



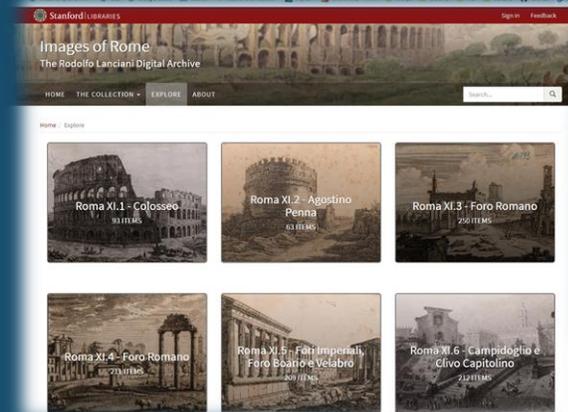
USING STRUCTURE FROM MOTION TO DOCUMENT ARCHAEOLOGICAL EXCAVATIONS: A CASE STUDY FROM CENTRAL ITALY

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Anthropology Lectures Series

Oregon State University
November 15, 2019

ABOUT ME



2002
BA, Archaeology

2007
Professional Doctorate, Archaeology

2002-2015
Professional Archaeologist

2015-2019
Researcher

2019
MS, Geography

STRUCTURE FROM MOTION

- The possibility to gather massive and accurate information without long presence on site.
- Moving of interpretation from the field to a post-processing step.
- Reduced costs and highly automated workflow.



THE INVENTION OF PHOTOGRAMMETRY: AIMÉ LAUSSEDAT (1819-1907)

- Photogrammetry is the process of making measurements of features through analysis of overlapping photographs.
- Invented by French Army surveyor, Aimé Laussedat
- Great technical skill and extensive manual calculation were required

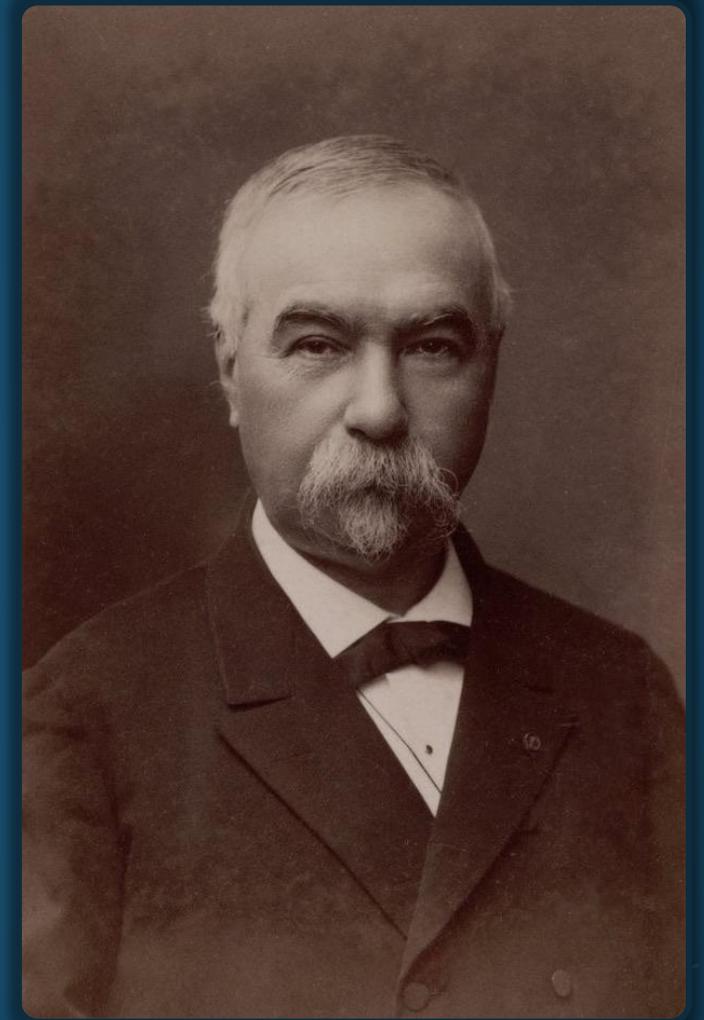


Image source: <http://www.geometres-francophones.org/>

EVOLUTION OF PHOTOGRAMMETRY

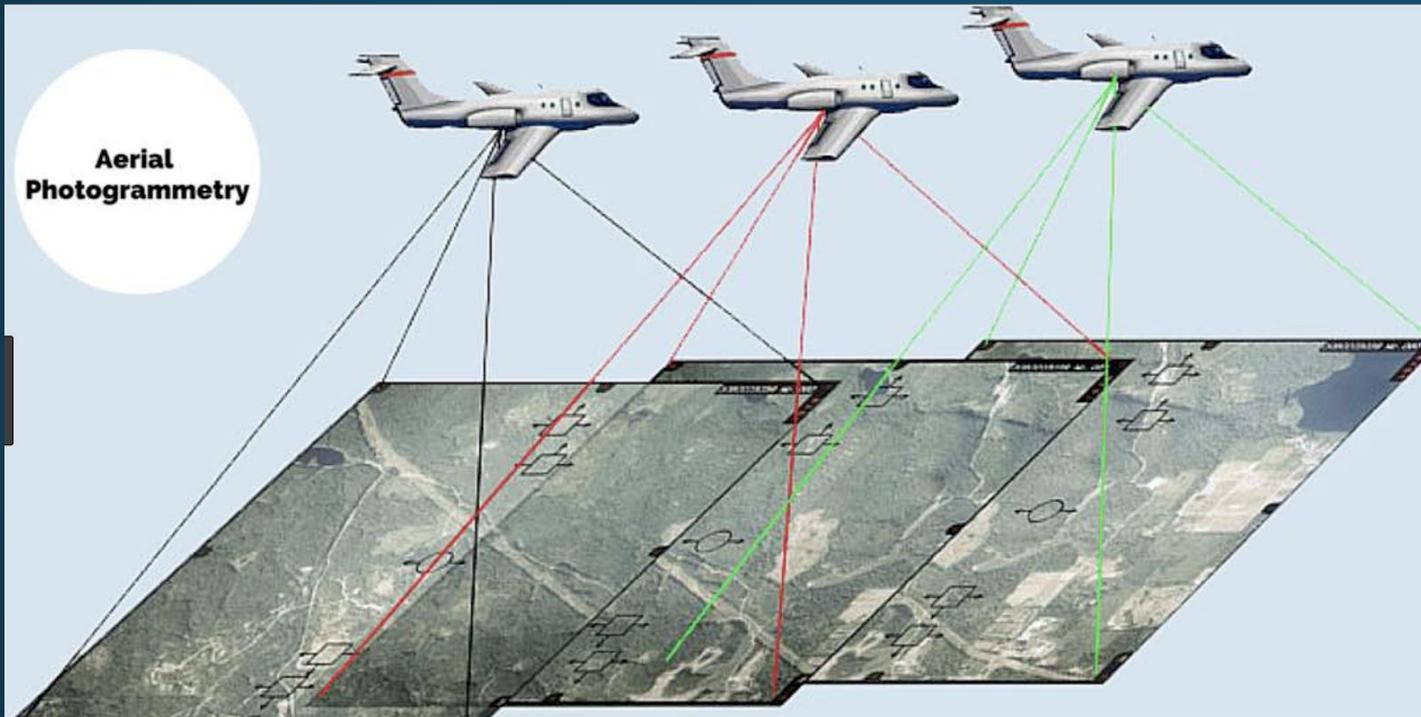


Image source: <https://www.aboutcivil.org/>

- Aerial topographic survey of large areas
- In the last decades of the 20th century efforts to automate the process
- In the early 1990's advent of digital photogrammetry

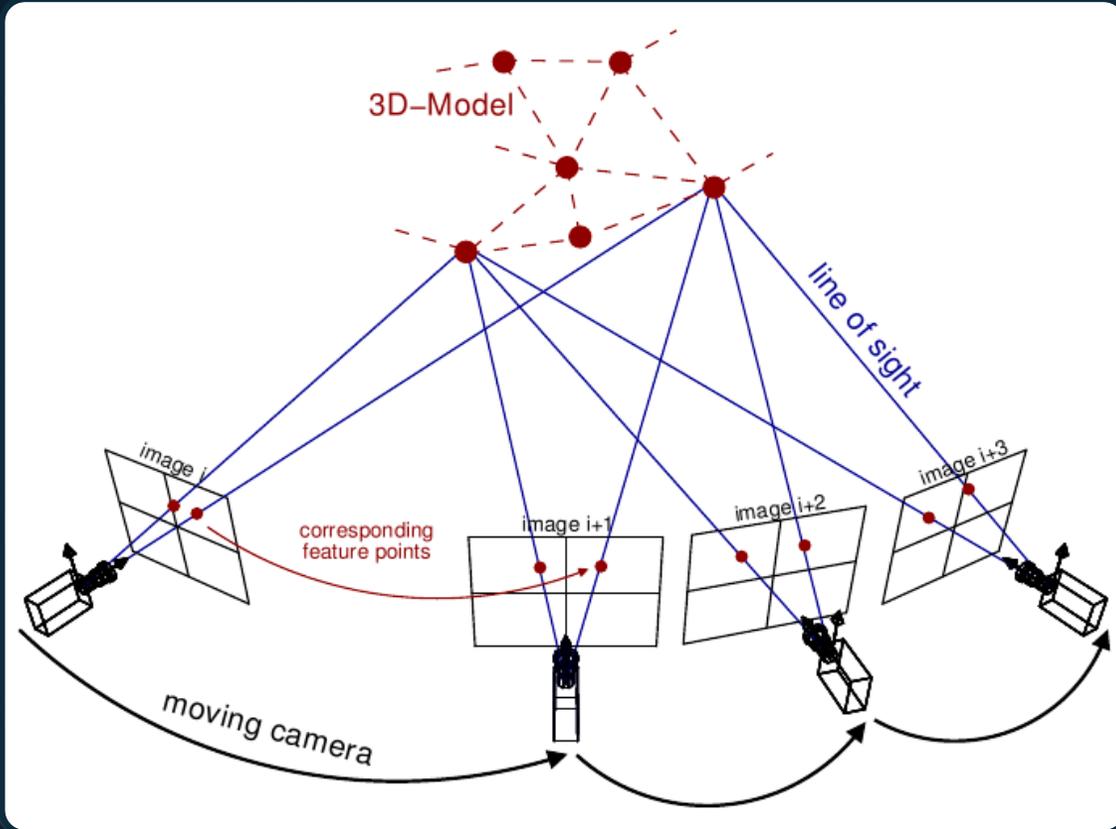


Image source: <https://www.researchgate.net/>

MULTI-IMAGE PHOTOGRAMMETRY

"The term 'Multi-image Photogrammetry' (sometimes used interchangeably with 'Structure from Motion') is used to describe an approach to photogrammetry, where stereo pairs are no longer the focus. Instead much larger datasets of overlapping digital images of a feature taken from different positions can be loaded into software capable of feature matching and reconstruction of 3-Dimensional models, with minimal manual input."

