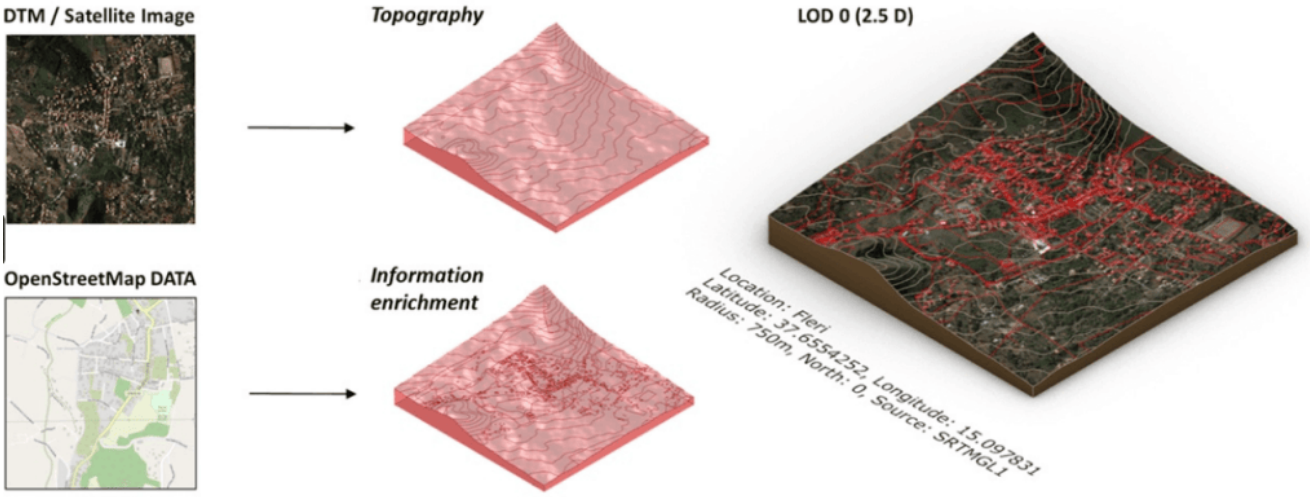
# 3DCITYGH: A Parametric Workflow for Digital Urban Survey and City Information Modeling

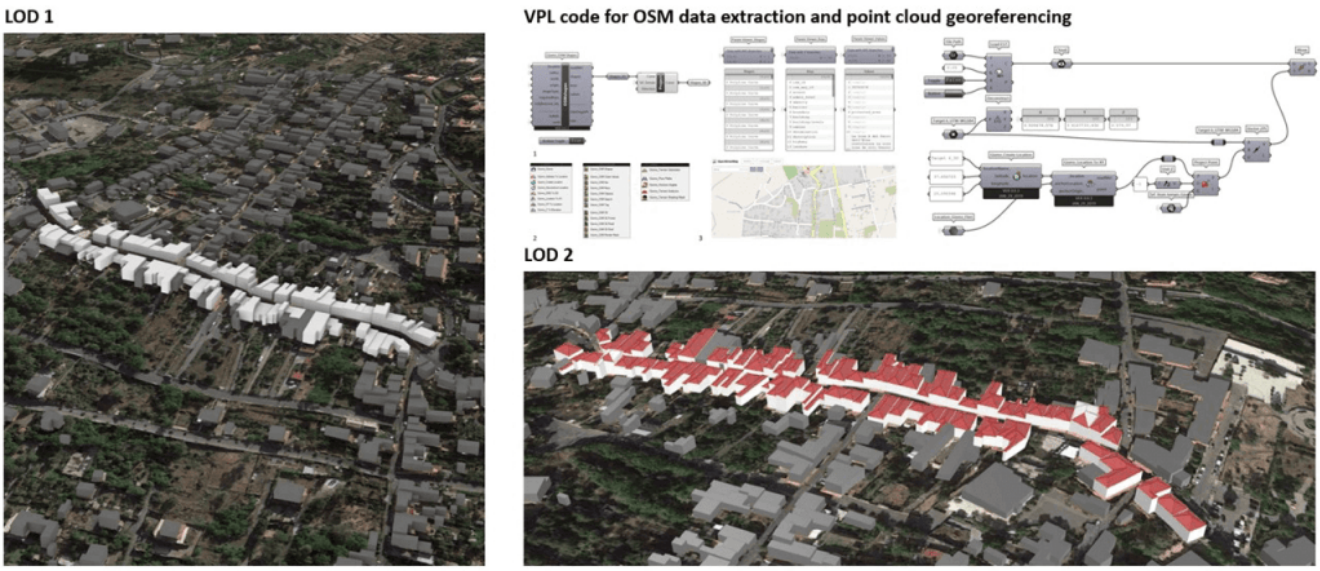
Developed as part of the PhD research of Federico La Russa – a candidate at the University of Catania – 3DCITYGH explores new parametric workflows for historic city modeling. This project introduces a dual-method approach that connects advanced survey data with structured City Information Models (CIM), using Rhinoceros and Grasshopper as central platforms.

