



POLITECNICO  
DI TORINO

Dipartimento di  
Architettura e  
Design

Master in Architecture for  
Sustainability  
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Thesis Title

**Gardella's Lost Legacy:  
The Church of Alessandria.**  
Study, 3D documentation and  
Analysis

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Board C

- TERRITORIAL CONTEXT
- GEOMATICS SURVEY
- 2D DOCUMENTATION
- HBIM DOCUMENTATION
- MATERIAL ANALYSIS
- CURRENT STATE OF  
CONSERVATION ANALYSIS  
AND SOLUTIONS
- THE PROPOSAL

The Church Building



## Processing the Data

### Step 6: Building 3D Products

#### Dense Cloud

It is a three-dimensional representation comprising millions of densely distributed points, each with precise spatial coordinates and color information. When creating a dense cloud, the software generates a depth map.

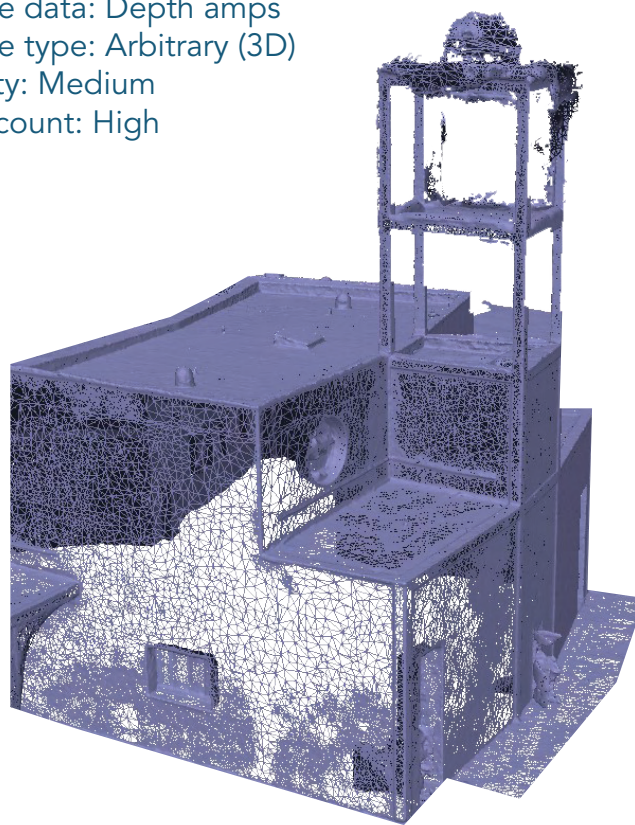
Quality: Medium  
Depth filtering: Mild



#### Mesh Cloud

It is a three-dimensional representation composed of a network of polygons, typically triangles, that form a continuous surface

Source data: Depth amps  
Source type: Arbitrary (3D)  
Quality: Medium  
Face count: High



#### Textured Cloud

It is a three-dimensional representation of the studied object where the original images are projected and mapped onto the geometry

Texture type: Diffuse map  
Source type: Images  
Mapping mode: Generic  
Blending mode: Mosaic  
Texture size: 8192 x 1