John McCarthy, 2014

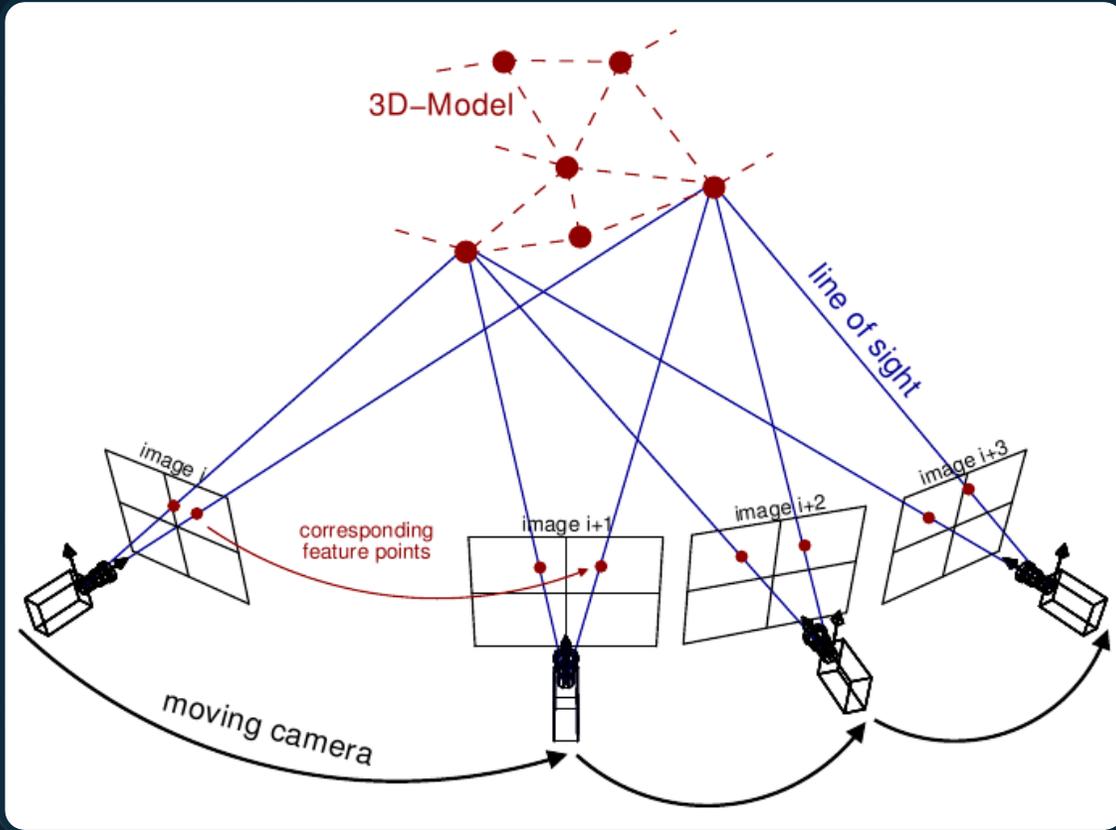


Image source: <https://www.researchgate.net/>

CHARACTERISTICS OF SfM

- Use of consumer-grade digital cameras
- High degree of overlap between images
- Highly automated low-cost or free software
- Scale-independent
- Easy implementation with little specialized knowledge