Designed to support scalable applications – ranging from disaster response to heritage conservation – **3DCITYGH** demonstrates how parametric design tools can help bridge survey data, architectural modeling, and structural analysis in complex urban contexts.

At its heart, **3DCITYGH** offers two complementary workflows: **Survey-to-CIM** and **Scan-to-CIM**. Both are designed to make urban-scale modeling feasible even in complex, resource-limited contexts.




*CIM setting up for Fleri's case study*



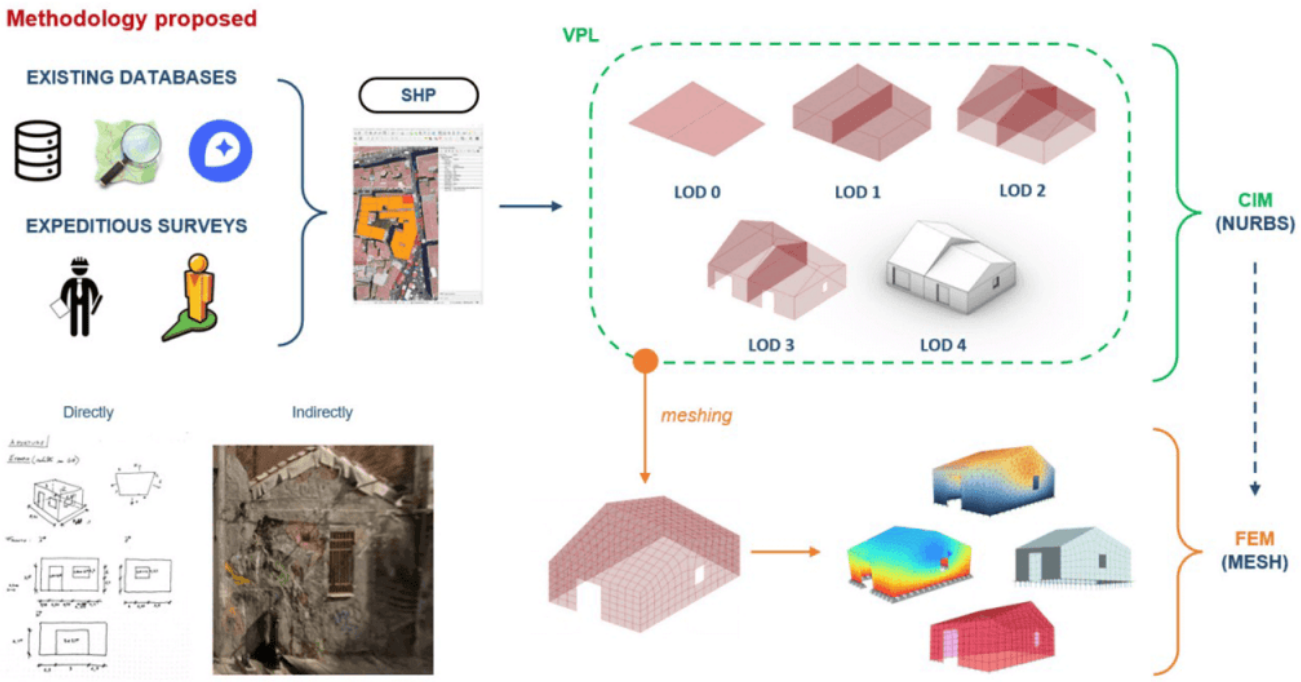

*‘Village’ Case Study (Fleri, Sicily, Italy) – CIM LOD 1 and LOD 2 (CityJSON standards)*

# SURVEY-TO-CIM: A PRAGMATIC SOLUTION FOR SMALL URBAN CENTERS

Applied in the Sicilian village of Fleri, which was damaged by a 2018 earthquake, the Survey-to-CIM workflow combines terrestrial laser scanning, 360° photogrammetry, orthophotos, and open-source GIS data.

This method leverages tools like Volvox and Cockroach in Grasshopper for point cloud alignment and overlays these with Open Street Map (OSM)-derived massing models. Architectural details such as windows and roof forms were refined through photo analysis, and further modeled with VisualARQ to create BIM-compatible elements at LOD 300.

Such workflow enabled efficient production of accurate structural models in a setting with limited surveying resources, helping bridge digital documentation with real-world recovery needs.