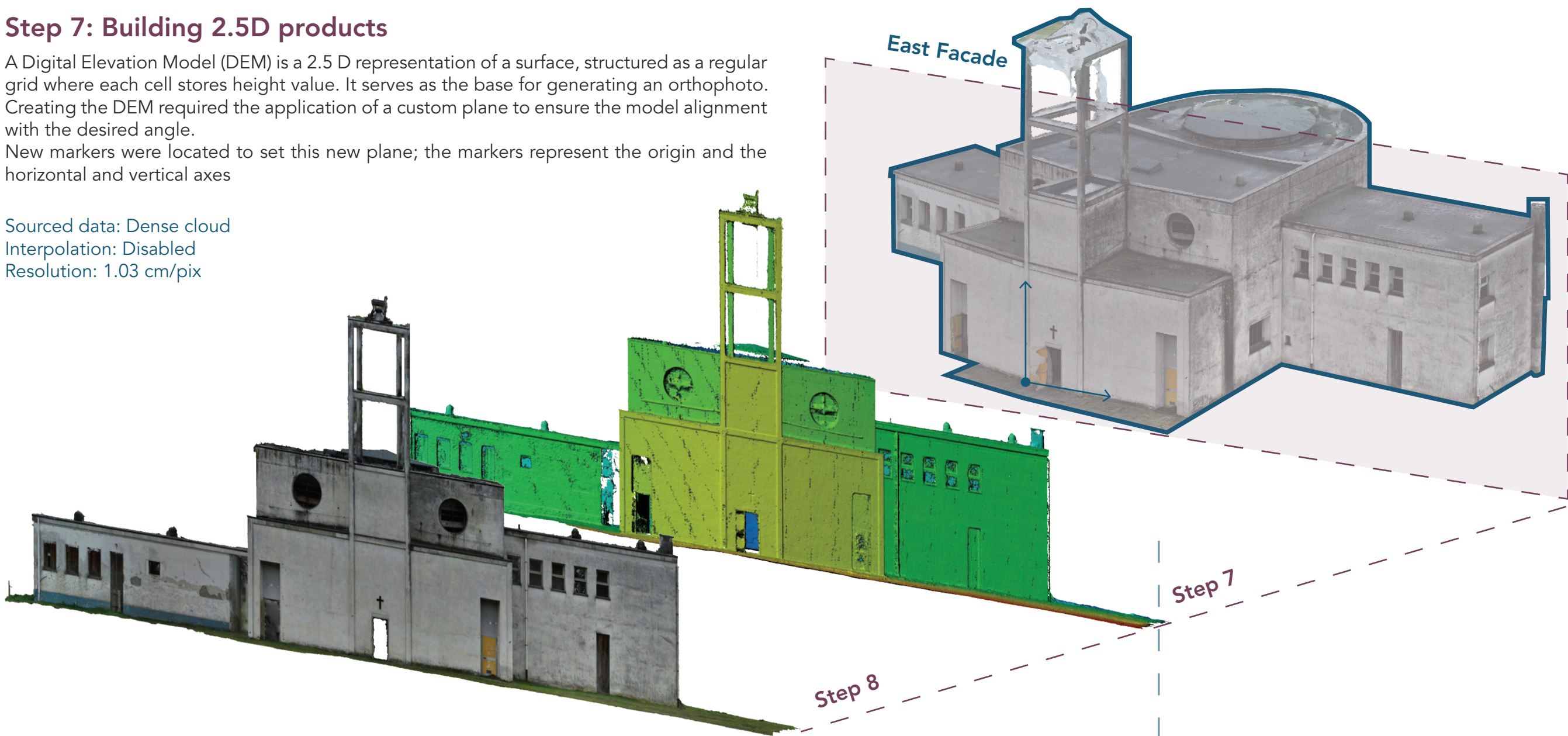


### Step 7: Building 2.5D products

A Digital Elevation Model (DEM) is a 2.5 D representation of a surface, structured as a regular grid where each cell stores height value. It serves as the base for generating an orthophoto. Creating the DEM required the application of a custom plane to ensure the model alignment with the desired angle.

