

ACCESSIBLE TECHNIQUES FOR DIGITAL BUILDING SURVEYING VOL.2

M. Sc. Architecture - HafenCity University Hamburg



ACCESSIBLE TECHNIQUES FOR DIGITAL BUILDING SURVEYING

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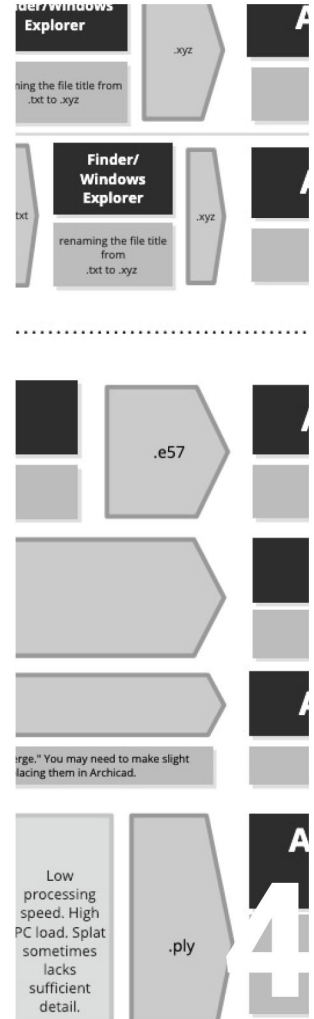
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INTRODUCTION

PREFACE

In the summer semester of 2024, we explored the possibilities of digital building documentation for the first time together with Master's students in Architecture at the Ohlendorff Villa in Hamburg. At that time, our primary objective was to investigate the wide range of available methods for digital building surveying and to identify the most suitable tools and workflows for architectural practice.

Building upon these experiences, our work in the summer semester of 2026 extended this research by evaluating additional technologies with a particular focus on the generation of three-dimensional building models. To facilitate reproducibility, the Appendix documents each workflow presented in this publication in a step-by-step manner, enabling readers to reproduce the validated processes on their own. Over the past two years, surveying technology has evolved rapidly. Today, the integration of point clouds into CAD software has become considerably more accessible. Alongside point clouds, a new three-dimensional image representation—3D Gaussian Splats (3DGS)—has emerged as a promising technology for digital building documentation.

Using the Hufnerhaus in Hamburg as a case study, we investigated and compared a variety of instruments and workflows for building digitization based on both point clouds and Gaussian Splats. In addition to smartphone applications, DSLR cameras, and 3D cameras, we employed the Lixel K1 handheld scanner and a DJI Matrice 4E drone. All participating student groups successfully generated usable point clouds with the selected technologies, while some of the tools also produced 3D Gaussian Splat models. Although we have not yet succeeded in integrating Gaussian Splats directly into CAD software, we are confident that such capabilities will become available in the near future.

This project would not have been possible without the generous support and trust of Mr. Christian Kottmeier and the members of the Jugendbauhütte. We are equally indebted to our esteemed colleague, Professor Thomas Kersten, whose pioneering work introduced us to these technologies and laid the foundation for this research. On behalf of everyone involved, I would like to express my sincere gratitude for their invaluable support.

My special thanks go to the students and contributing authors of this publication. Motivated solely by their professional curiosity and enthusiasm for learning, they participated in this project without any guarantee of success and dedicated themselves wholeheartedly to this publication from its inception to its completion.

Hamburg, July 2026
Bernd Dahlgrün



METHODS

01 MATRICE 4E



INTRODUCTION

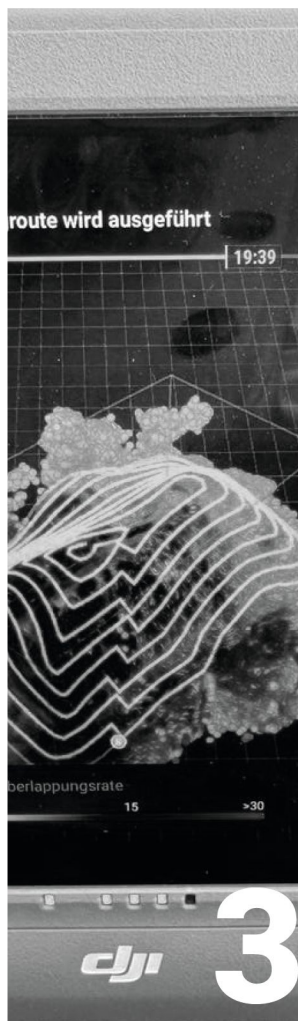
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DJI MATRICE 4E

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PREPARATION

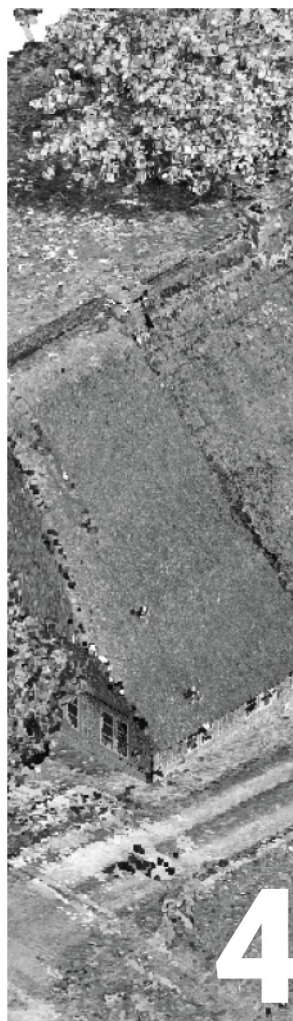
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1

INTRODUCTION



DESCRIPTION

This section examines the potential and applicability of the DJI Matrice 4E drone (Fig 1.1.1) as a tool for creating digital as-built models of buildings and analyzes its benefits for architectural planning and as-built surveys.

Using the Hufnerhaus as an example, the entire workflow, from preparation through data collection to the creation of a three-dimensional building model, is documented and evaluated. The DJI Matrice 4E is a professional Unmanned Aerial Vehicle (UAV) system specifically designed for geospatial applications such as surveying, mapping, and inspection tasks, particularly for the construction industry. By combining high-resolution imaging, automated flight planning, and software-assisted processing, the system enables the capture of precise building data for the creation of digital as-built models.¹

With the help of the DJI Manifold 3 onboard computer, the system can create a 3D model of the building even from a short distance and, based on this, generate a largely automated survey of the building.²

As part of the project, the software solutions Agisoft Metashape and WebODM were used to process the captured image data and were compared in terms of their suitability for creating usable building models.

The generated datasets were then imported into Archicad and used as the basis for building modeling.

In addition to the technical implementation, the project evaluated the required workload, the accessibility of the method, and the quality and



Fig. 1.1.1: DJI Matrice 4E

1 cf. DJI. "DJI Matrice 4 Serie - Technische Daten". Accessed 01.07.2026.

<https://enterprise.dji.com/de/matrice-4-series/specs>

2 cf. DJI. "Manifold 3 - Die Computing-Power Der Zukunft - DJI Enterprise". Accessed 01.07.2026.

<https://enterprise.dji.com/de/manifold-3>

usability of the generated data for architectural surveys.

Based on the insights gained, we developed a workflow tailored to the architect's work (Fig. 1.1.2)

The entire process of drone-based surveying can be divided into four sequential steps. These include the building survey, the photogrammetric reconstruction of the image data, the processing of the resulting point clouds, and the conversion into a BIM-compatible 3D model.

This structure forms the methodological framework of the study and serves as the basis for evaluating the quality of the survey, data processing, and architectural applicability in the following chapters.

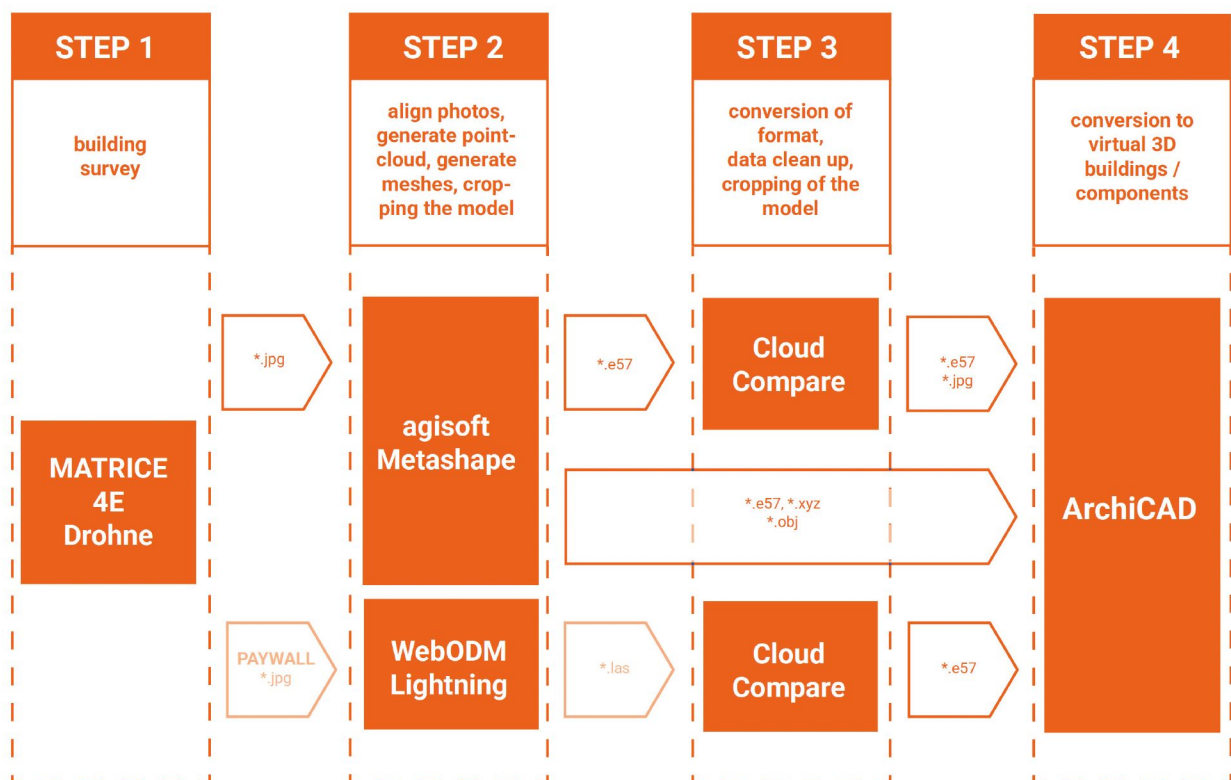


Fig.1.1.2: Schematic diagram of procedure

REQUIREMENTS

Hardware and Software

- The DJI Matrice 4E is being used for the digital survey of the Hunferhaus. It is particularly well-suited for this task, as it was developed for professional surveying and provides georeferenced image data for photogrammetric analysis.³ The drone is complemented by the DJI Manifold 3 onboard computer, which enables close-range and largely automated surveying of the building.⁴
- Sufficiently charged drone batteries are required for operation, as energy consumption is high during the survey.
- The DJI RC Plus 2 Enterprise remote control is required to control the drone and adjust the imaging parameters.⁵
- Additionally, a mobile device with an internet connection acting as a hotspot is required to retrieve satellite data.
- A high-performance computer is required to process the image data, as the photogrammetric analysis of large volumes of high-resolution images places correspondingly high demands on computing power and storage.
- Two different photogrammetric software approaches were used in the project: Agisoft Metashape (a 30-day trial version of the commercial full version) and WebODM Lightning, a cloud-based system operating on a credit-point basis.^{6,7}
- CloudCompare was used for further pro-

cessing of the point clouds and for generating orthographic views.

- The final geometric data was integrated into the BIM workflow using Archicad.

Legal Requirements

The operation of UAV systems within the European Union is subject to Regulation (EU) 2019/947. Depending on the operational scenario, at least a Category A1/A3 certificate of competence is required, while additional qualifications (e.g., A2 or Specific Category) may be necessary for more complex operations.⁸

In this project, all drone flights were conducted by operators holding an A2 certificate, as this qualification was required for the UAV used. Due to its take-off weight of approximately 1,200 g,⁹ the DJI Matrice 4E falls into a category that requires A2 competency under the applicable operational regulations. The A2 certification includes, among other things, knowledge of safe operating conditions, safe distances from bystanders, and the assessment of risks during flight operations.

In addition, it must be verified prior to operation whether the survey area is located within a geographically restricted airspace or is subject to other operational requirements. This verification is necessary to ensure that drone operations are conducted in compliance with the law and in accordance with local safety requirements.

On-Site Requirements

The survey area must be defined in such a way that no unauthorized overflights of non-appro-

3 cf. DJI. "DJI Matrice 4 Serie - Technische Daten". Accessed 01.07.2026. <https://enterprise.dji.com/de/matrice-4-series/specs>

4 cf. DJI. "Manifold 3 - Die Computing-Power Der Zukunft - DJI Enterprise". Accessed 01.07.2026. <https://enterprise.dji.com/de/manifold-3>

5 cf. DJI. "DJI Matrice 4 Serie - Das Zeitalter des intelligenten Fluges". Accessed 26.06.2026. <https://enterprise.dji.com/de/matrice-4-series>

6 cf. Agisoft Metashape. "Agisoft Metashape". Accessed 26.06.2026. <https://www.agisoft.com/>

7 cf. OpenDroneMap. "WebODM Lightning: Drone Mapping Software". Accessed 26.06.2026. <https://webodm.net/>

8 cf. Luftfahrt Bundesamt (LBA). "Dronen: Rechtliche Grundlagen". Accessed 26.06.2026. https://www.lba.de/DE/Drohnen/Allgemeine_Informationen/Rechtliche_Grundlagen/Legal_Basis_node.html

9 cf. DJI. "DJI Matrice 4 Serie - Technische Daten". Accessed 01.07.2026. <https://enterprise.dji.com/de/matrice-4-series/specs>

No	Type	Requirement	Notes
1	Hardware	DJI Matrice 4E Drone	UAV system for photogrammetric surveying and building documentation
2		DJI RC Plus 2 Enterprise Remote control	Remote controller for flight planning, mission control and monitoring
3		DJI Manifold 3 onboard computer	enables real-time edge computing
4		Mobile device	Smartphone with hotspot function to provide internet connectivity
5		PC/ Laptop	Required for post-processing; hardware requirements depend on project size and software used
6	Software	agisoft metashape	Photogrammetric processing of images into point clouds, meshes and orthophotos
7		WebODM (Lightning)	beginner friendly Cloud-based photogrammetry platform for image processing
8		Cloud Compare	post-processing of pointclouds
9		Archicad	BIM software used for modelling and evaluation of survey data
10	Legal	UAV pilot qualification	Appropriate certification required according to the operational category and national regulations
11		Airspace clearance	Verification of restricted areas, no-fly zones and local regulations
12	Onsite	Clear Survey Area	No obstacles, people or restricted overflight
13	Environment	Suitable Weather Conditions	Low wind speeds, no precipitation and sufficient visibility

Fig.1.1.3: Schematic diagram of requirements

ved areas (e.g., neighbors' properties) occur. At the same time, potential interfering factors such as trees, structural obstacles, or temporary objects must be taken into account in advance.

Photogrammetric methods require that the environment remain as stable as possible during the survey, since image registration is based on the recognition of unchanging visual features.¹⁰

Lighting Conditions

The quality of the image data is significantly influenced by the prevailing lighting conditions. Uniform and diffuse lighting improves the stability of feature detection and the quality of the generated images. Strong direct sunlight, on the other hand, can lead to overexposure and pronounced shadow areas, thereby impairing data quality.¹¹

Image Overlap and Capture Geometry

A sufficient overlap of ca. 70% is required for a stable photogrammetric reconstruction. This is defined as a key parameter in flight planning and determines the density of the imaging positions.

Complete geometric coverage results from the combination of the imaging area, object geometry, and flight parameters. A consistent reconstruction requires that all relevant building components be captured from multiple perspectives. In our specific project, these settings were configured by the drone operator and by the drone's automated system.¹²

Level of Detail and Data Volume

The quality of the resulting 3D model depends

largely on the number and spatial distribution of the captured images. A higher image density generally leads to a more precise geometric reconstruction. However, it also increases the computational effort required for data processing and, as in our case, the challenge of correctly matching images when dealing with small, repetitive elements such as thatch.¹³

10 cf. Agisoft Metashape. "3D-Kartierung Mit Agisoft Metashape: Der Komplette Leitfaden Für Professionelle Photogrammetrie". 19.07.2025. <https://www.agisoftmetashape.com/de/3d-kartierung-mit-agisoft-metashape-der-komplette-leitfaden-fuer-professionelle-photo-grammetrie/?srsltid=AfmBOorQ74DfQVhMsPlvaOdsYZEmWwiG3ew2yp0BKacnSv4ZuAl-2cWz#photo-capture>

11 cf. *ibid.*

12 cf. *ibid.*

13 cf. *ibid.*

2 PREPARATION

PREPARATION

The preparation for drone-based building documentation encompassed both organizational and legal aspects as well as the planning of the actual on-site operation. The goal was to create the conditions for safe and efficient data collection. The actual execution of the scanning process is described in Chapter 3.

Organizational Preparation

In the run-up to the project, we familiarized ourselves with the DJI Matrice 4E UAV system used, as well as the basic workflows involved in photogrammetric building documentation. This included, in particular, understanding the interaction between the drone, the remote control, flight planning software, and the data processing programs used later on.

A key part of the preparation involved clarifying the legal framework. The operation of unmanned aircraft systems within the European Union is regulated by the EU Drone Regulation.¹⁴ For professional surveying applications, the basic EU A1/A3 certificate of competence is often insufficient, depending on the drone type and operational scenario. For the use of the DJI Matrice 4E in the context of building documentation, the EU Remote Pilot Certificate A2 was also required. This is because, in this case, the DJI Matrice 4E, due to its mass of approximately 1,200 g¹⁵, can pose a safety hazard to people if operated incorrectly. This requires advanced training as well as an additional theoretical exam.¹⁶

Obtaining this qualification within the scope of the course would not have been feasible due to the additional time and financial costs invol-

ved. Therefore, drone operations were carried out by appropriately qualified personnel from the department. The required licenses were held by the professor leading the course and a research assistant. We were thus able to observe and document the scanning process but were not permitted to operate the drone independently.

Since we were not responsible for the operational control, our focus was less on the detailed operation of the remote control and more on understanding the overall process. Prior to the operation, we received instruction on how the system works, the basic operating procedures, and the steps involved in conducting an automated survey flight. In addition, it was necessary to verify prior to the mission whether the planned survey location was generally permitted for drone flights. This includes, in particular, aviation regulations such as no-fly zones, airport control zones, or other geographic areas with operational restrictions.¹⁷ The building under investigation was located on a private property in a rural area outside such restricted zones, so the flight could be conducted without special authorization.

Preparation of the Site

In addition to the organizational requirements, various technical and on-site conditions had to be checked.

First, it was necessary to ensure that there were enough fully charged batteries available to carry out the data collection. Although the DJI Matrice 4E has a comparatively long flight time of up to 49 minutes under ideal conditions, the actual flight duration is sometimes significantly reduced by wind, flight maneuvers,

14 cf. Luftfahrt Bundesamt(LBA). "Drohnen: Rechtliche Grundlagen". Accessed 26.06.2026. https://www.lba.de/DE/Drohnen/Allgemeine_Informationen/Rechtliche_Grundlagen/Legal_Basis_node.html

15 cf. DJI. "DJI Matrice 4 Serie - Technische Daten". Accessed 01.07.2026. <https://enterprise.dji.com/de/matrice-4-series/specs>

16 cf. Luftfahrt Bundesamt(LBA). "Drohnen: Rechtliche Grundlagen". Accessed 01.07.2026. https://www.lba.de/DE/Drohnen/Allgemeine_Informationen/Rechtliche_Grundlagen/Legal_Basis_node.html

17 cf. *ibid.*

safety margins, and the operation of sensors and cameras.¹⁸ Therefore, several fully charged batteries were kept on hand to ensure the scanning process could be carried out without interruptions. Furthermore, an empty microSD card with a storage capacity of approximately 128–256 GB had to be inserted prior to each flight to ensure sufficient storage for image data acquisition.

In addition, the survey area was inspected on-site to determine the specific area where data collection should take place. Particular care was taken to avoid flying over or unintentionally capturing neighboring properties whenever possible. This served both to comply with data protection requirements and to focus on the actual subject of the survey.

In addition, we investigated whether obstacles or temporary objects could affect the quality of the image. In the area around the Hufnerhaus, for example, there were individual scaffolding components that could not be removed and would therefore remain visible in the images. Potential hazards such as antennas, masts, trees, or other vertical obstacles were also identified and taken into account. Taking these elements into consideration later played an important role during the scanning process.

Another important aspect was ensuring the clearest possible view of the building facades. During the survey, no one was allowed to be in the immediate survey area if possible, as people can both obstruct the view of relevant building parts and introduce unwanted image details.

Finally, the weather conditions were assessed. For photogrammetric surveys, slightly overcast conditions are often considered particularly favorable, as diffuse lighting reduces harsh shadows and strong brightness contrasts. At the time of data collection, conditions were variable, with periods of sunshine and cloud cover.

Despite occasional direct sunlight, high-quality images were captured, and no strong winds or precipitation were expected, so the conditions were assessed as generally suitable for beginning the survey.

3

SITE MEASUREMENT



Fig. 1. 3.1: Drone located on the takeoff point

SITE MEASUREMENT

For the survey of the Hufnerhaus, the university provided us with the DJI Matrice 4E drone, including the mounted DJI Manifold 3 onboard computer. In addition to the drone itself, we needed the corresponding replaceable batteries with a charger, the DJI RC Plus 2 Enterprise controller, and a mobile device with an internet connection. Typically, a smartphone that provides mobile data via a hotspot is sufficient for this purpose.

Since we conducted the survey exclusively with the DJI Matrice 4E, the following descriptions refer solely to this system and the results obtained with it.

Before beginning the survey, we received a brief introduction to operating the drone and the remote control pad. The basic settings had already been configured in advance by staff from the department who possess the requi-

red drone license and expertise. In general, conducting such a drone scan requires the aforementioned qualifications as well as in-depth knowledge of the device settings. Since we were not permitted to perform the scan ourselves but could only observe, the briefing was relatively brief. However, the actual scanning process proved to be easy to follow due to the high degree of automation.

To perform the survey, the drone was unpacked, equipped with fully charged batteries, and positioned in an open area near the object to be surveyed. The chosen location served as both the takeoff and landing point.

Next, the remote control pad was turned on and first paired with the drone. It was also connected to a smartphone to provide a mobile internet connection. This connection is needed to retrieve the necessary satellite data for navigation and positioning. After successfully connecting all devices and confirming satellite reception, a new project was created. The settings already defined during a previous test flight were applied and confirmed. The scanning process with the DJI Matrice 4E consists of a total of three flights.

First Flight: Defining the Survey Area

The first flight is used to define the boundaries of the area to be scanned. For this, the drone is launched manually and controlled by the drone operator. The drone's current position, including GPS data, is displayed on a map on the remote control pad. To define the scanning area, the drone is positioned sequentially at four corner points. The respective locations are saved and form a rectangular frame that defines the boundaries of the subsequent scan. Once this process is complete, the drone returns to the starting point.

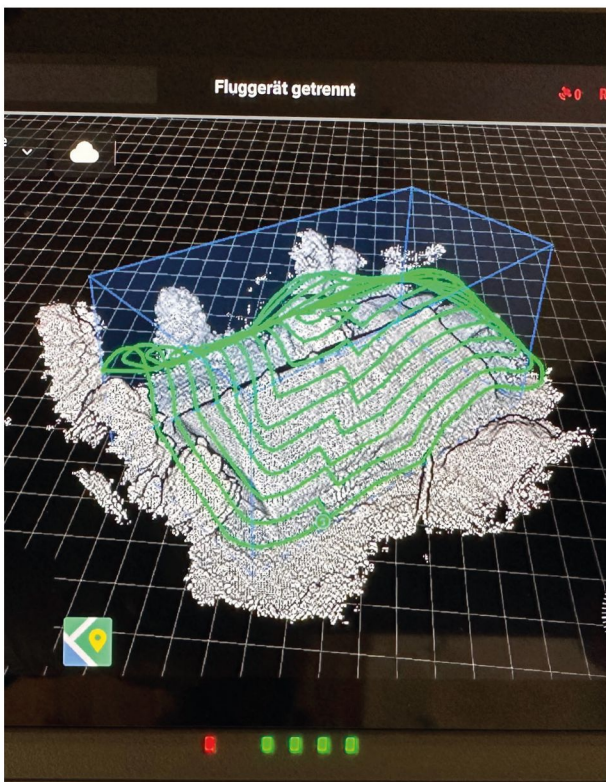


Fig. 1.3.2: Remote control after flight 2

Second Flight: Creation of a Preliminary Model

During the second flight, the previously defined settings are checked and confirmed. The flight is launched manually, after which it proceeds fully automatically. The drone flies around the previously defined object at high speed in a low distance and, with the help of its onboard computer, creates an initial rough 3D model in the form of a point cloud. This is particularly relevant in urban building environments, as without the DJI Manifold 3, the drone must operate at greater distances—up to approximately 400 m—when creating a 3D model. This model serves as the basis for planning the actual scan flight (Fig 1.3.2).

Third flight: Detailed scan of the building

The third flight involves a detailed survey of the building. Based on the model generated during the second flight, the software automatically calculates an optimal flight path (Fig 1.3.3).

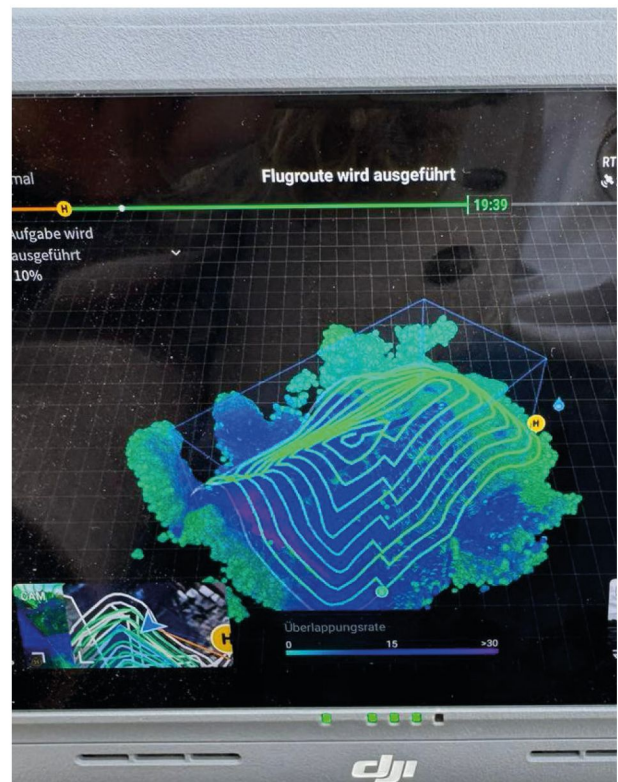


Fig. 1.3.3: Remote control flight 3

Before takeoff, only a few object-specific parameters need to be set.

A key parameter is the distance between the drone and the building. This influences both the level of detail in the images and the quality of the subsequent image stitching during post-processing. A minimum distance of approximately 3 m was generally maintained. For the data acquisition in this project, a flight distance of 5 m was chosen, which is very close but still resulted in reliable and successful image acquisition. Since the Hufnerhaus has a thatched roof with a very fine-grained structure, care had to be taken not to select a distance that was too short. The individual thatch stalks exhibit numerous similar structures, which can complicate the automatic alignment of images in photogrammetry software. It was therefore necessary to balance the need for the highest possible level of detail with the need for reliable post-processing of the image data.

In addition, the flight altitude was defined to avoid potential collisions with obstacles such as antennas, masts, or tree branches, which we had identified during the preparation phase. The Hufnerhaus has several narrow antennas that might not be reliably detected by the drone's sensor systems. Therefore, the flight altitude was set above these obstacles.

Once the settings were complete, the third flight was launched. The drone followed the calculated route fully automatically and captured the building from various perspectives. Approximately 500 individual images were taken of the Hufnerhaus. After the flight was complete, the drone returned autonomously to the starting point and concluded the scanning process.

The actual data collection took about 15 minutes in total, with the third flight accounting for the majority of the flight time. The captured images are stored as JPG files, including geo-referencing data, on the drone's memory card. The data can then be transferred to external storage media or directly to a computer for further processing.

From our perspective, conducting the scan proved to be straightforward and efficient. Despite the high-precision settings for the survey—particularly the short imaging distance of about five meters from the building—data collection was completed in a comparatively short time.

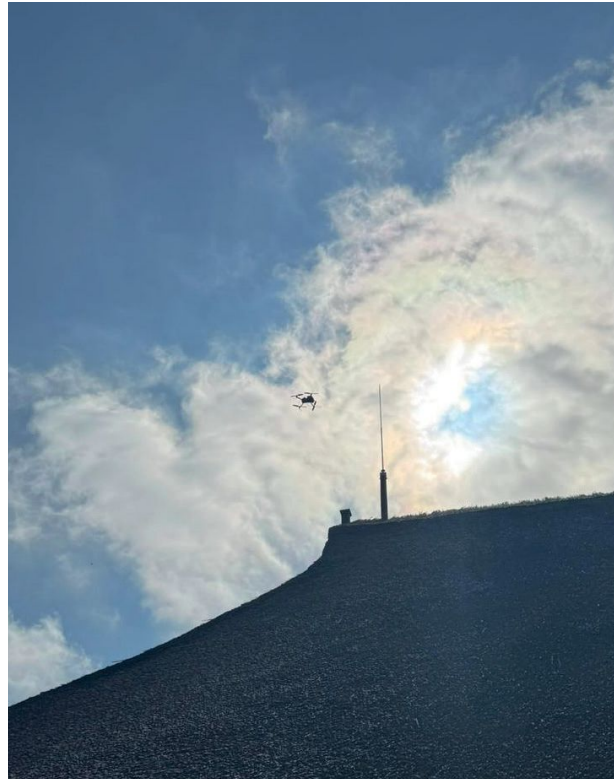


Fig. 1.3.4: Drone near the antenna

4

DATAPROCESSING

DATA EDITING

After transferring the captured image data to the computer, photogrammetric postprocessing could begin. The goal was to generate a three-dimensional model of the Hufnerhaus from the approximately 1.300 georeferenced individual images. To this end, two different programs were tested: WebODM and WebODM Lightning as cloud-based open-source solutions, and Agisoft Metashape as locally installable photogrammetry software. (Fig. 1.4.1)

WebODM Lightning

WebODM is open-source software for processing photogrammetric datasets. In addition to local installation, WebODM Lightning offers a cloud-based version in which computations are performed on external servers. During this study, we realized that even our relatively powerful computers were not sufficient to handle the local open-source version and the large volume of data, so we continued to use and evaluate only the cloud-based version moving forward. Using WebODM Lightning requires registration. New users receive a limited amount of processing credits (150 credits), which is sufficient for smaller projects.¹⁹

However, the available credits were not sufficient for our dataset of approximately 1,300 images. To be able to test the software nonetheless, we reduced the number of images to 285. We were aware that the smaller dataset would lead to a loss of information and reduced model quality.

WebODM proved to be particularly user-friendly for beginners. Preconfigured processing profiles are available for various use cases. For the reconstruction of the Hufnerhaus, we selected the “Buildings” profile, which is optimized for

capturing buildings. In addition, numerous parameters—such as point cloud density or mesh resolution—can be customized.

The model took 40 minutes and 18 seconds to compute. Once processing was complete, a full 3D model was available that could be viewed, cropped, and exported directly in the browser (Fig. 1.4.2). There was also the option to share the model directly with others via a link and to grant editing access. Despite the reduced number of images, the quality of the model was surprisingly high. Weaknesses were particularly evident in the area of the thatched roof. Since the images used were predominantly taken from similar flight altitudes, information from different viewing angles was missing in this area.

The model was then exported both as a point cloud in .las format and as a mesh in .obj format. The .las format cannot be imported directly into Archicad and therefore had to be further processed first.²⁰

Agisoft Metashape

Agisoft Metashape was used as the second software tool. The program can be installed as a local application and tested free of charge for 30 days.²¹ Unlike WebODM, all calculations are performed on the user’s own computer.

The software is generally intended for advanced users and offers a wide range of tools. As a team, we had no prior experience with the program but were able to get up to speed quickly, which is why we consider it suitable for beginners as well. While WebODM provides beginner-friendly, project-specific presets, reconstruction in Metashape is carried out through individual processing steps. However, the necessary settings are clearly structured and easy to follow.

19 cf. OpenDroneMap. “WebODM Lightning: Drone Mapping Software”. Accessed 26.06.2026. <https://webodm.net/>

20 cf. *ibid.*

21 cf. Agisoft Metashape. “Agisoft Metashape”. Accessed 26.06.2026. <https://www.agisoft.com/>

	WebODM Lightning	Agisoft Metashape
Acess	Credits Abos	Commercial license
Trialversion	150 free credits (337 images)	30-day trial version
Usability	++ Easy to use, even for beginners (pre- sets/modes available)	o Designed for professio- nal work, but usable for beginners
Required Proces- sing Power	None, runs via cloud	High-performance PC required depending on project size
Time required	<1 hour	approx. 6 hours
Point cloud result	+	++
Mesh Result	+	++
Sharing of the Model	Possible; collaborati- ve work on the model directly in the browser	Not an option
Archicad Compar- tibility	Good as a mesh (.obj) Point cloud must be formatted using CloudCompare (.ply to .e57)	Good as a mesh (.obj) Good as a point cloud (.e57)

Fig. 1.4.1: Comparison of WebODM Lightning and Agisoft Metashape

Moorfleeter Deich - 4.5.2026

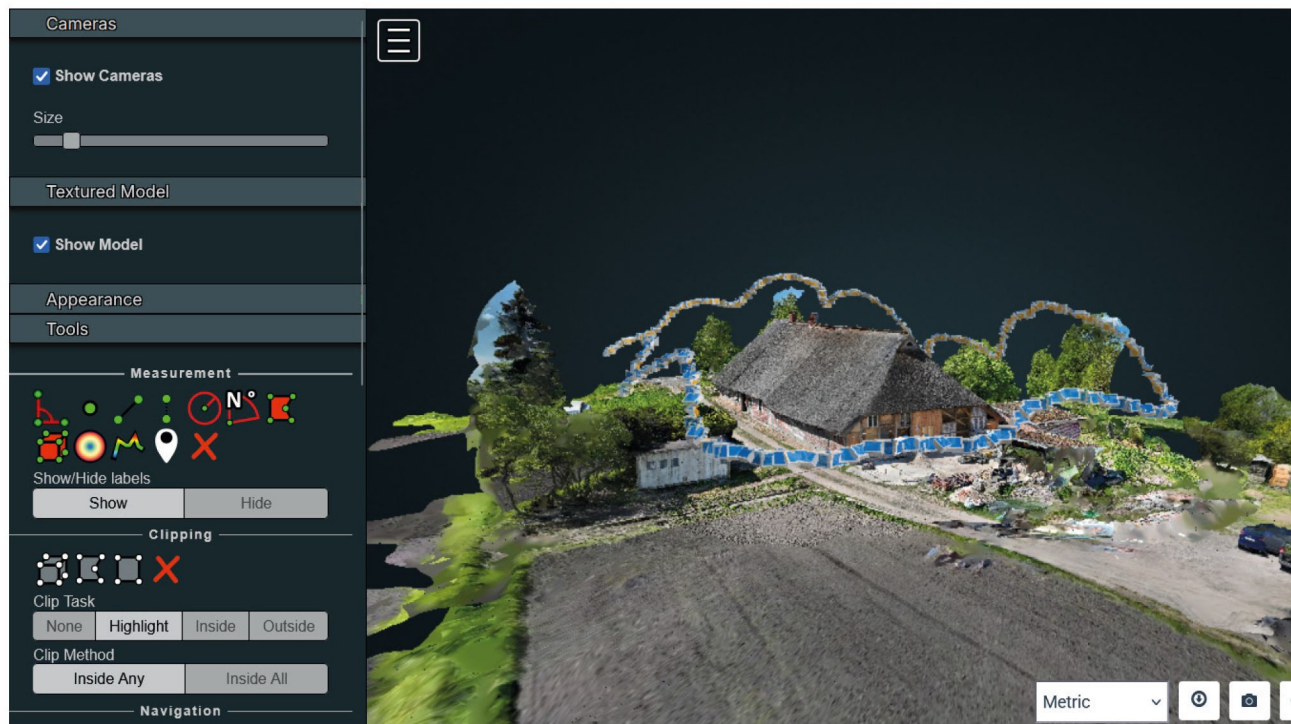


Fig. 1.4.2: 3D point cloud in WebODM Lightning

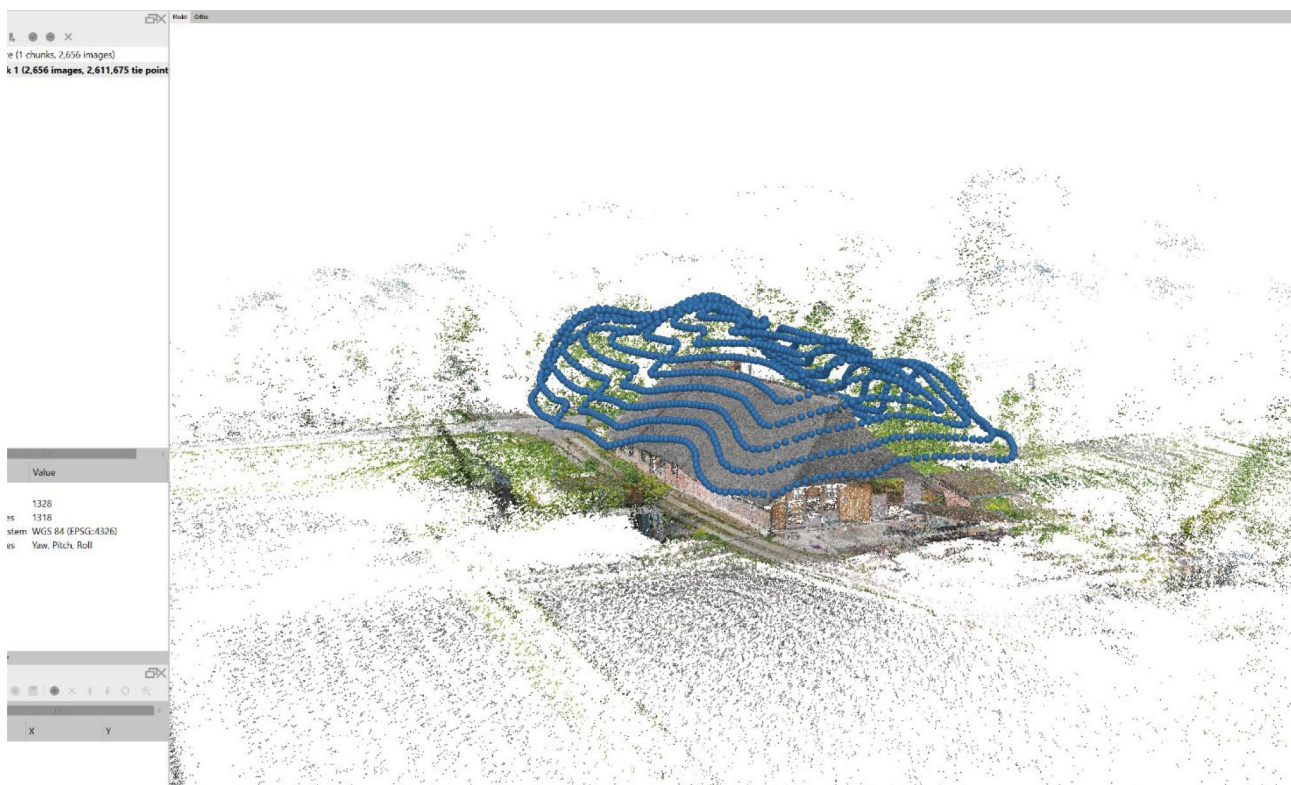


Fig. 1.4.3: 3D point cloud in Agisoft Metashape

Metashape supports the entire photogrammetric workflow, from image registration and the generation of dense point clouds to the calculation of textured 3D meshes and georeferenced orthophotos.²² For our dataset of approximately 1,300 images (Fig. 1.4.3), the processing time on a computer with average performance was around 12 hours. On more powerful systems, the computation time can be significantly reduced.

As with WebODM, the generated point clouds could be edited and cropped. A major advantage was that point clouds could be exported directly in E57 format. This format can be imported directly into Archicad to generate a 3D model. Additionally, export as an OBJ mesh was possible.

Data Processing with CloudCompare

The open-source software CloudCompare was used to further process the PLY file exported from WebODM. CloudCompare was originally developed for comparing dense point clouds and now offers numerous functions for visualizing, editing, segmenting, and converting point cloud and mesh data.²³

The point cloud exported from WebODM was first opened in CloudCompare and then exported to E57 format so that it could be used in Archicad. In our case, no further processing of the point cloud was performed.

In addition, we used CloudCompare to create orthographic views of the four sides of the building. These later served as the basis for modeling the facades in Archicad. Creating these views initially proved to be relatively complex. However, after a short learning curve, we were able to apply the workflow quickly and efficiently.

In principle, orthographic views can also be

generated directly in Agisoft Metashape. The software offers functions for creating orthomosaics and orthographic projections based on the reconstructed geometry.²⁴ These are of high quality. Nevertheless, we opted for CloudCompare because its key advantage was the ability to quickly and precisely trim the point cloud before generating the views—a feature that was very helpful for our project and will be explained in more detail below. This made the modeling process considerably easier. Any additional images or adjustments needed could be implemented quickly here.

Since the orthoimages were generated from a point cloud, their maximum resolution was limited. At high magnification, the individual points become visible, making material edges and fine details increasingly difficult to discern. Nevertheless, the generated views proved to be sufficiently precise for the subsequent modeling of the facades. The orthoimages were then exported as JPG files and integrated into Archicad to scale.

BIM-MODEL

In the next step, the generated E57 point clouds and the OBJ meshes were imported into Archicad. Compared to the point clouds, the OBJ meshes proved to be less suitable in terms of accuracy and level of detail and were therefore not used further (Fig. 1.4.4 vs. Fig. 1.4.5).

Due to their high geometric complexity, the OBJ meshes could not be opened directly in Archicad and used for the BIM workflow. Rhino was therefore also used for the analysis, as the software can process and edit even complex mesh geometries. The OBJ meshes could be displayed and edited without any problems in Rhino.

22 Agisoft Metashape. Agisoft Metashape User Manual: Professional Edition, Version 2.3, n.d.

23 Cloud Compare. "CloudCompare: Introduction". Accessed 25.06.2026. <https://www.cloudcompare.org>

24 Agisoft Metashape. Agisoft Metashape User Manual: Professional Edition, Version 2.3, n.d.

However, a direct comparison with the point cloud revealed that the 3D meshes provided a less clear representation of the actual building geometry. Although the derived dimensions generally showed good agreement with the point cloud data, edges, transitions, and fine geometric details appeared significantly more blurred. The surface interpolation of the mesh creates a closed surface, making individual deviations and irregularities less clearly discernible than in the point cloud.

The OBJ meshes therefore proved to be less suitable for architectural as-built modeling. While they can be used for general visualization or spatial representation of the building, they do not offer sufficient advantages over the point cloud for the precise analysis of existing geometries and the derivation of a BIM model.

Both E57 point clouds were successfully imported into Archicad and used for modeling. The point cloud generated from WebODM was already of good quality despite the reduced data set (Fig. 1.4.6). However, the point cloud generated with Agisoft Metashape showed a more consistent reconstruction overall, as well as a more precise representation of edges, component connections, and fine geometric details (Fig. 1.4.7).

The 3D Point Cloud

The point cloud exported from Agisoft Metashape had a very high point density. This allowed components and design details to be precisely captured and measured. At the same time, however, a typical limitation of photogrammetrically generated point clouds became apparent. When zooming in significantly, the distribution of individual measurement points becomes visible. As a result, edges and transitions between components can no longer be clearly identified as contiguous geometries, since no actual surface is represented between the individual points. This can limit the assess-



Fig. 1.4.4: Textured mesh in Archicad

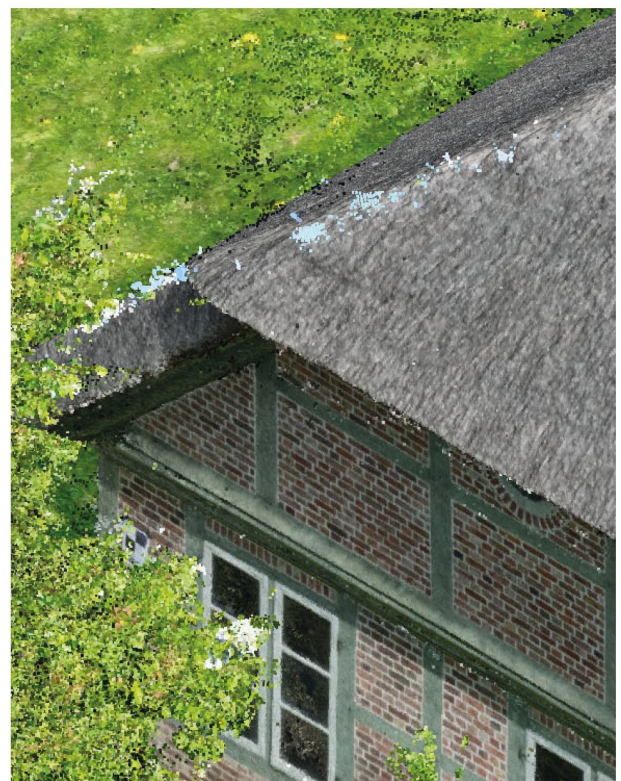


Fig. 1.4.5: 3D point cloud (Metashape) in Archicad



Fig. 1.4.6: 3D point cloud from WebODM in Archicad



Fig. 1.4.7: 3D point cloud from Agisoft Metashape in Archicad



Fig. 1.4.8: Orthographic view from point cloud uncutted

during very detailed examination.

To model the facades as accurately as possible, the orthographic views described earlier were therefore also used. The main advantage of this method is that image edges remain clearly recognizable even at high magnification (Fig. 1.4.8).

The additional capability in CloudCompare to create cropped orthophotos is particularly helpful for masking the widely projecting thatched eaves, making the actual upper edge of the exterior walls more visible and allowing for more accurate modeling (Fig. 1.4.9). However, this requires that the drone has sufficiently captured the relevant areas—including those below the eaves—while flying at a low altitude.

Since photogrammetry captures only the outer building envelope, wall thicknesses could not be derived from the scan data. These had to be determined through additional investigations or existing documentation.



Fig. 1.4.9: Orthographic view from point cloud cutted

The modeling of the exterior walls and timber-frame structures was, on the whole, very precise thanks to the creation of custom wall profiles in Archicad. (Fig 1.4.10) The reconstruction of the thatched roof proved to be significantly more labor-intensive. The irregular surface and the organically shaped eave edge can only be represented to a limited extent using traditional BIM tools. While the eave edge could be traced relatively easily using orthophotos, modeling the roof curvature required a considerable amount of manual work.

Assessment of Model Quality

The generated point cloud proved particularly well-suited for as-built modeling and geometric analysis of the building. The greatest strength of the drone-based surveying method lies not solely in the capture of individual measurements, but in the ability to directly compare the actual building geometry with the 3D model developed from it. Overlaying the modeled

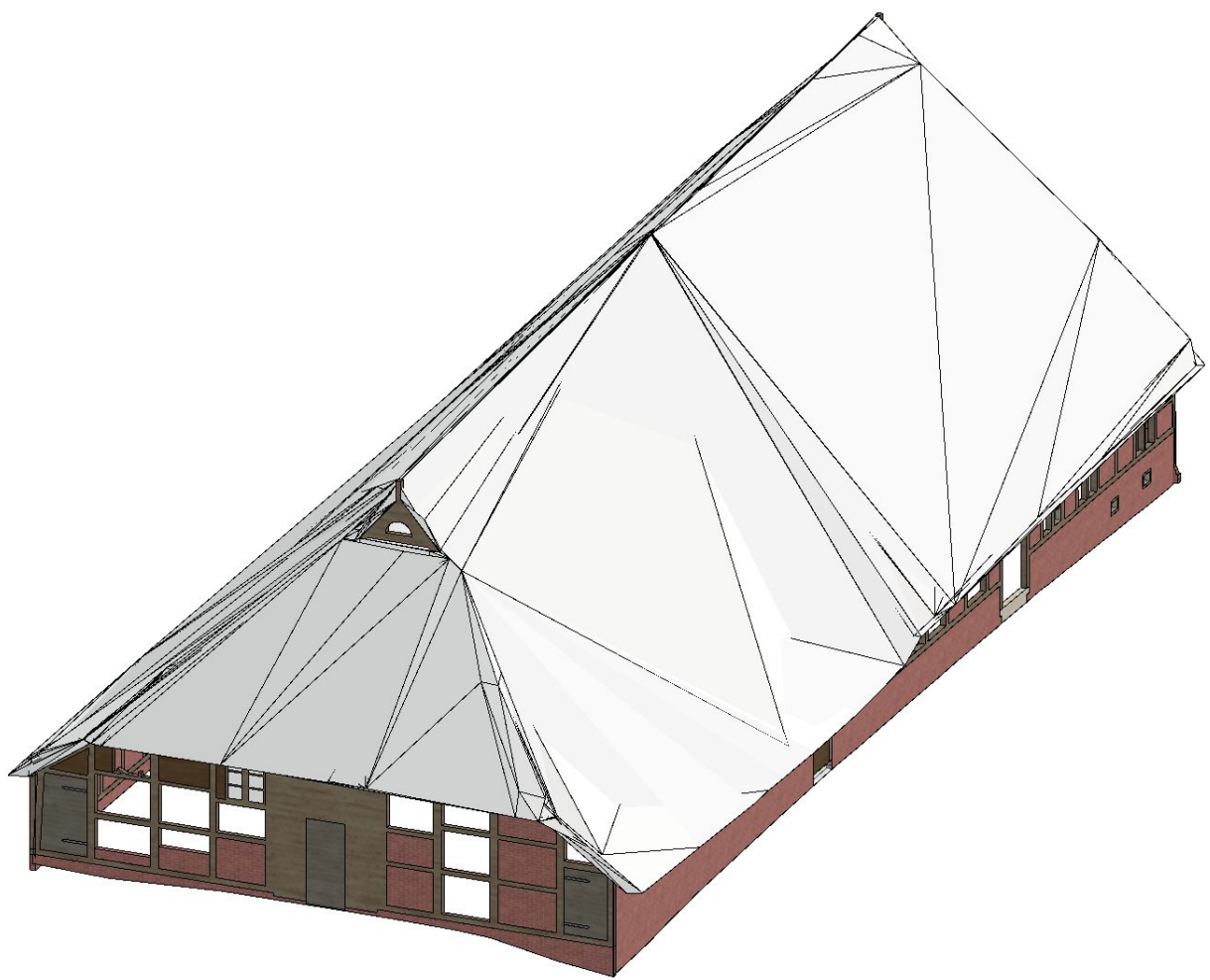


Fig. 1.4.10: 3D model

building with the point cloud creates a visual and geometric reference that allows deviations between the idealized model geometry and the actual structure to be systematically examined (Fig. 1.4.10).

This comparison revealed several structural features that would have required additional effort to identify during a traditional as-built survey. For example, it became apparent that the exterior wall facing the street and the long side of the building on the ground floor exhibit a slight bulge. In addition, a bend in the course of the long side starting from the area of the door was detected, which was not initially clearly recognizable in a model-based analysis.

Another example was the overhang of the base area. This detail was not initially taken into account during the original survey and modeling, but it could be clearly identified and subsequently evaluated through direct comparison with the point cloud. The point cloud served not only as the data basis for the modeling, but also as a verification and analysis tool for checking the actual building structure.

This ability to compare data is an advantage, particularly for existing buildings with complex structures, historic components, or handcrafted constructions such as the Hunferhaus. Deformations, deflections, wall deviations, or irregularities within timber-frame structures can be analyzed directly based on the deviations between the model and the captured geometry. With traditional measurement methods, such deviations could either only be detected through a large number of individual measurements or might remain undetected due to limited visibility.

The point cloud thus enables a more comprehensive analysis of the existing structure, as it not only documents individual measurement values but also preserves the spatial relationships and actual geometry of the entire structure.



Fig. 1.4.11: Overlay of the point cloud and the BIM model front



Fig. 1.4.12: Overlay of the point cloud and the BIM model back



Fig. 1.4.13: Point cloud view in Archicad



Fig. 1.4.14: Orthophoto view in Archicad



Fig. 1.4.15: 3D model view in Archicad



Fig. 1.4.16: View of the 3D model and overlaid point cloud in Archicad

5

EVALUATION

EVALUATION

Accessibility and Applicability of the Method

Conducting drone-based building documentation with the DJI Matrice 4E proved to be efficient and practical overall. At the same time, however, it became apparent that access to this method is associated with certain organizational and technical requirements. A major challenge is acquiring the necessary qualifications to operate professional UAV systems. In addition to legal requirements, the training required to operate the drone is particularly time-consuming.

The acquisition costs also present a certain barrier to entry. The DJI Matrice 4E is a professional surveying drone and is priced significantly higher than typical recreational drones. However, in relation to the results achieved and the capabilities of automated data collection, the system appears to be economically viable, especially for planning firms that regularly conduct as-built surveys.

Once these initial hurdles were overcome, practical application proved to be relatively straightforward. The system's high level of automation, facilitated by the DJI Manifold 3 onboard computer, significantly reduces the amount of manual work required. In particular, automated flight planning and data collection enable fast and reproducible surveys even for more complex buildings. A particular advantage is that no significant distance from the building is required, making this method highly suitable for use in urban areas.

Data processing required photogrammetric software solutions. While commercial programs such as Agisoft Metashape come at a cost, powerful open-source alternatives are available in the form of WebODM and CloudCompare. No exceptionally powerful computers were required for further use of the point clouds in Archicad. Processing the E57 point clouds and generating orthographic views

could be carried out on the workstations used in the project without any noticeable performance issues.

Potential Applications in Architecture

From an architectural perspective, the UAV system examined proved to be well-suited for digital as-built documentation. Especially for historic buildings with complex geometries, photogrammetry enables a rapid and comparatively complete documentation of the building's exterior envelope.

The actual on-site data collection took only about 15 minutes, accounting for a small portion of the total processing time. The preparation and post-processing phases also proved manageable after a brief training period. This reduces the time required compared to conventional surveying methods.

A key advantage lies in the high information density of the generated datasets. The point clouds not only enable the determination of dimensions but also the analysis of deformations, irregularities, and structural features. As part of the project, for example, deviations in the facade geometry were identified and reproduced in the digital model.

Furthermore, the generated data offers a high degree of flexibility for further planning. The point clouds can be used both as an accurate reference for BIM models and to verify the generated model—which is the greatest strength of this highly detailed measurement method. The ability to quickly check the 3D model for deviations is highly beneficial and has already demonstrated in our study how often deviations in the building's geometry are overlooked on-site; this method makes them visible and allows their severity to be assessed. Additionally, orthographic views, sections, or other documentation can be derived from them.

Limitations were particularly evident in areas with highly structured or organic geometry. The thatched roof of the Hufnerhaus posed

mesh from Agisoft Metashape, as well as those from WebODM Lightning—which used a smaller data set—both showed deviations of less than 1 cm from the two reference measurements. This demonstrates that the generated meshes generally contain reliable geometric information; however, in terms of model quality and geometric accuracy, they fall short of the point cloud generated by Agisoft Metashape. Overall, it was found that drone-based photogrammetry is an efficient method for the digital documentation of historic buildings. The generated data enabled both a precise geometric analysis and the creation of a detailed BIM model of the Hufnerhaus, with the 3D point cloud generally facilitating a better workflow.

Conclusion

Overall, drone-based photogrammetry using the DJI Matrice 4E proved to be a powerful method for digital as-built documentation. Despite the organizational requirements and the necessary training, the method enables rapid data collection while maintaining a high density of information. For architectural applications—particularly in the areas of as-built documentation, historic preservation, and BIM modeling—this method offers significant advantages over conventional surveying methods. The combination of short survey times, high automation, and the data's ease of further processing makes this method a promising tool for future applications in the work of architects.



Fig. 1.5.3: measurements OBJ mesh (WebODM)

02 LIXEL HANDSCANNER



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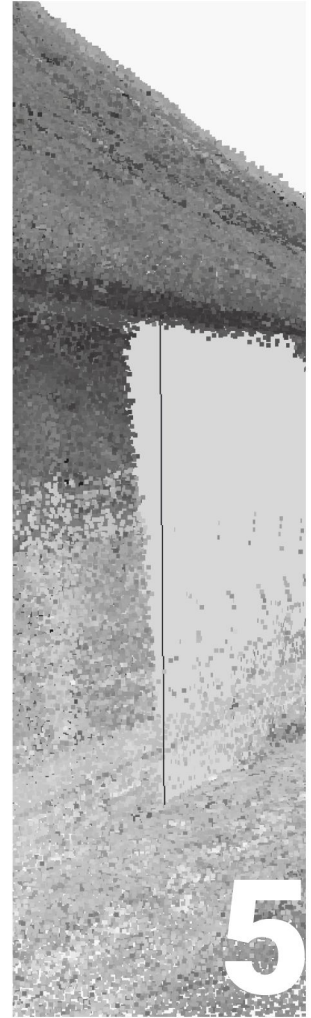
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1

INTRODUCTION



Fig. 2.1.1: XGRIDS Lixel Kity K1 with RTK Modul

DESCRIPTION

The following chapter documents the use of the Lixel K1 handheld scanner for the digital survey of the Hufnerhaus in Hamburg and the associated workflow from data acquisition to model generation. The project investigates the complete workflow from point cloud acquisition to CAD-based modelling, with a particular focus on accessibility, software limitations and practical application within an academic context.

The Lixel K1 is a handheld laser scanner that combines LiDAR sensors, cameras and GNSS positioning (Global Navigation Satellite System) to generate georeferenced point clouds while moving through a building. According to the manufacturer, the system can record data at distances ranging from approximately 0.5 m to 40 m. One advantage of this workflow is that the resulting point cloud is already scaled and georeferenced, reducing the need for additional measurements afterwards. The scanner uses GNSS positioning together with control points to orient and register the survey data.¹

The survey included both the interior and exterior of the Hufnerhaus. A first scan was carried out through the entire building in order to establish a common spatial reference using control points. Additional scans were then made in individual areas of the building to increase the level of detail and improve the documentation of spaces that were partially obstructed by furniture, renovation materials and other objects.

The hardware used in this study represents a different category of survey equipment compared to smartphone-based LiDAR applications or photogrammetric workflows, because of its cost, therefore its accessibility. While the scanner itself is comparatively easy to operate and produces large amounts of accurate data wit-

hin a short time, it is also a professional device associated with a proprietary software ecosystem.

The scanner is designed to work together with Lixel's own software environment. Survey data is processed through applications such as LixelStudio and Lixel CyberColor, which are available through commercial licences. As students, we did not have direct access to these software packages and therefore could not fully use the intended workflow. Although the free LixelGO mobile application is available for data acquisition, much of the recorded information remains connected to proprietary software solutions after the survey.^{2,3}

This dependency became one of the central questions of the project. The recorded datasets contain both openly accessible files and proprietary formats that cannot easily be accessed outside the Lixel ecosystem. Some data folders are protected and certain information, including image datasets required for image-based representations (Gaussian Splatting), could not be directly extracted. As a result, the project shifted its focus from simply producing a survey to testing how far the data could be processed using accessible third-party software. Three possible post-processing paths were initially considered:

- generation of Gaussian Splatting
- generation of mesh models
- use of point clouds for CAD-based modelling.

Due to data accessibility restrictions and difficulties encountered during processing, only the third workflow proved viable within this study. For this reason, the project focused not only on data acquisition but also on testing how far the survey data could be processed with accessible third-party software instead of relying on the proprietary ecosystem.



Fig. 2.1.2: Lixel K1 during scanning process

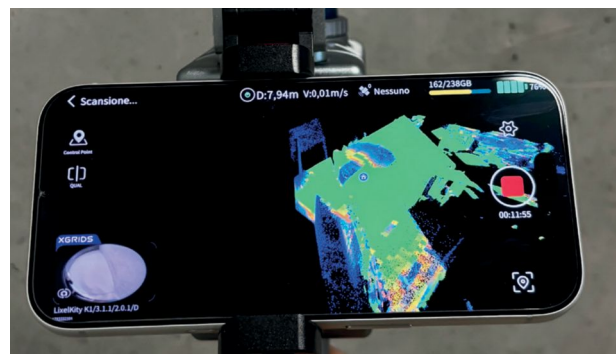


Fig. 2.1.3: LixelGo mobile application during scanning

- 1 cf. Laser Scanning Europe. "XGRIDS Lixel Kity K". Accessed 01.07.2026. <https://www.laserscanning-europe.com/de/produkte/geraete/mobile-laserscanner/xgrids-lixel-kity-k1>.
- 2 cf. XGrids. "LixelStudio". Accessed 29.06.2026. <https://www.xgrids.com/intl/lixelstudio>
- 3 cf. XGrids. "Lixel CyberColor". Accessed 29.06.2026. <https://www.xgrids.com/intl/lcc>

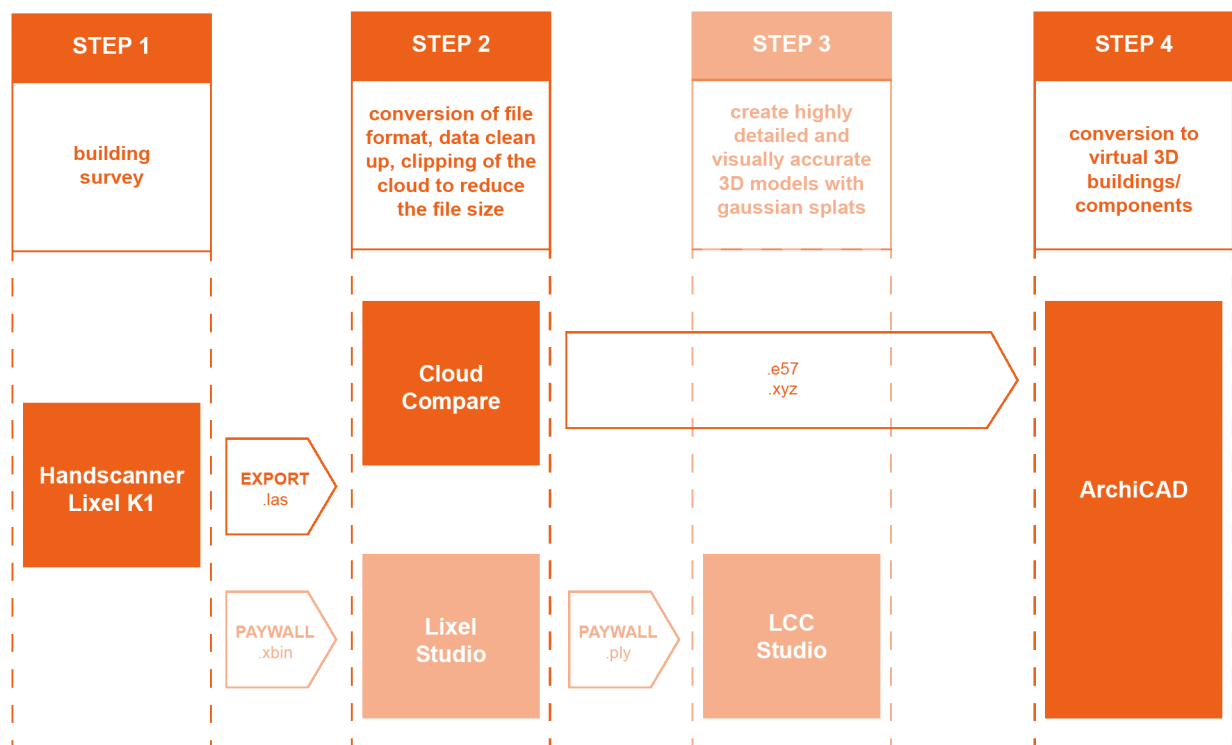


Fig. 2.1.4: Schematic diagram of procedure

4 cf. Laser Scanning Europe. "XGRIDS - LIXEL K1 RTK MODULE". Accessed 01.07.2026. <https://shop.laserscanning-europe.com/XGRIDS-Lixel-K1-RTK-module>

5 cf. XGrids. "LixelGO". Accessed 29.06.2026. <https://xgrids.com/intl/support/download?page=LixelGO>

REQUIREMENTS

Hardware

The survey was conducted using a Lixel K1 handheld scanner equipped with an RTK (Real-Time Kinematic) positioning module. The RTK module uses satellite correction data to georeference the scans with centimetre-level accuracy, allowing the recorded point clouds to be placed directly in real-world coordinates. While the scanner is accurate without RTK, the module is required when data must be referenced to a global coordinate system or several scans have to be assembled. In addition to the scanner itself, rechargeable batteries were required for continuous operation. During the survey of the Hufnerhaus, more than one battery was used, making spare batteries essential for uninterrupted work. The scanning process alone took a total of 64 minutes.⁴

The scanner is operated through a mobile phone connected to the LixelGO application. Battery life therefore had to be considered not only for the scanner but also for the mobile device. During the survey, two phones were used to ensure continuous operation throughout the day. A laptop or desktop computer was also required for transferring, storing and processing the recorded data after the survey.

Software

The scanner is connected to the LixelGO mobile application, which is available free of charge. The application is used to create projects, register control points and monitor the scanning process in real time.⁵ (Fig. 2.2.1)

However, most processing options remain linked to proprietary software developed by the manufacturer. Access to these applications requires commercial licences and was not available within the scope of this project. One objective of the study was therefore to inves-

tigate alternative workflows using accessible third-party software. (Fig. 2.1.4)

Control Points

The survey relied on a system of control points distributed around the building. These consisted of numbered black-and-white markers placed on stable surfaces both inside and outside the building (Fig. 2.3.1). Control points are used to georeference, orient and register different scans. They also help maintain a consistent scale across the project and make it possible to combine multiple surveys into a larger dataset. As all scans started and ended on previously registered control points, they formed the backbone of the acquisition workflow.