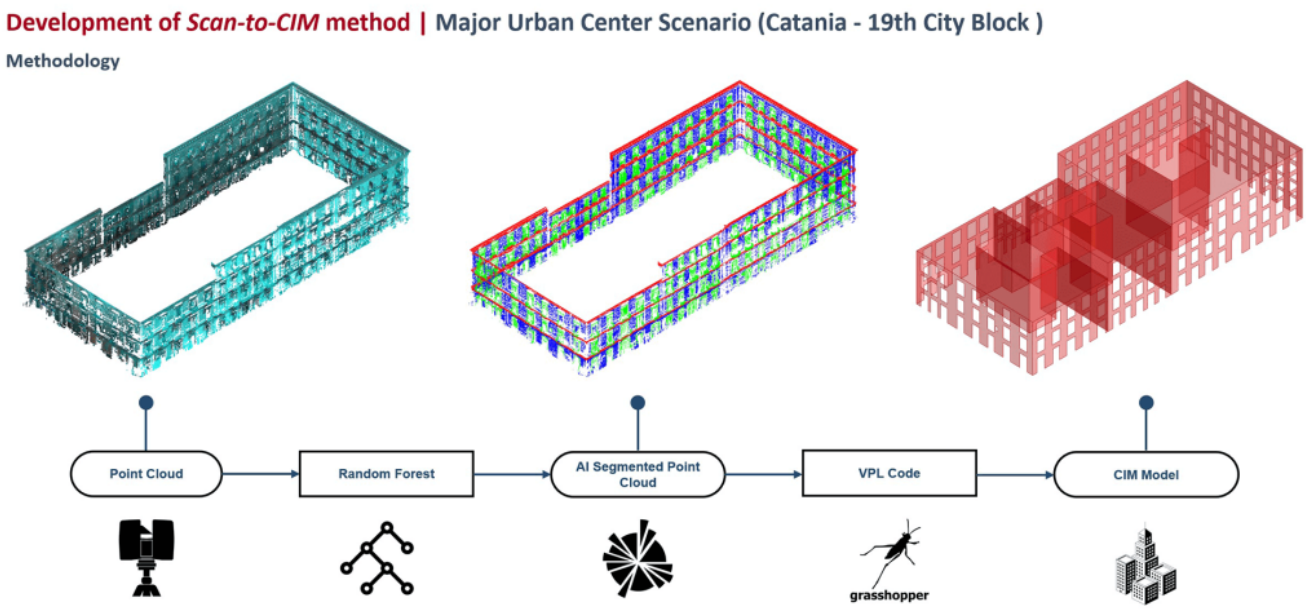

*Workflow for Survey-to-CIM*

# SCAN-TO-CIM: ADDRESSING THE COMPLEXITY OF DENSE URBAN FABRICS

For intricate urban environments like Catania's historic center, the team trained a Random Forest classifier to recognize architectural elements (walls, windows, string courses) directly from dense point clouds. The classifier output was processed within Grasshopper to construct LOD 1 to LOD 3 models (according CityJSON Level of Detail standards) of entire city blocks. LOD 4 (interiors) implemented via previous studies of Catania's municipality of ground level walls footprints.

This method uncovered discrepancies between official maps and the urban reality (unplanned extensions, hidden courtyards, and structural anomalies) underscoring the importance of AI-assisted segmentation for accurate digital city modeling.

The Cockroach plugin, used alongside Volvox, played a key role in the Scan-to-CIM workflow. It supported point cloud management, segmentation, and classification processes inside the parametric environment, helping automate the transformation of raw survey data into usable 3D models.



