Introduction to the photogrammetry and BIM / HBIM

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Geodetic work to define, map or document an object has been carried out for hundreds of years.

- classical geodetic measuring technique – hundred of years
- photogrammetry – since 1870
- Aerial photogrammetry – since WWI
- digital photogrammetry - since 1985
- laser scanning / aerial laser scanning - since 1990
- Automated digital photogrammetry (SfM and MVS) since 2000
- Mobile laser scanning on cars 2005
- Drones – since 2005
- PLS - since 2010
- Low-cost mapping devices – since 2020

BIM / H-BIM

Building Information Modeling / Historic Building Information Modeling

- BIM (Building Information Modeling) is a relatively new approach to the design, construction, and management of buildings, and its history can be traced back to the 1970s
- **mainly used for 3D modeling and visualization till 2000**
- **Today, BIM is considered a standard approach to building design and construction, and is used in a wide range of applications, from commercial construction to infrastructure projects to cultural heritage preservation**
- **BIM is used to manage buildings throughout their lifecycle and delivers economic savings**

BIM and Construction - ground and underground objects

- Newly designed buildings or structures are now implemented in BIM directly from the building design (from CAD, etc.)
- Old or historic buildings can be converted to BIM, but usually lack 3D data

It is necessary to obtain 3D data as a basic data set

How can we do it ???

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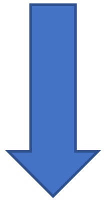
Creating a 3D model

Source data – point or vector data

Or

point cloud



- Classical gedetical measurement,
- Laser scanning
- Photogrammetry
- Combination of all methods

or

- Structural geometry (AutoCAD, SketchUp) based on projects

How can this be done?

a) classic geodetic measurement


M3
399.9993G
5.2633m
0.0316m


15
590
145
4

Classic geodetic measurement:

+ selected data

+ small data amount

+ precise

- small processed area

- laborious, often slow

Basis for the CAD drawing and cadastral mapping

How can this be done?

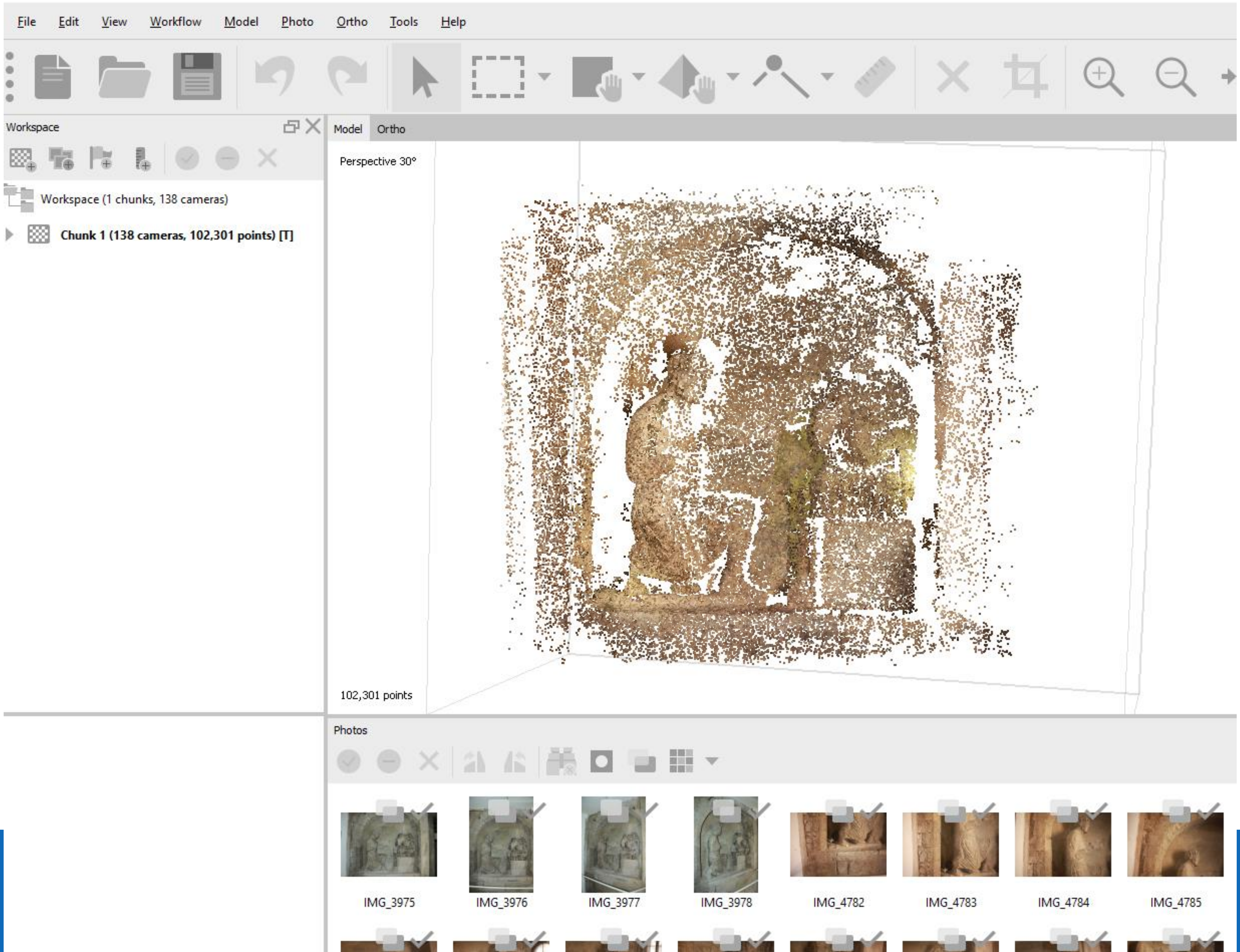
b) Terrestrial photogrammetry (IBMR - image based modeling and rendering)
Close-range photogrammetry

Digital camera + software based on digital image correlation
(Agisoft Photoscan - Metashape, Zephyr 3D, pix4D, 123catch, etc.)

Agisoft
Metashape

Digital camera + software based on digital image correlation (Agisoft Photoscan - Metashape, Zephyr 3D, pix4D, 123catch, etc.)

SfM + MVS (structure from motion and multi view stereo)



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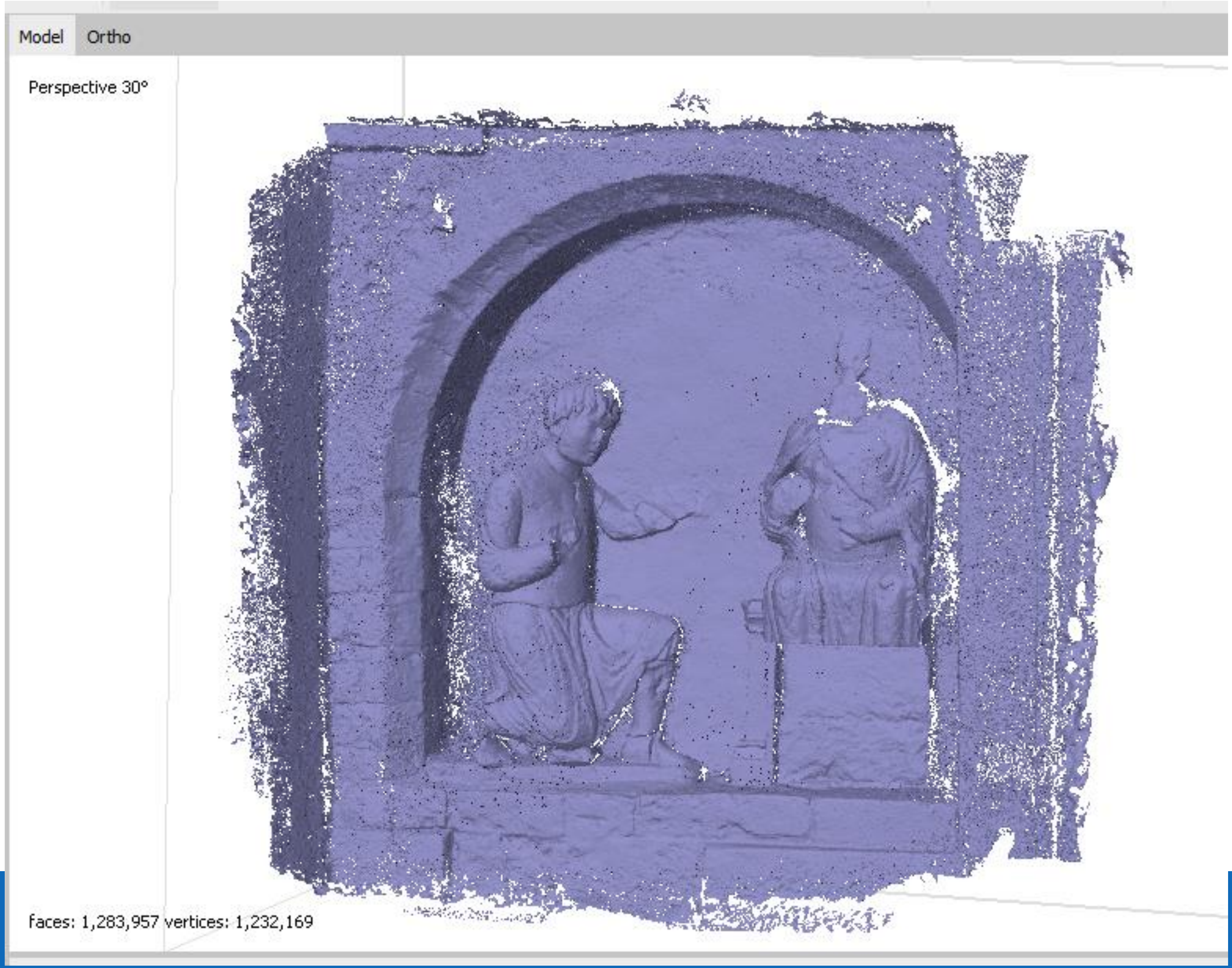
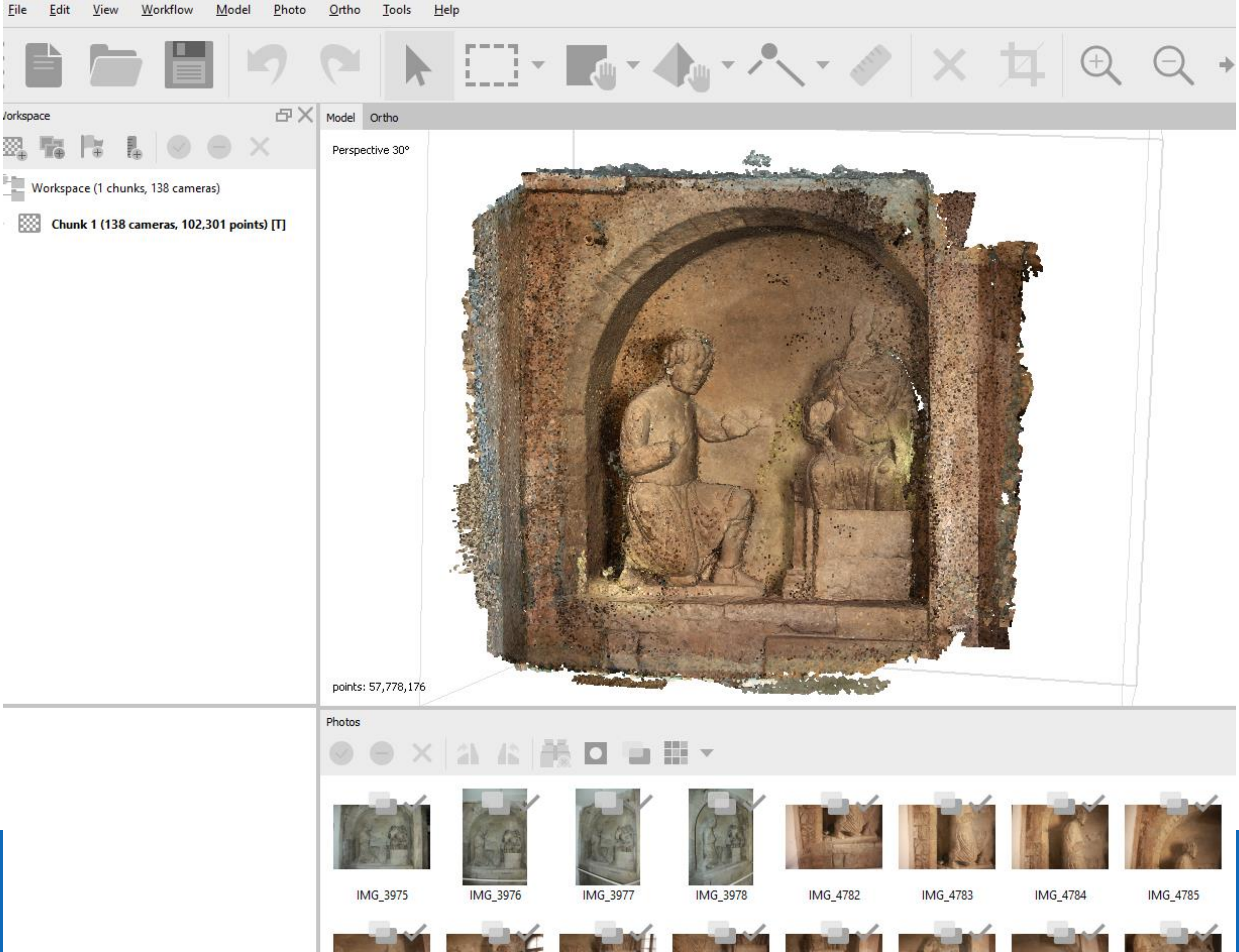

Model
Ortho
Perspective 30°
faces: 1,283,957 vertices: 1,232,169



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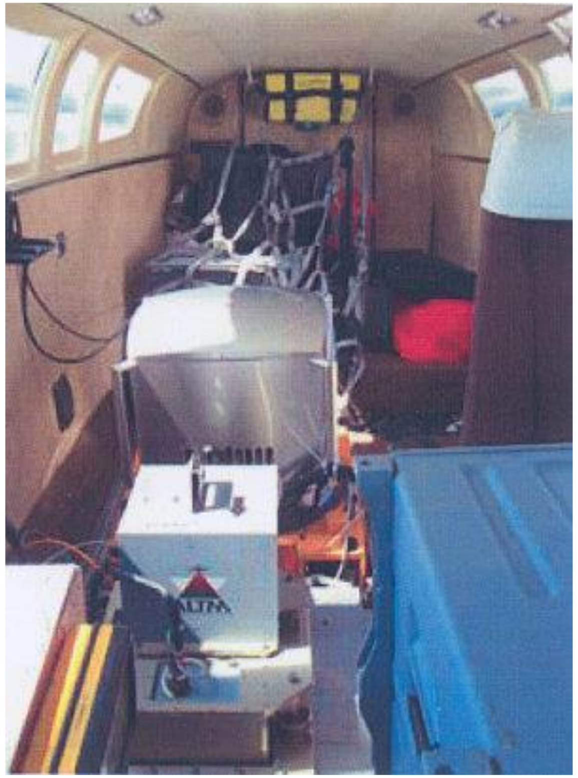
Point cloud vs. textured mesh

How can this be done?

c) Aerial or "drone" photogrammetry (IBMR - image based modeling and rendering) or stereophotogrammetry, or aerial laser scanning

L-410FG

UltraCamD
+ Laserscanner
ALTM 3100



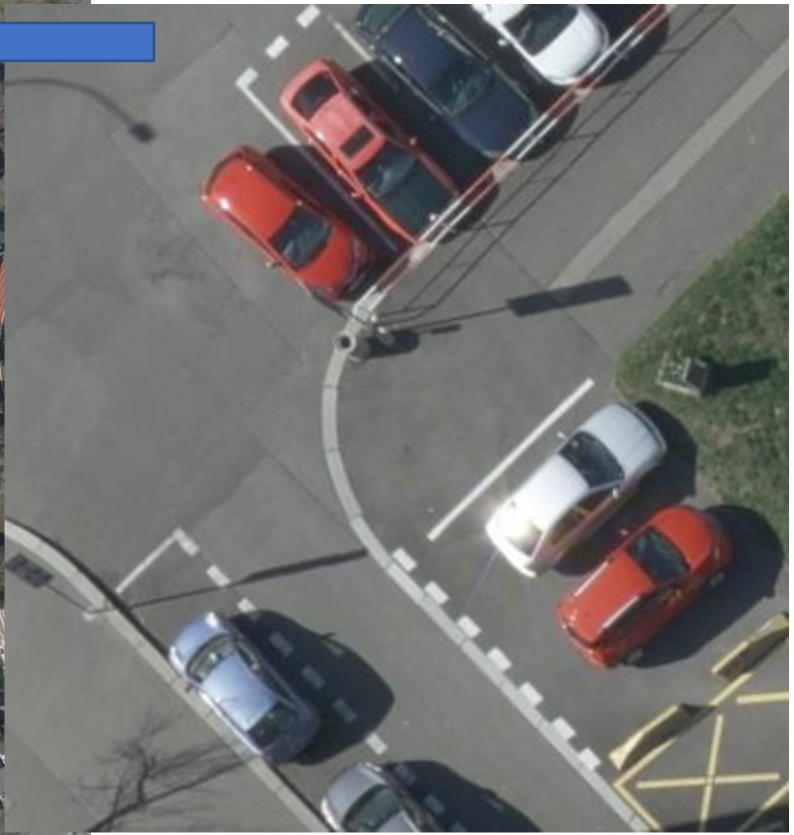
Digital stereophotogrammetry, vector data or ortophoto

Stereo vision kit with crystal glasses (Imagestation SSK), 1999

Current form of DPW (since 2015)

2003, GSD 50 cm

2015, GSD 15cm



Professional aerial photogrammetry:GSD 2 cm !