Survey Team

Although the scanner can technically be operated by a single person, the survey was carried out by a team of three. One person operated the scanner, a second monitored the mobile application and the acquisition process, while a third coordinated the route and documented the workflow.

Site Conditions

Several environmental conditions can influence the quality of the survey. Physical obstructions such as furniture and renovation materials can block parts of the building and create gaps within the point cloud. For this reason, additional scans or overlapping survey paths may be required in areas with many obstacles.

Reflections on window glass can also cause inaccuracies by generating points behind the reflective surface. Strong sunlight and deep shadows can further affect data quality, particularly during exterior surveys. Although moving people can usually be removed during later processing, minimising movement within the survey area helps improve the overall consistency of the recorded data.

2 PREPARATION

PREPARATION

Before the survey of the Hufnerhaus, a test scan was carried out approximately one week in advance using the same equipment and software that would later be used on site. The purpose of this preliminary exercise was not to evaluate the quality of the final output but to become familiar with the acquisition process and the operation of the scanner.

The test scan was carried out on a waste bin at the university and focused exclusively on data acquisition rather than data processing. During this process, the group learned how to assemble the scanner, connect it to the LixelGO application, register control points and start and stop scans correctly (Fig. 2.2.4). Particular attention was given to handling the device while moving, maintaining the correct scanning angle, understanding the interface of the mobile application and monitoring the quality indicators displayed during acquisition.

The test scan also helped familiarise the group with practical aspects of the workflow, such as changing batteries and monitoring the acquisition process over longer periods of time. As the scanner was new to all group members, the exercise mainly served to understand the basic logic of the system and gain confidence before the actual survey.

Based on the specifications of the scanner and the first test acquisition, several assumptions were made before the survey. As the Lixel K1 is a professional handheld scanner designed for rapid data collection, we expected the workflow to be relatively fast, easy to learn and capable of producing accurate results without extensive preparation. The large acquisition range of the scanner also suggested that extensive areas could be recorded through a normal walking pace. We also expected the use of control

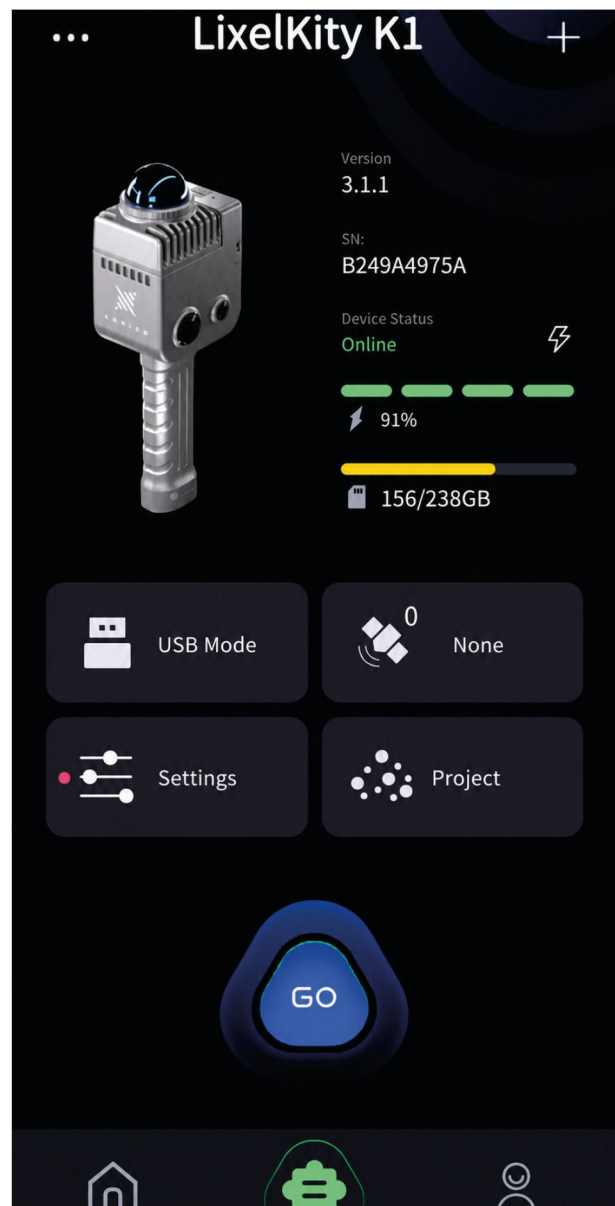


Fig. 2.2.1: Interface of the LixelGo App

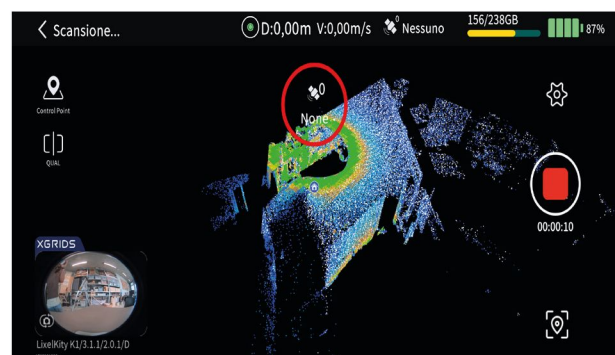


Fig. 2.2.2: User interface of LixelGo application during a scan

points to simplify the registration of multiple scans and reduce the need for additional measurements afterwards.

No extensive preparation of the building itself was carried out beforehand. Furniture, renovation materials and other objects remained in place and became part of the survey conditions encountered on site. The exact distribution of control points, the division of the building into scanning sections and the survey strategy were developed directly on site according to the conditions encountered during the measurement process.

The assumptions made during preparation were later evaluated against the actual survey experience and the subsequent post-processing workflow.



Fig. 2.2.3: Equipment case of the Handscanner



Fig. 2.2.4: Test scan carried out at University

3

SITE MEASUREMENT

SITE MEASUREMENT

During the survey, each member of the team took on a specific role. One person operated the scanner, while a second person monitored the LixelGO interface attached to the device and checked the status of the acquisition. This allowed the operator to focus on the survey path and avoid obstacles while carrying the equipment. A third person coordinated the route and documented the process. To reduce the chance of appearing in the point cloud, the team moved through the building in a line behind the scanner operator. As the scanner had to be carried continuously during the survey, the role of operator was exchanged several times throughout the process.

The survey was divided into several separate scans. A first scan covered the entire building and included all control points. This initial scan

acted as a general reference survey and established the relationship between the different control points distributed across the site (Fig. 2.3.3).

Additional scans focused on specific parts of the building, including the entrance area, the main room, the upper floors, the basement and the exterior spaces. Rather than recording the entire building in a single dataset, each room or area was generally recorded as an independent scan (Fig. 2.3.2). Previously registered control points were reused between scans in order to maintain a common reference system.

The acquisition process began by positioning the scanner on a control point. The base of the scanner contains a target hole that allows it to be centred directly above the black and white marker (Fig. 2.3.1).



Fig. 2.3.1: Registration of a control point

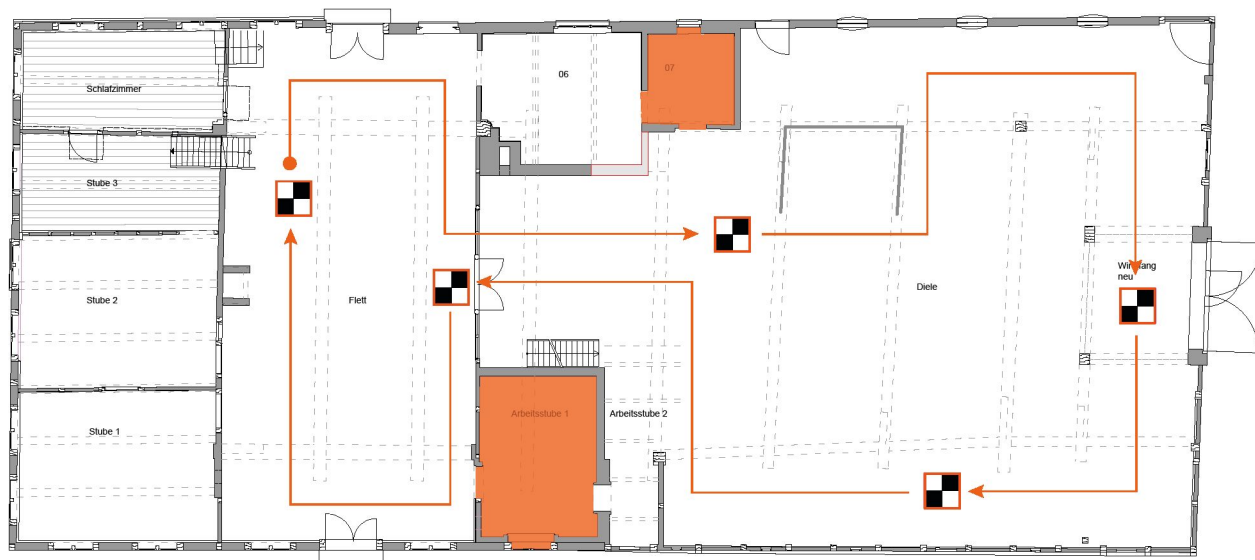


Fig. 2.3.2: Plan of the Hufnerhaus with control points, inaccessible rooms and scanning route



Fig. 2.3.3: Areal view of the Hufnerhaus with control points and scanning route

After starting the scan in the LixelGO application, the scanner was lifted and carried through the building at a normal walking pace. Whenever another control point was reached, the scanner was briefly positioned above the marker and the point was registered within the application using its assigned name or identification number (Fig. 2.3.2). Once the control point had been recorded, scanning continued immediately. To complete a scan, the operator returned to the same control point where the recording had started and stopped the acquisition there.

During the survey, the team tried to avoid abrupt turns, walking backwards or repeatedly crossing the same path. Continuous movement generally produced the most stable results. Each scan lasted approximately five minutes, although larger areas occasionally required slightly more time. The longest scan took around 13 minutes and the shortest scan took 3 minutes. The survey itself was completed relatively quickly, while most of the morning on site was spent sharing the building with other survey groups working in parallel.

In total, nine scans were carried out. Two exterior scans were recorded at different heights in order to improve the documentation of the roof and upper parts of the façade. Although the scanner captured a considerable amount of information from the roof area, complete coverage was difficult to achieve from ground level. For this reason, additional aerial documentation was carried out by another survey team using a drone (see Chapter 1).

Several factors influenced the acquisition process. Furniture, renovation materials and temporary objects occasionally obstructed parts of the building and required additional attention during scanning (Figs. 2.3.5 - 2.3.6).

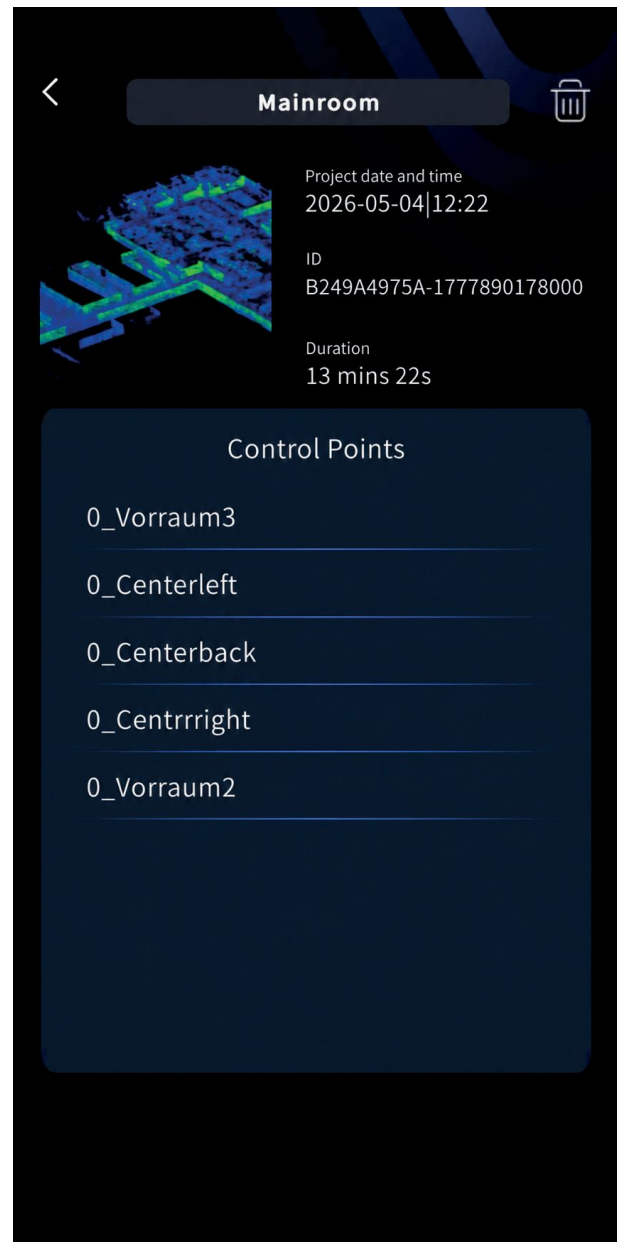


Fig. 2.3.4: List of registered control points in the main room scan

Reflecting surfaces such as windows were considered a potential source of inaccuracies, as they can generate additional reflection points. Exterior surveys were also affected by strong sunlight and deep shadows. The scanner proved more tolerant to these conditions than expected. Notifications regarding tracking quality or positioning appeared only occasionally and generally did not interrupt the survey process. Compared to the preliminary tests carried out at the university, fewer warnings occurred during the actual survey.

Before the survey, the possibility of combining the handheld scanner data with other survey methods, such as drone photogrammetry, was also considered. Some software platforms appeared to support the integration of different datasets within a single workflow. In practice, however, the amount of data generated by the scanner was already substantial and proces-

sing became increasingly demanding in terms of time, hardware capacity and software workload, causing continuous crashes. The largest file had a size of 10,2GB and the smallest file size was 1,7GB. For this reason, the combined workflow was only tested briefly and was not pursued further within the scope of this study.

One of the most noticeable characteristics of the system was the speed of acquisition. Large parts of the building could be recorded during a normal walkthrough without requiring additional measurements. On average, each scan took 7 minutes. At the same time, the scanner produced very dense datasets, which later influenced the processing workflow. While the acquisition itself remained relatively simple, the amount of recorded data became an important factor during the subsequent stages of the project.



Fig. 2.3.5: Photo of obstacles in the Hufnerhaus



Fig. 2.3.6: Photo of areas obstructed by building materials

4 DATA PROCESSING

DATA EDITING

After the survey, each scan was exported as a separate project containing several files and folders. Every project included a proprietary .xbin file, a .las point cloud and a project folder containing the control point information (.csv), GNSS data (Global Navigation Satellite System, used for georeferencing) and scanner poses. Another folder containing log files was protected by a password that was not provided and therefore could not be accessed. Although the scanner also recorded image data, these files were not accessible within the exported project. At the beginning of the project, different post-processing workflows were considered. The intention was to test whether the survey could be used not only for CAD modelling but also for mesh generation and image-based representations such as Gaussian Splatting. Since some software appeared to support the combination of LiDAR, drone and photogrammetric surveys, this possibility was also investigated. In practice, however, the amount of data generated by a single survey and the limited accessibility of the exported files made this workflow difficult to pursue.

Software Selection

The first software tested was RealityScan 2.0, mainly because it is freely available and supports different types of survey data. The initial expectation was that the recorded point clouds could be imported directly and processed into a mesh model. RealityScan could not read the exported files directly. After some research, CloudCompare was used to convert the .las files into the .e57 format, which RealityScan could import.⁶

MESH GENERATION

After importing the converted point cloud into RealityScan, different reconstruction steps were tested in order to generate a mesh model. The workflow itself was relatively straightforward, and compared to the other software used during the project, the interface was easier to understand.

Although a mesh could be generated, the results were not usable (Figs. 2.4.1 - 2.4.2). Large artificial extensions appeared around the building, mainly above the roof and below the ground, where the point cloud contained the least information. Different attempts were made to clean the model by removing isolated meshes and unwanted connections automatically generated by the software, but these extensions remained. The generated texture also appeared much lower in quality than expected for a high-end scanner.

From our observations, the workflow seemed to rely on information that was not available in the exported project. Since the scanner images were not accessible and the control point information could not be reused inside the software, the reconstruction remained incomplete. Another possible explanation is that RealityScan generates a watertight mesh, meaning that it automatically closes holes and creates a continuous surface even where information is missing. This approach appears to work better when the software has access to more complete datasets, for example by combining LiDAR with drone or photogrammetric surveys.

For these reasons, the mesh workflow was not developed further.

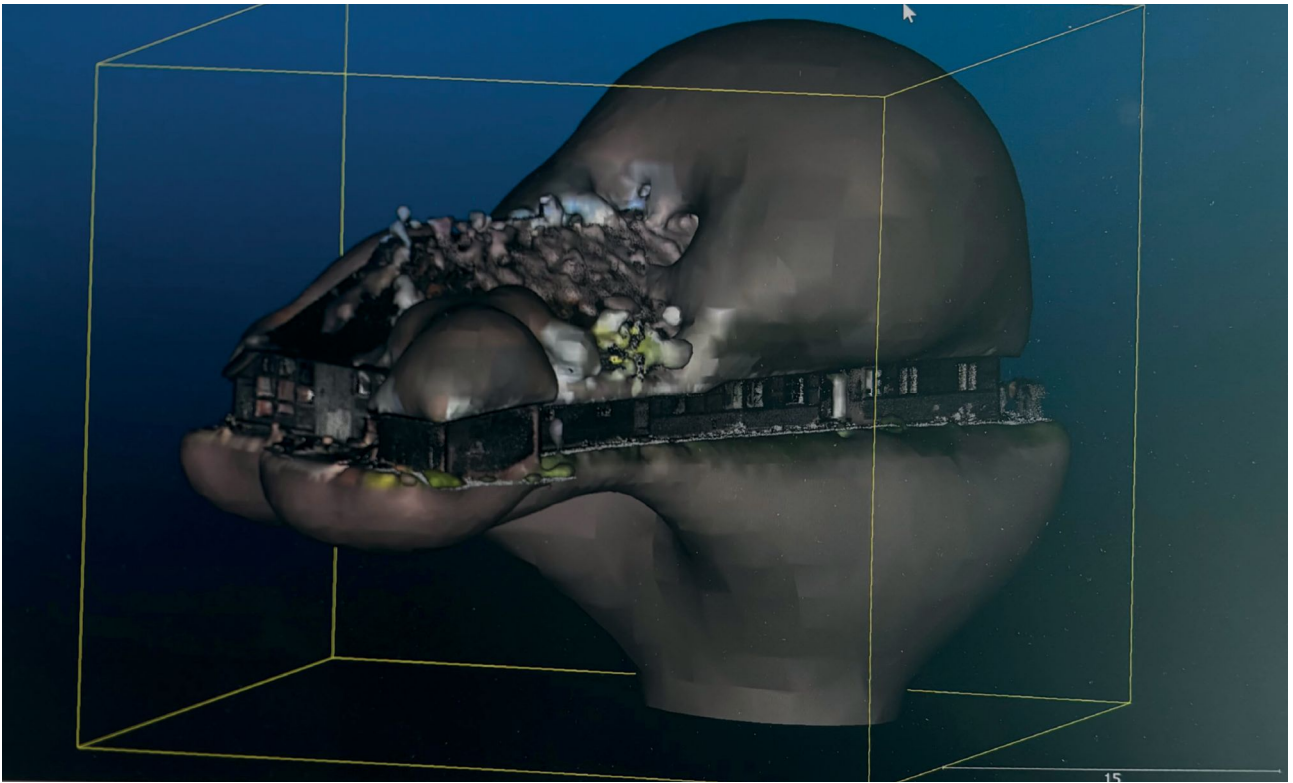


Fig. 2.4.1: Mesh Generation from CloudCompare

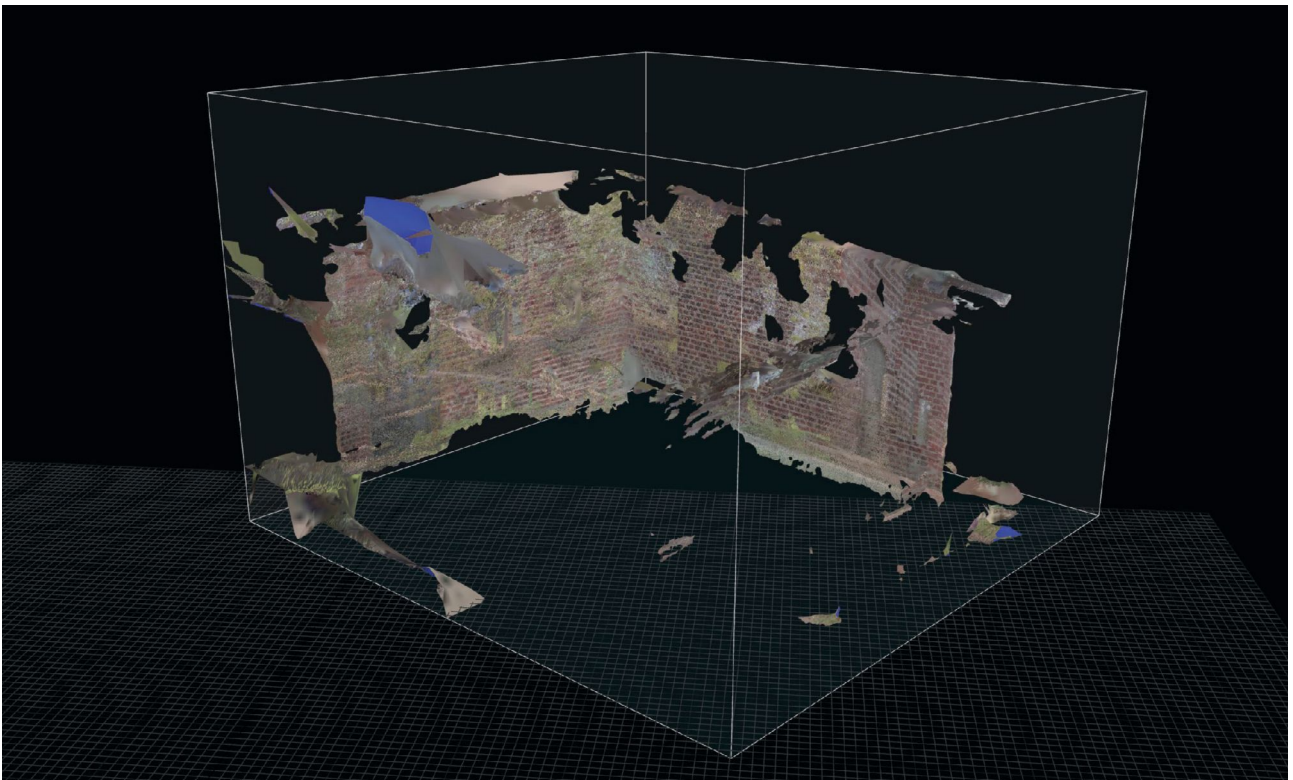


Fig. 2.4.2: Mesh Generation from RealityScan



Fig. 2.4.3: Raw point cloud in CloudCompare

POINT CLOUD PROCESSING

The project then shifted to CloudCompare, focusing on preparing the point clouds for CAD modelling. Each scan was imported separately as a .las file. Unnecessary areas were removed using the segmentation tool, after which the different scans were roughly aligned manually.⁷

CloudCompare also offers a registration workflow based on corresponding reference points. However, this method requires the coordinates of the control points, which were not accessible from the exported project. Instead, the scans were positioned visually and then refined using CloudCompare's registration tool. Although this required more manual work, the results proved accurate enough for the following modelling process.

Once aligned, the individual scans were merged into a single point cloud (Fig. 2.4.4). The merged dataset contained few hundred million points and quickly became difficult to handle on a standard laptop. For this reason, the point cloud was subsampled before export (Fig. 2.4.5). Reducing points improved performance in CAD software while maintaining enough geometric information for modelling.

For operations where visual detail was more important (orthographic views of façades, wall details), we initially assumed that keeping as many points as possible would produce better results. In practice, however, the resolution of the scan itself became the limiting factor. In several areas, additional points simply overlapped each other without noticeably improving the quality of the exported images.

7

cf. CloudCompare. "3D point cloud and mesh processing software". Accessed 30.06.2026. <https://www.cloudcompare.org>

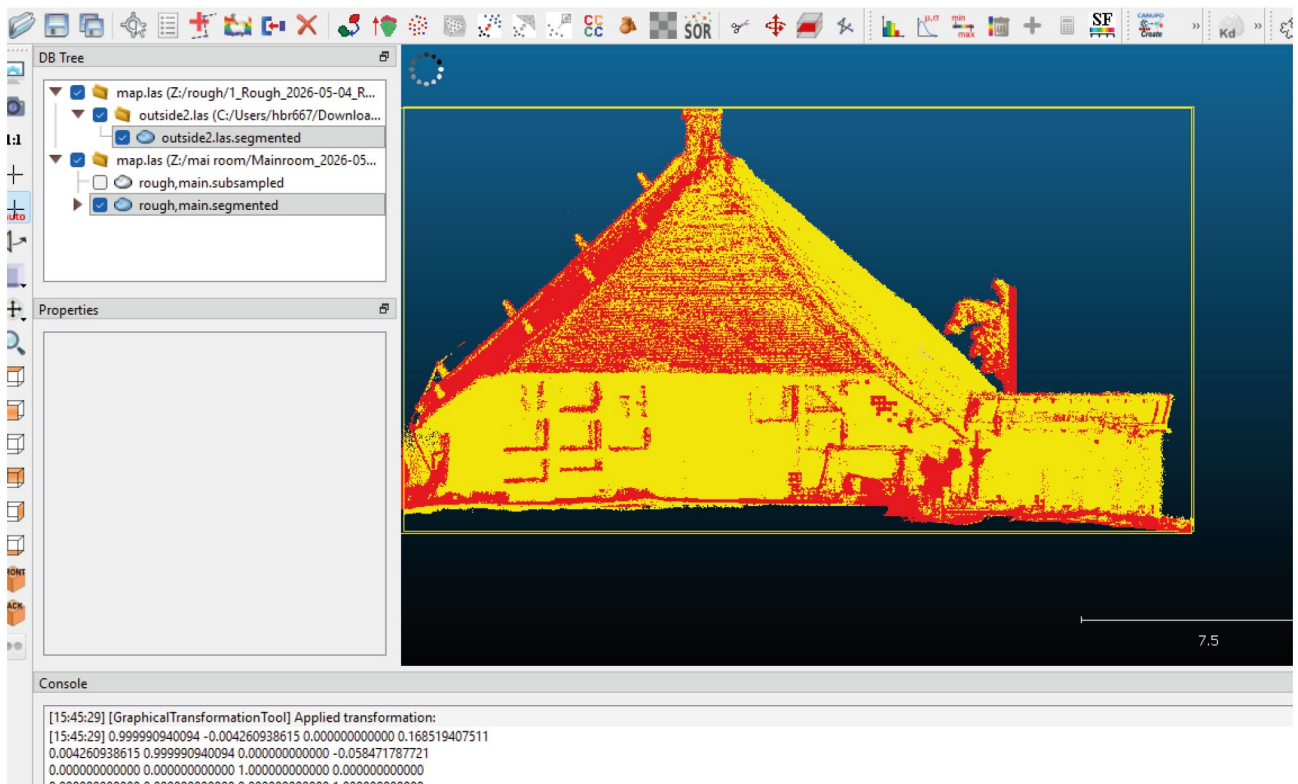


Fig. 2.4.4: Merge process of two point clouds in CloudCompare

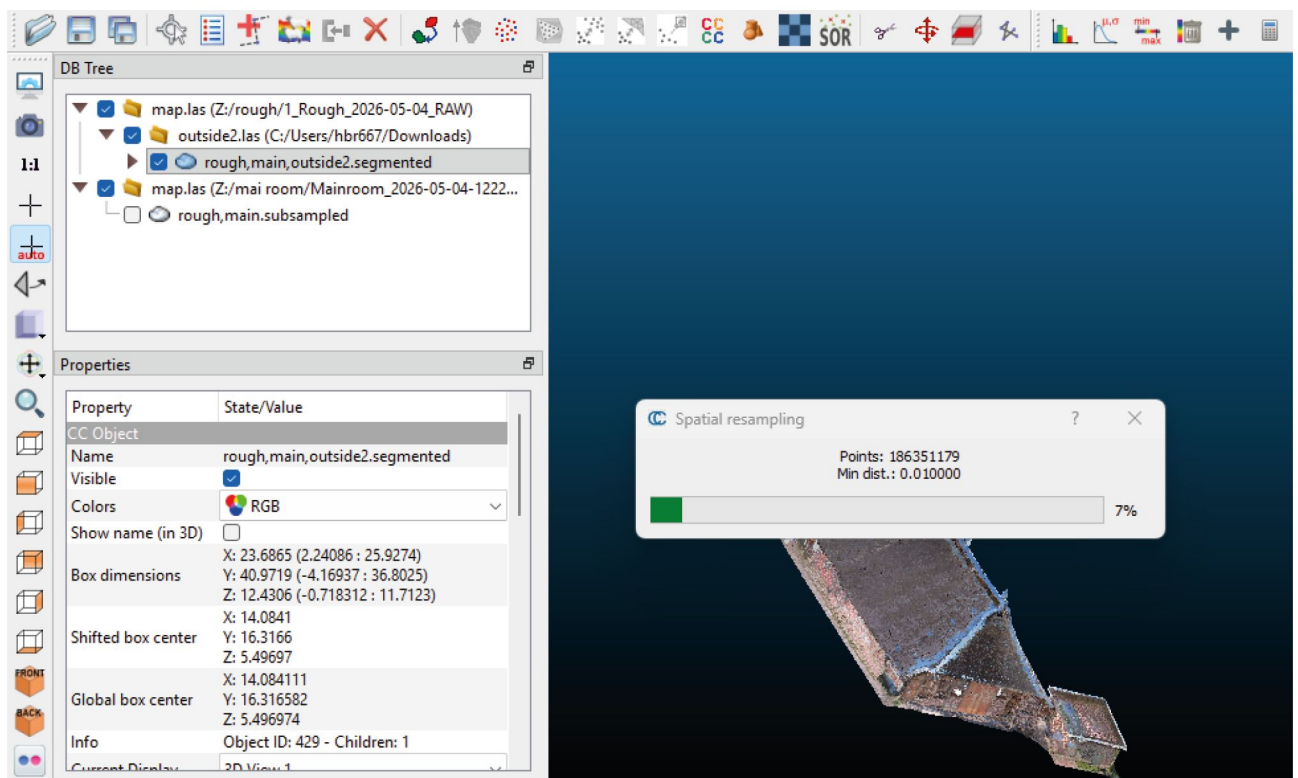


Fig. 2.4.5: Subsampling the point clouds in CloudCompare

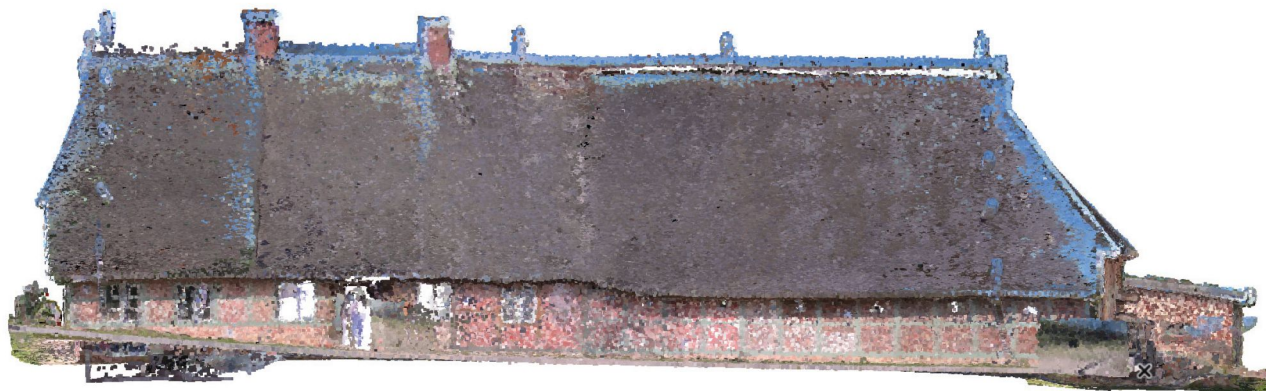


Fig. 2.4.6: Point cloud elevation of the east side in Archicad

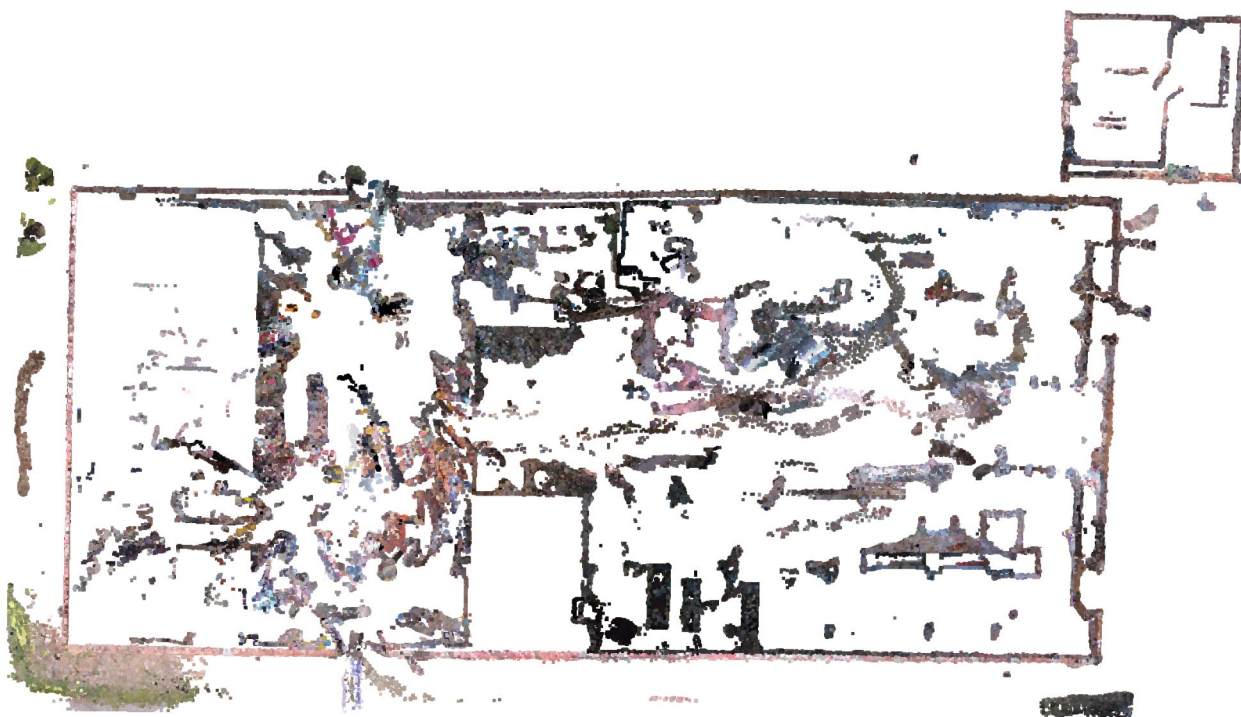


Fig. 2.4.7: Point cloud floorplan in Archicad



Fig. 2.4.8: Point cloud perspective of the north-east side in Archicad



Fig. 2.4.9: Point cloud perspective of the main room in Archicad

MODELLING

After cleaning, aligning and subsampling the survey data, the merged point cloud was exported as an .e57 file and imported into Archi-cad. The modelling was carried out directly in the same file using a single merged point cloud containing approximately 15 million points, which proved manageable on a standard laptop after the subsampling process.⁸

The aim of this phase was not to produce a highly detailed model of the entire building, but to test how the point cloud could be used as a geometric reference for architectural modelling and documentation. (Fig. 2.4.10)

Rather than following a fixed modelling sequence, the work focused on the overall structure of the building. The point cloud was continuously inspected through plan views, sections and

three-dimensional views, switching between them whenever necessary. This proved particularly important because the building does not consist only of regular orthogonal geometry. Many walls show slight rotations and deviations not only in the plan but also in elevation.

One of the most interesting observations was that a wall drawn as perfectly vertical in plan often appeared tilted when checked against the point cloud in section or elevation (Fig. 2.4.11). The survey therefore revealed geometric irregularities that would have been difficult to capture through conventional measurements alone. Which is exactly what makes these methods have more potential in a existing building context.

Wall thicknesses could generally be read directly from the merged point cloud, as both interior and exterior scans were available for

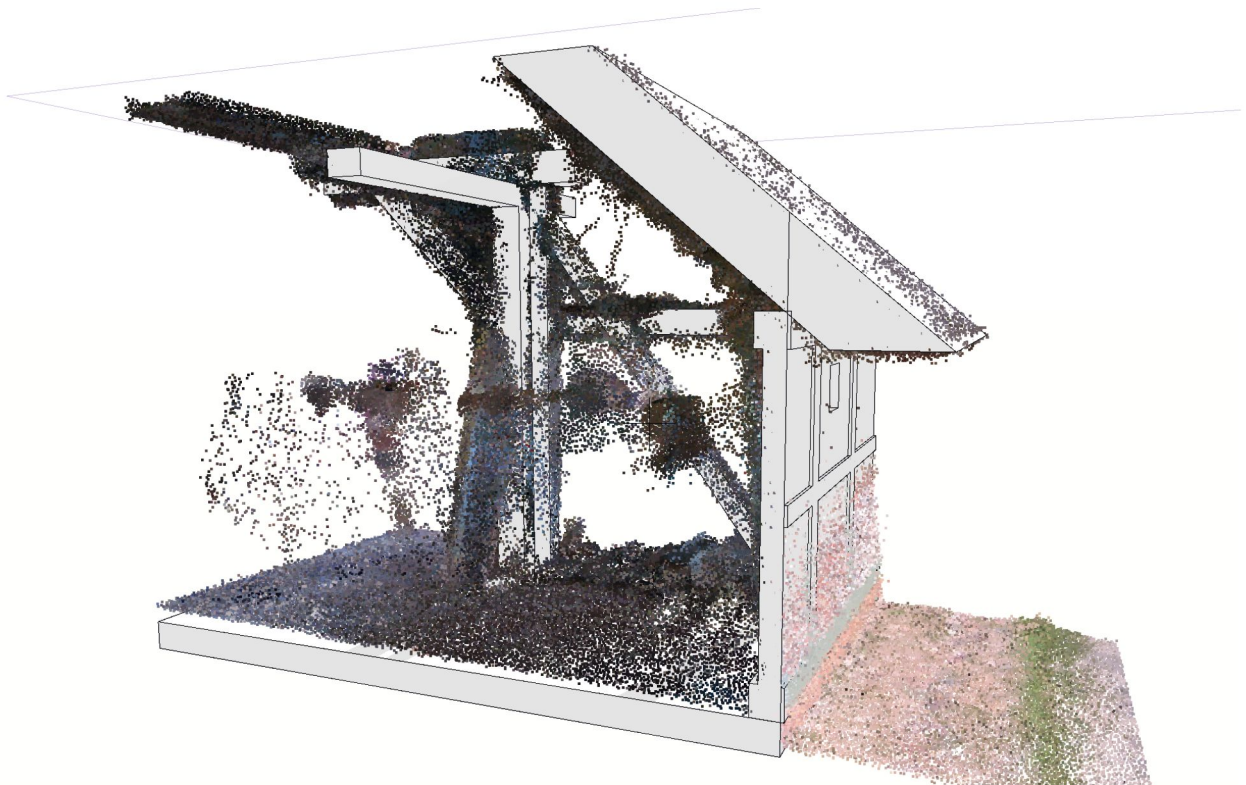


Fig. 2.4.10: Cross-section model with point cloud blending

many parts of the building (Fig. 2.4.7). In section views, the accumulation of points on both faces of a wall made it possible to estimate the wall thickness and the position of the inner void. The process was not always straightforward, however, because furniture, renovation materials and other temporary obstacles occasionally obscured parts of the geometry.

Since the project focused primarily on the workflow rather than on completing a full architectural model, not all elements of the building were modelled in detail. Doors, windows and roof geometry were used mainly as references for testing the process and evaluating how the point cloud could support further documentation.

A key advantage of this survey method was that the point cloud was already scaled by the scanner itself. No additional scaling was required during modelling. The imported cloud was compared with existing plans, drawings provided at the beginning of the course and several measurements taken on site, and the overlays proved to be consistent and sufficiently accurate for architectural documentation.

After subsampling, the modelling workflow became relatively smooth. The original unprocessed point clouds were considerably heavier and caused performance problems, while the reduced dataset allowed navigation, measurement and modelling to be carried out much more comfortably.

Photographs and orthographic exports were used mainly as visual references, especially for checking proportions and details, since precise measurements directly within the point cloud were not always easy to read.



Fig. 2.4.11: Exterior wall that tilts inward

5

EVALUATION

Accessibility

One of the main goal of this project was to understand how much of the Lixel K1 workflow could be reproduced without relying on the proprietary software ecosystem. Although the scanner itself is a professional surveying device, the acquisition process proved to be relatively easy to learn. After a short test session, the workflow became intuitive and the survey could be carried out with little previous experience. The free LixelGO application was sufficient to create projects, register control points and monitor the acquisition in real time.

The situation changed after the survey. While the recorded point cloud could be accessed and processed with freely available software, other workflows depended on data that were not accessible outside the proprietary environment. During the project, examples generated with the manufacturer's software sho-

wed highly detailed textured models based on Gaussian Splatting, demonstrating the quality that can be achieved within the complete ecosystem (Figs. 2.5.1 - 2.5.4). However, these results could not be reproduced with the files available to us, as some of the required project data remained inaccessible.

For this reason, the project did not compare proprietary and open workflows as alternatives, but investigated which parts of the workflow could realistically be reproduced in an academic context. The CAD-based workflow proved to be the most accessible solution, while mesh generation and Gaussian Splatting could not be completed with the available data.



Fig. 2.5.1: Gaussian Splat of the mainroom created with LCC Studio

Data Quality

The quality of the recorded point cloud proved sufficient for architectural documentation and CAD modelling. Since the scanner records metric information directly, the dataset was already correctly scaled and did not require additional adjustments before modelling.

To verify the results, the point cloud was compared with the drawings provided at the beginning of the project and with measurements taken on site. The overlays showed a consistent correspondence between the different surveys, confirming that the recorded dimensions could be used as a reliable reference throughout the modelling process. (Figs. 2.5.2 - 2.5.3)

Beyond dimensional accuracy, one of the most valuable aspects of the survey was its ability to capture the irregular geometry of the existing building. Slight rotations, leaning walls and

non-orthogonal conditions became immediately visible in the point cloud, both in plan and in section. Rather than simplifying the building into idealised geometry, the survey documented its actual condition and made these irregularities available for interpretation during modelling.

Some limitations nevertheless remained. Reflections on glazed surfaces, temporary obstacles such as furniture and renovation materials, and the limited visibility of the roof reduced the completeness of the dataset in certain areas. These limitations were mainly related to the site conditions rather than to the accuracy of the measurements themselves.

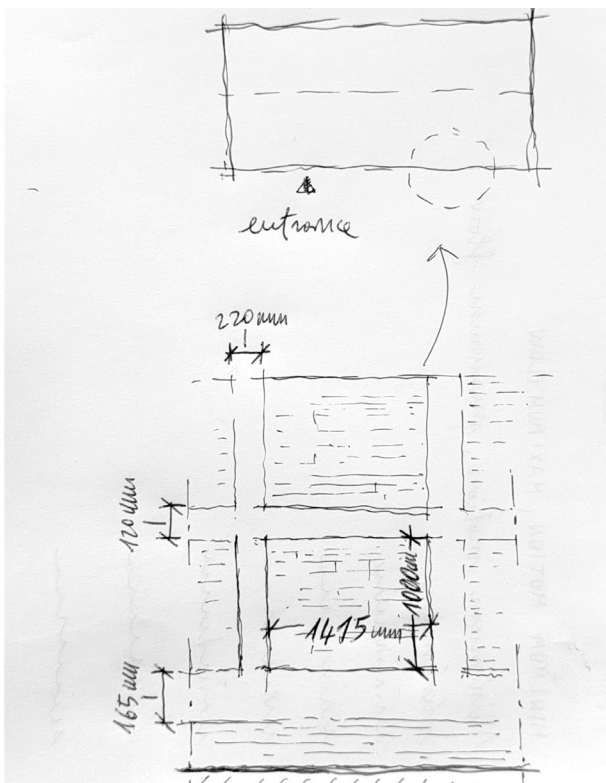


Fig. 2.5.2: Hand measurement taken on site



Fig. 2.5.3: Measurement in the point cloud in Archicad

Workflow

Three different post-processing workflows were investigated during the project. The first aimed to generate a Gaussian Splatting model. Although this type of output was successfully demonstrated with the proprietary software, it could not be reproduced with the accessible project files because the required image data were not available.

The second explored mesh generation using RealityScan 2.0 and CloudCompare. While both programs were able to generate a mesh from the point cloud, the resulting models contained large artefacts and incomplete geometry that made them unsuitable for further architectural work.

The third workflow used the point cloud directly as the basis for CAD modelling. After cleaning, aligning and subsampling the scans in CloudCompare, the merged point cloud could be imported into Archicad and used successfully as a geometric reference for modelling. Among all tested workflows, this proved to be the most reliable, accessible and reproducible approach.

Use in Architecture

Within the scope of this project, the workflow proved particularly suitable for documenting existing buildings and producing architectural drawings based on a measured point cloud. Rather than replacing the modelling process, the survey provided a reliable geometric reference that could be interpreted according to the required level of detail.

For students and researchers, this approach offers a practical way of working with professional survey data even when access to proprietary software is limited. While some advanced outputs remain linked to the manufacturer's ecosystem, the point cloud itself can still support the production of plans, sections, elevati-

ons and simplified three-dimensional models using widely available software.

The workflow also highlights an advantage over conventional manual surveying. Because the building is recorded continuously, its geometric irregularities are preserved together with its dimensions. Existing deformations, slight rotations and inclined surfaces therefore become part of the documentation instead of being simplified during the measurement process.

Final Considerations

At the beginning of the project, we expected learning how to use the scanner to be the main challenge. In practice, the acquisition itself proved to be the simplest part of the workflow. After a short preparation, the survey became fast, intuitive and produced a large amount of usable data within a relatively short time.

Most of the work instead focused on understanding how the recorded data could be accessed, converted and reused outside the proprietary software ecosystem. The main challenge was therefore not collecting the information, but making effective use of it afterwards.

Although the complete workflow offered by the proprietary software could not be reproduced, the project demonstrated that the point cloud can still be processed with accessible software and successfully used for CAD modelling. For the purposes of this study, this proved to be the most reliable and practical workflow, showing that a significant part of the surveying process can remain accessible even outside the manufacturer's software environment.



Fig. 2.5.4: Gaussian Splat of the Hufnerhaus created in LCC Studio



Fig. 2.5.5: Point cloud of the northern facade of the Hufnerhaus in Archicad

03 360° RICOH THETA V



INTRODUCTION

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-------------	----

```

import PIL import Image
port py360convert as p360

===== Einstellungen =====
PUT = "panos/" # Ordner mit 360°-Bildern ODEF
OUTDIR = "output/"
MODE = "perspective" # "perspective" = 108 Einze

#perspective-Modus (für Photogrammetrie)
V = 74 # Grad, entspricht -24 mm KB-Brennwei
OUT_SIZE = 3000 # Pixel (quadratisch)
W_STEPS = 36 # 360°/36 = 10°-Schritte
PITCH_LIST = [-30, 0, 30] # Grad

#Cube-Modus
FACE_W = 2048 # Kantenlänge pro Würfelfläche

===== Hilfsfunktionen =====
def load_panos(path):
    os.path.isfile(path):
        turn [path]
        ts = ("*.jpg", "*.jpeg", "*.png", "*.tif", "*.tiff")
        es = []
        re in exts:
            es += glob.glob(os.path.join(path, e))
        turn sorted(files)

def split_perspective(eimg, stem, outdir):
    w_step = 360 / YAW_STEPS
    = 0
    r v in PITCH_LIST:
        r k in range(YAW_STEPS):
            = k * yaw_step
            ew = p360.e2p(eimg, fov_deg=(FOV, FOV), u_deg
            it_hw=(OUT_SIZE, OUT_SIZE), mode="bilinear")
            ime = f"{stem}_p{v:+03d}_y{int(u):03d}.jpg"
            iage.fromarray(view).save(os.path.join(outdir, n
            += 1
        turn n

def split_cube(eimg, stem, outdir):
    ces = p360.e2c(eimg, face_w=FACE_W, cube_for
    r face, arr in faces.items():
        iage.fromarray(arr).save(os.path.join(outdir, f")
        turn len(faces)

===== Hauptlauf =====
makedirs(OUTDIR, exist_ok=True)
al = 0
if in load_panos(INPUT):
    em = os.path.splitext(os.path.basename(f))[0]
    mg = np.array(Image.open(f)).conver
    ib = os.path.join(OUTDIR, stem) # l...stan
    .makedirs(sub, exist_ok=True)
    MODE == "cube":
        tal += split_cube(eimg, stem, sub)
    se:
        tal += split_perspective(eimg, stem, sub)
    intf(f"{stem}_fortia")

```

2

PREPARATION

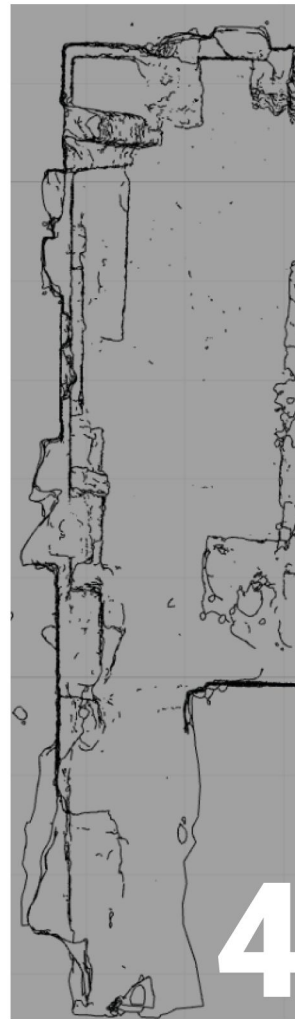
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1

INTRODUCTION



Fig. 3.1.1: Ricoh Theta V 360° camera

DESCRIPTION

The aim of this study was a simple, compact workflow that can be easily integrated into an architect's working routine, in order to create a digital inventory model, that is easy to follow, built around the Ricoh Theta V, a 360° camera¹. The camera was already available to us and did not have to be purchased. This workflow relies only on existing hardware, namely the camera, a tripod and a computer, together with freely available software. Programmes - that we also tested during the workflow - that are behind a paywall, or ruled out for other reasons, were excluded and are listed in the appendix for this chapter.

We documented one example room of the Hufnerhaus with panoramic photographs and reconstructed a 3D point cloud from them. Using the point cloud as a reference, we built a 3D CAD model from the floor plan and overlapped both, so we could derive 2D plans and sections from it.

The procedure follows five steps, two of them optional (see Fig. 3.4.1: Processdiagram), and leads from the raw panoramic image to a CAD model in ArchiCAD or Rhino. It builds and showcases further discoveries on the chapter „Photo – Theta 360°“ from the 2024 publication „Accessible techniques for digital building surveying“² and is best read alongside it.

-
- 1 cf. RICOH THETA V, Ricoh Company, Ltd. Tokyo: Ricoh, 2017. Accessed 23.06.2026. <https://theta360.com/en/about/theta/v.html>
 - 2 cf. Bernd Dahlgrün and Till Rudolph, eds., Accessible Techniques for Digital Building Surveying (Hamburg: HafenCity Universität Hamburg, 2024). <https://repos.hcu-hamburg.de/handle/hcu/1083>
 - 3 cf. Blender. Blender Foundation. <https://www.blender.org/>. Accessed 23.06.2026
 - 4 cf. Cheng Sun, py360convert, GitHub repository. Accessed 23.06.2026. <https://github.com/sunset1995/py360convert>
 - 5 cf. Agisoft Metashape Professional. Agisoft LLC. Accessed 23.06.2026. <https://www.agisoft.com/>

No	Type	Requirement	Notes
1	Hardware	Ricoh Theta V (360° camera)	tripod, tripod with bubble level, charging cable
2		iOS/ Android device	for bluetooth remote shutter release, check battery charge
3		PC/ Laptop	for further processing of the photogrammetry, with capable NVIDIA graphics card
4	Software	Blender ³	with a Python script to split the panoramas and create a tripod mask, or a standalone py360convert ⁴ script
5		Agisoft Metashape ⁵	photogrammetry; free educational version
6		CloudCompare ⁶	For point-cloud cleanup; PointCab origins ⁷ tested for automated 2D extraction
7		Rhino ⁸ or ArchiCAD ⁹	For the CAD step (alternatively AutoCAD ¹⁰ , Revit ¹¹ or SolidWorks ¹²)
8	Onsite	defined scale references, even illumination	known distances for scale bars, a static scene
9	Scan positions	scan in grid, sufficient overlap	overlap between adjacent positions

Fig. 3.1.2: Requirements

- 6 cf. CloudCompare. open-source project Accessed 23.06.2026. <https://www.cloudcompare.org/>
- 7 cf. PointCab Origin., PointCab GmbH. Accessed 23.06.2026. <https://www.pointcab-software.com/>
- 8 cf. Rhinoceros (Rhino). Robert McNeel & Associates. Accessed 23.06.2026. <https://www.rhino3d.com/>
- 9 cf. Archicad. Graphisoft SE. Accessed 23.06.2026. <https://graphisoft.com/>
- 10 cf. Autodesk. Inc., AutoCAD. Accessed 23.06.2026. <https://www.autodesk.com/products/autocad>
- 11 cf. Autodesk. Inc., Revit. Accessed 23.06.2026. <https://www.autodesk.com/products/revit>
- 12 cf. SolidWorks. Dassault Systèmes. Accessed 23.06.2026. <https://www.solidworks.com/>

2

PREPARATION

Before the survey, the workflow and the tool chain had to be defined. A first pipeline based on Blender and Meshroom¹³, tested in a different room, failed (see appendix for this chapter). We therefore switched to Agisoft Metashape, which handles 360° imagery reliably.

For the site measurement, we carried out a test with the camera both indoors and outdoors and found that objects and walls are displayed better indoors. We therefore decided to capture the interior of the Hufnerhaus and planned the camera positions, arranging them in a regular grid across the width, depth and height of the room, so that successive shots would overlap. Good photographs depend above all on even, diffuse lighting. All lights in the room should be switched on, while bright window areas, reflective surfaces and strong contrasts are best avoided, because the software recognises them poorly. Ideally, the camera sits at about 90° to strong light sources and to direct sunlight. Overcast weather is an advantage here: diffuse daylight casts few hard shadows on the surfaces.

The panorama splitting is optional, since Metashape can also process the panoramas directly as spherical images. In our case, however, splitting them into perspective images gave better results in Agisoft. For this, a Python script drove a virtual camera in Blender: it rotated through a yaw of 0 to 360° and recorded the pitch angles -30°, 0° and +30°, which produced several overlapping perspective images per panorama. We later rebuilt the same step as a standalone `py360convert` script that works without Blender.

Panoramas carry no inherent scale. Known reference distances were therefore prepared in advance, so that scale bars could be set in Metashape afterwards.

PREPARATIONS FOR A CLEAN CAPTURE

- a static scene, with no people or moving objects in the frame
- everyone out of the camera's field of view during each shot (the remote shutter release helps)
- sufficient overlap between adjacent positions, and moderate distances between them
- the tripod masked out, for which the Python splitting can create a tripod mask

13

cf. Meshroom. AliceVision. Accessed 23.06.2026.
<https://alicevision.org/>

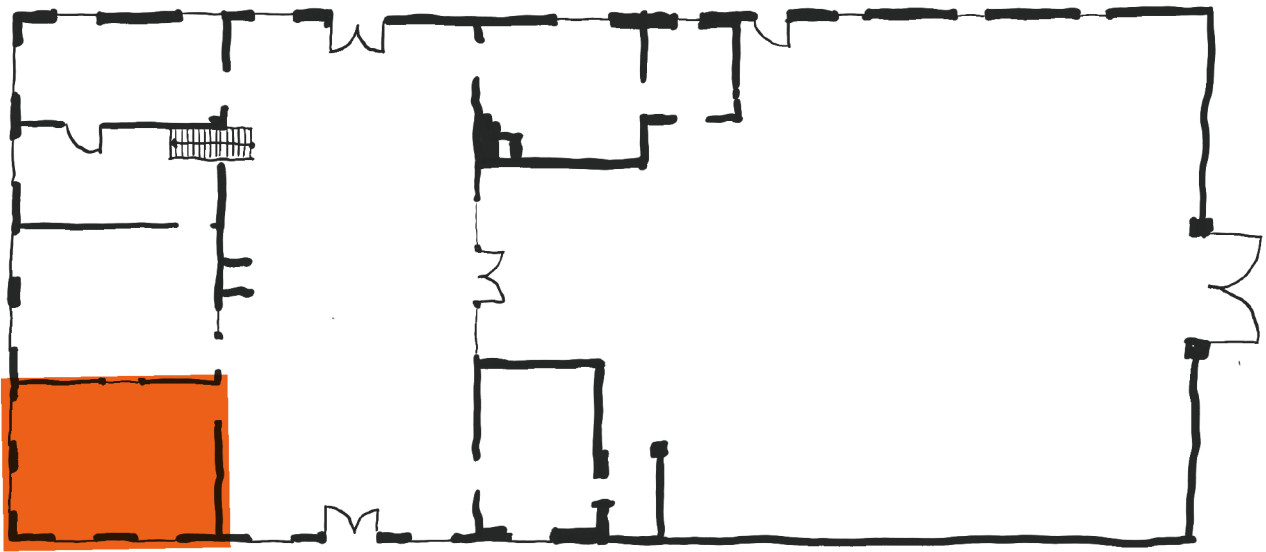


Fig. 3.2.1: floorplan Hufnerhaus, selected room for the survey in orange

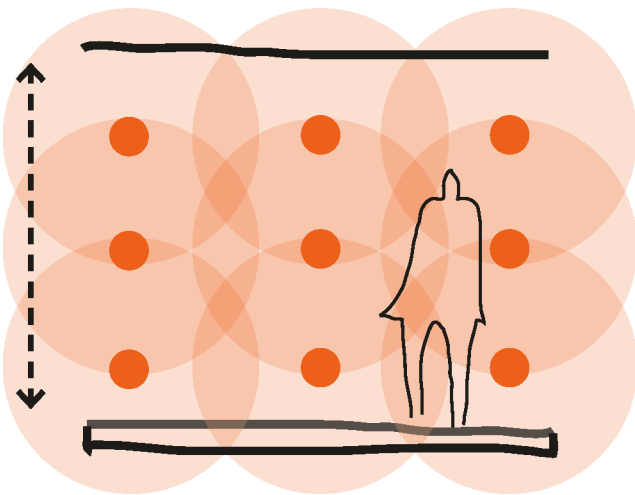


Fig. 3.2.2: planned camera positions vertical in three different heights

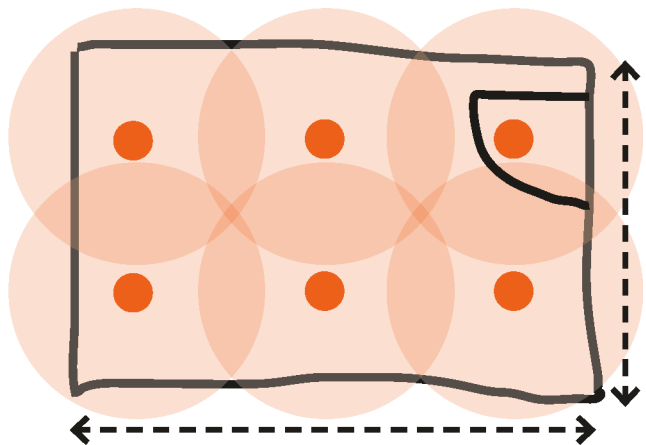


Fig. 3.2.3: planned camera positions horizontal in the floorplan

3

SITE MEASUREMENT

Originally, we had intended to capture the entire building, but since the capture took considerably longer than expected, we ended up documenting only a single room. Mounted on the tripod, the Theta V camera captured the room on a regular grid: at each grid point we took three panoramas at three heights, which gave 18 panoramas. Adjacent positions overlapped and the scene stayed static. The lighting in the room was relatively even, but was stronger coming from the two outer walls with windows. Afterwards, we walked through the room a second time, handheld and without the tripod, and photographed the areas that the grid had not covered well, for example the corners behind stacks of wood, under the table between different kind of boxes and on the table, amongst various craft supplies and other boxes. These

additional shots were meant to close gaps. Known reference distances were also recorded, in order to safeguard the later scaling in Metashape.

The equipment is minimal: one camera and one tripod. Each 360° shot records the full surroundings of a position at once, which keeps the on-site effort low.

The capture itself took longer than expected, namely around two hours. Before each shot, the tripod height had to be adjusted, and everyone had to leave the room to not block the view. With the room empty, the Bluetooth connection between the smartphone app and the camera was often weak, and the images were slow to load. The handheld pass went faster (30 min.), since no tripod had to be set up and the remote shutter release could be used directly.



Fig. 3.3.1: floorplan Hufnerhaus overlay with Mesh, camera positions in the selected room for the survey



Fig. 3.3.2: camera position 1 top



Fig. 3.3.6: camera position 2 top



Fig. 3.3.3: camera position 1 middle



Fig. 3.3.7: camera position 2 middle



Fig. 3.3.4: camera position 1 bottom



Fig. 3.3.8: camera position 2 bottom



Fig. 3.3.5: camera position 3 top



Fig. 3.3.9: camera position 4 top



Fig. 3.3.10: camera position 3 middle



Fig. 3.3.14: camera position 4 middle



Fig. 3.3.11: camera position 3 bottom



Fig. 3.3.15: camera position 4 bottom



Fig. 3.3.12: camera position 5 top



Fig. 3.3.16: camera position 6 top



Fig. 3.3.13: camera position 5 middle



Fig. 3.3.17: camera position 6 middle



Fig. 3.3.18: camera position 5 bottom



Fig. 3.3.22: camera position 6 bottom



Fig. 3.3.19: camera position random 1



Fig. 3.3.23: camera position random 4



Fig. 3.3.20: camera position random 2



Fig. 3.3.24: camera position random 5



Fig. 3.3.21: camera position random 3



Fig. 3.3.25: camera position random 6

4 DATA PROCESSING

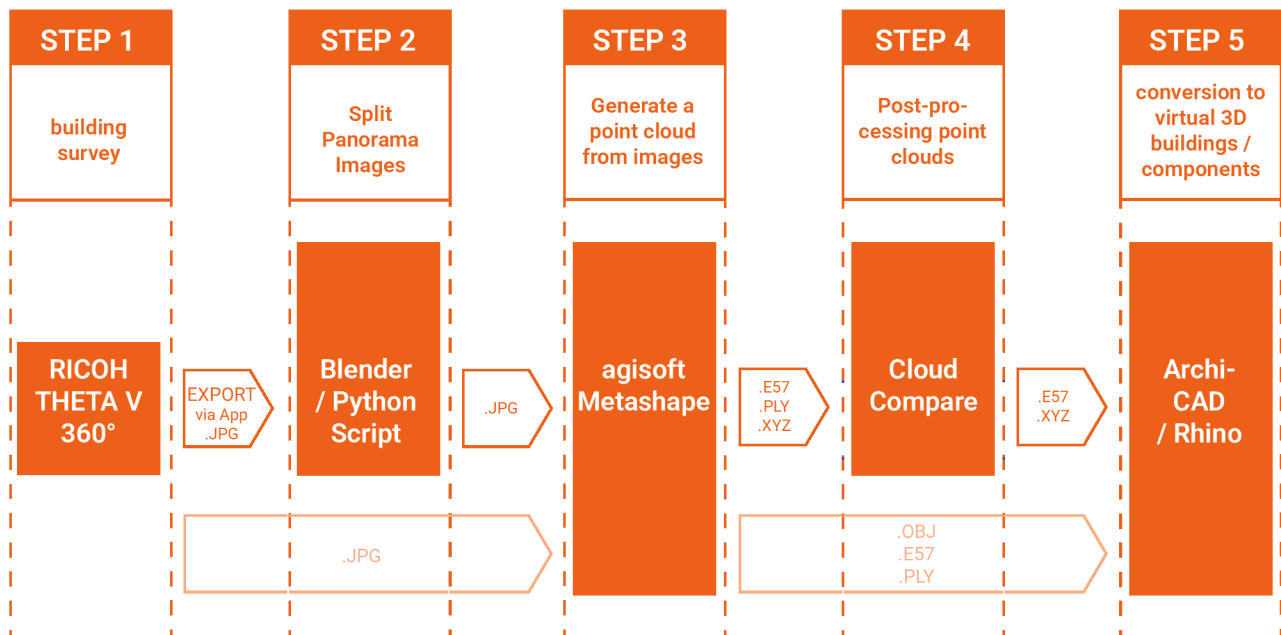


Fig. 3.4.1: Process diagram

A detailed step-by-step guide with screenshots is provided in the appendix for this chapter. The following overview summarises the workflow (see Fig. 3.4.1: Processdiagram):

- Capture 360° panoramas on a grid (Ricoh Theta V) >> JPG
- (optional) Split the panoramas into perspective images (Python) >> JPG
- Photogrammetry in Metashape: alignment, dense point cloud, scale bars >> E57
- (optional) Point-cloud cleanup in CloudCompare >> E57
- CAD model in Rhino or ArchiCAD: point-cloud overlay and manual tracing >> DWG / native

DATA EDITING

First, we captured the room as described above in the ‘Site Measurements’ chapter: we set up the camera, established a bluetooth connection and captured the room using overlapping photos.