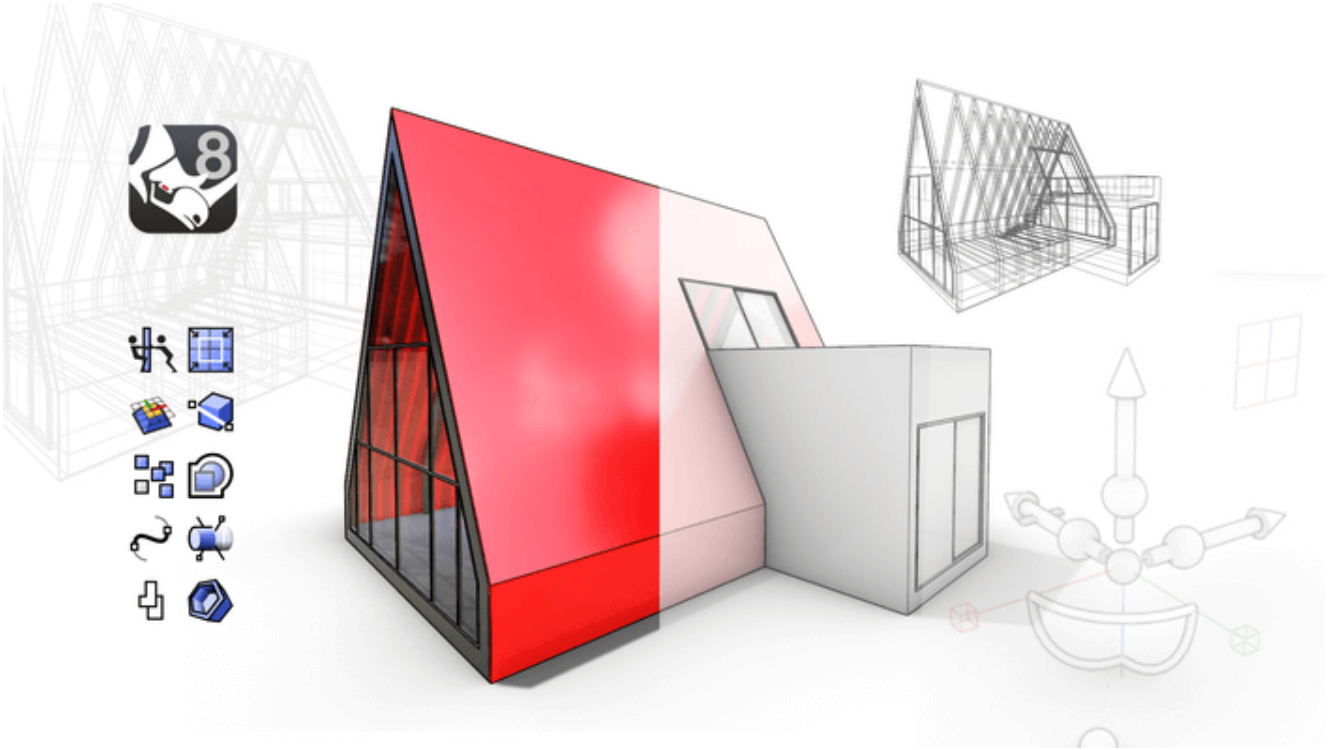

*Scan-to-CIM workflow*

# A PARAMETRIC FRAMEWORK DRIVEN BY GRASSHOPPER

Grasshopper's role went beyond geometry manipulation. It served as the backbone for:

- **Data management and alignment** of heterogeneous sources
- **Semantic structuring** using **CityGH**, a custom logic inspired by CityJSON but tailored to Grasshopper's native Data Trees
- **Geometry generation**, driven by survey overlays and architectural feature recognition
- **FEM preparation and mesh export** for structural analysis via Karamba3D, Alpaca4D, SAP2000, and FEM-Design
- **BIM model enrichment** with parametric data for IFC export through VisualARQ

This structure allowed large portions of the modeling process to be automated, while maintaining flexibility for refinement and rapid updates as new data became available.



See Also

INTRODUCTION TO RHINO 8

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# ADDRESSING COMMON CHALLENGES IN PARAMETRIC URBAN MODELING

Several technical hurdles shaped the workflow:

**Working with Point Clouds**: Managing dense point clouds without sacrificing performance required a hybrid approach: aligning scans with Volvox and GNSS control points in Fleri, and leveraging AI-driven segmentation in Catania, achieving around 84% classification accuracy.

