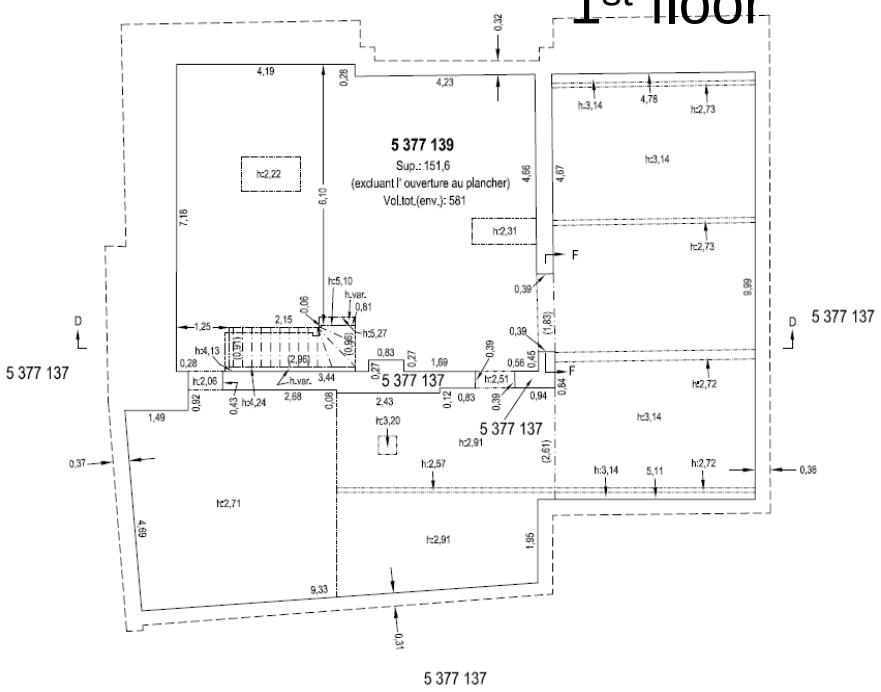




Ground floor



1st floor



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