

# Integrated Projects



Madonna di Pietranico  
Pompeii insula V1

VISUAL COMPUTING LAB  
ISTI-CNR

# La Madonna di Pietranico



# Pietranico's Madonna



Terracotta statue, destroyed by an earthquake.

We used digital 3D technologies to create documentation and support the restoration.

Many fragments, large incomplete areas, difficult to manipulate all the fragments, due to fragmentation and missing parts the statue could not stand on its own.

3D was used to plan the restoration and find problems, before committing to physical intervention...

# Pietranico's Madonna



All fragments digitized with the Minolta Vi 910, color mapped from (calibrated) photos, taken inside a light-tent



# Pietranico's Madonna



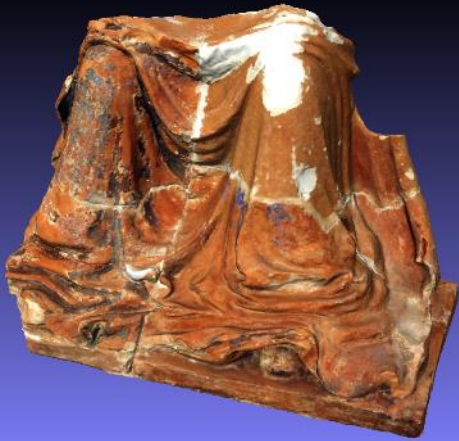
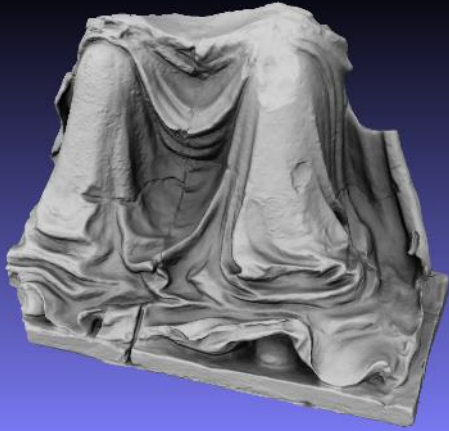
27 fragments, from 15 to 60 scans each. 6GB of raw data.  
Not very complex pieces, but a lot of surface to cover.

Target resolution around 0.5mm.

«Master» 3D models from 1 to 6 millions triangles, then  
decimated to smaller resolutions for easier rendering and  
work.

Models were already a precise metric documentation of the  
pre-restoration state.

# Pietranico's Madonna



# Pietranico's Madonna

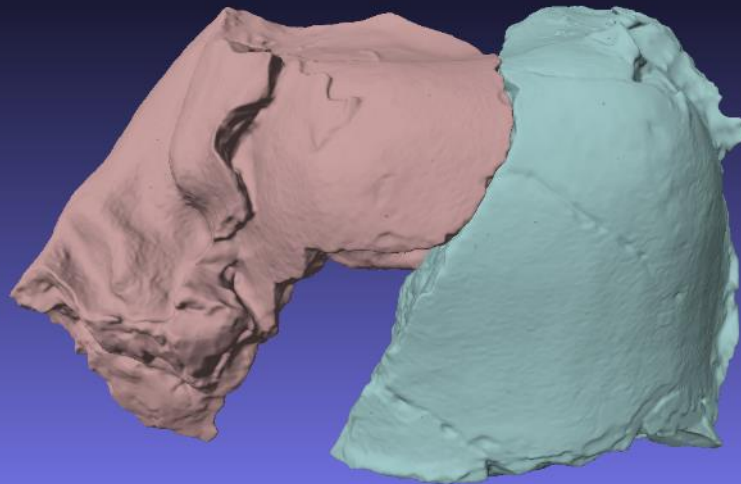
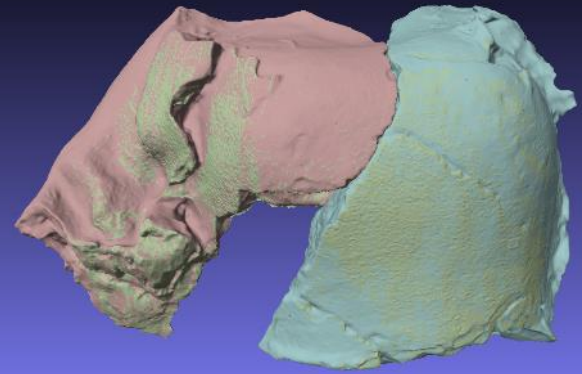
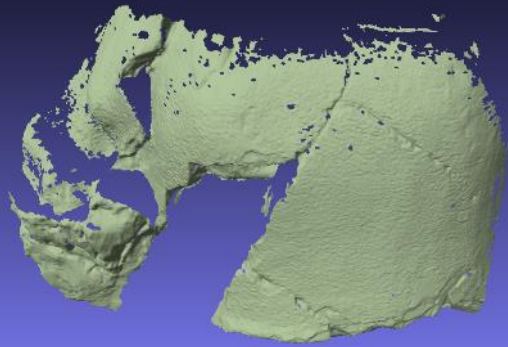


Digital reassembly: impossible to automatically compute fragment matching (non-clean break, small contact area). So we used a trick.

We have model of part A and part B, restorers know relative position of parts A and B. We put them in the correct position, and do a single scan (AB\_bridge). We then align 3D model A with the range scan AB\_bridge, then we add 3D model B and align it to the same range scan AB\_bridge. We remove range scan AB\_bridge and the 3D models A and B are in the correct position.

We used more than 1 bridge for each couple (for a better rigidity) and we added ALL the fragments and bridges, doing a global align and optimization.

# Pietranico's Madonna





# Pietranico's Madonna

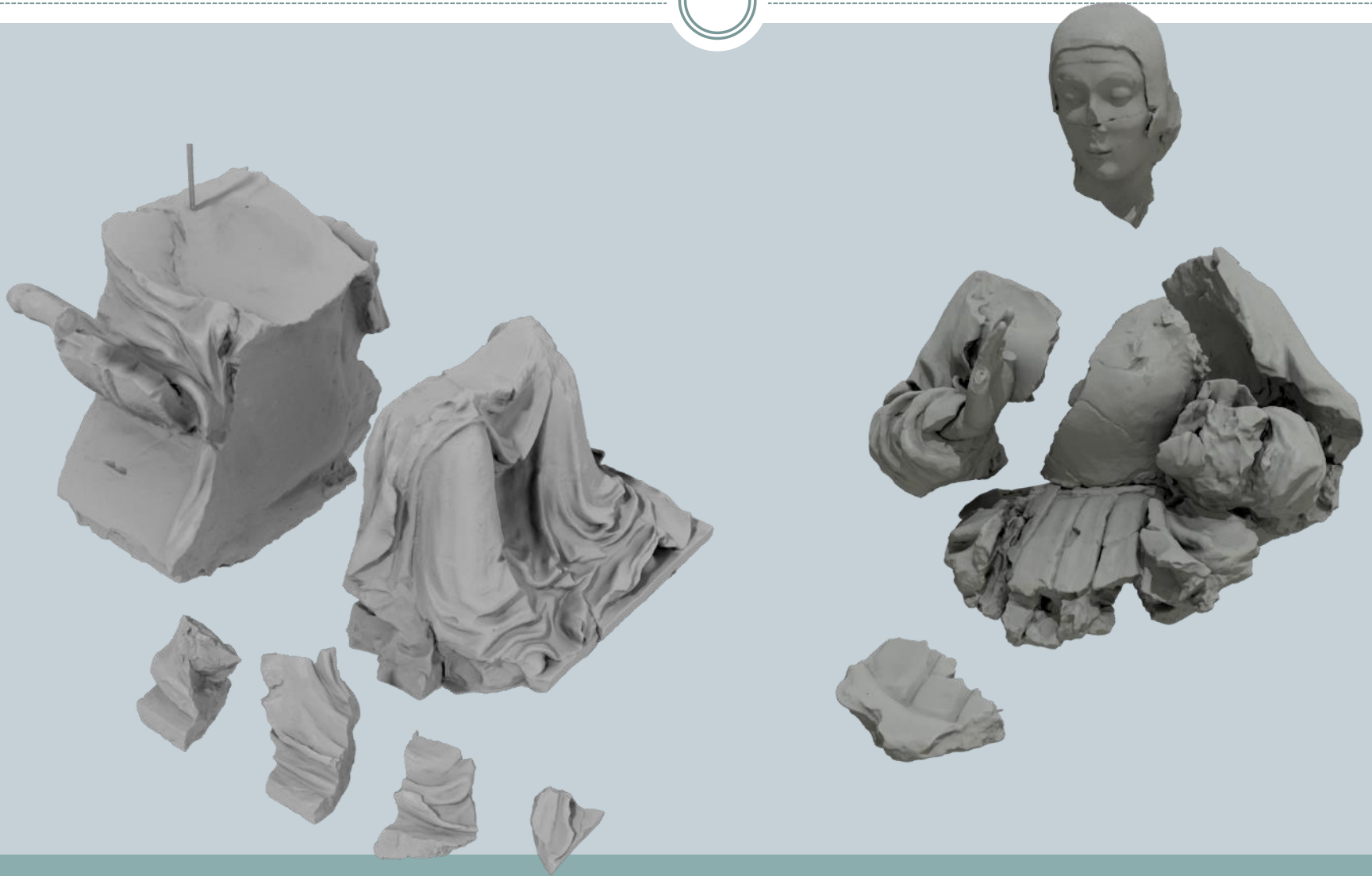


Worked very well, quick and effective.