CASE STUDY: RIETI



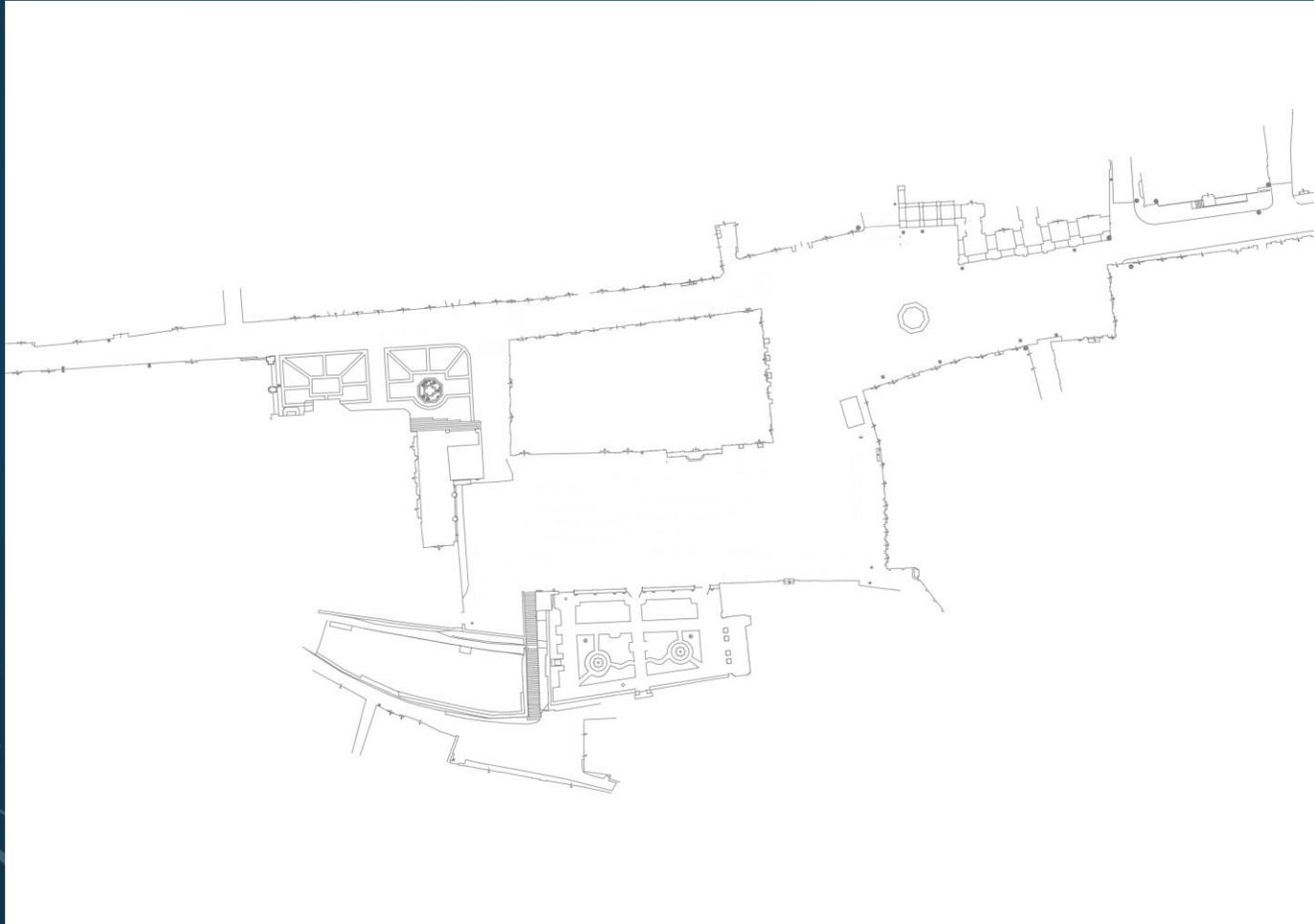
CASE STUDY: RIETI



CASE STUDY: RIETI



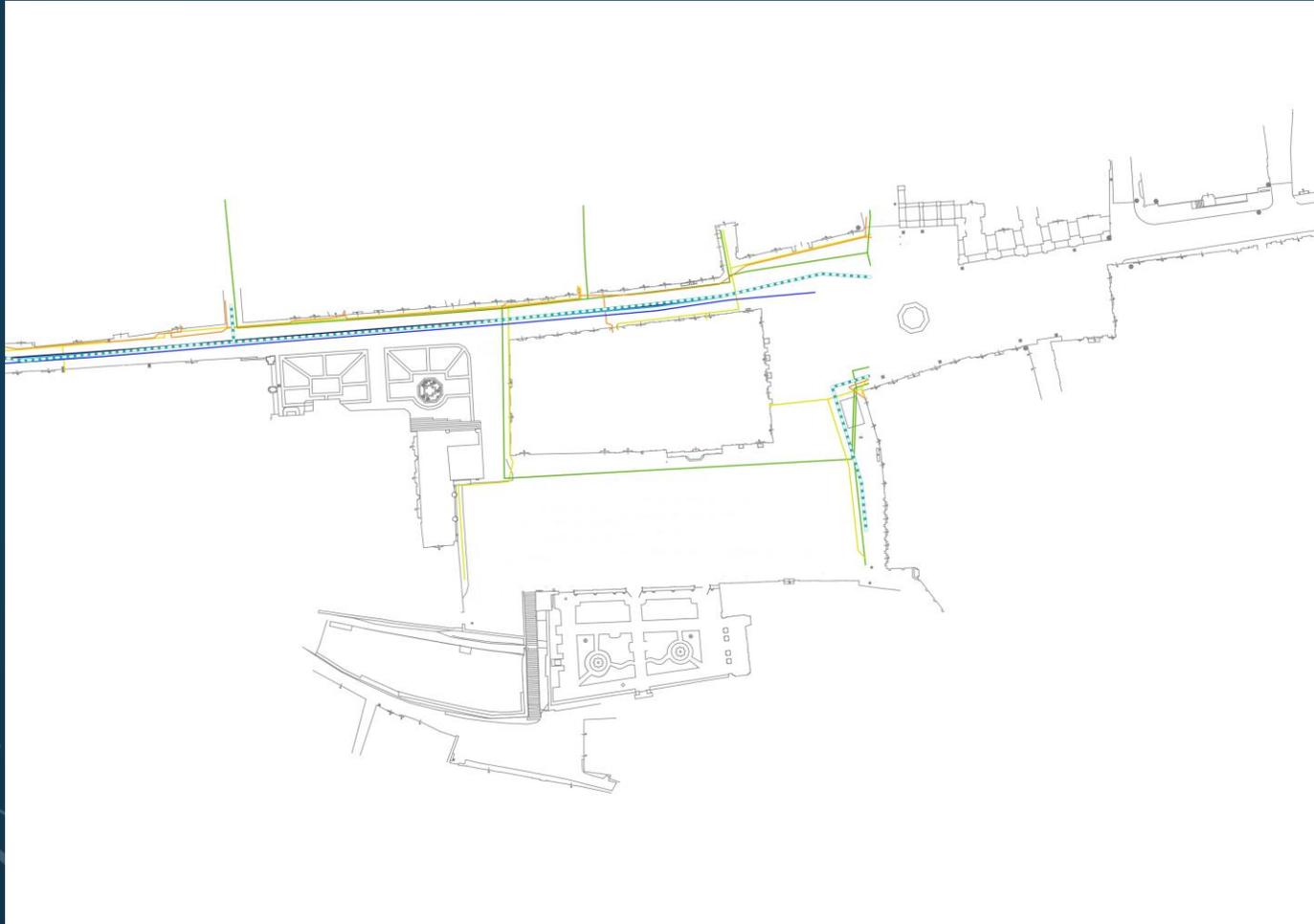
CASE STUDY: RIETI



GIS Layers:

❖ Cadastral map

CASE STUDY: RIETI



GIS Layers:

- ❖ Cadastral map
- ❖ Sewage and electrical lines

CASE STUDY: RIETI



GIS Layers:

- ❖ Cadastral map
- ❖ Sewage and electrical lines
- ❖ Aerial imagery

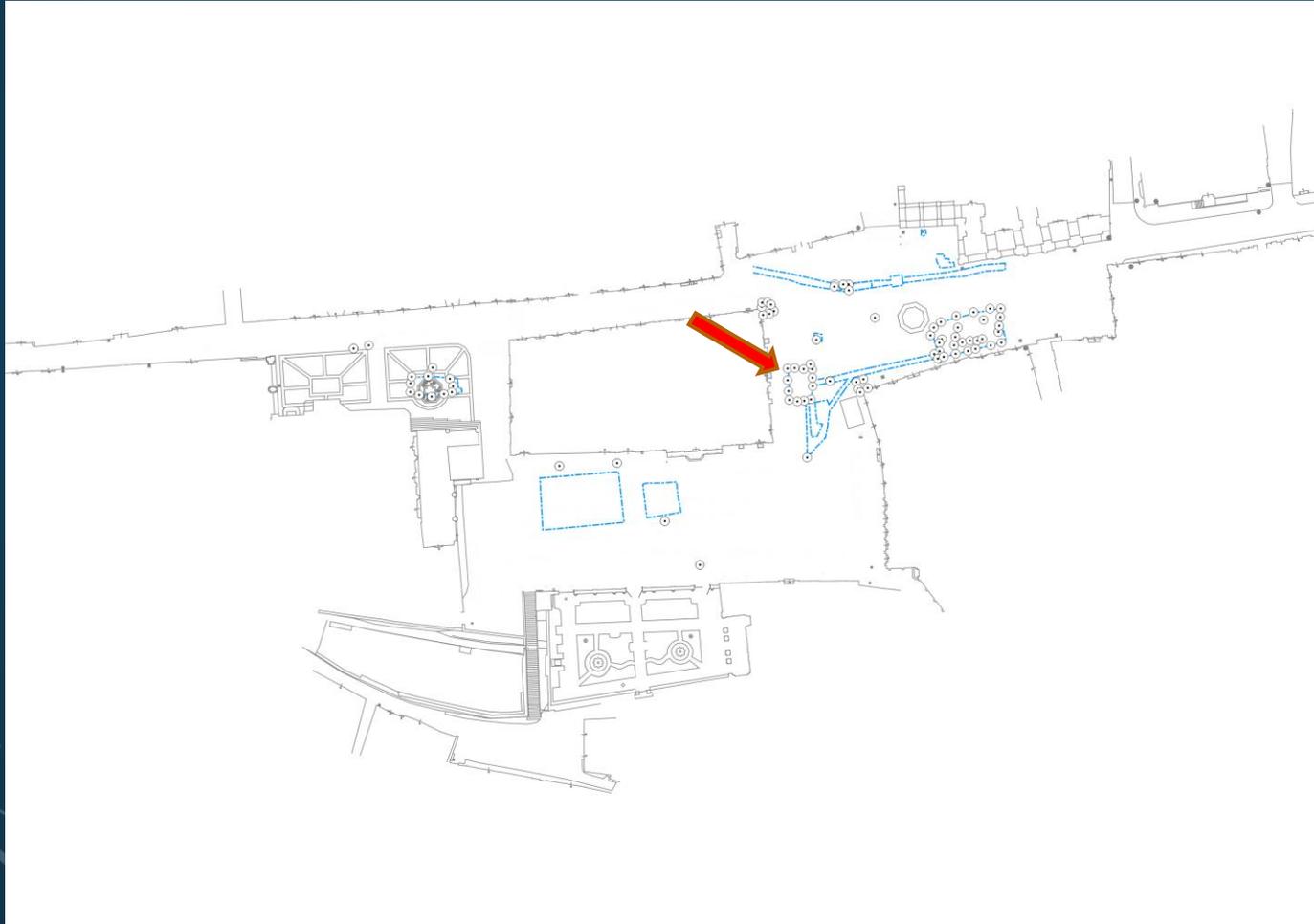
CASE STUDY: RIETI



GIS Layers:

- ❖ Cadastral map
- ❖ Sewage and electrical lines
- ❖ Aerial imagery
- ❖ Historic maps