RPAS - remotely piloted aerial system

RPAS = UAS (unmanned aerial system)

RPA = UAV (unmanned aerial vehicle)

Drones…
…today thousands models

Using of RPAS

- Ortophoto, DTM
- 3D models and cubatures
- Obligue images (pictometry)
- Documentation and monitoring of hardly accesible areas
- payload: camera (VIS, NIR)
- Special devices: thermovision, thermal imaging, laser scanner, hyperspectral scanner, multispectral scanner

Drones … mulicopters

DJI Mavic pro

DJI Phantom 4 RTK

Winged drones (fixed wings

eBee Plus

Recognisance of object

Multicopter can be used for recognisance of historical objects without moving platforms or scaffolding, or usefull in PR

Creating of 3D models(from a drone and terrestrial taken images

Processing: set of overlapping images, Agisoft Metashape, Zephyr, Reality Capture etc.

Photogrammetry:

- Aerial, Drone, Terrestrial
- offten combination or joining of drone and terrestrrial data

- unselected data
- big data amount

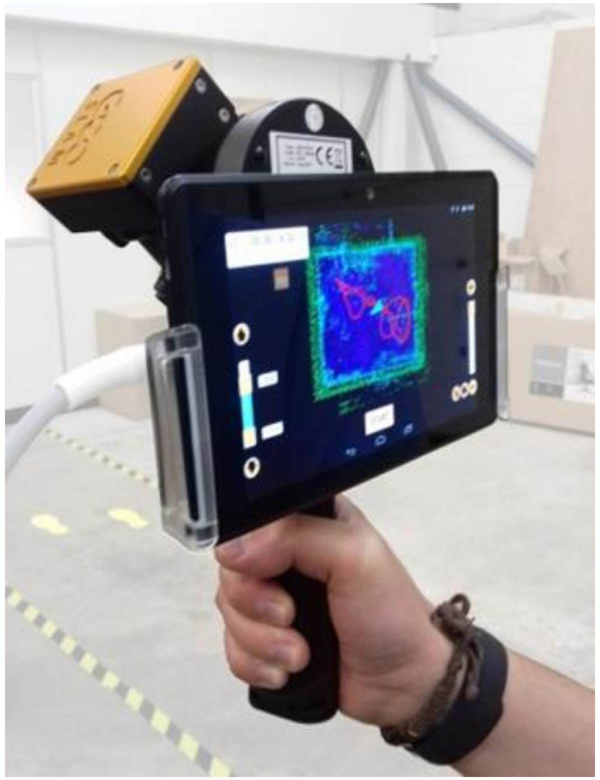
+/- can be precise

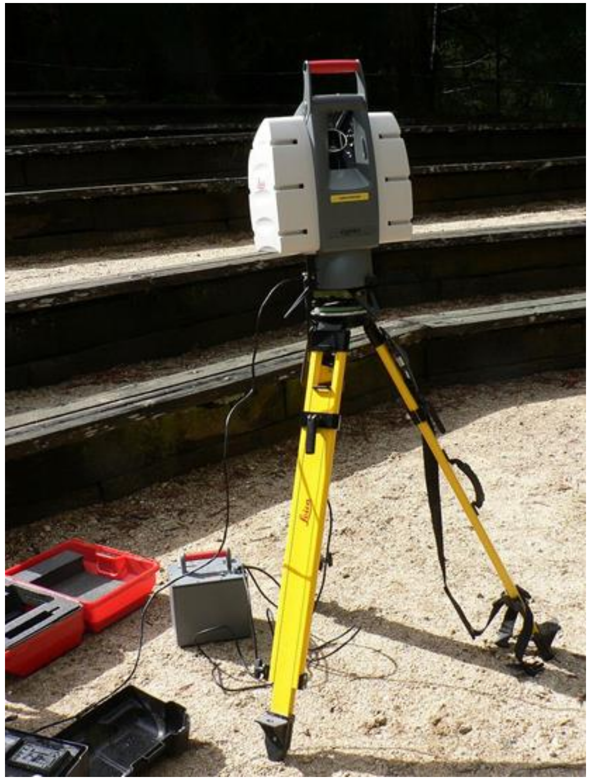
+ big processed area
+ offten automated process, fast results

Basis for the mapping and creating of 3D models

How can this be done?

d) Using laser scanning (terrestrial or mobile laser scanning)





Callidus

Optech

Surphaser

Riegl

Trimble

Z+F

Faro

Leica

Leica BLK 360

Callidus, 2003

Stationary laser scanner

· all together 40 kg (heavy tripod, scanner,

cables, special computer and heavy baterry

· Range (0.6 m—30 m)

· Accuracy 6 mm at 10 m

Leica BLK360, 2019

· Stationary laser scanner

· Light (around 1 kg)

· Range (0.6 m—60 m)

· Accuracy 4 mm at 10 m

· Resolution setting

    · 5 mm at 10 m

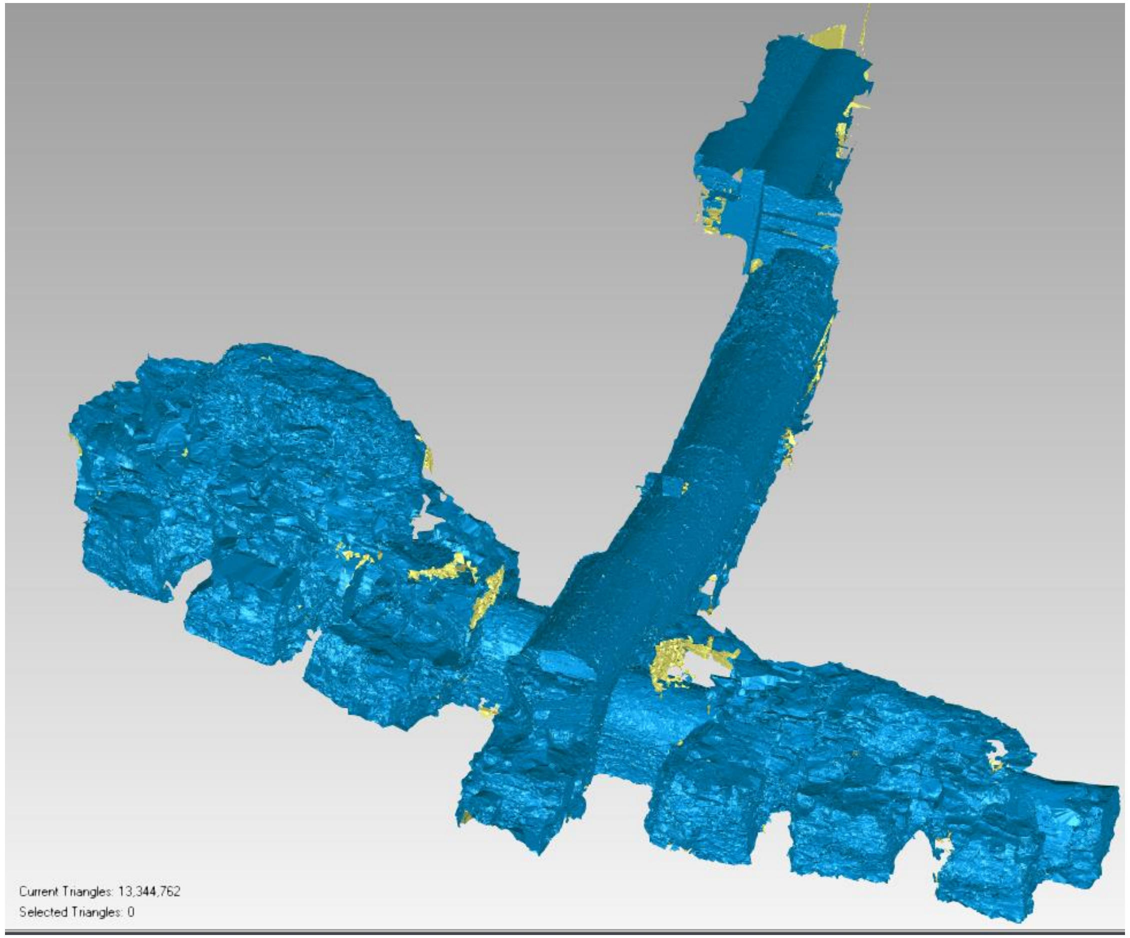
· Operated via app Cyclone FIELD 360

    · registering

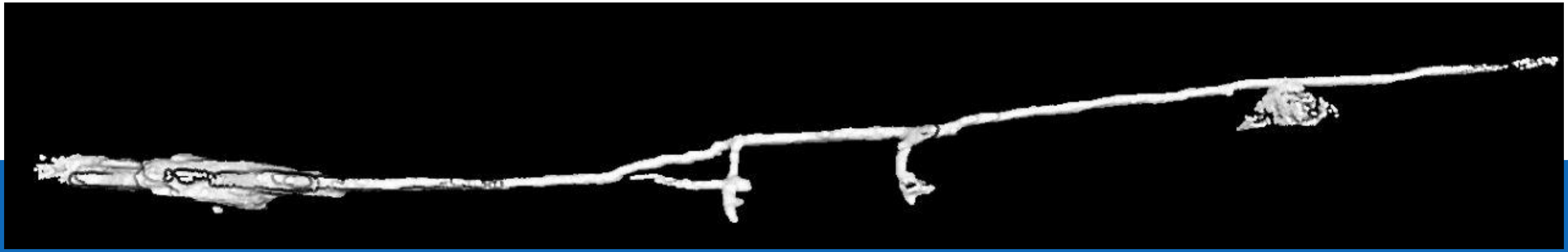
Plasy - Baroque vault

Skorkov

Laser scanning is useful method for underground spaces documentation – here is an example of Historical underground cross corridor and medieval tin mine



mediaval tin mine, Mauritius



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Using laser scanning

- modern method from the turn of the millennium

+ fully automated measurement

- unselected data, point cloud (coloured, if is a camera included)
- big data amount

-/+ precise, but very detailed

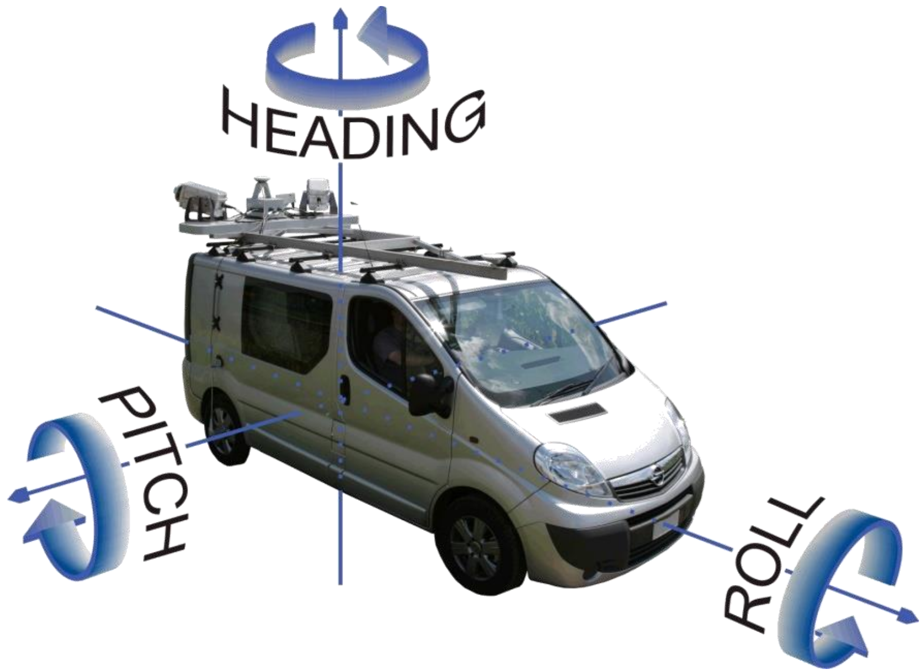
- small processed area (many measurement stations)

+ measures in the dark

Today basis for the 3D documentation

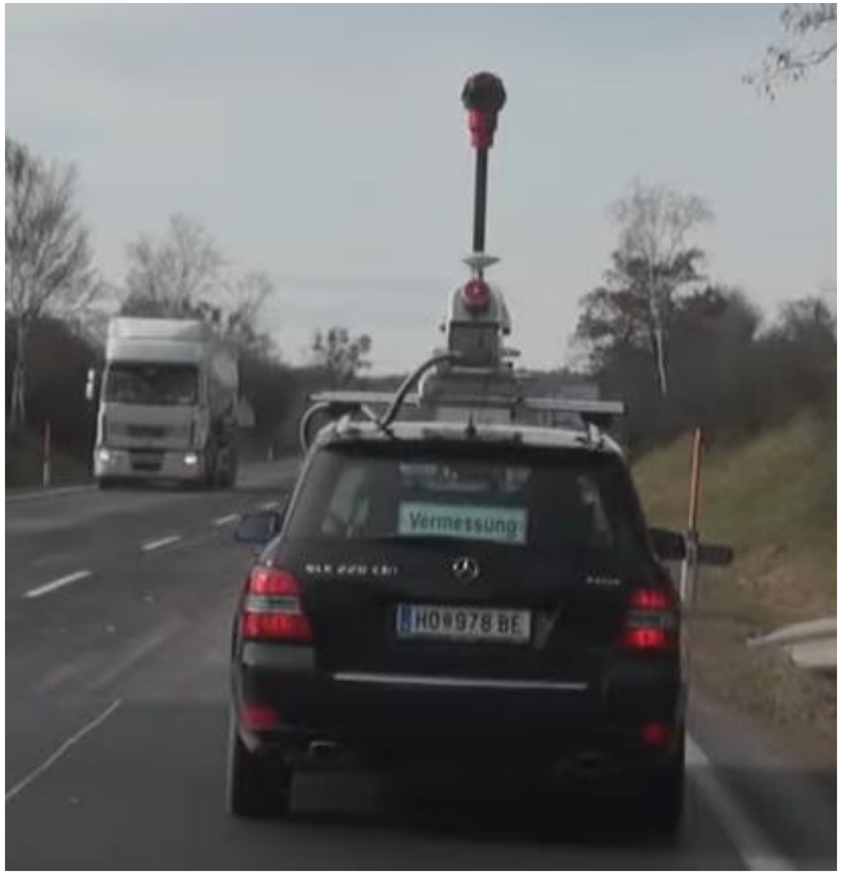
e) Mobile mapping system, MMS

	With GNSS signal	1 minute without GNSS signal
X,Y (m)	0.020	0.100
Z (m)	0.050	0.120
Tilt (°)	0.005	0.020
Rolling (°)	0.020	0.020