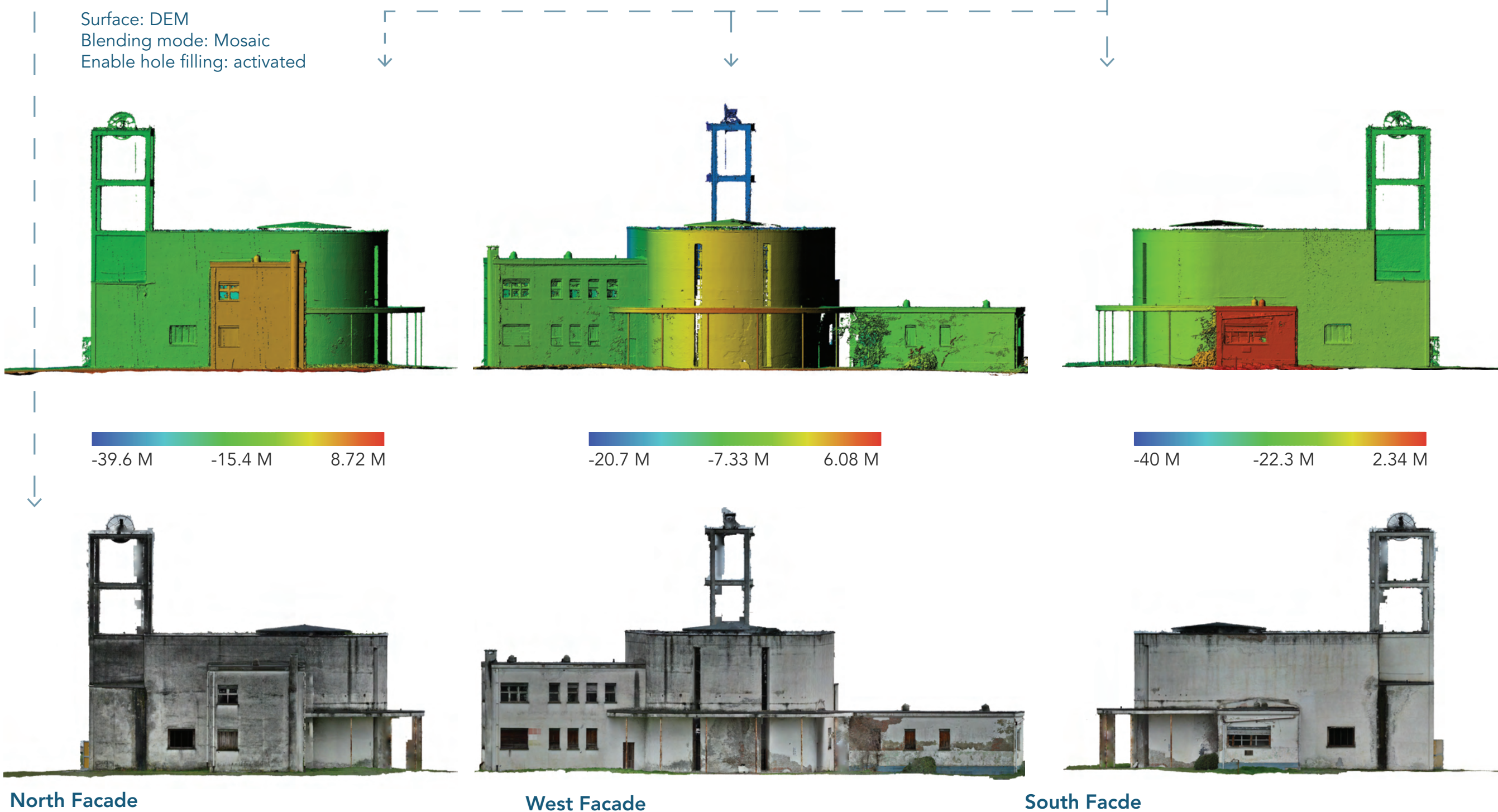
New markers were located to set this new plane; the markers represent the origin and the horizontal and vertical axes

Sourced data: Dense cloud  
Interpolation: Disabled  
Resolution: 1.03 cm/pix



### Step 8: Building Orthophotos

The orthophoto is a combined image created by the projection of the original images seamlessly merged on top of the object surface and transformed into the selected projection. An orthophoto is an invaluable tool for documenting Cultural Heritage, as it combines radiometric data with precise measurement, enabling comprehensive and accurate representation of the analyzed object