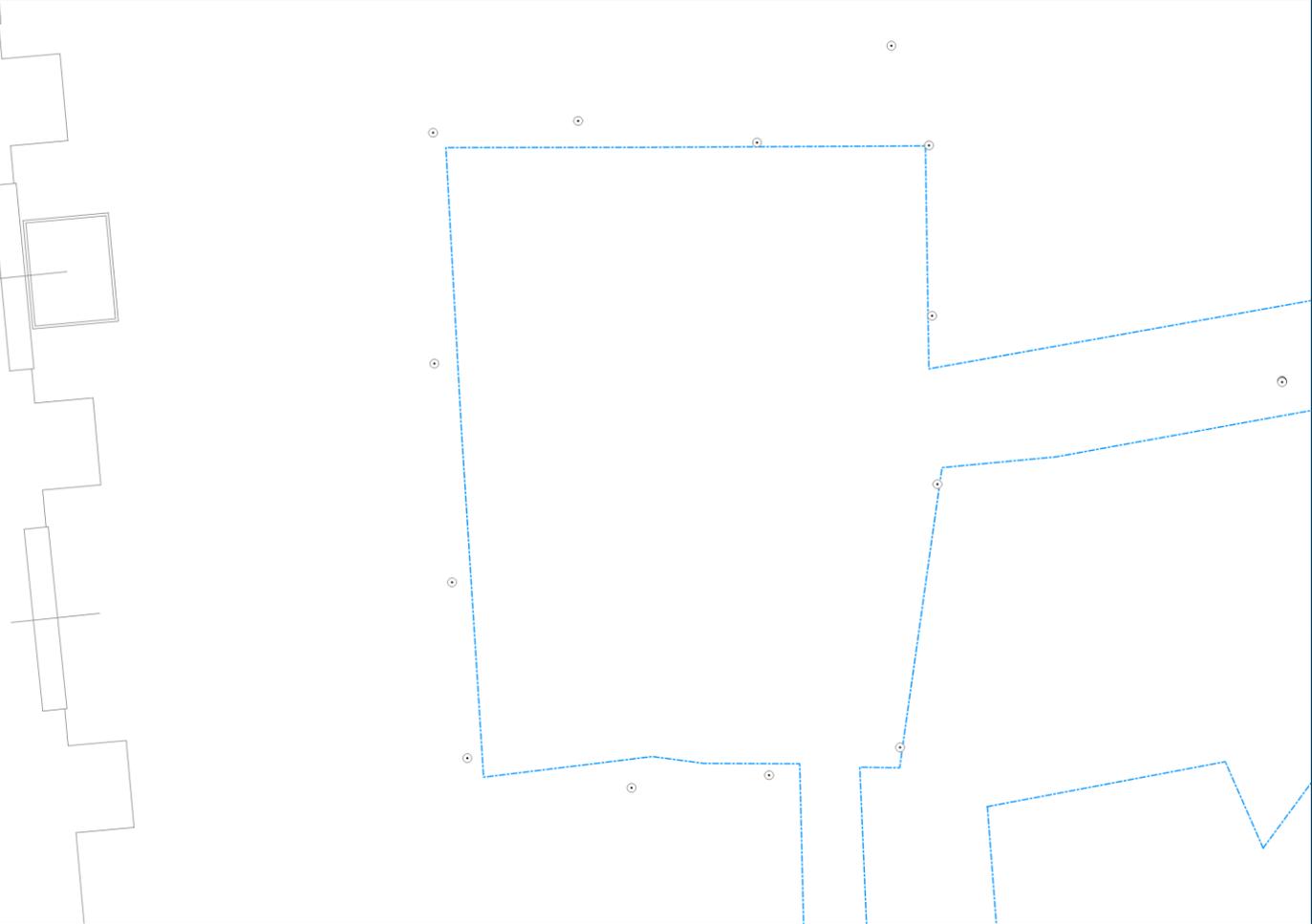
CASE STUDY: RIETI



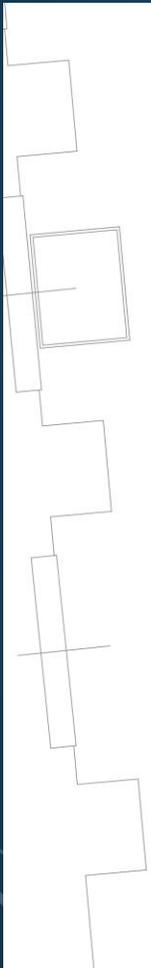
GIS Layers:

- ❖ Cadastral map
- ❖ Sewage and electrical lines
- ❖ Aerial imagery
- ❖ Historic maps
- ❖ Excavations and GCP

CASE STUDY: RIETI



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CASE STUDY: RIETI



COMUNE
DI RIETI



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P.L.U.S. RIQUALIFICAZIONE PIAZZE
CENTRALI

Piazza Vittorio Emanuele II

Tav.5 - Saggio 3
Prospetti dei resti dell'edificio templare

15 luglio 2015

Formato: A3

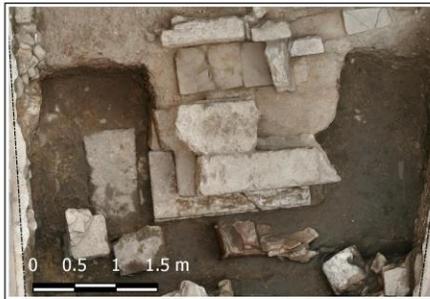
Scala:1:20

Rilievo
dott. Giovanni Svevo

Funzionario responsabile
dott.ssa Sandra Gatti

ACTUSrsl
indagini territoriali

SOPRINTENDENZA
PER I BENI
ARCHEOLOGICI
DEL LAZIO



Planimetria (scala 1:50)

metri slm

404.0

403.5

403.0

402.5



Prospetto SUD



Prospetto OVEST

404.0

403.5

403.0

402.5



Prospetto EST

0 0.2 0.4 0.6 0.8 1 m



CASE STUDY: RIETI



COMUNE
DI RIETI



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**P.L.U.S. RIQUALIFICAZIONE PIAZZE
CENTRALI**

Piazza Vittorio Emanuele II

Tav.4 - Saggio 3
Prospetti dei resti dell'edificio templare

15 luglio 2015

Formato: A3

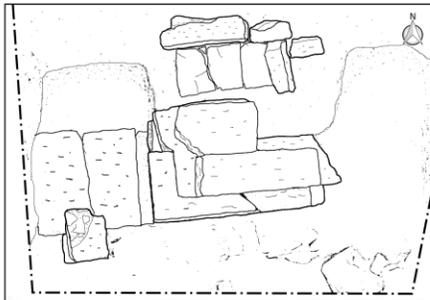
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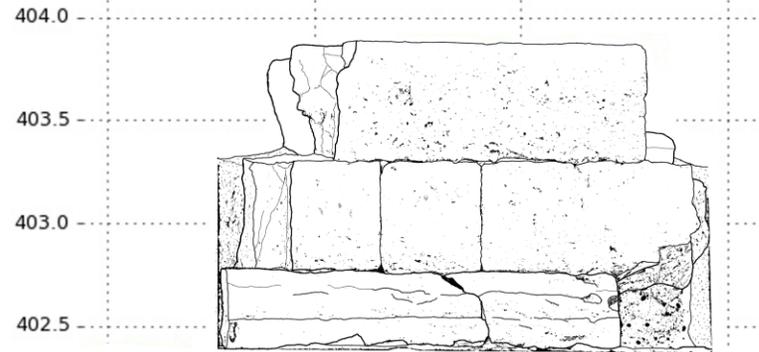
ACTUSsrl
indagini territoriali

ASL SOPRINTENDENZA
PER I BENI
ARCHEOLOGICI
DEL LAZIO



Planimetria (scala 1:50)