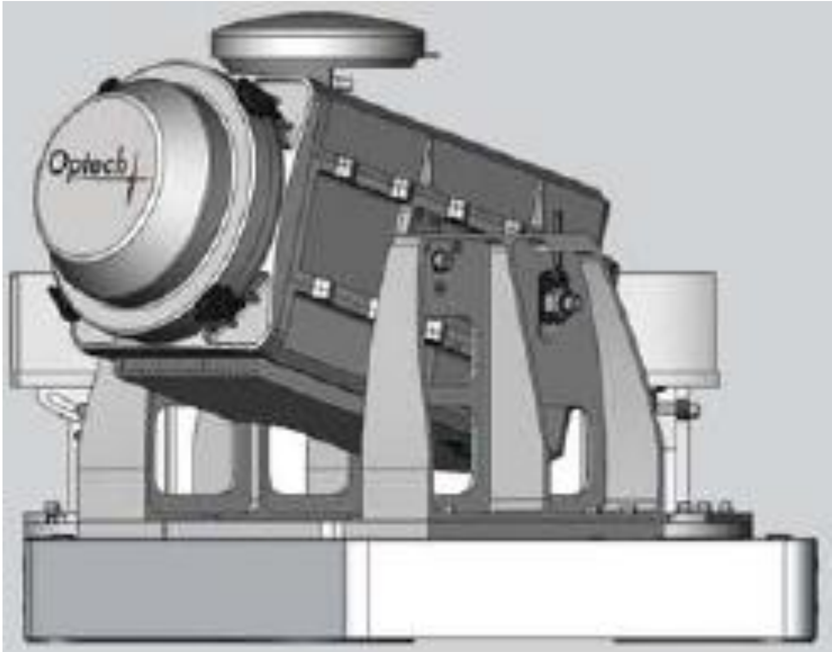
Applanix POSLV 4202 Trimble Zephyr GNSS receivers, DMI (Distance Measuring Indicator), IMU (Inertial Measuring Unit, gyroscopes + accelerometers)

New technologies:
mobile mapping devices- carried by a person, on a car or other vehicle

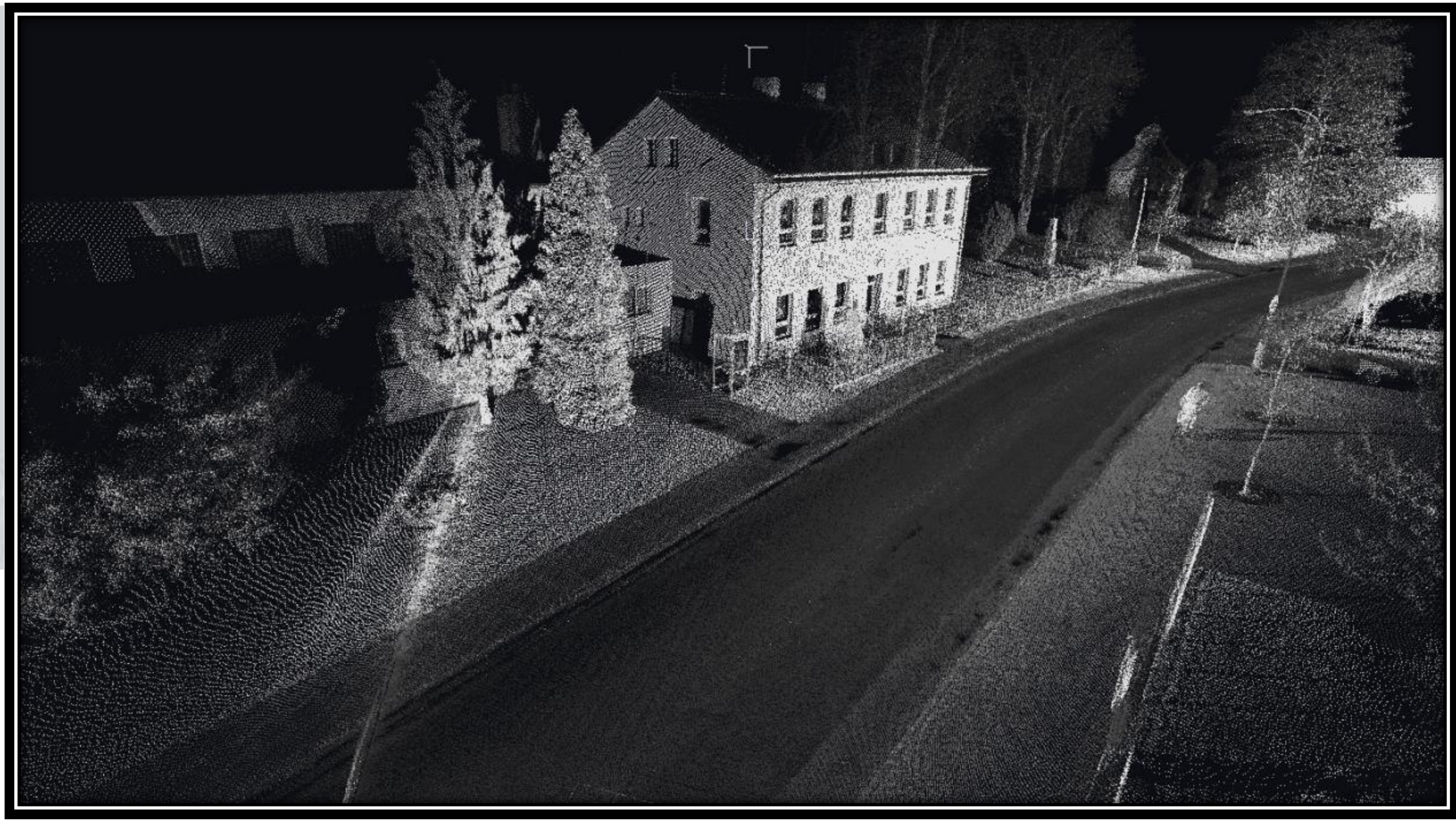


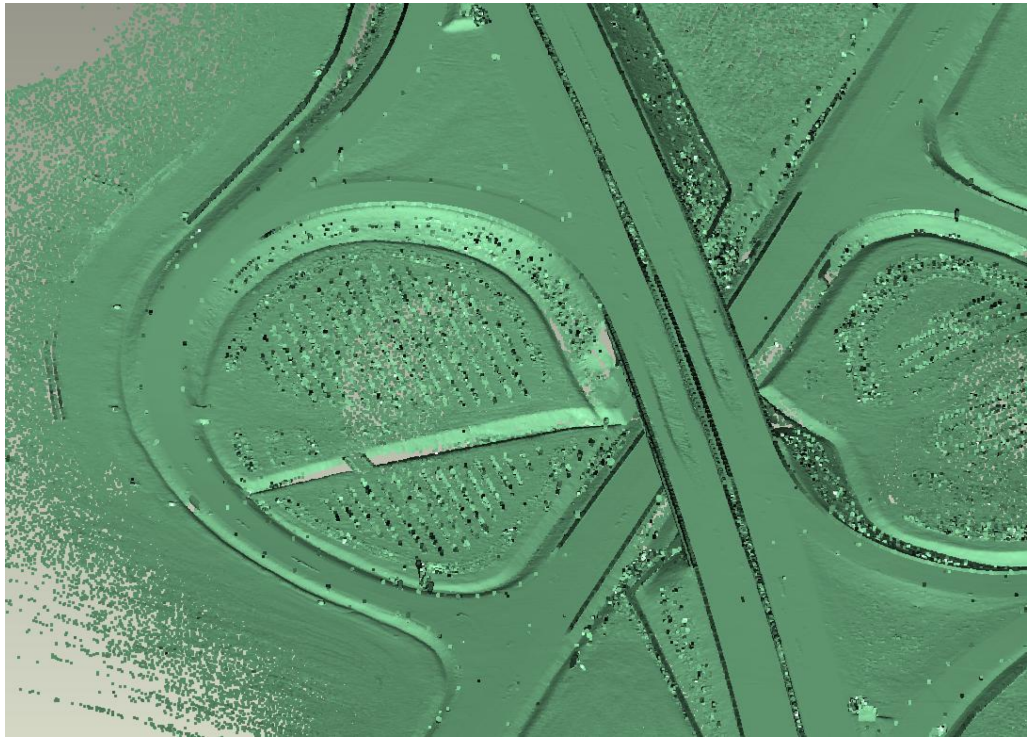
MMS

Sample data - absolute accuracy of points +/- 5 cm (Geovap Pardubice)

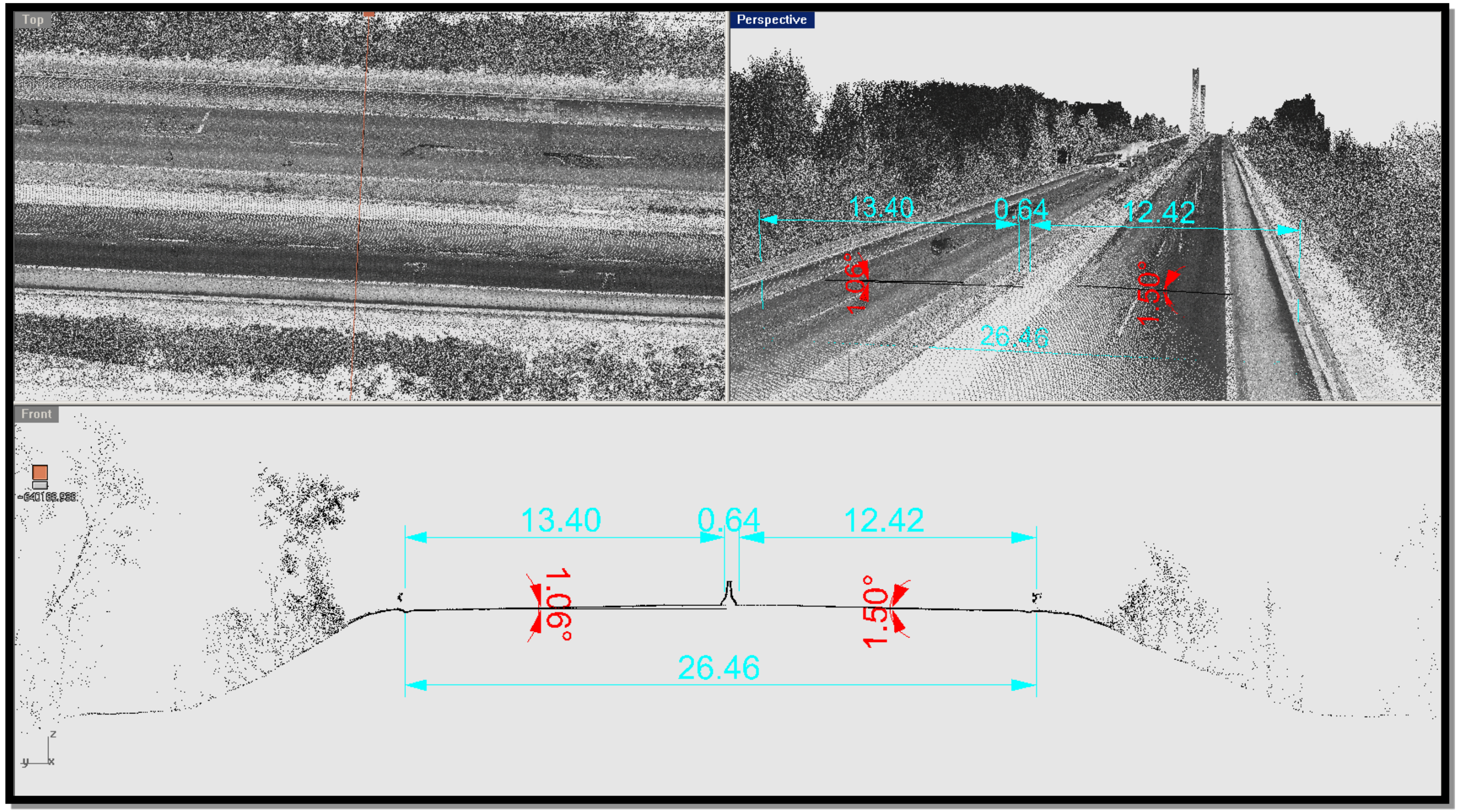


System LYNX, 2010



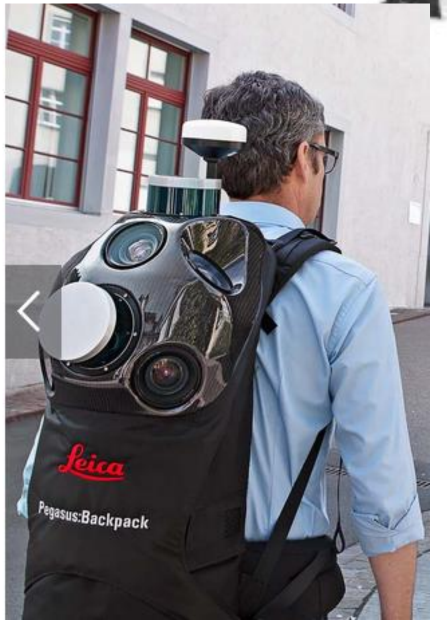


Mobile mapping system (MMS)