We also found a new contact point (impossible to find it on the physical object without assembly the whole statue).

We had now a digital reassembly of the statue, useful to restorers to plan the intervention.

# Pietranico's Madonna



# Pietranico's Madonna



The statue was BUILT in two parts.

Due to its collapse and a previous (very old) restoration the correct relative position of top and bottom was lost.

We tried, using the digital models, to recreate the original symmetry...

Relative position based on symmetry of detail & hand-made intervention, under the supervision of restorer and art historian.

# Pietranico's Madonna



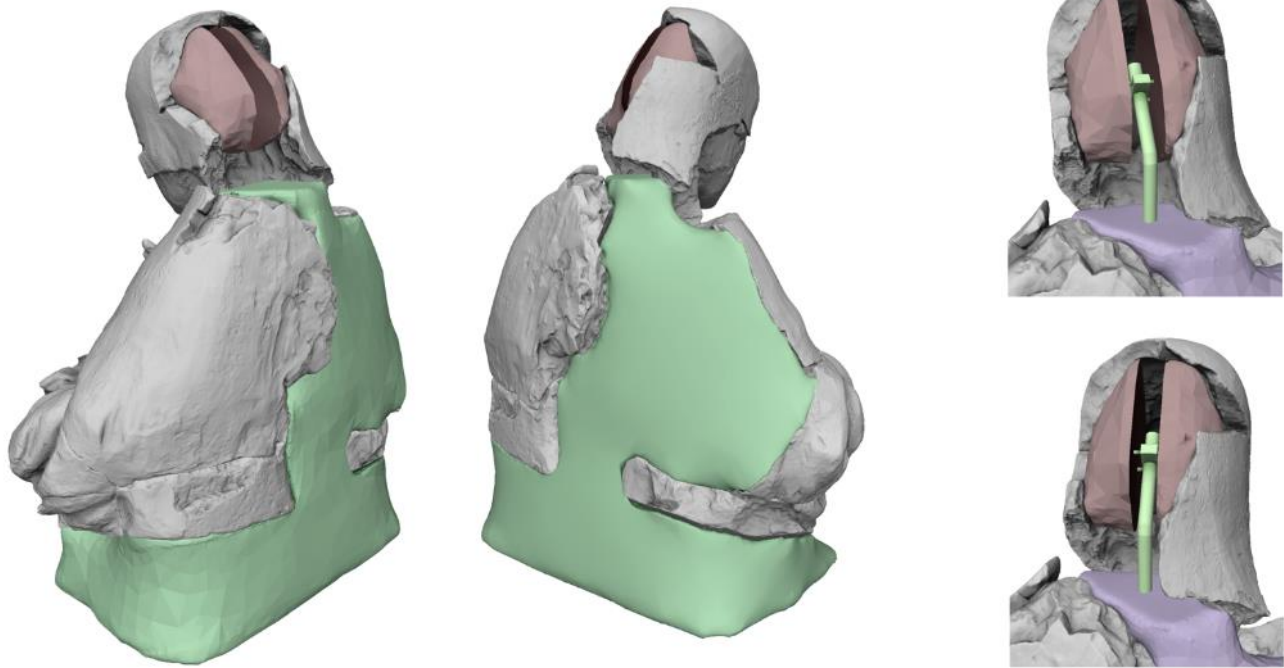
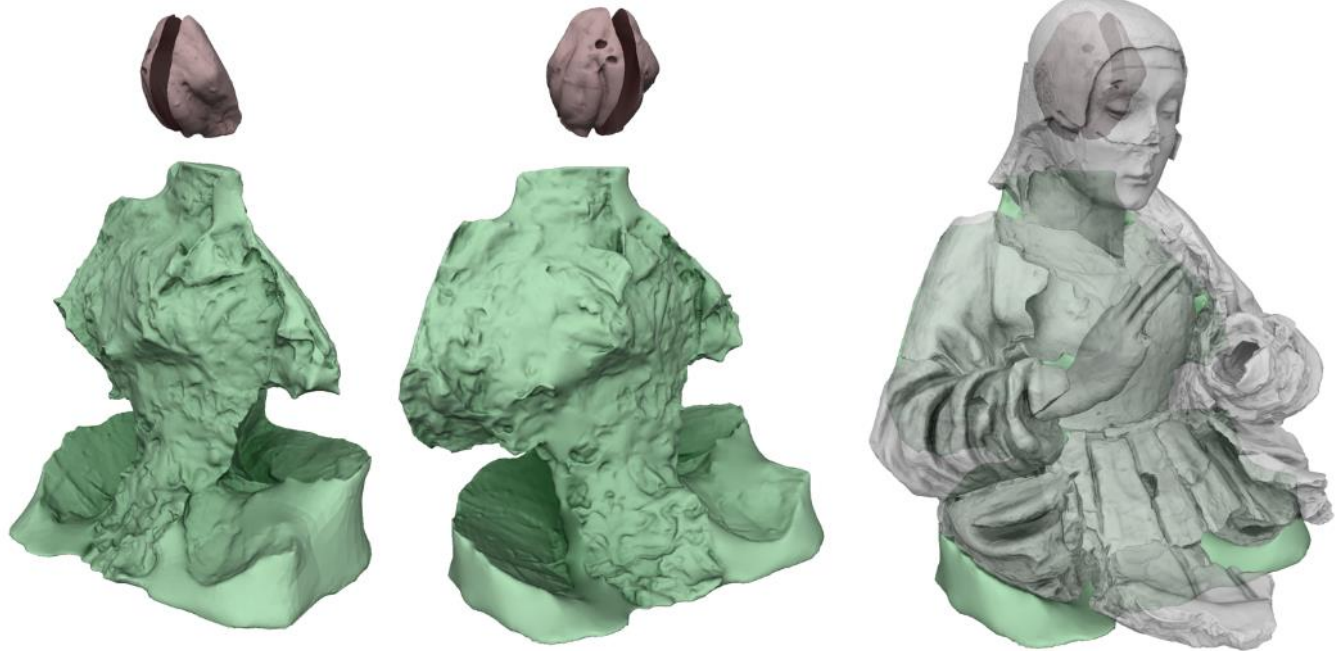
# Pietranico's Madonna



The fragments cannot stand on their own, due to missing parts and the fractures. How to support the fragments?

The statue is hollow (from construction)... so we:

- Selected all the fragment surfaces facing INSIDE the hollow.
- Inverted the normals of these areas, and create a 3D model of the inside hollow (Poisson merging)...The result is a 3D object that perfectly fits the inside volume
- 3D-printed the result, and used it as a support for the physical reconstruction



# Pietranico's Madonna



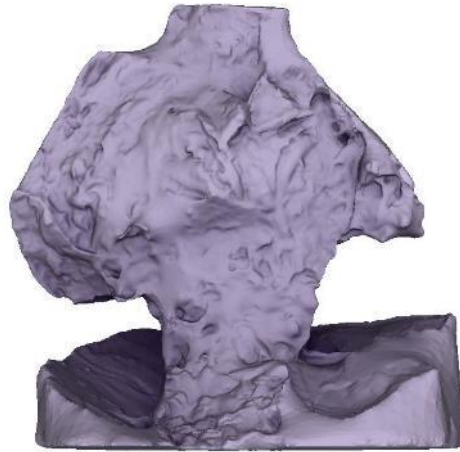
The head was made similarly, then splitted in 2, to allow insertion and have a screw to dilate the two halves to fix it

Lot of manual editing (sculpting) to avoid small intersections between surfaces, and undercuts (which would prevent the physical assembly).

It worked, but still required a lot of file-work when assembling (impossibel to comute the exact physical assembly constraints)

As far as we know, it was the first time this technique has been used!