Second, the grid panoramas and the handheld shots were split into perspective images, as described in Preparation. This produced 200 overlapping images.

In Metashape, we loaded these 200 images, aligned the cameras (Align Photos) and computed the dense point cloud. Metashape produced reliable results, whereas the earlier Meshroom attempt had failed.

During scaling, non-uniform scale errors appeared, indicating distortion. We corrected the scale with scale bars in Metashape, based on the known reference distances, rather than by rescaling afterwards in CloudCompare.

The dense point cloud was exported from Metashape as E57. Cleanup in CloudCompare is optional, since the cloud can also be edited directly in Rhino. We still preferred CloudCompare: editing is more convenient there, and its filters optimise the cloud more effectively. In CloudCompare, the Segment tool removed unwanted areas, and the SOR and Noise filters removed outliers; the export back to E57 works only if a single cloud is selected.

We also tried PointCab Origins to derive the 2D floor plan automatically from the point cloud. This did not work for our scan. PointCab returned only isolated line fragments that never closed into a coherent room outline. Correcting them into usable geometry would have taken more effort than drawing the plan by hand. We therefore traced the edges manually, using the TIFF as a background reference.

CAD MODEL

In Rhino, the cleaned point cloud served as a reference beneath a 3D model that we built from the floor plan. From this, 2D plans and sections were derived with the Make2D command. The main difficulty lay in aligning the point cloud. It had to be rotated and positioned so that it matched the floor-plan model along all three axes, and getting this orientation right took several attempts. Rhino offers a broad set of tools for this, which kept the alignment manageable. The same model was also built in ArchiCAD, on the basis of the same point cloud. Aligning the

cloud proved to be more difficult here, because ArchiCAD provides fewer tools for handling and orienting point clouds than Rhino. Positioning the cloud correctly therefore took more effort, and the overall workflow was less flexible. Working with the point cloud differs strongly between the programmes:

- In Rhino the cloud is fully editable: points can be selected, moved and reworked, distances can be taken between individual points, and geometry can be traced directly over the cloud using it as a snap reference.
- In ArchiCAD, the cloud is treated as a single object. Individual points can therefore neither be snapped to, measured nor moved, and the cloud only acts as a visual reference for tracing.

One limitation applies regardless of the programme: in a dense and slightly noisy cloud it is hard to hit the exact intended point, so measurements taken directly from the cloud carry some uncertainty. For this reason, we took the dimensions from the clean CAD model rather than from the raw points.

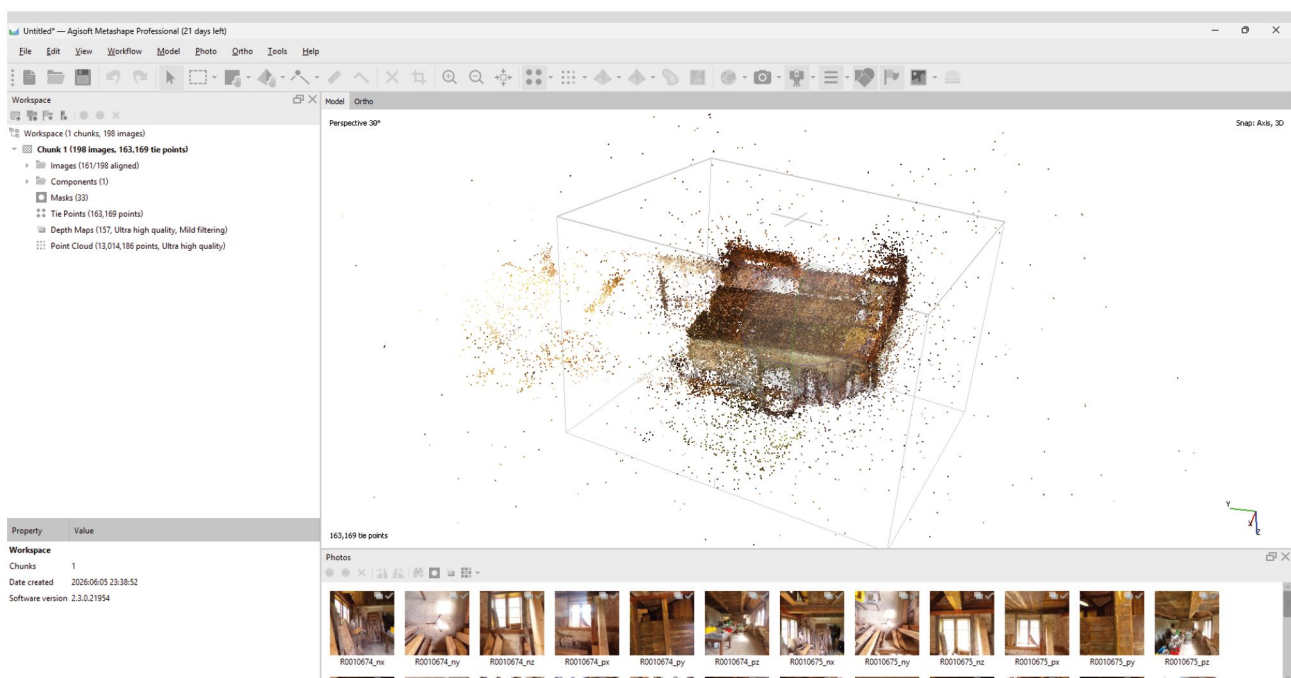


Fig. 3.4.2: Screenshot workspace Metashape, Pointcloud

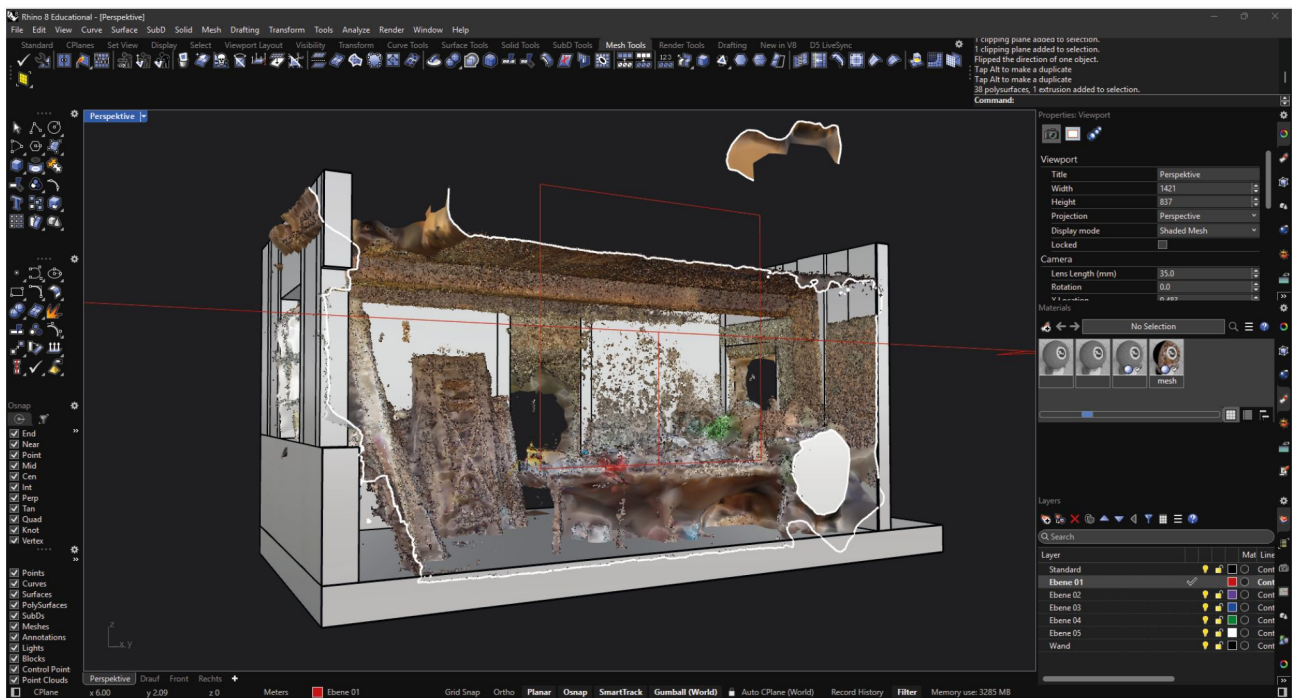


Fig. 3.4.3: screenshot workspace Rhino, Pointcloud

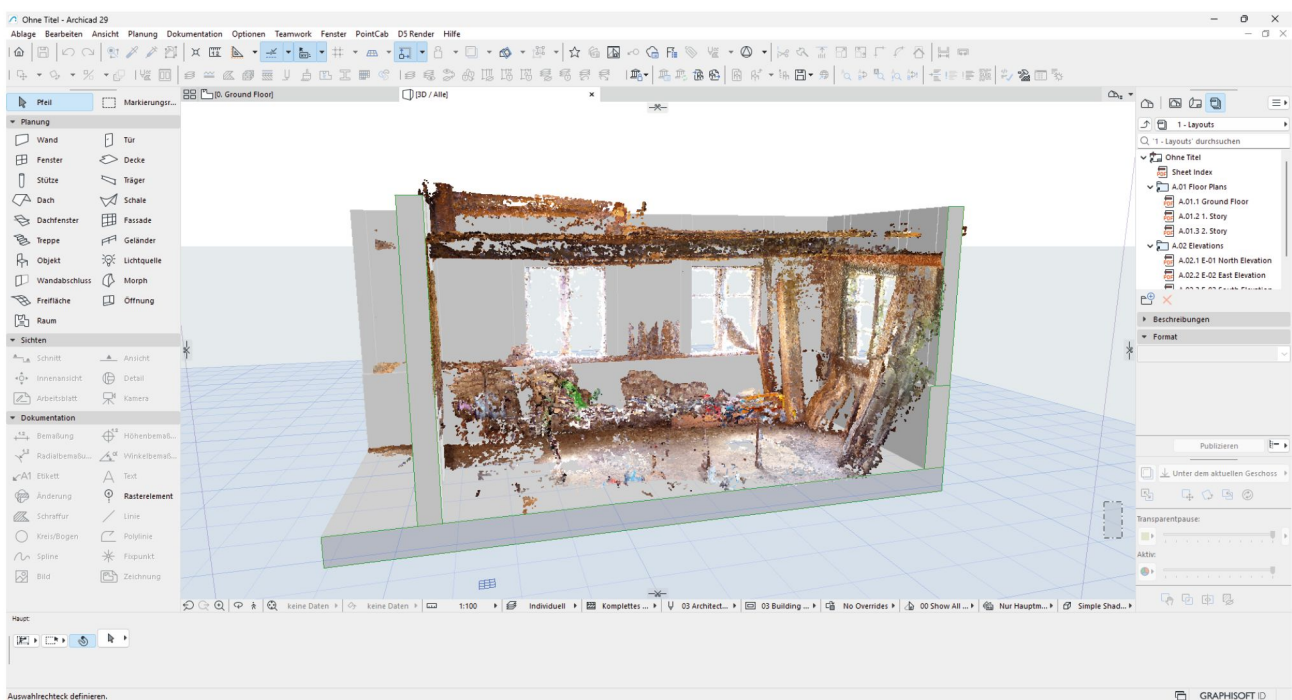


Fig. 3.4.4: screenshot workspace ArchiCAD, Pointcloud

GAUSSIAN SPLATTING (PARALLEL PATH)

Alongside the photogrammetric pipeline, we tested Gaussian splatting on the same imagery, which can also be found in the appendix. The method was never intended to produce measurable geometry; its strength is the photorealistic render. In that render, the position of objects and the location of cracks or damage can be read clearly, which makes it useful as a visual record of the room's condition. For a measured

survey, however, it is not suitable.

The tools came with practical limits. Nerfstudio¹⁴ trained a splat but did not export a usable mesh, Jawset Postshot¹⁵ sat behind a paywall, and SuperSplat¹⁶ allows viewing only.

Further development in review with the chapter „Photo – Theta 360°“ from the 2024 publication „Accessible techniques for digital building surveying“

14 cf. Nerfstudio. Nerfstudio Team. Accessed 23.06.2026. <https://docs.nerf.studio/>

15 cf. Postshot. Jawset. Accessed 23.06.2026. <https://www.jawset.com/>

16 cf. SuperSplat. PlayCanvas. Accessed 23.06.2026. <https://supersplat.at/>



Fig. 3.4.5: screenshot workspace SuperSplat, Gaussian Splat 3DGS

5

EVALUATION

PRECISION

The achievable accuracy depends on three factors: the overlap between positions, the image quality, and correct scaling. Without scale bars, the model stays dimensionless or non-uniformly distorted; only with reference distances do the measurements become usable for building documentation. Fine detail is limited by the resolution of the Theta V, and reflective, dark or low-texture surfaces reduce the point density.

The comparison of a door opening confirms the overall dimensional accuracy of our workflow. Our point cloud measured 92 cm at this location, against a reference value of 93 cm taken on site. This deviation of one centimeter, roughly one percent, lies within the expected tolerance for a photogrammetric survey at this scale. Such minor discrepancies typically stem from scale bar placement and mesh smoothing rather than fundamental modeling errors. The workflow therefore proves sufficiently accurate for architectural documentation.



Fig. 3.5.1: reference measurement overlay pointcloud and 3D Model

FURTHER DEVELOPMENT IN REVIEW WITH THE CHAPTER „PHOTO – THETA 360°“ FROM THE 2024 PUBLICATION „ACCESSIBLE TECHNIQUES FOR DIGITAL BUILDING SURVEYING“

In 2024, the panoramas were loaded into Metashape directly with the spherical camera setting, and the resulting E57 point cloud was imported into ArchiCAD. Because the cloud arrived at the wrong scale and could not be scaled in ArchiCAD, the team had to draw the floor plan first and rescale it afterwards by reference dimensions. We developed the workflow further in several respects:

- Splitting instead of spherical loading: each panorama is split into perspective images, which gives more and better distributed input for the alignment.
- Capture at three heights, plus a handheld pass to close gaps, rather than the two tripod heights used in 2024.
- Correct scale from the start: scale bars in Metashape fix the scale before export, so the drawing no longer has to be rescaled afterwards.
- An added CloudCompare step cleans and optimises the point cloud before the CAD work.

WHAT WORKED WELL IN THE DATA PROCESSING

- Metashape reconstructed a reliable point cloud from the 200 split images.
- Scale bars in Metashape removed the non-uniform scale error.
- The CloudCompare cleanup (Segment, SOR and Noise filters) worked reliably.
- Point-cloud overlay with manual modelling in Rhino and ArchiCAD suited the irregular historic geometry.
- Both the hardware and the software were available at no additional cost.

WHAT DID NOT WORK WELL IN THE DATA PROCESSING

- Meshroom failed; only Metashape produced a usable result.
- PointCab did not derive the 2D floor plan automatically, so the edges had to be traced by hand.
- Matterport¹⁷ exports only with a paid subscription, so without one the captured data cannot be taken into CAD.
- Low-texture, reflective and dark surfaces, together with overly large distances between positions, caused gaps and noise.
- Aligning the point cloud to the model was tedious, and more so in ArchiCAD than in Rhino.
- The capture was time-consuming, mainly because of the tripod adjustment and an unstable Bluetooth connection.

OUTLOOK

Beyond the tools tested, the most productive improvement lies in the capture itself: HDR imaging, more standpoints, and scale bars set directly in Metashape. For a purely visual record, Gaussian splatting remains a promising option to develop further, even though it does not replace a measured survey.

CONCLUSION

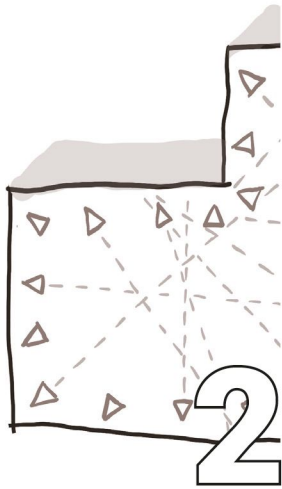
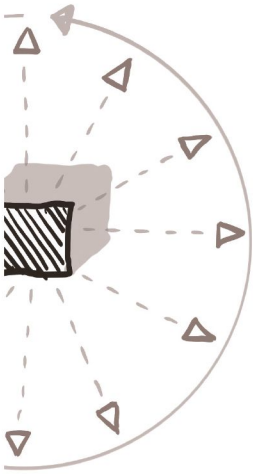
In retrospect, the workflow is cost-free, because it uses only existing hardware and free software. At the same time, it is time-consuming and reaches only moderate accuracy. We would therefore not recommend buying a Ricoh Theta V specifically for this purpose. Today's LiDAR-capable smartphones achieve comparable, and in part better, results with a usually simpler workflow. However, the camera is a useful tool for capturing existing spaces, allowing you to then move around within a 360-degree image and take in the whole space within a single image.

17 cf. Matterport, Matterport, Inc.. Accessed 23.06.2026.
<https://matterport.com/>.

04 PHOTOGRAMMETRY

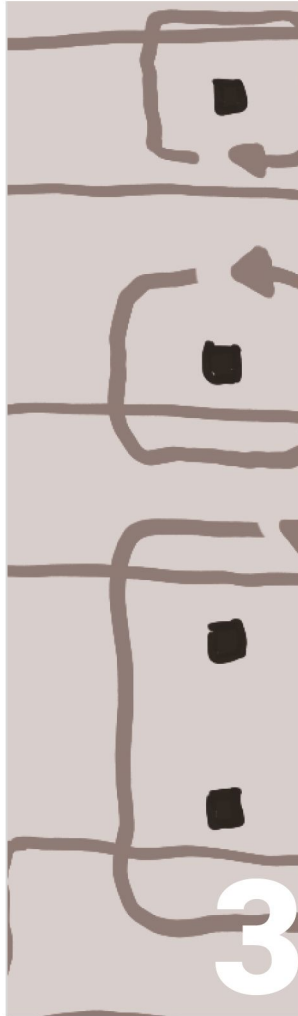


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1

INTRODUCTION



DESCRIPTION

This photogrammetry workflow utilizes high-resolution images from DSLR (Digital Single-Lens Reflex) or DSLM (Digital Single-Lens Mirrorless) cameras to generate 3D models. Together with the free program “ActualityScan,” it creates a transparent workflow that offers a high degree of control, by making every parameter available to get the outcome you wish to achieve.

Photogrammetry converts 2D photos into 3D models (.xyz, .fbx and .obj).

To do this, the process compares overlapping images of a building or object, identifies matching pixels, and calculates how the camera must have moved and where the photographed location is in 3D space. When performed correctly, this accessible method yields very precise results.

The goal of this project was to complete the entire workflow from start to finish using only free software, in order to keep the barrier to entry as low as possible without compromising the quality and accuracy of the point cloud or the model.

Laptop or PC—A Windows system is required for our workflow. The recommended specifications for the other components are as follows:
CPU: 4 cores
RAM: 16GB
GPU: CUDA 6.1 with 1GB VRAM



Fig. 4.1.1: equipment Fujifilm

REQUIREMENTS

Hardware

Camera - High-resolution DSLR/DSLM cameras with large sensors are well-suited for this workflow.

We used:

- Sony a7ii (24,7MP Fullframe)
- Fujifilm XT5 (40,2MP APS-C)

The higher the resolution, the more detail can be captured per image. Larger sensors also have a higher dynamic range (the difference between the brightest and darkest points in an image) and require less light.

Lens - A wide-angle lens is best suited here. The wider field of view, paired with a high-resolution camera, is particularly advantageous because it maintains a high level of detail. However, fisheye lenses (<16mm) should be avoided due to their high distortion. The same applies to focal lengths over 35mm, as the field of view becomes too narrow and the depth of field (area of sharpness) decreases significantly.

Of course, other types of cameras (e.g., smartphones, digital cameras, or drones) can also be used instead of a DSLR. However, due to their automatic image processing and exposure settings there is less control over the outcome using a phone. Exposure settings may vary between individual images, consequently a lower quality of the resulting coloured point cloud can be expected.

Since we focused exclusively on DSLR cameras, alternative camera systems were not investigated in sufficient detail to provide specific recommendations.

Laptop or PC - A Windows system is required for our workflow, to run RealityScan.¹ The recommended specifications for the other components, based on information given on the RealityScan website², are as follows:

- CPU: 4 cores
- RAM: 16GB
- GPU: CUDA 6.1 with 1GB VRAM

Software

RealityScan³ - Free software from Epic Games where all data processing takes place.

Darktable⁴ - A free image editing program where you can adjust the exposure of the images. This step is optional and only worthwhile if the model is needed for renderings.

ArchiCAD (or other CAD software)⁵ - Students can use the free educational license and import scans as point clouds or meshes.

1,2 cf. MatejKuro. "Hardware and Operating System Requirements". Epic Games Community. Accessed 05.07.2026. <https://dev.epicgames.com/community/learning/knowledge-base/DB58/realityscan-hardware-and-operating-system-requirements>

3 cf. RealityScan. Accessed 04.07.2026. <https://www.realityscan.com/?lang=de>

4 cf. Darktable. Accessed 04.07.2026. <https://www.darktable.org/>

5 cf. Graphisoft. ArchiCAD. Accessed 04.07.2026. <https://www.graphisoft.com/de-de/plans-and-products/archicad/>

2 PREPARATION

Project Scope

It must be determined in advance where the scan will take place - Indoors or outdoors.

If the scan is taken outdoors, the lighting conditions are clearly dictated by the sun and the sky - a cloudy day is ideal here.

The diffuse light from the clouds not only casts softer shadows, which makes the model more suitable for visual purposes, but also reduces the dynamic range of the scene (the difference between the brightest and darkest points in the scene). New cameras now have a high dynamic range, but in direct sunlight, there is always a risk of data loss in underexposed and overexposed areas of the image.

Rainy days should also be avoided, as flat, wet surfaces reflect light and can thus cause difficulties when stitching the images together or create artifacts.

When shooting indoors, windows provide the light. In most cases, care should be taken to ensure that the room is illuminated as evenly as possible. Dark corners should therefore ideally be illuminated with static light sources.

Next is the question of what is being scanned.

Object

Whether it's a small, movable object (cup, table, etc.) or a large, static object (ornament, fountain, building, etc.), it is at the center of the imaginary scene.

Ideally, you can circle around it and capture it from various heights.

Depending on the size, the camera distance can be adjusted to increase the level of detail; the focal length can also be slightly longer in this case.

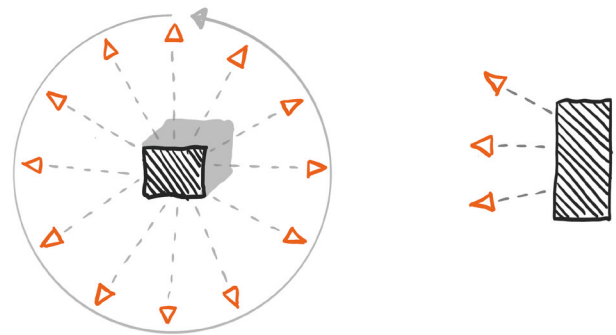


Fig. 4.2.2: camera position object

Room

Rooms must be photographed differently. The walls can be used as a guide line here, but the opposite side of the room is photographed. In both cases, it makes sense to plan a walking route in advance to follow as you survey the location. This route should be cleared of obstacles, and loose objects that could move during the scanning process (e.g., doors, curtains blowing in the wind, or tall grass) should be secured or removed.

For all types of shots, however, it is especially important to ensure overlap - that is, the images must share content so they can be linked together later in the software.

- An overlap of at least 20-30% should be maintained.
- It is important to move between the two images.

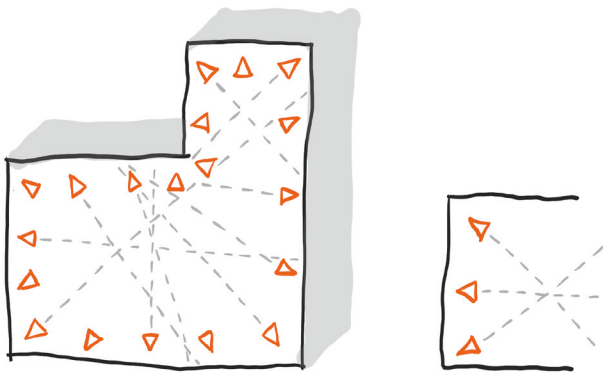


Fig. 4.2.3: camera position room

Camerasettings

It is important to get a few settings right. For maximum control, set the camera to Manual mode.

Aperture - Lenses are sharpest in the f/8.0-11.0 range. If the room is particularly dark, you can open the aperture a bit more - but be careful! The depth of field will continue to decrease.

Shutter speed - To take sharp, blur-free photos handheld, the shutter speed should be at least twice the focal length (16mm → 1/32; 50mm → 1/100)

ISO - Keep it as low as possible! High ISO values produce significant image noise, which results in grainy pictures and artifacts in the model. An ISO of 10.000 was used with the Sony as a last resort in really dark areas - it worked, but only as a last resort.

For even exposure in rooms with uneven lighting, you can also use Aperture Priority mode.

3

SITE MEASUREMENT

Room

To test our method, we chose the workshop on the west side of the Hufnerhaus.

The scanned area is approximately 40 m² and presented several challenges (see Fig. 4.3.4). Three columns flank the north wall of the house, on which the roof and the recessed intermediate floor rest. Many boards and struts run along them - numerous details that must be properly captured and processed. Additionally there are very fine details such as ladders and tools. The room was lit by fluorescent lights as well as through windows and slits, which created strong contrasts. The room was scanned exactly as it was found.

Planning

After familiarizing ourselves with the space, we planned walking routes that covered the space in a grid pattern (see Fig. 4.3.5).

We walked through the space as a whole in wide, serpentine lines. We documented objects and ornaments by photographing them from all angles. We used two different heights from a straight-on perspective: one while crouching and one with outstretched arms.

When photographing rooms, the floor and ceiling should be considered separately. We moved in a "waltz rhythm" - that is, a large step to the side, photo from below, photo from above, and so on. Accordingly, we proceeded in a grid-like pattern to photograph the floor and ceiling. We noticed that the photography process works a bit differently here: the more directly we point the camera at the floor or ceiling, the less floor is captured, and the more images

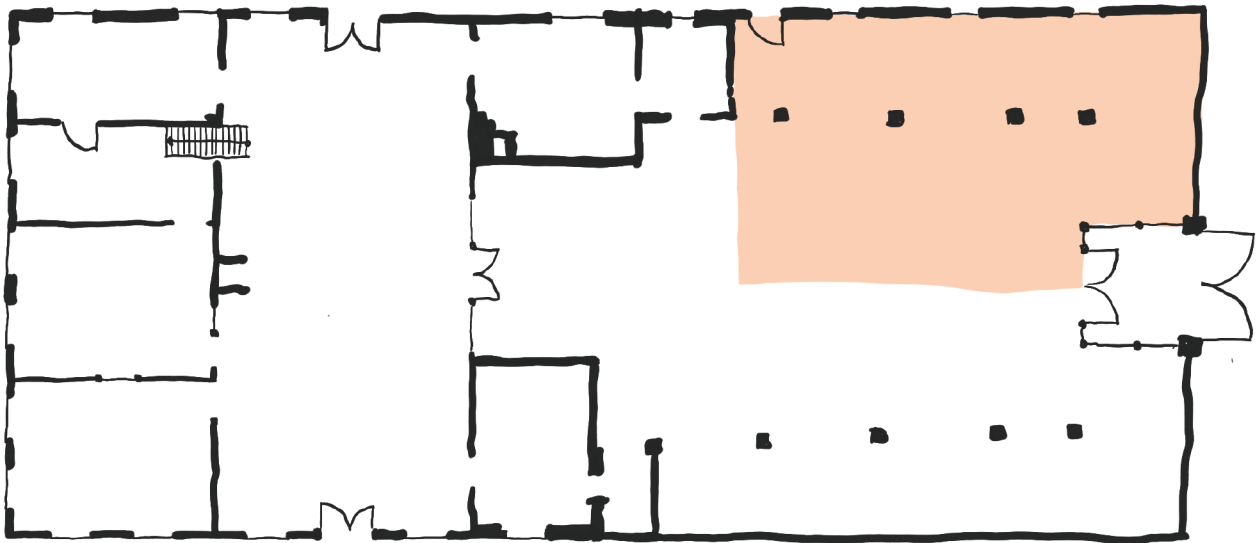


Fig. 4.3.4: floorplan scanned Area

are needed. The more we tilted the camera, the more was captured. It's important to find a good balance here and always make sure that your own feet aren't included in the shot. RealityScan was able to handle the shown tilt (see Fig. 4.3.6.-9.) well during postprocessing.

To test the pros and cons of different setups, we captured the room using three different combinations.

It's noticeable that the Fuji took about 30% fewer photos than the Sony, which is due to its shorter focal length. The number of images in the video is so high because two images were extracted for every second of video recorded.

	Fuji	Sony	Fuji Video
focallength	16mm	24mm	16mm
resolution	48MP APS C	24MP FF	8MP APS C
pictures	251	351	723

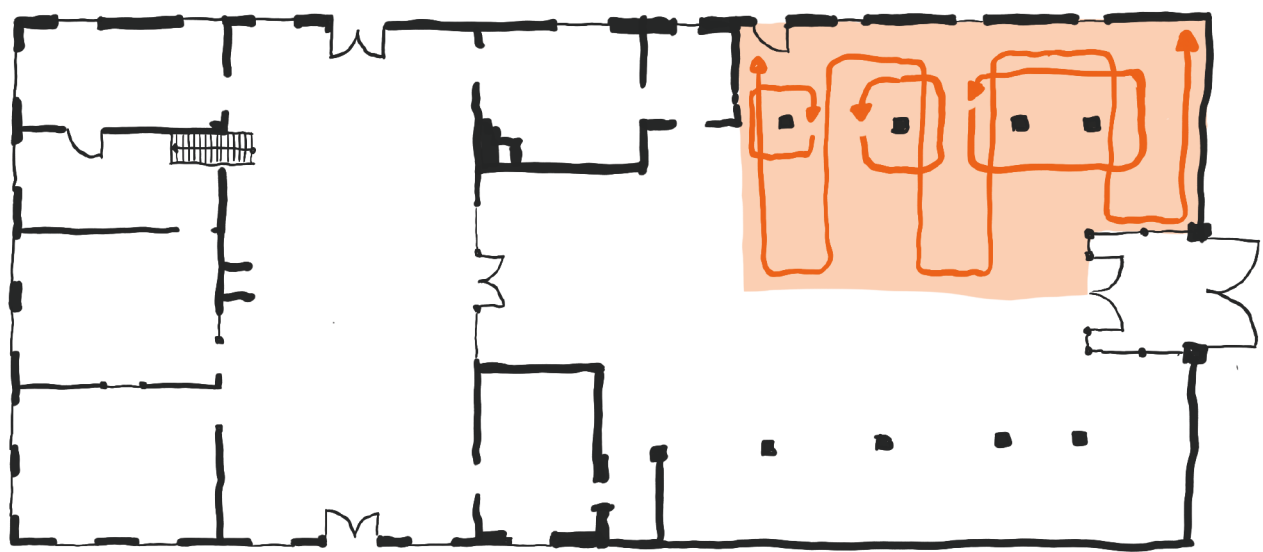


Fig. 4.3.5: walk with the camera



Fig. 4.3.6: photos floor



Fig. 4.3.7: photos around column



Fig. 4.3.8: photos column different heights

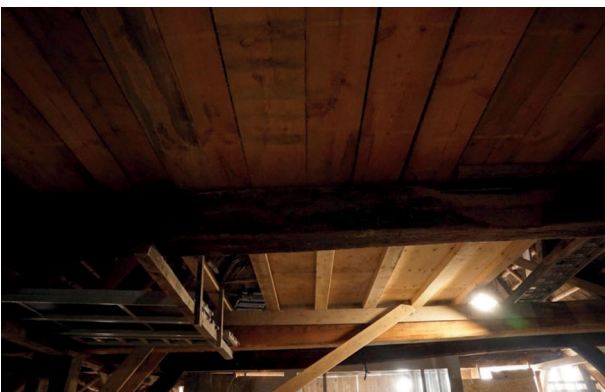
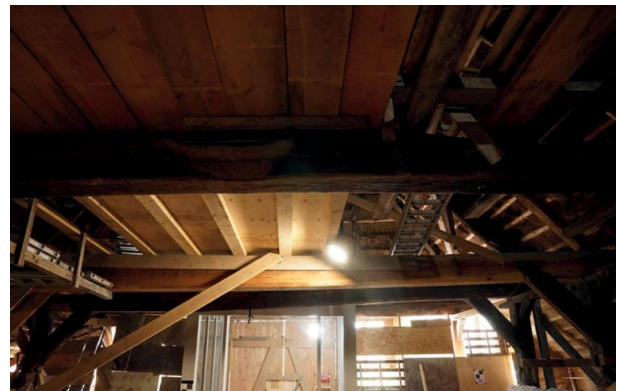
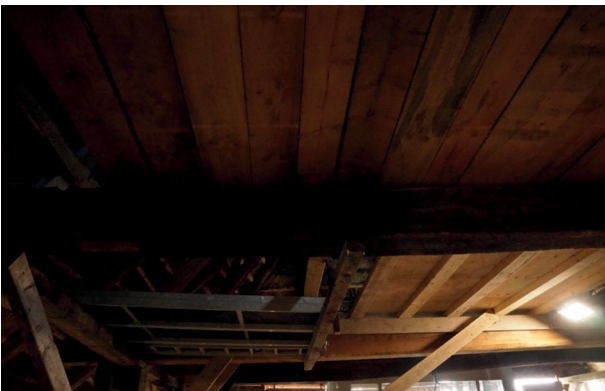


Fig. 4.3.9: photos ceiling

4 DATA PROCESSING

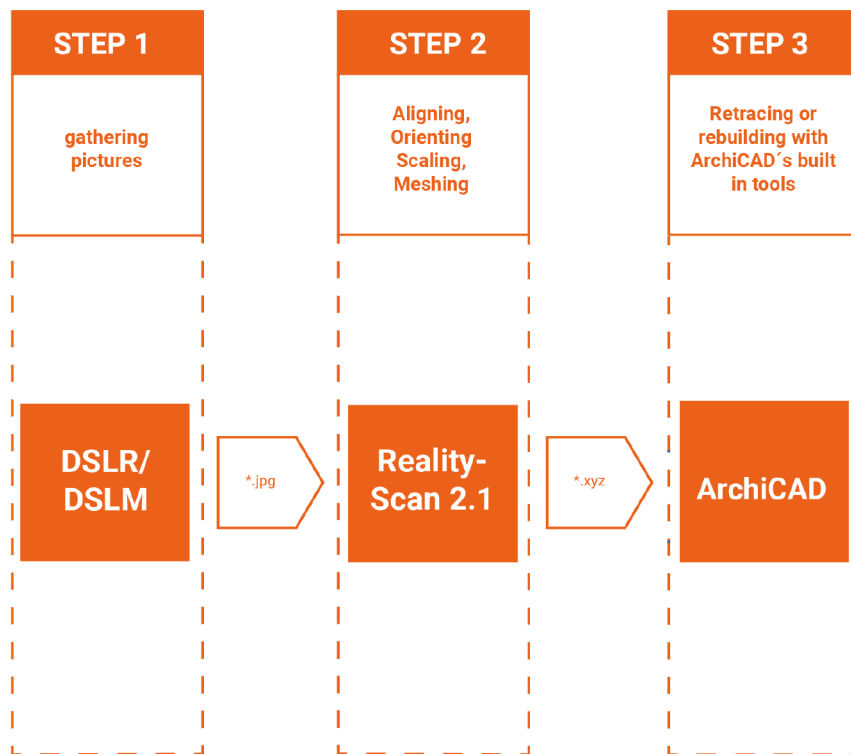


Fig. 4.4.10: Schematic diagram of workflow

For postprocessing, we chose RealityScan because the program has already proven itself in past projects. It is easily accessible, free, and user-friendly.

In the program, an algorithm compares the images and uses triangulation to estimate the relative positions of the cameras in relation to one another - a process called alignment. If the model is skewed, it can be easily aligned in the coordinate system (Set Ground Plane).

If the model's dimensions do not match reality, it can be scaled using two reference points and a reference measurement (Define Distance) (see Fig. 4.4.14).

In the next step, the program creates a high-resolution mesh (Normal Detail) (see Fig. 4.4.15), which we can export as a dense point cloud.

All steps are explained in detail, with illustrations, in the step-by-step guide in the appendix.

The three data sets captured from the Hufnerhaus were processed in separate RealityScan projects but with identical settings.

	Fuji	Sony	Fuji Video
processed images	236/251	335/351	538/723
polygon count	280 mio	130 mio	110 mio

The resulting polygon model (mesh) clearly illustrates the accuracy of the point cloud from which it was created (see Fig. 4.4.15).

However, models of this size cannot be displayed as a mesh, but only as a dense point cloud, which makes it difficult to assess surface quality outside of CAD.

To enable a comparison, we processed a small, central part of the room and generated it with equal precision settings. The process only took a couple of minutes. This time may vary though, regarding the specific hardware you have. We did not have any crashes whilst working on the models.

Our setup:

- CPU: Intel i9
- RAM: 32GB RAM
- GPU: NVIDIA 4070ti mit 12GB RAM

This comparison made differences in the quality of contours and surfaces highly visible. The model created from the video stands out significantly here, as it has the most pronounced artifacts and inaccuracies (see Fig. 4.4.12).



Fig. 4.4.12: mesh Fuji camera - Video



Fig. 4.4.11: mesh Sony camera



Fig. 4.4.13: mesh Fuji camera

Some of these are certainly due to missing image data, but even well-captured areas of the model exhibit rough surfaces and jagged edges.

The two photo-based models are closer in quality, but interesting differences are apparent:

The contour sharpness of both models is nearly identical, but the surface quality differs significantly. The Fuji model renders surfaces that are actually smooth as rough (e.g. bucket, beam), whereas the Sony model handled this better, though it was not perfect either. Both cameras were working with high ISO whilst capturing the room. Larger sensors are capable to run higher ISO without too much noise being present. The Fuji, even with lower ISO values, had significantly more noise and a drop in sharpness, as seen in the raw pictures (see Fig. 4.4.17).

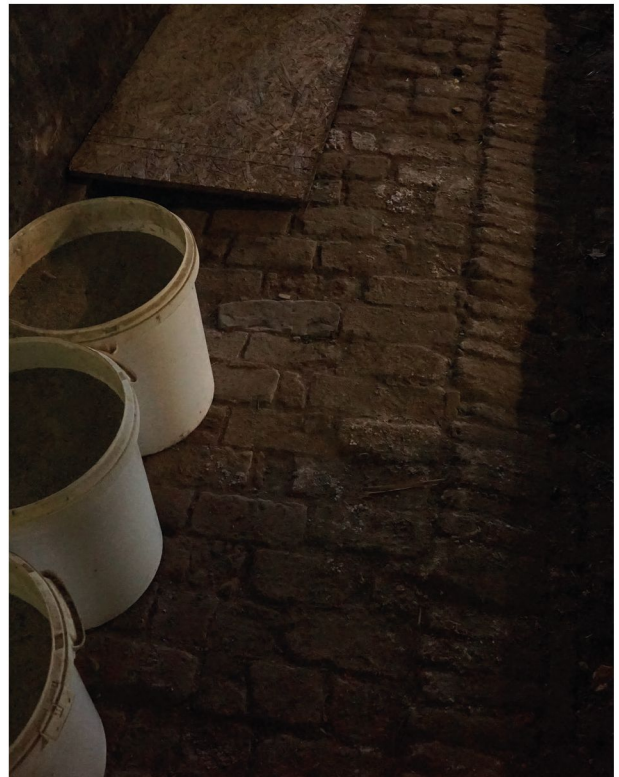


Fig. 4.4.14: picture Sony camera



Fig. 4.4.15: zoom Picture Sony camera



Fig. 4.4.16: picture Fuji camera



Fig. 4.4.17: zoom Picture Fuji camera



Fig. 4.4.18: measured Object

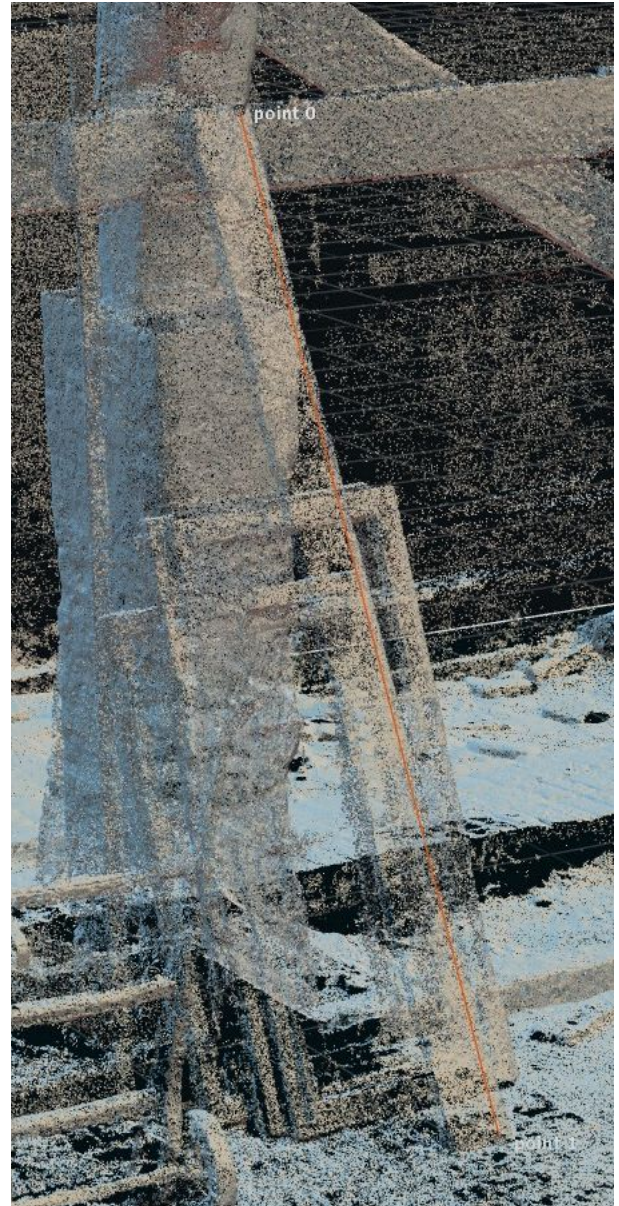


Fig. 4.4.19: reference points in RealityScan

Selected constraint(s) 	
Name	distance 0
A	point 0
B	point 1
Enable	Enable
Units	Meter
Defined distance	2.205000
Calculated distance	8.303452
 Accuracy	
Defined distance accuracy	0.001000
Units	Meter

Fig. 4.4.20: define distance reference points pointcloud

REALITYSCAN

For further postprocessing of our point cloud, we used the images from the Sony camera. We chose this option due to the better surface quality. We were able to scale the entire point cloud using two reference points and a measured object in the Hufnerhaus (see Fig. 4.4.18). Each reference point has to be confirmed in three separate images. It's the only way to ensure that the correct measurement is used.

Through scaling we now have a true-to-scale point cloud from which additional reference dimensions can now be derived (see Fig. 4.4.21).

A comparison of another reference dimension and the one taken for scaling reveals no distortion within the point cloud (see Fig. 4.4.19). This demonstrates the precision of this method.

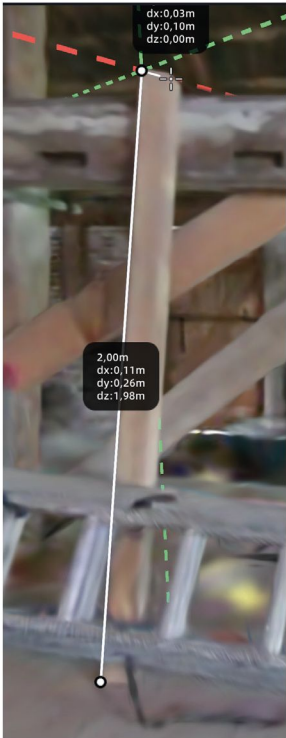


Fig. 4.4.21: second reference measurement seperate Project



Fig. 4.4.22: second reference points RealityScan



Fig. 4.4.23: mesh RealityScan (before export as pointcloud)

ARCHICAD

Finally, as described in the process diagram (see Fig 4.4.10), we imported our generated point cloud into ArchiCAD. We chose to work with ArchiCAD because it offers an intuitive workflow and a smooth 3D navigation for handling point clouds.

Importing a point cloud into ArchiCAD is very simple. ArchiCAD itself also is easy to learn, and there is not much prior technical knowledge needed to become familiar with the program. Compared to a mesh, the 3D view and navigation, of the pointcloud, within the model works flawlessly.

Here, it is now possible to generate sections from the 3D model and use them as the basis for 3D model construction.



Fig. 4.4.24: section pointcloud ArchiCAD



Fig. 4.4.25: pointcloud ArchiCAD

5

EVALUATION

To assess the overall performance of the workflow, its prerequisites, applicability, and results are discussed in the following section:

PREREQUISITES

Aside from access to a camera and a laptop, this method poses no additional financial barriers.

APPLICABILITY

The process is simple in that it involves only a few steps and programs.

However, some of these steps are very time-consuming and prone to errors.

To achieve high-quality results, particular attention must be paid to the preparation and scanning process, as errors here can render the final result unusable. Common sources of error and challenges include:

within preparation

- poor lighting of the scene
- moving objects or people
- wet or reflective surfaces
- heavy light contrasts
- direct sunlight

whilst scanning

- incorrect camera settings (underexposure/overexposure, camera shake, shallow depth of field)
- insufficient overlap (the software cannot stitch the images together)
- too few images / blind spots (too few images for parts of the room result in low accuracy)
- insufficient movement during the scan (each image must be taken from a different position)

If these errors are avoided, the dataset will be in the best possible condition for further processing.

In RealityScan, we've described the workflow in detail with the step-by-step guide (see Appendix). While it took us quite a bit of experimentation to get the hang of the software, the program's interface is actually quite intuitive. The tools and menus are also explained in great detail on the "Help" page within the file, and there is a wide range of video tutorials available online.

If you follow the instructions and guidelines carefully, you'll end up with a truly accurate point cloud or mesh.

A detailed review of the three scan attempts and their resulting datasets shows:

	Fuji	Sony	Fuji Video
processed images	236/251	335/351	538/723
resolution	48MP	24MP	8MP
pictures	236/251	335/351	538/723
polycount	280 mio	130 mio	110 mio

As already described in the Data Processing section, the video model stands out due to its significant artifacts and blind spots. We suspect that recording a video might give a false sense of security regarding the amount of footage captured, leading to a less precise route and angle coverage.

However, even well-lit areas have noticeably less detail than the other two models. This is clearly related to the lower resolution. And in addition to this, the camera doesn't change

it's settings during the video capture, so it isn't possible to make slight adjustments to the ISO. As previously described, the two photo models are more comparable.

We were able to attribute the differences in image quality here to the cameras' low-light performance - specifically, the image noise in the captured photos.

Due to the dim lighting on site, both cameras had to shoot at a high ISO, which increases noise. Added to this is the difference in sensor size between the two cameras. Full-frame sensors are more than twice as large as APS-C sensors, making them clearly superior in low-light conditions.

That's why the Sony camera was able to produce the higher-quality model despite being half the size. In good lighting conditions, however, we found that the Fuji, with its twice-as-high resolution, was able to produce models with greater accuracy.

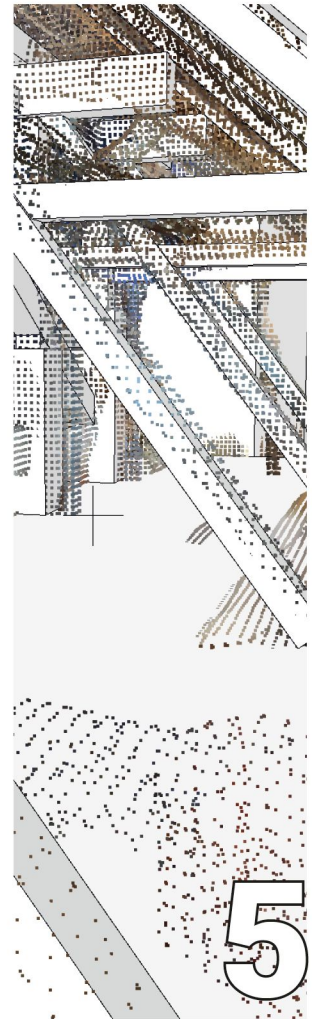
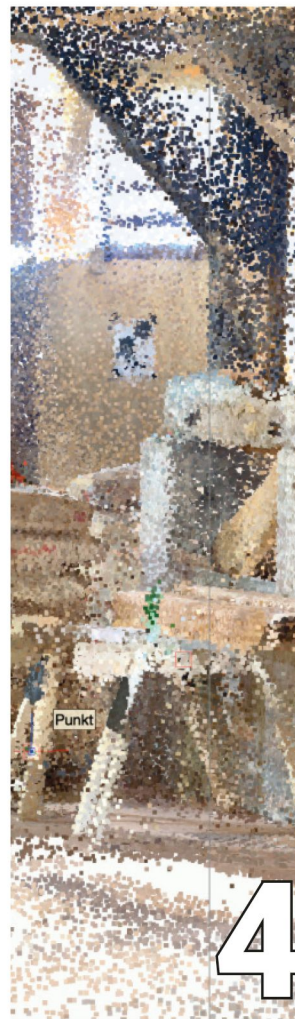
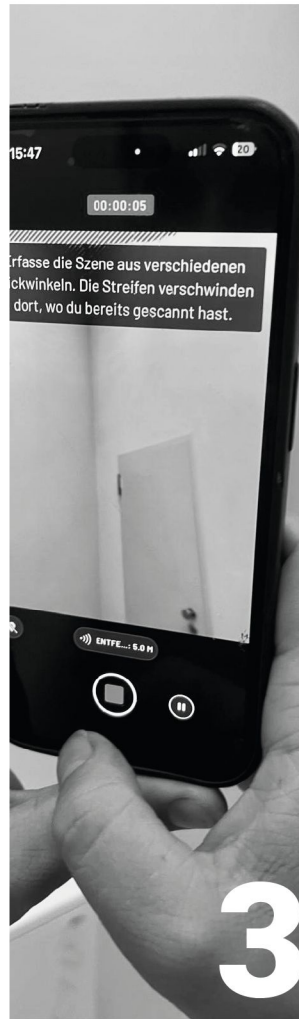
Depending on the scenario, you should therefore consider wheather quality, light sensitivity or resolution is most important.

05 LIDAR - APPS



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1

INTRODUCTION



Emma Stiehle



Ben Kröger



Emma Göpfert



Gloria Knopf

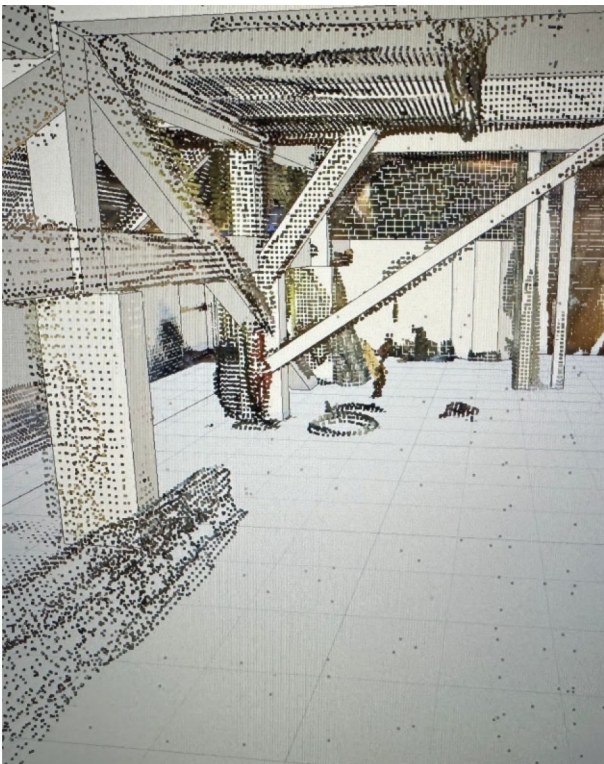


Fig. 5.1.1: Cross-fades between the 3D model and the point cloud from Scaniverse Classic

DESCRIPTION

How can we achieve the best possible digital building survey using resources available to many people? This is the key question that motivated us to take a closer look at LiDAR technology – which is found in most mobile phones – and to test out various apps. The only hardware required for this type of digital building survey is a smartphone with LiDAR capability, a scanning app installed on it, and a laptop. The apps used here access the LiDAR scanner built into newer Apple devices (iPhone Pro models from the iPhone 12 Pro onwards and iPad Pro models from 2020 onwards). LiDAR (Light Detection and Ranging) measures distances by emitting laser light pulses and detecting their reflections. The device calculates precise depth data of the surroundings from the transit times. These measurements can be used to determine distances and capture spatial information. This enables the creation of three-dimensional models of objects and buildings.¹

A more detailed description can be found in last year's paper *Accessible Techniques for Digital Building Surveying*².

To begin with, we tested a wide range of scanner apps. However, only three applications proved suitable for further processing into a usable CAD model: Scaniverse Classic (version 5.2.5), Scaniverse New (version 5.2.5) and Vectorworks Nomad. These apps can be used to create pointclouds, meshes and Gaussian splats. The applications that were ruled out include, amongst others, Polycam, RealityScan

1 cf. Bastian Plaß und Thomas Klauer. "Potenziale von LiDAR-Smartphones und Machine Learning zur Bewertung der altersgerechten Nutzbarkeit von Wohnraum". AVN 131 (2024): 31.

2 cf. Bernd Dahlgrün and Till Rudolph, with students. "Accessible Techniques for Digital Building Surveying". student research project, HafenCity University Hamburg, 2024, HCU Repository.

and iTwin Capture, which were not considered further due to limitations in scan quality or features that required payment. The three apps are briefly presented below (according to the providers) – at the end of the chapter, they are listed again in a comparative table and described in terms of their actual use.

Scaniverse Classic is well suited to smaller rooms and individual objects. Processing takes place directly on the smartphone, so no cloud connection is required. Gaussian splats, meshes and pointclouds can be exported.³

Scaniverse New is designed for larger projects such as entire buildings, large interior spaces or outdoor areas. Processing takes place in the cloud and also allows multiple scans to be merged. The available output formats are Gaussian Splats, meshes and VPS maps, although VPS maps are not relevant to our use case.⁴

Vectorworks Nomad is particularly well suited if the scan data is to be further processed in Vectorworks at a later stage, as the scan file can be easily opened and worked on in Vectorworks without the need for additional interfaces. If required, the data can also be converted into other formats after export.⁵

CAD and post-processing programmes used is required for further processing of the scan data. MacBooks of various generations were used for this project. The software required consists of scanning apps, which can be downloaded free of charge from the App Store. For this project, Scaniverse Classic (version 5.2.5), Scaniverse New (version 5.2.5) and Vectorworks Nomad were used. The CAD and post-processing programmes Archicad, Vectorworks, Blender and Rhino were used to process the scanned models.

REQUIREMENTS

The hardware required for scanning is a smartphone or tablet with LiDAR functionality (iPhone Pro models from the iPhone 12 Pro onwards, and iPad Pro models from 2020 onwards).

A computer or laptop capable of running the

3 cf. Niantic Spatial. "Niantic Spatial Scaniverse Frequently Asked Questions". Accessed 22.06.2026. <https://www.nianticspatial.com/faq/scaniverse>

4 cf. Niantic Spatial. "Niantic Spatial Scaniverse Frequently Asked Questions". Accessed 22.06.2026. <https://www.nianticspatial.com/faq/scaniverse>

5 cf. Vectorworks. "Mobiles Scannen in Vectorworks". Accessed 22.07.2026. <https://www.vectorworks.de/news/mobiles-scannen-vectorworks>

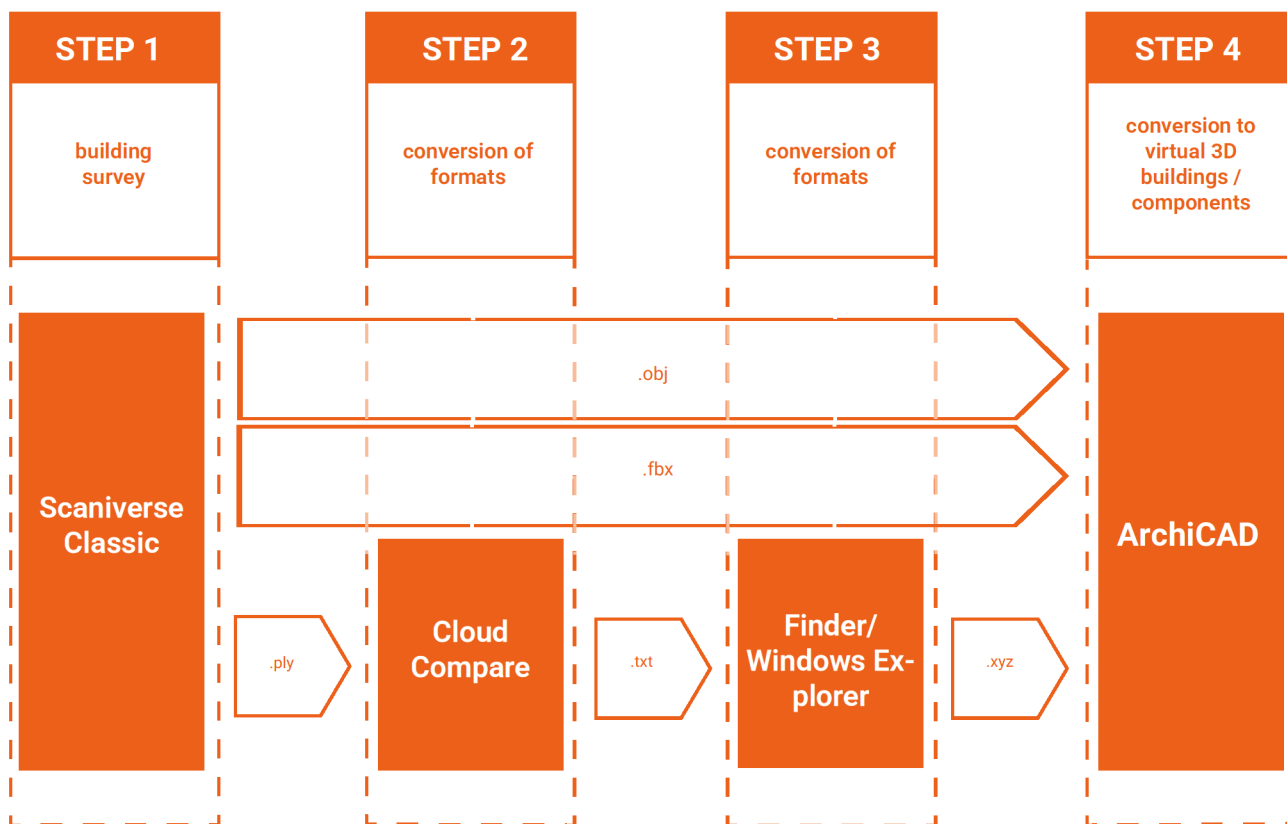


Fig.5.1.2: Schematic diagram of Scaniverse Classic procedure

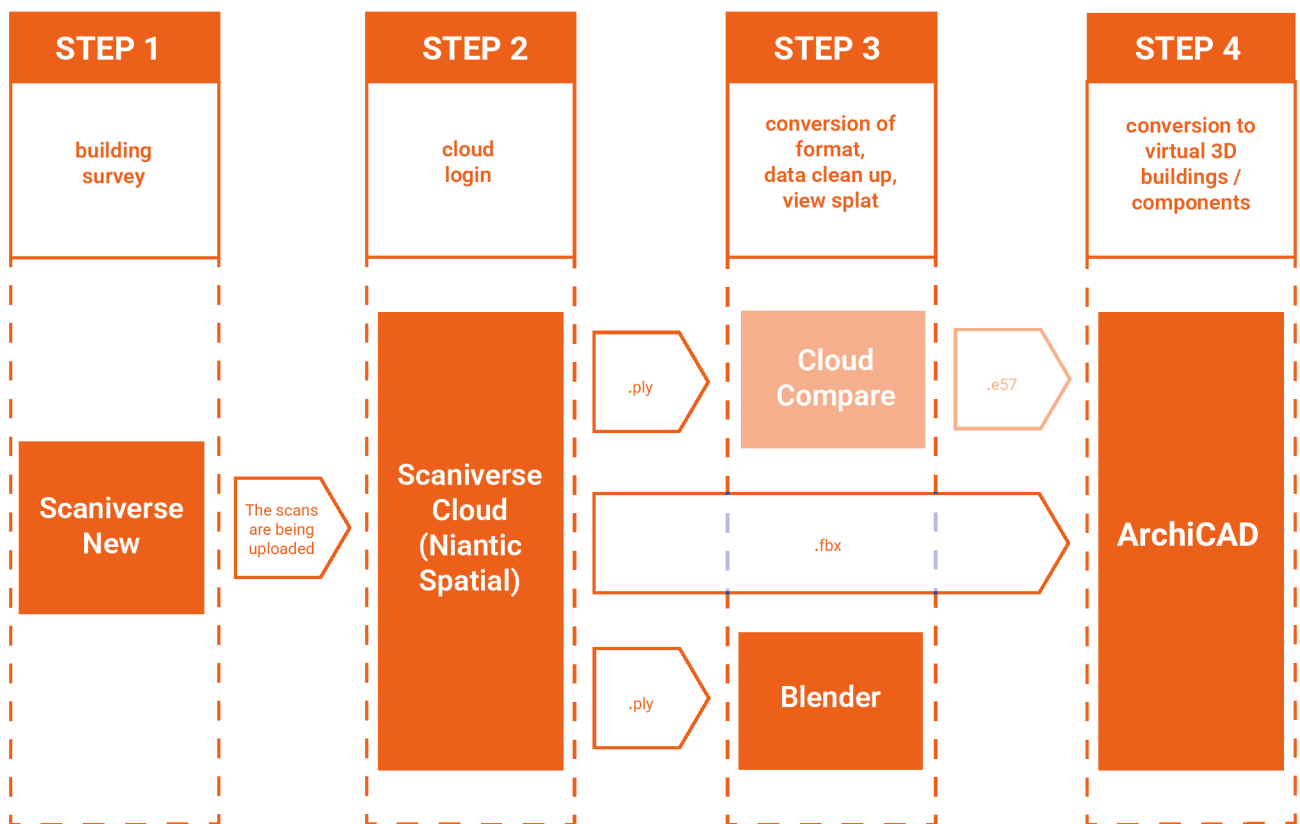


Fig. 5.1.3: Schematic diagram of Scaniverse New procedure

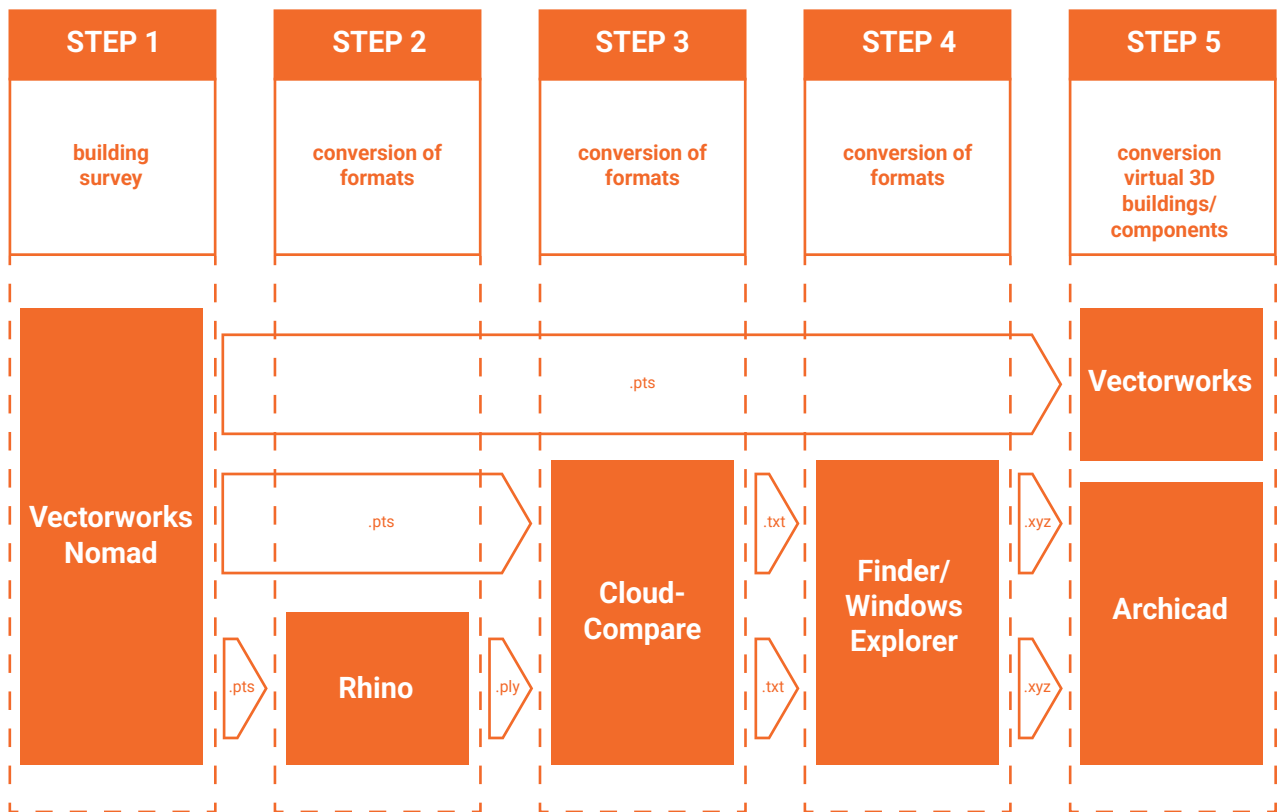


Fig.5.1.4: Schematic diagram of Vectorworks Nomad procedure

2 PREPARATION

RESEARCH AND INSTALLATION

Before deciding which apps to use for the final scan at the Hufnerhaus, we tested a number of popular scanning apps. These included Scaniverse Classic (version 5.2.5), Scaniverse New (version 5.2.5), Vectorworks Nomad, Polycam, RealityScan and iTwin Capture. For the test scan, we chose a room at HafenCity University which is located inside the building, is artificially lit and therefore always has consistent lighting conditions. Using a laser rangefinder, we measured this room to obtain reference values for comparing the scans from the various apps. This enabled us to assess the image quality and precision of the LiDAR scanning apps.