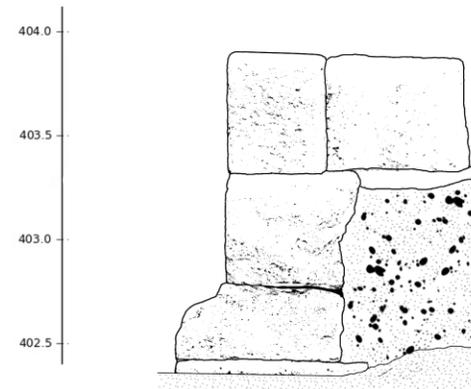
metri slm



Prospetto SUD



Prospetto OVEST

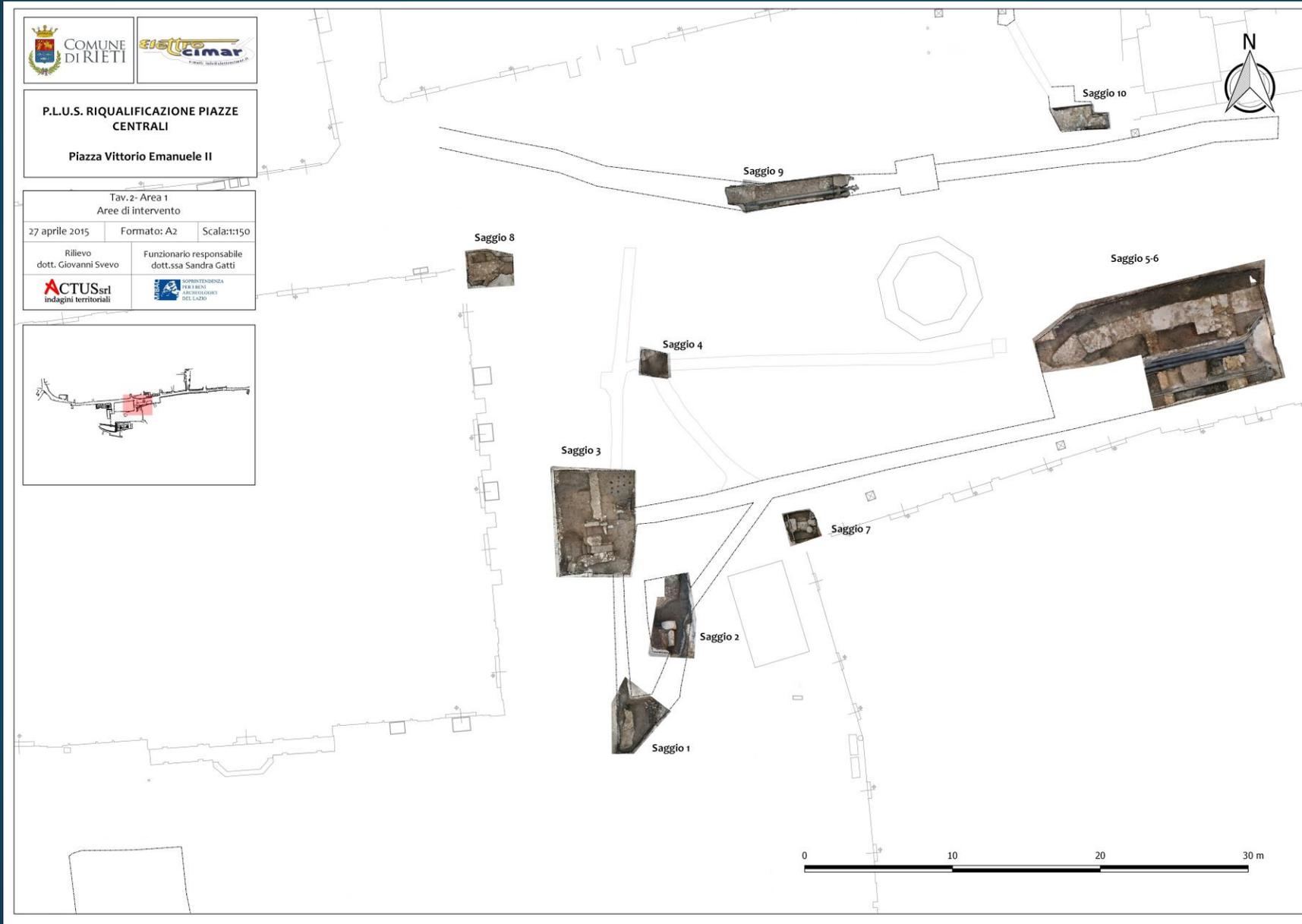


Prospetto EST

0 0.2 0.4 0.6 0.8 1 m



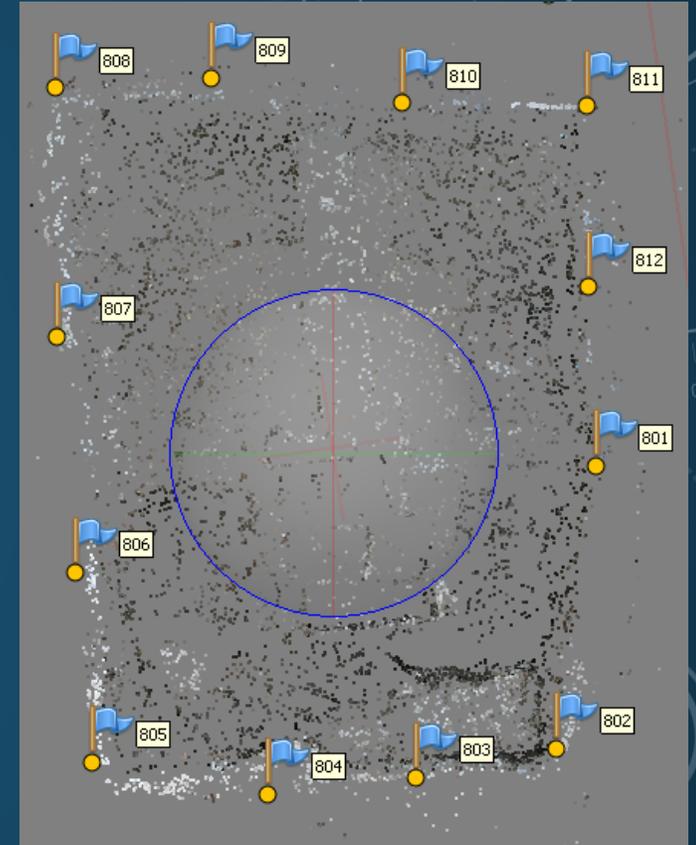
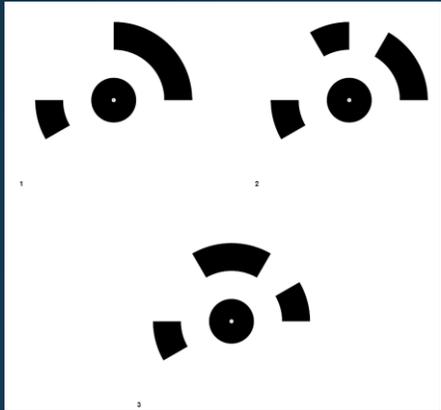
CASE STUDY: RIETI



WORKFLOW



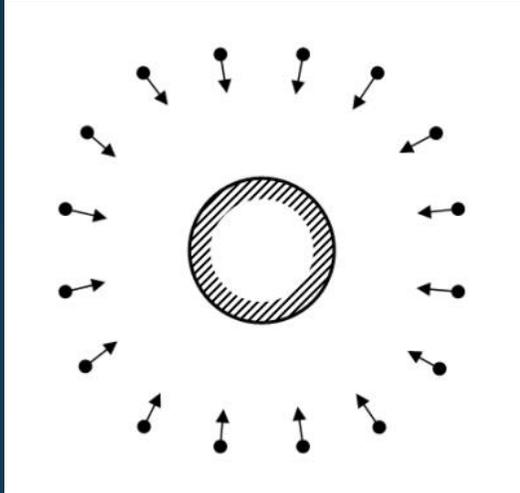
WORKFLOW



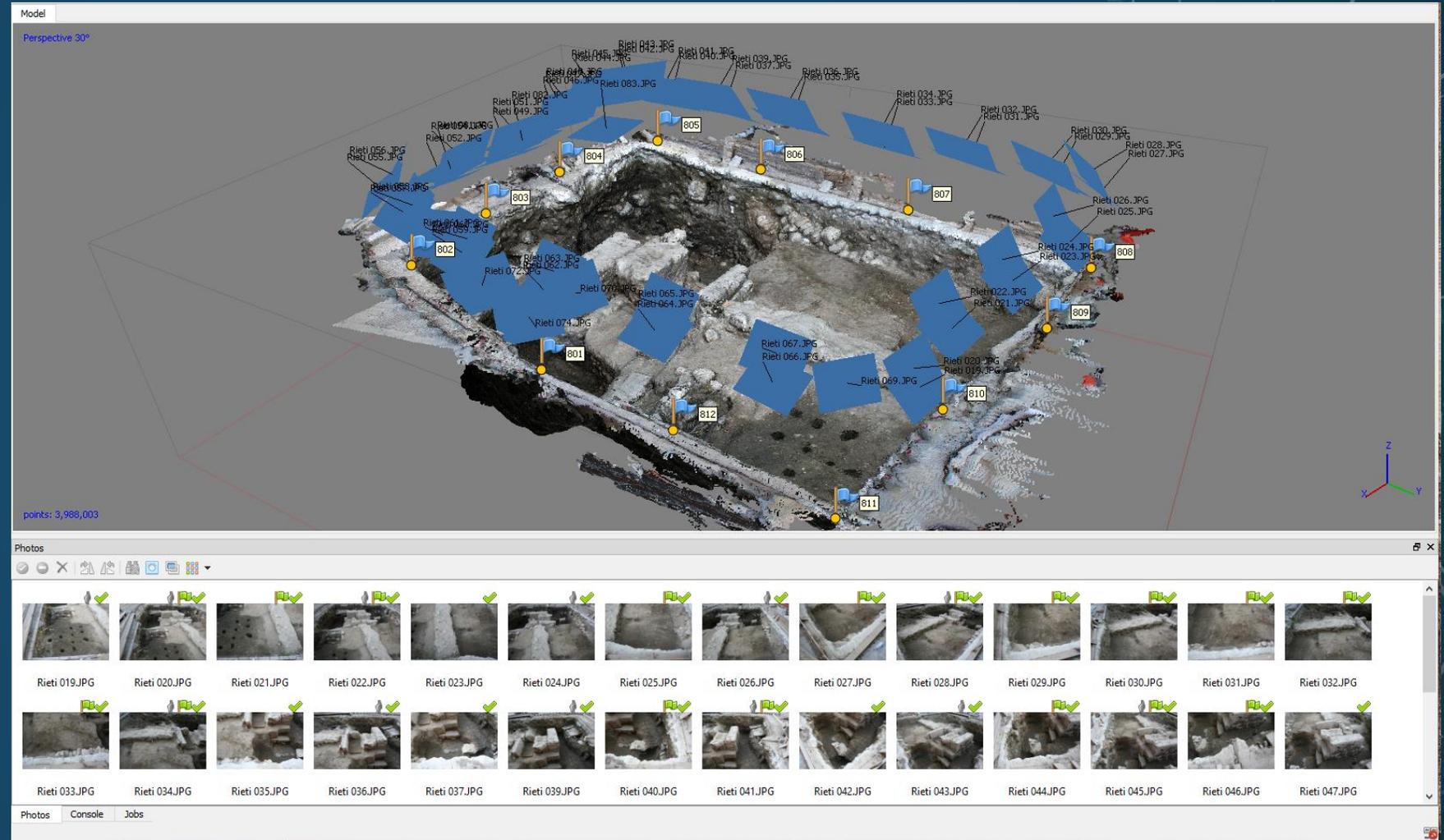
Markers	Easting (m)	Northing (m)	Altitude (m)	Accuracy (m)	Error (m)	Projections
<input checked="" type="checkbox"/> 801	323915.404000	4696670.697000	453.996000	0.005000	0.019106	5
<input checked="" type="checkbox"/> 802	323914.982000	4696667.712000	454.051000	0.005000	0.009258	5
<input checked="" type="checkbox"/> 803	323913.501000	4696667.396000	454.127000	0.005000	0.009269	4
<input checked="" type="checkbox"/> 804	323911.946000	4696667.254000	454.174000	0.005000	0.012035	2
<input checked="" type="checkbox"/> 805	323910.090000	4696667.590000	454.173000	0.005000	0.007363	2
<input checked="" type="checkbox"/> 806	323909.916000	4696669.585000	454.160000	0.005000	0.004608	1
<input checked="" type="checkbox"/> 807	323909.717000	4696672.066000	454.165000	0.005000	0.008369	2
<input checked="" type="checkbox"/> 808	323909.702000	4696674.685000	454.168000	0.005000	0.019730	2
<input checked="" type="checkbox"/> 809	323911.343000	4696674.818000	454.153000	0.005000	0.002569	4
<input checked="" type="checkbox"/> 810	323913.364000	4696674.573000	454.096000	0.005000	0.018571	4
<input checked="" type="checkbox"/> 811	323915.309000	4696674.541000	454.055000	0.005000	0.010452	3
<input checked="" type="checkbox"/> 812	323915.343000	4696672.608000	454.065000	0.005000	0.016563	2
<input checked="" type="checkbox"/> 888	323914.883000	4696675.671000	454.253000	0.005000		0
Total Error						
Control points					0.012752	
Check points						