# Pietranico's Madonna



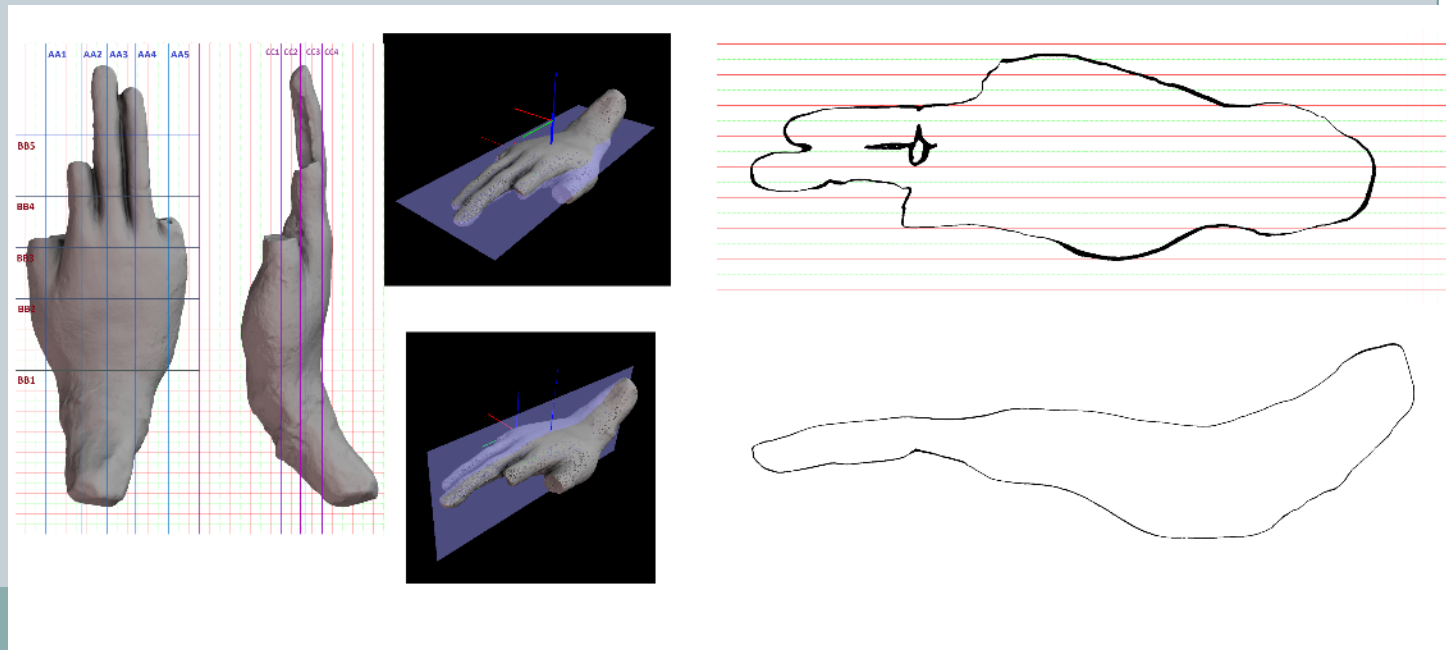


# Pietranico's Madonna



They wanted to have an artist to recreate, still using terracotta, some missing parts, exploiting symmetry.

We produced sections and orthographic views as templates.



# Pietranico's Madonna

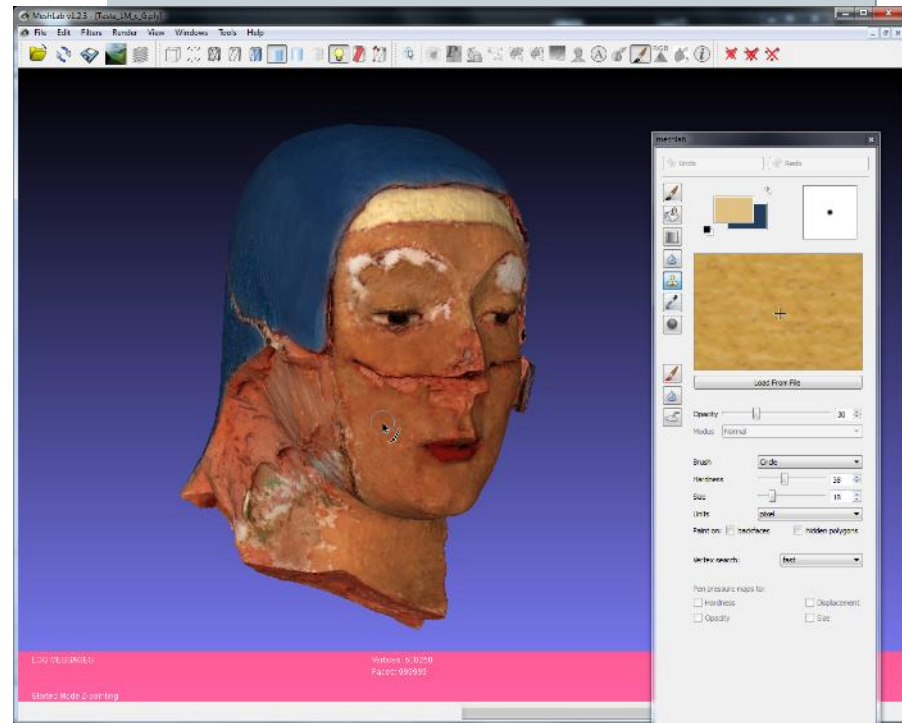


Color reconstruction: we tried, starting from historical documentation and the small residues of color, to reconstruct the original appearance.

Remaining spots of the original color were photographed (calibrated photos), and the small areas used to synthesize larger textures, used for painting over the geometry.

Just a hypothesis, still lot of data missing.

# Pietranico's Madonna



# Pietranico's Madonna



Main publication, with all the details:

<http://vcg.isti.cnr.it/Publications/2013/AECDFAS13/>

Video:

<https://www.youtube.com/watch?v=2dquqRwkpqk>

# Pompeii insula V1



# Pompeii Insula V1



Collaboration with the Lund University (Sweden).

Pompeii insulas (an insula is like a city block) are sometimes given "in external management" to foreign universities for study and documentation.

We were involved in the 3D documentation of the two main houses of Insula V1, then we decided to do the entire insula...



THE SWEDISH POMPEII PROJECT

<http://www.pompejiprojektet.se/index.php>

# Pompeii Insula V1



# Pompeii Insula V1



The insula is around 100x50 meters (without considering the roads)... we covered ALL the rooms and areas, with a target resolution of 1cm. In many areas, we have a much higher res.

2 scanning team, with two similar devices (FARO Photon 120 and FARO Focus3D).

2.5 days scanning in the first year (to cover the two main houses), 3.5 days in the second year (to cover the rest).

More than 310 scans used, all with 360° coverage...



# Pompeii Insula V1



- Casa Epigrami and bakery (epi)
- Casa Cecilio lucundus (cec)
- Casa Torello di Bronzi (tor)
- Biber-area (bib)

South street (sts)  
 West Street (stw)  
 North Street (stn)  
 East street (ste)



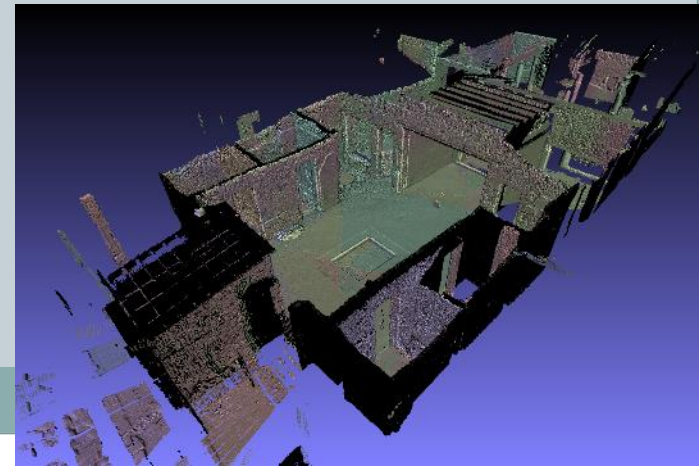
# Pompeii Insula V1



All scans subsampled at different resolutions (1cm, 2cm, 3cm) using Poisson-disk sampling.

Alignment has been done in parts (each house or houses cluster, each street) and then put together using common areas between subparts.

Alignment started on the 3cm dataset, then moved to 2cm and refined, and then to 1cm and refined again. In this way we had less data at the begin, where most manual work was needed, and higher density later, when only automatic calculation was used.



# Pompeii Insula V1



All aligned scans merged using Screened Poisson, we used scans at 2cm resolution, the 1cm dataset would not fit in memory.

The result was a 40+ millions triangles global model, covering the entire insula...

Full res scas were merged only on smaller areas (individual houses), to create additional "detail" models.

# Pompeii Insula V1



# Pompeii Insula V1

Some areas of the insula have been manually textured by the Lund university staff, and imported in their CAVE system, for immersive navigation...