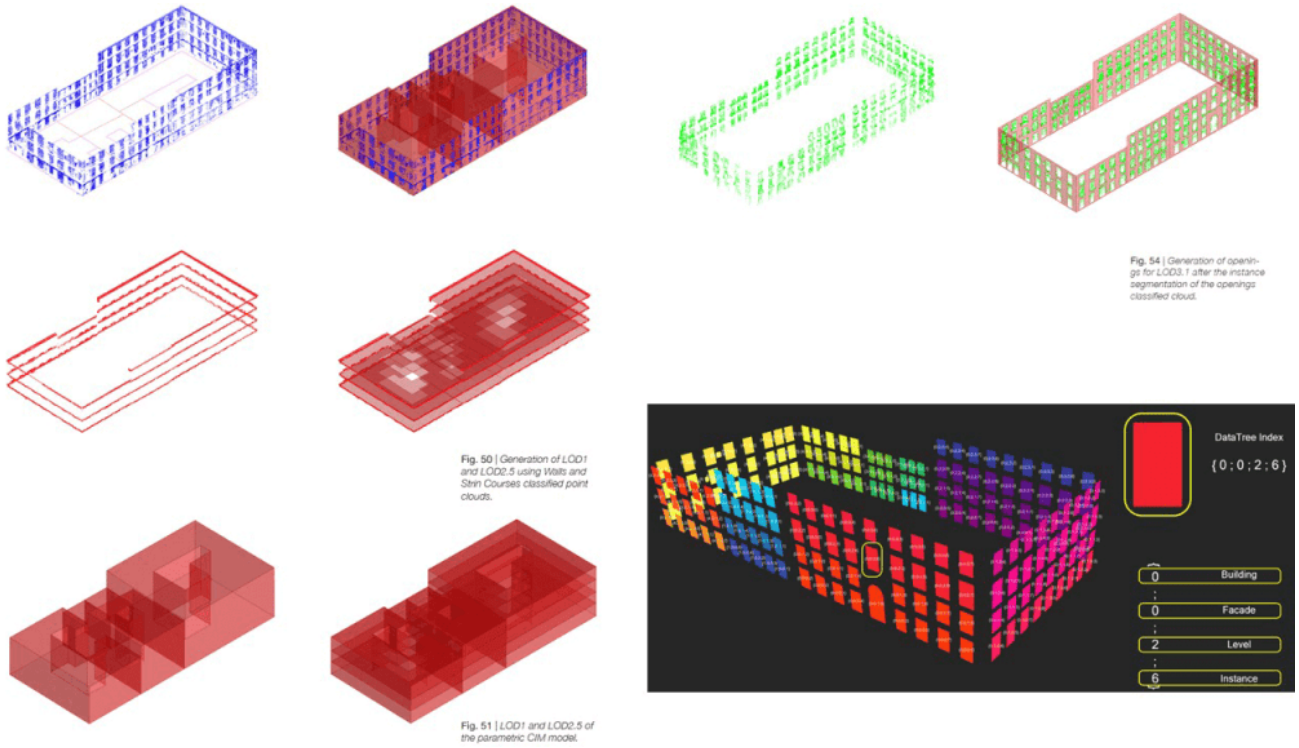


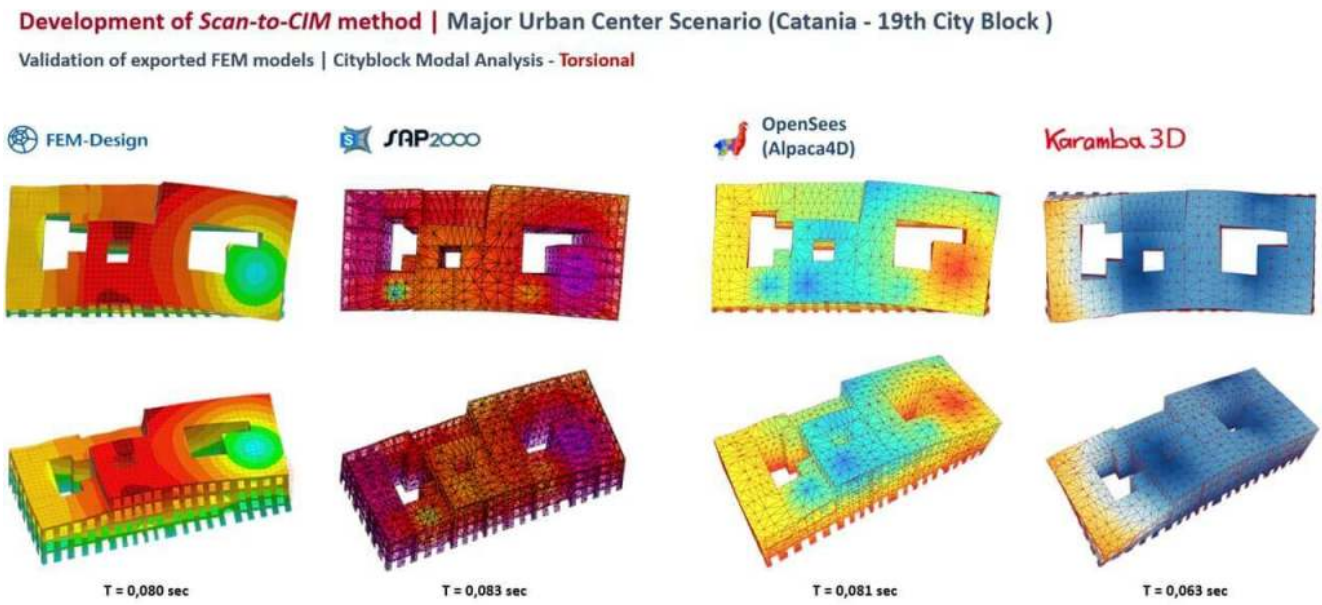

Fig. 50 | Generation of LOD1 and LOD2.5 using Walls and Strin Courses classified point clouds.