### Step 8: Building Orthophotos

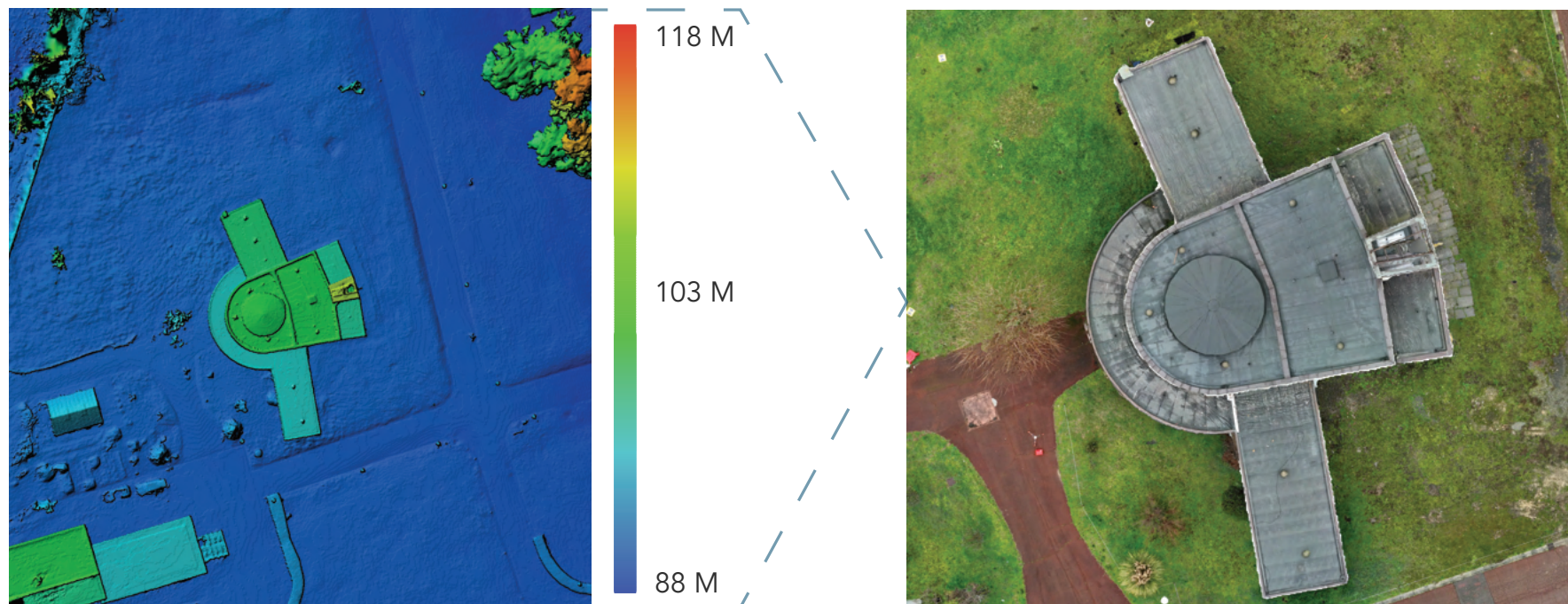
To choose the quality of the orthophoto, there must be taken into account, the scale at which the orthophoto will be working (analyzed) and the ground resolution of the initial images.

#### Aerial Close range-chunk

Ground resolution: 2.63 mm/pix  
Orthophoto pixel size: 1 cm/pix

#### Aerial Close range-chunk

Ground resolution: 1.99 cm/pix  
Orthophoto pixel size: 2 cm/pix



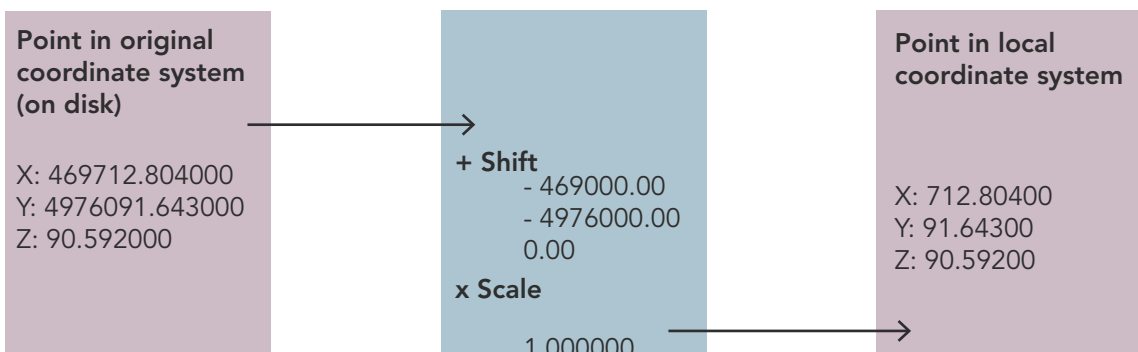
### Step 9: Merging in Cloud Compare

Align the point clouds which were acquired through different capture methods, such as drone-based photogrammetry (used to obtain the aerial and aerial close-range cloud) and ground-based laser scanning (LiDAR) used for the interior of the church.