Step 1 – Control Points

WORKFLOW

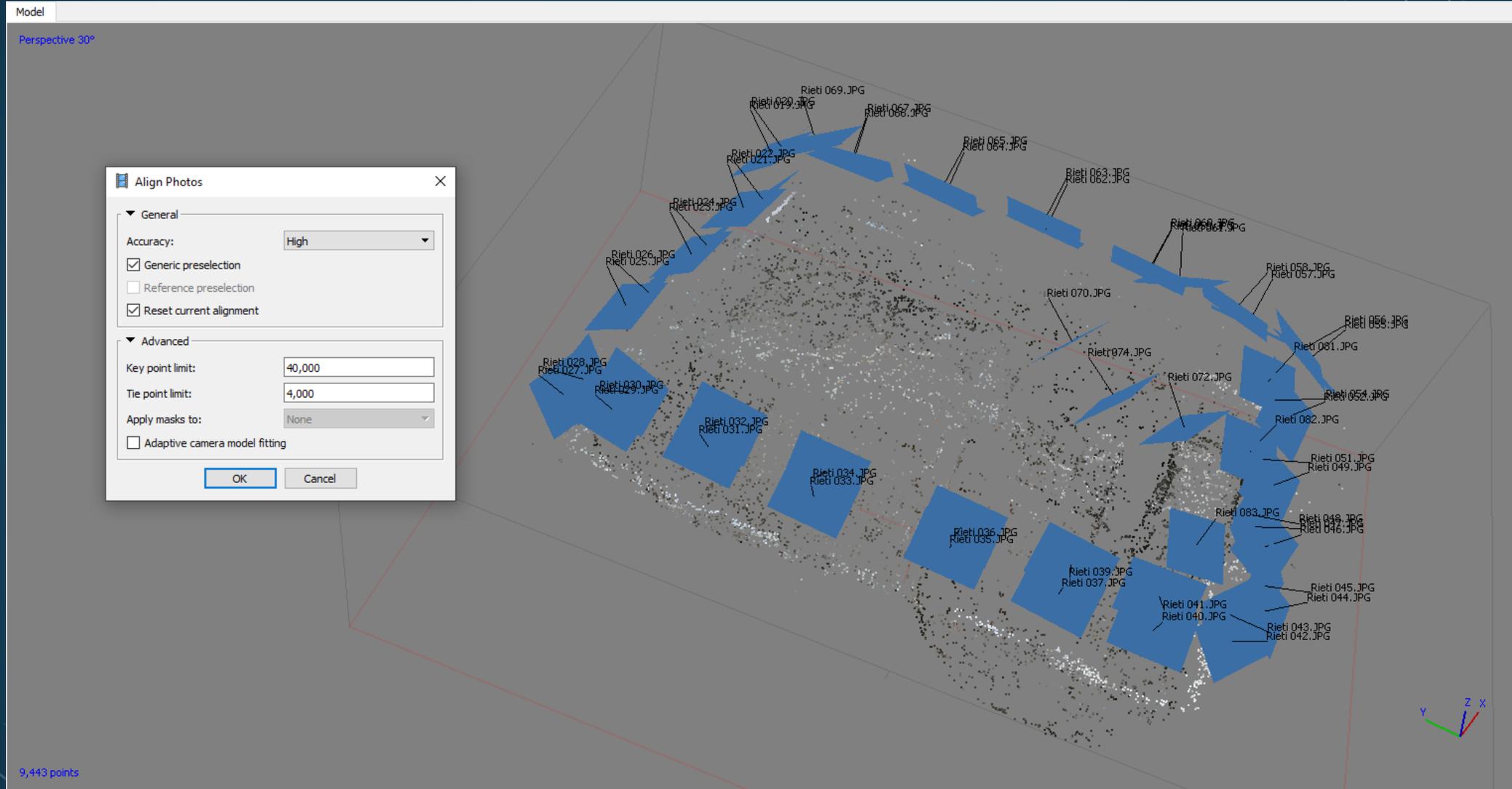


- 5 Mpx resolution at least
- 60% of side overlap
- 80% of forward overlap
- Avoid plain/monotonous and glittering surfaces