We have decided to use the Scaniverse Classic, Scaniverse New and Vectorworks Nomad apps for the scan of the Hufnerhaus, as these apps offered the best combination of scan precision and image quality for large spaces, as well as the best post-processing capabilities for our needs.

The apps can be downloaded from the Apple App Store. To use the Scaniverse New and Vectorworks Nomad apps, you must either create an account within the respective app or log in with an existing account. In the Scaniverse app, you can choose between Scaniverse Classic and Scaniverse New; however, unlike Scaniverse New, no login is required to use Scaniverse Classic.

BEFORE THE SCAN

Based on the preliminary study carried out at HafenCity University, several criteria were identified that are important for a successful scanning process:

- The camera on the device being used should be cleaned before the scan begins and kept free of dirt or fingerprints so as not to affect the image quality.
- The mobile device must have sufficient battery charge to avoid interruptions during the scanning process.
- Furthermore, it is essential to prepare the rooms to be scanned properly. This includes opening doors (or closing them if a single room is to be scanned), removing any obstructing objects, and ensuring that no changes occur during the scanning process. Highly reflective surfaces should be covered, as these negatively affect image quality and make it difficult for the scanner app to recognise the surfaces.

The Hufnerhaus does not offer ideal conditions for carrying out a scan. There were numerous large pieces of furniture on site which could not easily be moved for the scan. Furthermore, doors and windows could not be opened, meaning that reflections on glass surfaces could not be avoided. In the following, we will examine the extent to which these conditions affected the quality of the scan results.

3 SITE MEASUREMENT

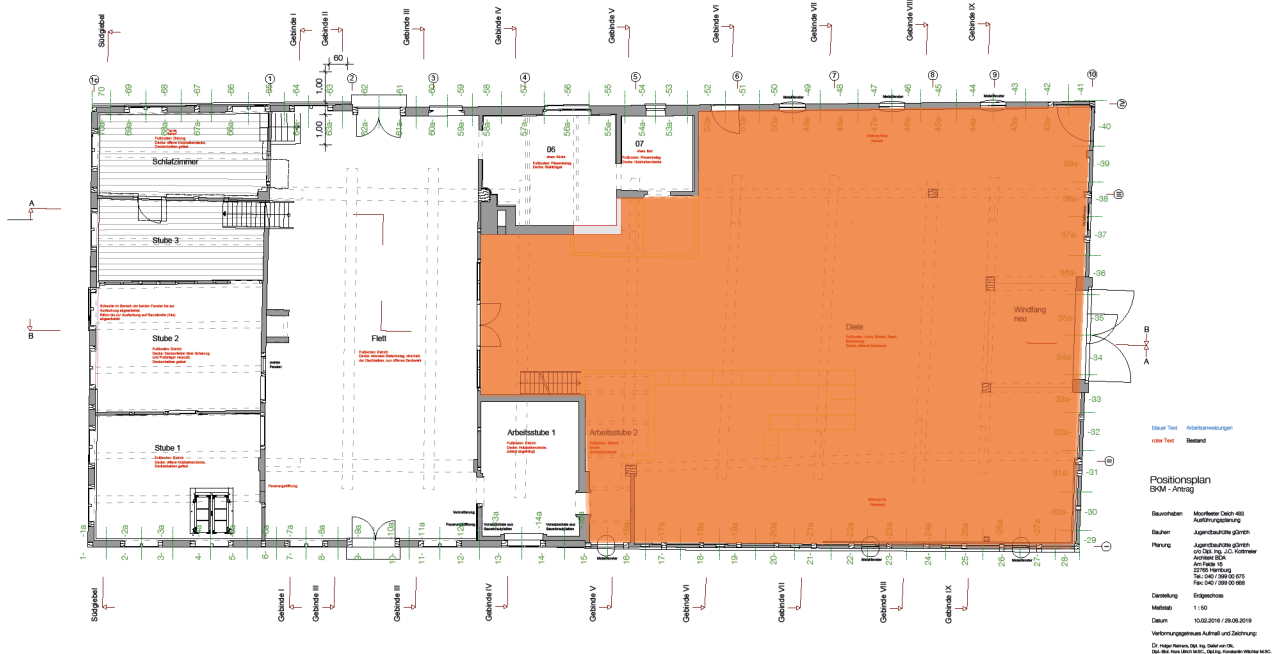


Fig. 5.3.1: floor plan Hufnerhaus scanned area

IN GENERAL

We began by carrying out an inspection of the farmhouse, both inside and out. In consultation with the groups who were testing other scanning methods on site, the responsibilities for the respective areas to be scanned were defined. We were assigned to scan the large main room of the Hufnerhaus – this covers an area of approximately 200 m² (see Fig. 5.3.1).

The scans started then simultaneously using the respective smartphones and various apps in different areas of the room. The scanning process is generally intuitive across all apps, as the areas already scanned are visually highlighted within the apps' camera mode. Nevertheless, several cross-app aspects were identified during the process that are important for successful, high-quality data collection:

- The smartphone should be moved smoothly and slowly; avoid jerky movements.
- To ensure reliable data capture, care must be taken to ensure uniform and adequate lighting; situations involving strong back-lighting should be avoided.
- All areas should be scanned with sufficient overlap. Critical features, such as corners, recesses or technical installations, should be scanned several times if necessary.
- Differences in height, particularly steps or landings, should be measured from as close a distance as possible to ensure accurate measurement.
- Encounters with other people during the scanning process can be avoided by deliberately moving out of their way or by changing the direction in which the device is moving. This made it possible, in this particular case, for several people to carry out scans at the same time.

- The maximum scanning distance specified by the respective applications must be taken into account, as this has a significant impact on the accuracy of data capture.
- A continuous scan without interruptions usually produces better results; however, not all applications support continuous scanning without a pause.

SPECIAL FEATURES SCANIVERSE CLASSIC

The Scaniverse Classic version can be selected directly within the Scaniverse app. It is not essential to create a user account to carry out scans, so the scanning process can be started straight away.

The app initially offers the option to capture scans either as a mesh or as a splat. The mesh function was used for the digital capture of the Hufnerhaus. The main reason for this decision was that Splats can currently only be processed to a limited extent in Archicad. Furthermore, capturing Splats is more time-consuming and, compared to meshes, fewer export formats are available.

Navigation during and after the scan is relatively intuitive, as the app provides recommendations on the most suitable processing and saving methods depending on the object being captured. Once the scan is complete, the model is saved to the app's library. From there, various export formats are available, including point clouds in .ply format and 3D mesh models in .fbx and .obj formats. The desired export format can be selected at any time afterwards within the library.

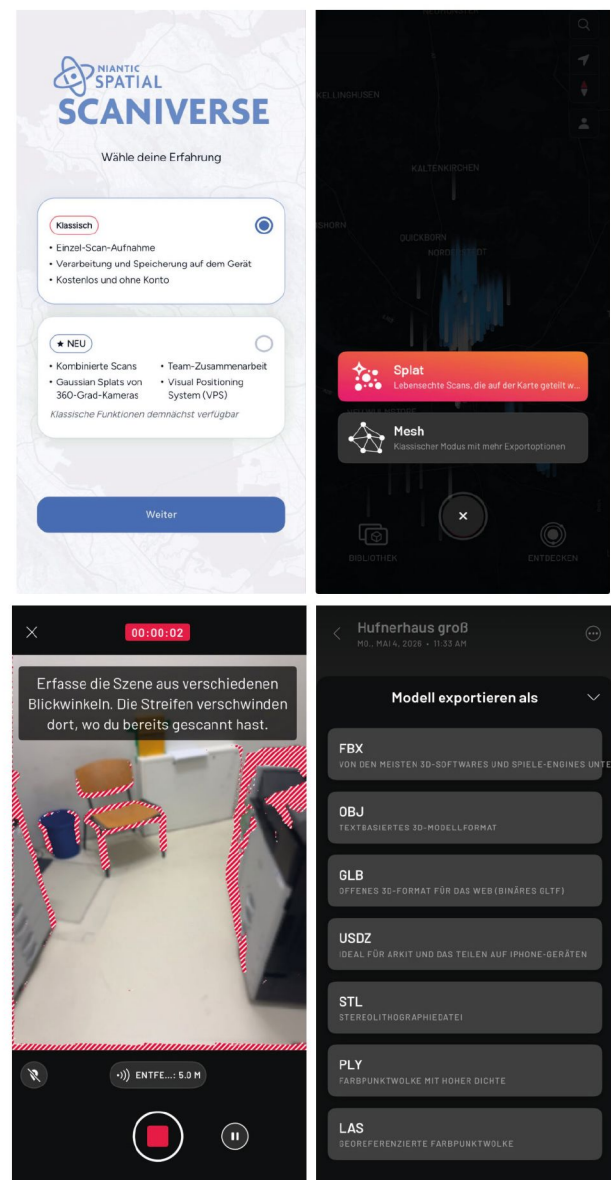


Fig. 5.3.2 - 5.3.5: App usage site measurement scaniverse classic

SPECIAL FEATURES SCANIVERSE NEW

The new version of Scaniverse can be accessed via the same „Scaniverse“ app. We decided to test the cloud-generated creation of Gaussian splats in particular with the new version of Scaniverse, as this function is highlighted by the provider as a key feature of the new version. Furthermore, Scaniverse New promises high-quality scanning even of large rooms and environments.⁶

As we assumed that the scanning technology used to create meshes and pointclouds is identical to that of the Scaniverse Classic version, we decided not to rescan the Hufnerhaus for these data types. When using the new version, a number of specific conditions and restrictions must be taken into account: The duration of a single scan is limited to a minimum of 15 seconds and a maximum of 5 minutes. Once this time limit is reached, the scan ends automatically.

For this reason, the Hufnerhaus was scanned in several consecutive partial scans. During the scanning process, as with other applications, areas that have already been scanned and those that have not yet been scanned are visually highlighted.

Once the scan is complete, it can be viewed in the app and the data must be uploaded to the cloud in order to export the file. The duration of this process depends largely on the length and complexity of the scan and may therefore take some time. In the case of the Hufnerhaus, the upload process took around an hour. During this time, the application must not be closed, as this could result in data loss. After using the „Generate Assets“ function, the scan can be previewed either as a „Gaussian Splat“ or as a mesh (see detailed instructions in the appendix). The scan of the large room in the Hufnerhaus used up approximately 11,000 of the 20,000 free credits. A key point to note when using the new version of Scaniverse is

6

cf. Niantic Spatial. „Scaniverse FAQ“. Accessed 28.06.2026. <https://www.nianticspatial.com/en/faq/scaniverse>

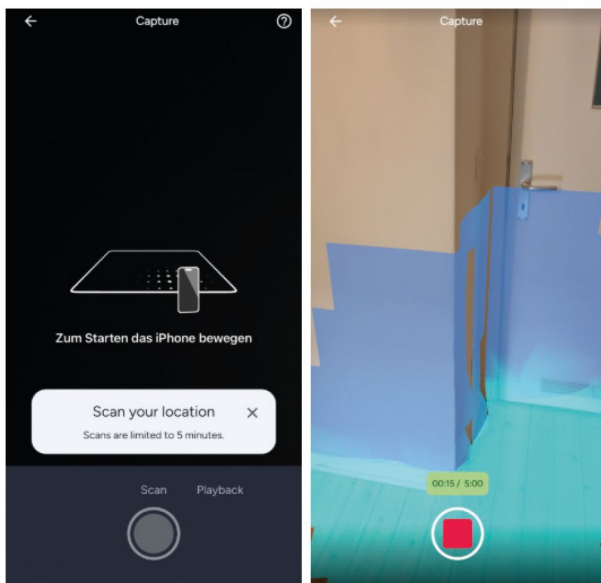


Fig.5.3.6: App usage site measurement Scaniverse New



Fig. 5.3.7: scanned object in app Scaniverse New

that it is not possible to export the generated data directly via a smartphone.

Instead, you must log in to your Scaniverse account via a desktop PC. This restriction is not explicitly mentioned within the mobile app beforehand. It is only in the web-based version of Scaniverse that the available export options become fully visible. The export can then be carried out in various file formats. For the mesh, these are .fbx and .glb; for the Splat, they are a compressed .spz and an uncompressed .ply.

SPECIAL FEATURES VECTORWORKS NOMAD

„Vectorworks Nomad“ can be used with a Vectorworks account and a valid, activated Education licence.

To create a pointcloud using the Vectorworks Nomad app, select „Punktwolke“ from the app menu and start the scanning process. There is no time limit on the scanning process; however, it is recommended that a larger room, such as the main room of the Hufnerhaus, be divided into several scans, as otherwise saving the scan can take a very long time. However, if the room is divided into several scans, it is important to ensure that the scans overlap to some extent, so that they can be more easily assembled into a point cloud later on.

Once the room has been scanned, tap „Sichern“. The scan is then processed in the Vectorworks Nomad app and uploaded to the Vectorworks Cloud. Depending on the size of the scan, this may take a few minutes. Once uploaded, the point cloud can be viewed in the Vectorworks Nomad app.

The Vectorworks Nomad app saves pointclouds in the .pts file format. The pointcloud can then be used on a computer. The individual scans are also stitched together on a computer.

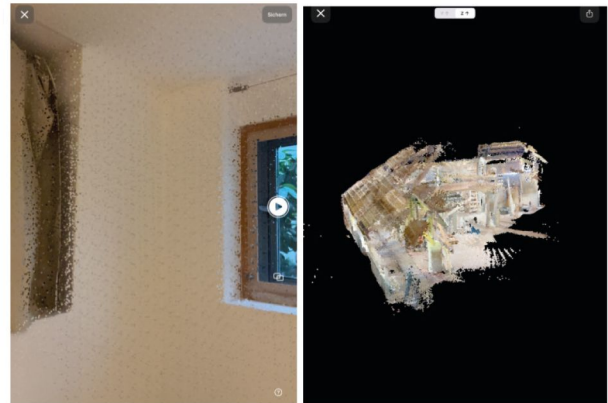


Fig. 5.3.8: app usage site measurement Vectorworks Nomad

4 DATA PROCESSING

SCANIVERSE CLASSIC

Models captured using Scaniverse Classic can be exported in various file formats. Coloured mesh models are available directly as .fbx or .obj files. These can be opened in Archicad either via the „Interoperabilität“ – „Dazuladen“ function in the Storey window, or via „Bibliotheken und Objekte“ – „OBJ oder FBX als GDL-Objekt importieren“ to integrate them into the Archicad library and then place them in the project.

It should be noted that the imported mesh models are not georeferenced or inserted with precise positioning; instead, they must be positioned manually by the user. This is particularly important when merging multiple scans, as

precise alignment of the individual models is required. Merging multiple mesh models in Archicad is challenging due to the absence of, or only partially defined, straight edges. However, alignment can be facilitated by using common reference points that are clearly identifiable in the individual scans and enable the models to be superimposed.

However, when creating a CAD model, meshes should be regarded more as a supplementary data source. Due to their irregular nature and the fact that their edges are often not consistently sharp or straight, they are therefore of limited use for direct superimposition onto a CAD model. Nevertheless, geometric deviations can already be identified in the mesh, which means it can provide guidance for modelling and plausibility checks.

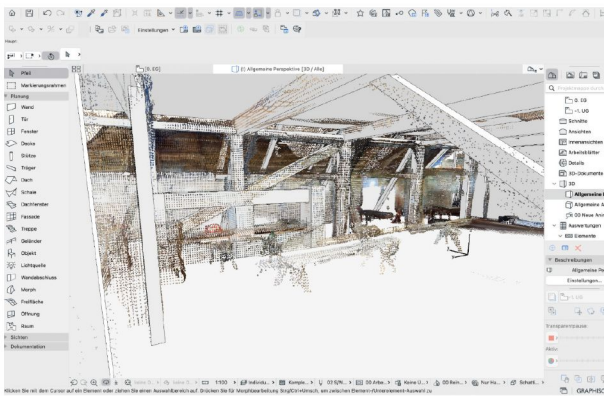


Fig. 5.4.1: Blending the pointcloud with the CAD model

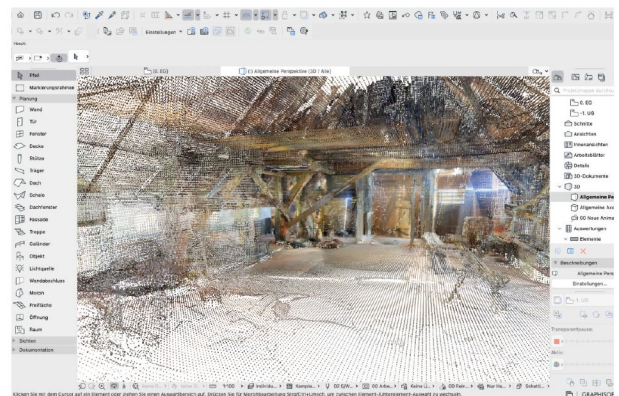


Fig. 5.4.3: The pointcloud in Archicad

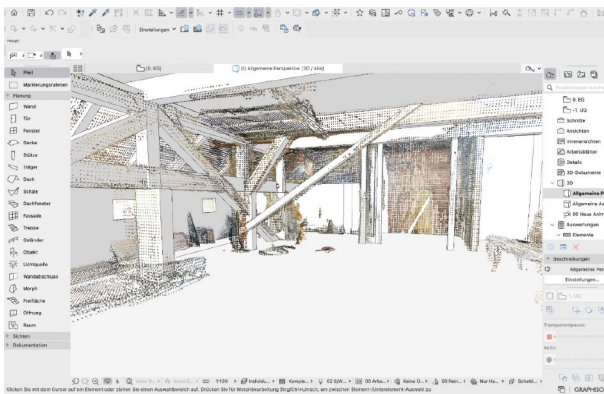


Fig. 5.4.2: Blending the pointcloud with the CAD model

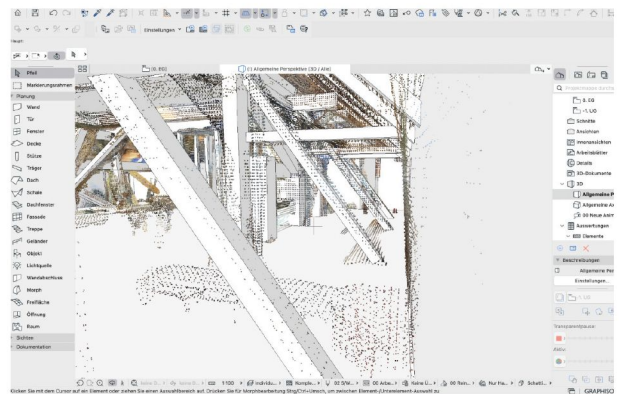


Fig. 5.4.4: Blending the pointcloud with the CAD model

Another aspect concerns the volume of data. Each mesh is exported as a single, contiguous model, which can noticeably slow down performance in the Archicad 3D window, particularly with larger scans. On the positive side, however, the processing time is short: for the scans captured as part of this study, both the export from Scaniverse Classic and the subsequent import into Archicad took less than ten minutes each.

The coloured pointclouds can be exported from Scaniverse Classic in .ply format. As this file format is not directly supported by Archicad, conversion is required first. To do this, the .ply file is exported to .txt format in CloudCompare and then converted to the .xyz format supported by Archicad by renaming the file extension in Windows Explorer or Finder. The point cloud can then be imported into Archicad without any problems via „Interoperabilität“ and „Punktwolken importieren“.

Compared to the mesh models, the pointclouds from Scaniverse Classic have a significantly smaller file size and do not noticeably affect the operating speed in the 3D window. Furthermore, they are particularly well suited for overlaying onto a CAD model, as deformations and geometric deviations are clearly visible in the pointcloud. Particularly good visual comparability is achieved when the CAD model is displayed in white. We created the 3D model based on the pointcloud file, both in the floor plan window and on the 3D plane. In the top view in the floor plan window, for example, the edges of columns are clearly visible, as they are excluded from the points and thus stand out clearly.

A detailed, step-by-step guide to the pointcloud process can be found in the appendix.

SCANIVERSE NEW

Once the splat has been exported from Scaniverse New, the scan is available as a .ply file. This is opened in Blender for further processing. As Blender cannot display Gaussian splats in colour in render mode by default, a suitable add-on must be installed. The 3DGS Renderer from Kiri Engine was used for this study.⁷ The installation and use of the add-on are explained in an online guide.⁸

Once installed, the PLY file can be imported into Blender via drag-and-drop. The Gaussian splat is displayed in colour via the Render menu. Blender's standard navigation and editing functions are then available, allowing the model to be cropped, reduced or optimised. However, there are limitations when it comes to further processing in CAD or BIM programmes. Gaussian splats do not consist of traditional mesh or BIM geometry, but rather of point or splat data, and are therefore not natively supported by programmes such as Archicad. Whilst it is possible to export the splat as a mesh or point cloud, the colour information is lost, particularly when exporting as a point cloud. Furthermore, as no significant advantages over the point clouds generated using Scaniverse Classic could be identified, the use of Scaniverse New is not recommended for further processing in CAD applications.

Detailed step-by-step instructions can be found in the appendix.

7 cf. Kiri Engine. "3DGS Render by Kiri Engine". Accessed 22.06.2026. <https://www.kiriengine.app/3d-tools/3dgs-render>

8 cf. 3DGS Render. "3DGS Render Addon for Blender 2.1 Update – Full Tutorial". YouTube video, 29.11.2024. https://www.youtube.com/watch?v=ubeD3Vp_7hU



Fig. 5.4.5: Gaussian Splat in Blender

VEKTORWORKS NOMAD

The quickest way to use the pointcloud in a CAD or BIM programme is to import the generated point cloud into Vectorworks. As Vectorworks Nomad and the CAD/BIM programme are from the same manufacturer, the integration between the app and the programme is very straightforward. The .pts file can be imported and used in Vectorworks via „Datei“ – „Import“ – „Import Punktwolke“. Once imported, it is easy, if necessary, to align the scans along the x, y and z axes and assemble them by rotating them.

However, as we all use the Archicad CAD programme, our aim was to import and use the pointcloud in Archicad. Archicad does not support the import of .pts pointclouds; it only im-

ports pointclouds in the .xyz and .e57 file formats.

To use the pointcloud in Archicad, we have found the following method: The individual scans can be imported into the „Rhino“ programme as .pts files. In Rhino, the individual pointclouds can be correctly aligned and merged into a single scan. The finished pointcloud can now be exported from Rhino as a .ply file and converted into a .txt file using the Cloud-Compare programme. This .txt file can then be renamed from „filename .txt“ to „filename.xyz“ in Finder/Windows Explorer. It is then possible to import the pointcloud as an .xyz file into Archicad and use it.

Detailed step-by-step instructions can be found in the appendix.



Fig. 5.4.6: Pointcloud in Archicad



Fig. 5.4.9: Blending the point cloud with the CAD model

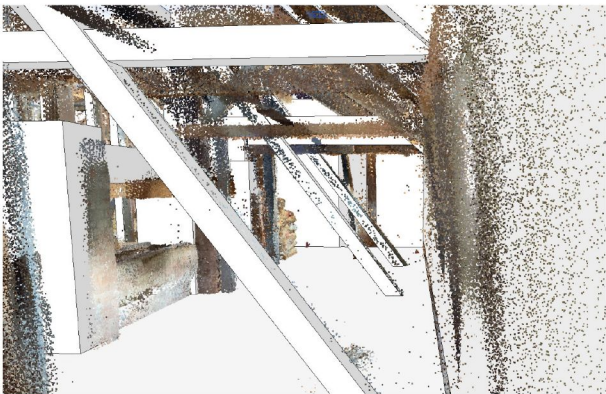


Fig. 5.4.7: Blending the point cloud with the CAD model



Fig. 5.4.10: pointcloud in Vectorworks

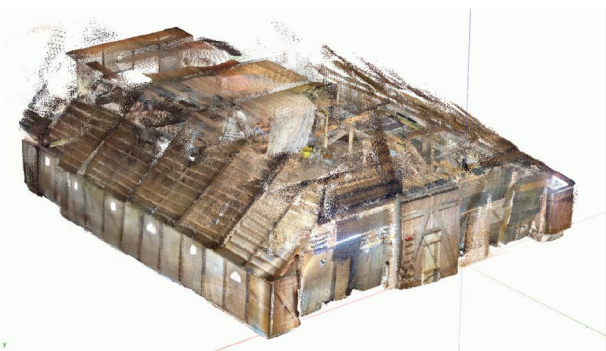


Fig. 5.4.8: pointcloud in Vectorworks

5

EVALUATION

criteria	Scaniverse Classic	Scaniverse New	Vektorworks Nomad
scanning time	Hufnerhaus: 25 min	Hufnerhaus: 25 min. max. scanning time: 5 min	Hufnerhaus: 30 min
kind of model	pointcloud, mesh, gaussian splat	mesh, gaussian splat	pointcloud, mesh
export formats for further processing	.fbx, .obj, .ply, .glb, .usdz, .stl, .las	.fbx, .ply	.pts
file size of the model	.ply: ca. 11,8 MB .fbx: ca. 28,8 MB .obj: ca. 19,3 MB	.ply: ca. 920 MB .fbx: ca. 16 MB	.pts: ca. 600 MB
scan quality	mesh: not all elements captured, overall okay pointcloud: overall good, but the points are less dense	mesh: not all elements captured, overall okay 3DGS: some mistakes, overall okay-good	Overall, good, high density
data processing time	10 min. - 15 min.	60 min. (3 Scans, each 5 min)	15 min. (5 Scans, each 3 min)
postprocessing time	10 min. - 15 min.	40 minutes	30 min. - 45min
usage as CAD file	mesh okay pointclouds good	mesh okay GS not usable	good
accuracy of measure- ments	high accuracy with small deviations of up to half a centimeter. (pointclouds refer to the reference measu- rement)	good accuracy in the meshes with deviati- ons of up to 5 centi- meters	high accuracy with small deviations of up to half a centimeter. (pointclouds refer to the reference measu- rement)
user-friendliness/ app guide during scan	Good, shows very well where already scanned and easy to navigate	good, shows very well where to scan and where already scan- ned	Good, but sometimes long loading times
overall rating	●●●●○	●●○○○○	●●●○○○

Fig. 5.5.1: comparison of the different scanner apps

COMPARISON OF THE MEASUREMENTS

To evaluate the scan results, reference measurements taken on site at the Hufnerhaus were compared with the corresponding measurements from the models generated from the scans. The pointcloud models from the Scaniverse Classic and Vectorworks Nomad applications, as well as the mesh models from Scaniverse (Classic and New), were used for this purpose. Overall, the scan results from the applications examined demonstrate a high degree of dimensional accuracy. The reference measurements used were the width of the doorway between the entrance hall and the large room, and the height of the vestibule in the large room of the Hufnerhaus. When evaluating the pointclouds, however, it must be borne in mind that the measurement results may vary depending on the chosen measurement position. This is due in particular to the differing point densities of the generated pointclouds. The pointcloud model from Vectorworks Nomad has a significantly higher point density than that of Scaniverse Classic. This allows measurement points to be placed more precisely on the actual object edges. In the

less dense pointcloud model from Scaniverse Classic, even a slight offset to the left or right when selecting a measurement point can lead to measurable deviations. Point density is therefore a key factor influencing the accuracy of measurements derived from pointclouds.

At the same time, the lower point density of the Scaniverse Classic model offers the advantage of greater clarity. Individual measurement points can be identified and selected more easily, which can make it easier to navigate the pointcloud, particularly during manual measurements. There is therefore a trade-off between a high point density, which enables more precise measurements, and a lower point density, which improves usability and clarity.

The CAD model was created on the basis of the pointcloud from Scaniverse Classic. When the pointcloud from Vector Nomad was overlaid onto the CAD model, deviations of up to 25 cm were observed. Nevertheless, when superimposed on the CAD model, both pointcloud models enable a reliable identification of the geometric deformations of the Hufnerhaus. For example, it becomes clear that the external wall is not perfectly straight. Similarly, the unevenness of the floor, which slopes down towards the rear

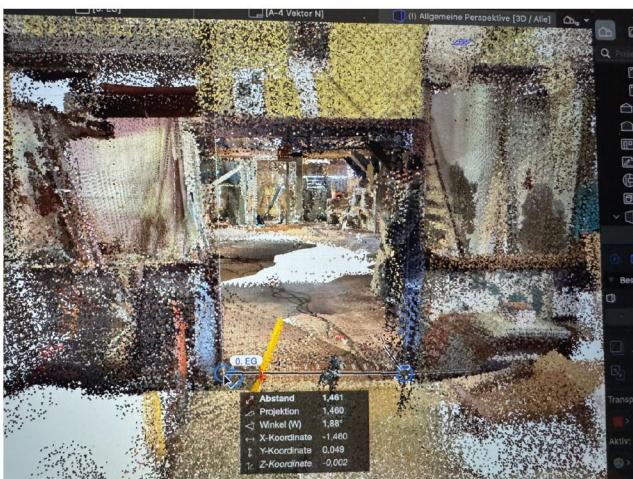


Fig. 5.5.2: measurement vektorworks nomad

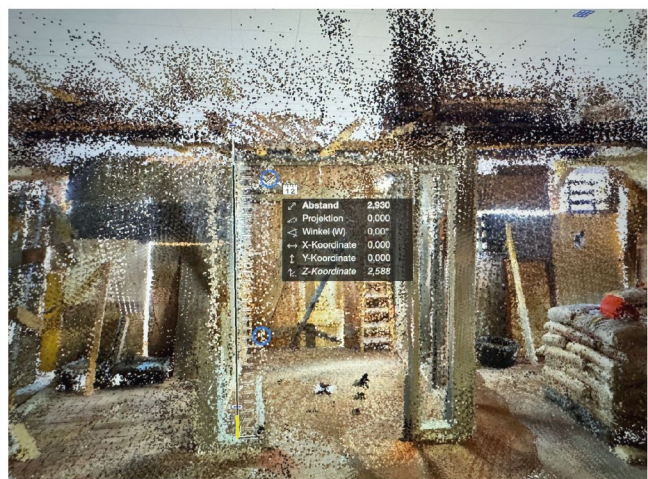


Fig. 5.5.3: measurement vektorworks nomad

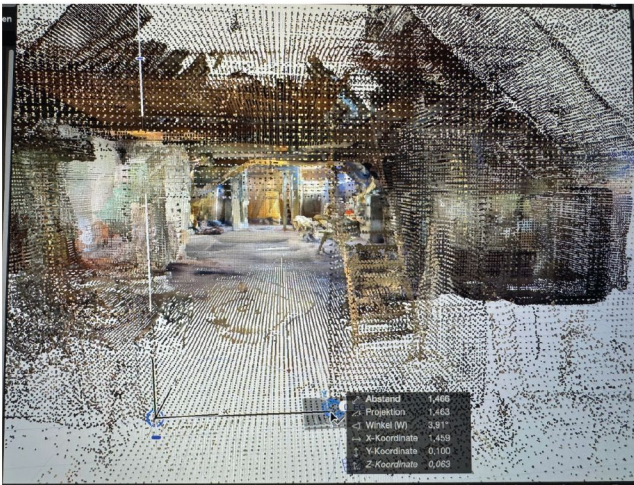


Fig. 5.5.4: measurement scaniverse classic

of the room, is clearly visible.

These deformations can be traced in both pointcloud models and thus provide a valuable basis for analysing the building stock.

- Reference dimensions: door to the large room: 1,46 m / height porch: 2,90 m
- Vectorworks Nomad - Pointcloud: 1,461 m / 2, 93 m
- Scaniverse Classic - Pointcloud: 1,459 m / 2,90 m
- Scaniverse Classic - Mash: 1,454 m / 2,907 m
- Scaniverse New - Mesh: - / 2,95 m

RECOMMANDATION

In our view, of the apps we examined in detail, the Scaniverse Classic app is the most suitable for digital surveying via an app. This app comes closest to meeting the objective set out at the outset: to find a low-threshold and as simple as possible way to scan a building in 3D. The scanning process itself, the export and post-processing stages, and the final result impressed us the most; scanning within the app is intuitive, the export formats for scans from the app are

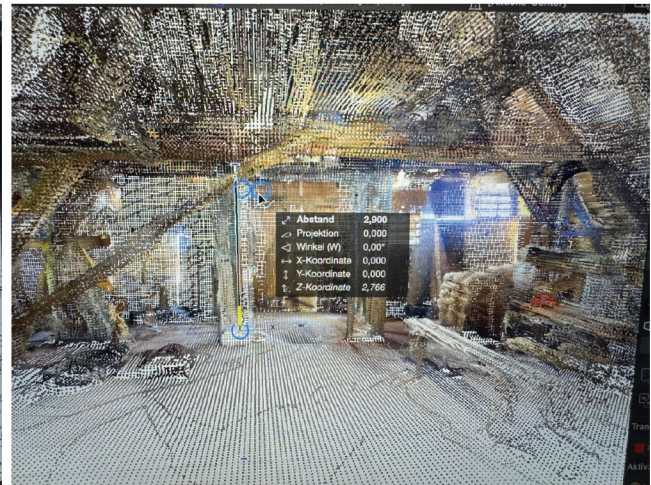


Fig. 5.5.5: measurement scaniverse classic

compatible with Archicad's required import format specifications, and the quality, particularly that of the pointclouds, is impressive. The building can be modelled most effectively using the pointclouds from Scaniverse Classic.

We weren't impressed by Scaniverse New, as it cannot export a usable pointcloud file and the quality of the mesh file is no different from that of the Scaniverse Classic app. At the same time, compared to the Classic version, the app has the disadvantage that a scan can last a maximum of 5 minutes and that only a limited number of scans can be exported. The advantage of the Gaussian Splats does not help us in our intended application, which is a CAD programme. Although Vectorworks Nomad ultimately produces a similar result in the pointcloud file, the process from scanning in the app to generating the pointcloud in Archicad is significantly more complex – furthermore, there is no option for a mesh or Gaussian splat file format.

OUTCOME

CONCLUSION

Today, renovation and refurbishment projects involving existing buildings are typically preceded by a digital survey of the existing structure, with the objective of generating a digital building model at the outset of the project. Such surveys are predominantly carried out using terrestrial laser scanning, mobile mapping systems, and photogrammetric reconstruction. These methods generally produce digital point clouds with geometric accuracies ranging from the millimetre to the centimetre scale.

In recent years, however, a new method of digital building documentation—Gaussian Splatting—has emerged, enabling an exceptionally detailed visual representation of complex building geometries. It is precisely this visual fidelity that distinguishes Gaussian Splatting from geometrically highly accurate point clouds obtained through laser scanning or photogrammetry. Gaussian Splatting is capable of documenting visually significant but fine-scale features that are essential for refurbishment projects, such as crack patterns, material characteristics, and deterioration of the building fabric.

Both point clouds and Gaussian Splatting models can capture valuable information, including deformations, settlements, and other structural irregularities that cannot be adequately represented within conventional 3D CAD models. To prevent the loss of this information, the integration of these data formats into CAD-based planning workflows is of critical importance. Only by superimposing 3D CAD models with point clouds or Gaussian Splatting datasets do these essential characteristics become fully apparent within the digital model. Uneven floors and walls, deformed building elements, settlements, and similar conditions thus become directly visible to planners and conservation professionals.

For this reason, our work has focused not only on the generation of these datasets but also on their integration into CAD-based design processes, which is described in detail in the Appendix.

All five methods investigated produced useful and practically applicable results. However, the documentation workflow based on the Ricoh Theta V proved to be more time-consuming and technically demanding than image acquisition using a digital single-lens reflex (DSLR) camera, without offering any significant advantages. Surveying with a DSLR camera requires careful preparation and a solid understanding of photographic techniques. The quality of the resulting model depends critically on selecting the appropriate camera settings. When these parameters are configured correctly, the method delivers remarkably accurate and virtually error-free results.

The LiDAR-enabled smartphone applications likewise generated surprisingly accurate datasets. Their principal limitations lie in the spatial extent that can be captured and, in some cases, the manageable data volume. In contrast to DSLR-based photogrammetry, however, they require little specialist knowledge, as their operation is highly intuitive and readily accessible to non-expert users.

The DJI Matrice 4E drone and the Lixel K1 handheld scanner are professional-grade instruments costing several thousand euros. When operated correctly, following the procedures described in the Appendix, they produce highly accurate and practically valuable datasets for documenting existing buildings. As the required level of geometric precision and visual detail increases, however, so do the resulting data volumes, necessitating high-performance graphics processing units (GPUs) and powerful computing hardware for efficient processing.

These technologies therefore remain financially out of reach for many students and smaller architectural practices, for whom DSLR-based photogrammetry and LiDAR-enabled smartphone applications represent the most practical and cost-effective alternatives.

APPENDIX

01 MATRICE 4E

APPENDIX

1

PROCESSDIAGRAM

Processdiagram 130

2

STEP-BY-STEP MANUAL

Photogrammetry 132
- WebODM Light-
ning

Photogrammetry 134
- Agisoft
Metashape

Post-Processing 136
- Cloud Compare

BIM-Model 140
- Archicad

1

PROCESSDIAGRAM

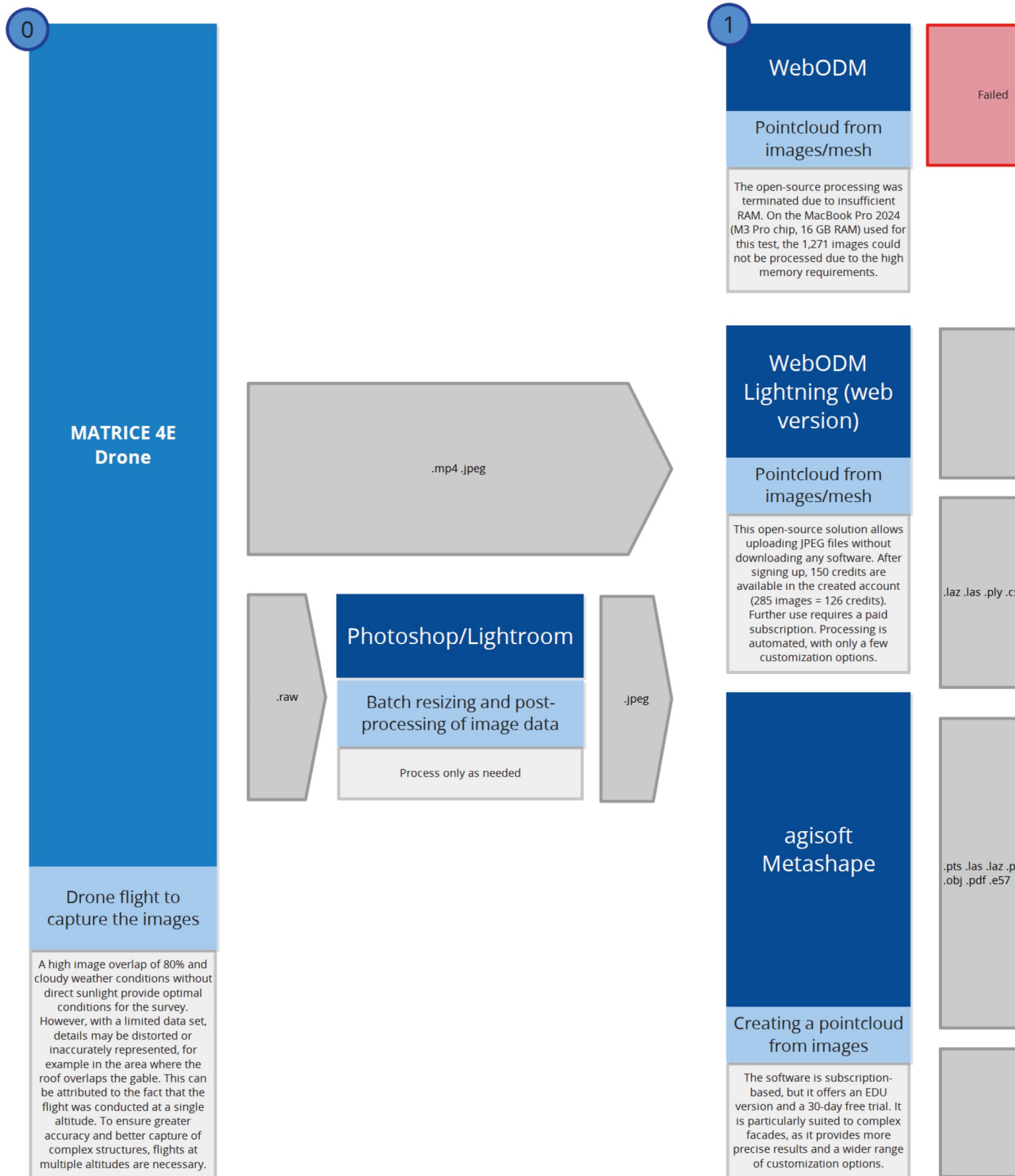
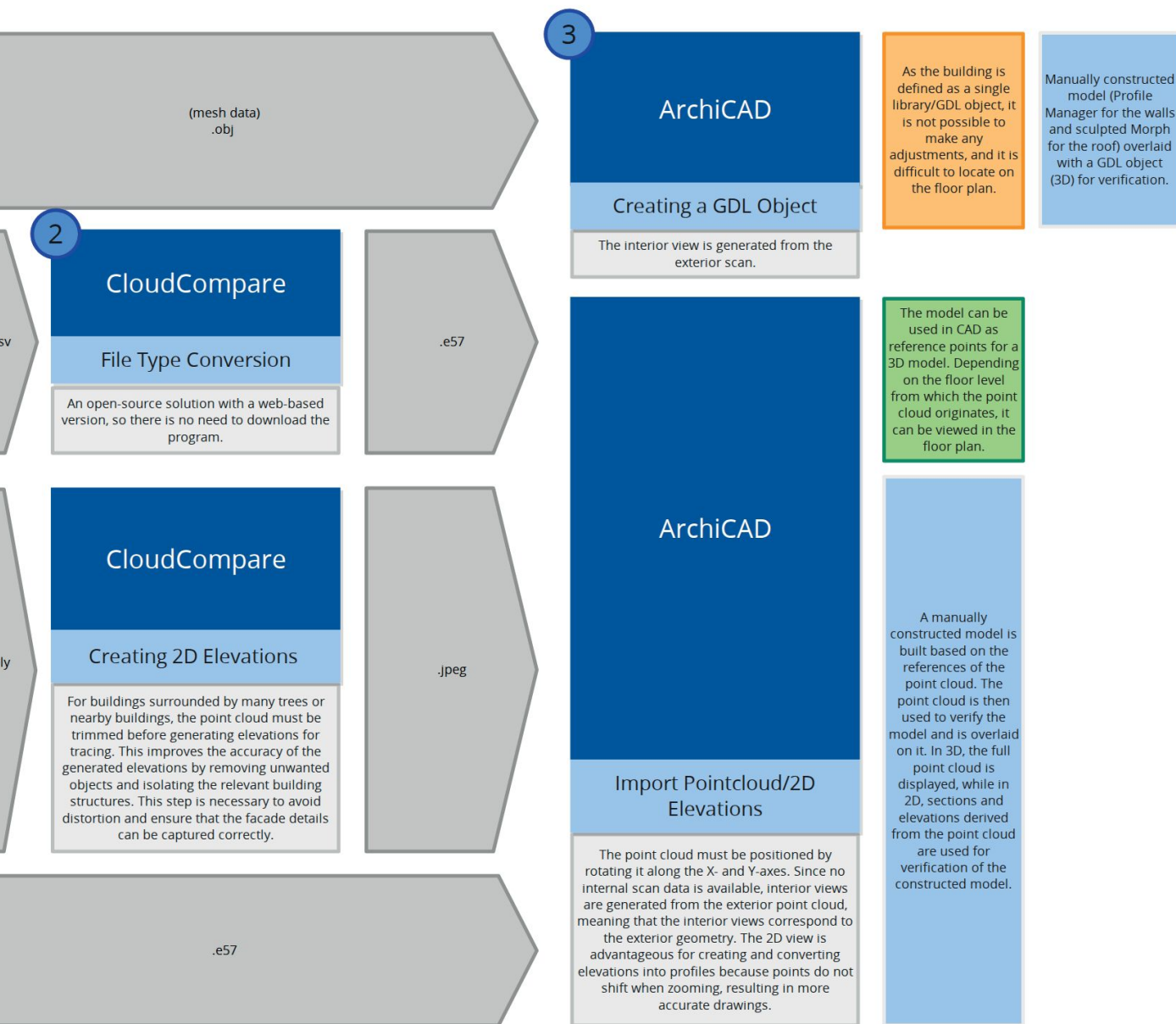
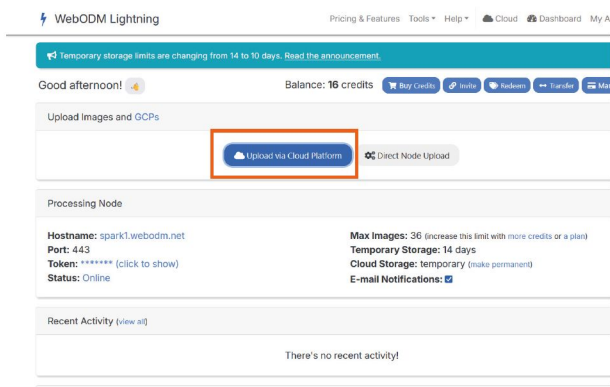


Fig. 1.6.1: Processdiagram



2 STEP-BY-STEP MANUAL



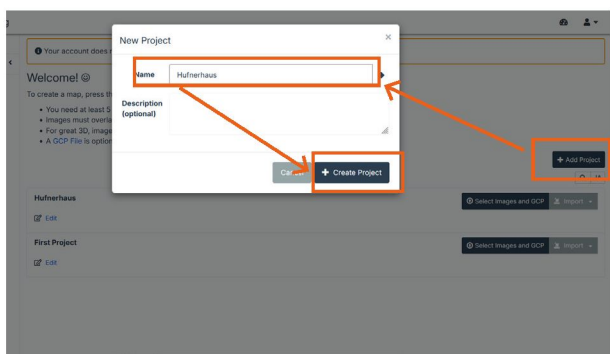
PHOTOGRAMMETRY WebODM Lightning

Start

1. Click „Upload via Cloud Platform“.

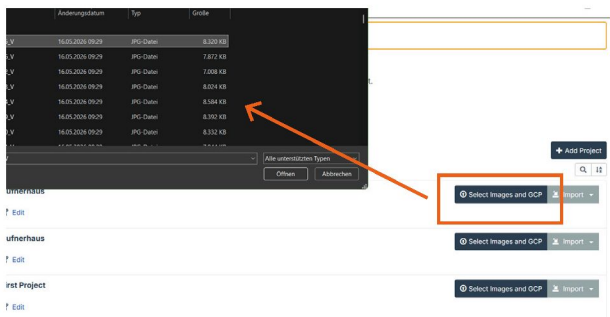
Create Project

2. Click „Add Project“, then enter a suitable project title. Confirm by clicking „Create Project“



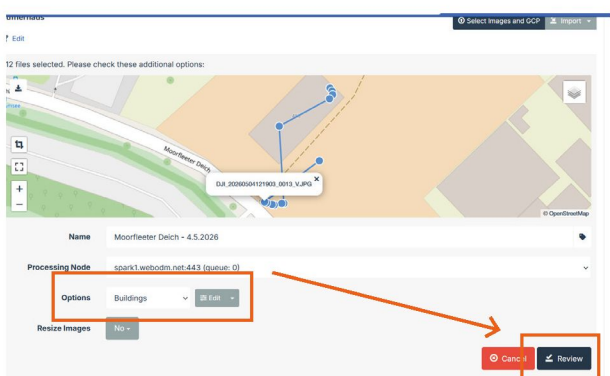
Upload Drone Photos

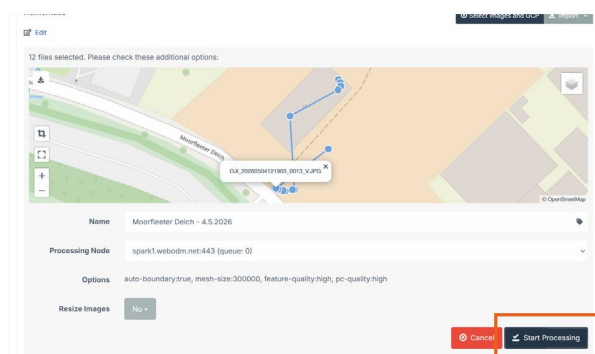
3. Click „Select Images and GCP“, then select all the drone images you want to use.



Make Presets

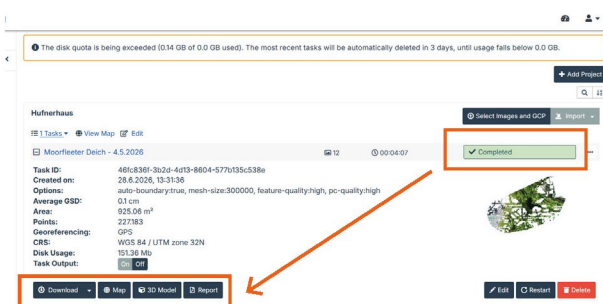
4. Select suitable presets under „Options“, e.g., „Buildings“. If needed, you can click „Edit“ right next to it to adjust deeper settings. Confirm your settings with „Review“.





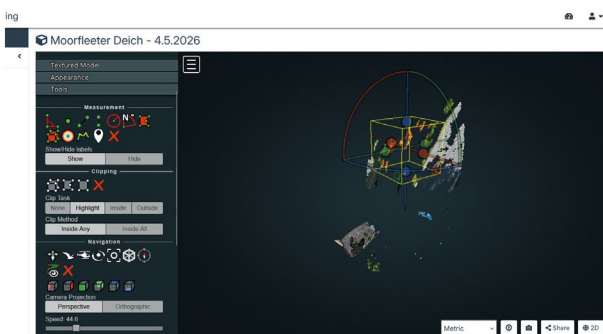
Start Processing

5. Click „Start Processing“ to begin generating the model.



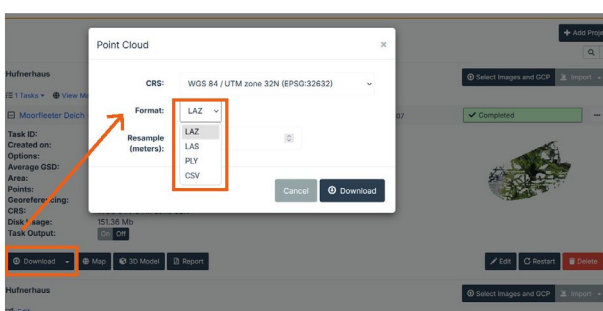
Project Completed

6. After the project has finished processing, the „Completed“ bar will appear green. You now have various options (bottom left). You can download the model directly or view and edit it beforehand. Clicking „3D Model“ takes you to the viewing and editing mode of the model.



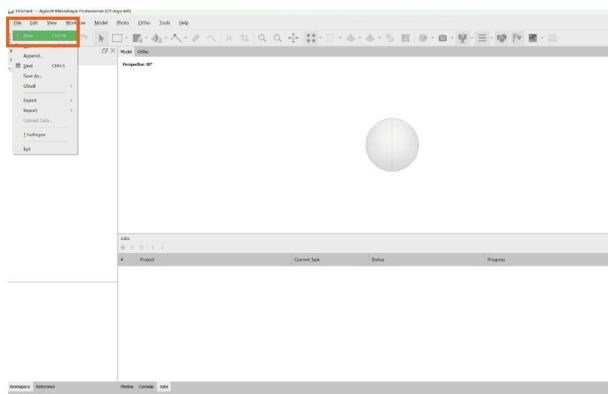
3D Model

7. Here you can inspect the mesh and the point cloud and, if necessary, perform measurements, cleanups, etc., beforehand.



Mode: Download

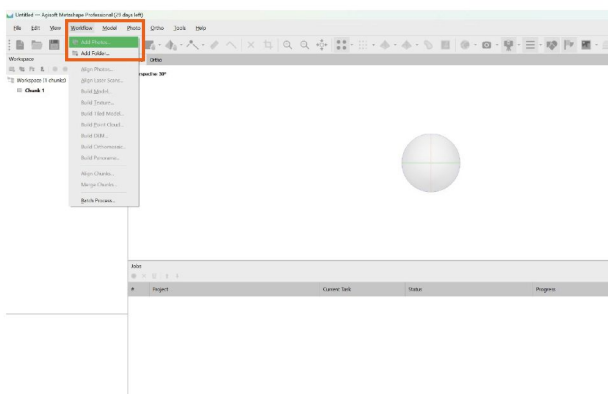
8. By clicking on „Download“, you can choose between different exports (Orthophoto, Point cloud, Textured model/Mesh, and Data). Afterward, you can select which format you want to download. For the Point cloud (see image), you can choose between .las, .laz, .ply, and .csv.



PHOTOGRAMMETRY Agisoft Metashape

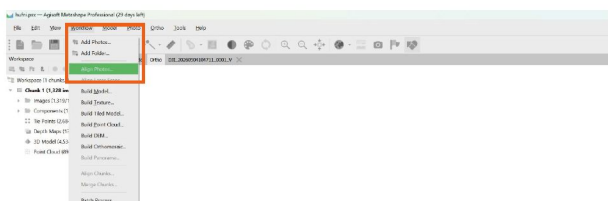
Start: Create Project

1. Start the Agisoft Metashape software. Go to „File“, then „Save As...“ and save the empty project with an appropriate title.



Upload Drone Photos

2. Go to „Workflow“ at the top and click on „Add Photos...“. Select all the drone photos you want to use.



Align Photos

3. Go to „Workflow“ again, click „Align Photos...“ and adjust the values. Example:

Accuracy: High

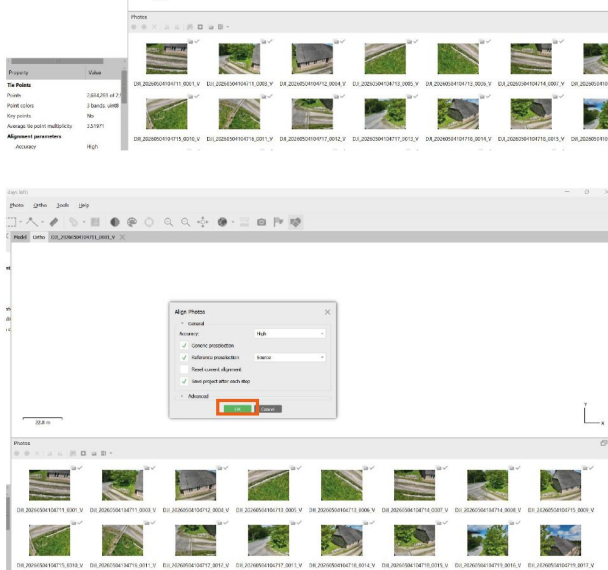
Generic preselection: Enabled

Reference preselection: Source

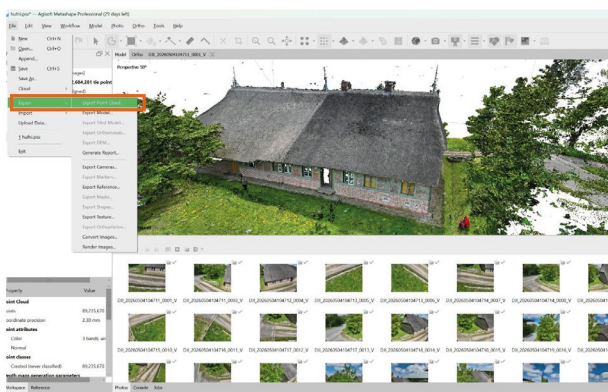
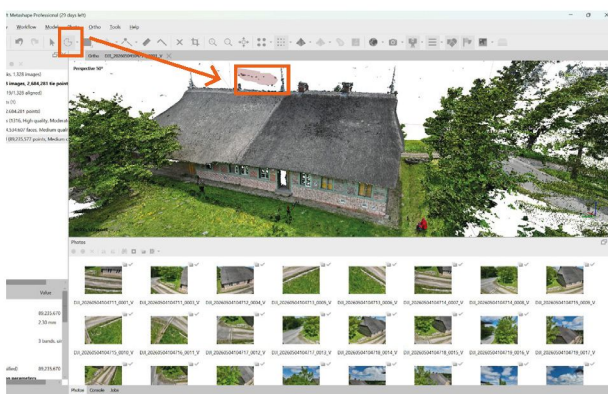
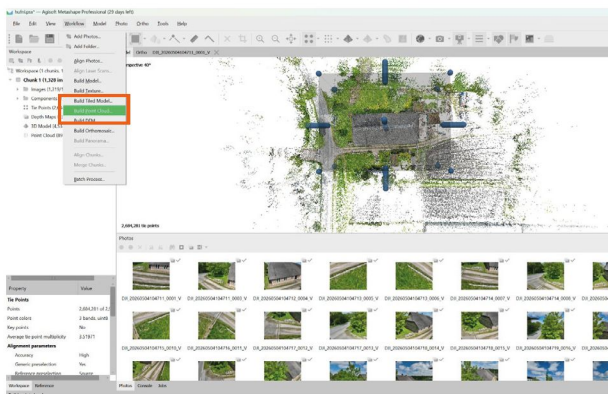
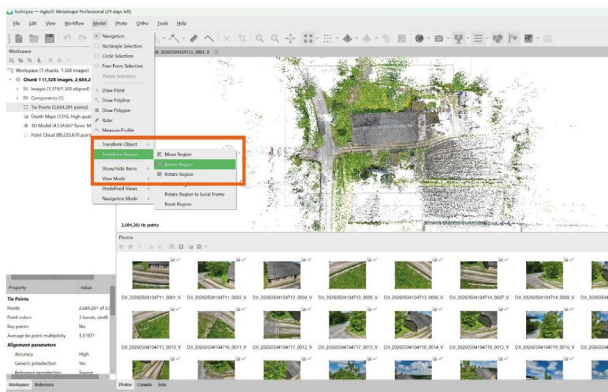
Key point limit: 40,000 Tie point limit: 10,000

Exclude stationary tie points: Enabled

Adaptive camera model fitting: Enabled



4. Confirm all entries with „OK“.



Cropping

5. After the process is complete, a sparse point cloud will be visible. Now, before the dense point cloud is calculated, the cloud can be cropped. To do this, click in the top menu on „Mode“ -> „Transform Region“ -> „Resize Region“.

Generate Point Cloud

6. Go to „Workflow“ and click „Build Point Cloud...“.

Example settings for a good PC:

Quality: Medium (From 1,500 photos onward, setting it to „High“ on systems with less than 64 GB RAM will lead to a system crash).

Filtering mode: Moderate.

Calculate point colors: Enabled.

Click „OK“ to start.

Post-Processing:

7. Once the point cloud is generated, you can access it on the left in the Workspace window by double-clicking the newly generated „Point Cloud“ entry. Now, ghost points can be removed. Use the Lasso tool in the top bar to encircle any artifact points still floating in the air and press Delete (Entf).

Export als Punktwolke

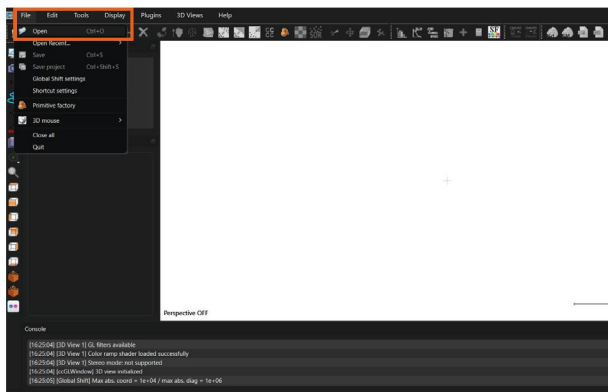
8. Go to „File“ -> „Export“ -> „Export Point Cloud...“. Select .e57 as the file type.

Export settings:

Source data: Point Cloud

Coordinate System: Local Coordinates (m)

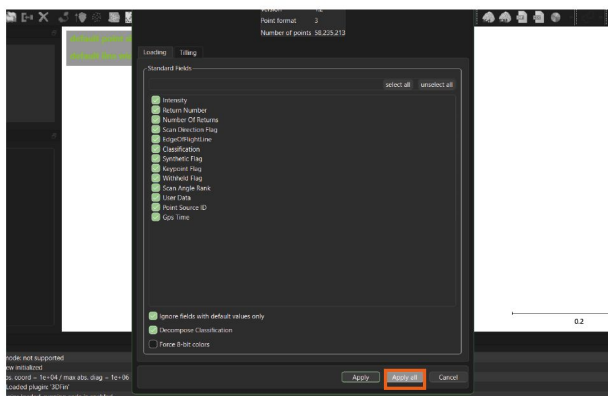
Point attributes: Check the boxes for Color and Normal



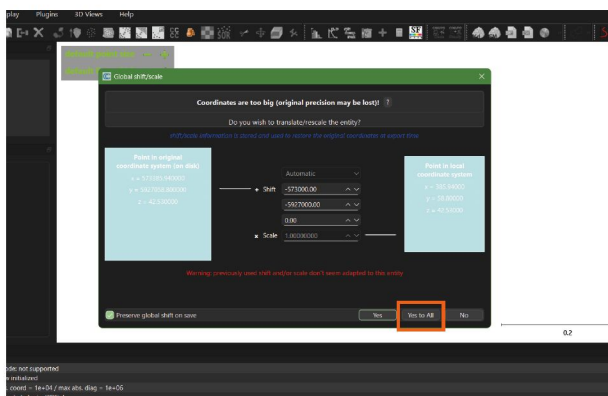
POST-PROCESSING: CloudCompare Change Format

Start:

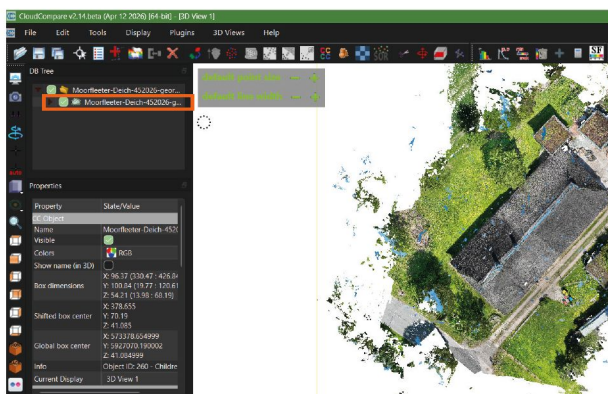
1. Open the file to be formatted (e.g., .las, .ply) under: File -> Open.



2. Confirm „Apply All“



3. Confirm „Yes to All“



4. Highlight the point cloud in the DB-Tree on the left side.

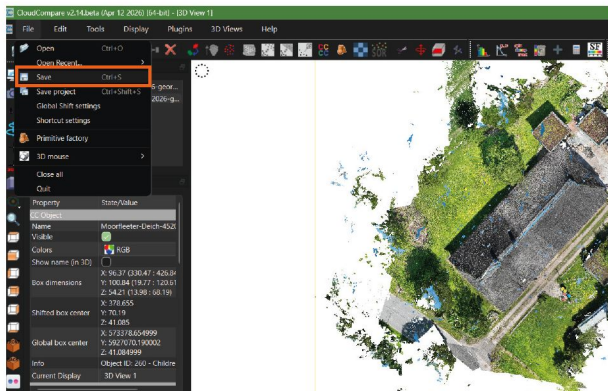
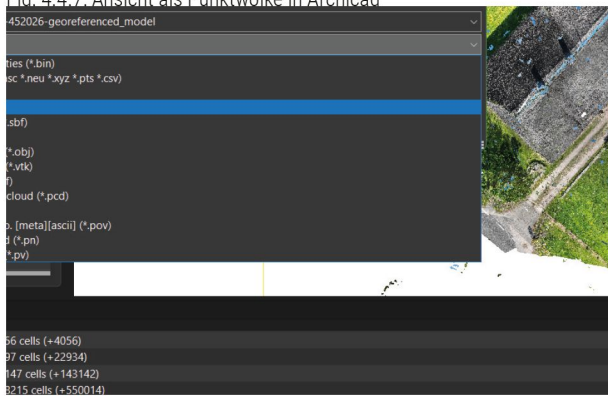
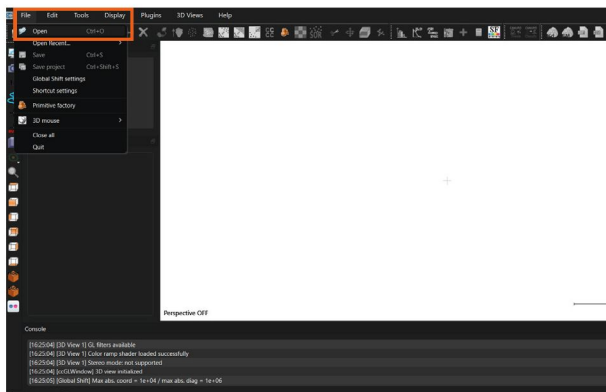


Fig. 4.4.7: Ansicht als Punktwolke in Archicad



5. Save the point cloud via: File -> Save.

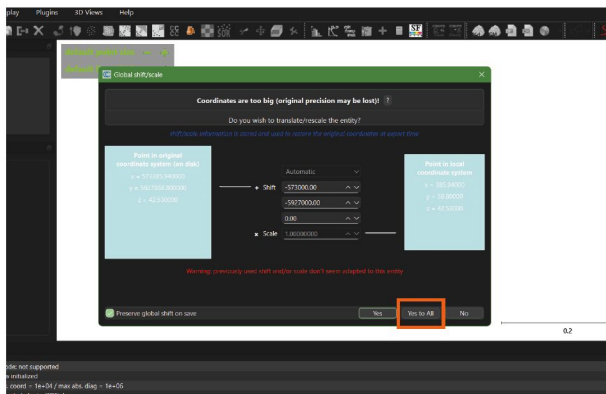
6. Choose the desired storage location and the desired format (e.g., .e57 for importing into Archicad).