Personal laser system, PLS

PLS backpack



PLS – hand-held

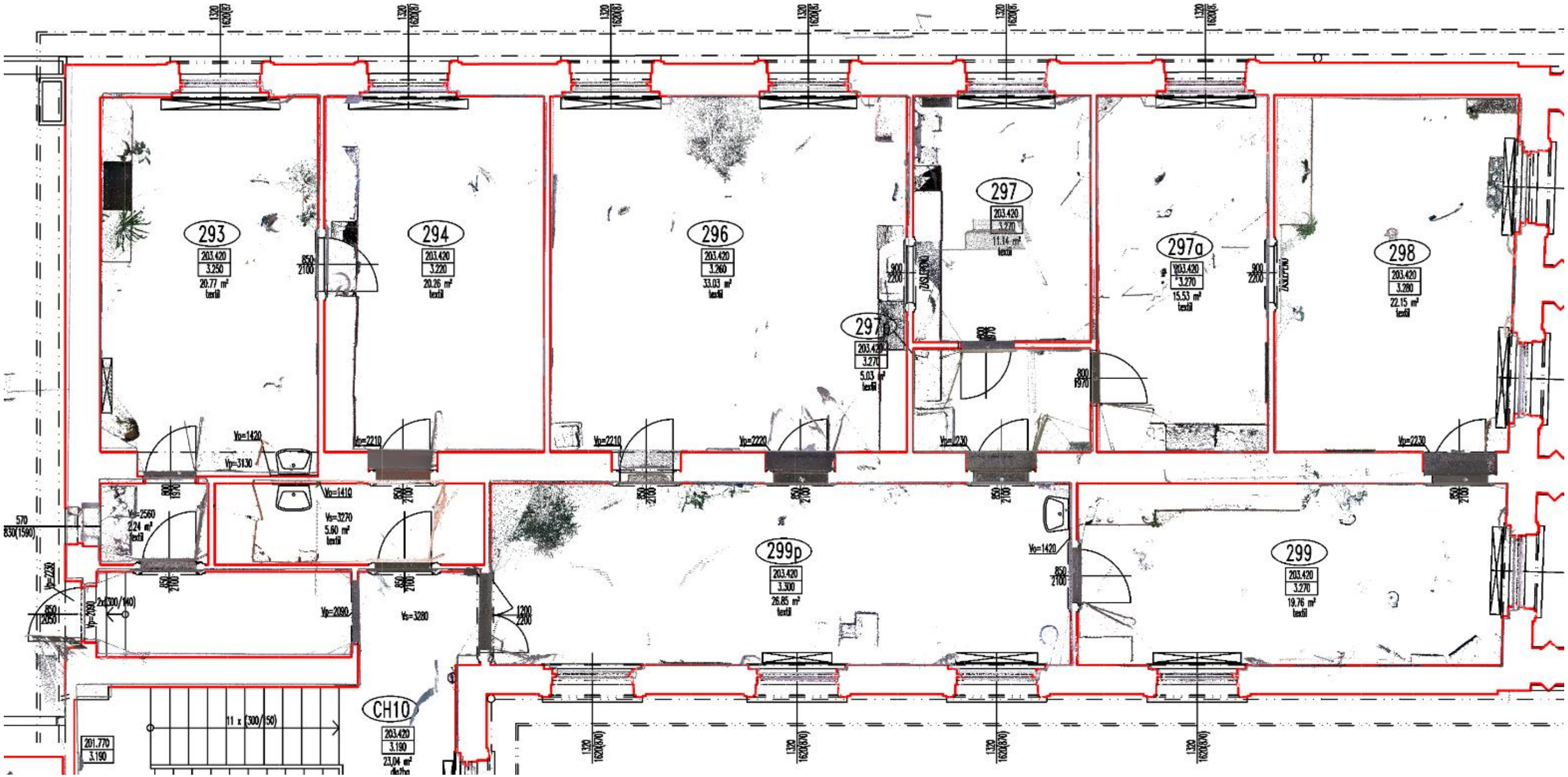
laser backpack, 2010

A portable, laser backpack for 3-D mapping has been developed at the University of California, Berkeley where it is being hailed as a breakthrough technology capable of producing fast, automatic and realistic 3-D mapping of even difficult interior environments. Credit: Credit: John Kua, University of California, Berkeley

Leica BLK2GO, 2020

- SLAM technology
- Handheld
- Light and very fast
- Range (0.5 m—25 m)

- Operated via mobile app BLK2GO live app
  - Only for trajectory checking


293
203.420
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textil
294
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textil
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297
297a
203.420
3.270
15.53 m²
textil
298
203.420
3.280
22.15 m²
textil
299p
203.420
3.300
26.85 m²
textil
299
203.420
3.270
19.76 m²
textil
CH10
203.420
3.190
11 x (300/150)
201.770
3.190

New trend: low-cost technology and istruments:

Videophotogrammetry or smart-phone photogrammetry

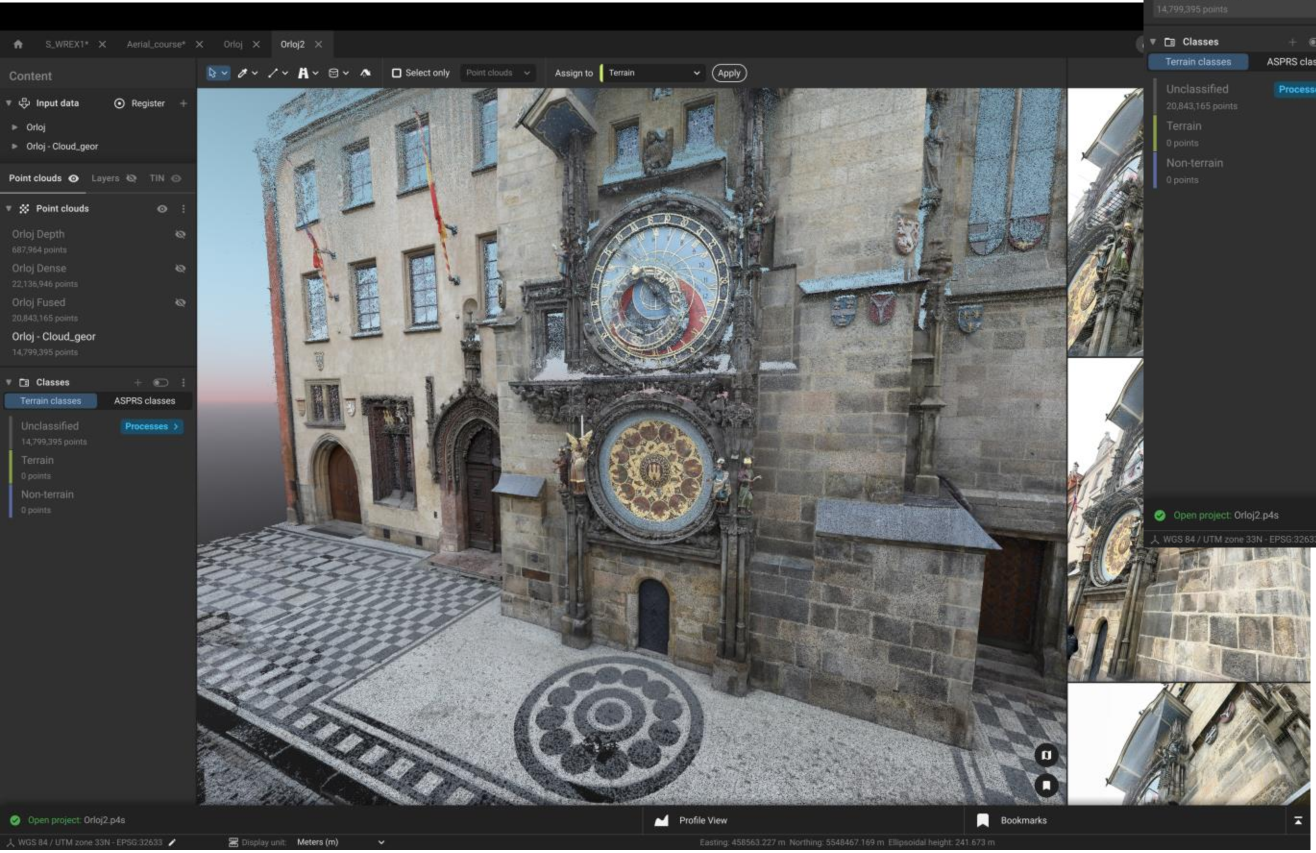
Smart phones with GNSS RTK device

- ideal with lidar sensor

The viDoc RTK rover for PIX4Dcatch is specially designed for accurately capturing 3D spaces from the ground with selected iOS devices equipped **with LiDAR sensors**, but also works with other selected models, including Android devices.

The viDoc RTK rover with PIX4Dcatch

Faro



S_WREX1*
Aerial_course*
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Orloj2
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Point clouds
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Orloj - Cloud_geor
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Orloj Dense
22,136,946 points
Orloj Fused
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ASPRS classes
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Processes
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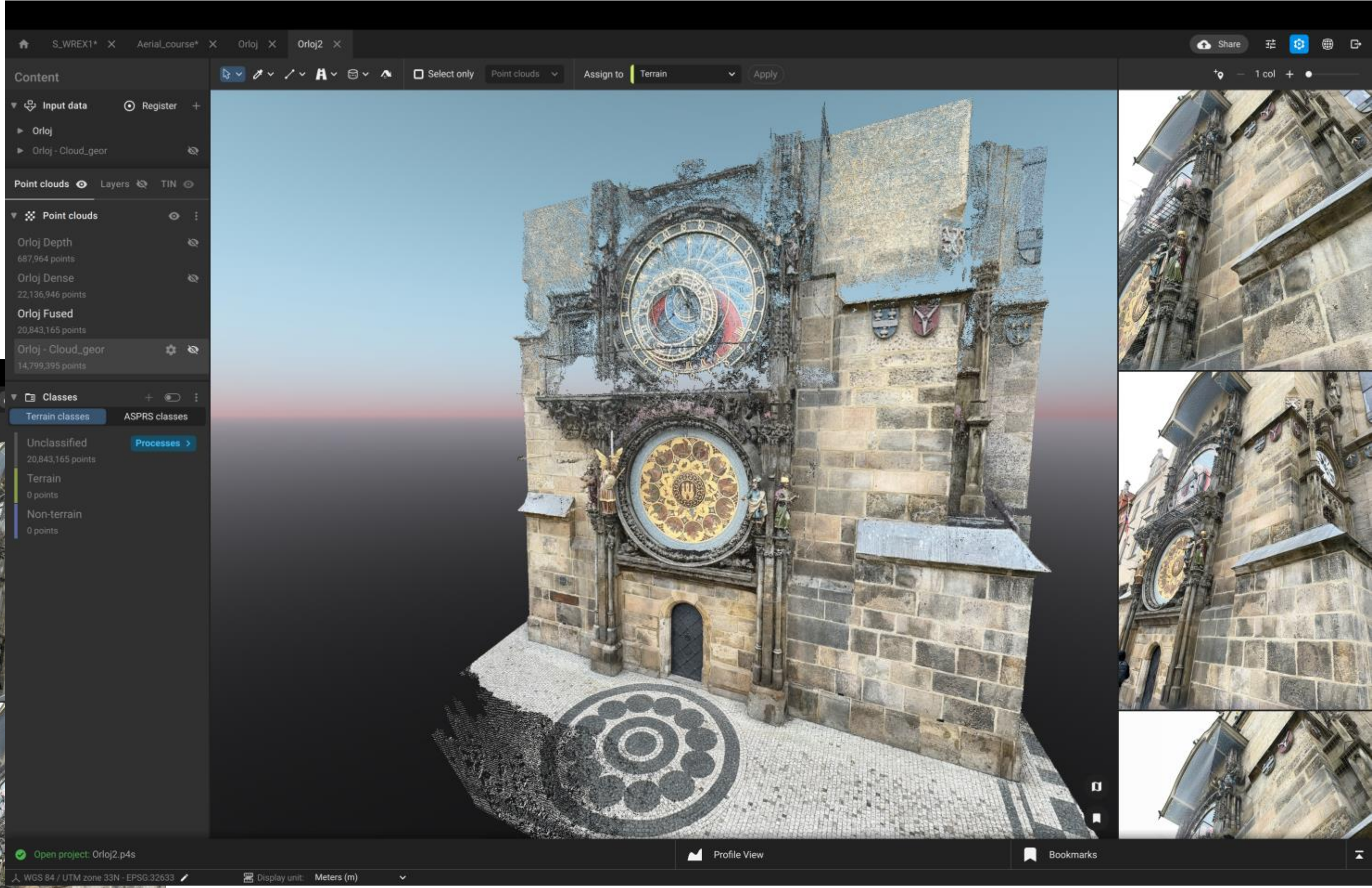
Open project: Orloj2.p4s
Profile View
Bookmarks
WGS 84 / UTM zone 33N - EPSG:32633
Display unit:
Meters (m)
Easting: 458563.227 m Northing: 5548467.169 m Ellipsoidal height: 241.673 m



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Non-terrain
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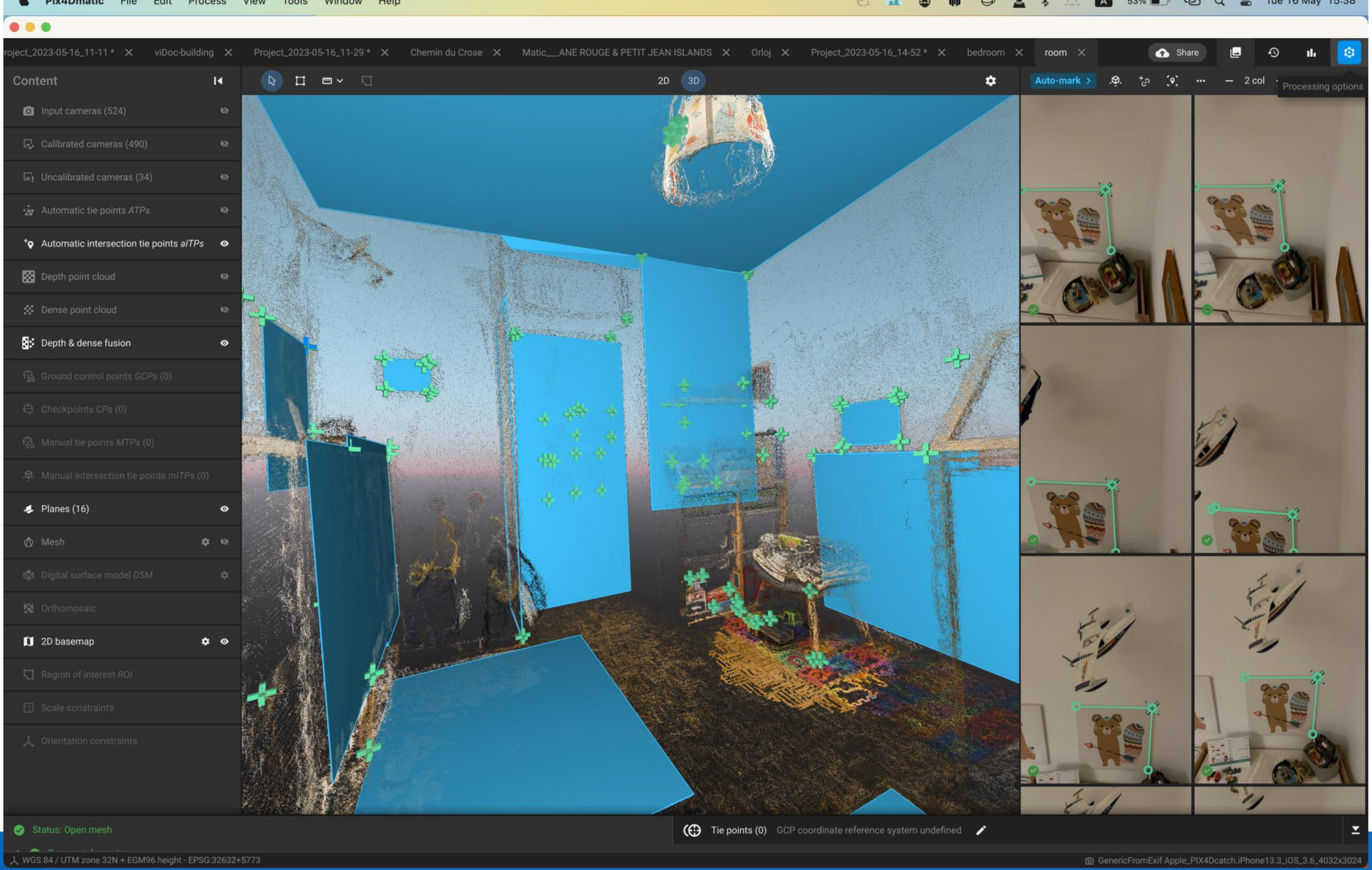
Open project: Orloj2.p4s
Profile View
Bookmarks
WGS 84 / UTM zone 33N - EPSG:32633
Display unit:
Meters (m)