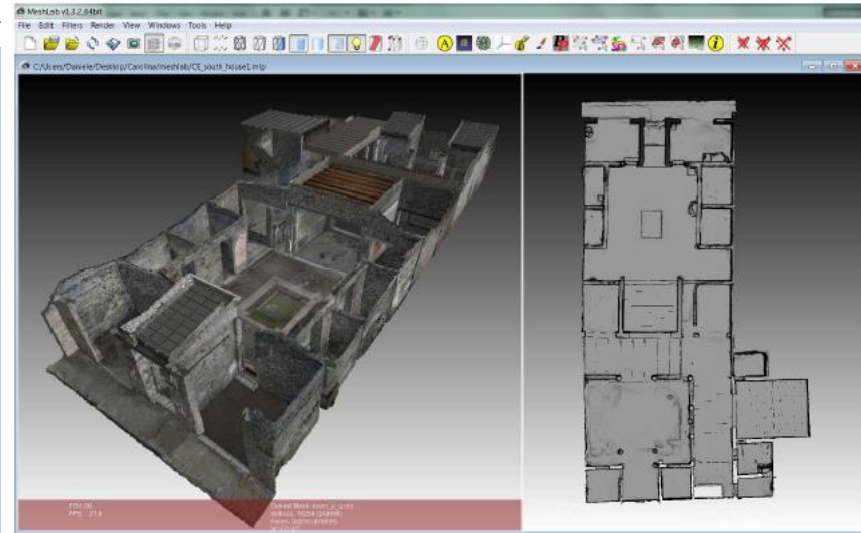


Fig. 4. A snapshot of the final colored model

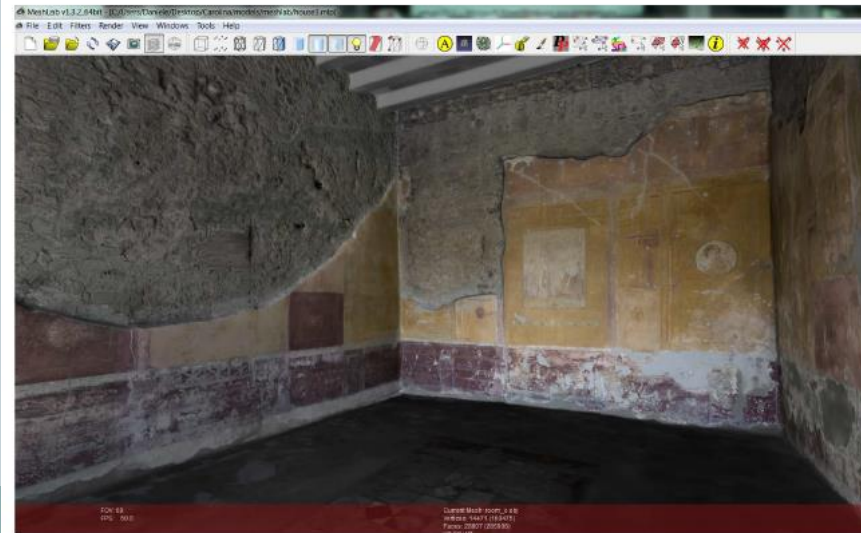


Fig. 5. detail of a colored mesh

# Pompeii Insula V1



## Reconstruction:

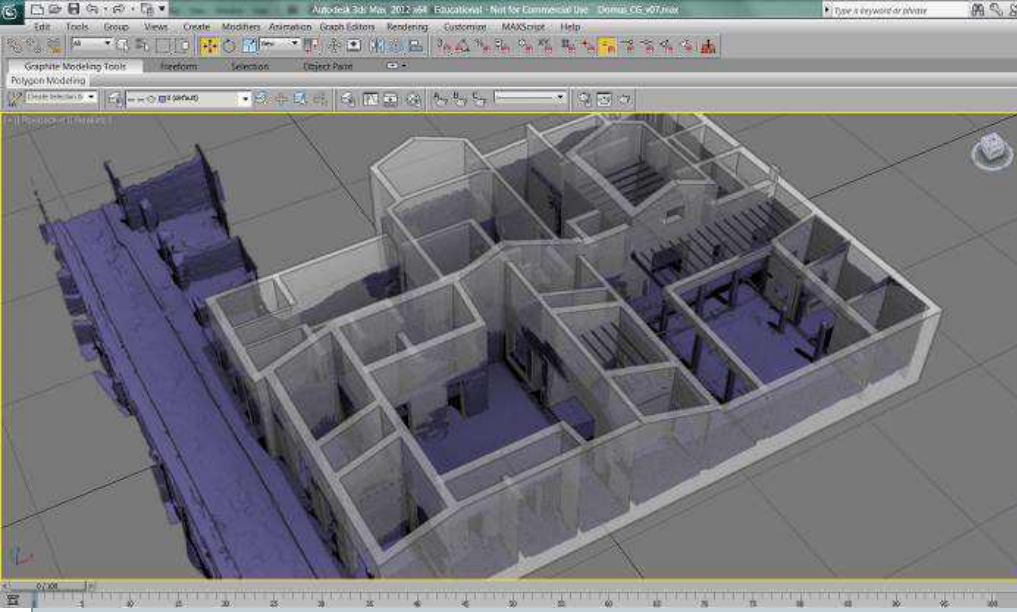
Starting from the Cecilio Giocondo house 3D model, archeologists built a 3D reconstruction of the original state.

The reconstruction is metrically correct, thanks to the 3D survey data. The 3D model was also useful because a lot of the traces of the missing structures are still visible in the walls, and the survey is accurate enough to make them visible (and measurable)

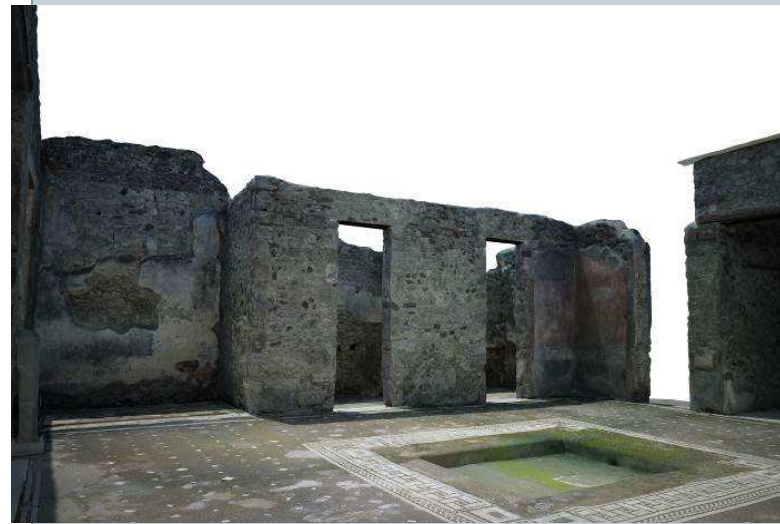
Main publication available here:

<http://vcg.isti.cnr.it/Publications/2013/DFLDCL13/>

(most work done by Lund & Daniele Ferdani)



# Pompeii Insula V1



# Pompeii Insula V1



One of the most interesting aspect is the CONFIDENCE mappig and visualization...

Every part of he reconstruction is marked according to the kind of reasoning that was used to create that specific element (from direct evidence, from analogy, from pure deduction, from structural coherence...). This makes the reconstruction scientifically valid, and this color mapping may be used to communicate this information to the public...



# Pompeii Insula V1



- |   |                           |  |                            |
|---|---------------------------|--|----------------------------|
|  | Objective Information     |  | Consistency to the Sources |
|  | Consistency to the Style  |  | Hypoteses                  |
|  | Consistency for Decuction |  |                            |

# Pompeii Insula V1



## GIS:

The 3D models have been georeferenced, and imported in GIS tools, with drawings, photos and other "classical" documentation.