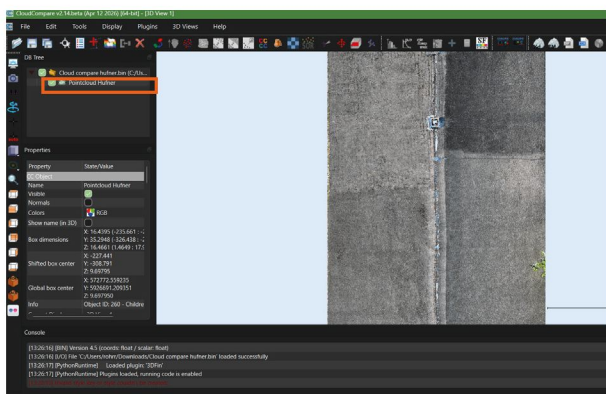
POST-PROCESSING: CloudCompare Orthographic Images

Start:

1. Open the desired file from which the views should be created under: File -> Open.

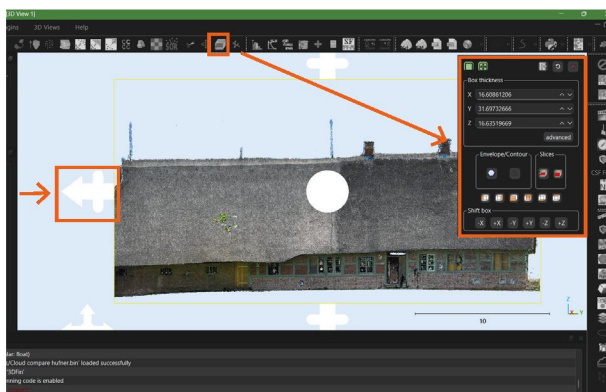


2. Confirm „Apply All“.



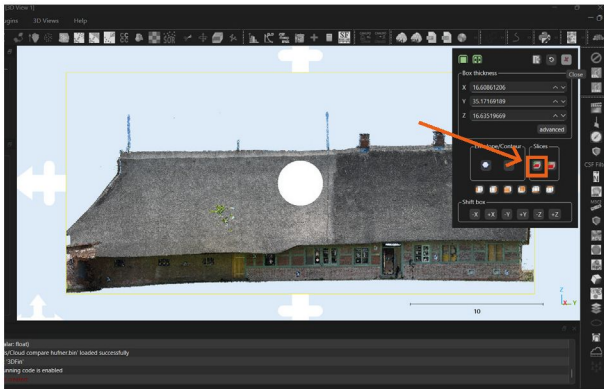
Highlight Point Cloud

Highlight the point cloud in the DB-Tree on the left side.



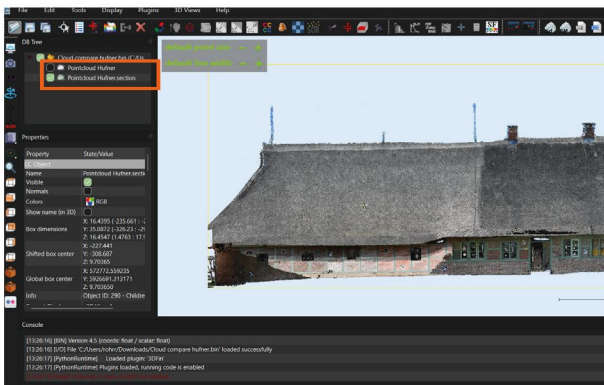
Crop Views

4. Click on the Cross Section icon (Slicing tool) in the top toolbar. Use the window that opens on the right and the graphical sliders on the display to crop the building so that distracting elements from the surroundings (e.g., trees, neighboring buildings) no longer block the facades.



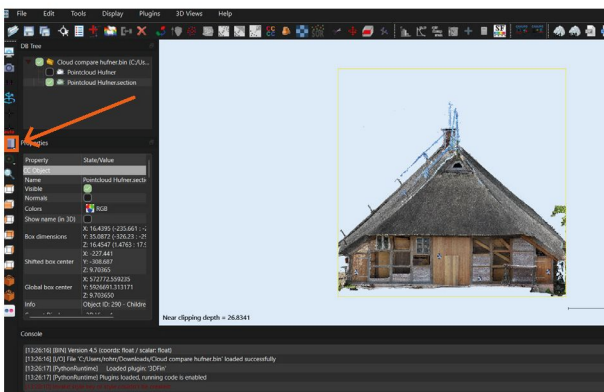
Save the Crop

5. Once all sides are cropped to your satisfaction, navigate to the Slices tab in the Cross-Section window and select Export selection as new entities. Close the Cross-Section window by clicking the red „X“ (Close icon).



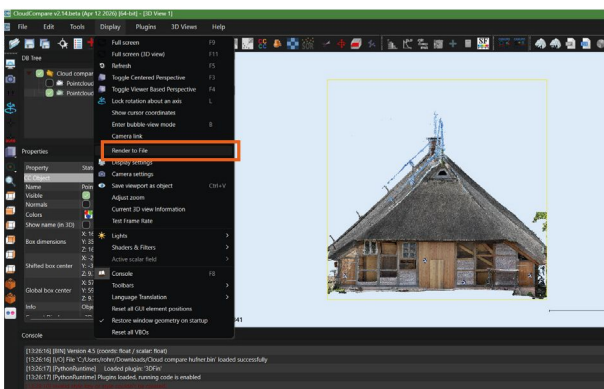
Select the Cropped Point Cloud

6. Activate the newly created, cropped project in the DB-Tree on the left side (check the box). At the same time, uncheck the box for the original, uncropped point cloud.



Set the View

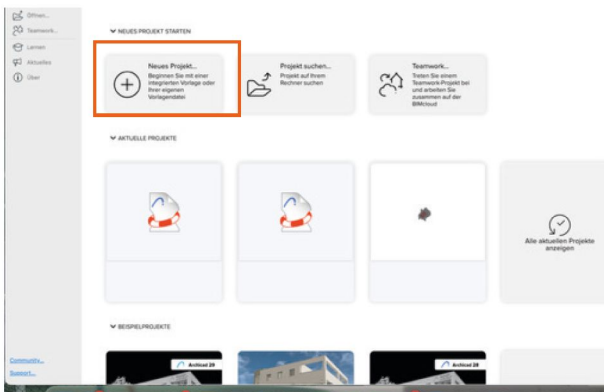
7. Before exporting, it is mandatory to change the projection mode: Click on the Set current view mode icon in the left vertical bar and select Orthographic projection. Align the view on the display exactly to the desired facade side (e.g., using the predefined view buttons like Front, Left, Top).



Export View

8. In the top menu bar, select: Display -> Render to file.

Set the desired zoom factor in the render dialog. Note: Depending on the density of the point cloud, different zoom levels are suitable for achieving a sharp result (experimentation is recommended here). Confirm with OK to save the facade view as a .jpg or .png file.



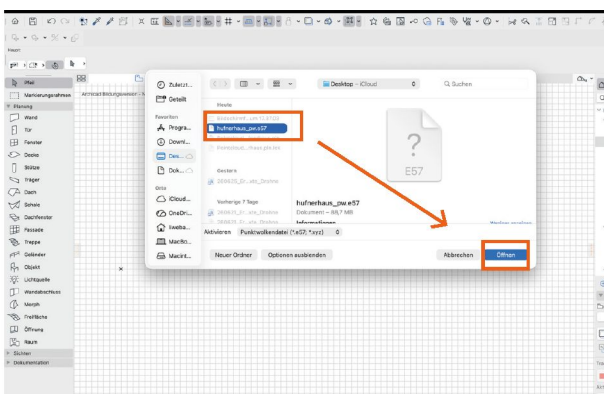
BIM-MODEL: Archicad Import Point Cloud

Start: Create Project

1. Start Archicad and create a new empty project under: File -> New

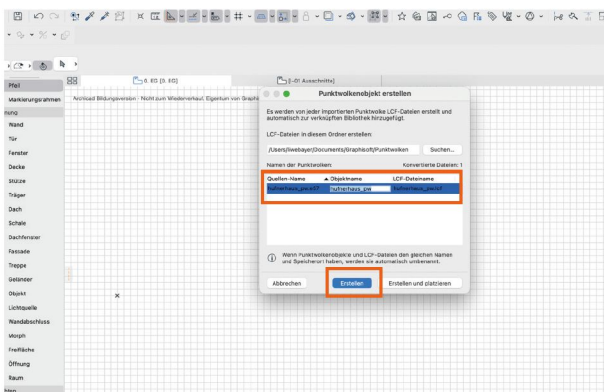
Import Point Cloud

2. Import the .e57 file via „File“ (Ablage) -> „Interoperability“ -> „Import Point Clouds“.



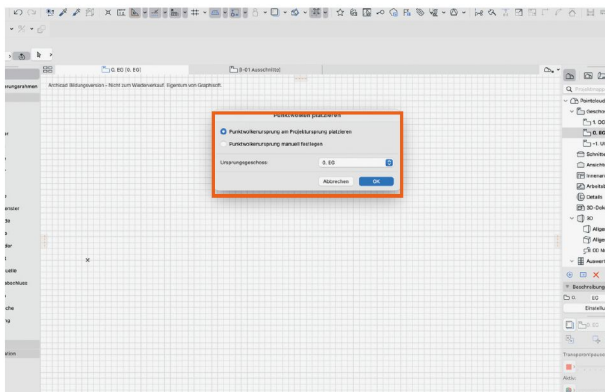
Select Point Cloud

3. Select your point cloud file in the file explorer and confirm by clicking „Open“.



Confirm LCF File

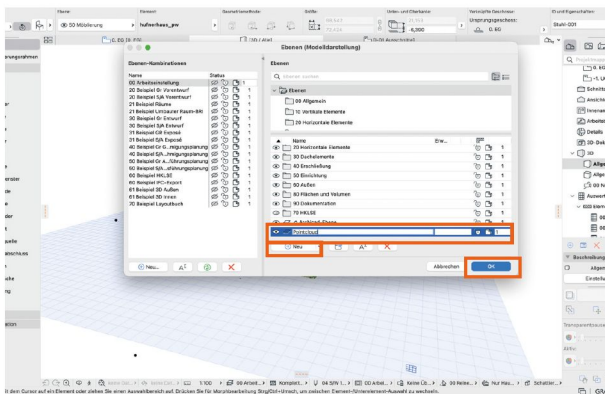
4. A window will open asking where Archicad should save the LCF files that it creates when importing the point cloud. Choose your desired storage location and confirm by clicking „Create“.



Placing the Point Cloud

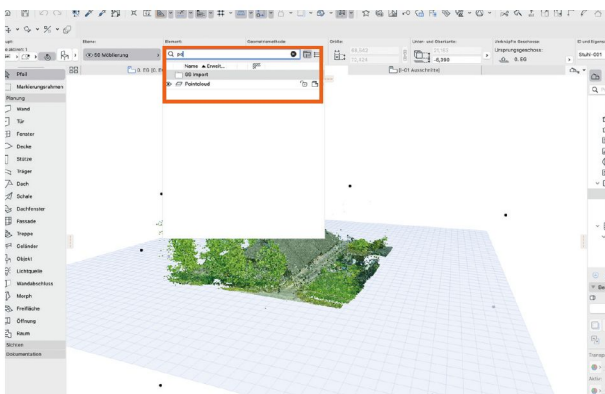
5. A new window opens in which you must select where the point cloud should be placed. We choose:

Place Point Cloud Origin at Project Origin.
Home Story: Ground Floor (EG).



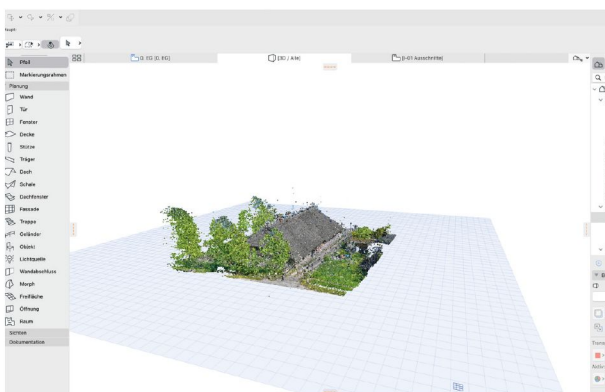
Create Own Layer

6. In order to organize the project and be able to show/hide it, we create a dedicated layer. Open the layer settings using Ctrl + L (Cmd + L). Click „New“ to add a new layer and name it. Example: „Pointcloud“. Confirm with „OK“.



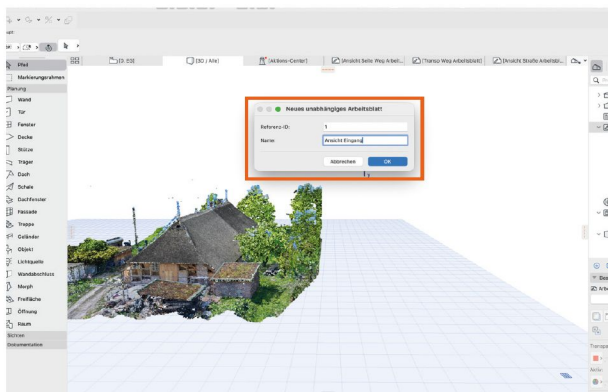
Move to New Layer

7. To place the point cloud on the new layer, click on the point cloud in the floor plan or in 3D mode. Then click on Layer at the top, select the new layer, and confirm with „Enter“.



Initial Setup Created

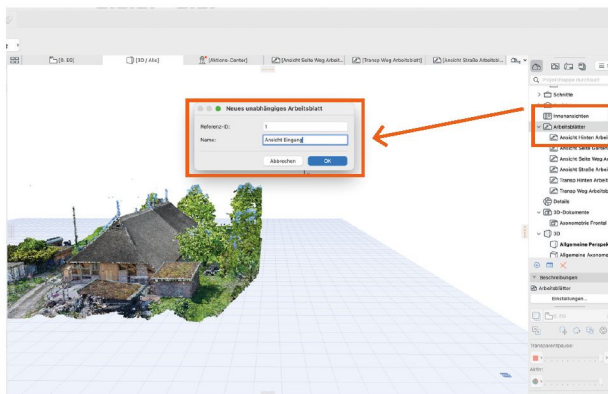
The point cloud is now fully placed and can serve as the base for BIM modeling.



BIM MODEL: ArchiCAD Create Exterior Walls

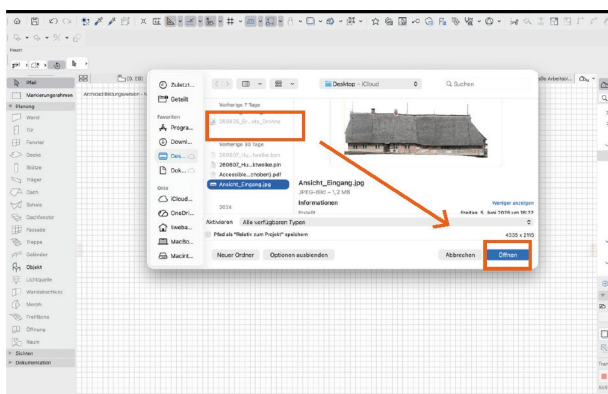
Start: Create Elevations

1. Create an elevation for each exterior wall that runs exactly parallel to the wall. Select the Elevation tool on the left and draw the elevation line. Confirm with „Enter“.



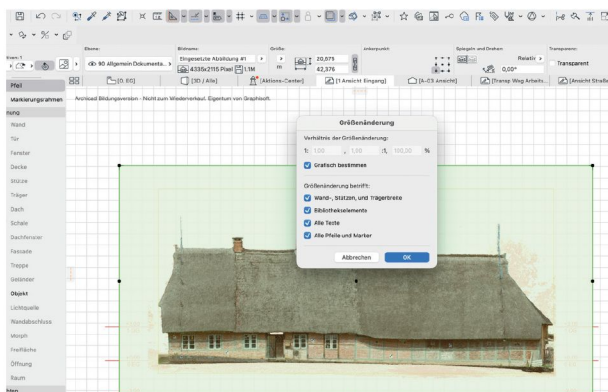
Create Worksheets

2. A separate worksheet is created for each facade side. To do this, go to the Project Map in the Navigator on the right side of the screen, down to the „Worksheets“ folder. Right-click it and select „New Independent Worksheet...“. The new worksheet must then be named. Click „Create“.



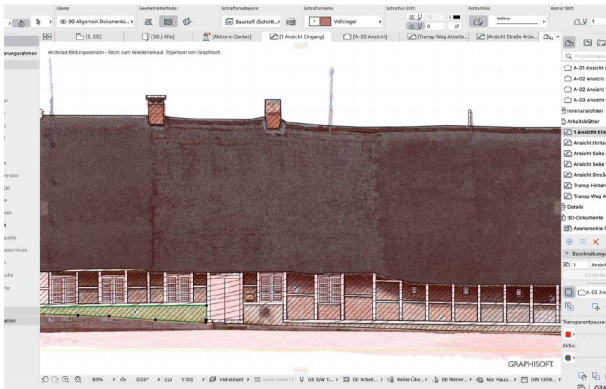
Import Orthographic Views

3. Because point cloud views blur when zooming in, we import the views into our respective worksheet as orthographic images (see instructions: Create Orthographic Images in CloudCompare). To do this, we choose: „File“ -> „External Data“ -> „Place External Drawing“.



Scale Orthographic View

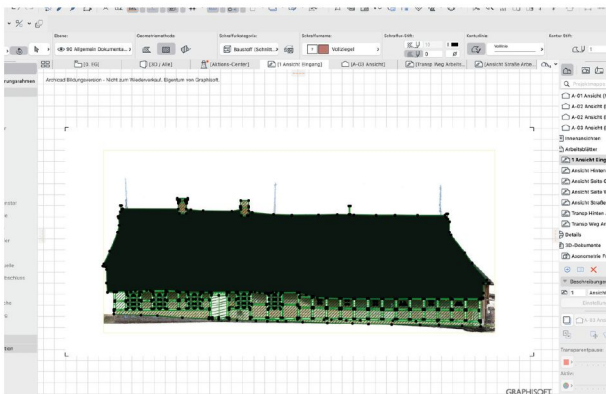
4. To ensure the view can be used accurately to scale as a drawing base, it must be scaled. To do this, right-click on our worksheet in the Navigator on the right and select: Show as Trace Reference. We select the corresponding view as the trace reference (point cloud). Now, we scale the images using Ctrl + K / Cmd + K so that they exactly match the point cloud view.



Drawing the Wall from 2D Fills

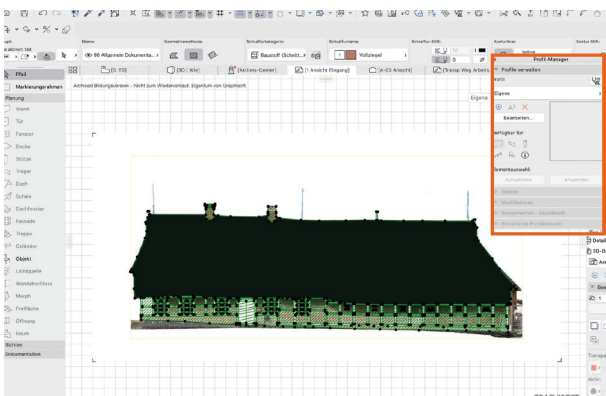
5. Trace the exterior wall precisely using the Fill tool. Draw window openings or projections/recesses depending on the desired Level of Detail (LOD).

Tip: Use a fill that already corresponds to the later building material structure (e.g., masonry or reinforced concrete).



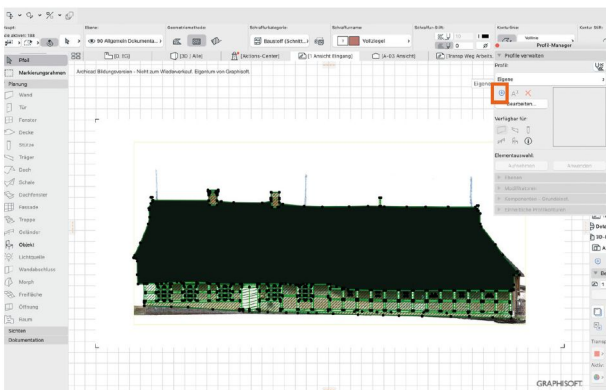
Copy 2D Wall

6. Select the completely drawn wall fill (including all elements that belong to this wall section) and copy it to the clipboard (Ctrl + C / Cmd + C).



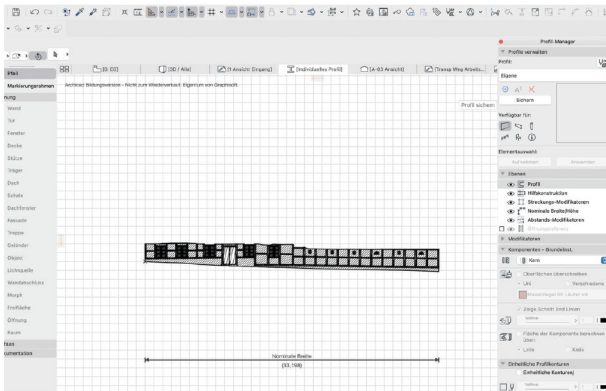
Profile Manager

7. Open the Profile Manager via the path: Options -> Element Attributes -> Profile Manager.



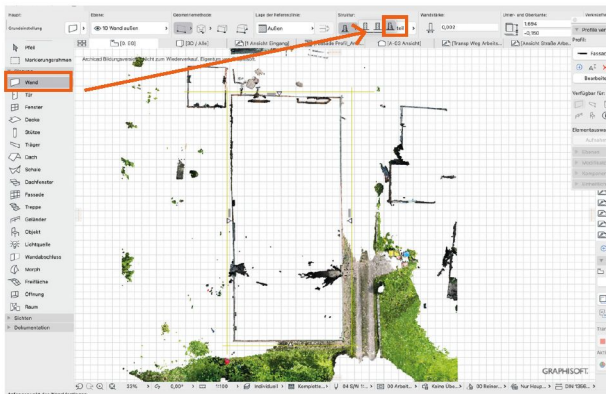
Create New Profile

8. Click on the plus symbol (New) to create a new profile and give it a unique name (e.g., „Exterior_Wall_North“). Define the use type by activating the icon for the Wall tool in the Profile Manager (deactivate icons for columns or beams if necessary).



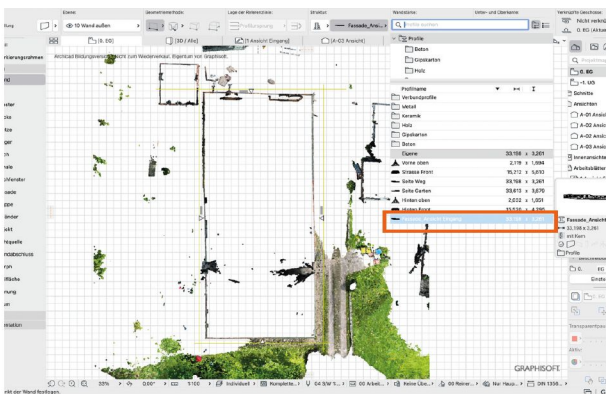
Construct Profile

9. Paste the copied 2D wall into the editing window of the Profile Manager. Move the fill so that the desired reference edge of the wall (e.g., the base/sockel) is placed exactly on the origin crosshair (zero point) of the window. Afterward, click Save (Sichern) to save the wall profile. If the wall has depth variations in 3D, a separate profile must be created for each plane.



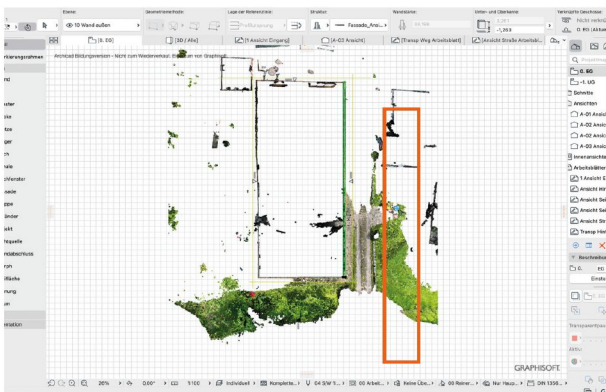
Wall in Floor Plan

10. Switch back to the floor plan and activate the Wall tool.



Select Wall Profile

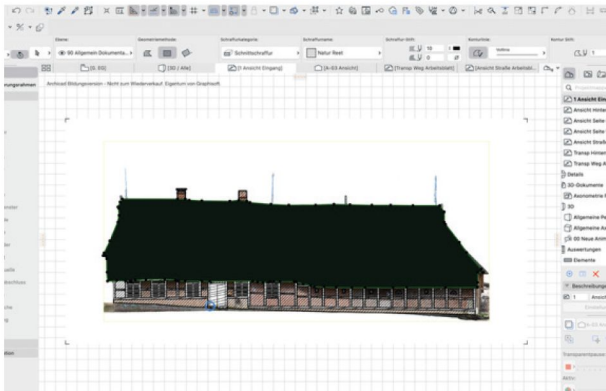
11. In the Wall Selection Settings (Info Box or Settings Dialog), change the structure to Profile (Complex). Select the previously created wall profile from the dropdown menu.



Align Wall to Point Cloud

12. Place the wall in the floor plan along the point cloud reference. The component will now automatically be generated in 3D with the exact geometry and height of the facade drawing.

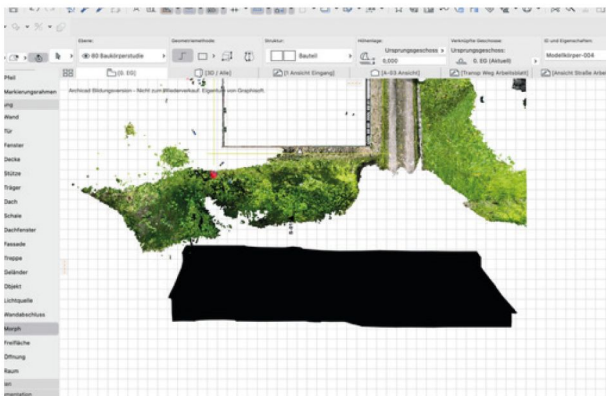
Repeat this process for all other exterior walls or profiled components required for an accurate model of the building.



BIM MODEL: Archicad Modeling the Roof

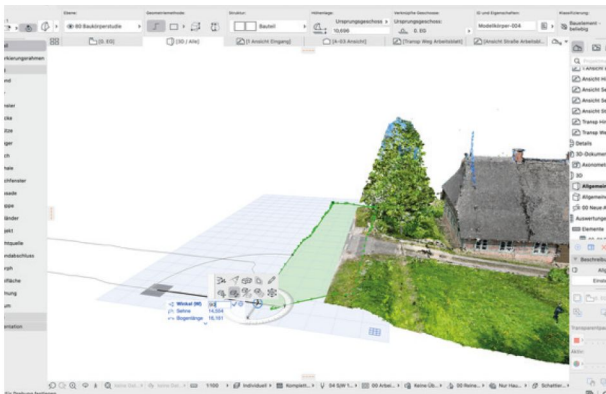
Start: Create Roof Views

1. Open the worksheet of the corresponding building side where the scaled facade view is already located. Trace the visible roof contour precisely using the Fill tool.



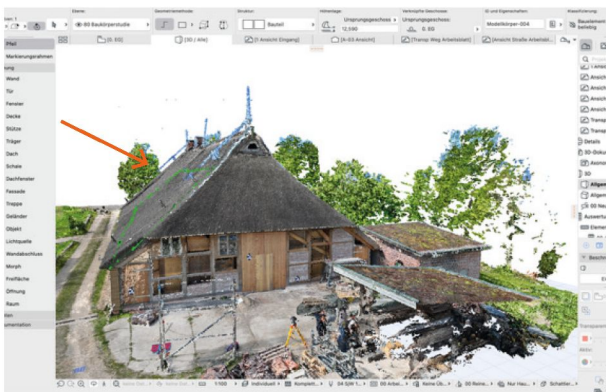
Insert Roof Fill into Floor Plan

2. Select the completed roof fill and copy it to the clipboard (Ctrl + C / Cmd + C). Switch to the floor plan and paste the fill at the same position (Ctrl + V / Cmd + V).



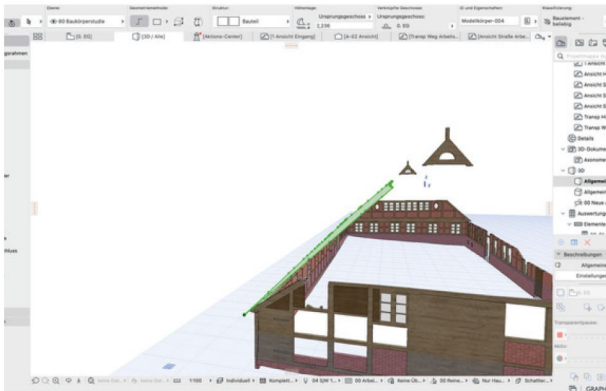
Create Morph

3. Select the Morph tool via the path: Design (Planung) -> Morph. Convert the fill into a Morph by holding down the Spacebar (Magic Wand) and clicking on the roof fill. Afterward, check the 3D window to ensure the Morph was generated correctly.



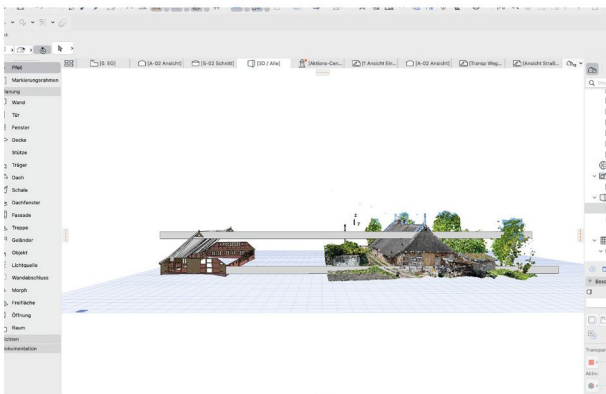
Rotate Morph

4. Select the Morph in the 3D window. Choose the Rotate function from the pet palette menu or the context menu. Rotate the Morph to the estimated roof angle. Then align the roof surface with the point cloud and adjust the angle step-by-step until the roof surface matches the measured roof points as closely as possible.



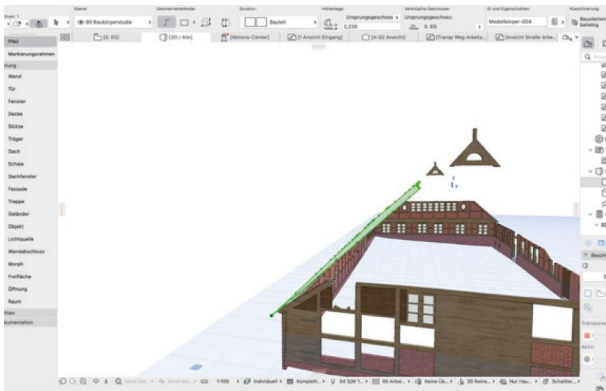
Placement in the 3D Model

5. Position the rotated Morph onto the previously modeled exterior wall profiles. Drag the upper roof edge or the ridge points of the Morph to the correct height.



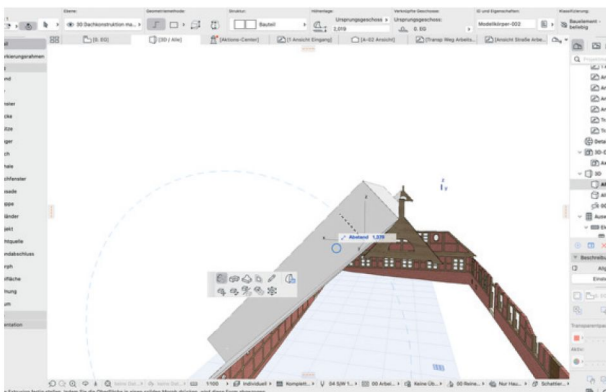
Adjust Height

6. Align the ridge height based on the point cloud and check the alignment at prominent roof points. If necessary, use additional reference elements for height control. These can be extended from clearly identifiable points of the point cloud across the wall and roof areas to serve as 3D guide lines.



Adjust Geometry

7. Afterward, adjust individual Morph points, edges, or faces manually until the roof geometry matches the point cloud as precisely as possible.



Assign Roof Thickness

8. Select the finished roof Morph in 3D. Assign a corresponding material thickness to the Morph. To do this, select a flat face of the Morph. Use the Push/Pull (Ziehen/Drücken) function from the pet palette to define the roof thickness. Enter the desired value to adjust the material thickness of the Morph.

LIXEL HANDSCANNER

APPENDIX

1

2

PROCESSDIAGRAM

STEP-BY-STEP

Processdiagram 150

CloudCompare 152

Archicad 157

1

PROCESSDIAGRAM

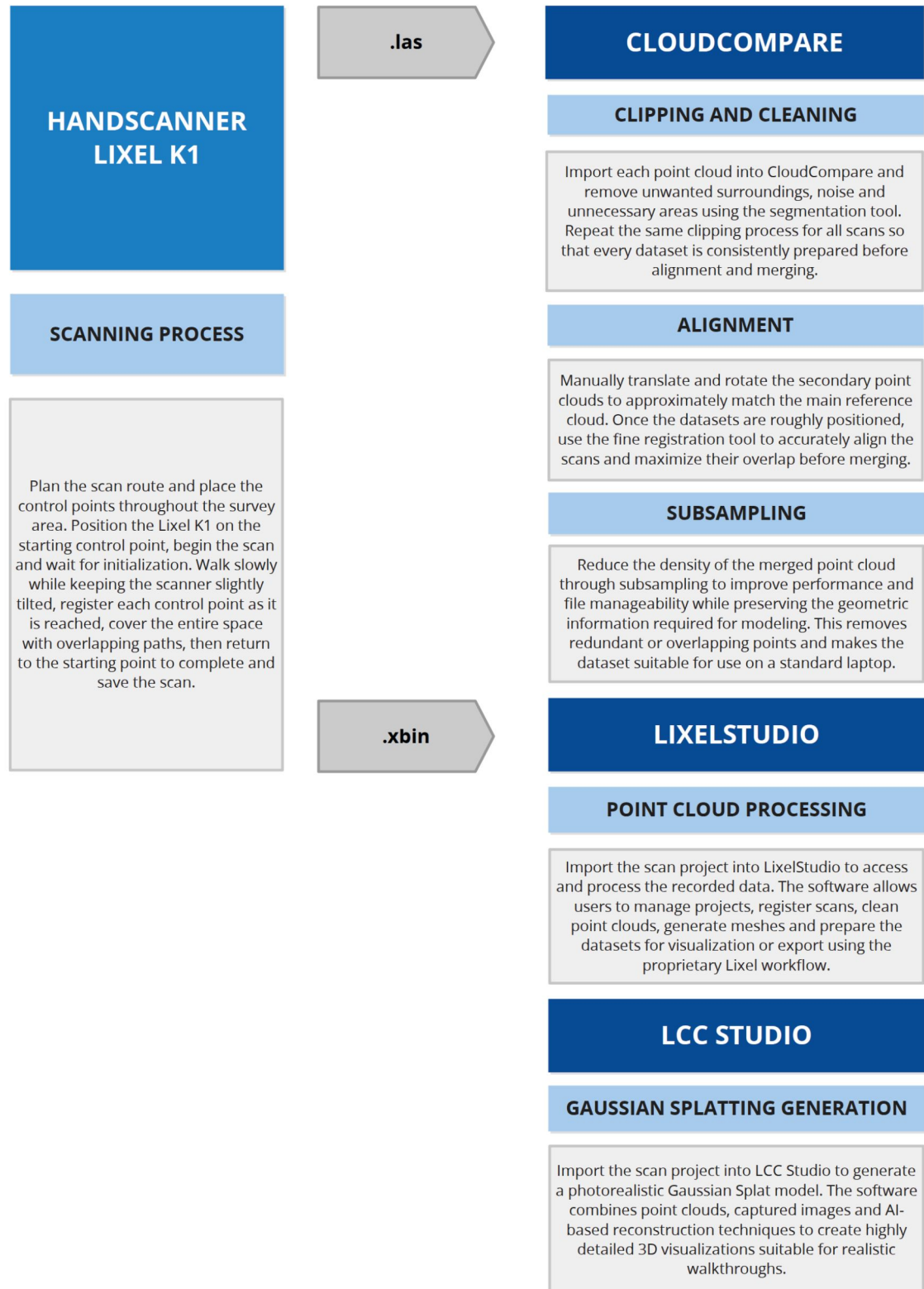


Fig. 2.App.1: Processdiagram with detailed descriptions

.e57

ARCHICAD

POINT CLOUD IMPORT

Import the processed .e57 point cloud via File → Interoperability → Place Point Cloud. Verify the position, orientation and scale of the dataset before using it as the geometric reference for the modeling process.

3D MODELLING

Create the architectural model manually by using the imported point cloud as a geometric reference. Continuously compare plans, sections and 3D views to interpret the scan and approximate the building geometry according to the required level of detail.

REALITYSCAN 2.0

MESH GENERATION

Import the converted point cloud into RealityScan and run the reconstruction workflow to generate a textured watertight mesh. The software reconstructs a continuous surface from the available point cloud data, creating a model that can be visualized and exported for further processing.

PAYWALL

PAYWALL

The Pointcloud is usable as reference points for a 3D model in CAD.

The point cloud can be overlaid with the 3D CAD model, allowing visual comparison to clearly identify differences between them.

FAILED

Lack of quality on the mesh

2 STEP-BY-STEP MANUAL

CloudCompare

Visit the Website www.cloudcompare.org there you can find informations about the software.

Download CloudCompare

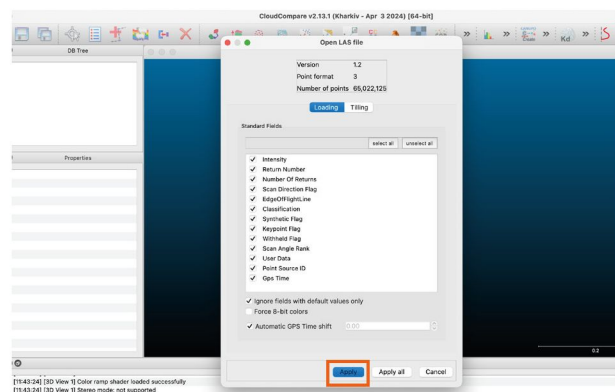
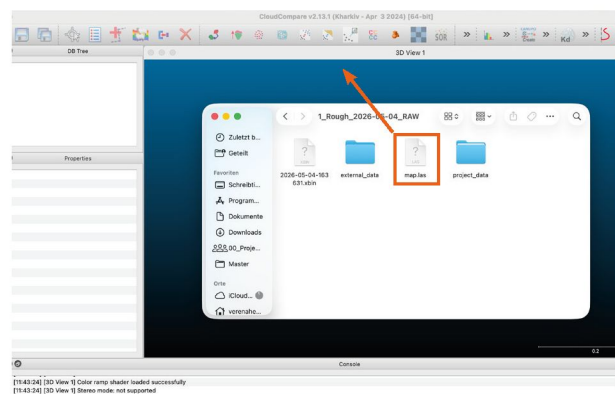
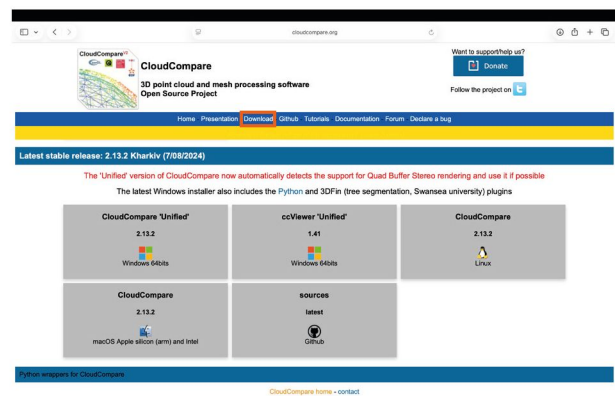
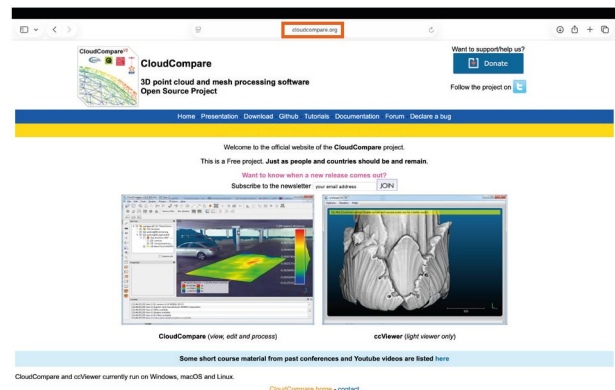
Under the “Download” tab, you’ll find various options. Select the option that matches your computer’s operating system. Be sure to download the latest stable version, not the latest beta release, since the beta release doesn’t run smoothly.

Importing the .las file

Import the .las file located in the folder created by the scanner into CloudCompare using drag-and-drop.

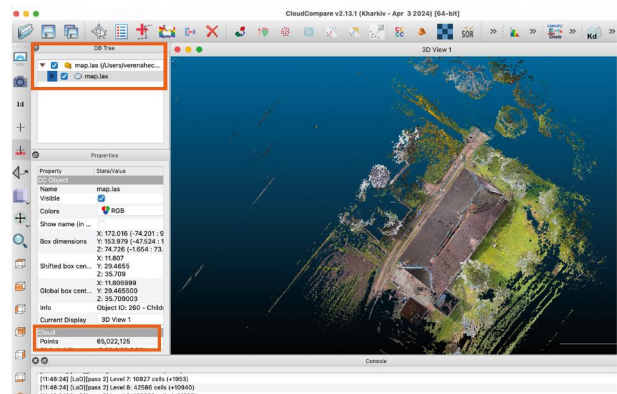
Importing options

A window with import options opens. We didn’t change any of the default settings and clicked “Apply” to confirm.



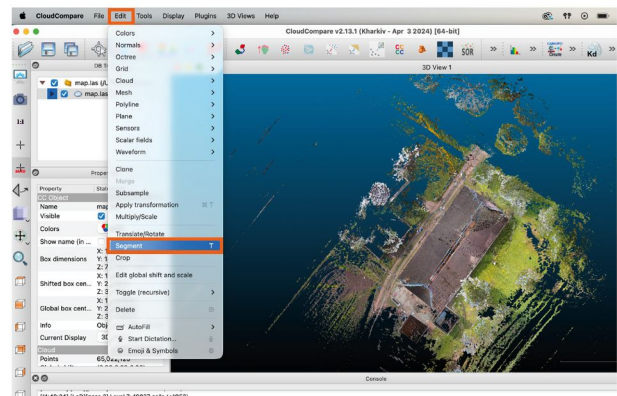
Check the Import

The point cloud is now displayed on the left side of the “DB Tree”; there, you can rename it and see the number of points.



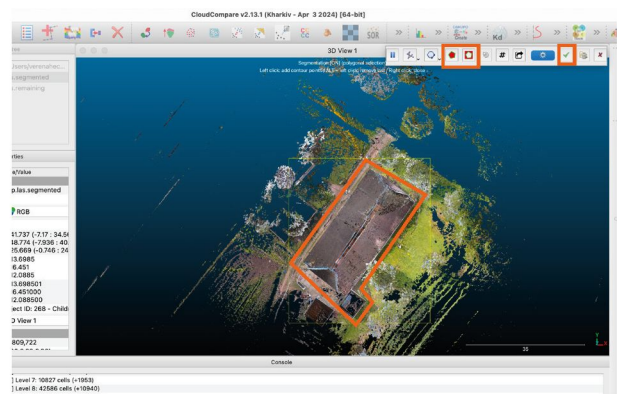
Segment the point cloud

First, select the file that you want to clip in the DB Tree. Then open the “Segment” tool by clicking the ‘Edit’ tab and then “Segment.”



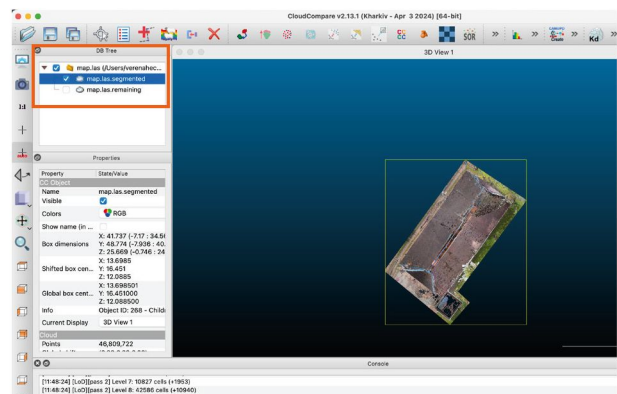
Segment with a polyline

Draw a polyline in the desired view (plan, elevation, or 3D) and adjust its dimensions, including the length, depth, and height. Once the shape is defined, close the polyline by right-clicking. Then, choose whether to keep the points inside or outside the selected area. Finally, confirm the segmentation.



Seperate Layers

The two parts are now displayed as two separate layers in the DB Tree. The layer containing the surroundings can now be deleted to improve the workflow.



Repeat Steps

If you want to merge different scans, repeat the steps described above for the remaining point clouds, and then follow the instructions starting with the next step.

Rotating/ Translating

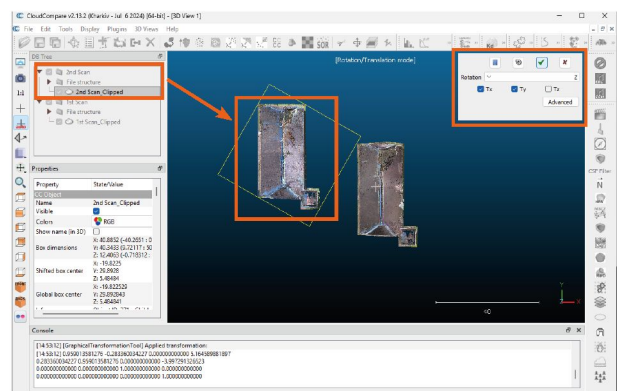
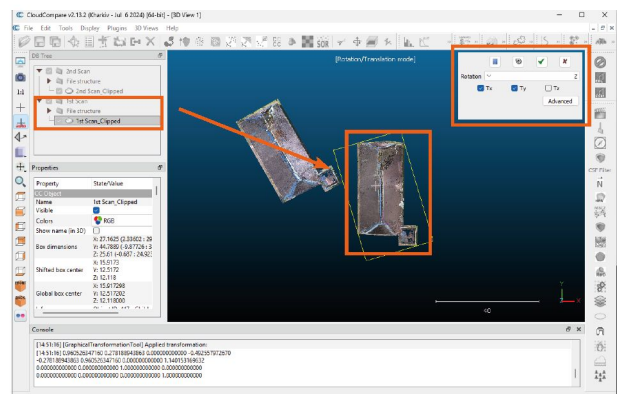
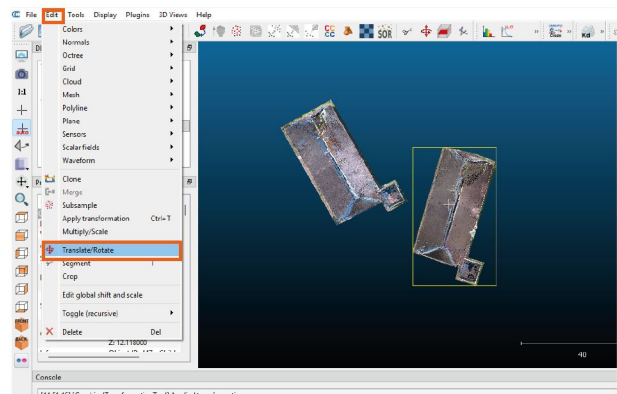
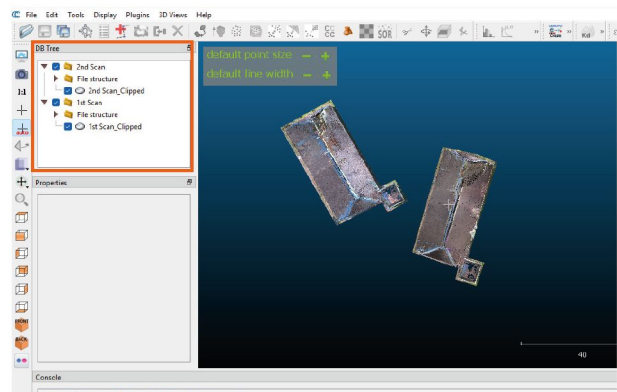
To rotate a layer, first select the layer to be rotated in the DB Tree. In this case choose the main point cloud. Then, open the „Rotation/ Translation“ command under the tab „Edit“.

Align the point cloud with the axis

Rotate the point cloud around z-axis only, in order to keep the height information. Left click to rotate. Now align the point cloud to the default x and y-axis.

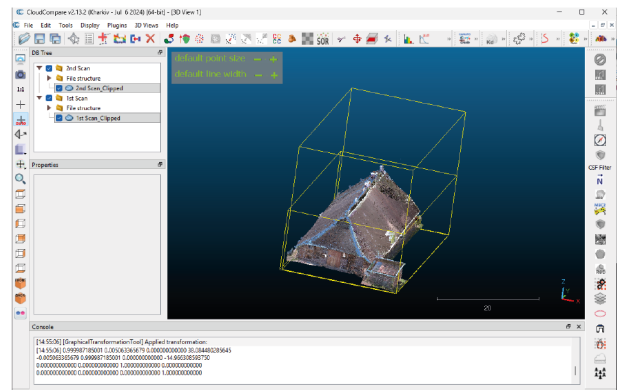
Align additional point clouds

For additional point clouds repeat the step before. Translate the point cloud along the X, Y, and Z axes as required. Right-click to apply the translation.



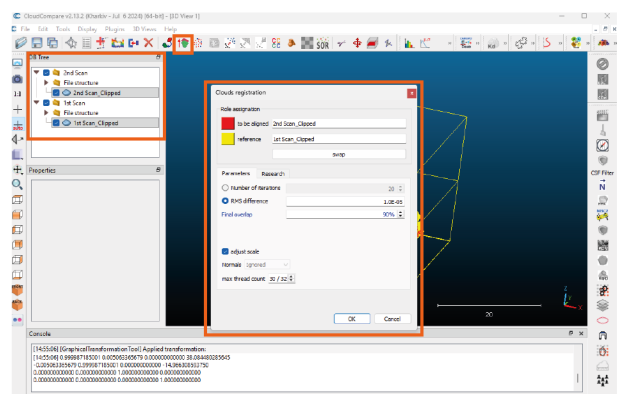
Rough manual alignment

Align the point cloud with the main point cloud and check the alignment from different views to ensure an accurate match. Repeat the process for each additional point cloud if multiple point clouds need to be aligned.



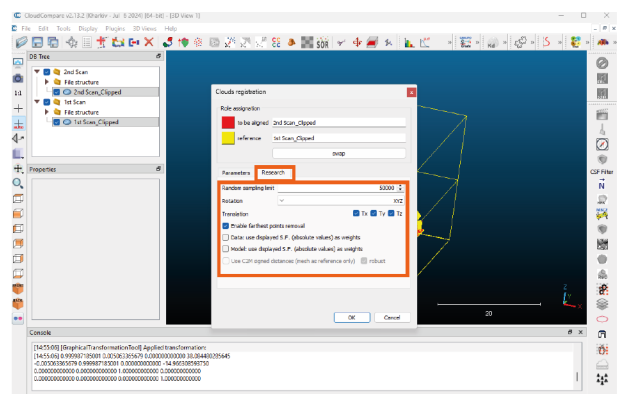
Aligning the different point clouds

For the final alignment select the roughly aligned point clouds in the DB Tree. Then select the tool „finely register already (roughly) aligned entities“. Set the main point cloud as „reference“ (yellow) and the secondary point cloud as „to be aligned“ (red). We set the „final overlap“ to 90% and checked „adjust scale“.



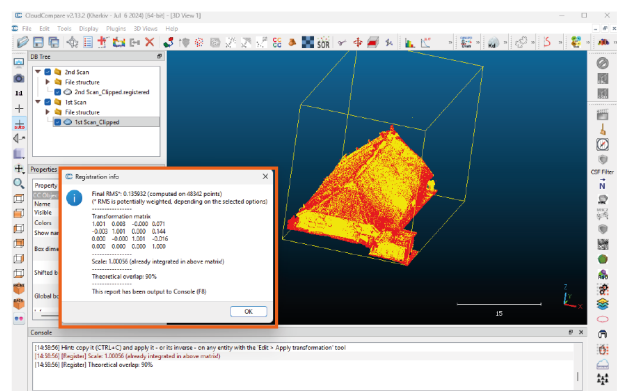
Alignment settings

You can configure additional settings in the "Research" tab. We set the "random sampling limit" to 50,000. Set the rotation to XYZ and checked the translation Tx, Ty, Tz. We also checked the box of "enable furthest points removal". If all the settings. Once all settings are configured, you can confirm by clicking „OK“.



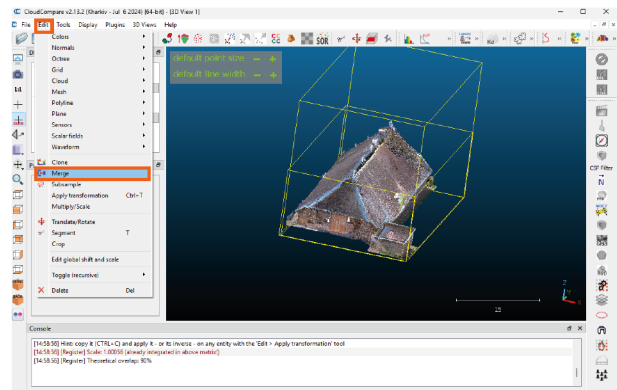
Aligned point clouds

A window titled "Registration Info" will appear. It contains detailed information about the final overlap.



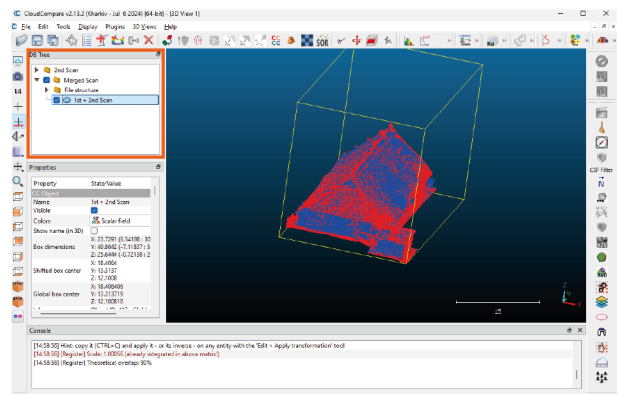
Merge point clouds

To merge the two point clouds, select both clouds in the DB Tree, go to “Edit” and then select “Merge”. Confirm the merge by clicking „OK”.



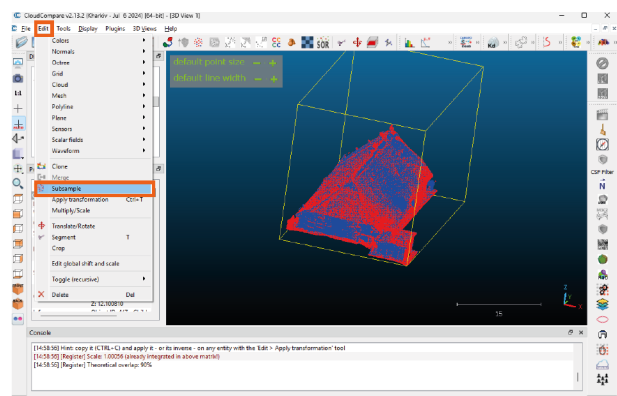
Rename merged point clouds

The merged point clouds now appear as a single cloud in the DB Tree. To keep track of them, you can rename the file.



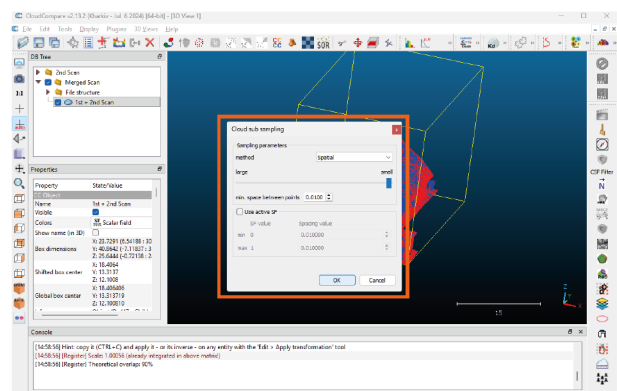
Subsample point clouds

To simplify the following steps, the number of points in the point cloud need to be reduced. To do this, select the point cloud in the DB Tree, go to „Edit” and then to „Subsample”.



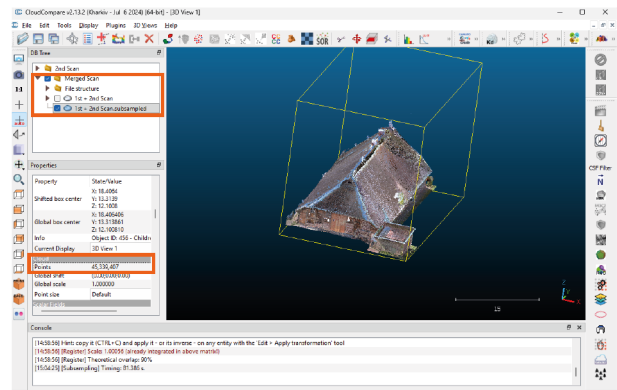
Subsample settings

As the “method” we selected “Spatial” We set the “min. space between points” to 0.01. This distance must be increased if the number of points is still too large. To confirm the action click „OK”.



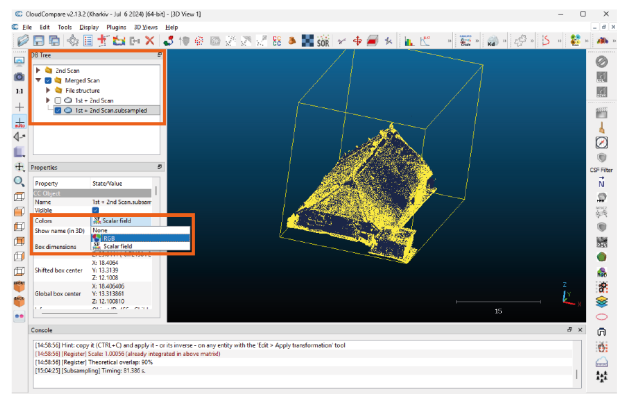
Subsample result

A second point cloud will appear in the DB Tree with the suffix "subsampled". Select it and check the number of points. For a smooth workflow in Archicad, we recommend no more than 20 million points. If the number of points is too high, select the original point cloud in the DB Tree and repeat the previous step using a larger distance between the points.



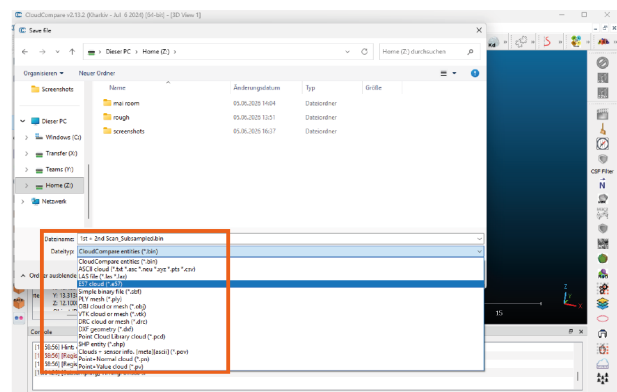
Adjusting the visualisation colour

If the colour of the point cloud has changed in the last step, select the cloud in the DB Tree, go to "Colours" in the "Properties" menu, and change the setting from Scalar Field to RGB.



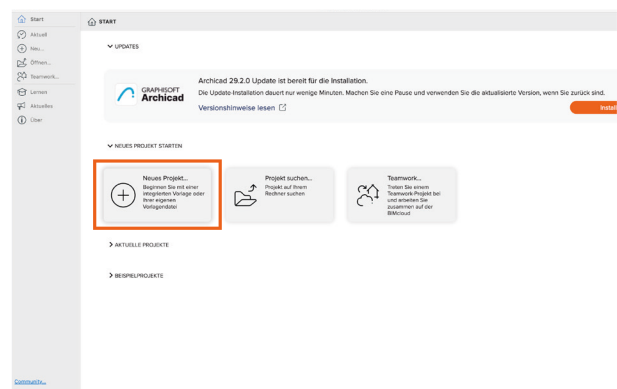
Saving the file

To save the file, go to the "File" tab and click "Save," or use the keyboard shortcut "Ctrl+S." Select a location on your computer, choose a name for the file you want to save, and choose "E57 cloud (*.e57)" as the file type. This file format can be imported directly into Archicad.



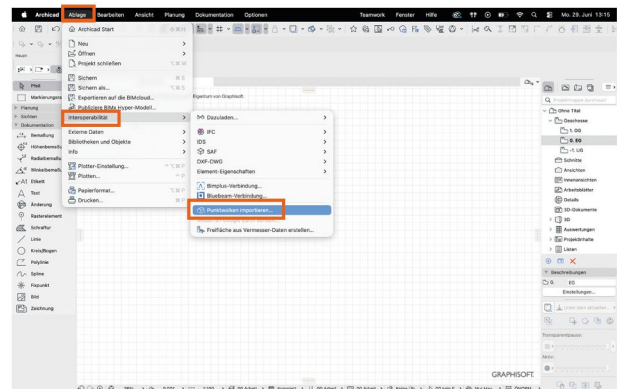
Create a new Archicad file

Open Archicad and start a new project.



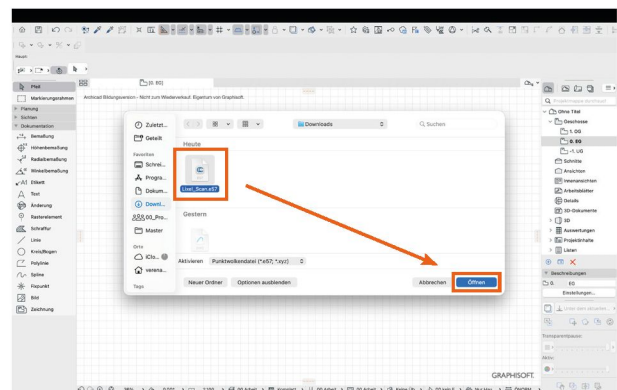
Import the Pointcloud

To import the processed point cloud into Archicad, go to „File“ > „Interoperability“ and then select „Import Point Cloud...“



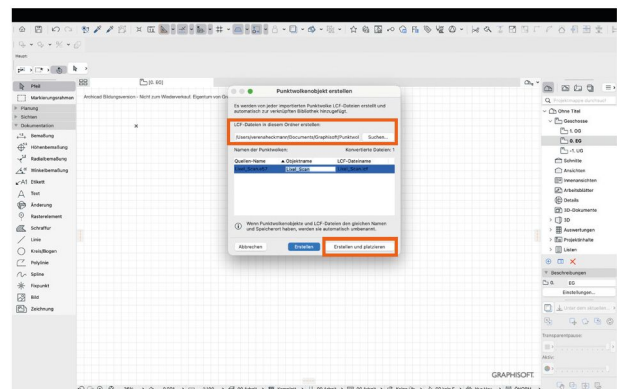
Select the .e57 file

Select the pointcloud you want to import and click „open“.



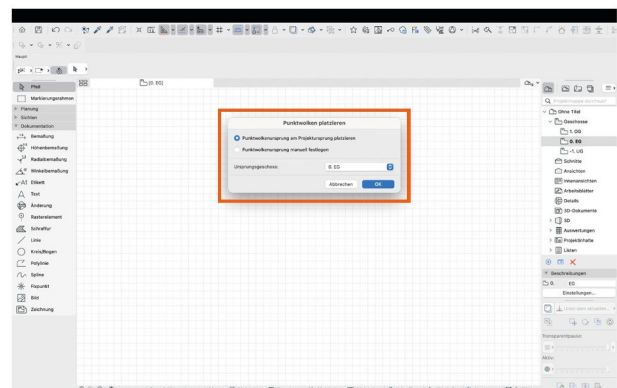
Confirm LCF File

A window will open where you can select where Archicad should save the LCF files (Library Container File) it creates when importing the point cloud. Select the desired location and confirm by clicking "Create and Place."



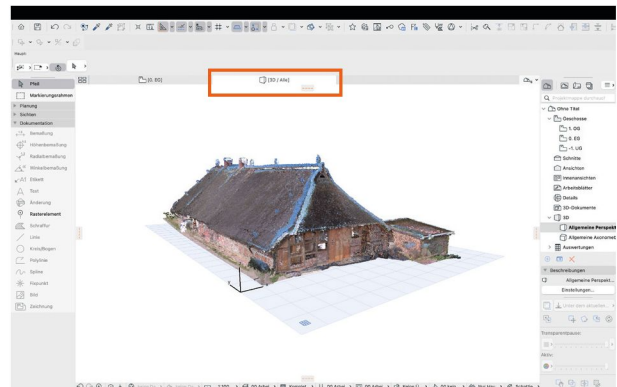
Placing the Pointcloud

A new window opens where you can select where the pointcloud should be placed. Choose „Place pointcloud origin at project origin“ and „Ground floor as the origin floor“. Confirm by clicking „OK“.