Fig. 51 | LOD1 and LOD2.5 of the parametric CIM model.

Fig. 54 | Generation of openings for LOD3.1 after the instance segmentation of the openings classified cloud.

*Model generation from point clouds ML classified and windows GH data tree management*

**Bridging to BIM and FEM**: To ensure compatibility with analysis tools, parametric models were converted using VisualARQ and mesh routines, making them suitable for both architectural documentation and structural assessment. As part of the research, a dedicated Grasshopper plugin was developed to automatically generate models for structural FEM analysis. The plugin enables exporting geometry in .dxf and .3dm formats compatible with SAP2000, streamlining the integration with engineering tools.



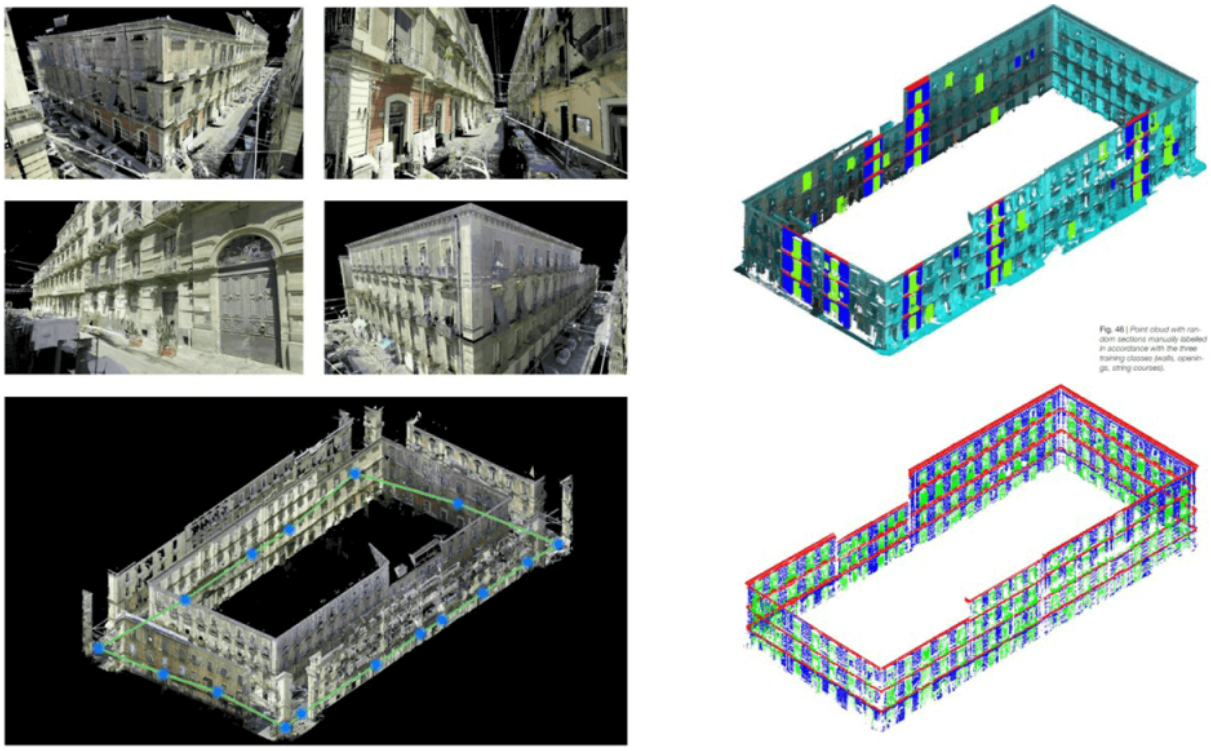

*Generation for FEM models and preliminary analysis for assessing seismic safety*

**Ensuring Versatility Across Projects**: The team built modular Grasshopper scripts capable of blending automated routines with manual intervention, adapting the workflow to different urban scenarios without losing consistency or efficiency.