viDOC


Content
Input cameras (524)
Calibrated cameras (490)
Uncalibrated cameras (34)
Automatic tie points ATPs
Automatic intersection tie points aITPs
Depth point cloud
Dense point cloud
Depth & dense fusion
Ground control points GCPs (0)
Checkpoints CPs (0)
Manual tie points MTPs (0)
Manual intersection tie points mITPs (0)
Planes (16)
Mesh
Digital surface model DSM
Orthomosaic
2D basemap
Region of interest ROI
Scale constraints
Orientation constraints
viDoc-building
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Processing options
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Tie points (0)
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WGS 84 / UTM zone 32N + EGM96 height - EPSG:32632+5773
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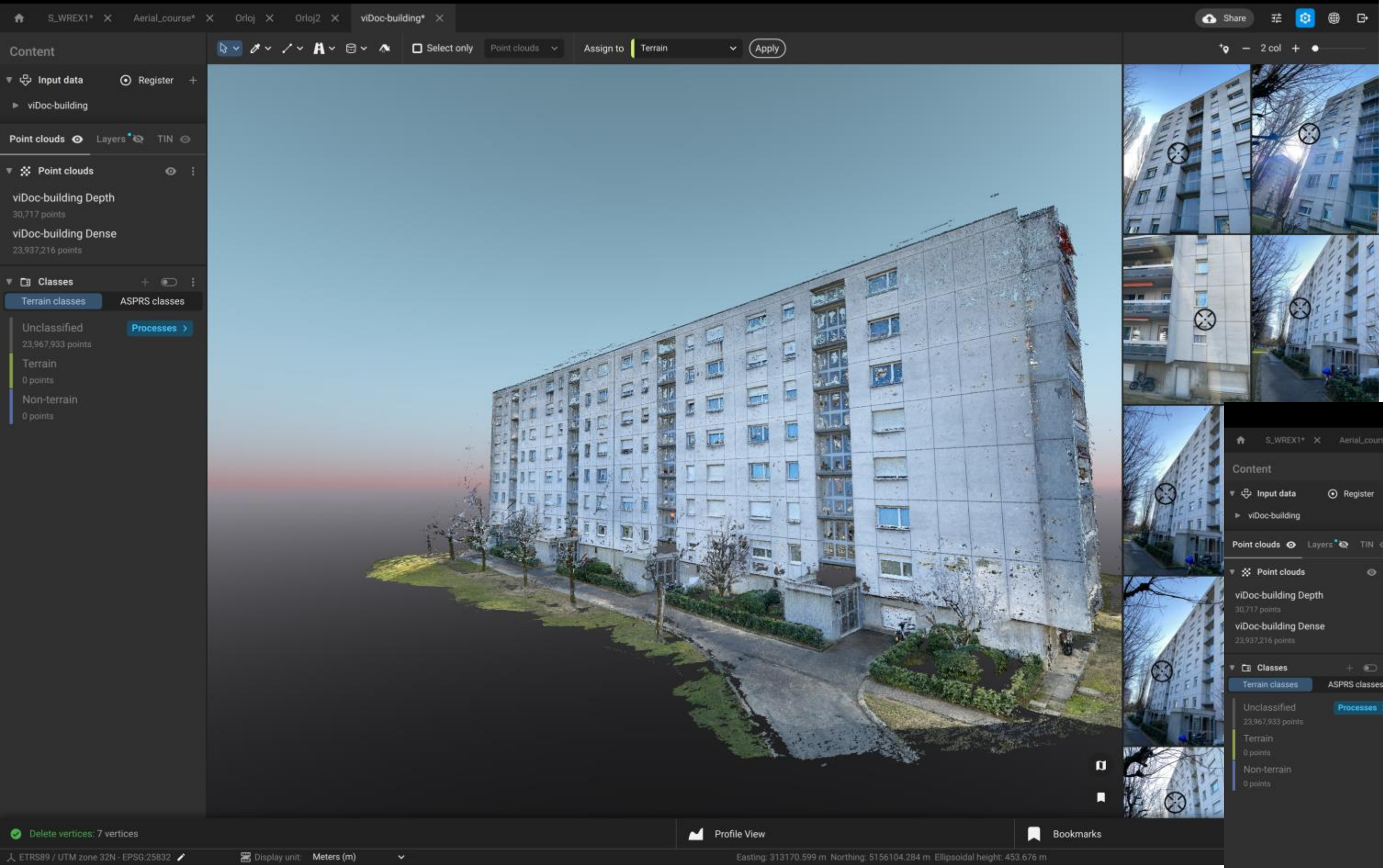
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viDoc-building Depth
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ASPRS classes
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Terrain
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Non-terrain
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Delete vertices: 7 vertices
Profile View
Bookmarks
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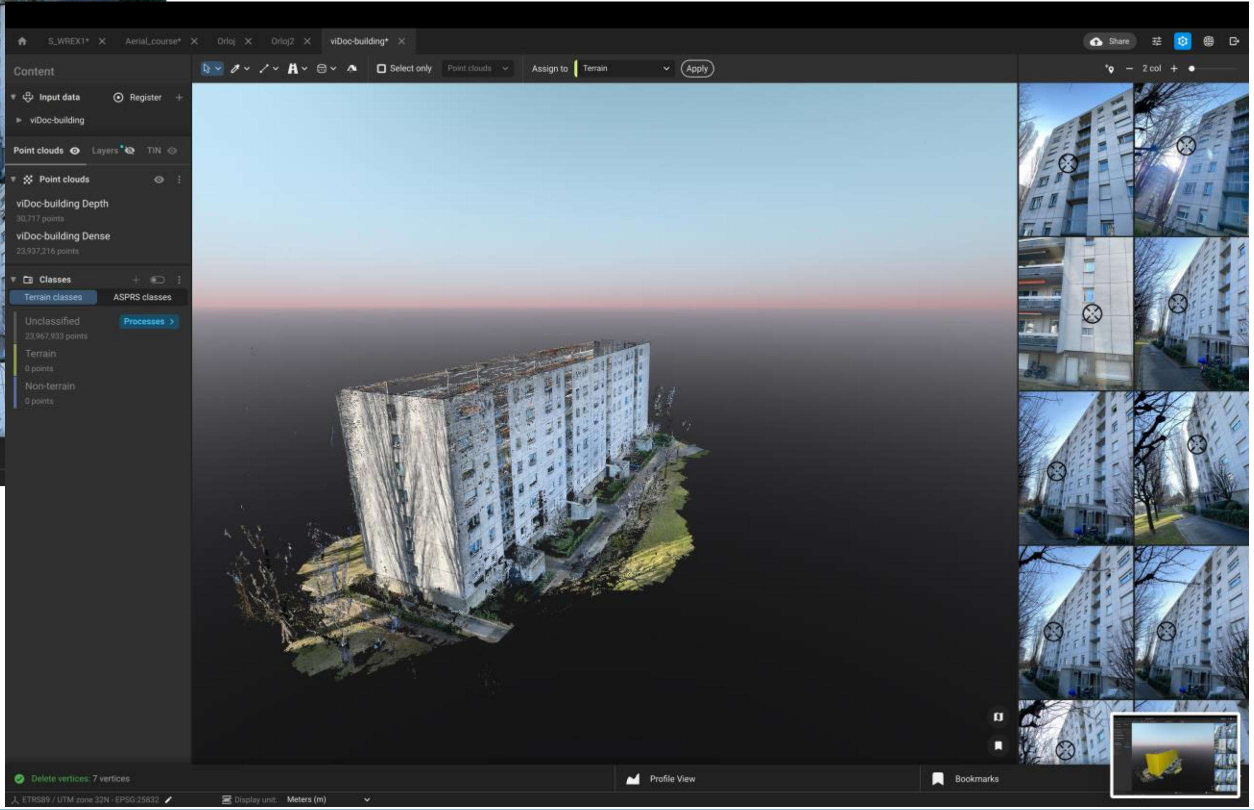
Easting: 313170.599 m Northing: 5156104.284 m Ellipsoidal height: 453.676 m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Terrain classes
ASPRS classes
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Processes
Terrain
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Delete vertices: 7 vertices
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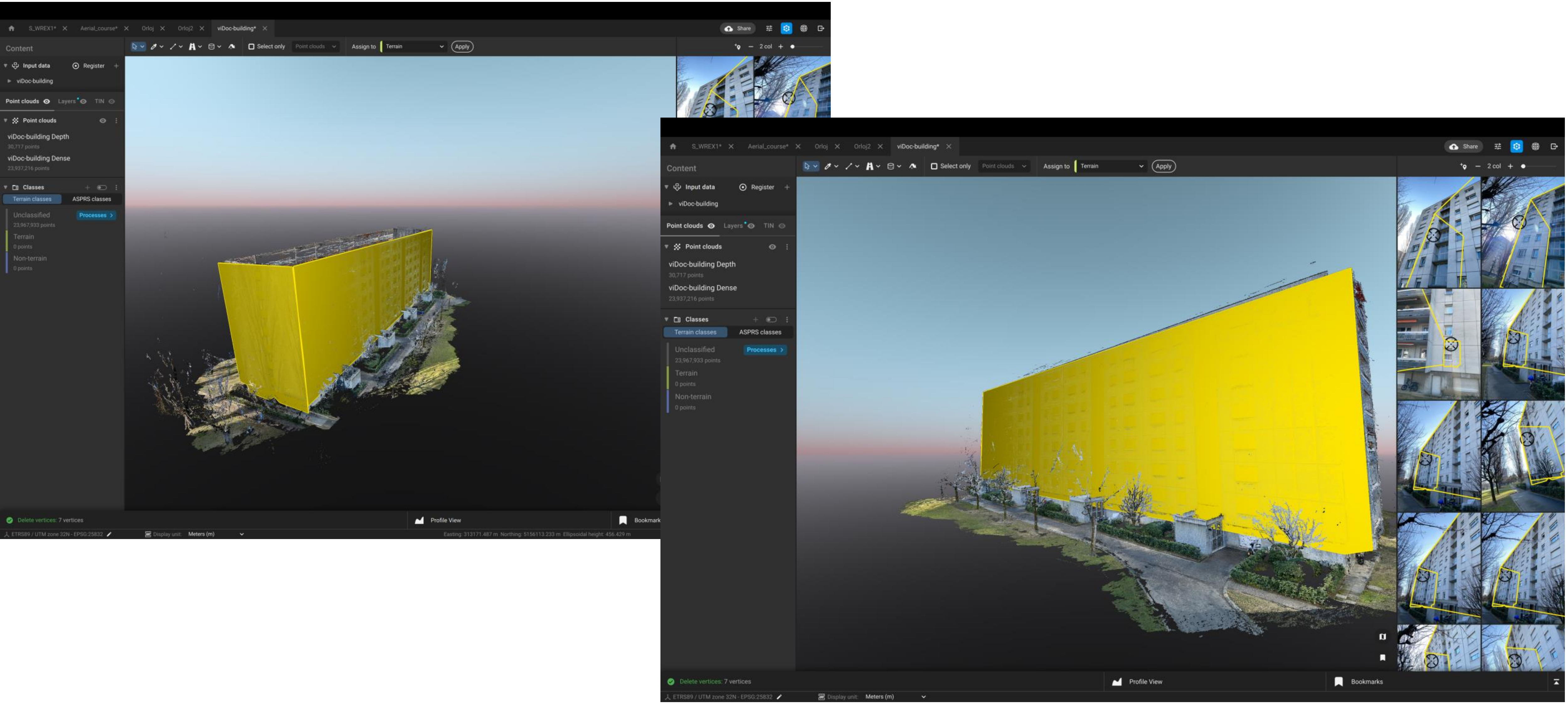
Display unit:
Meters (m)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Aerial_course*
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viDoc-building*
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Point clouds
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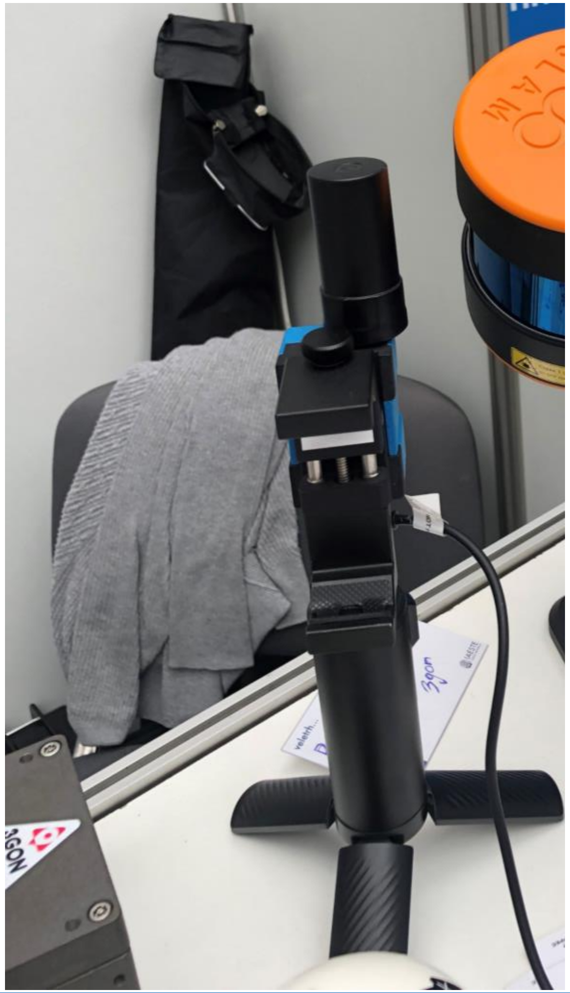
Display unit:
Meters (m)