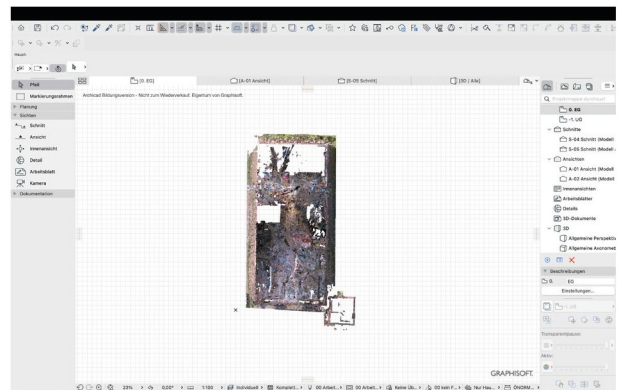
Check the Import

Select the „3D/All“ view in Archicad and check whether the import was successful and the point cloud is visible.



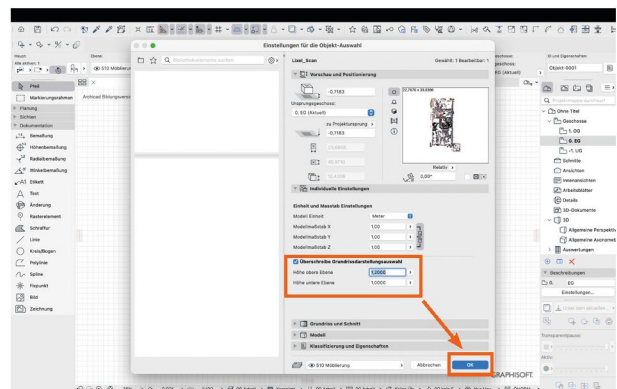
Prepare the floor plan

In the „0. OG“ tab of the floor plan you can only see the top view of the pointcloud. To correctly display the floor plan for later processing, there are a few steps you need to follow.



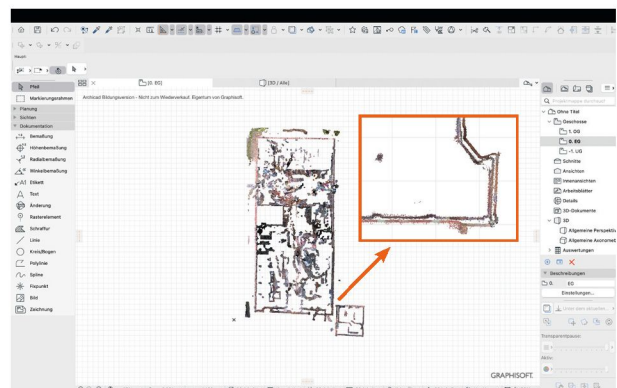
Override the floor plan display selection

Select the point cloud in the floor plan window. Open the settings using the Ctrl+T command and check the “Override floor plan display selection” box. Set a height for the lower and upper levels. We have set the height to 1–1.2 meters. Confirm the changes by clicking “OK.”



Groundwork finished

Now, all points outside this range are hidden in the floor plan, making it easier to see the walls and columns. This establishes the foundation for further editing and the creation of a 3D model.



03 360° RICOH THETA V

APPENDIX

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1

PROCESSDIAGRAM

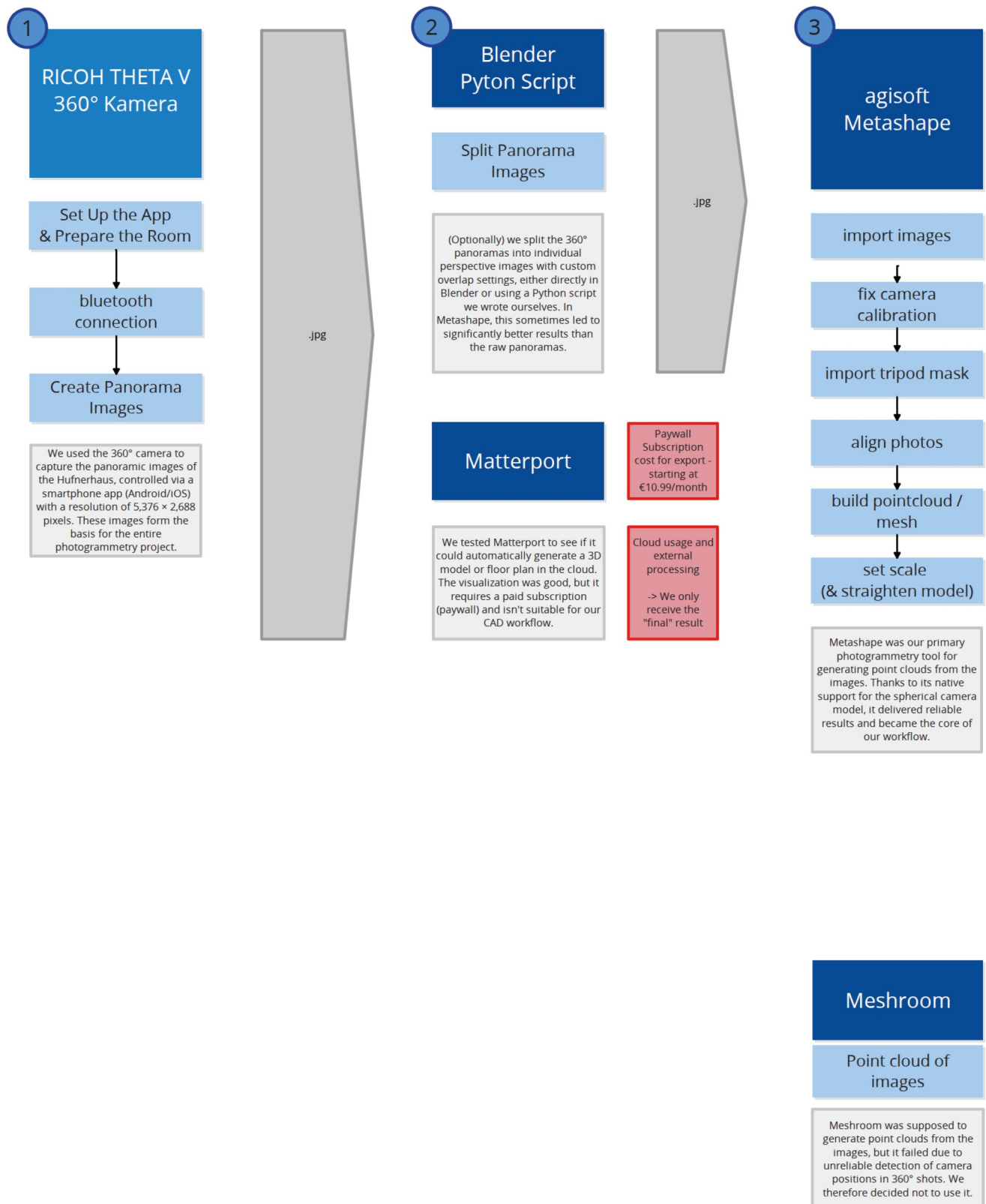
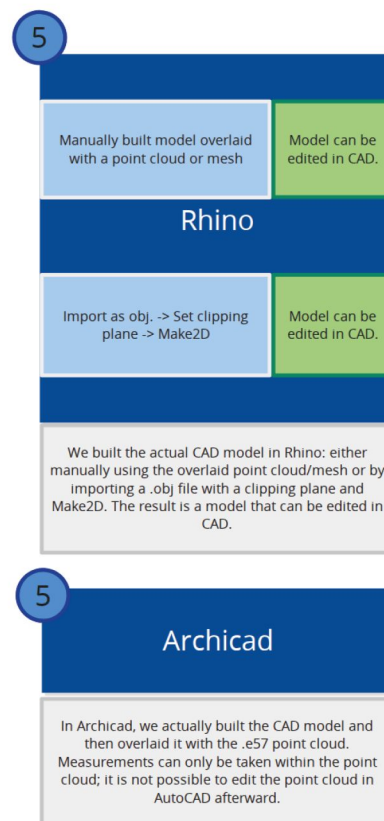
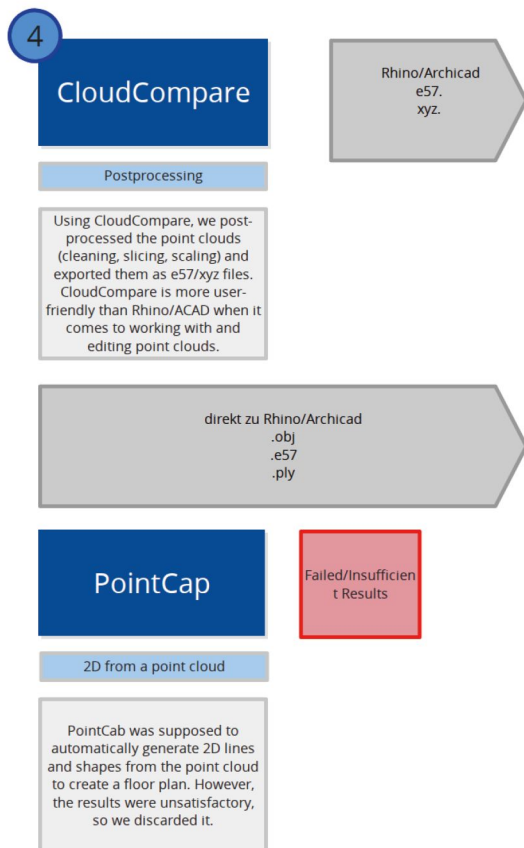
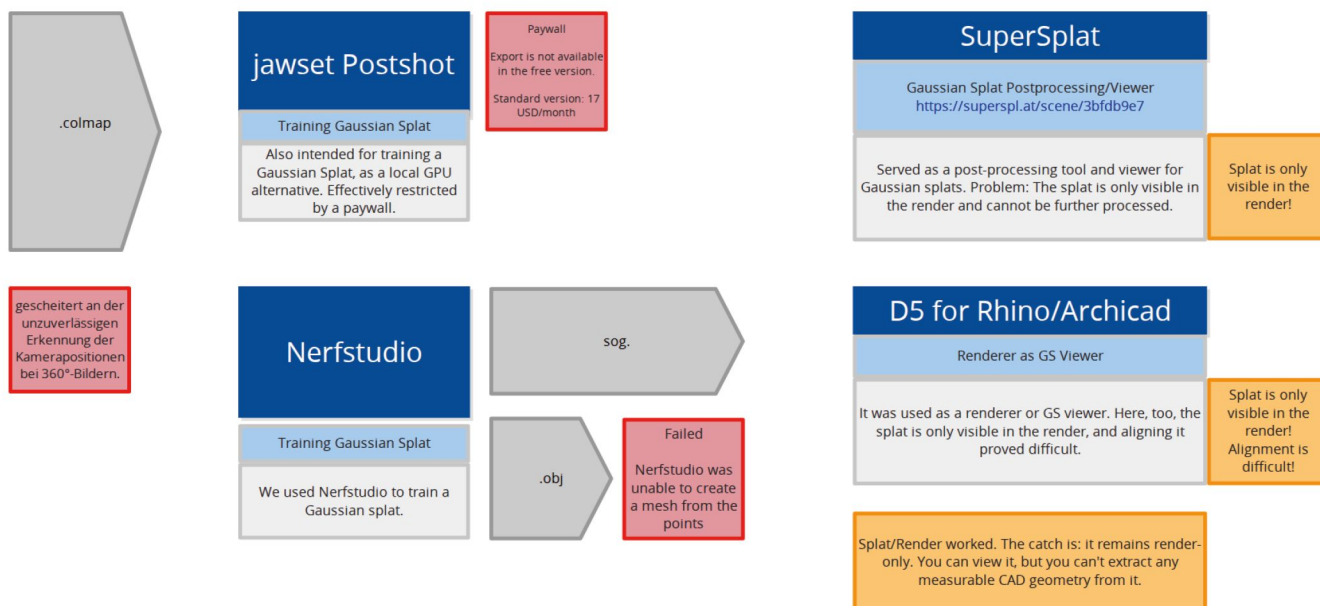


Fig. 3.App.1: processdiagram complete



.....



2

STEP-BY-STEP MANUAL

2.1 CUBE MAPPING: 360° PANORAMA > CUBE FACES (SCRIPT)

This is the one step that always needs a script: turning the distorted 360° panoramas into normal, undistorted images that Metashape can use. It runs in a terminal – just copy the command, no programming required.

Run it from a terminal inside the project folder.

Open PowerShell, then:

```
cd „C:\Path\To\Project“
```

(Replace with wherever your project folder is.)

WHY CUBE MAPPING?

A 360° panorama is stored as one stretched 2:1 image (equirectangular). Metashape can't reconstruct well from that distortion. So each panorama is projected onto the six sides of a cube, producing 6 normal photos with a 90° field of view each – exactly what photogrammetry expects.

SETUP (ONCE) – PYTHON AND PACKAGES

The script uses Python plus a few free libraries. You install them once.

1. Install Python 3 (from python.org), ticking “Add Python to PATH”.
2. Install the libraries: `pip install py360convert numpy pillow`

RUN THE SCRIPT – EQUI2CUBE.PY

Reads every panorama from Fotos and writes 6 cube faces per panorama into `out\cubefaces`. The `--contact` option also writes a single overview image (a “contact sheet”) so you can check the result at a glance.

RUN IT:

```
python scripts\equi2cube.py --contact
```

Result: 198 cube faces in `out\cubefaces` (6 per panorama), plus the contact sheet:

```
PS C:\Project> python scripts\equi2cube.py --contact
```

```
33 panoramas found. Output -> ...out\cubefaces
```

```
Contact sheet written: ...out\kontaktbogen.png
```

```
[1/33] R0010674: faces written
```

```
[2/33] R0010675: faces written
```

```
...
```

```
[33/33] R0010715: faces written
```

```
Done. 198 face images (6 per panorama) in ...out\cubefaces
```

```
Pinhole calibration for Stage 3: f = 672 px, cx = cy = 0, face = 1344 px, no distortion.
```




USEFUL OPTIONS:

- – drop-nadir – skip the floor face (the one with the tripod) entirely.
- – face N – force a face size in pixels (default = panorama width $\div$ 4 = 1344 px).

WHAT THIS GIVES STAGE 3 (METASHAPE)

Because each cube face is an ideal pinhole camera with a 90° field of view, its lens values are known exactly. You enter them as a fixed calibration in Metashape, which makes the alignment more stable:

(See the Metashape guide, Step 3 “Fix the camera calibration”.)

Value	Setting	Meaning
Focal length	$f = 672 \text{ px}$	$= \text{face size} \div 2$
Principal point	$cx = 0, cy = 0$	exactly the image centre
Distortion	none	$k1...k4 = p1 = p2 = 0$

2.2 METASHAPE PRO – COMPLETE GUI WORKFLOW

This guide walks you through Agisoft Metashape Pro from zero: load images -> settings -> point cloud -> scale -> export. Every step lists the exact menu path, what to set where, and why it matters. No prior photogrammetry knowledge required.

Version: tested with Metashape Pro 2.3. Input: the cube faces from Step 2, located in out\cube-faces (198 images). Goal: a coloured, true-to-scale point cloud + cameras.xml + a quality report.

STEP 0 – ENABLE THE GPU (ONCE)

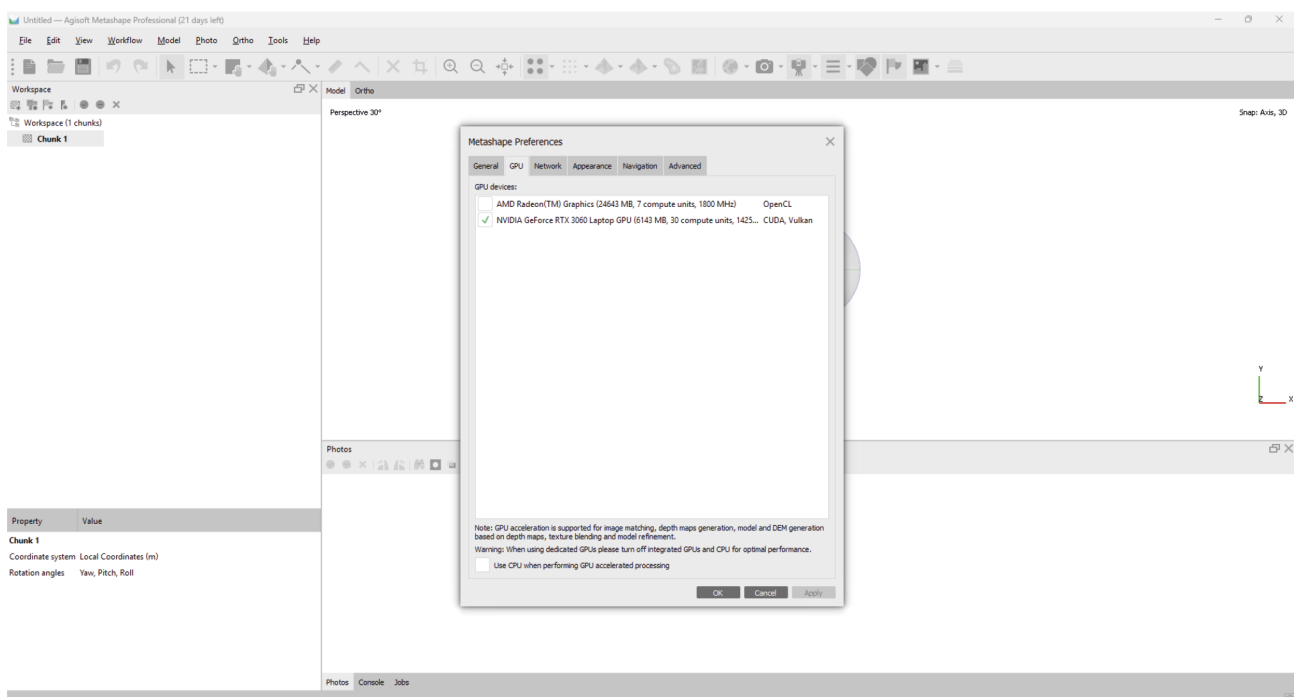
Photogrammetry is heavy maths. Letting Metashape use your graphics card (GPU) makes the whole process many times faster.

1. Tools -> Preferences... -> tab GPU.
2. Tick the checkbox next to your graphics card.
3. Turn off “Use CPU when performing GPU accelerated processing” if your GPU is strong.
4. Click OK.

STEP 1 – CREATE AND SAVE A NEW PROJECT

Saving immediately creates the project's data folder, so intermediate results are stored on disk and nothing is lost if the program crashes during a long calculation.

1. File -> New.
2. File -> Save As... -> save as meinprojekt.psx in your project's out\metashape folder.



STEP 2 – ADD THE IMAGES (ADD PHOTOS)

This loads the photos Metashape will reconstruct from. The cube faces are normal, undistorted images – exactly what photogrammetry needs.

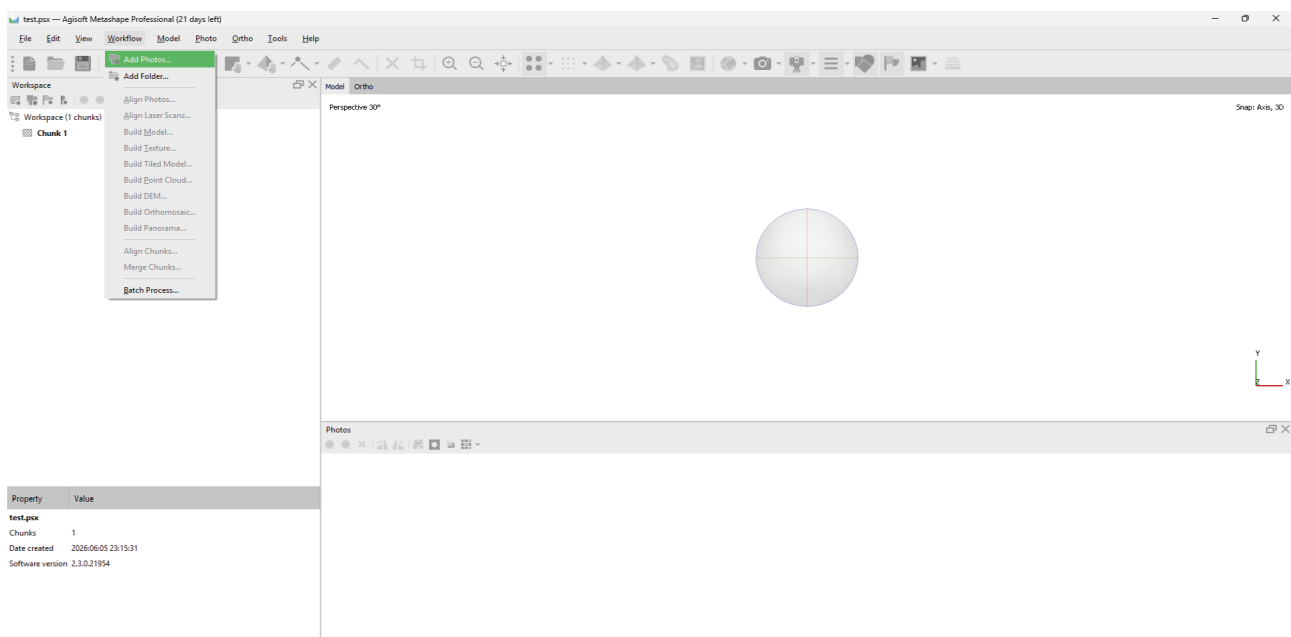
1. Workflow -> Add Photos....
2. Browse to your out\cubefaces folder.
3. Select all images: click inside the folder, then Ctrl + A ->Open. (There are 198 cube faces.)
4. If asked how to group the cameras, confirm Single cameras / the default.
5. The photos appear on the left in the Workspace under “Chunk -> Cameras”.

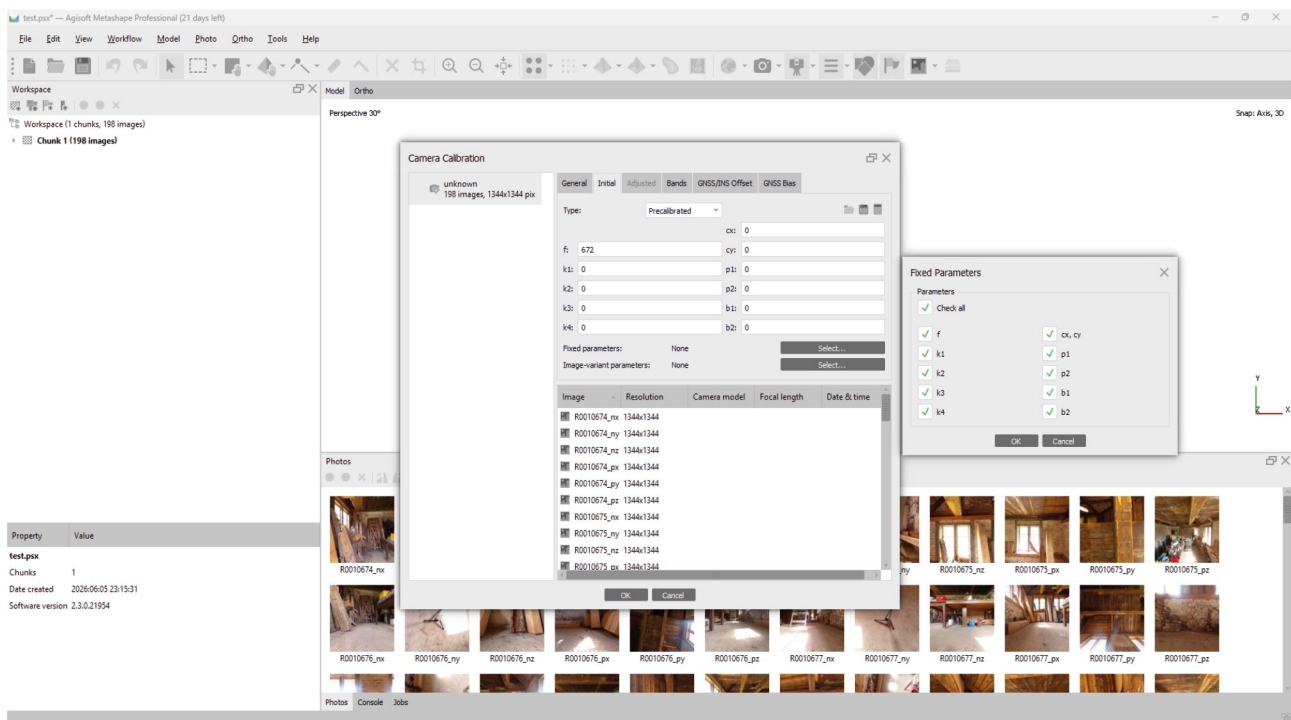
GOOD TO KNOW: Metashape sees that all images share the same size (1344×1344) and creates one “sensor”. We set that sensor’s camera values by hand next.

STEP 3 – FIX THE CAMERA CALIBRATION (IMPORTANT!)

The cube faces are mathematically perfect pinhole cameras – we know their lens values exactly. By fixing them, Metashape doesn’t have to guess, which makes the alignment more stable and accurate.

1. Tools -> Camera Calibration....
2. On the left, select the sensor (named e.g. “unknown”, 1344×1344).
3. Camera type: Frame.
4. Open the Initial tab and enter:
 - $f = 672$ (focal length in pixels = image width $\div 2$)
 - $cx = 0, cy = 0$ (principal point exactly at image centre)
 - $k1 = k2 = k3 = k4 = 0, p1 = p2 = 0$ (no distortion)
5. Tick Fix calibration so these values are not changed during alignment.

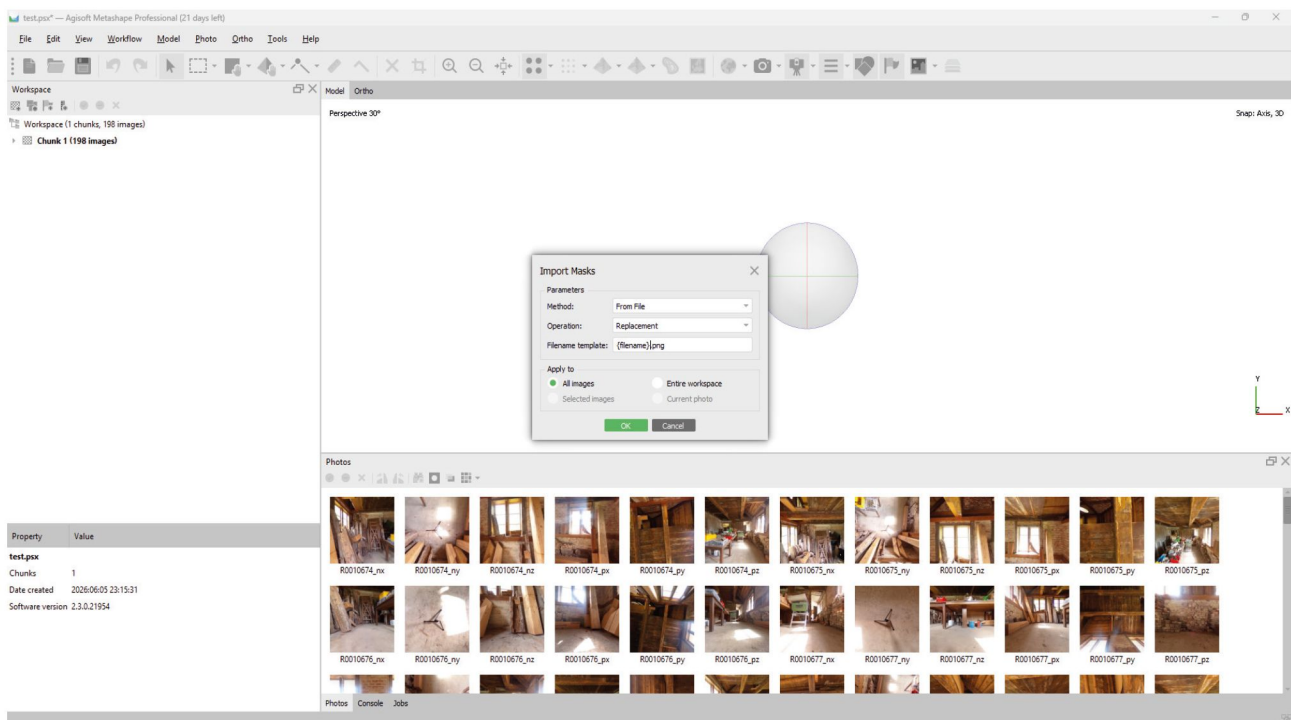




STEP 4 – IMPORT TRIPOD MASKS

The same tripod appears in every downward (nadir) image. Without masking, Metashape mistakes it for a shared feature and creates a “ghost tripod” or misalignments. The masks tell it to ignore that area. (Create the masks beforehand with the helper script; they live in out\masks.)

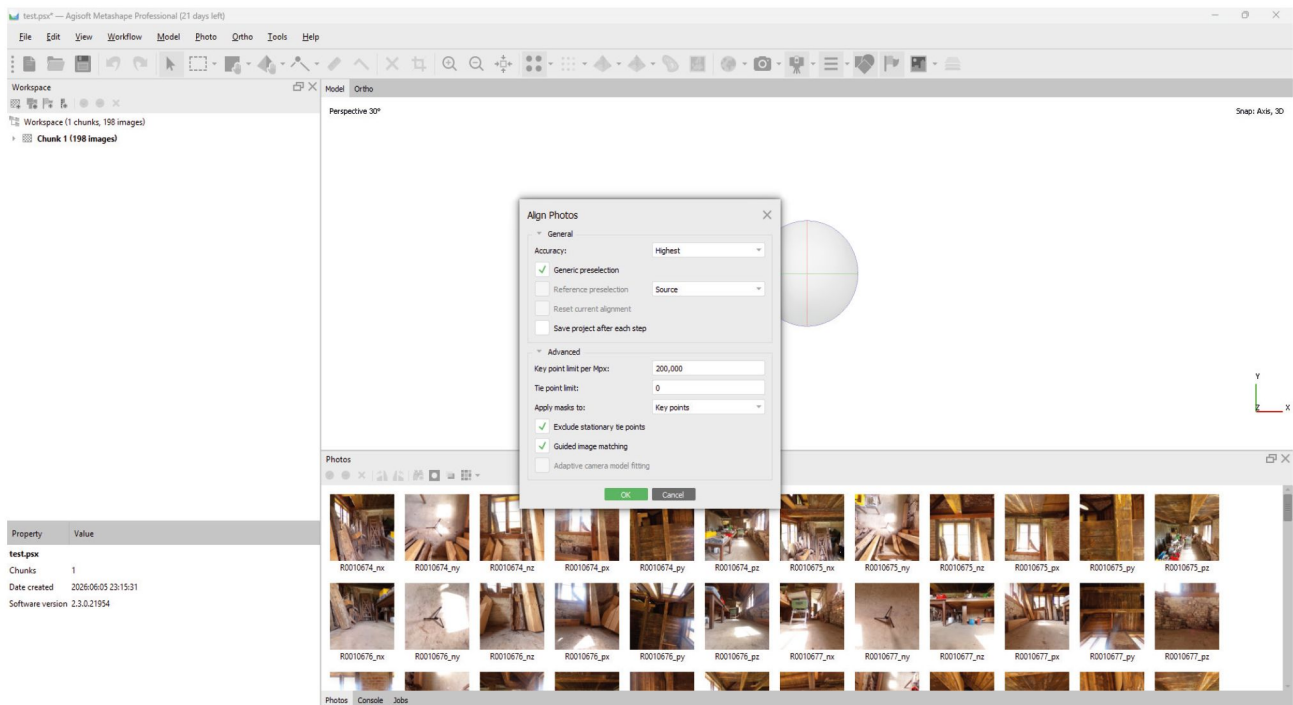
1. File -> Import -> Import Masks....
2. Settings:
 - Method: From File
 - Filename template: {filename}.png
 - Path: your out\masks folder
 - Apply to: All cameras
3. Click OK. Only the ~33 nadir images receive a mask (the others have no file – that is intended).



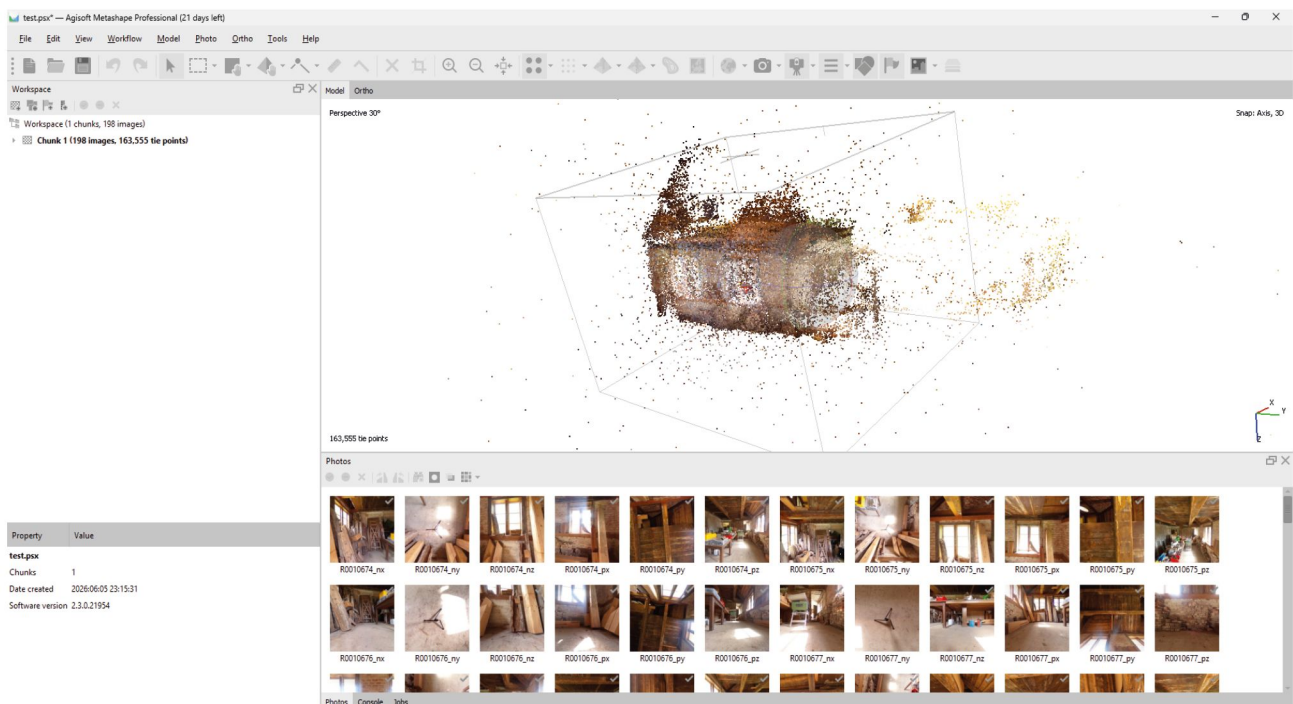
STEP 5 – ALIGN THE PHOTOS (ALIGN PHOTOS)

This is where Metashape works out from where each photo was taken (the camera positions), by finding the same points across many images. It produces a sparse cloud of “tie points”.

1. Workflow -> Align Photos....
2. Settings:
 - Accuracy: High -> full image resolution, sharp tie points.
 - Generic preselection: yes -> speeds up finding image pairs.
 - Reference preselection: no -> we have no GPS data.
3. Expand Advanced:
 - Key point limit: 500000 -> empirically a clearly better alignment than the default for this kind of repetitive interior. It is an upper limit; on a 6 GB GPU it is memory- and time-intensive. If you run out of memory, try 200000.
 - Tie point limit: 0 (unlimited -> more robust geometry).
 - Apply masks to: Key points -> no points are created in the masked (tripod) area.
 - Adaptive camera model fitting: no (the calibration is fixed).



Click **OK** and wait. You then see a thin cloud of tie points plus the camera positions.



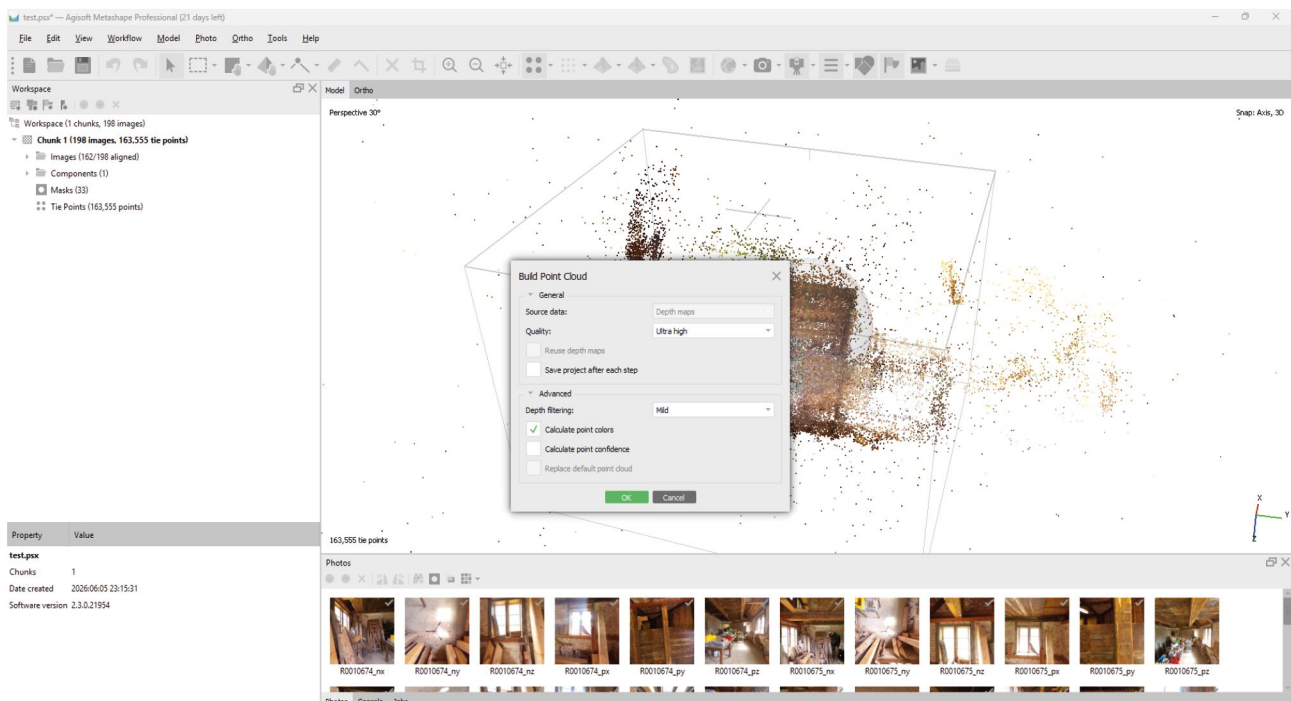
CHECK: In the Workspace, the number behind “Cameras” shows how many were aligned (e.g. 161 of 198). If very few align, see “Troubleshooting” below.

STEP 6 – BUILD THE POINT CLOUD (INCL. DEPTH MAPS)

This turns the photos into the dense, coloured 3D point cloud. In Metashape 2.x the depth-map settings live inside this dialog – there is no separate “Build Depth Maps” menu item.

Note (Metashape 2.x): “Build Depth Maps” is no longer a separate menu item; quality and filtering are now part of Build Point Cloud, and both are computed in one step.

1. Workflow -> Build Point Cloud....
2. Settings:
 - Quality: Ultra High -> this is the depth-map quality, maximum density and detail. Low on graphics memory (≤ 6 GB)? Use High – nearly as good and much faster.
 - Depth filtering: Mild -> keeps fine interior edges (beams, window reveals); stronger filtering would smooth them away.
 - Calculate point colors: yes -> a coloured cloud.
 - Calculate point confidence: yes > lets you later filter out low-quality points.



Click OK and wait (the most compute-heavy step). The finished dense cloud appears in the 3D view.

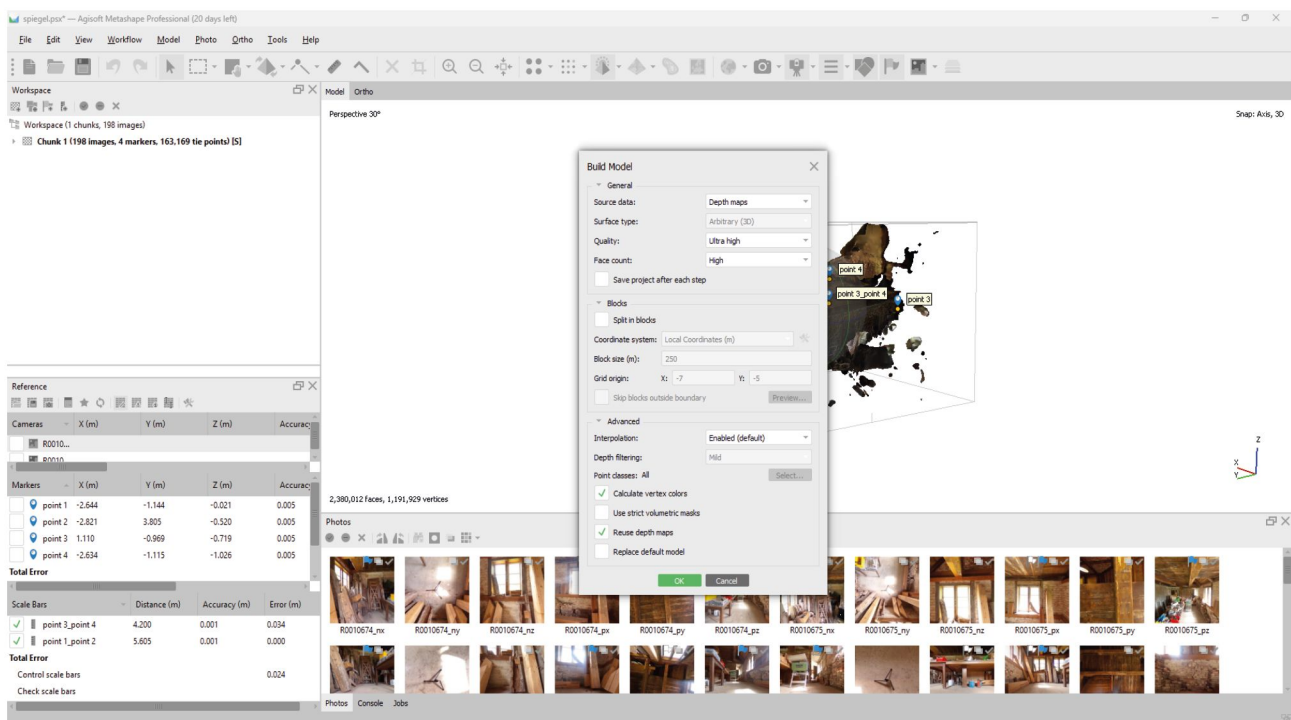
STEP 6B – (OPTIONAL) BUILD A MESH

A mesh is a closed surface in addition to the point cloud (in Rhino you can overlay cloud + mesh). Order: build the mesh first, then straighten (6c), then export both – that keeps cloud and mesh aligned to each other.

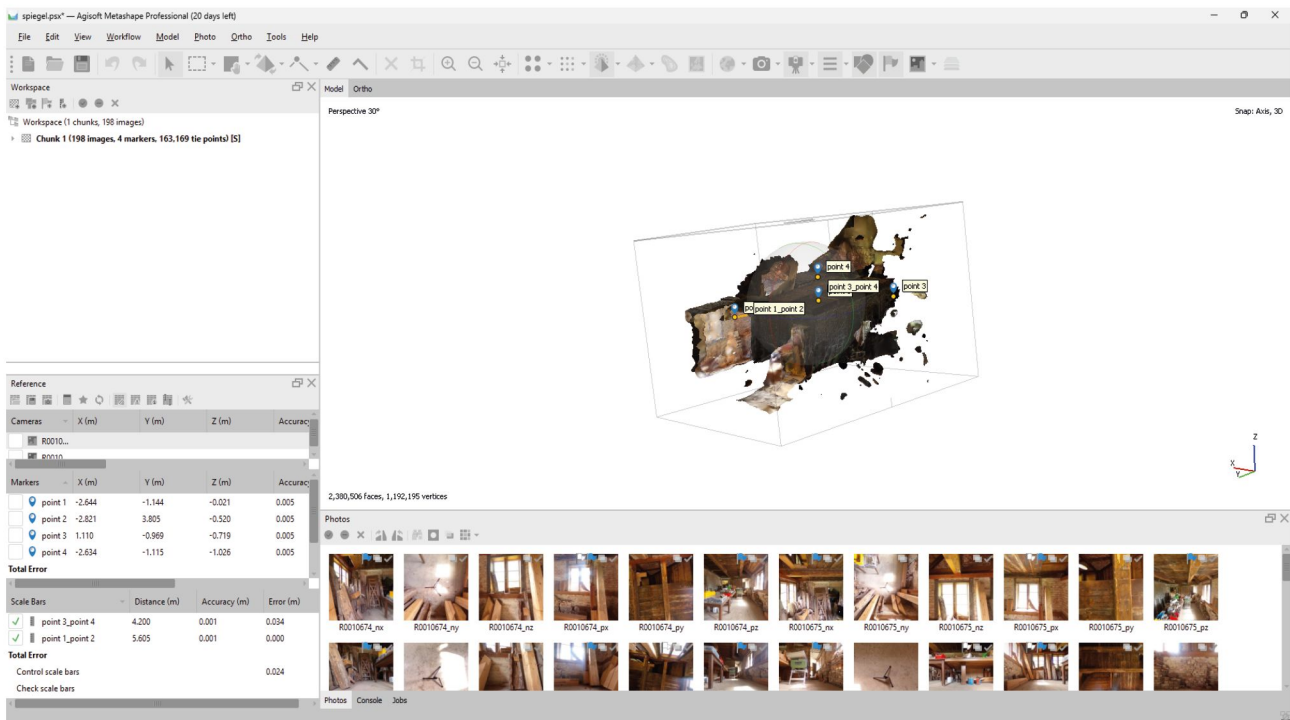
1. Workflow -> Build Mesh....

2. Settings:

- Source data: Depth maps -> uses the Ultra-High depth maps, finest surface.
- Surface type: Arbitrary (3D) -> an interior, not 2.5D terrain.
- Face count: High -> a dense mesh.
- Interpolation: Enabled -> closes small holes.
- Calculate vertex colors: yes -> a coloured mesh.



Click OK and wait. The mesh then appears in the 3D view.



6B OPTION: BAKE A TEXTURE (WORKFLOW -> BUILD TEXTURE...)

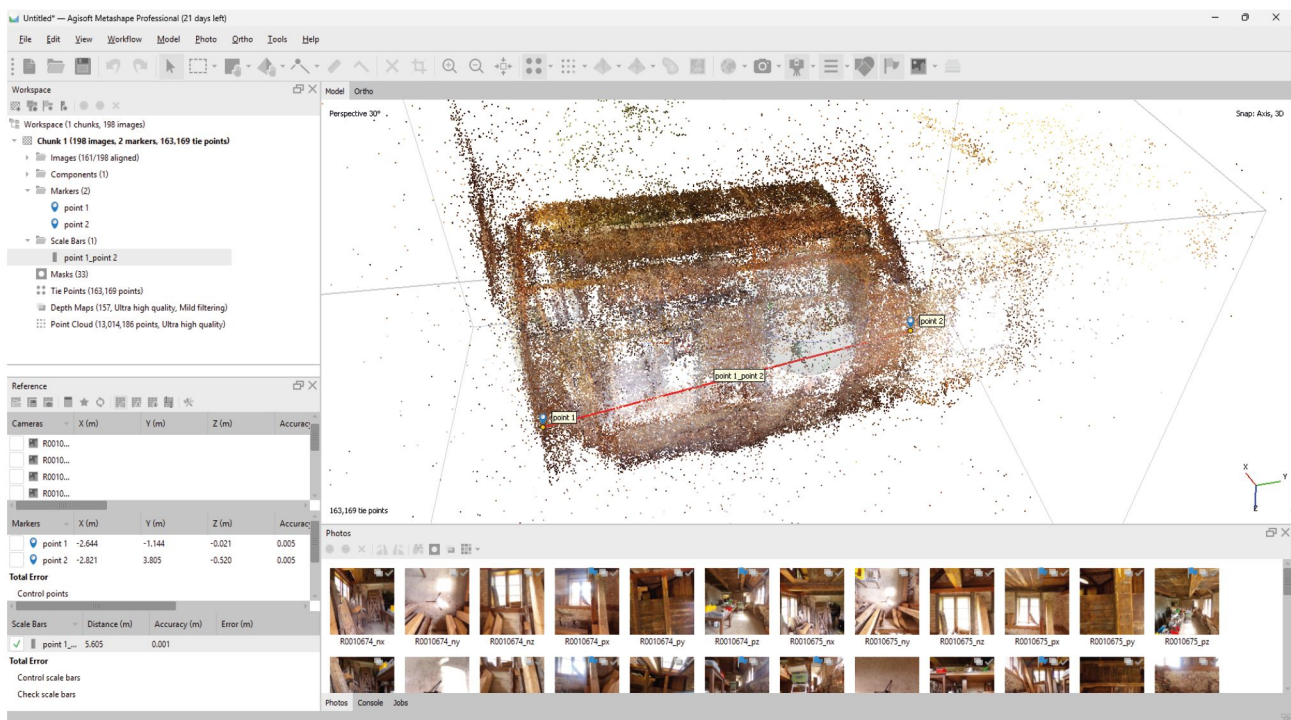
A texture makes the mesh look photorealistic. You only need it for presentation or rendering – for a pure geometry comparison in Rhino it is not required (vertex colours are enough, and the Gaussian splat is more photorealistic anyway).

1. Workflow -> Build Texture....
2. Settings: Texture type Diffuse map · Source data Images · Mapping mode Generic · Blending mode Mosaic (best quality) · Texture size 4096 (or 8192 for more detail) · Enable hole filling yes · Enable ghosting filter yes.
3. Click OK. When exporting OBJ you then also get a .mtl file + a texture JPG – keep all three files together when importing into Rhino.

STEP 7 – SET THE SCALE (REQUIRED FOR REAL MEASUREMENTS)

Photogrammetry from photos has no real size. You give it a real size with one known distance (e.g. a measured wall length). Without it the cloud is correct in shape but not in metres. Known distances from the floor plan: 5.605 m (main reference), 4.20 m (check).

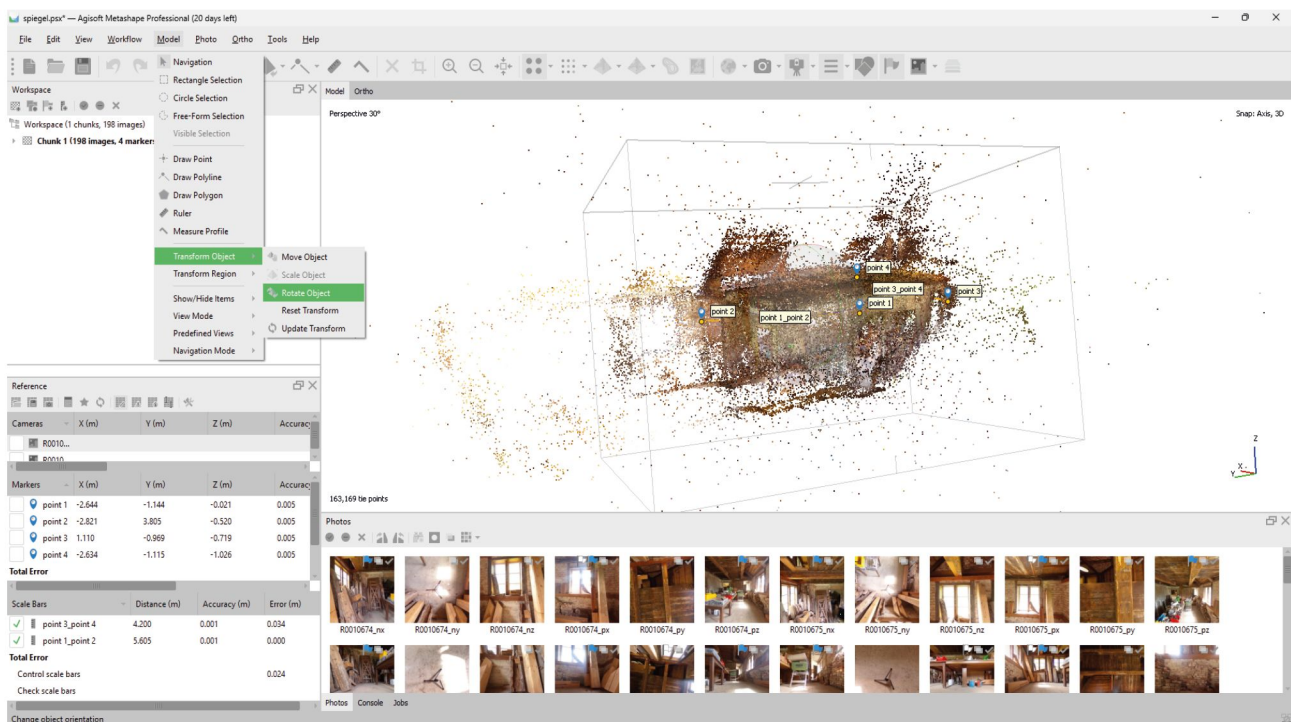
1. Right-click the first wall corner of the 5.605 m line -> Add Marker -> "point 1". Do the same for the opposite corner -> "point 2".
2. Select both markers with Ctrl -> right-click -> Create Scale Bar.
3. Open the Reference panel: menu View -> Reference (this is not "Workspace", and it is often not open!) -> scroll all the way down to the Scale Bars section.
4. In the scale bar (point 1_point 2) double-click the Distance (m) cell -> type 5.605 -> Enter, with the checkbox ticked.
5. Tick the scale bar's checkbox and click Update Transform -> in the Reference toolbar -> only now is the scale applied (check: that scale bar's Error (m) is then ~0).
6. Check: add a second scale bar across the 4.20 m line, enter 4.200 but leave its checkbox unticked (an independent check) -> look at its Error (m) column (< ~0.04 m is good)



STEP 7B – STRAIGHTEN THE MODEL (IF Z POINTS DOWN)

Without georeferencing the model is often upside down (the Z axis points down). This rotates the whole chunk (affects both cloud and mesh).

1. Activate the Rotate Object tool (toolbar group Move/Rotate/Scale Object, or Model -> Transform Object -> Rotate Object).
2. Drag the gizmo ~180° around the horizontal axis until floor is at the bottom, roof at the top.
3. Check the axis tripod (bottom right) – Z must point up.



It doesn't have to be perfectly exact: in Rhino, Orient3Pt aligns the cloud precisely to your existing model anyway. The point here is just that the export is no longer upside down. Important: after rotating, re-export the point cloud (below), otherwise the file keeps the old orientation.

STEP 8 – EXPORT (POINT CLOUD + MESH)

This writes the results to files so other programs (CloudCompare, Rhino, Nerfstudio) can use them.

8a – Point cloud

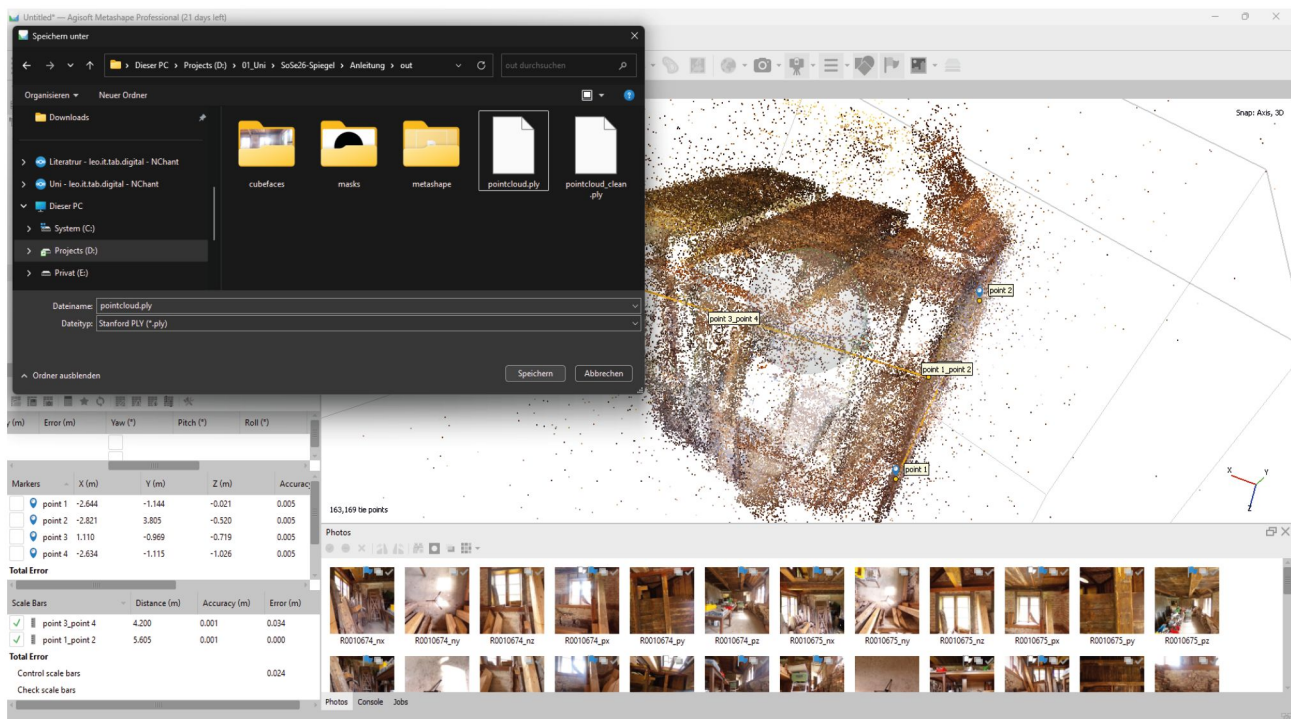
1. File -> Export -> Export Point Cloud....
2. File name pointcloud.ply, format PLY, tick colours (and normals). (Re-export/overwrite after straightening!)

8b – Mesh (if built in 6b)

1. File -> Export -> Export Model....
2. File name mesh.obj, format OBJ (Rhino-friendly), include vertex colours / texture.

8c – Cameras (for the optional splat) and report

1. File -> Export -> Export Cameras... -> format Metashape XML -> cameras.xml (needed later for Nerfstudio – no COLMAP required).
2. File -> Export -> Generate Report... -> report.pdf (alignment stats, camera positions, reprojection error).
3. Save the project (Ctrl+S).



TROUBLESHOOTING

Problem	Cause	Fix
Very few cameras aligned	too little overlap / textureless walls	Accuracy High, remove blurry images, shoot from more positions
„Ghost tripod“ in the cloud	tripod treated as a shread feature	use the nadir masks (Step 4); in Align set „Apply masks to: key points“
Calibration „drifts“	Fix box not ticked	Step 3: tick „Fix calibration“
Depth/cloud aborts (out of memory)	GPU memory too small at Ultra High	set Quality to „High“, close other GPU apps
Model „too small/ large“	no scale set	Step 7: scale bar + Update Transform

2.3 CLOUDCOMPARE – COMPLETE GUI WORKFLOW

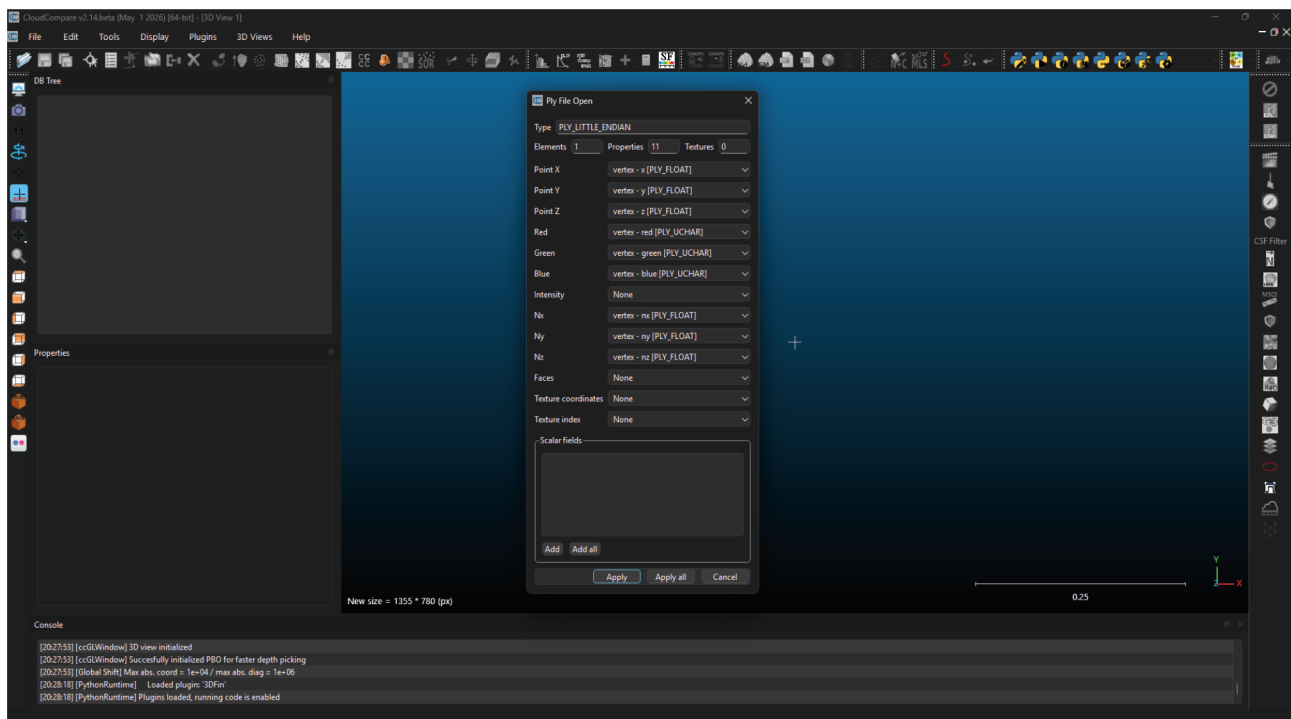
Clean up the point cloud: remove outliers, even out the density, optionally crop, and export.
Input: out\pointcloud.ply · Output: out\pointcloud_clean.ply.

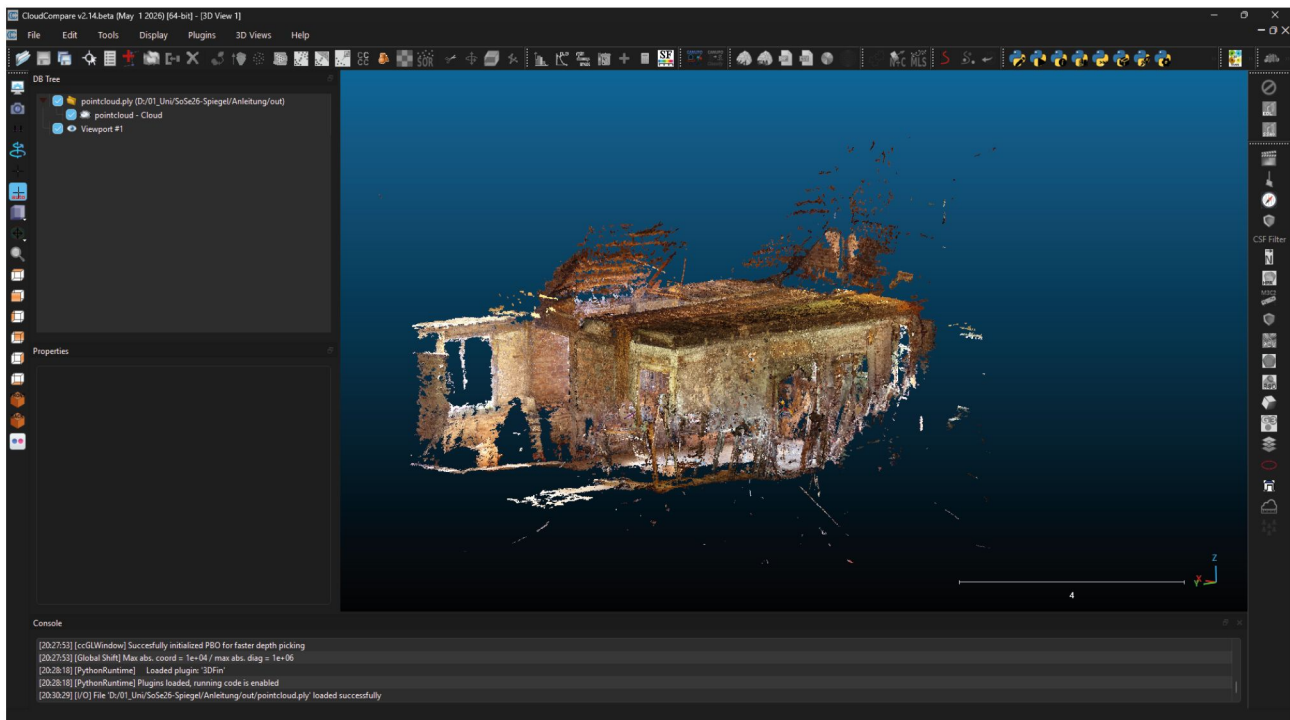
CloudCompare's interface is in English. Version: current 2.13+.

STEP 1 – OPEN THE CLOUD

1. File -> Open -> your out\pointcloud.ply.
2. If a “Global shift/scale” dialog appears (for large coordinates): click Yes / accept the suggested shift. For a PLY scalar-field question, just click OK.
3. The cloud appears on the left in the DB Tree and in the 3D view.

Nothing visible? Click the cloud in the DB Tree -> in the Properties below set “Colors” to RGB; if needed raise Point size to 2–3.