- The drone-based clouds were manipulated as follows:
  - Global shift and scale
  - Cleaning the clouds
  - Distance computation analysis and Merging

#### 1. Global shift and scale

Applied to prevent numerical precision loss when handling very large georeferenced coordinates by shifting the data to a more manageable local system without affecting its spatial relationships.



#### 2. Cleaning the clouds

Removing unwanted points to improve data quality, facilitate analysis, and optimize storage. Each cloud is cleaned separately before merging. Different strategies were used as:

##### > Interactive Segmentation

Manually selection by drawing a 2D polygon to remove points inside or outside the region of interest.

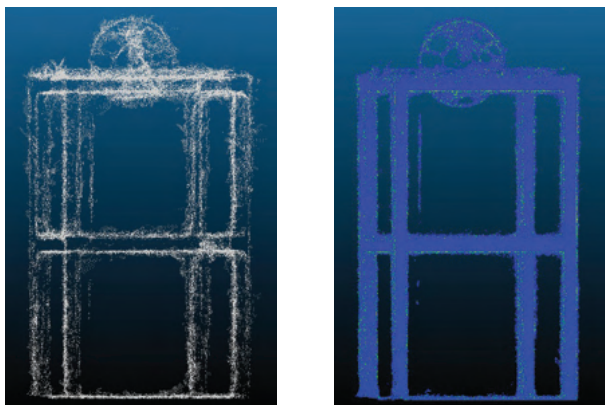
- 1. Create polygon
- 2. Segment in



##### > Filter by value

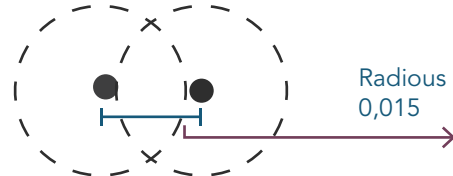
Separating points based on scalar fields like surface variation, intensity, number of neighbor, planarity, etc.

- Unwanted points
- Remaining points



##### > Remove Duplicate points:

Eliminates redundant points based on a specified minimum distance between points.



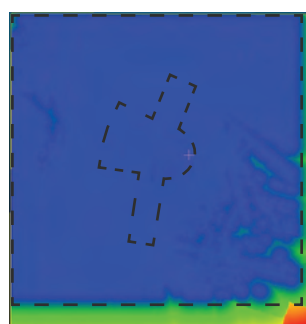
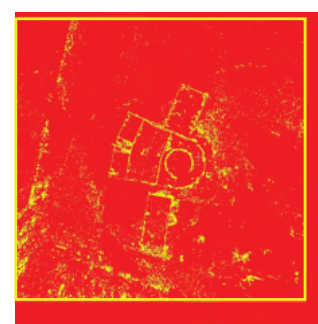
#### 3. Distance computation analysis and Merging

##### > The Cloud-to-Cloud distance (C2C) tool

It calculates the euclidean distance between each point in a compared cloud (red) and its nearest point in a reference cloud (yellow). This tool helps to verify the alignment between the clouds.