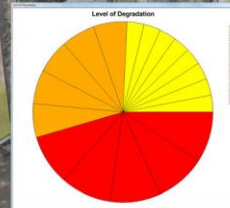
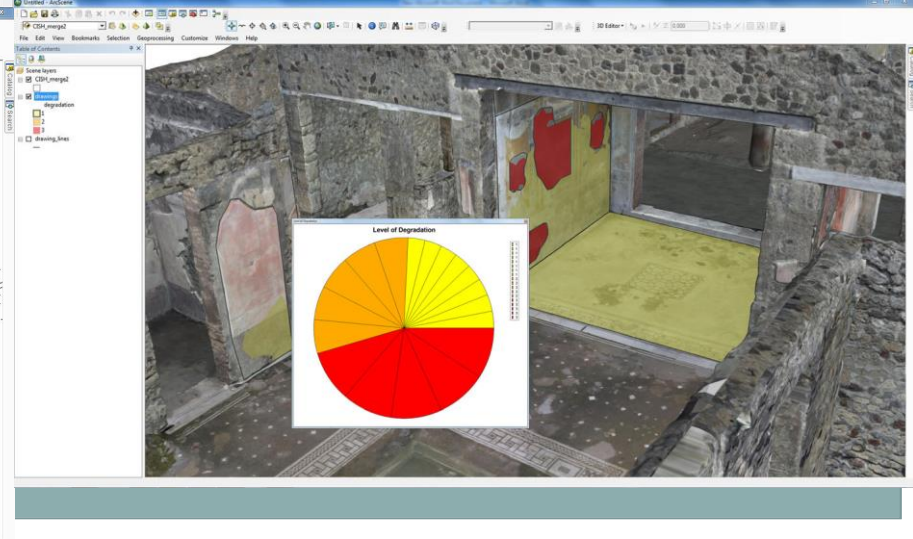
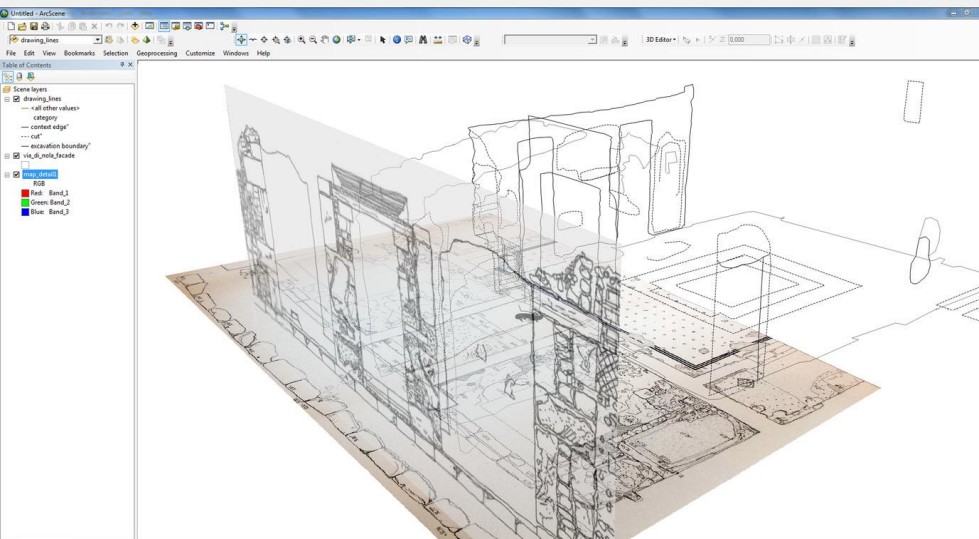
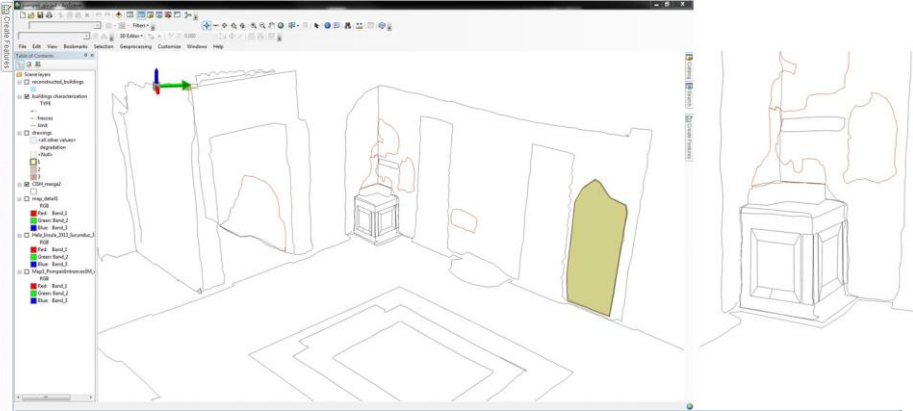
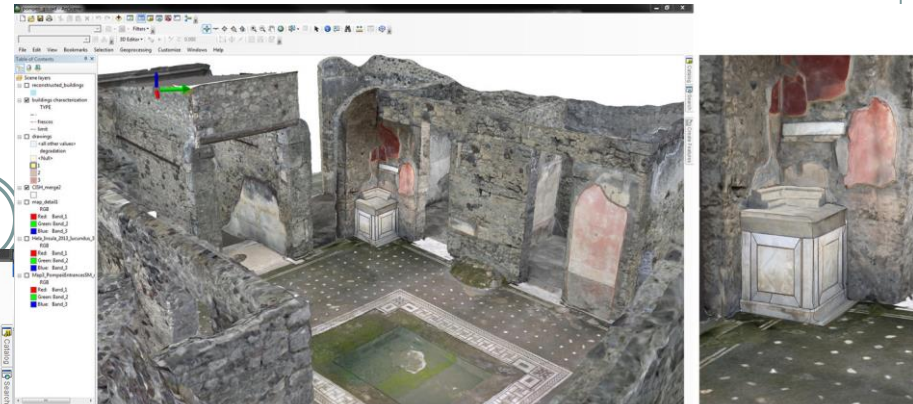
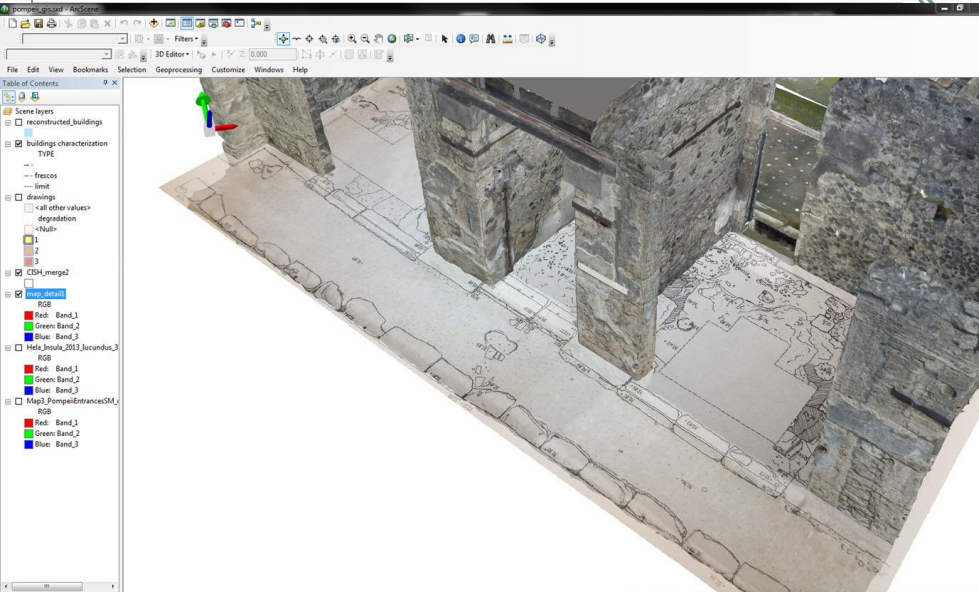
All thi georeferenced data is used for mapping problems and archeological annotations, to be able to do SPATIAL QUERIES

Main publication available here:

<http://vcg.isti.cnr.it/Publications/2015/DLLDCF15/>

(most work done by Lund)