STEP 2 – REMOVE OUTLIERS (S.O.R. FILTER)

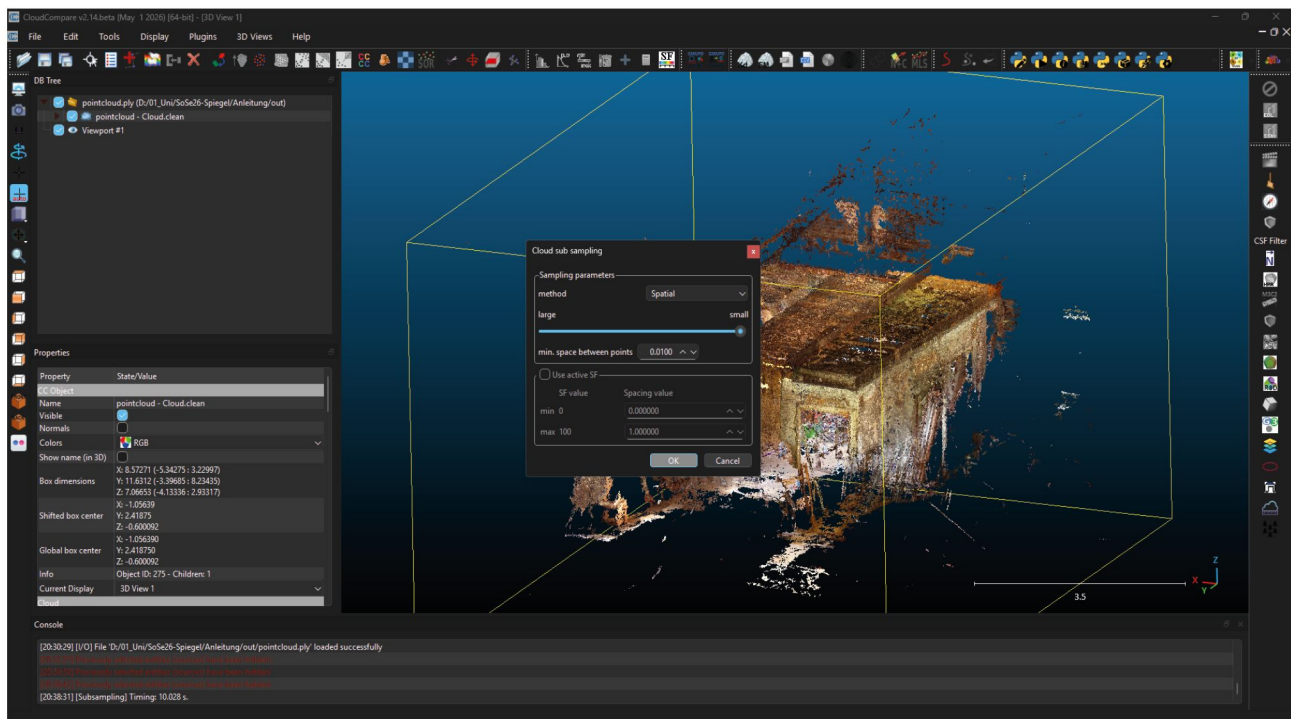
Reconstruction leaves stray points floating in space. This filter looks at each point's neighbours and removes the ones that sit much further away than usual – i.e. noise.

1. In the DB Tree click the cloud (select it – otherwise the tools are greyed out).
2. Tools -> Clean -> S.O.R. filter (Statistical Outlier Removal).
3. Values:
 - Number of points (mean distance estimation): 6
 - Standard deviation multiplier (nSigma): 1.0
4. Click OK -> a new cloud ...clean appears in the DB Tree.

STEP 3 – EVEN OUT THE DENSITY (SUB-SAMPLE)

Some areas are far denser than others. Spatial subsampling keeps at most one point per small cube, giving a uniform density and a much smaller file – easier to handle in Rhino.

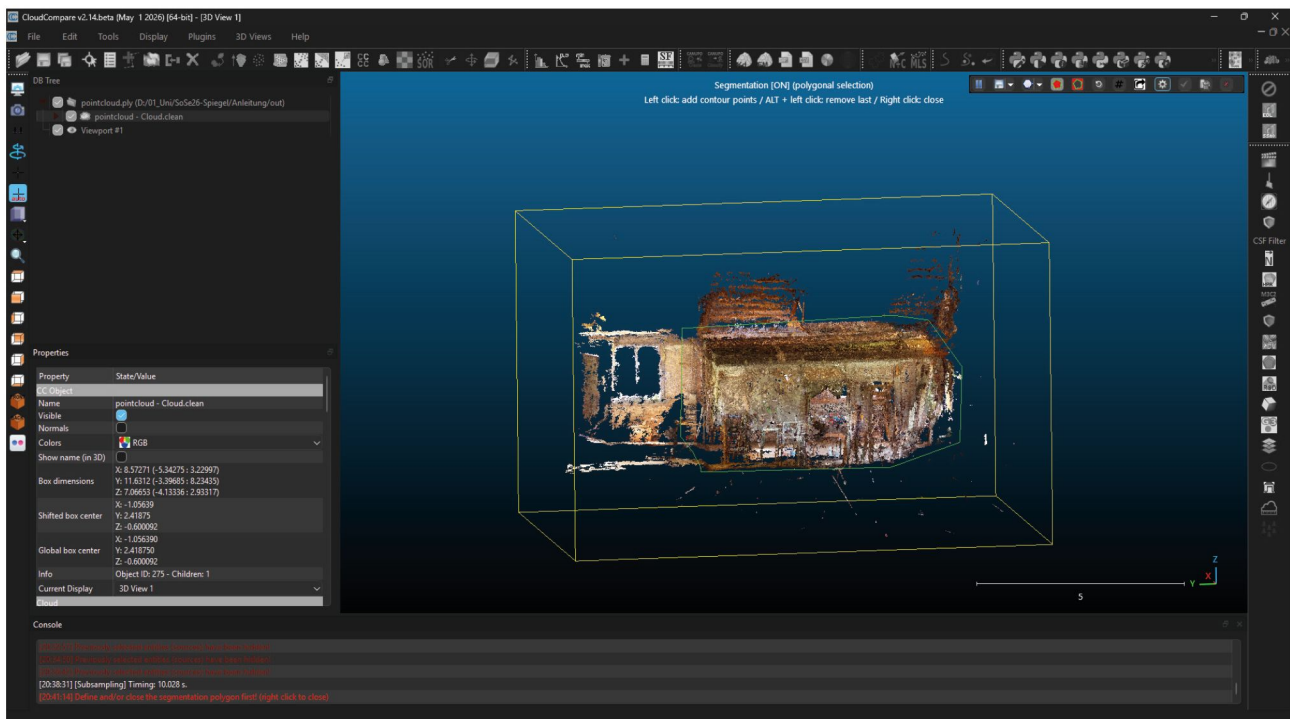
1. Select the ...clean cloud.
2. Edit -> Subsample.
3. Method: Space (spatial). Min. space between points: 0.01. Meaning: at most one point per 1 cm cube. Important: this value is in model units – only if the cloud was scaled in Metashape does 0.01 equal a real 1 cm.
4. Click OK -> a new, thinned cloud.



STEP 4 – (OPTIONAL) CROP / CUT AWAY UNWANTED PARTS

The cloud still contains stray points outside the room (e.g. seen through windows). Cutting them away gives a clean, room-only cloud.

1. Select the cloud -> Edit -> Segment (or the scissors icon in the toolbar).
2. Draw a polygon around the area with clicks, close it with a right-click.
3. Segment In (keep) or Segment Out (remove) – toolbar buttons – then confirm (the tick).



STEP 5 – (OPTIONAL) MERGE TWO CLOUDS (ALIGN + ICP)

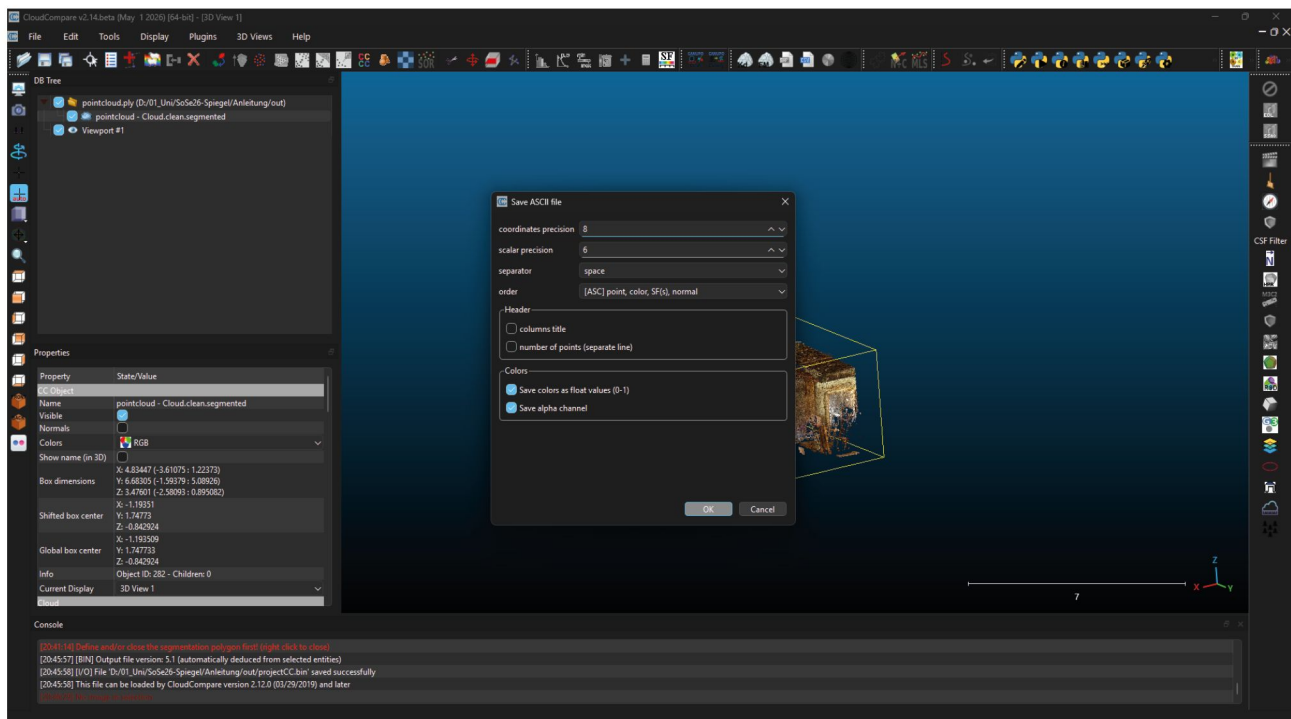
Only needed if you have more than one cloud and want to combine them into one coordinate system.

1. Select both -> Tools -> Registration -> Align (point pairs picking) -> click ≥ 3 matching point pairs -> Align.
2. Then refine: Tools -> Registration -> Fine registration (ICP).

STEP 6 – EXPORT

Save the cleaned cloud so Rhino (and others) can use it.

1. Select the final cloud in the DB Tree.
2. File -> Save -> file type PLY -> out\point-cloud_clean.ply.
3. PLY options: Binary (smaller) or ASCII; OK.



TROUBLESHOOTING

Problem	Fix
Cloud invisible / black	Properties > Colors RGB, raise Point size
Tools greyed out	select the cloud in the DB Tree first
Subsample too coarse / fine	value is in model units – adjust to your scale
Huge coordinates / lag	accept Global shift when opening

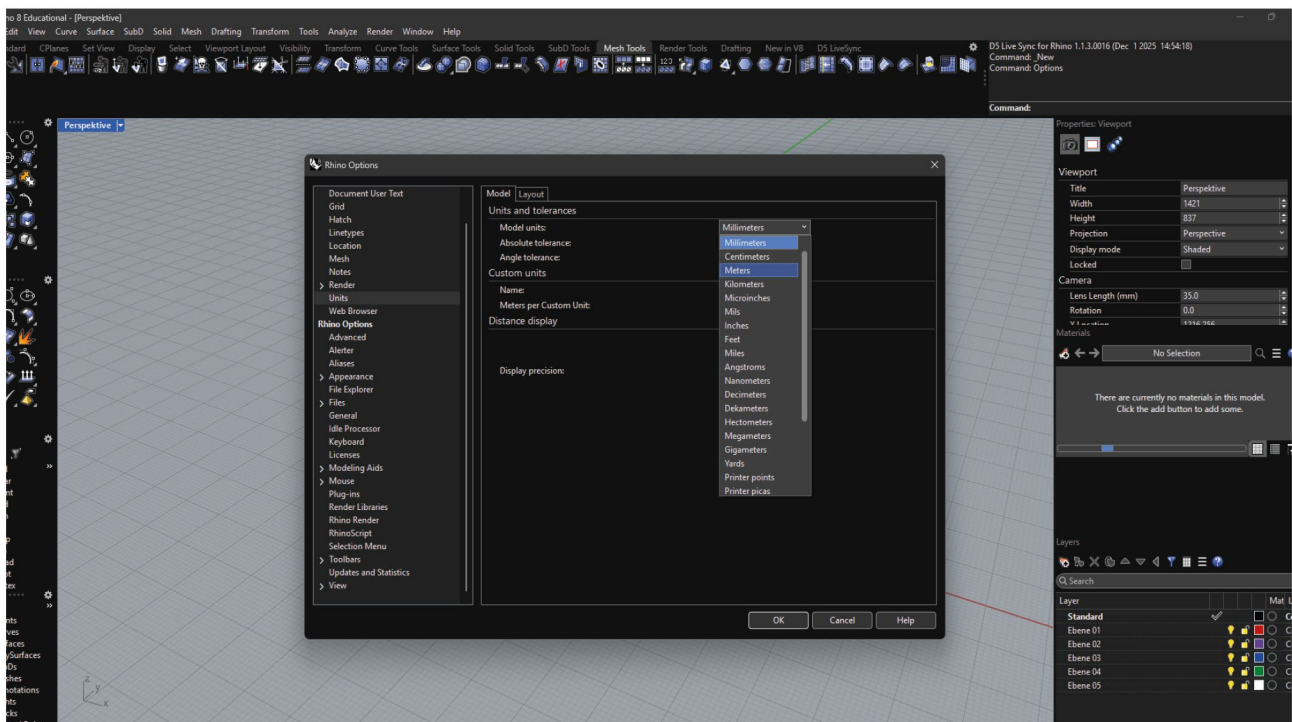
2.4 RHINO – OVERLAY THE POINT CLOUD + MESH WITH THE EXISTING MODEL

Fit the cleaned, true-to-scale point cloud and the mesh into your existing Rhino model, overlay them, and check for deviations. Input: out\pointcloud_clean.ply + out\mesh.obj + your Rhino model.

STEP 1 – OPEN THE EXISTING MODEL AND CHECK UNITS

The cloud is in metres. If your model is in millimetres, the cloud would import 1000× too small/large – so the units must match.

1. Open your existing Rhino model.
2. Check the units: command Units (or DocumentProperties ▢ Units).
- If the model is in millimetres, scale on import (factor 1000) or change the document unit.

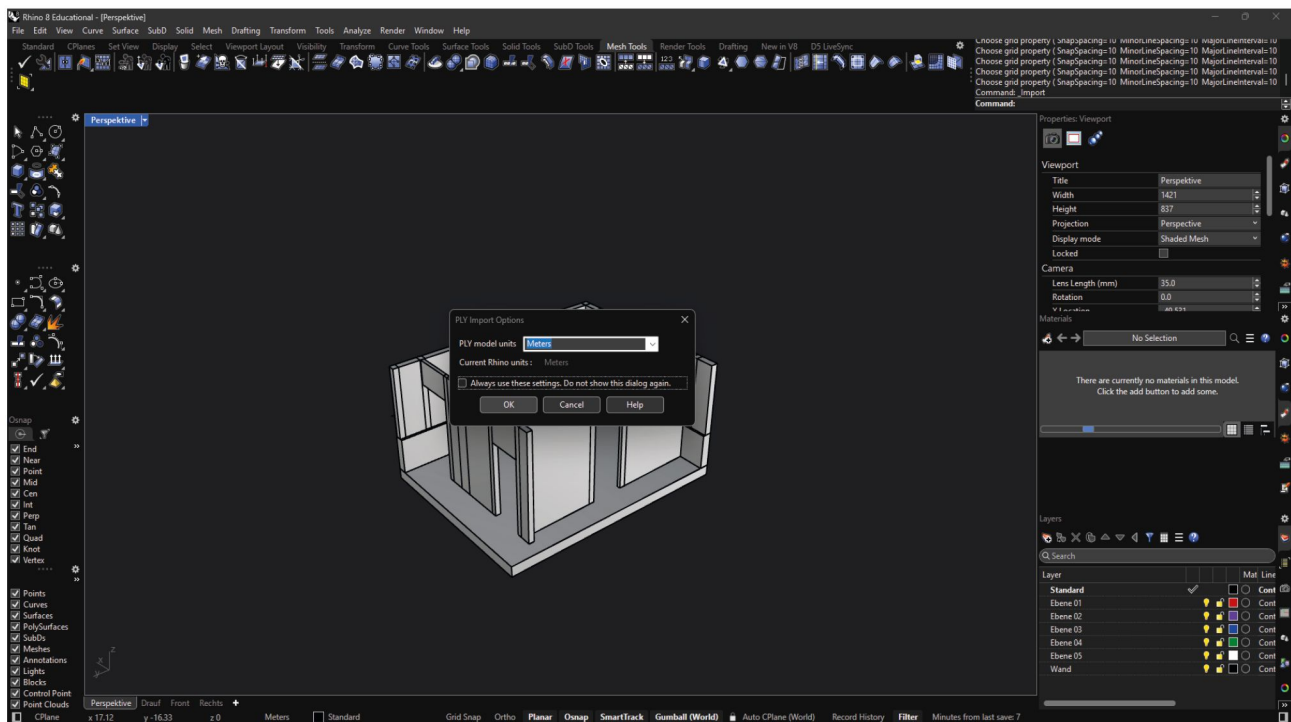


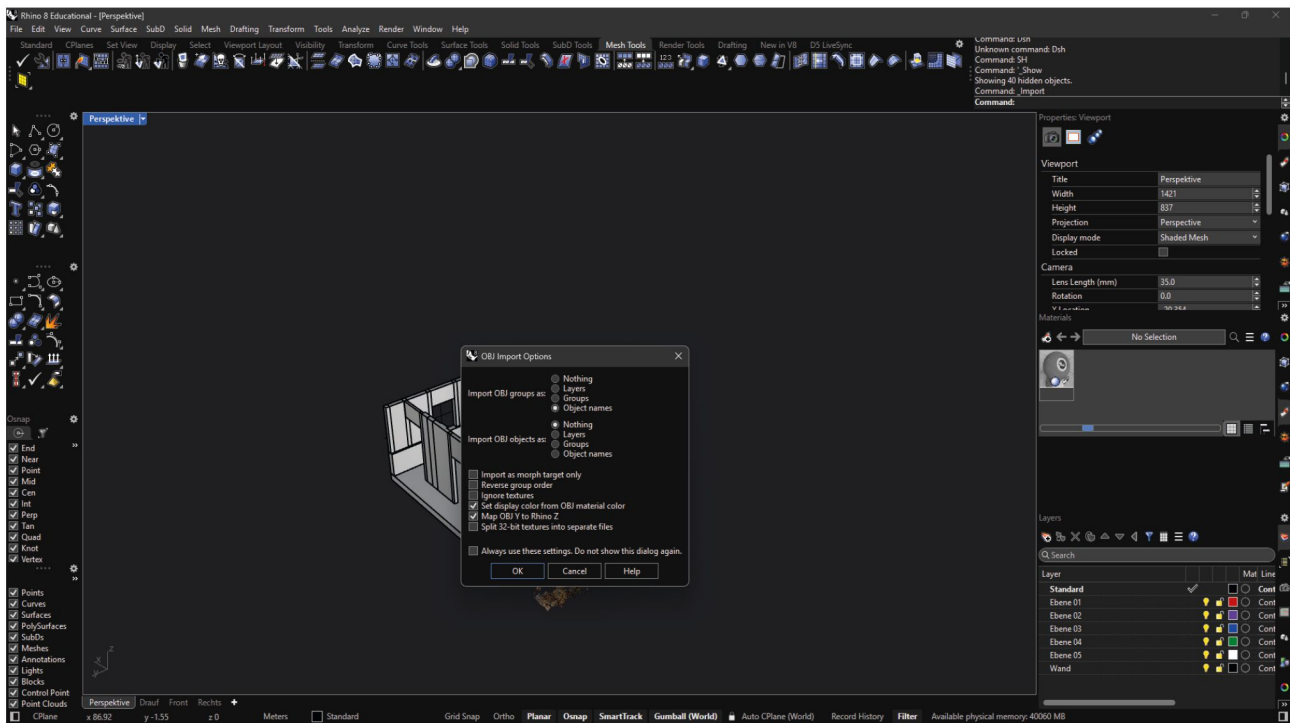
STEP 2 – IMPORT THE POINT CLOUD AND THE MESH

Loading both lets you compare them against your CAD model and against each other. Since both come from the same (straightened) Metashape project, they line up automatically.

1. File -> Import... (or command `_Import`) -> out\pointcloud_clean.ply. -> a PointCloud object. Keep vertex colours, OK.
2. File -> Import... again -> out\mesh.obj -> the mesh is added.
3. Put them on separate layers (e.g. "Point-Cloud" / "Mesh") so you can show/hide each one. Because they share the same straightened origin, they sit exactly on top of each other.

Units trap: if Rhino asks for the unit on import, choose metres. Otherwise use Scale (factor 1000 or 0.001) – treat both objects the same. Upside down? If you didn't straighten in Metashape: select both together and Rotate 180° (or Orient3Pt onto the existing model) – cloud + mesh stay aligned.





STEP 3 – MAKE IT VISIBLE/LEGIBLE

Point clouds default to tiny dots; a larger point size makes the room readable.

1. Click the cloud Properties under Point-Cloud raise Point size to 2–3.
2. If black/invisible: set the display mode to Shaded/Rendered and check the layer is on.

STEP 4 – SHOW THE EXISTING MODEL AND PLACE ROUGHLY

Get the scan and the CAD model into roughly the same place before fine alignment.

1. Turn on the layer of your CAD model.
2. Rough align with Move and Rotate until cloud and model roughly match.

STEP 5 – ALIGN PRECISELY (ORIENT3PT)

Orient3Pt snaps the scan onto the model using three matching point pairs – fast and accurate, and it also corrects any leftover rotation (including an upside-down model).

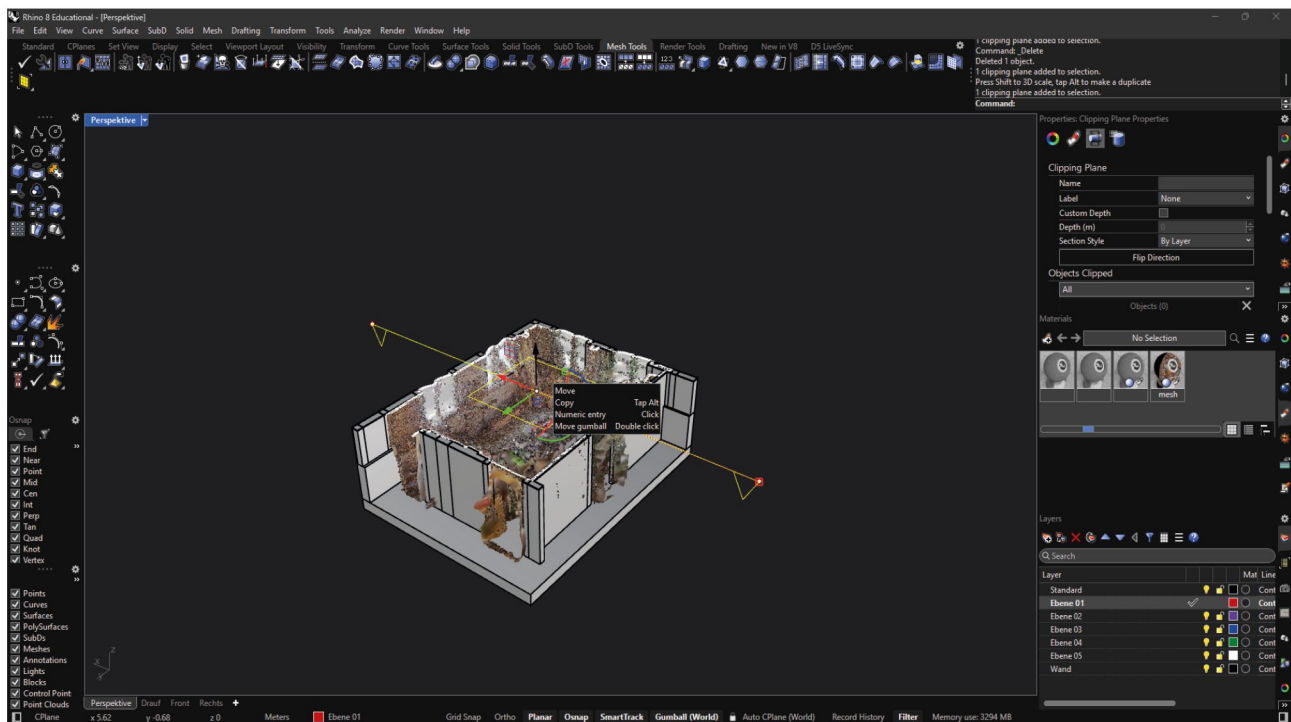
1. Command Orient3Pt.
2. Click 3 reference points on the point cloud (e.g. three clear room corners)...
3. ...then the 3 matching points on the existing model. -> Rhino places the cloud exactly onto the model.
4. Fine-tune with the Gumball (small moves/rotations).

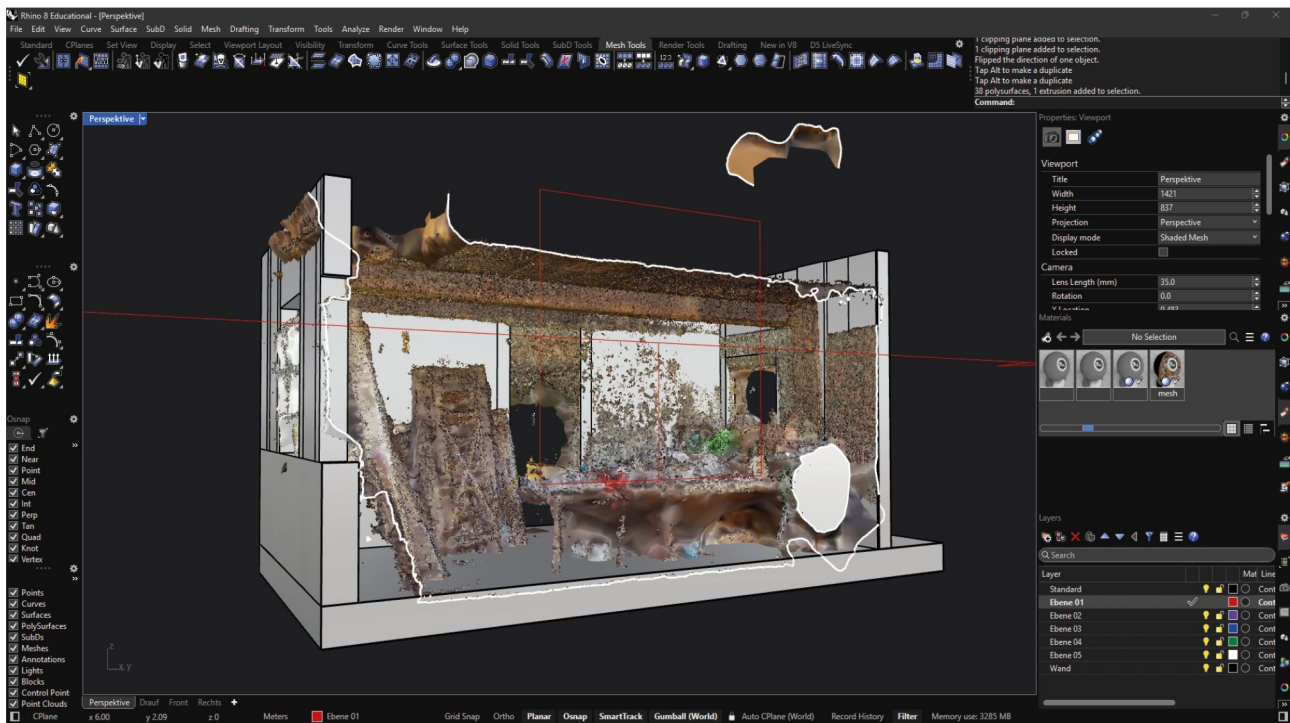
Snapping tip: to snap onto cloud points, enable “Point” in the OSnap options.

STEP 6 – CHECK DEVIATIONS

This is the actual purpose – seeing where the as-built scan differs from the CAD model.

1. Section or a ClippingPlane through both cloud and model.
2. In the section, measure offsets between cloud and model edges with Distance.
3. Big scale errors? Don't scale in Rhino – fix the scale in Metashape (scale bar) and re-export.

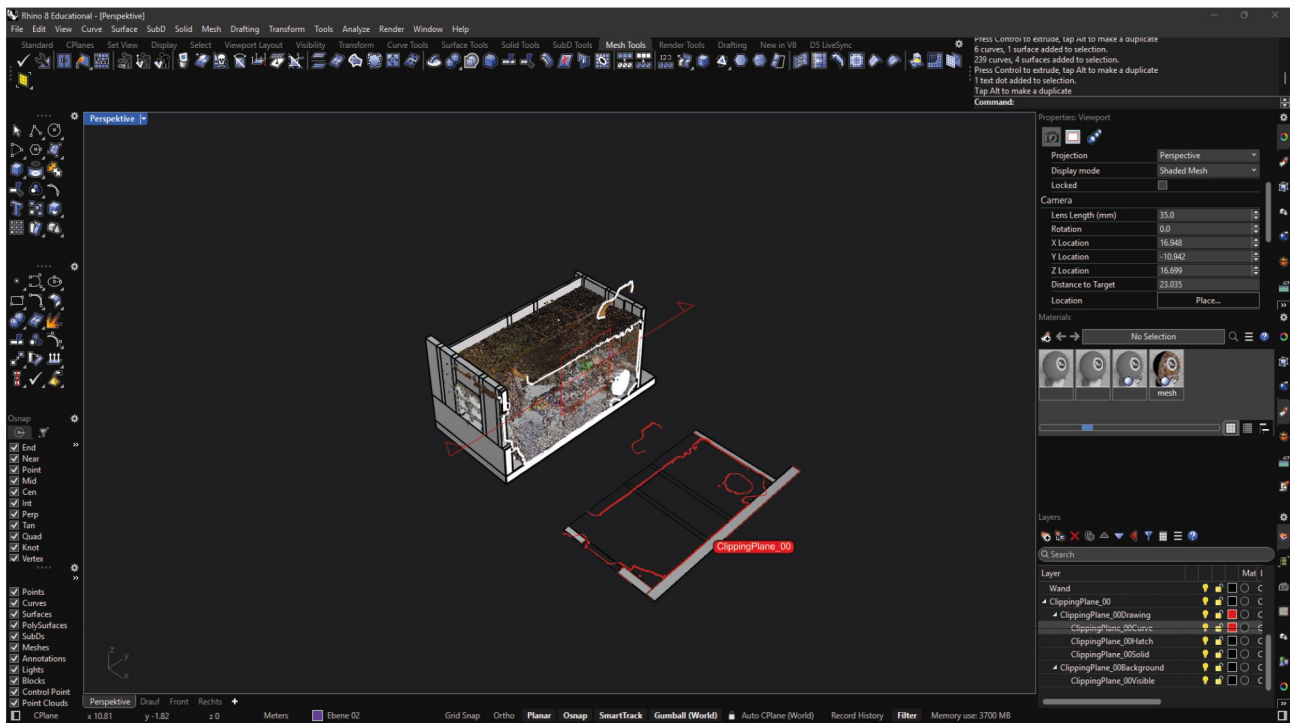




STEP 7 – CREATE A CLIPPING DRAWING

A clipping plane slices through the overlaid cloud + model; from that slice you can produce a clean 2D drawing (a section or a floor plan) to document, dimension, or print.

1. Command ClippingPlane -> draw the plane where you want the cut (horizontal for a floor plan, vertical for a section). Everything beyond it is hidden in that view.
2. Move/rotate the plane with the Gumball to the exact cut height/position.
3. In the clipping plane's Properties, set which objects it clips if needed.
4. Generate the 2D drawing from the cut – e.g. Make2D of the clipped view (or place it on a layout) – then you can dimension and export it.



TROUBLESHOOTING

Problem	Fix
Cloud invisible	Point size 2-3, layer on, display mode
Cloud tiny / huge	units metres vs. millimetres – scale 1000 / 0.001
Can't snap to points	enable OSnap „Point“
Cloud + model don't fit	Orient3Pt with well-spread, unambiguous corners

2.5 POINT CLOUD DIRECTLY TO ARCHICAD 9 (SKIPPING RHINO)

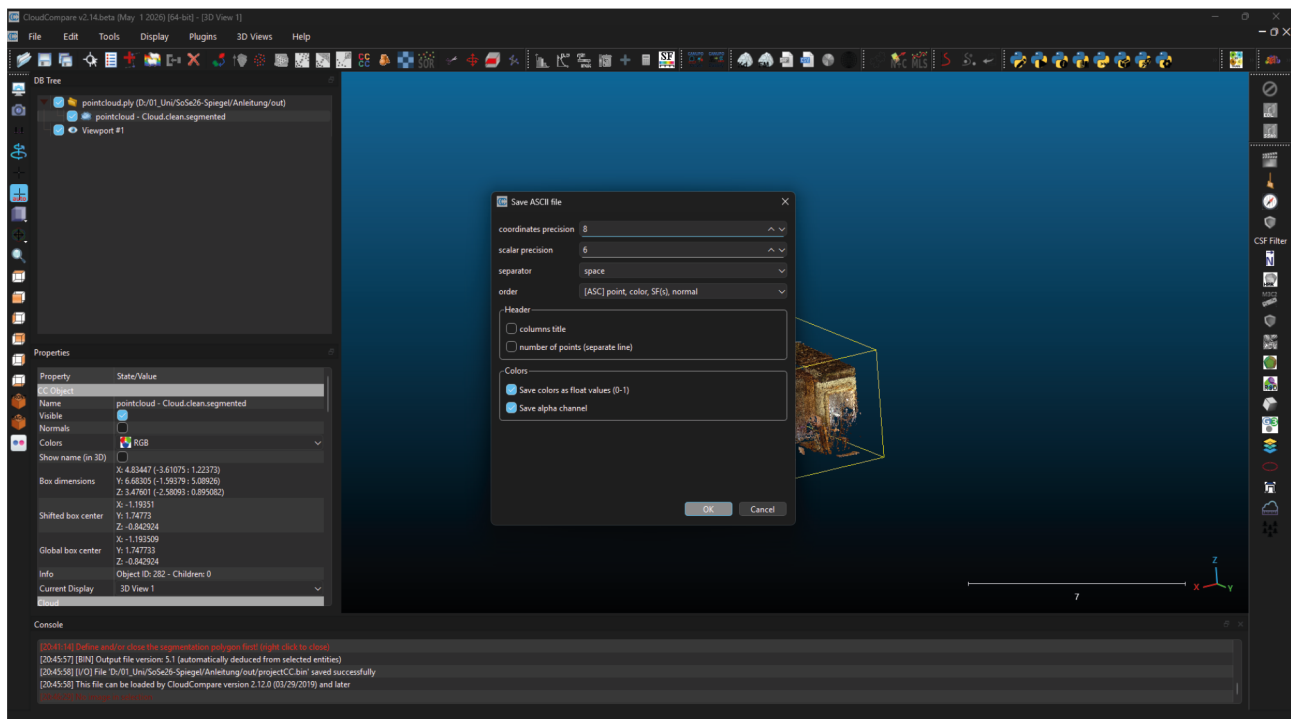
If your goal is to model the as-built directly in Archicad (draw walls, slabs etc. over the scan), you don't need Rhino at all. You bring the cleaned point cloud straight into Archicad and trace over it.

Input: the cleaned cloud from CloudCompare.
Important: Archicad does not read .ply. It reads point clouds as .e57 or .xyz, so you first export the cloud to E57.

STEP 1 – EXPORT THE CLOUD AS E57 (IN CLOUDCOMPARE)

Archicad needs E57 (or XYZ); E57 is the cleaner choice because it carries the units and colours and needs no conversion on import.

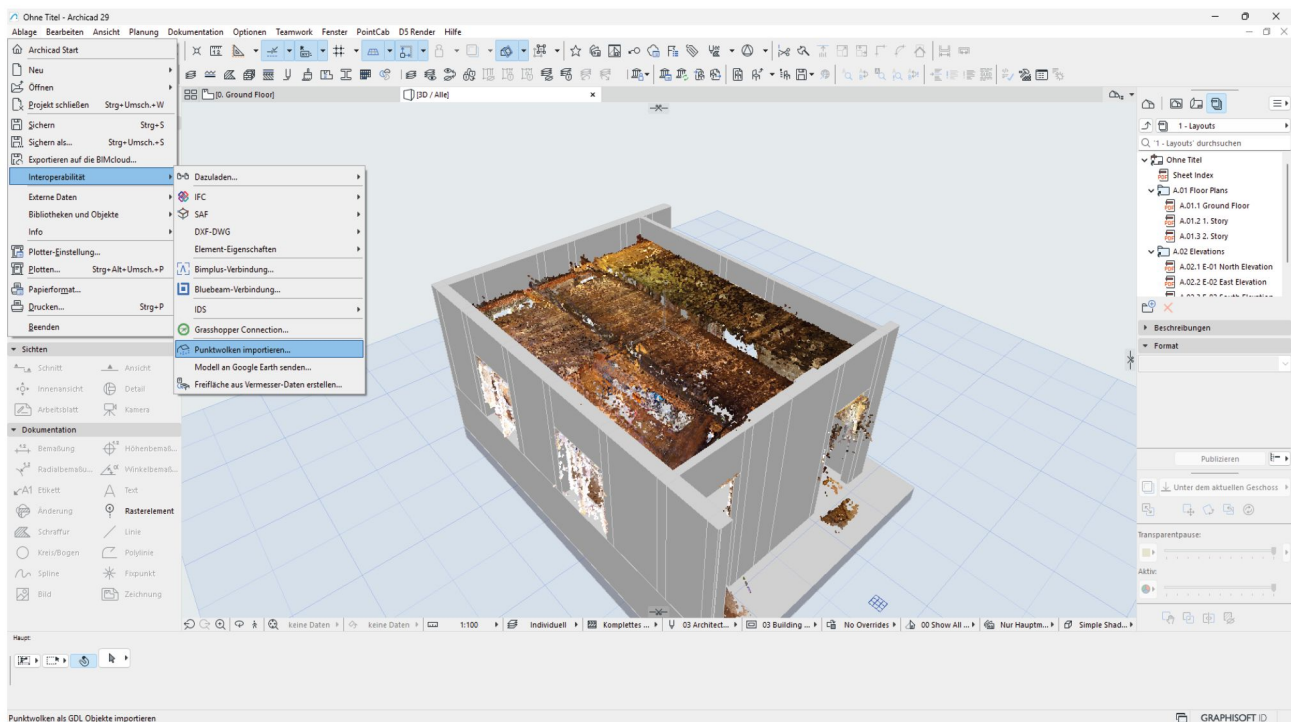
1. In CloudCompare, select the cleaned cloud in the DB Tree.
2. File -> Save -> choose file type E57 (.e57) -> save as pointcloud_clean.e57.
3. Keep the cloud reasonably light (the CloudCompare subsample already did this). Archicad's limit is 4 GB per file, and fewer points = smoother tracing.



STEP 2 – IMPORT THE CLOUD INTO ARCHICAD

This brings the scan in as a point-cloud object you can place and see in plan and in 3D.

1. In Archicad: File -> Interoperability -> Import Point Cloud.
2. Pick your pointcloud_clean.e57.
 - E57: no conversion dialog – it imports directly.
 - (If you used XYZ instead, a Format Conversion dialog appears – assign the columns for X, Y, Z and the RGB colours.)
3. Archicad converts it into a point-cloud object; place it on the Floor Plan. It also shows in the 3D window.



STEP 3 – POSITION AND LEVEL THE CLOUD

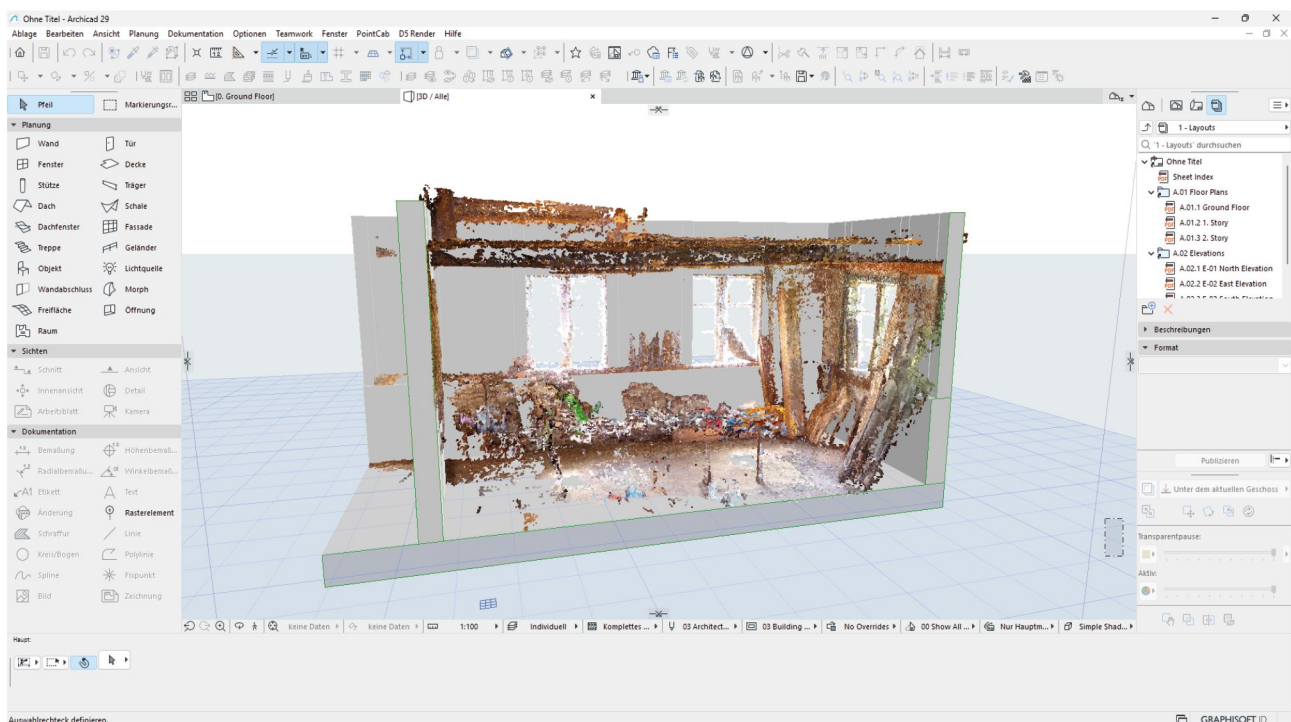
The cloud comes in at the import origin; you set it to the right place and height so it lines up with your storeys.

1. Select the placed point-cloud object.
2. Set its elevation/level (so the floor of the scan sits on your 0.00 storey) and rotation in plan, using the standard move/rotate tools (or the object's settings/coordinates).
3. Check the units: the scan is in metres; Archicad projects are usually in mm. If it comes in 1000× off, re-check the E57 units or scale the object.

STEP 4 – TRACE / MODEL OVER THE SCAN

Now you build the actual Archicad model using the cloud as a reference.

1. Work in section/elevation windows and on the Floor Plan: the point cloud is visible there, so you can snap and trace.
2. Draw Walls, Slabs, Roofs, Columns etc. directly onto the cloud outline.
3. Show/hide the cloud via its layer to compare your model against the scan at any time



TROUBLESHOOTING

Problem	Fix
Archicad won't open the file	it must be .e57 or .xyz, not .ply – export from CloudCompare first
Cloud 1000 x too big / small	units mismatch (m vs. mm) – check the e57 units or scale the object
Very slow / heavy	subsample more in CloudCompare; keep well under the 4 GB limit
Cloud not visible in a section	Make sure its layer is shown and the section range cuts through it

04 PHOTOGRAMMETRY

APPENDIX

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PROCESSDIAGRAM

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STEP-BY-STEP MANUAL

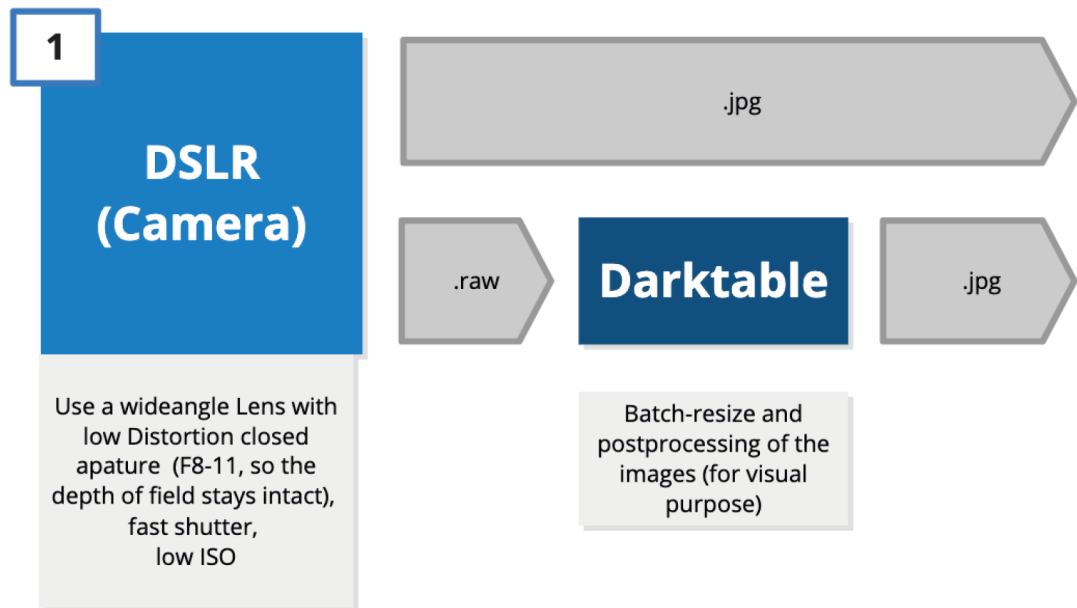
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1

PROCESSDIAGRAM



Our processdiagram evolved continuously throughout the project. It illustrates the workflow that we ultimately selected and successfully implemented. Through targeted research and initial trials, we were able to avoid switching between different software solutions and establish a functional and efficient workflow early on.

This allowed us to focus on the camera technology and the photographic capture process in order to achieve the most precise results possible. At the same time, we were able to gain valuable insights into image capture and derive corresponding recommendations for practical implementation .

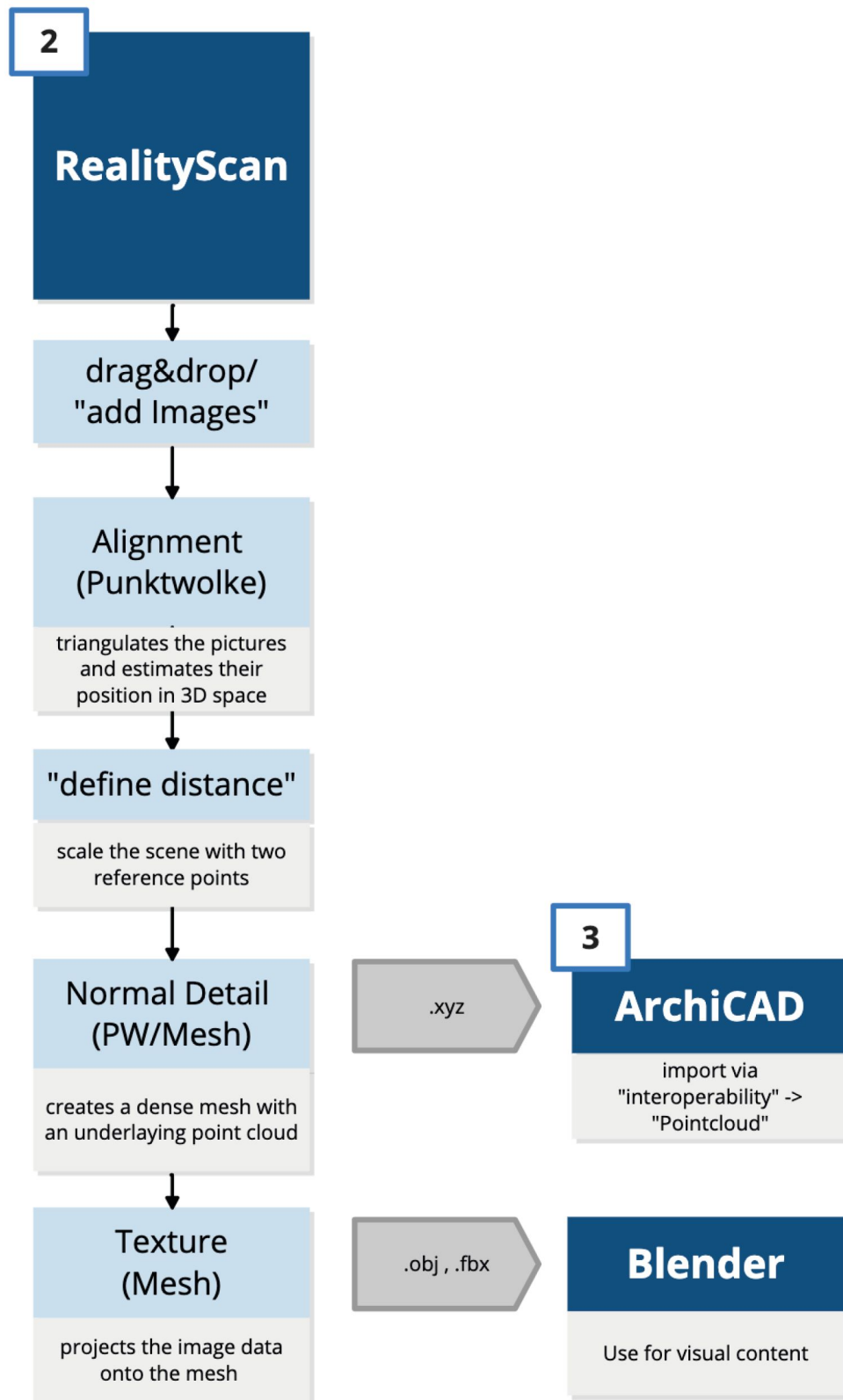


Fig. 4.App.26: processdiagram - workflow during the semester

2

STEP-BY-STEP MANUAL

STEP 1 - SETUP

A) SET UP THE CAMERA

Use a DSLR (Digital Single-Lens Reflex) camera to take the photos.

Turn off automatic mode and set the camera to the following settings:

- 16-35 mm (lens focal length)
16 mm = very wide-angle (shows a lot of the scene, but there's a risk of distortion).
35 mm = less wide-angle, slightly closer to the subject.
- f/8.0-11.0 (aperture) --> this ensures as much of the image as possible is in focus
Disadvantage: Less light reaches the sensor, so you need to pay attention to the lighting conditions (see Step 1.B).
- 1/100 (shutter speed) --> to prevent camera shake
- Low ISO up to 10 000 (sensor's light sensitivity) --> for the best image quality with minimal noise

B) LIGHTING CONDITIONS

To achieve the best final result, you need sufficient light. Take photos of scans outdoors on a cloudy day to avoid harsh shadows and, if the room needs to be lit, use only static light sources whenever possible

C) TAKING PHOTOS

Now that everything is set up, start taking the photos.

Take photos of:

- objects, rooms, and ornaments—all the way around, from all sides
- from 2–3 different heights
- the floor and ceiling in a “grid pattern,” from as high up as possible.

Note:

- hold the camera as straight as possible to avoid distortion
- the images should always overlap so they can be easily reused later

D) REFERENCE MEASUREMENT

Measure a prominent object in the room. We'll use this as a reference measurement later. Be precise and write down the measurement.

E) UPLOAD PHOTOS TO A COMPUTER

Upload your photos to a Windows computer for the next steps

STEP 2 - REALITYSCAN

A) DOWNLOAD AND SET UP THE SOFTWARE

Before you can start creating a 3D model, you must install RealityScan on your Windows computer.

To do this, you'll need to download the Epic Games Launcher. RealityScan is distributed via the Epic Games Launcher:

- open the Epic Games website (<https://store.epicgames.com/?lang=de>)
- download the Epic Games Launcher for Windows

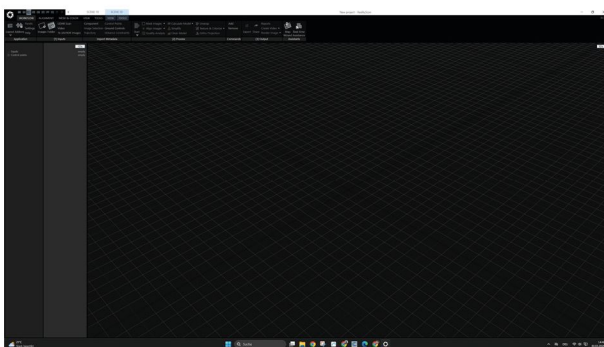
After the download is complete, open the installation file and follow the instructions in the installation wizard. Wait until the installation is complete.

- create an Epic Games account or log in
- launch the Epic Games Launcher



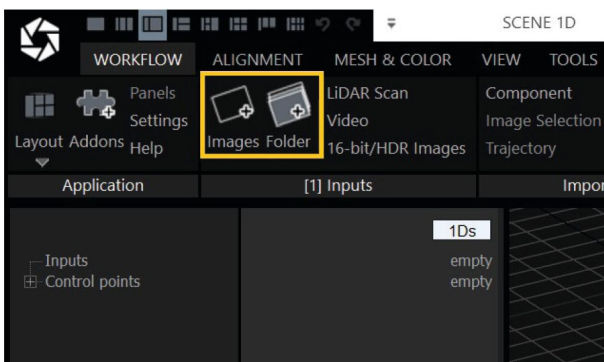
Install RealityScan (Depending on your internet speed, the download may take a few minutes)

- open the Epic Games Launcher
- select the Store section from the left-hand menu or use the search function
- search for RealityScan and open the product page
- click Install or Add to Library
- select the desired installation folder
- start the installation
- once the installation is complete, you can launch RealityScan (Setup may take a little longer the first time you run the program.)
- create a New Project
- after opening RealityScan, you can start a new project right away. After opening RealityScan, you can start a new project right away



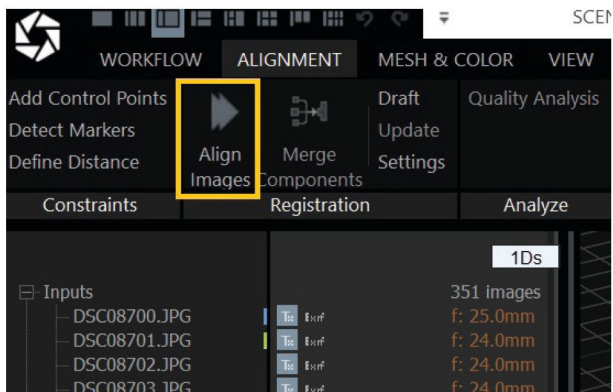
The program looks like this:

- Left: File contents such as inputs, models, and textures (1Ds)
- Right: The 3Ds pane for viewing and editing models
- Top: The toolbar

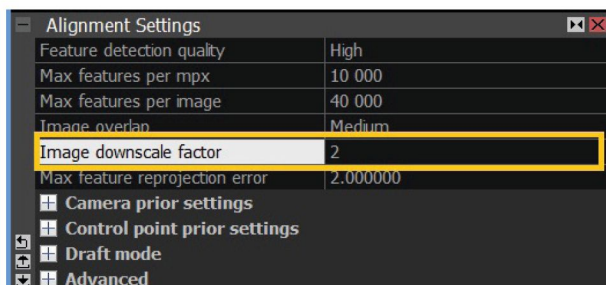


B) IMPORT AND ALIGNMENT

Now you can import images (.jpg) or videos (.mp4) via drag-and-drop or by clicking the "Add Images" button (top left) and begin the reconstruction.



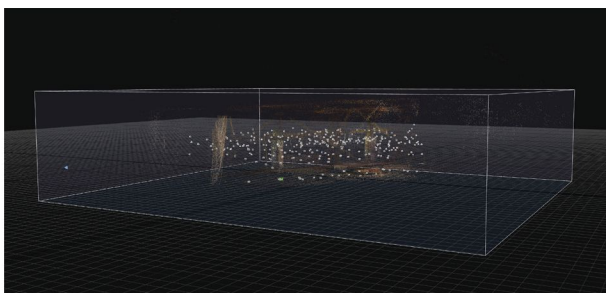
You can now link the images via the ALIGNMENT tab. Click the Align Images button



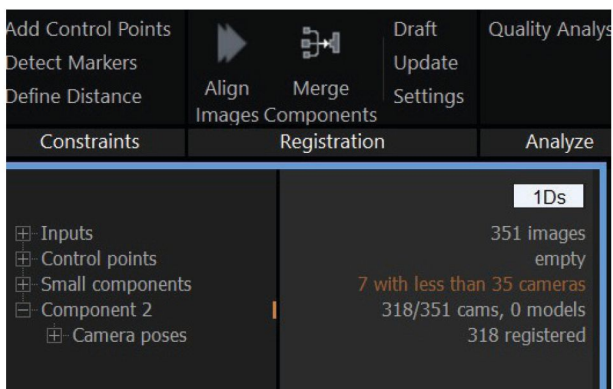
Alignment settings

Optionally, the Image Downscale Factor can help speed up the process:

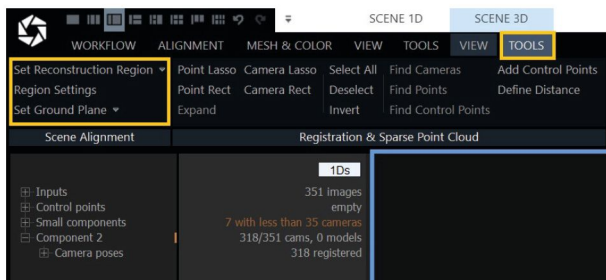
- 1 = uses full image quality for matching
- 2 = halves the resolution
- 3 = further reduces the resolution



After alignment, you'll get a sparse point cloud that gives you an idea of the model and shows all the virtual camera positions.

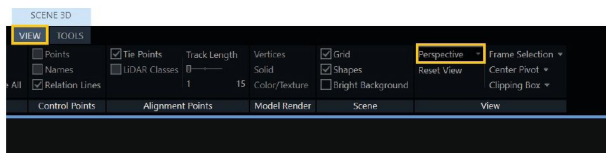


In 1Ds, you'll see the created component and how many of the images were successfully used.

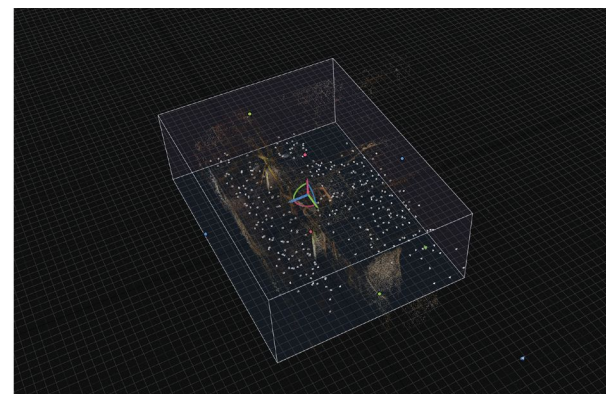
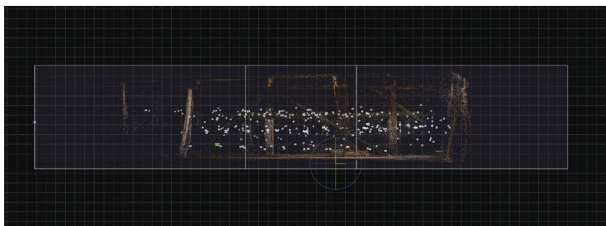


C) LEVEL AND DEFINE THE POINT CLOUD

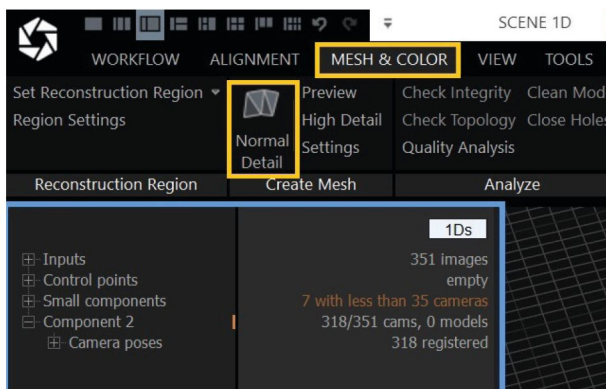
If the point cloud is tilted in 3Ds, use TOOLS > Set Ground Plane to align the model.



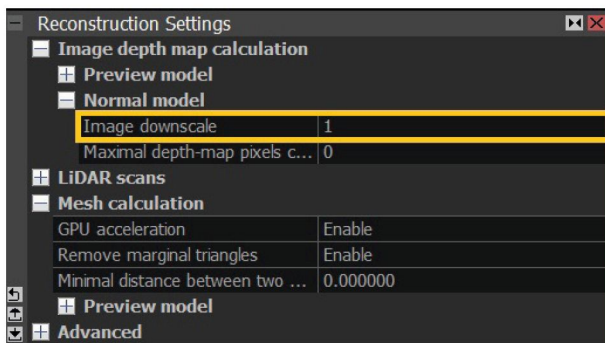
Under VIEW > Perspective, you can change the projection type to make editing easier.



Once everything is correctly aligned, you can deactivate the tool by clicking it again. At the same time, you can define the Reconstruction Region. Only the points within this region will be further processed and refined.

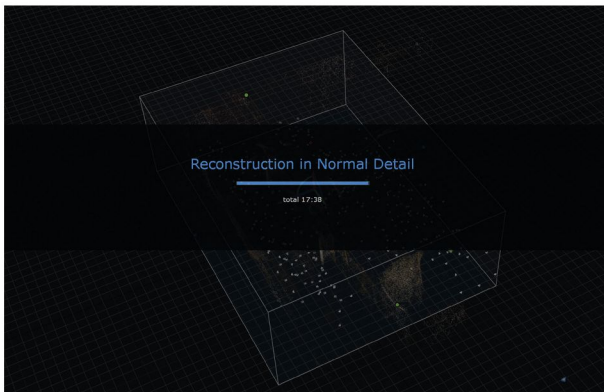


In the MESH & COLOR tab, you can now generate the high-resolution mesh
--> Normal Detail



To do this, use Image Downscale via Reconstruction Settings > Image depth map calculation. It works the same way here as it does for alignment (see above)

1 = full resolution
2 = halved, etc.

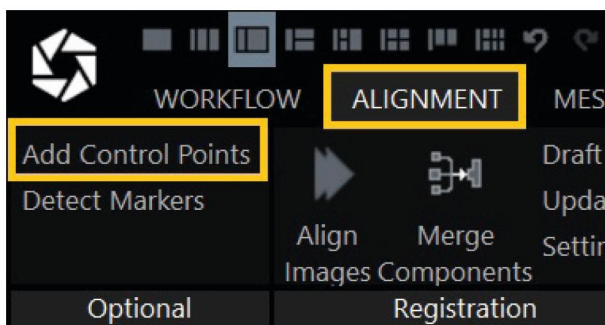


This process takes the longest to complete. You'll be rewarded with a high-resolution mesh. Note: If the mesh exceeds a certain number of points, it will be displayed as a dense point cloud because it no longer fits into the graphics card's memory - so don't worry.

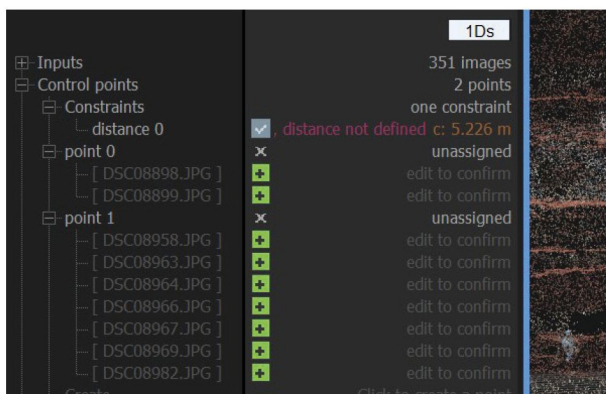


C) SCALING THE POINT CLOUD

We want a true-to-scale point cloud for later import into ArchiCAD. To achieve this, you've taken a reference measurement, which is now important:



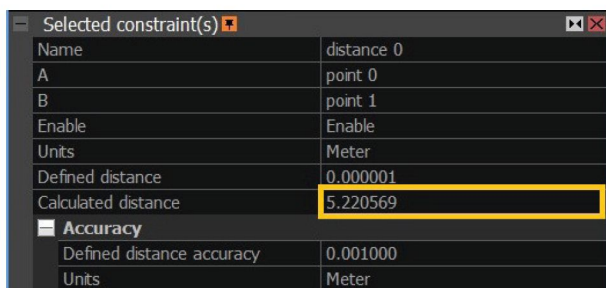
Use "Add Control Points" to add a point at each end of the distance you measured in reality. In the 2D window, you can check the point's position in the image and adjust it if necessary. (using the cursor/arrows)



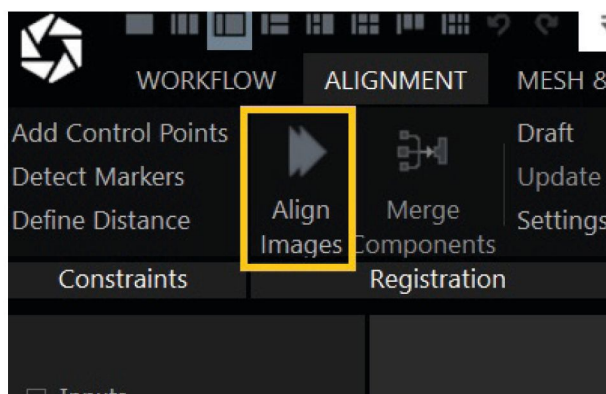
RealityScan will now suggest images in which the two selected points are visible. You can add them by clicking the green plus sign. At least three images must be stored for each control point for it to be usable.