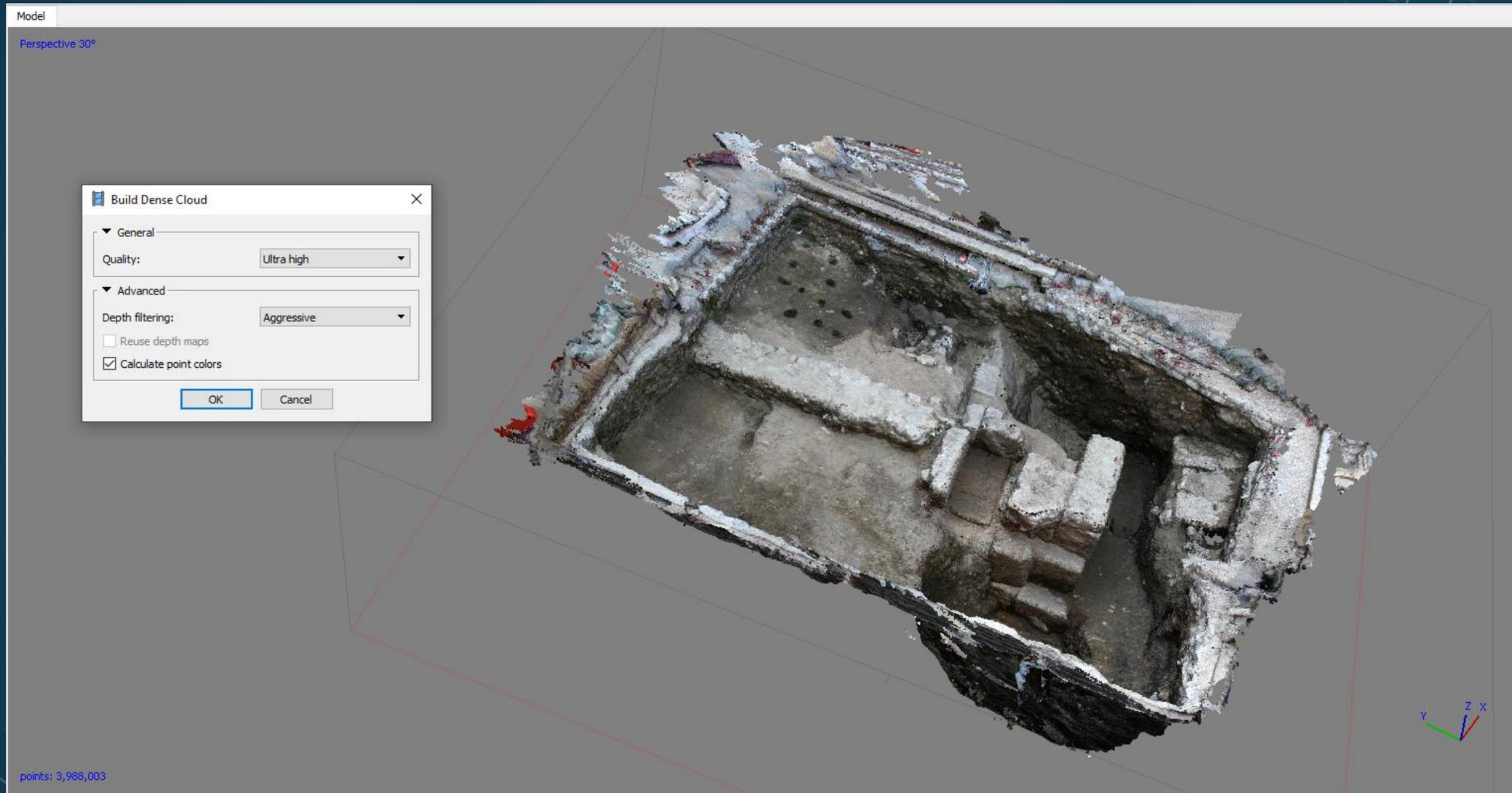
Step 2 – Image Capture

WORKFLOW



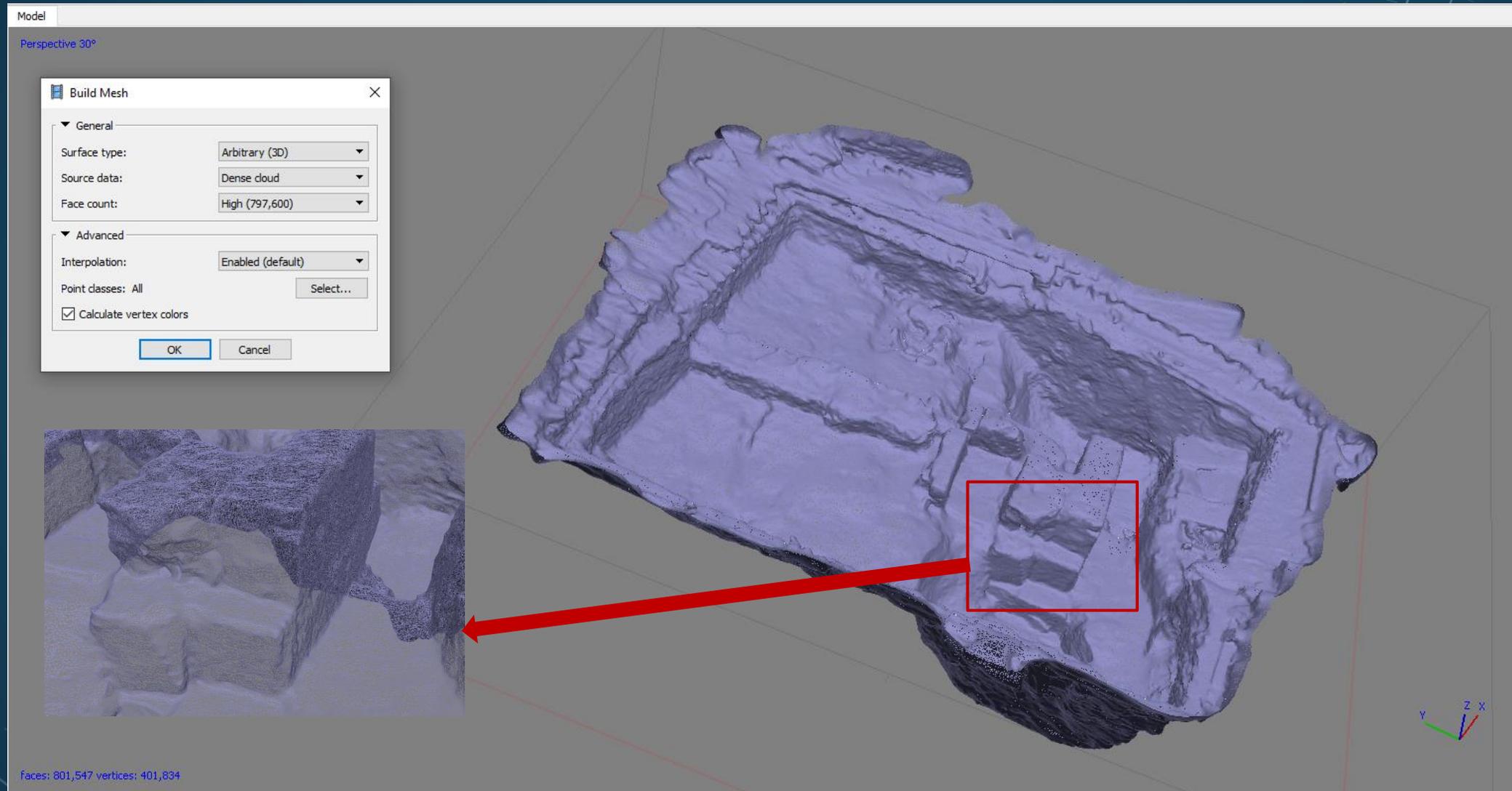
Step 3 – Image Alignment

WORKFLOW



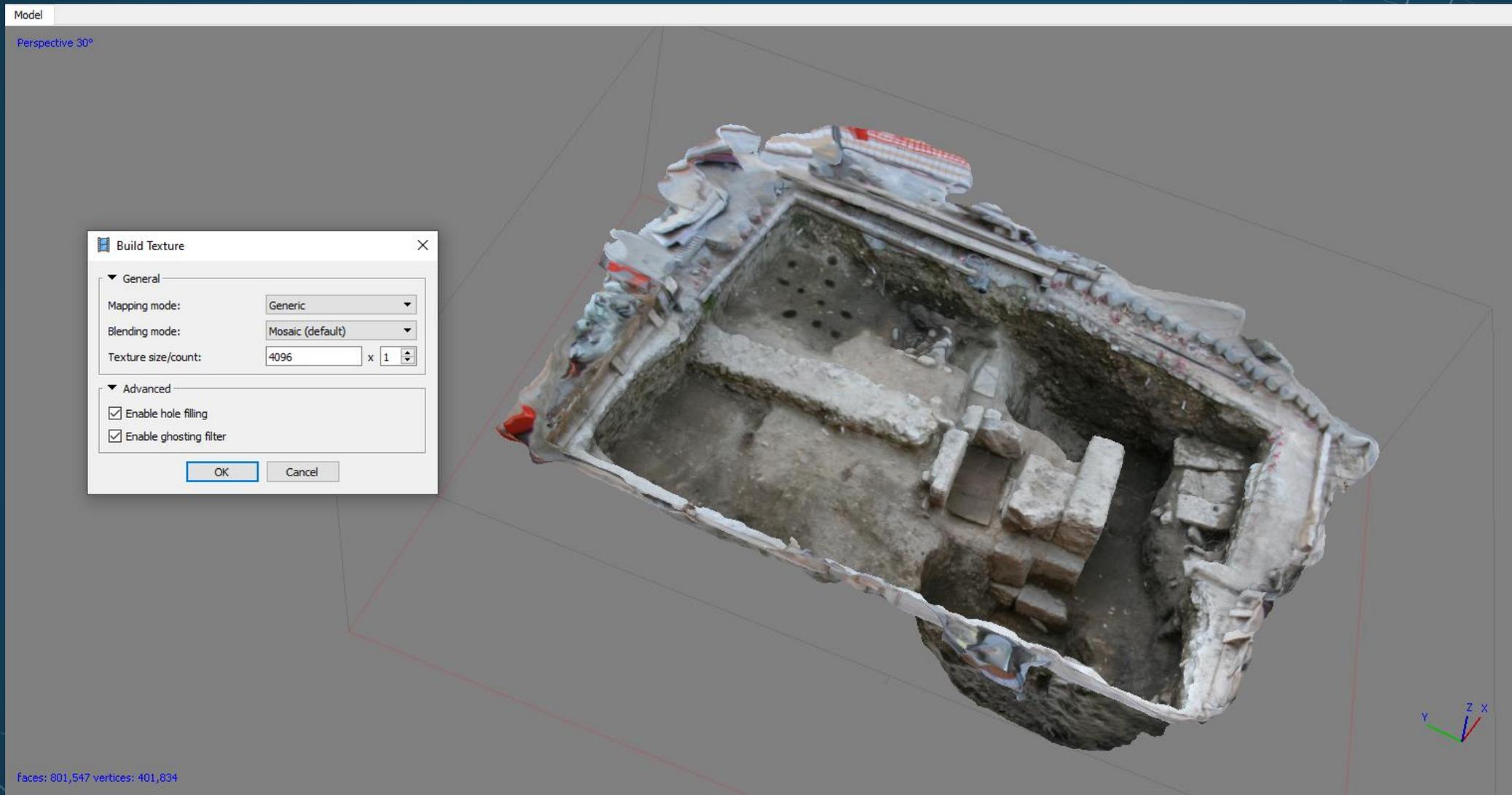
Step 4 – Dense Cloud

WORKFLOW



Step 5 – Build Mesh

WORKFLOW



Step 6 – Build Texture

WORKFLOW

Build DEM

Projection

Type: Geographic Planar Cylindrical

WGS 84 / UTM zone 33N (EPSG::32633)

Parameters

Source data: Dense cloud

Interpolation: Enabled (default)

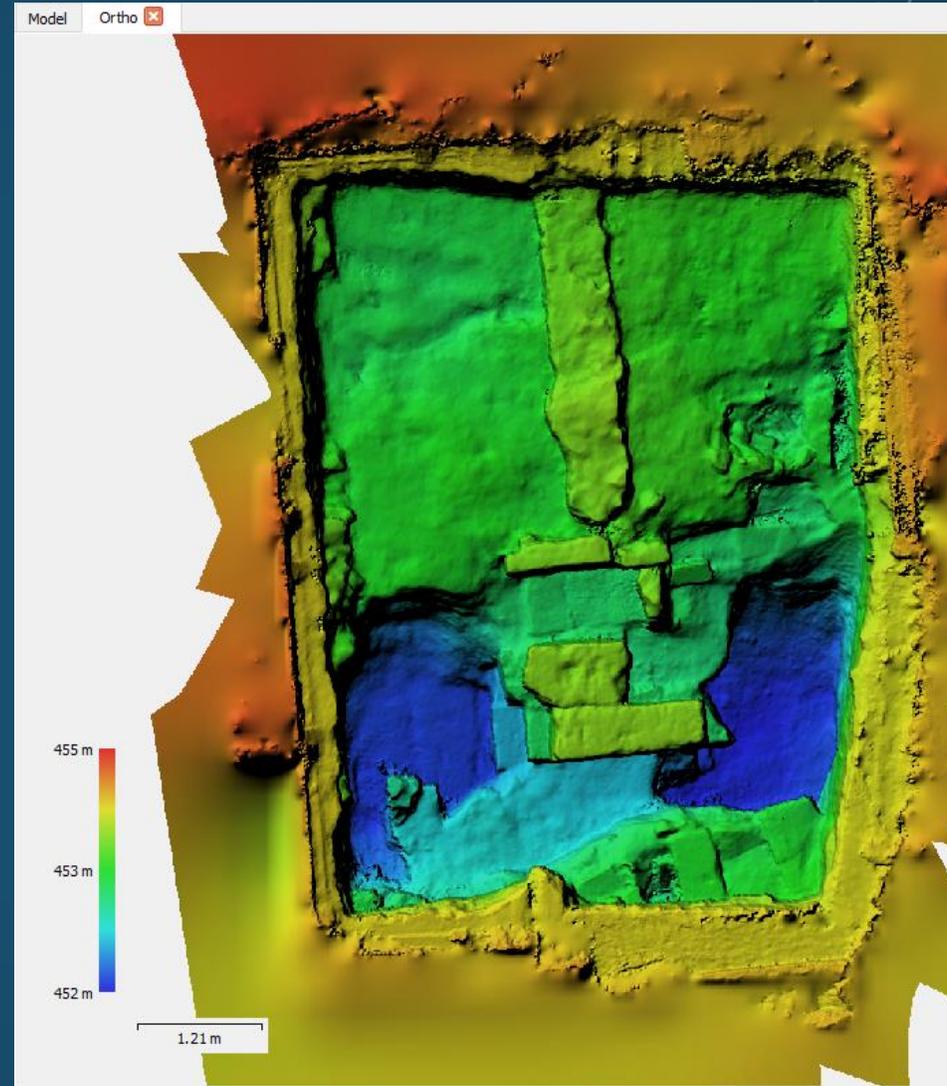
Point classes: All

Region

Setup boundaries: 323907.439 - 323917.849 X
4696664.368 - 4696677.339 Y

Resolution (m): 0.00471367

Total size (pix): 2208 x 2751



Step 7 – Build DEM

WORKFLOW

Build Orthomosaic

Projection

Type: Geographic Planar Cylindrical

WGS 84 / UTM zone 33N (EPSG::32633)

Parameters

Surface: DEM

Blending mode: Mosaic (default)

Enable hole filling

Enable back-face culling

Pixel size (m): 0.0011784 X

Metres... 0.0011784 Y

Max. dimension (pix): 4096

Region

Setup boundaries: [] - [] X

Estimate [] - [] Y

Total size (pix): [] x []

OK Cancel



Step 8 – Build Orthomosaic

WORKFLOW

The screenshot displays the QGIS interface with a 3D terrain model of an archaeological site. A dialog box titled 'Informazioni Risultati' is open, showing the following data:

Geometria	Valore
0	Saggio3_Finale2_DEM
Saggio3_Finale2_DEM	
Banda 1	453.48038
(Derivato)	
(coordinata X cliccata)	12.8603
(coordinata Y cliccata)	42.4024