# OUTCOMES & ONGOING IMPACT

**3DCITYGH** demonstrated a feasible approach for translating diverse survey data into structured urban models applicable to both emergency response and conservation planning. Its workflow supports the automatic generation of semantically rich models ready for simulation or BIM/GIS platforms.

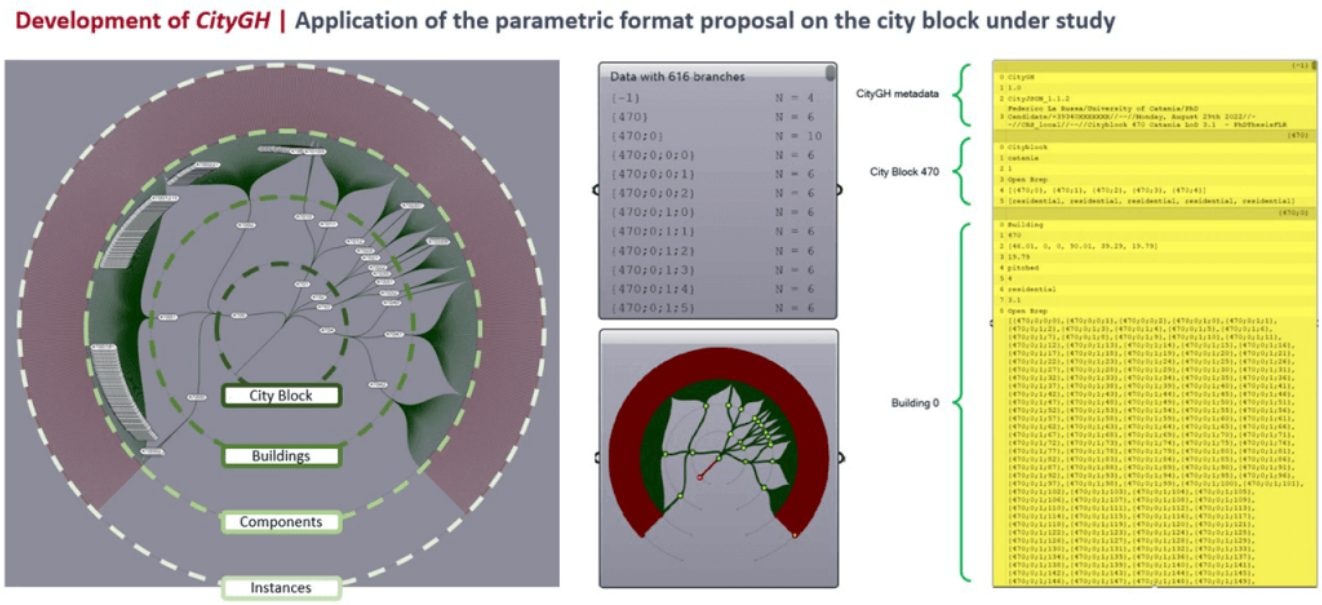
Beyond technical achievement, the project revealed hidden layers of urban complexity in places like Catania, showing how digital modeling can reveal aspects of the built environment that conventional surveys miss.



*Acquisition of point cloud for 2nd case study in Catania (Catania, Sicily, Italy)*

The research attracted attention at key academic forums, including **Digital Twin 2021** and **3D-ARCH 2022**, and sparked collaborations with institutions like TU Delft, Fondazione Bruno Kessler – 3D Optilcal Metrology unit (3DOM), and the Cyprus Institute. Interest from disaster management agencies, such as Italy's National Institute of Geophysics and Volcanology (INGV), points to its potential in pre- and post-disaster risk assessment workflows.

In both heritage-rich and vulnerable urban areas, **3DCITYGH** stands as a proof of concept for a parametric, data-driven approach to city modeling, bringing together advanced surveying, AI, and structural analysis within a flexible design environment.




*DataTree structure for defininig CITYGH standard*

# CREDITS

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