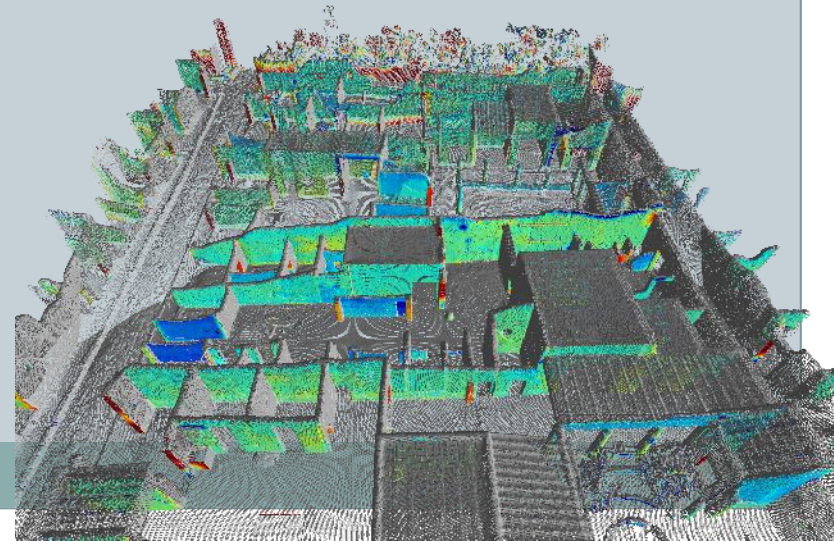
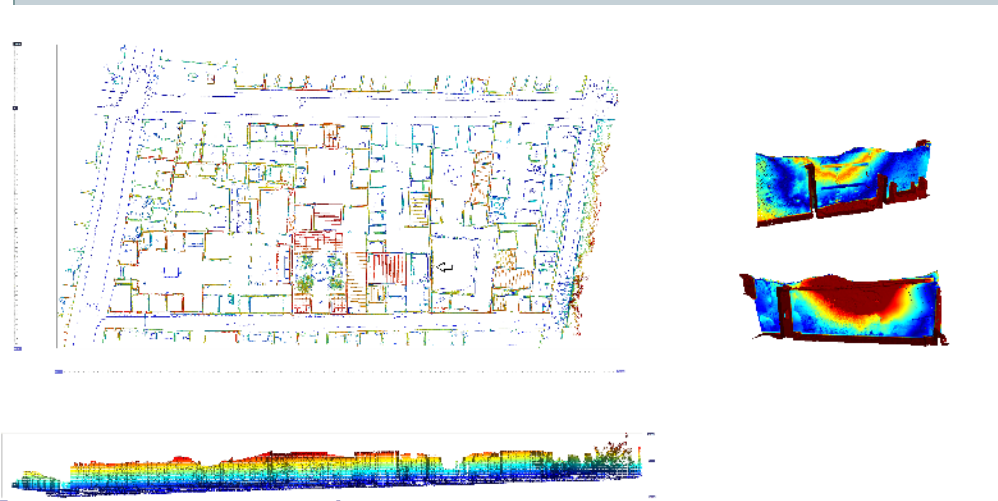
# Pompeii Insula V1



# Pompeii Insula V1



We are now working on ways to AUTOMATICALLY calculate geometric information (wall thickness, wall inclination, holes...) and other information taken from photos (presence of moss, plaster, cracks) and transfer this values, mapped on surfaces to the GIS tool for more complex spatial queries...



# Pompeii Insula V1



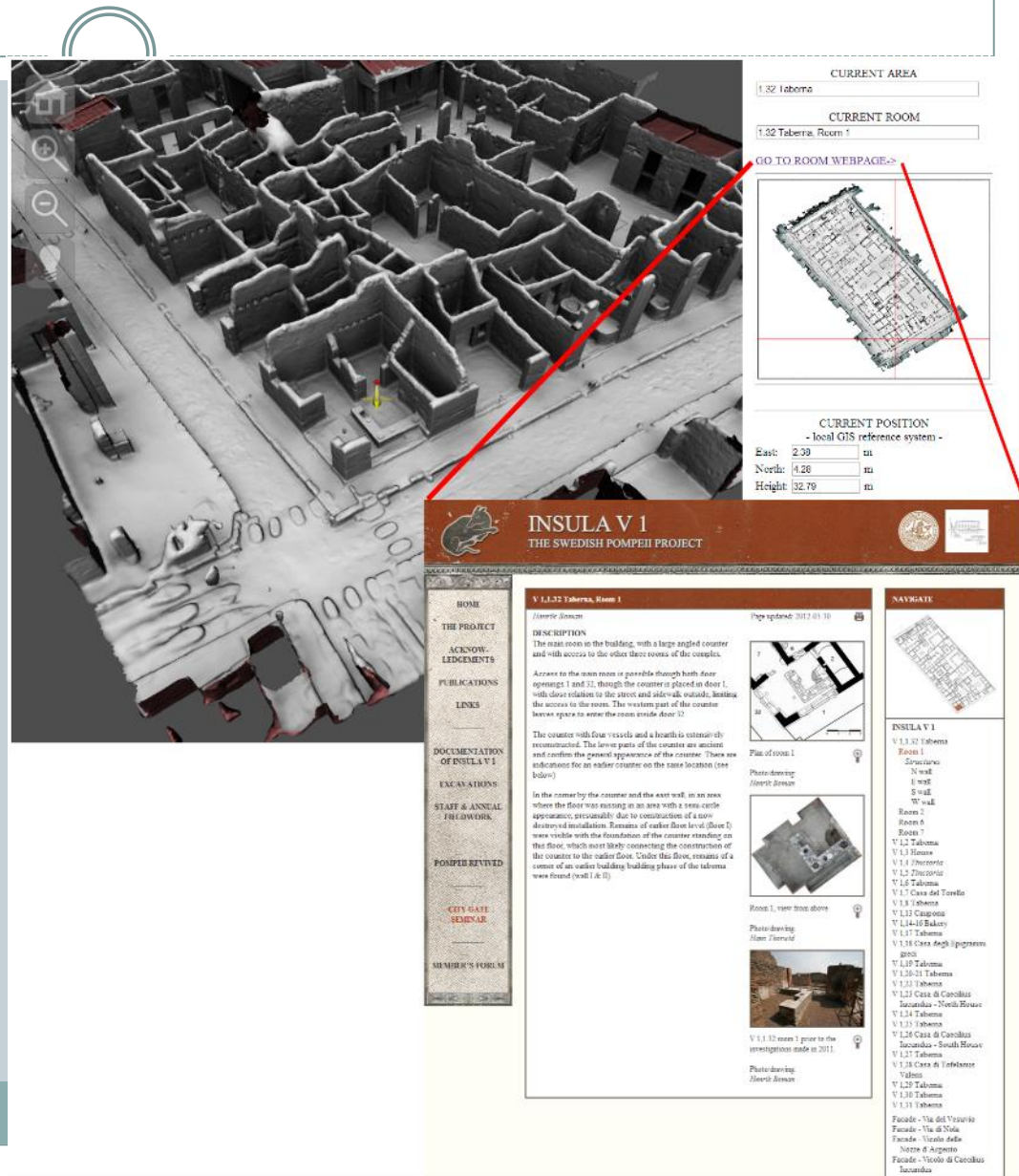
- Minimap with click-to-go feature
- User position is shown using georeferenced coordinates
- Switch from flyover view to first-person view (with wall collision)

The viewer is re-usable for other similar terrain+buildings datasets, just changing the data

# Pompeii Insula V1

The viewer knows in which room is the user (only on the bottom aprt of the insula, it is still a work in progress), and can bring the user directly to the corresponding page on the swedish pompeii project website.

The idea is a mixed navigation, 3D exploration, 2D map, room list....



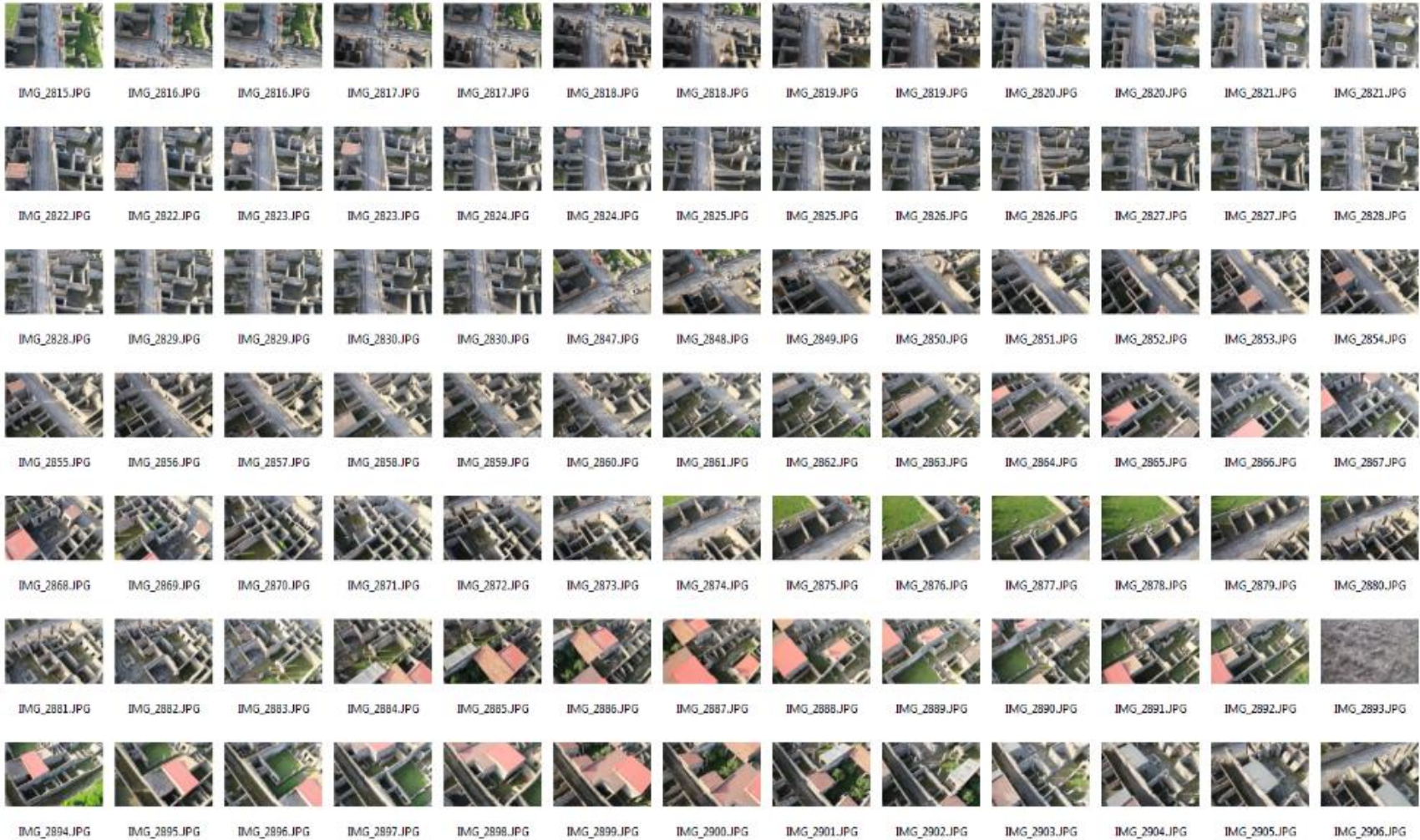
The screenshot displays the website interface for the Swedish Pompeii Project, specifically for Insula V 1. The main content area is divided into several sections:

- 3D Model:** A large 3D reconstruction of the insula's ground floor, showing multiple rooms and a central courtyard. A red arrow points from the 2D floor plan to a specific room in the 3D model.
- Navigation and Information:** A top navigation bar includes "HOME", "THE PROJECT", "ACKNOWLEDGEMENTS", "PUBLICATIONS", "LINKS", "DOCUMENTATION OF INSULA V 1", "EXCAVATIONS", "STAFF & ANNUAL FIELDWORK", "POMPEII REVIVED", "CITY GATE SEMINAR", and "MEMBER'S FORUM".
- Room Details (V.1.32 Taberna, Room 1):**
  - DESCRIPTION:** The main room in the building, with a large angled counter and with access to the other three rooms of the complex. Access to the main room is possible through both door openings 1 and 3, through the counter or placed in door 1, with close relation to the street and sidewalk outside, limiting the access to the room. The western part of the counter leaves space to enter the room inside door 3?
  - Notes:** The counter with four vessels and a hearth is intensively reconstructed. The lower parts of the counter are missing and confirm the general appearance of the counter. There are indications for an earlier counter on the same location (see below).
  - Location:** In the corner by the counter and the east wall. In an area where the floor was existing in an area with a semi-circle appearance, presumably due to construction of a now destroyed installation. Remains of earlier floor level (Blue D) were visible with the foundation of the counter standing on the floor, which most likely connecting the construction of the counter to the earlier floor. Under this floor, remains of a corner of an earlier building building phase of the taberna were found (wall I & II).
- 2D Floor Plan:** A top-down view of the room, showing the counter and door openings. It includes a "Photo-drawing / floor plan" and a "Photo-drawing / floor plan" with a scale bar.
- Room List (NAVIGATE):** A list of rooms in the insula, including:
  - Room 1
  - Room 2
  - Room 3
  - Room 4
  - Room 5
  - Room 6
  - Room 7
  - V.1.2 Taberna
  - V.1.3 House
  - V.1.4 / Peristyle
  - V.1.5 Taberna
  - V.1.6 Casa del Tavolito
  - V.1.8 Taberna
  - V.1.11 Caponova
  - V.1.14-16 Bakery
  - V.1.17 Taberna
  - V.1.18 Casa degli Ippogranchi
  - gates
  - V.1.19 Taberna
  - V.1.20-21 Taberna
  - V.1.22 Taberna
  - V.1.23 Casa di Caecilius Iucundus - South House
  - V.1.24 Taberna
  - V.1.25 Taberna
  - V.1.26 Casa di Caecilius Iucundus - South House
  - V.1.27 Taberna
  - V.1.28 Casa di Iulianus Valens
  - V.1.29 Taberna
  - V.1.30 Taberna
  - V.1.31 Taberna
- Current Area and Room:** A section with dropdown menus for "CURRENT AREA" (1.32 Taberna) and "CURRENT ROOM" (1.32 Taberna, Room 1).
- Current Position:** A section with a "GO TO ROOM WEBPAGE" button and a "CURRENT POSITION - local GIS reference system -" table:

East:	2.39	m
Nordic:	4.28	m
Height:	32.79	m



# Pompeii Insula V1





# Pompeii Insula V1

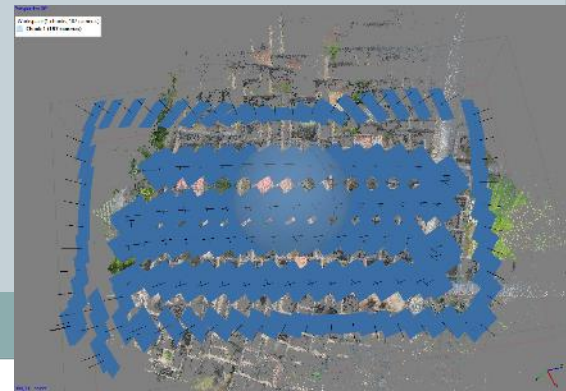


The photos have been processed using PhotoScan, working in chunks (each chunk is made of two coverage direction, plus the global round)

Chunks have then been merged in a single project using common photos (the global round). The global round has then been removed, to only keep photos with higher resolution on the buildings...

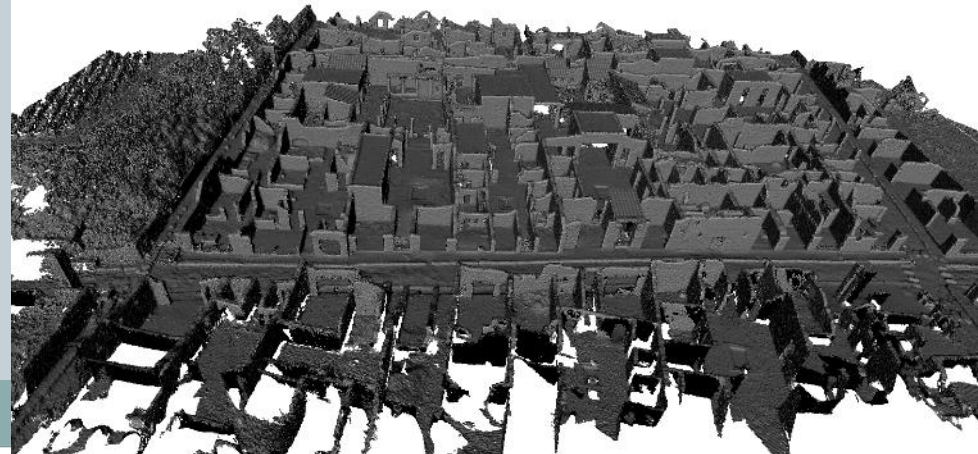
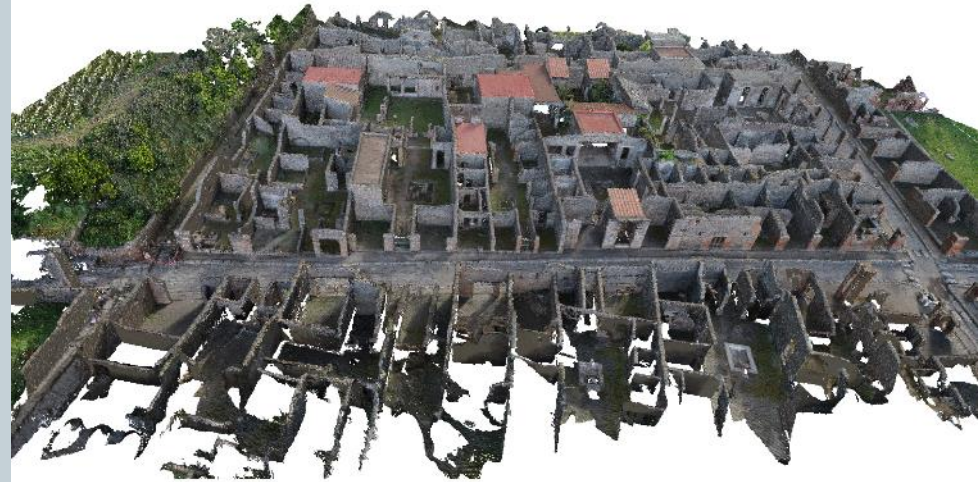
In total, used 581 photos, and obtained a 35 million points model

All the processing (chunks, and final cloud generation) took some days (99% is pure calculation time).