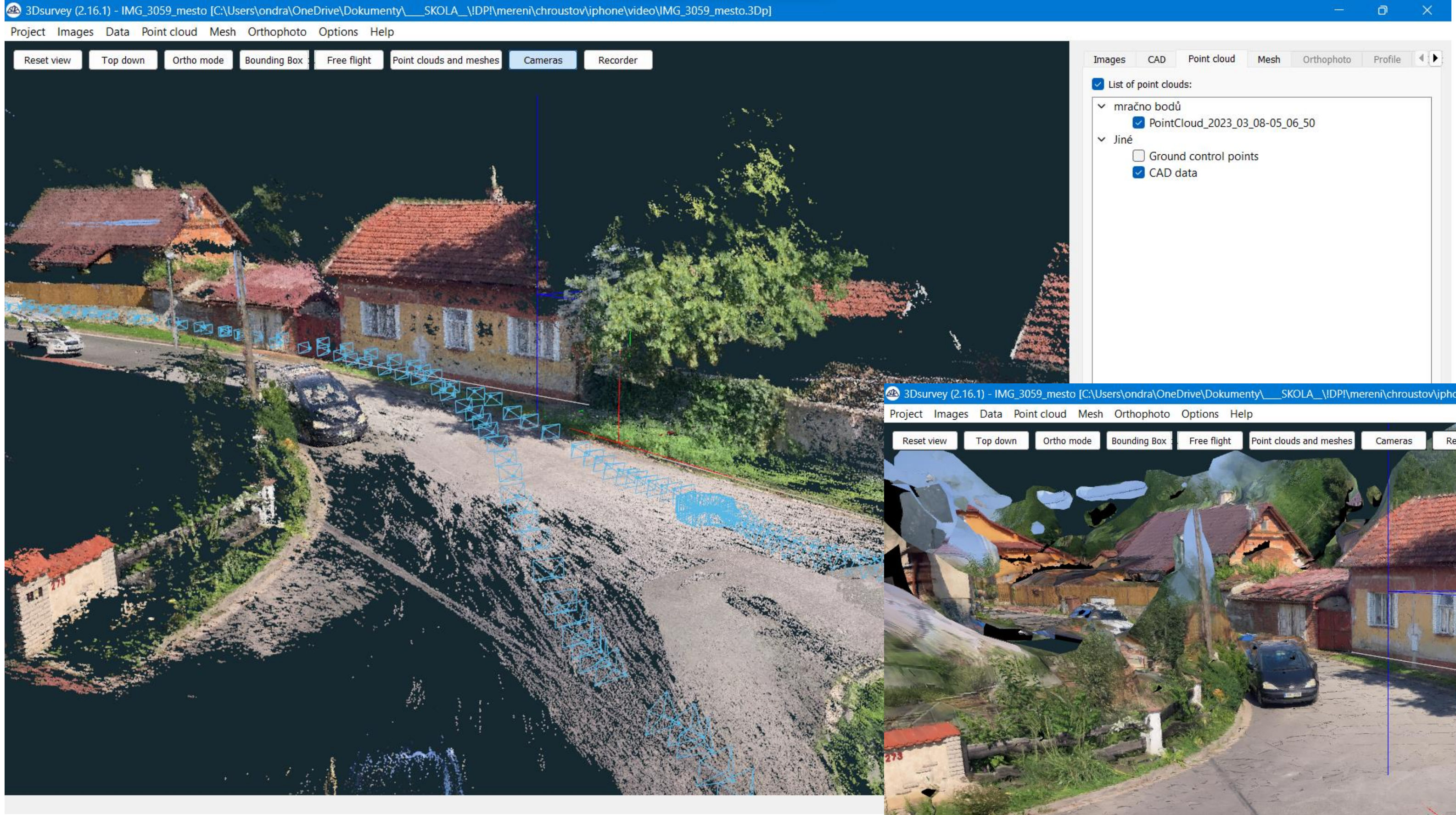
3D Survay

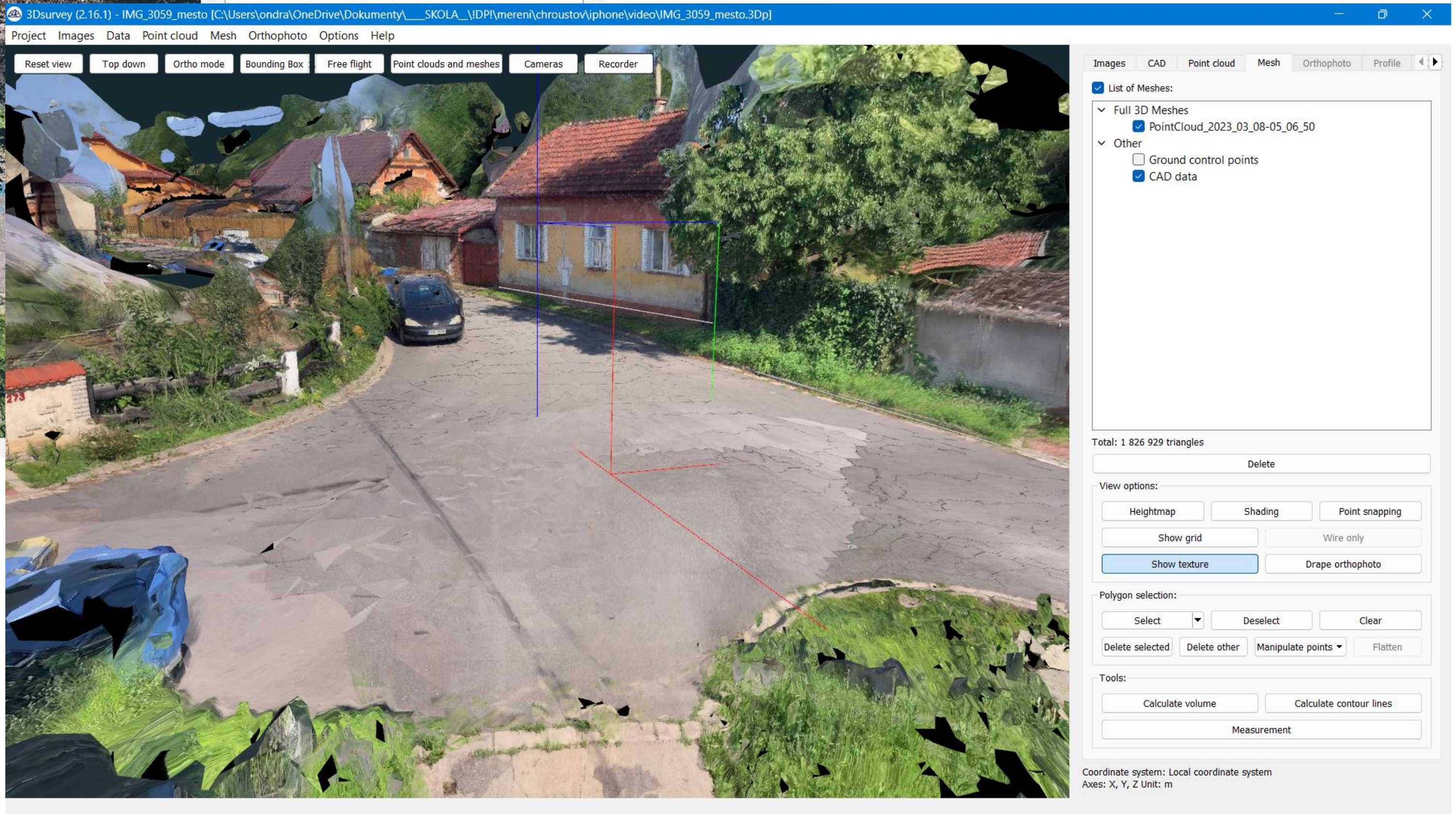
3Dsurvey

Smart phone with GNSS RTK

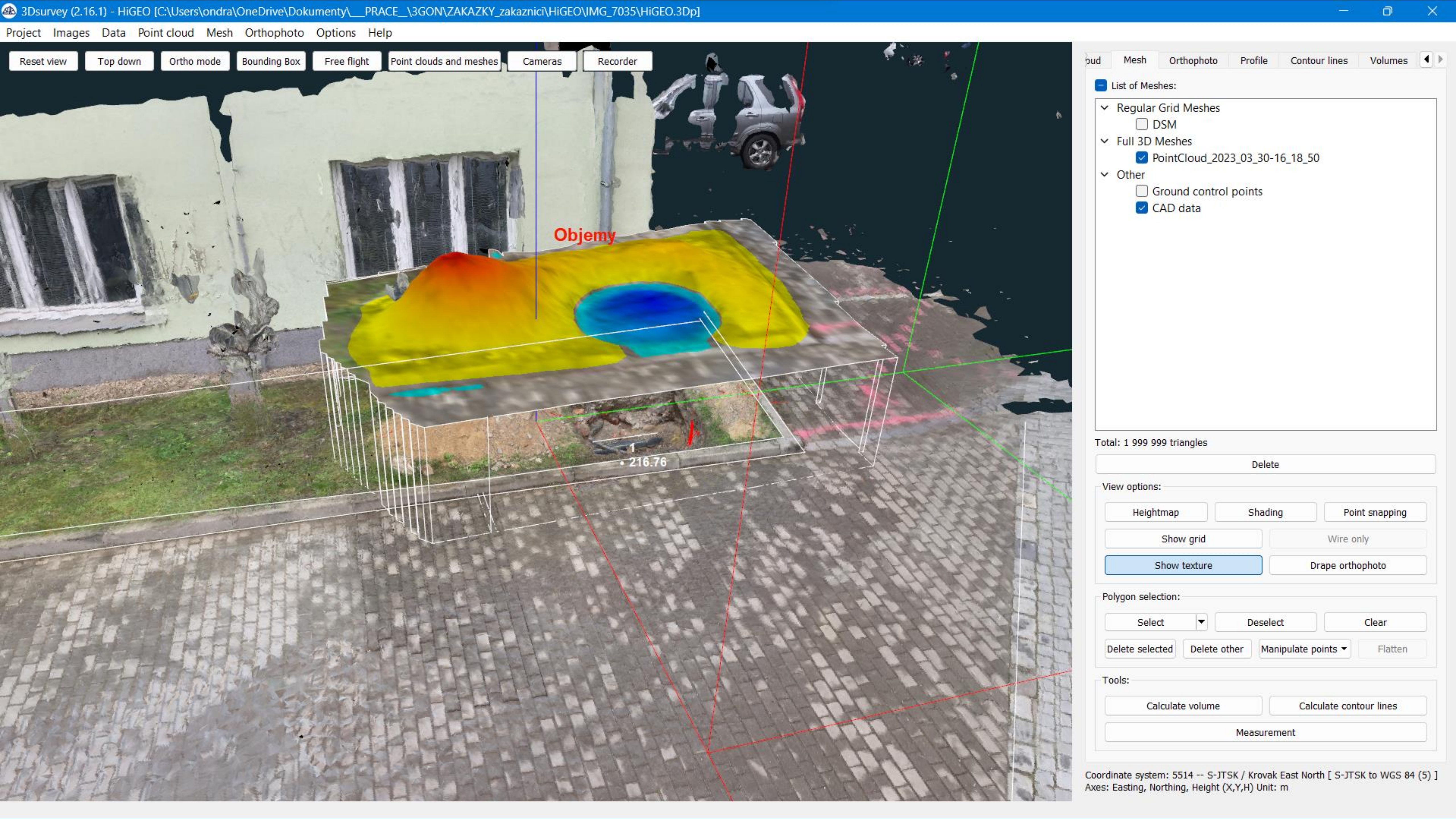


videophotogrammetry





videophotogrammetry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Regular Grid Meshes
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Total: 1 999 999 triangles
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View options:
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Shading
Point snapping
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Wire only
Show texture
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Clear
Delete selected
Delete other
Manipulate points
Flatten
Tools:
Calculate volume
Calculate contour lines
Measurement
Coordinate system: 5514 -- S-JTSK / Krovak East North [S-JTSK to WGS 84 (5)]
Axes: Easting, Northing, Height (X,Y,H) Unit: m

3Dsurvey

Aerial image processing software
Version 2.16.1

Report

Project:	videoTELC
Date of image acquisition:	No data

Camera model	Resolution	Focal length	Sensor size	Pixel size
No data	2160 × 3840	0mm	No data	No data

Orthophoto size:	97.94m × 19.21m	**Pixel resolution:**	0.010m

What's better? Conventional surveying, laser terrestrial scanning, mobile mapping system or photogrammetry?

It depends on the project, but:

1)Selective point set - for simple objects, small amount of previous structured data, good approximation of object shape with necessary details, suitable as input for CAD3D model can be created directly in CAD and converted to BIM

2) Non-selective point clouds - automatic process, for spatially complex objects, large amount of data, it is necessary to select information from the point cloud

After calculating the mesh and texturing the mesh, a virtual model with the original texture can be automatically created from the point cloud

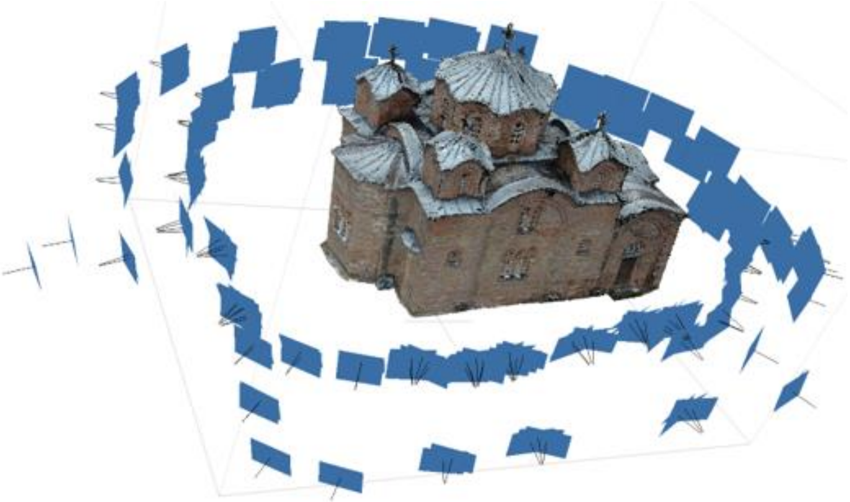
The 3D model is created in specialized software and needs to be converted to CAD / BIM, HBIM

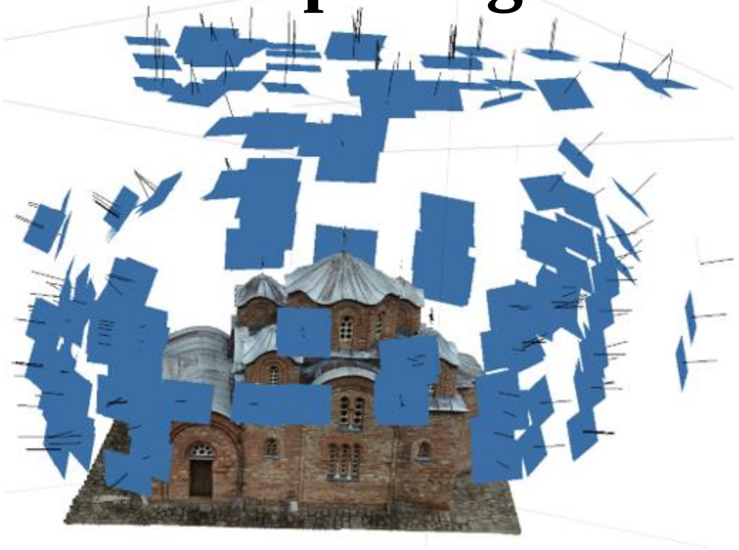
Case studies

Case study 1 St. Panteleimon, Skopje

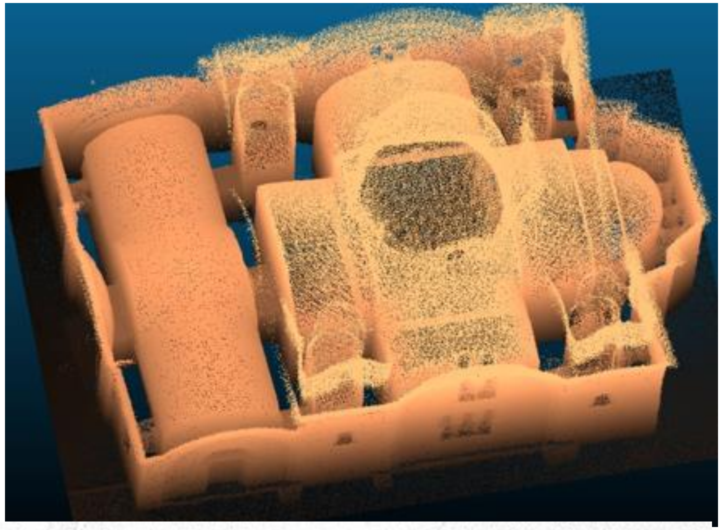
The church of St. Panteleimon at Nerezi is one of the major surviving monuments of twelfth-century Byzantium. According to the painted inscription in the church, it was built in 1164 by Alexios Komnenos, a member of the famous Komnenian dynasty that ruled Byzantium during the eleventh and twelfth centuries. The St. Panteleimon church is one of a very few surviving five-domed buildings and so it highlights this important, but rarely preserved architectural type

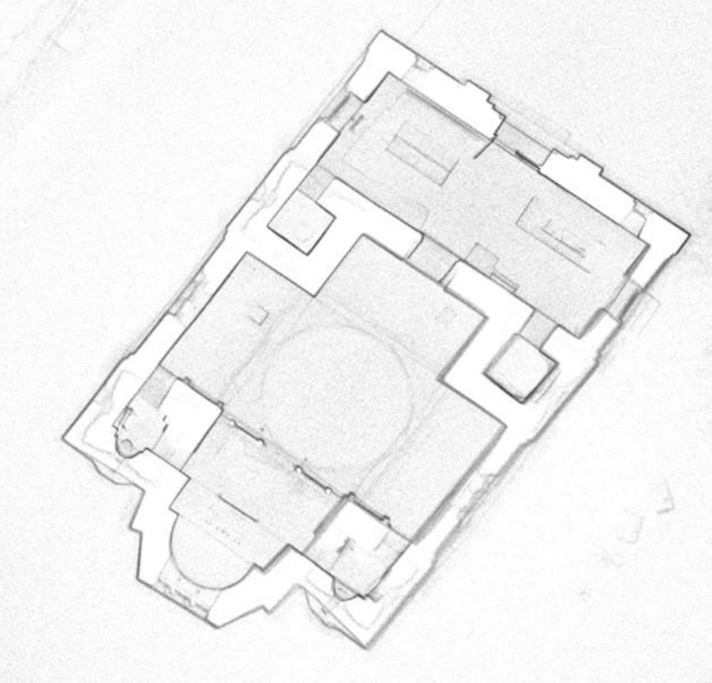
Joining of terrestrial close-range photogrammetry with drone photogrammetry