##### Defying the role

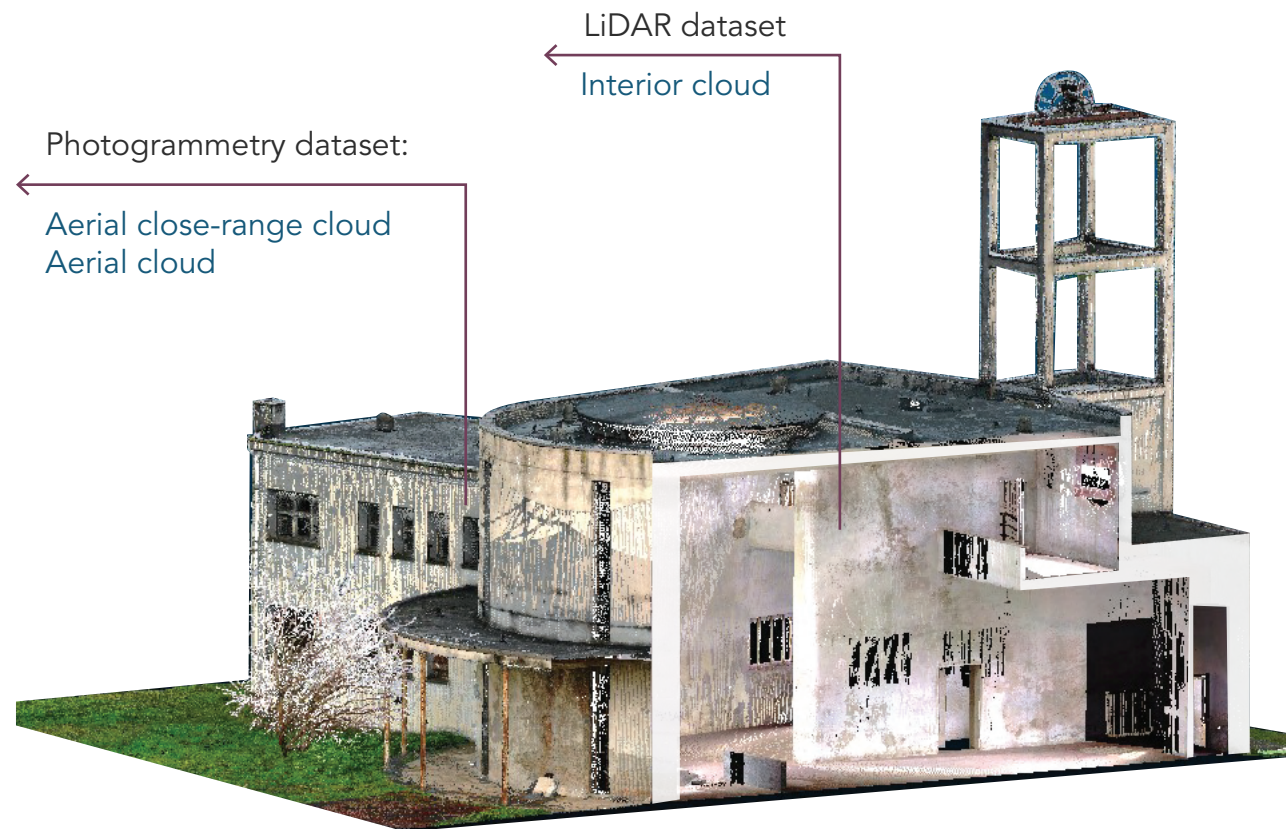
- Aerial cloud
- Aerial-Close cloud



Results  
0.00 M 16.56 M

##### > Merging

Is the process of combining multiple point clouds into a single dataset while preserving key metadata such as RGB colors, scalar fields, and georeferencing information.



## Digital Plotting in 2D and 3D

The creation of precise 2D documentation for Ignazio Gardella's Church exemplifies the integration of modern geomatics technologies with traditional architectural drafting principles. This process focused on generating scaled plans, sections, and elevations, emphasizing accuracy and compliance with architectural and heritage preservation standards. This process is divided into two phases, depending on the input sources utilized for its execution.

### Input source: Orthophoto

Programs used: Autocad  
Outputs: Roof plan - Elevations

When exporting the orthophoto from Metashape, the "Write World File" checkbox is selected, which will be used when importing image into AutoCAD to maintain spatial accuracy and correct scale as follows:

- Pixel size in the X - direction:
- Rotational term
- Rotation term
- Pixel size in the Y - direction
- X - Coordinate of the upper left corner
- Y - Coordinate of the upper left corner



### Input source: Dense Cloud

Programs used: PointCap - Autocad  
Outputs: Ground and first floor plan - Sections

PointCap is specialized software for processing and interpreting georeferenced point clouds obtained from CloudCompare. The data remains intact throughout the workflow, ensuring no loss of spatial accuracy when transferred to PointCap and later exported to AutoCAD.

The results were classified into three categories, allowing for a detailed analysis of the building's plans and sections.