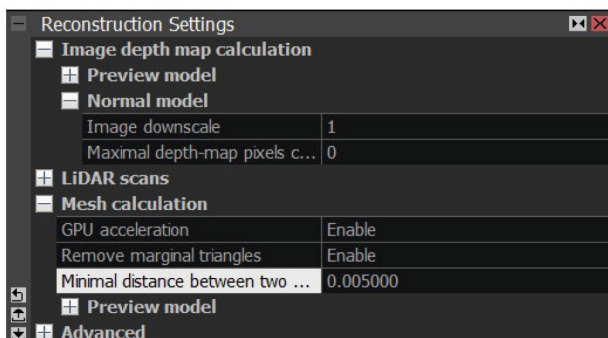
Select **TOOLS > Define Distance** and click on the two points you created.



In the settings (bottom left), you can see the distance “calculated” by RealityScan. Enter the actual length above this value.



To apply the scaling, the images must be triangulated again using **ALIGNMENT**.

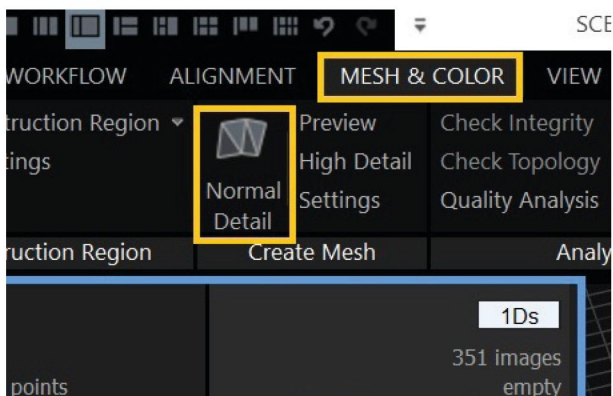


D) DETERMINING THE LEVEL OF DETAIL FOR THE POINT CLOUD

In the Normal Detail settings, you can control the model's resolution by adjusting the minimum distance between points. Reconstruction Settings > Mesh calculation > Minimal distance between two ... > We select 5 mm (0.005 m).

This time, set the Image Downscale to 1 to achieve maximum resolution (see Step 2. B).

Create a Normal Detail again, this time at the correct scale.



Export Your Creation



E) Specify the point cloud detail level
You can now export via WORKFLOW.
Select (misleadingly) "Dense Mesh" as the LOD set and choose the ArchiCAD-compatible XYZ Point Cloud (.xyz) format

STEP 3 - ARCHICAD

A) INSTALL ARCHICAD

Note: If ArchiCAD is already installed on your computer, you can skip this step.

Download the ArchiCAD Student Edition (Visit Graphisoft's official education page. > Download the free ArchiCAD Student Edition for your operating system (Windows or macOS).)

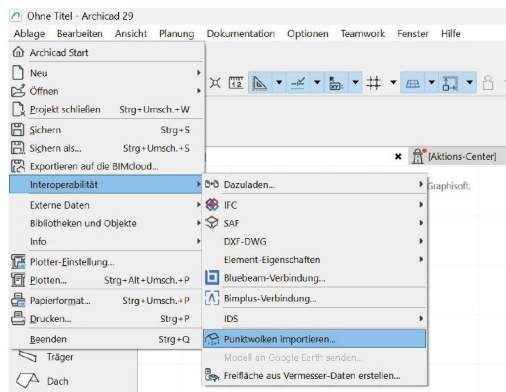
Follow the instructions on the website.

B) LAUNCH ARCHICAD

Open ArchiCAD (after successful installation) and, if necessary, log in with your Graphisoft account.

Create a new project or open an existing project file.

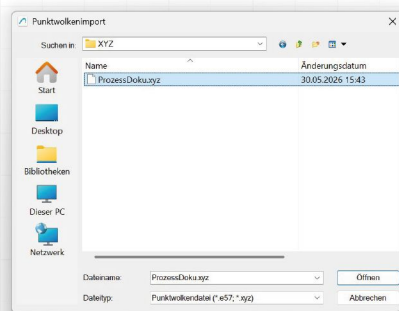
ArchiCAD is now ready for the next steps.



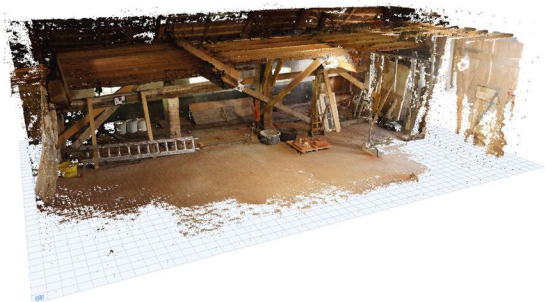
C) IMPORT POINTCLOUD

In ArchiCAD, you can add a point cloud using the Interoperability feature.

Select File > Interoperability > Import Point Cloud



Then select the previously saved .xyz file. Open it.



It will take a moment to load, and then the colored point cloud should appear in the ArchiCAD workspace. It is now ready for the next steps.

05 LIDAR - APPS

APPENDIX

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PROCESSDIAGRAM

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STEP-BY-STEP MANUAL

Scaniverse Classic 210

Scaniverse New 218

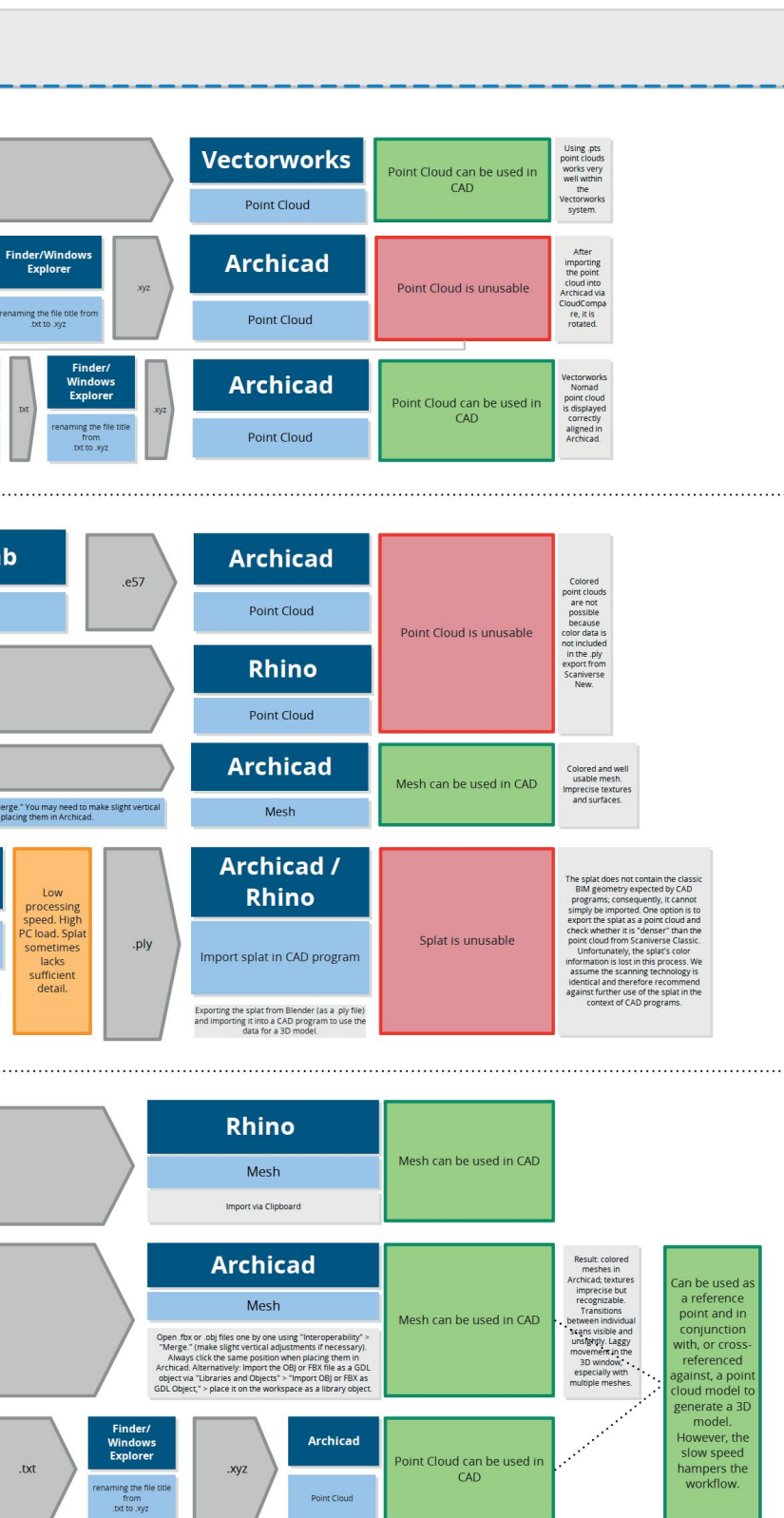
Vectorworks Nomad 224

1

PROCESSDIAGRAM



Fig. 5.6.1: Detailed process involving the failure of the three apps



2

STEP-BY-STEP MANUAL

SCANIVERSE CLASSIC - ARCHICAD

Requirements:

A sufficiently charged smartphone or tablet with a LiDAR scanner, and the Scaniverse app installed. You will also need a PC with ArchiCAD installed and a valid licence, as well as the Cloud Compare app installed for post-processing.

Note: We have used Scaniverse version 5.2.5 for our scans.

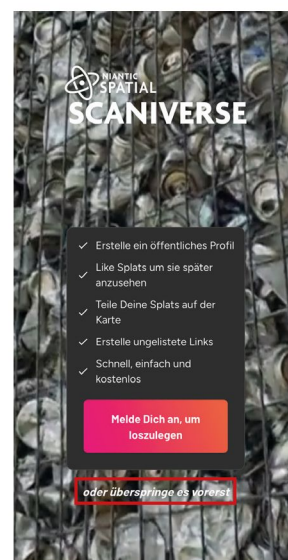
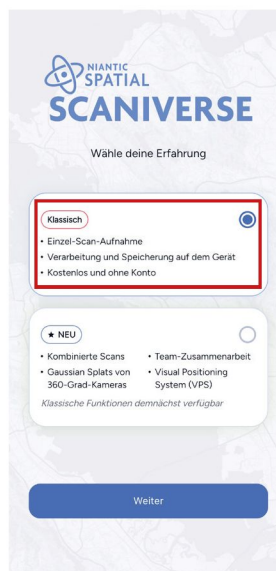
Before the Scan:

First, open the Scaniverse app and select the Classic version. You then have the option to create a user account. However, this is not essential for carrying out the scans or for further processing.



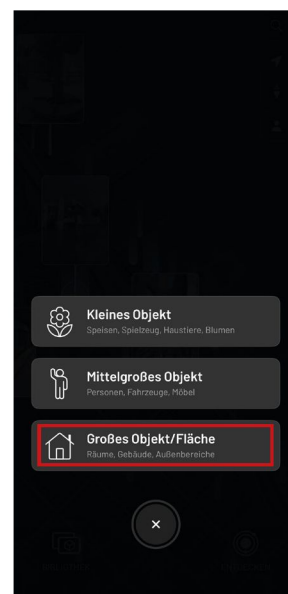
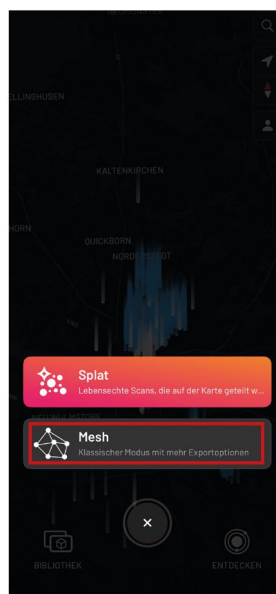
Scaniverse - 3D Scanner

Scan & share your world in 3D



The Mesh option is chosen because it scans relatively quickly compared to Splat and offers a wide range of export options.

To start the scan, you first need to select the most suitable mode. The three options list a number of examples to help you classify the object to be scanned into one of the categories. For rooms, select the „Großes Objekt/Fläche“ category.



Scan:

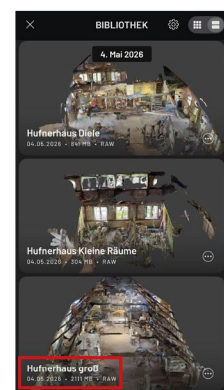
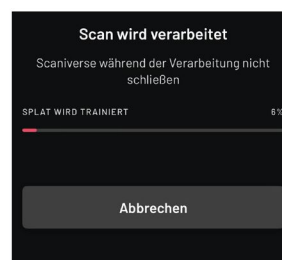
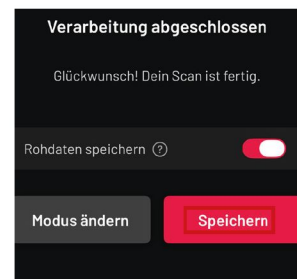
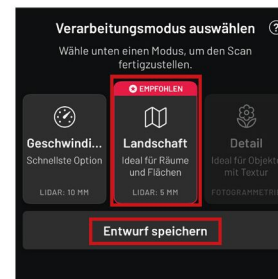
Tap the red record button to start the scan. During the scan, the app provides tips or comments. The red and white stripes indicate the area that still needs to be scanned. Tap the red record button again to finish the scan.

Processing in the App:

The scan is now in the library. In processing mode, the scan is now being edited. Here, too, there are three options to choose from, one of which is recommended directly by the app. The „Landschaft“ processing mode is ideal for rooms.

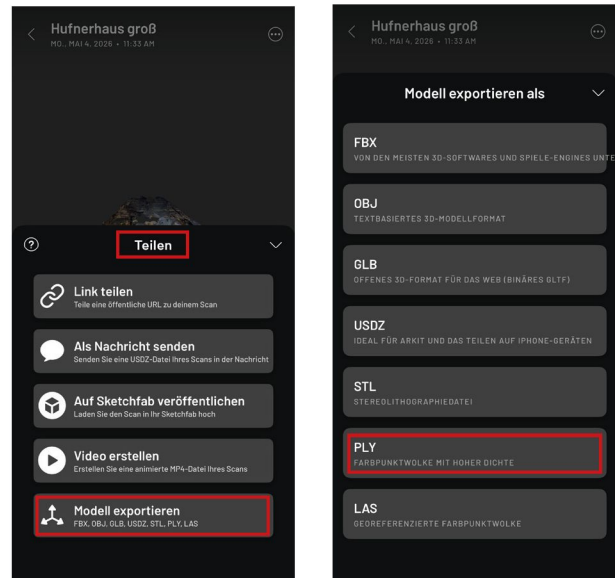
Once the processing mode has been selected, the scan is processed by clicking on „Entwurf speichern“ and saved to the app's internal library. It is also possible to save the raw scan data so that further adjustments can be made.

All scans are listed in the library. Clicking on the relevant scan opens it. In this window, you can edit the scan, take measurements and export it.



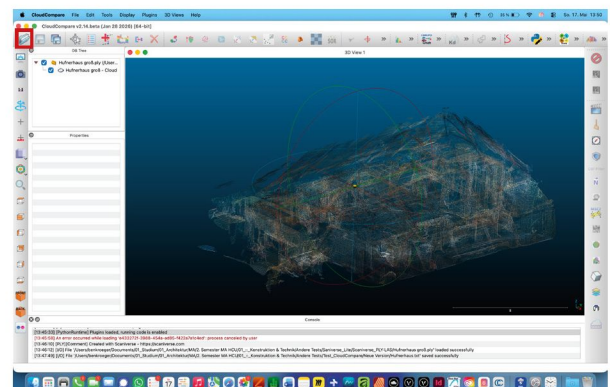
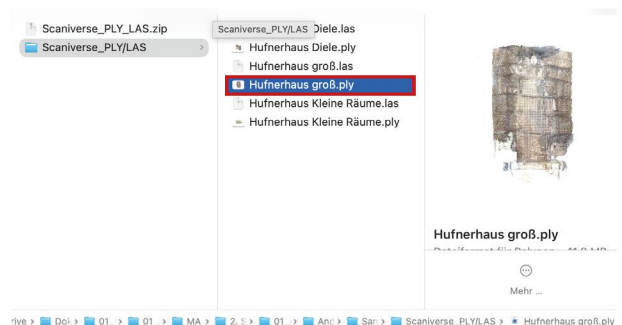
Export:

By clicking on „Teilen“ and then on „Modell exportieren“, the scan can be exported in various file formats. For pointclouds, the scan must be exported as a „PLY“ file. Simply click on the selected file format to save or share the file.



Import in Cloud Compare:

In order to import the pointcloud into Archicad, the file format must first be converted. The first step is to load the scan's .ply file into Cloud Compare

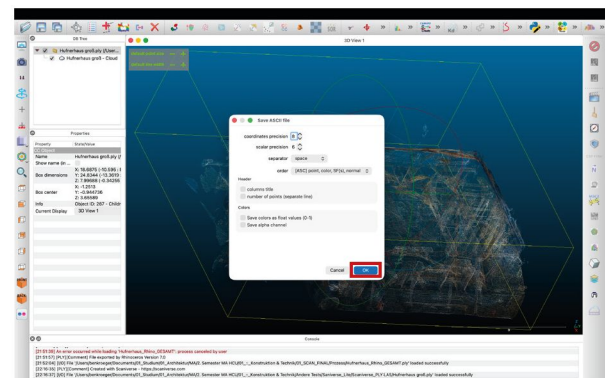
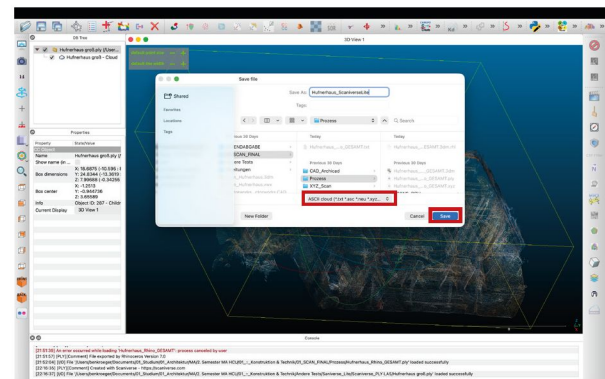
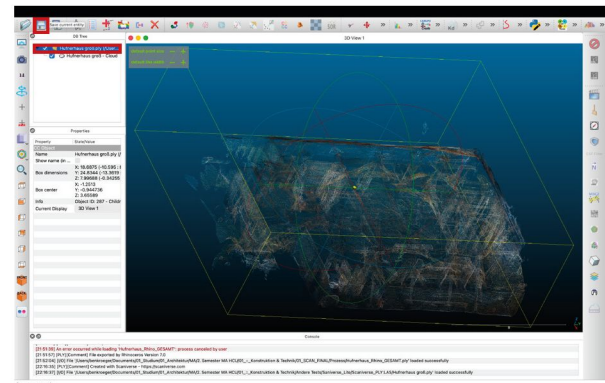


Export as .txt Datei:

The next step is to export the .txt file. You can save the file as a .txt file using the „Save file“ option.

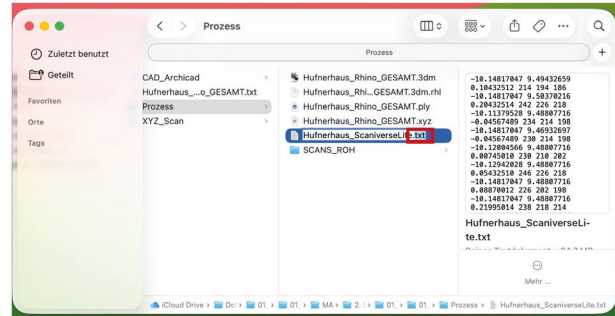
The next step is to export the .txt file. You can save the file as a .txt file using the „Save file“ option.

During the saving process, you have the option to adjust the precision of the coordinates. However, this function and these adjustments are not necessary for the rest of the process.

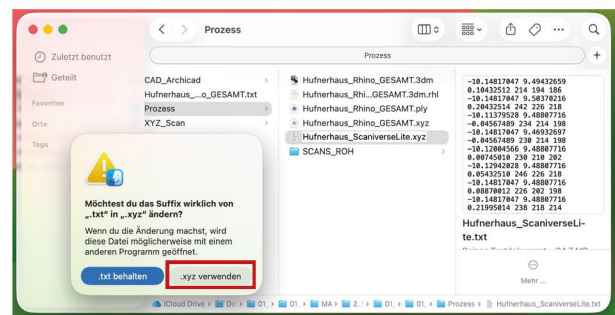


Renaming the file from .txt to .xyz:

To obtain an Archicad-compatible file format, the .txt file must then be manually renamed to a .xyz file. In Finder or Windows Explorer, the .txt file can be renamed by manually changing the file extension to .xyz.

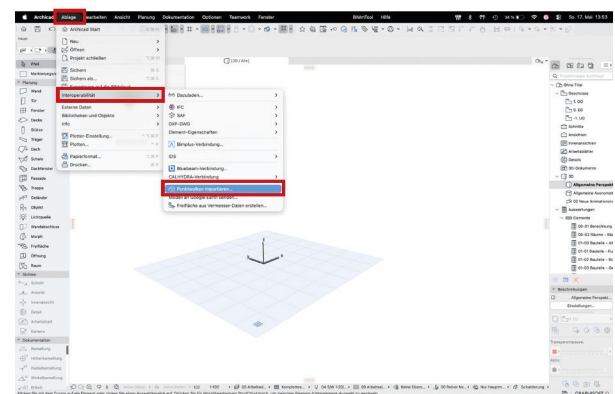


Once the file has been renamed, you must confirm the file change; selecting „xyz verwenden“ will now convert the file into an Archicad-compatible file.

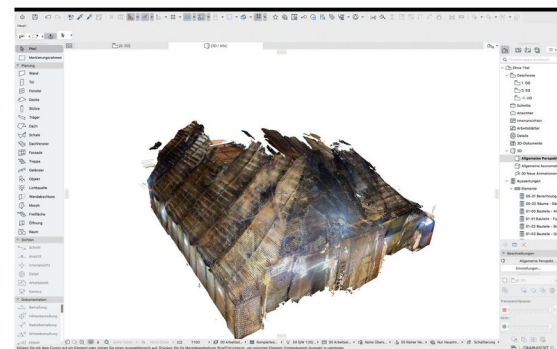


Import the Pointcloud in Archicad:

The .xyz pointcloud file can now be imported directly into Archicad via „Ablage“, „Interoperabilität“ and „Punktwolke importieren“.



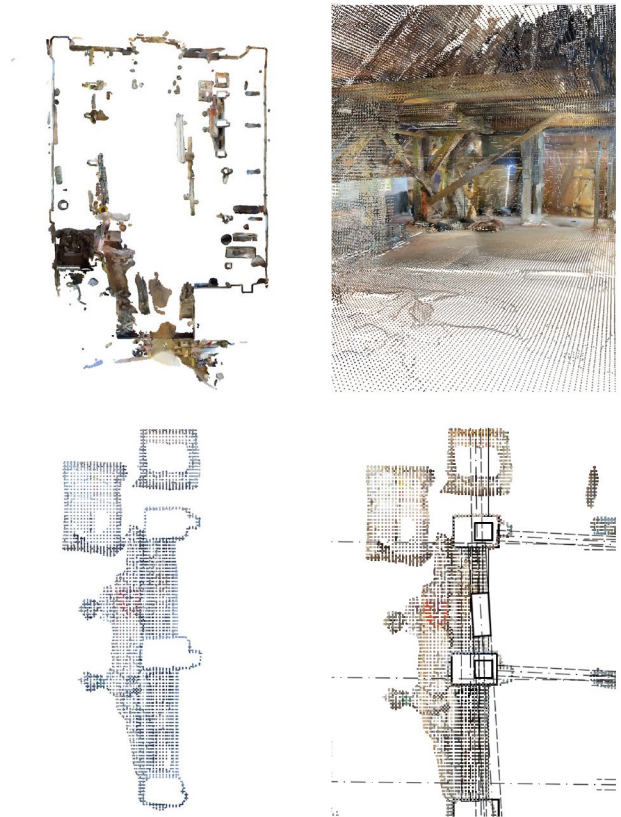
The pointclouds are not large files, which is why they do not slow down or delay Archicad's performance.



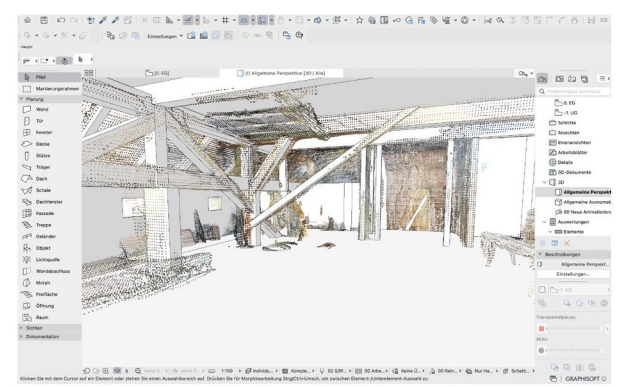
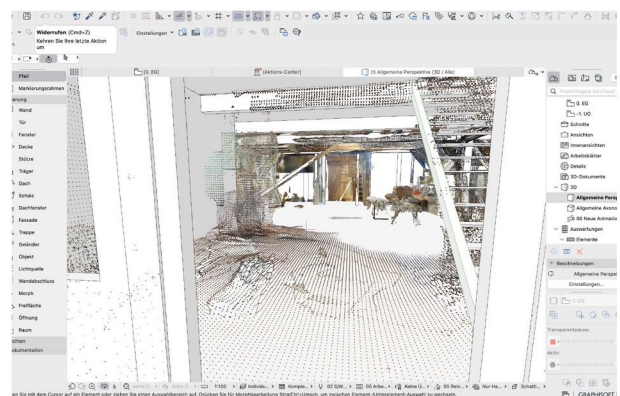
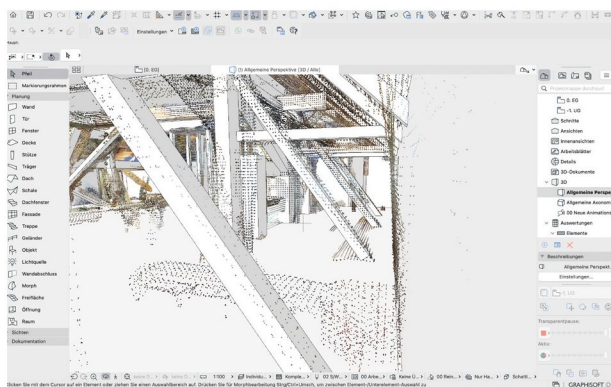
Modelling the 3D Model/Transition:

Once the pointcloud has been imported into Archicad, work on the 3D model can begin. A neutral 3D model can be created using the floor plan or top view and the 3D pointcloud model.

In some cases, components such as columns can be clearly identified in the top view, as the points in the pointcloud clearly exclude this area, thereby enabling relatively precise positioning and accurate reconstruction.



Overlaying the data with the pointcloud can reveal the deformations and deviations in the scanned existing building. For example, as shown in Fig. 5.6.29, one can see the subsiding ground, and in Fig. 5.6.24, the wall sloping inwards can be identified as a deviation from a straight wall.



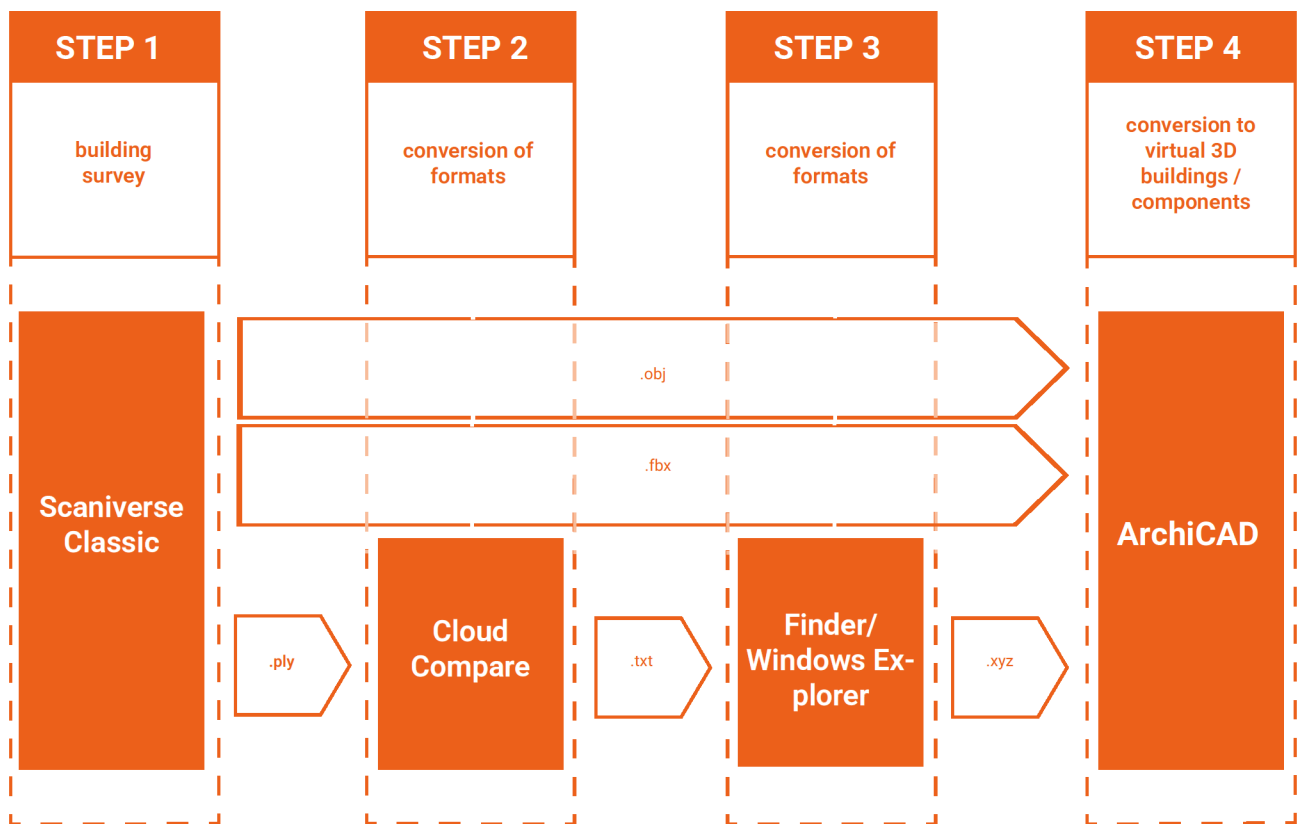
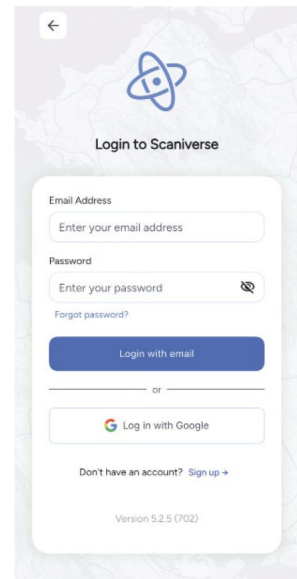
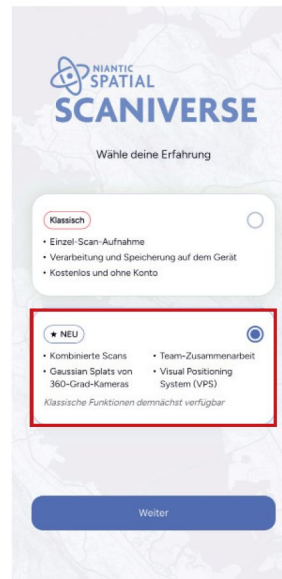
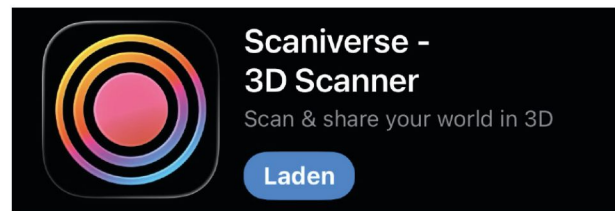


Fig.5.6.30: Schematic diagram of Scaniverse Classic procedure

SCANIVERSE (NEW) - BLENDER

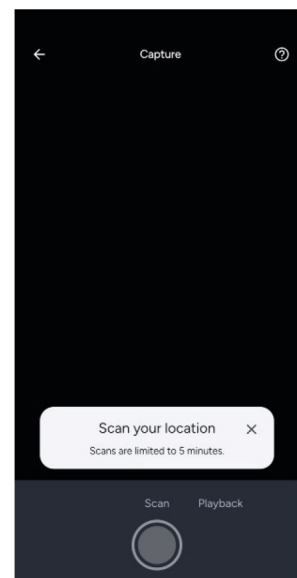
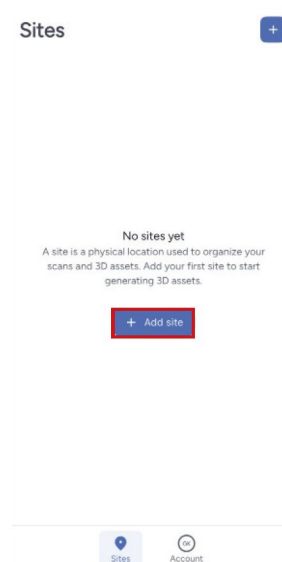
Requirements:

The smartphone must be capable of LiDAR scanning. Download the Scaniverse app from the App Store. Select the „new“ Scaniverse version for Gaussians Splats. Create an account. Note: We have used Scaniverse version 5.2.5 for our scans.



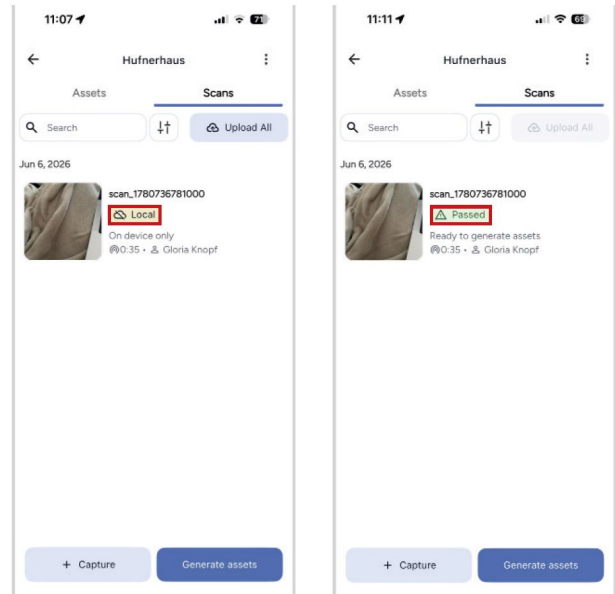
Scan:

Click on „+ Add Site“ to create a new scan. The scan is limited to 5 minutes. If the room is larger, you will need to carry out several scans.



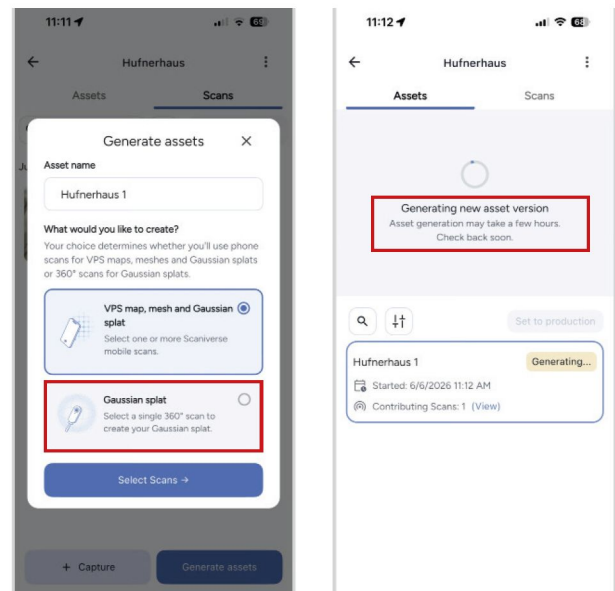
Processing in the App:

Once the scan has been completed, it is initially saved locally within the app. To be able to use it further, it must be uploaded (click on the scan and select „Upload“). The scan will then appear in green with the status „passed“. You can now carry out further scans.



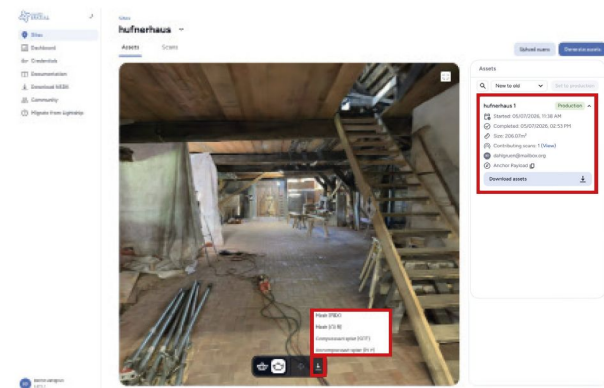
To export the scan from your smartphone, you first need to use the „Generate Assets“ function. When you click on this, select the option „VPS map, mesh and Gaussians Splat“. This is the only option available if the scan was taken with a mobile phone. Next, select the scan, click „Generate“ and then „Confirm“.

Important: You are allocated 20,000 free credits for asset generation. After this, you will need to pay for any further exports! The „Generating new asset version“ process may take some time!



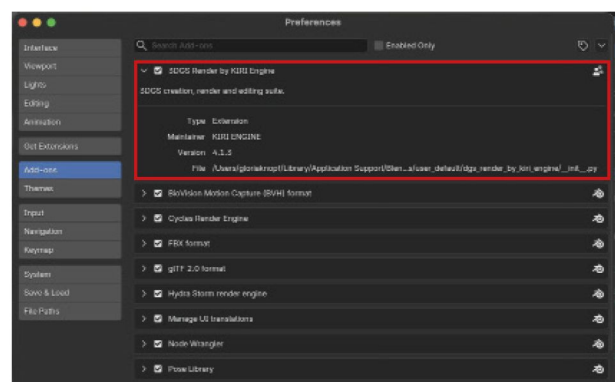
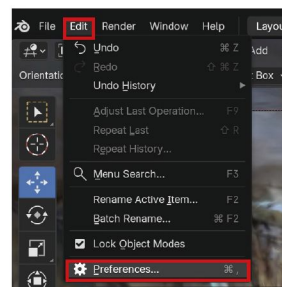
Export:

The next step is to export the Gaussian splat. A key point to bear in mind when using the Scaniverse New version is that it is not possible to export the generated data directly via a smartphone. Instead, you must log in to your Scaniverse account via a desktop PC. This restriction is not explicitly mentioned within the mobile app beforehand; you must therefore first log in to the desktop version. It is only in the web-based version of Scaniverse that the full range of export options becomes visible. The data can be exported in various file formats. For the mesh, these are FBX and GLB; for the splat, they are a compressed SPZ and an uncompressed PLY.



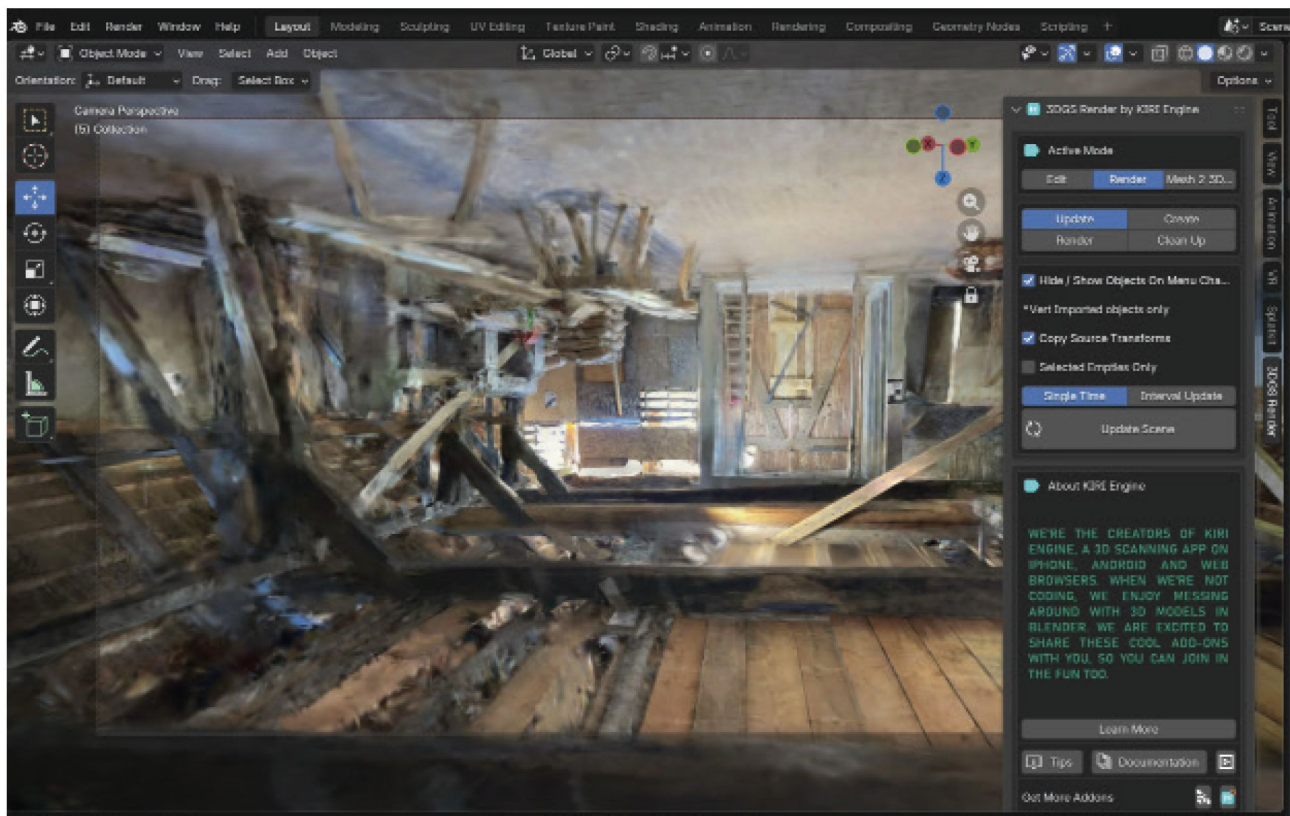
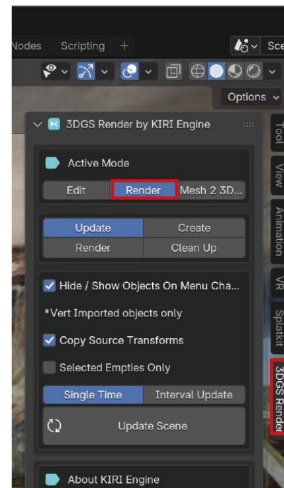
Blender and 3DGS Renderer by Kiri Engine:

Scaniverse New generates a PLY file. To display the splat correctly, it is opened in Blender. However, Blender itself cannot display the splat in colour in render mode. An add-on is required for this. In this case, the 3DGS renderer was used. This can be downloaded from the Kiri Engine website (<https://www.kiriengine.app/3d-tools/3dgs-renderer>). The add-on can be installed and used correctly by following the instructions: https://www.youtube.com/watch?v=uDeD3Vp_7hU



Press the „N“ key to open the panel, where you can access the 3DGS Renderer. You can now import the PLY file into Blender using drag and drop.

The Splat becomes visible in colour via the „Render“ tab, highlighted in blue. You can now use the camera settings to navigate within the model. Furthermore, the model can be cropped, reduced and optimised using various tools (see the YouTube tutorial).



Export in CAD and further steps:

A Splat does not contain traditional BIM/mesh geometry, but rather point/Splat data. Gaussian Splats are not BIM objects, surfaces or solid bodies.

However, CAD programmes expect meshes, morphs, GDL objects or BIM geometries. Gaussian Splats are not natively supported.

If you wish to visualise a photorealistic environment in Archicad, you could re-export the Splat as a mesh. If you only need the reference data, you can export it as a pointcloud.

One option is to export the Splat as a pointcloud and check whether it is „denser“ than the pointcloud from Scaniverse Classic. Unfortunately, the colour information of the Splat is always lost at this stage. We assume that the scanning technology is identical and therefore recommend that you do not continue working with Scaniverse New (in relation to CAD programmes) at this stage.



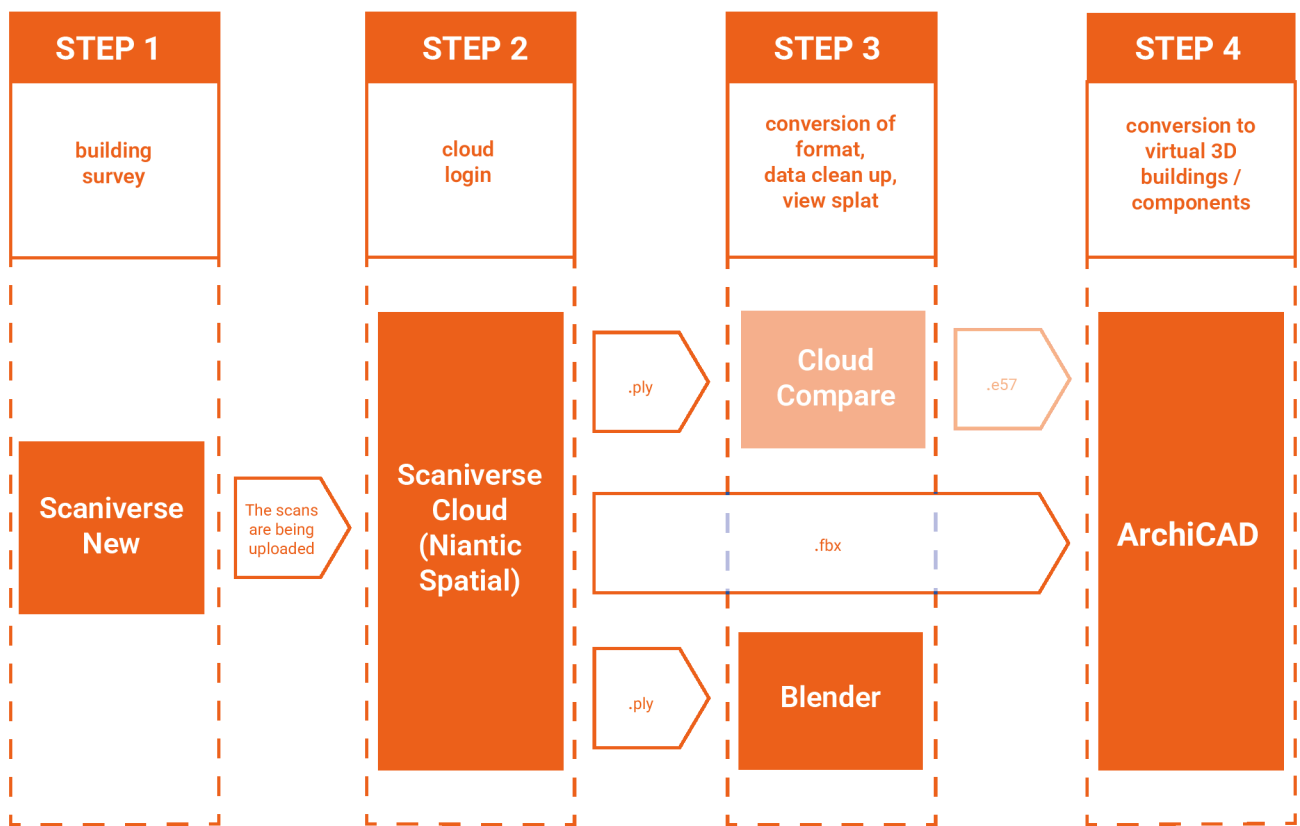


Fig. 5.6.46: Schematic diagram of Scaniverse New procedure

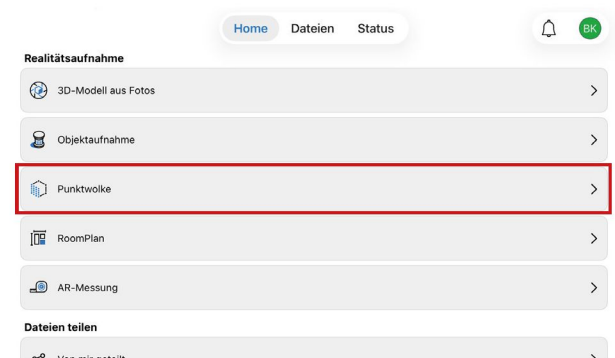
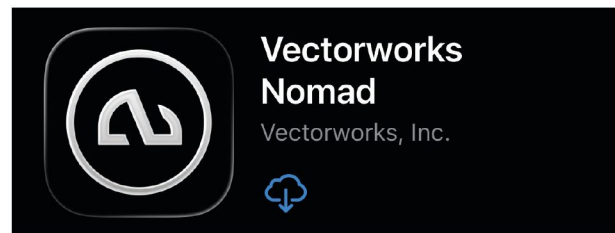
VECTORWORKS NOMAD - VECTORWORKS

Requirements:

A sufficiently charged smartphone or tablet with a LiDAR scanner and the Vectorworks app installed. You will also need a PC with the Vectorworks programme installed and a valid licence, and you will need to set up Vectorworks on the devices to be used for scanning and post-processing.

Scan:

To carry out a point cloud scan, select „Punktwolke“. You can then start the scan by clicking „Play“.

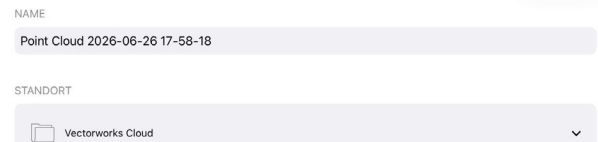


The dots in the camera image show which areas of the room have already been scanned.



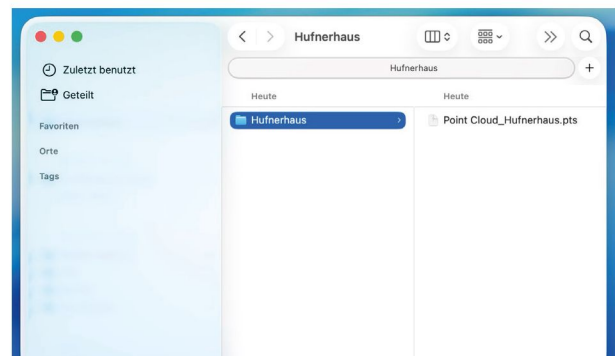
Saving the Pointcloud:

Clicking „Sichern“ completes the scan.
You then select the folder in the Vectorworks Cloud where you want to save the pointcloud.



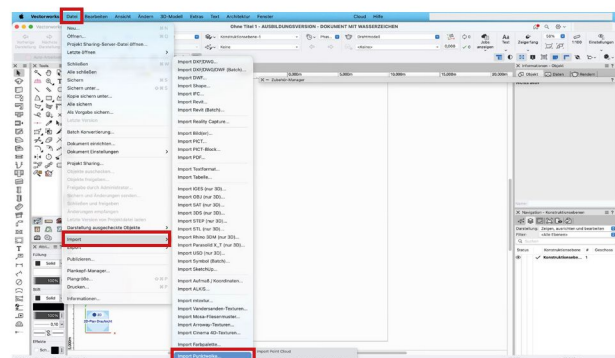
Vectorworks Cloud:

The Vectorworks Cloud synchronises automatically, so that the pointcloud can be further processed on a smartphone or tablet, or on a Mac or PC, once the scan is complete.
The pointcloud is displayed as a .pts file in the Finder.



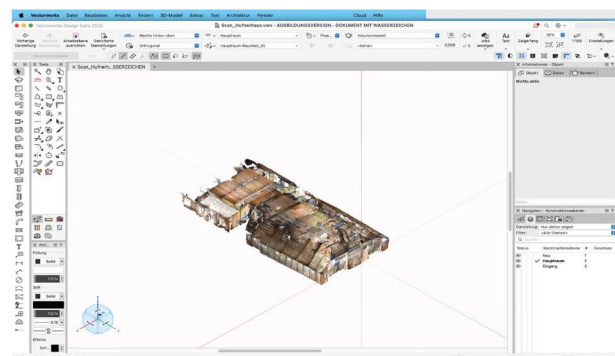
Import in Vectorworks:

The scan can be imported into Vectorworks via „Datei-Import-Import Punktwolke“.



Pointcloud in Vectorworks:

If the pointcloud is not displayed correctly after import, you may need to rotate it using „D“.



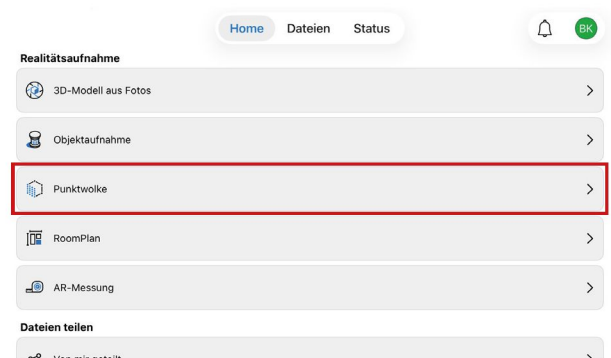
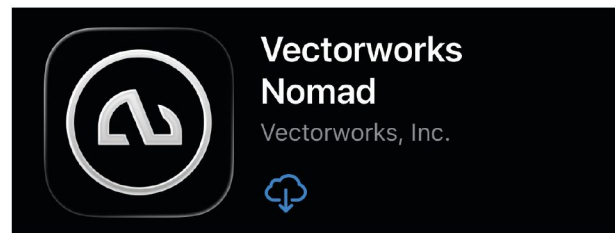
VECTORWORKS NOMAD - ARCHICAD

Requirements:

A sufficiently charged smartphone or tablet with a LiDAR scanner and the Vectorworks app installed. You will also need a PC with Rhino, the Cloud Compare app and Archicad installed.

Scan:

To carry out a point cloud scan, select „Punktwolke“. You can then start the scan by clicking „Play“.



The dots in the camera image show which areas of the room have already been scanned.



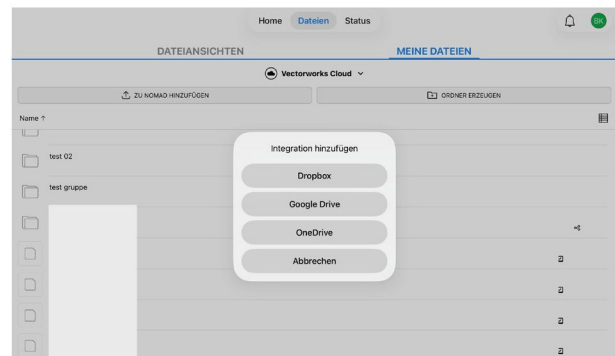
Saving the Pointcloud:

Clicking „Sichern“ completes the scan. You are then prompted to select the folder in the Vectorworks Cloud or another trusted storage provider where the pointcloud is to be saved.



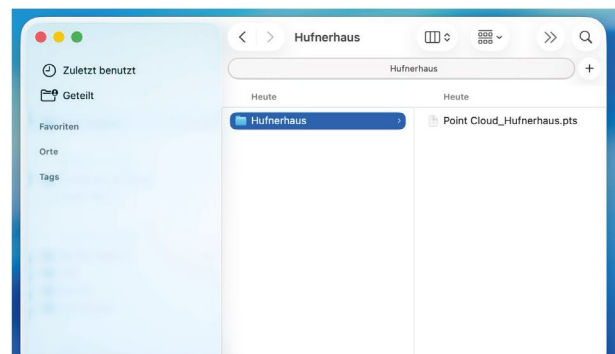
NAME
Point Cloud 2026-06-26 17-58-18

STANDORT
Vectorworks Cloud



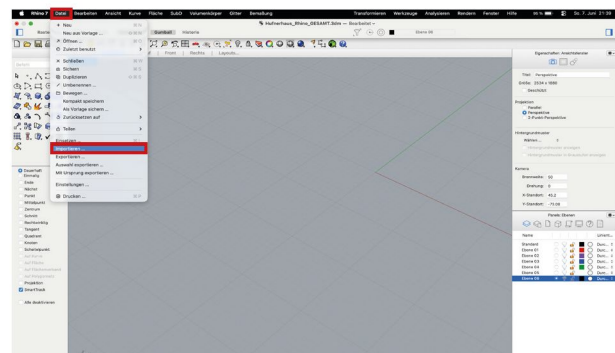
Cloud:

The scan is transferred to the Mac or PC via the selected cloud solution, where it can then be processed further.



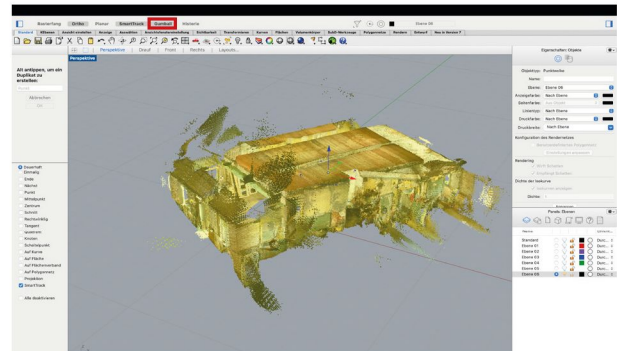
Import in Rhino:

To merge several scans into one or to rotate the scans, the .pts files must be imported into Rhino.



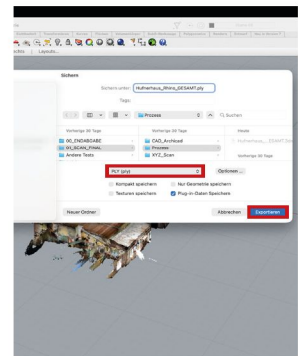
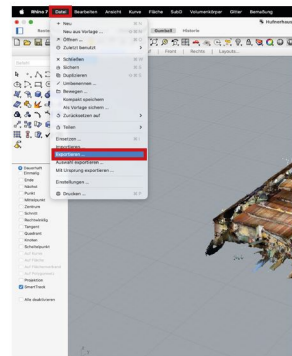
Rotate scan:

If necessary, the scans can be rotated in Rhino using the „Gumball“ tool.



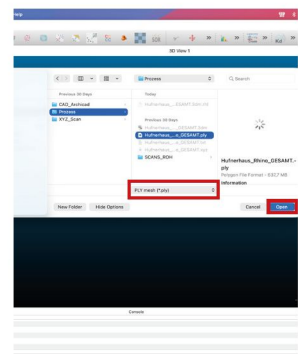
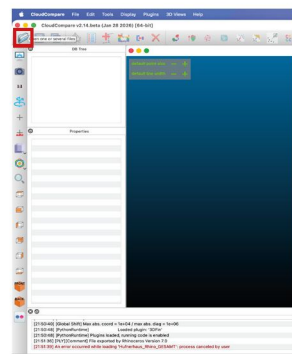
Export as .ply:

Once the scan has been aligned along the x, y and z axes, the pointcloud must be exported from Rhino as a .ply file.



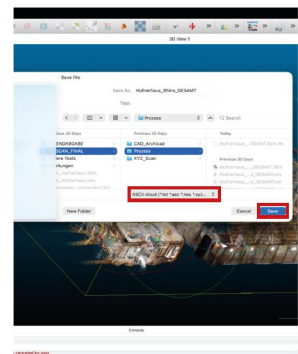
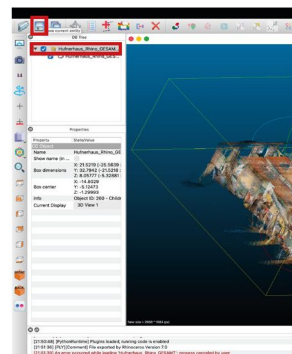
Import in CloudCompare:

The .ply file must then be uploaded to CloudCompare in order to convert it from .ply to .txt format.



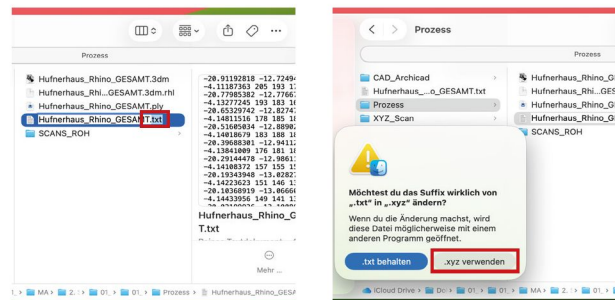
Export out of CloudCompare as .txt:

Use the „Save current entity“ option to export the pointcloud as a .txt file.



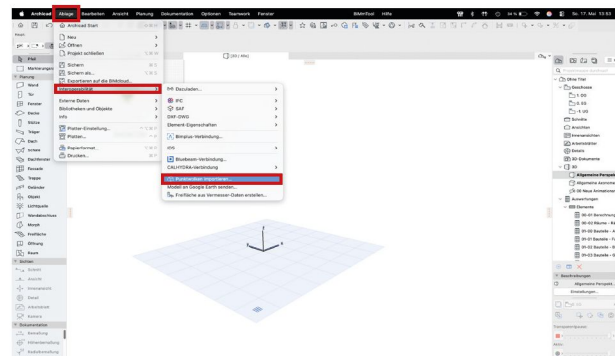
Renaming the file:

The next step is to rename the .txt file in Finder/Windows Explorer from filename.txt to filename.xyz.



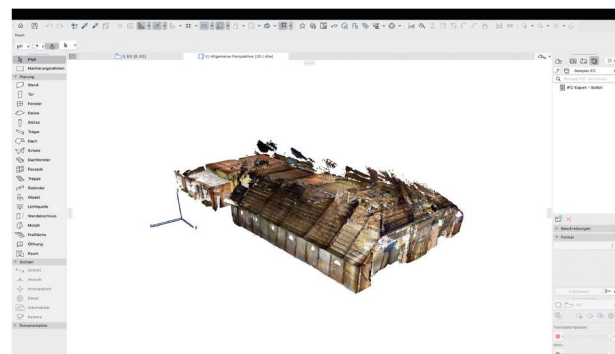
Import in Archicad:

The .xyz file can be imported into Archicad via „Ablage-Interoperabilität-Punktwolken importieren“.



Pointcloud in Archicad:

The pointclouds generated by Vectorworks Nomad are very dense, which makes it easy to identify and recreate building elements and spaces. When combined with a white CAD model, irregularities and deviations can be depicted and identified very clearly.



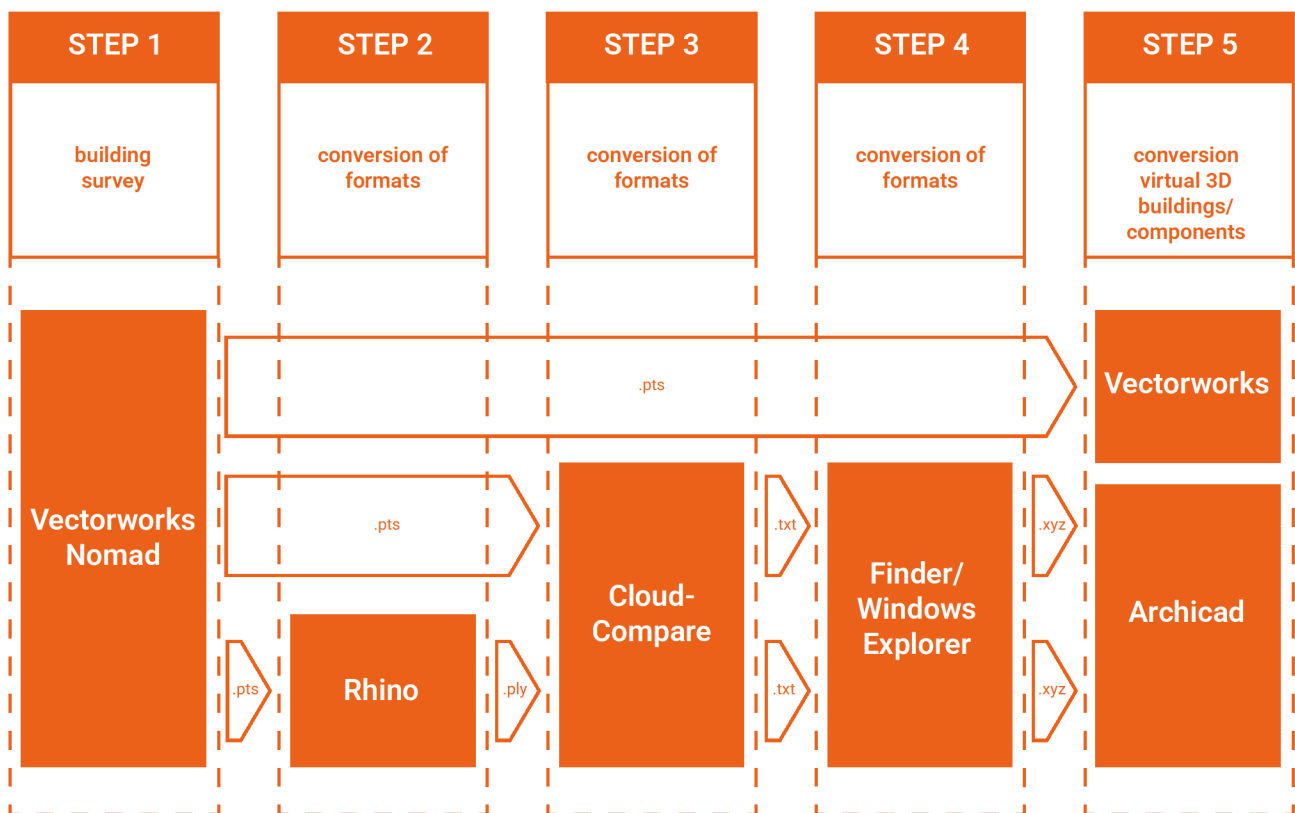


Fig. 5.6.75: Schematic diagram of Vectorworks Nomad procedure

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IMPRINT

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