# Pompeii Insula V1

This is the cloud coming from the drone photos, scaled and oriented with respect to the 3D scanned dataset.



# Pompeii Insula V1

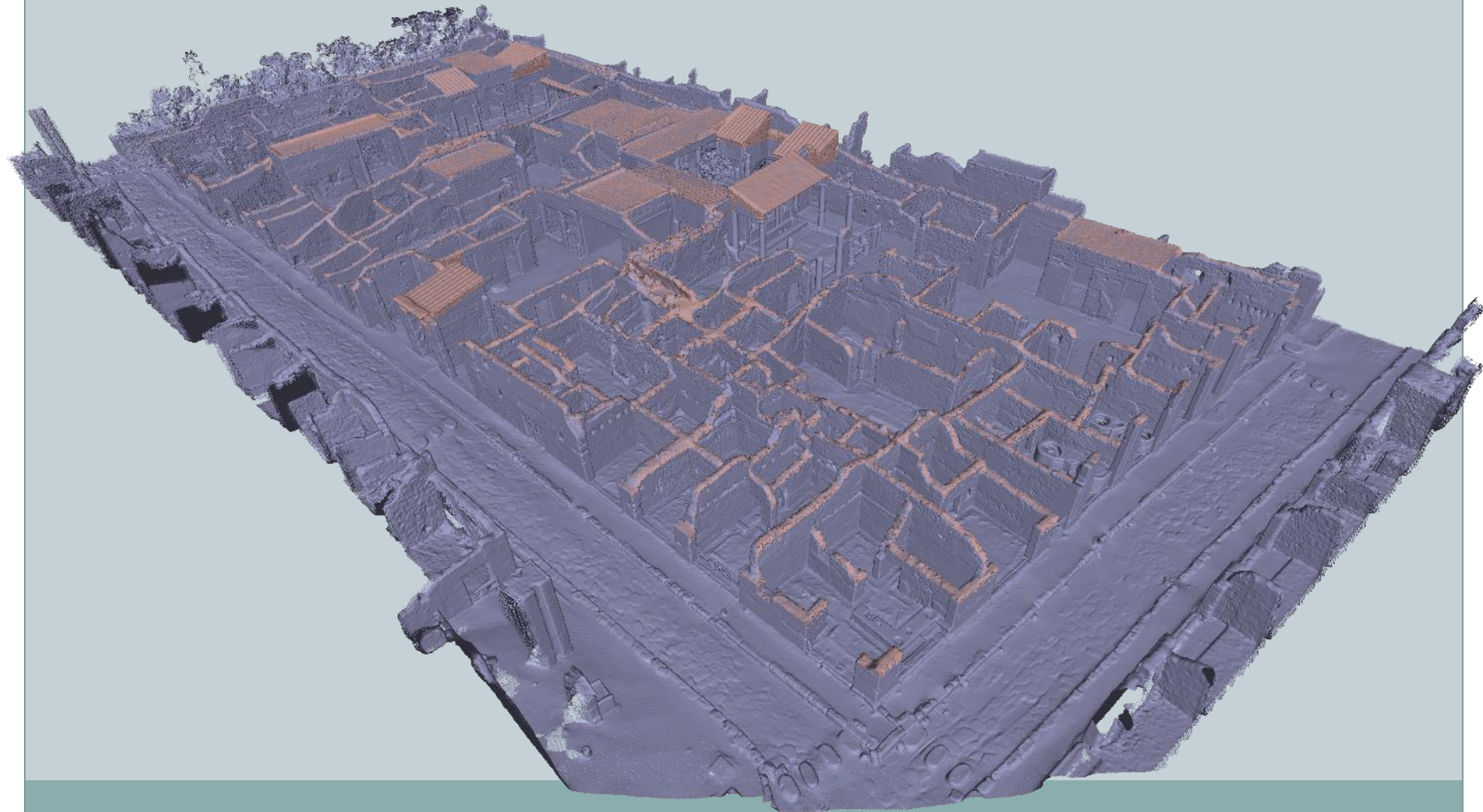


Laser Scanner data is still denser and more precise, so we manually isolated from the Drone photos 3D model only the upper parts (and other areas of the surrounding streets).

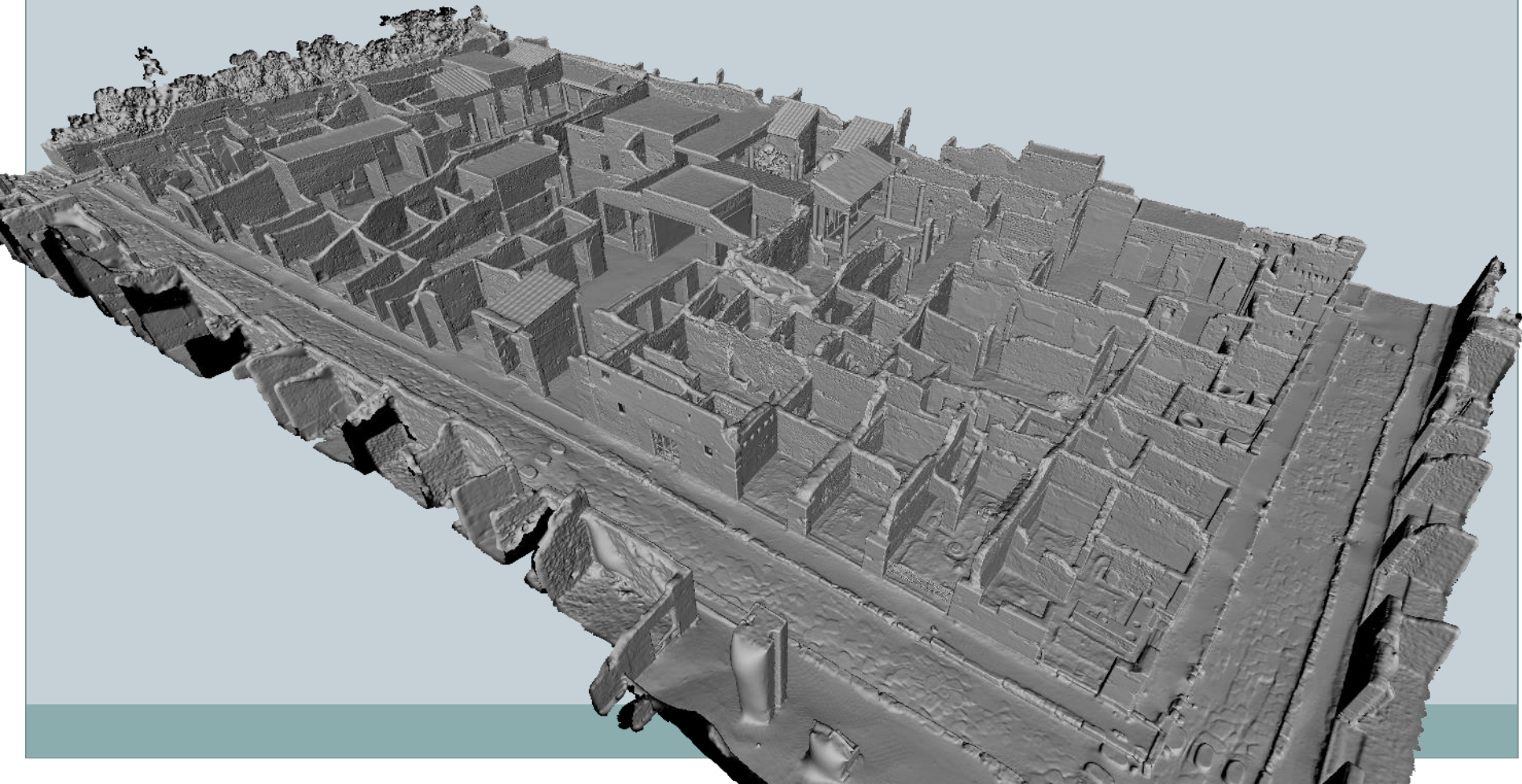
We did a new merging (again, with screened poisson), using the original scans (aligned and cleaned), and these new areas coming from the drone.

In this way, the data is seamlessly merged, preserving the detail and ensuring maximum coverage.

# Pompeii Insula V1



# Pompeii Insula V1



# Pompeii Insula V1



We now have a complete 3D model of the insula... with color (for most of the areas, the drone photos does not cover the inside of the rooms).

We will put this in the viewer (and possibly finish it 😊)

It is still an ongoing work, both for the online use + interactive exploration, and the automatic GIS data mapping + annotation.

# Pompeii Insula V1