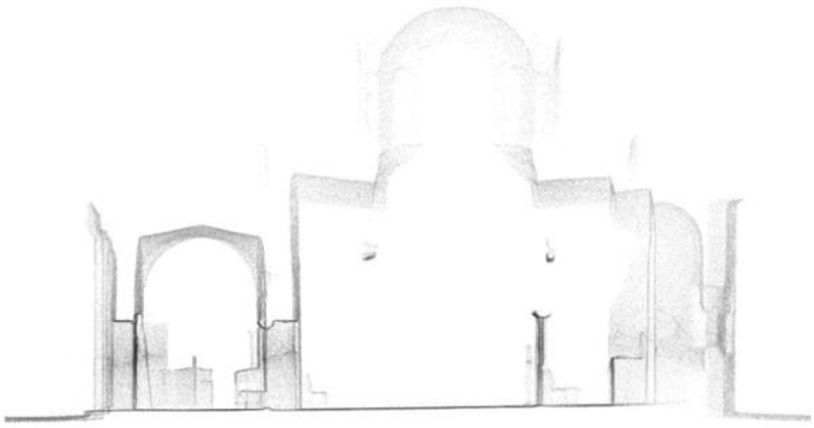


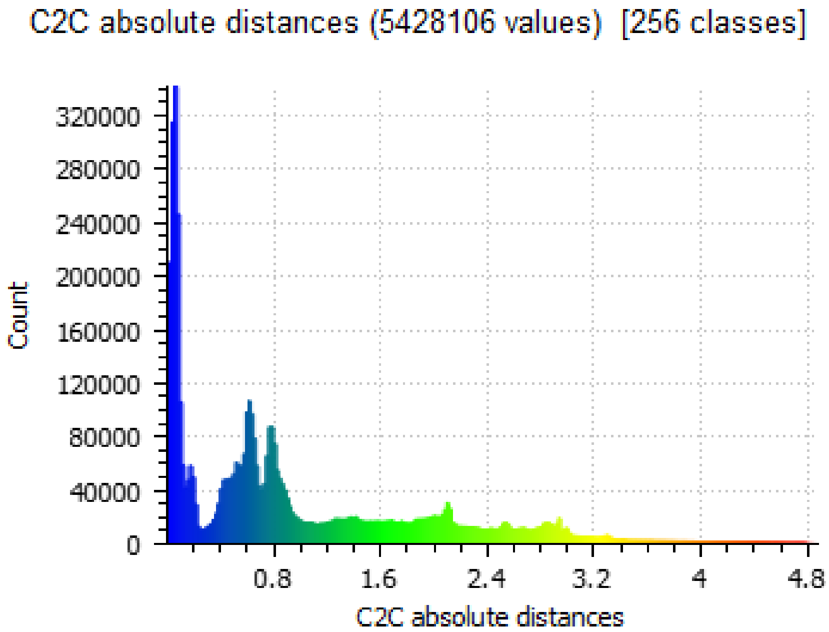


Point cloud from PLS ZEB REVO



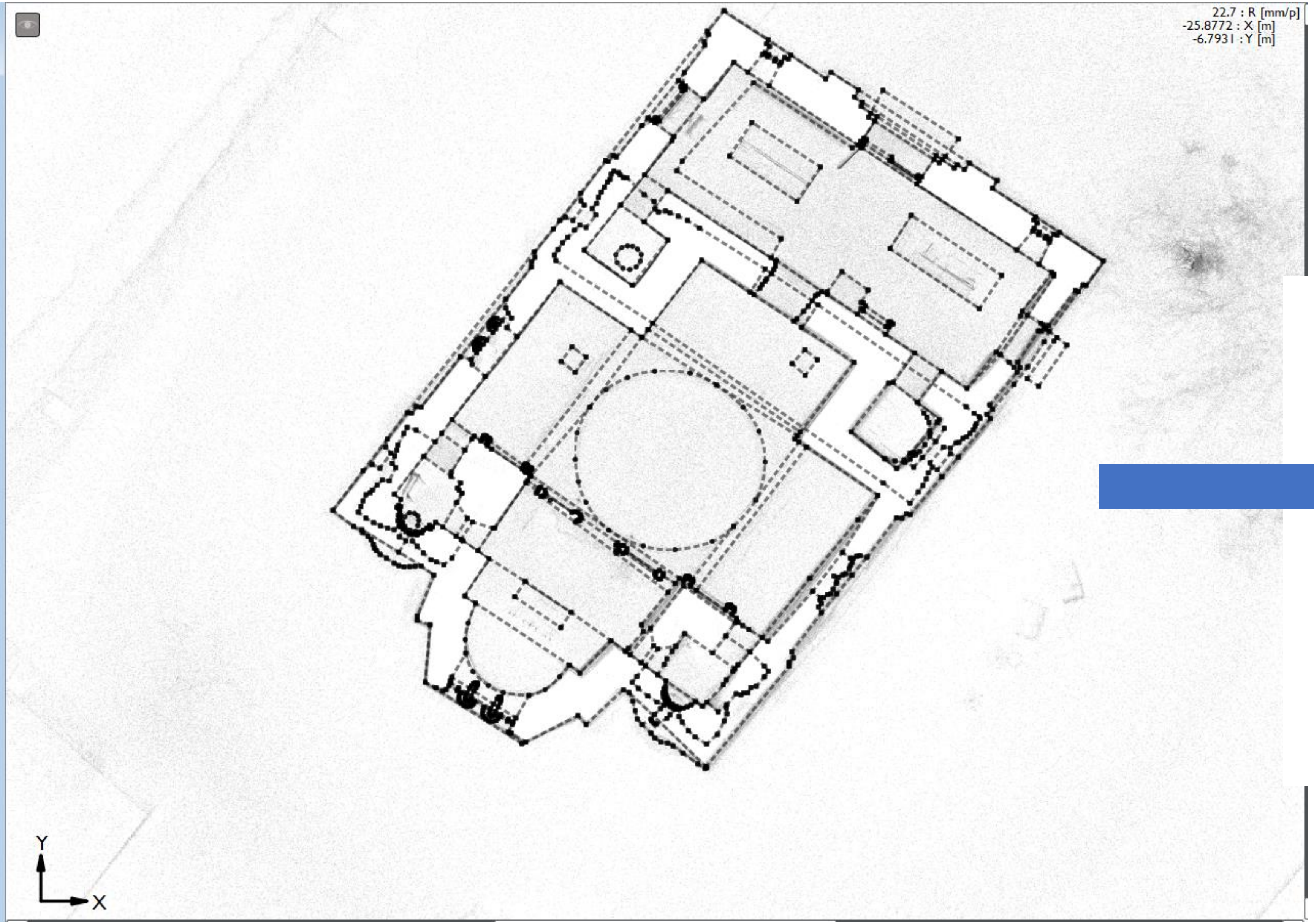


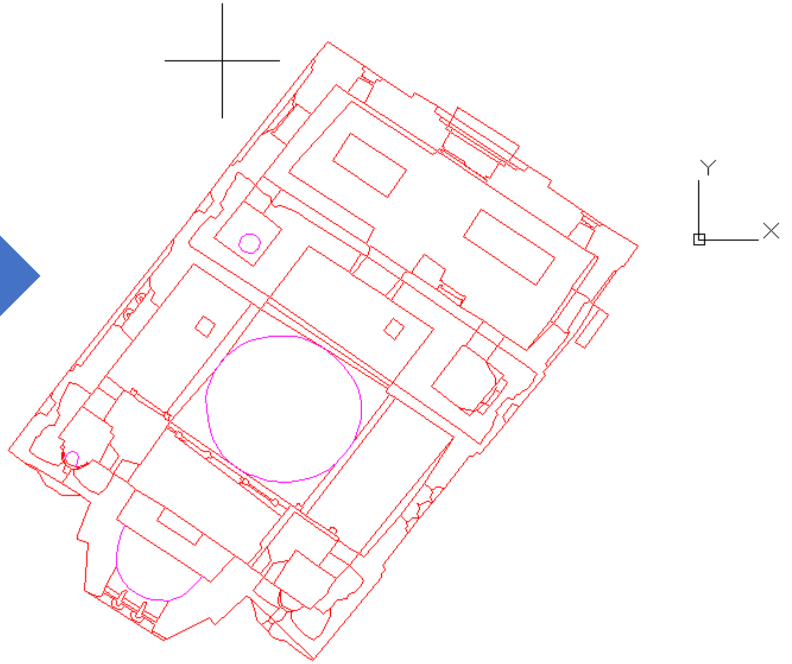


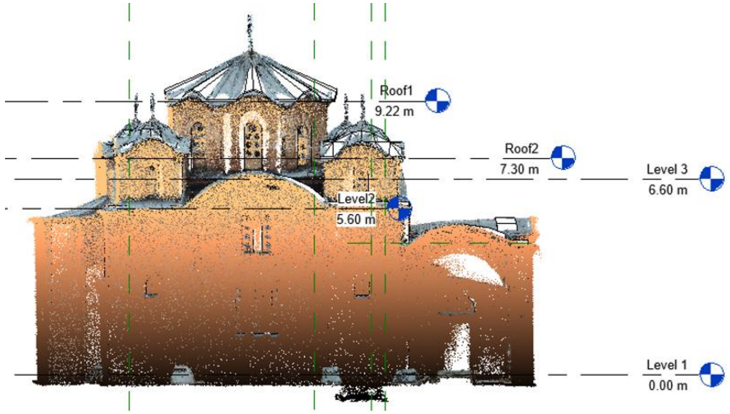


Differences between point cloud from combined terrestrial and aerial photogrammetry

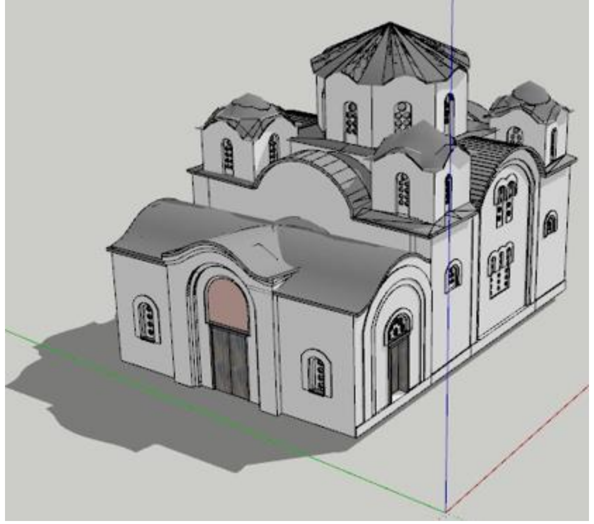
Device	Accuracy [mm] on 10 m	Range [m]	Acquiring points/sec	Data size [MB]	Time [minutes]
Nikon D3200	5-20	10	~30 photos/minute	~10/photo	~30 photos/minute
DJI Mavic Pro	5-30	30	~20 photos/minute	~4/photo	~20 photos/minute
ZEB-REVO	10-30	30	43000	100/min	slow walking
BLK360	4	30	360000	600/scan	6/scan

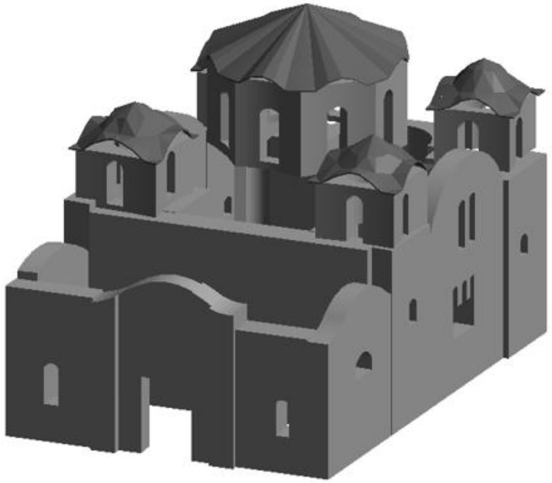

22.7 : R [mm/p]
-25.8772 : X [m]
-6.7931 : Y [m]
Y
X

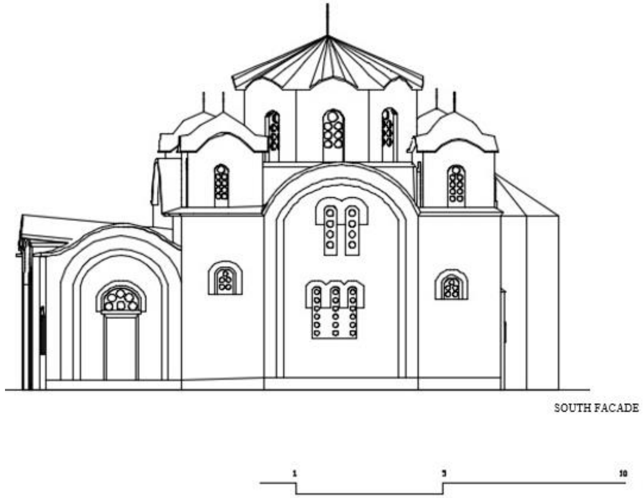

Y
X



Defining of levels for creating of simplified model


Model from SketchUp


Model from Revit



Generated views from simplified models (SketchUp)

Generated VR model with texture (UnrealEngine)


VR model rendered in Lumion

Comparison of both 3D models: BIM geometrical basic model (grey), photogrammetrical model (blue)