Additional details from the dialog box:
Modalità: Layer in uso
Vista: Albero
Apri modulo automaticamente:
Guida button

The status bar at the bottom shows: Coordinate 12.8603,42.4024 | Scala 1:47 | Lente d'ingrandimento 100% | Rotazione 0,0° | Visualizza | EPSG:32633

Step 9 – QGis

WORKFLOW

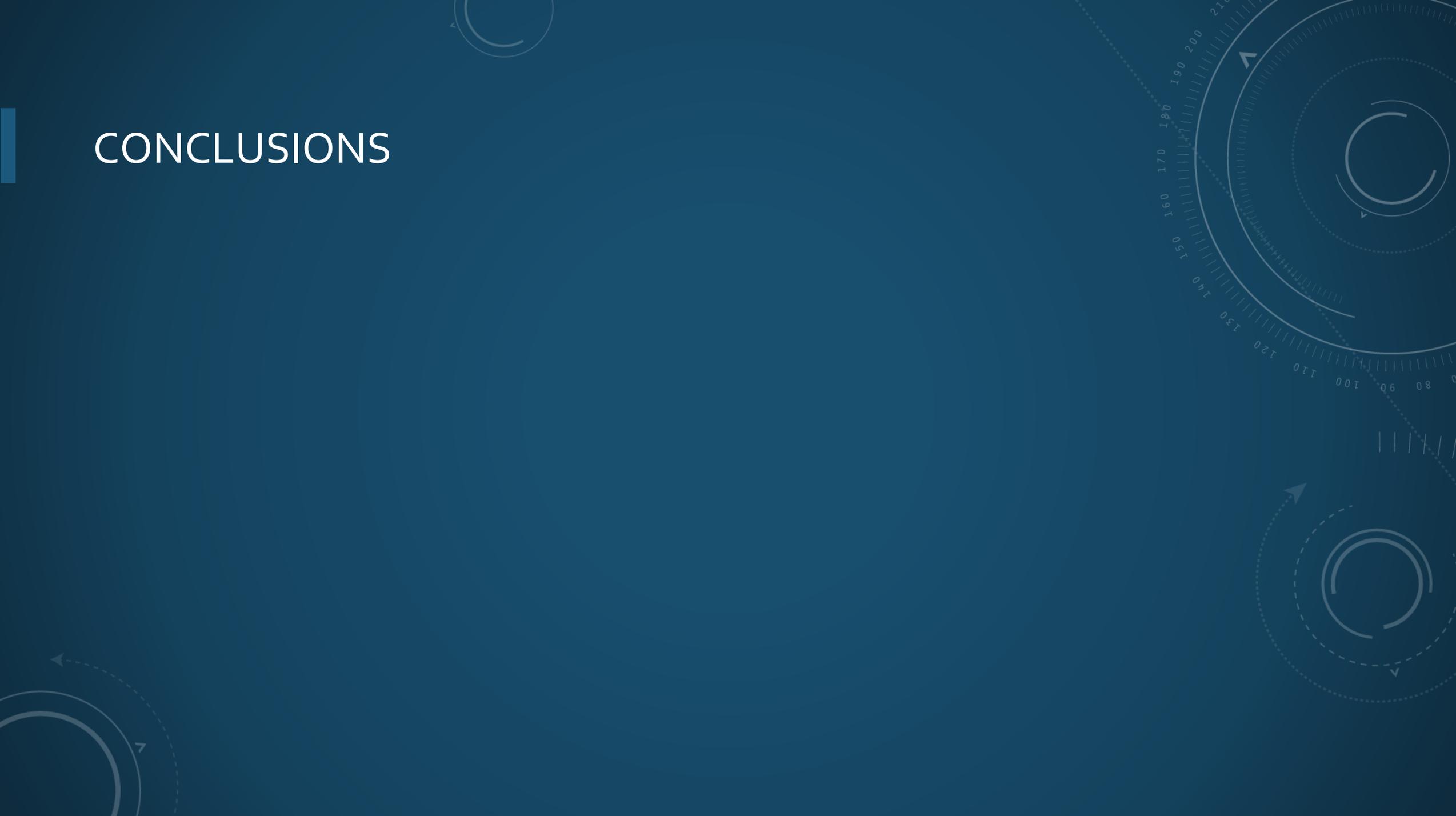
The screenshot shows the QGIS interface with the following components:

- Browser:** Lists project folders and data sources like GeoPackage, SpatialLite, PostGIS, and MSSQL.
- Layer:** Shows a list of layers, including 'usm...', 'Sagg...', 'Croc...', 'USM...', 'Absi...', and multiple 'Sagg...' layers.
- Main Canvas:** Displays an aerial photograph of an archaeological site with a red line indicating the profile path.
- Profile Window:** A graph showing elevation (y-axis, 452.0 to 455.0) versus distance (x-axis, 0 to 7). The profile line is red.
- qProf Plugin:** A window for configuring topographic profile sources. It includes sections for 'Input DEMs', 'Input line', 'GPX input', 'Profile statistics', and 'Profile plot'. The 'Input line' section is selected, showing options for 'Digitized line', 'Line layer', and 'Point list'. The 'GPX input' section has 'DEM input' selected.

Coordinate: 12.8603,42.4024 | Scala: 1:47 | Lente d'ingrandimento: 100% | Rotazione: 0,0° | Visualizza | EPSG:32633

Step 9 – QGis

CONCLUSIONS



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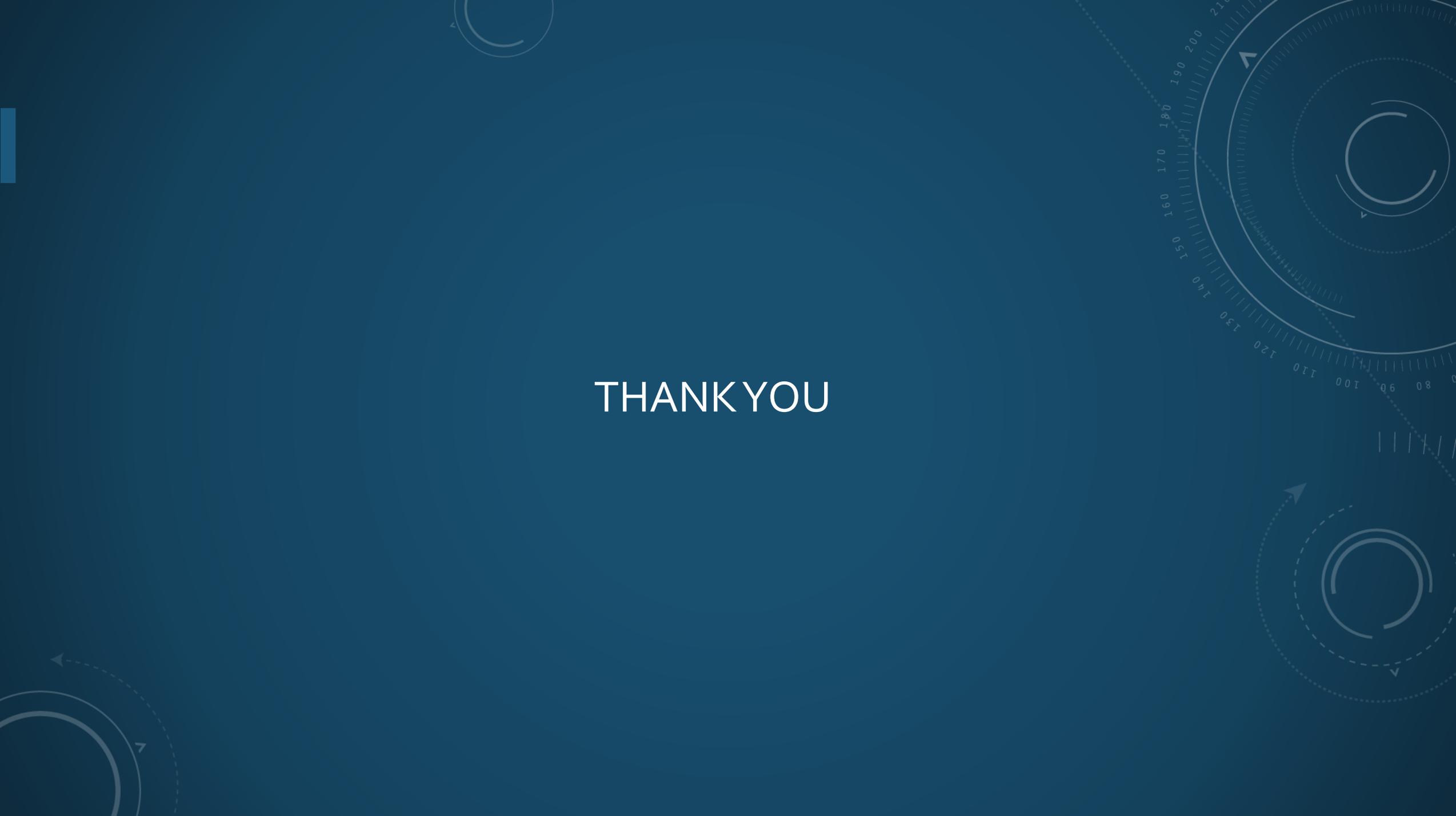
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- On site Interpretation – Risk of replacing on-site interpretation of phasing and context with SfM process
- Preservation – High volumes of data storage. Multiple output formats



THANK YOU

SUGGESTED READINGS

- McCarthy, J. - *Multi-image photogrammetry as a practical tool for cultural heritage survey and community engagement*, Journal of Archaeological Science, Volume 43, March 2014, Pages 175-185
- Waagen, J. - *New technology and archaeological practice. Improving the primary archaeological recording process in excavation by means of UAS photogrammetry*, Journal of Archaeological Science, Volume 101, January 2019, Pages 11-20