Church of Saint Panteleimon, Skopje

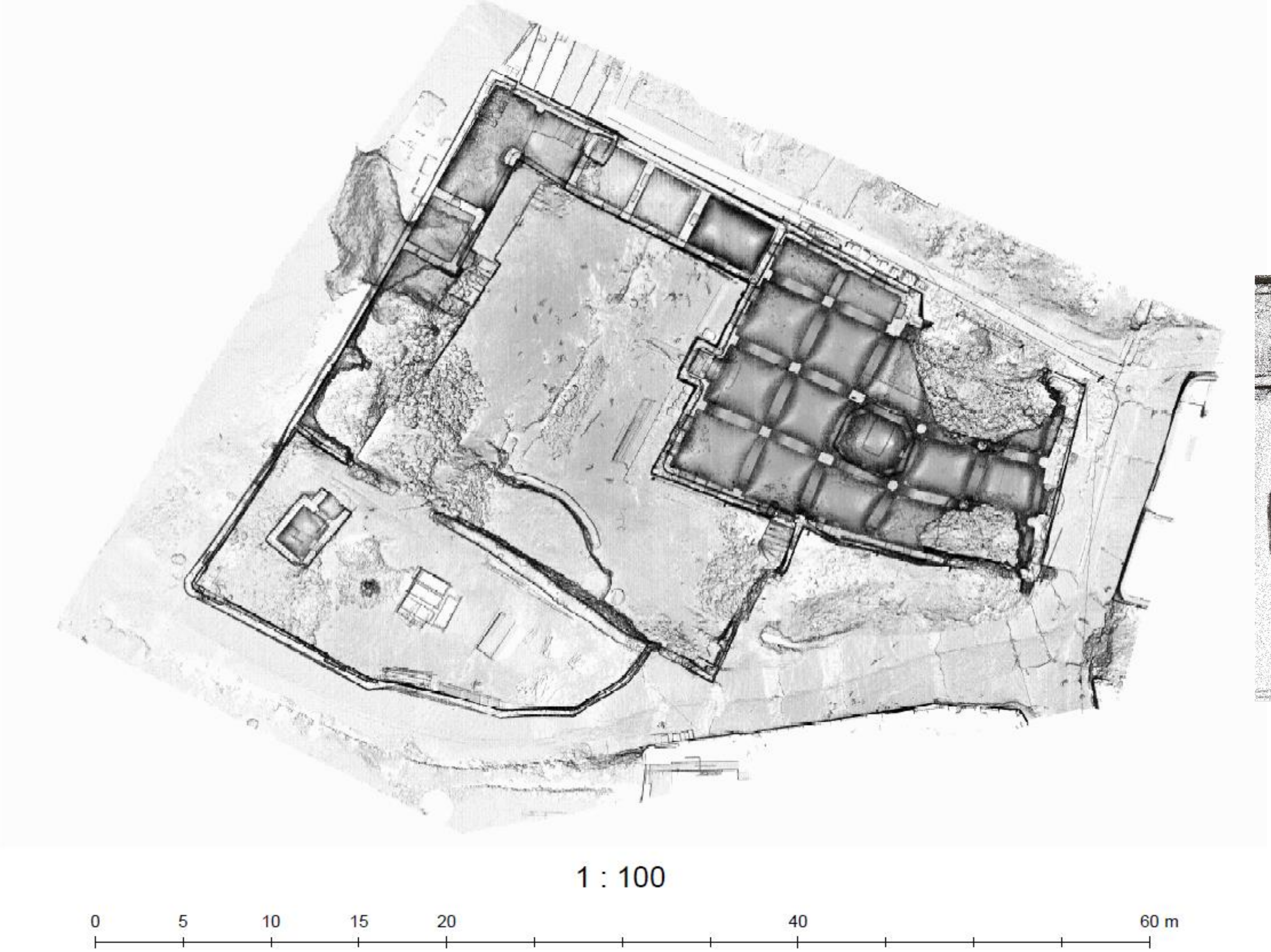

Perspective 30°
Snap: Axis, 2D
Faces: 5,270,156 vertices: 2,648,118
Z
X
Y

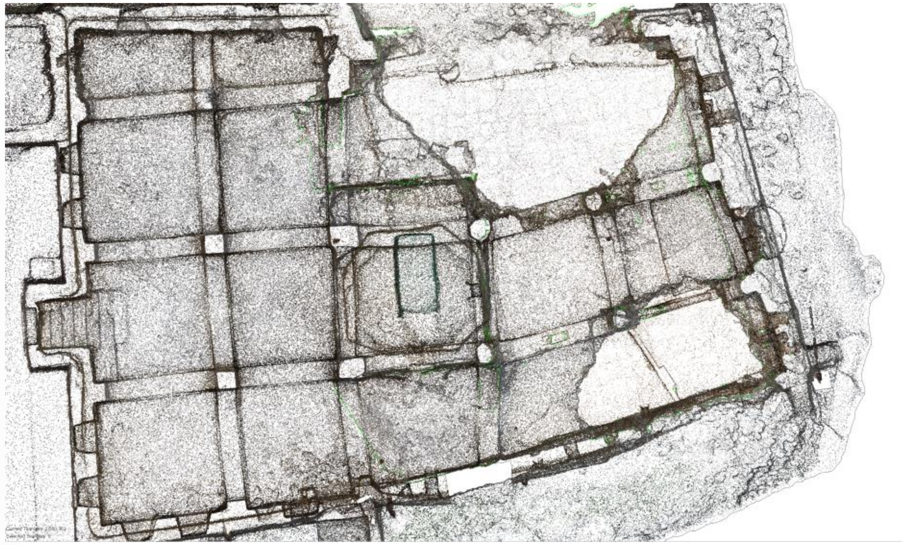
Case study 2 – the shrine of prophet Nahúm, Alqosh, Iraq / Kurdistan

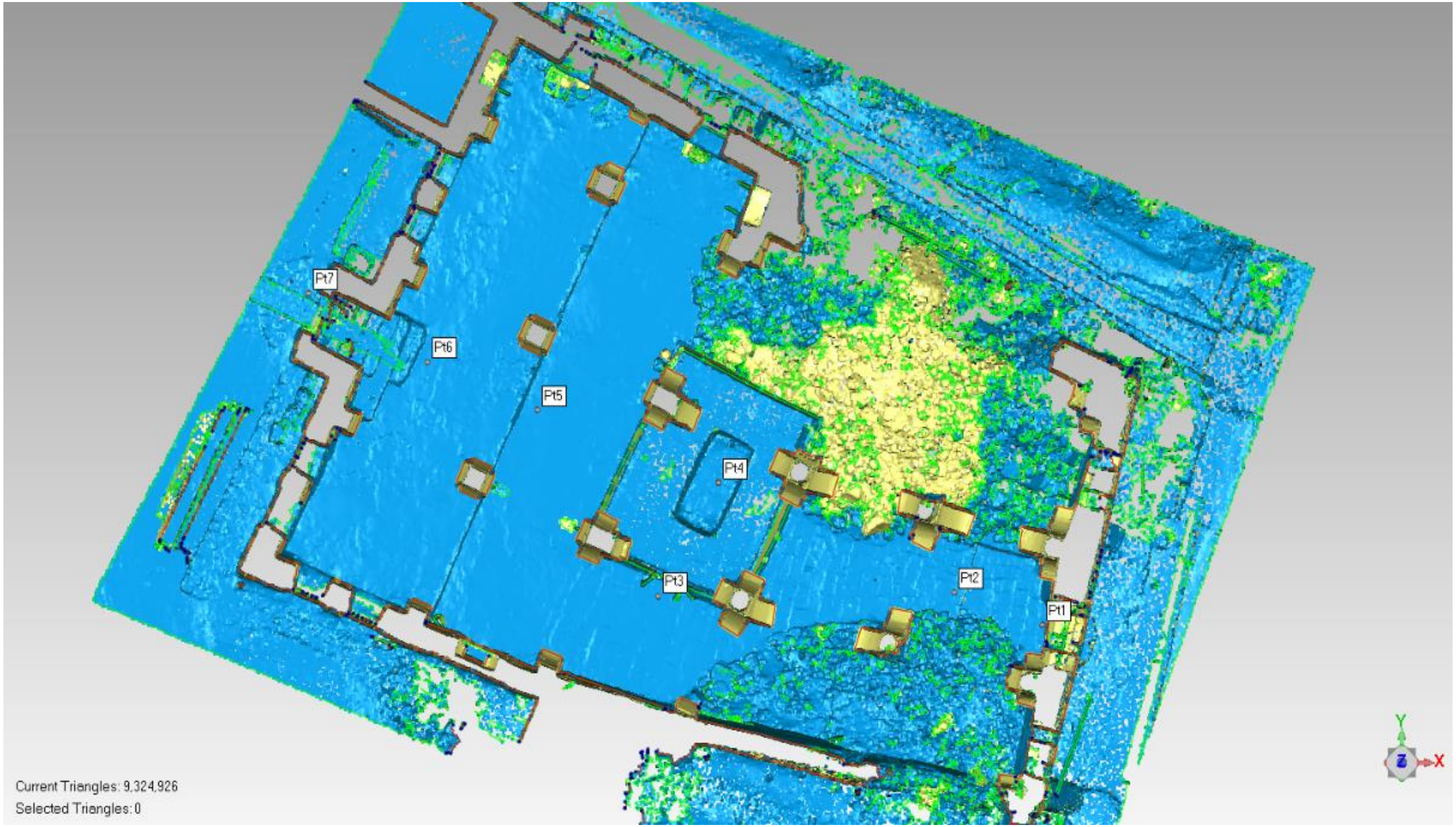
- Practical 3D documentation using all possible technologies
- Online consultation with other experts using VR
- Creating a geometrical model for H-BIM

Case study 2 – the shrine of prophet Nahúm, Iraq / Kurdistan

2019


1 : 100
0
5
10
15
20
40
60 m




Pt7
Pt6
Pt5
Pt4
Pt3
Pt2
Pt1
Y
Z
X
Current Triangles: 9,324,926
Selected Triangles: 0

Completion of the model, filling on of missing parts

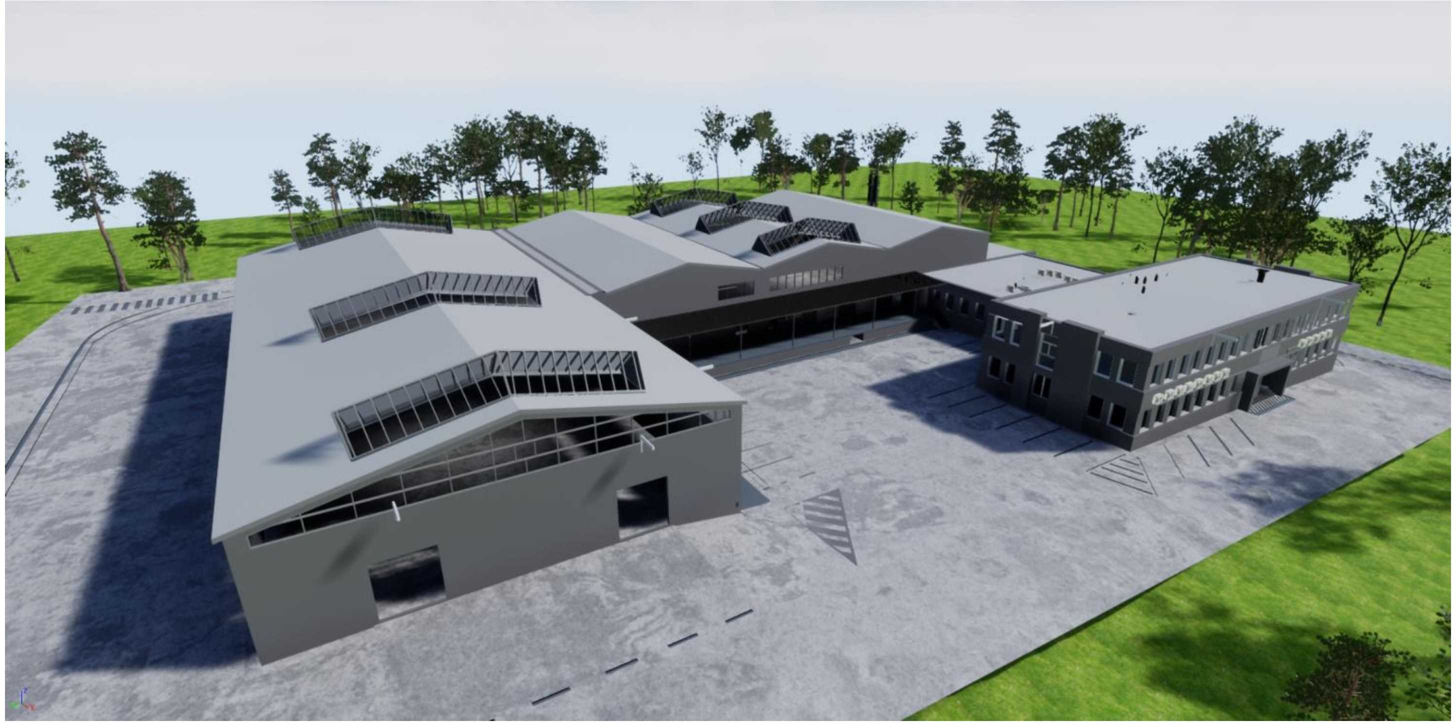
Reconstruction 2019-2020

After reconstruction, final documentation


6,898,921 vertices: 3,454,937


Perspective 30°

Case study 3: technical building



An industrial complex that had two parts: the first part was a warehouse and the second part was an office building, the model contained approximately **5,400 components and covered approximately 3,000 m2**

Faro laser scanner, 3 days, 153 stations (indoors and outdoors, 30 GB), semi-automated process - connecting into a single point cloud, the required accuracy of 2-3 cm, processing to BIM: 3-4 weeks

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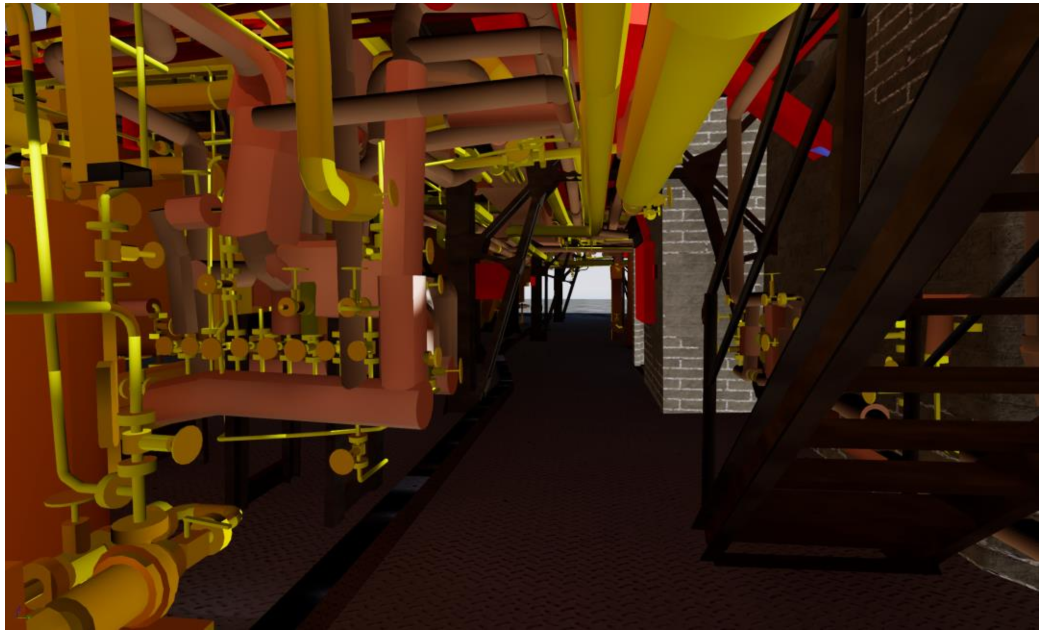
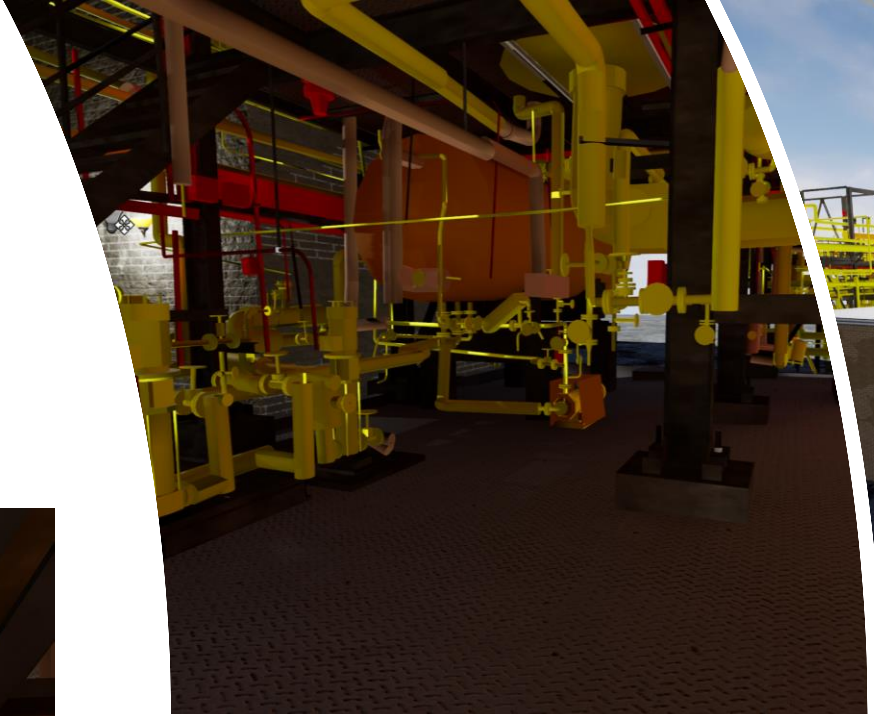
Using VR and AR XR for visualisation, training and building / construction management

VR in industry





Conclusion

- an original 3D model can be created from laser scanning, photogrammetry or classical geodetic technology, designed for future BIM, VR, AR and XR
- the implementation of VR is now fully possible
- data transfers between systems and formats is needed, high cost of visualization hardware, big-data
- IT technology development focused on portable visualition instruments (online on site– tablets, smartphones etc.), for portable devices it si necessary online data transmission, data decimation and other service, in reserch and process now

Thank you for your attention

E-mail: pavelka@fsv.cvut.cz