Geodesy and Geospatial Engineering

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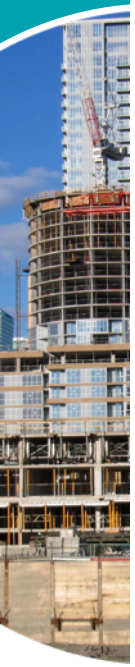
Department of Engineering



Scanning the Past: A 3D Model of Trausch's Library

Norman Teferle[1], Lars Wieneke[2], Shahoriar Parvaz[1], Quentin Bebon[1], and Dietmar Backes[1]

[1]Geodesy and Geospatial Engineering, Department of Engineering, FSTM, University of Luxembourg

[2]Luxembourg Center for Contemporary and Digital History (C²DH), University of Luxembourg

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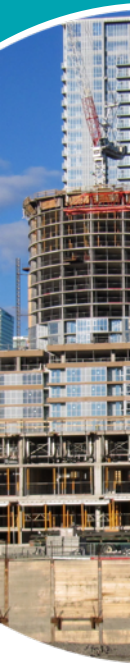
C²DH

Contents

- Introduction and Background
- 3D Survey
  - Establishing a coordinate reference
  - Capturing the building and bookshelves
- 3D Modelling
- The Virtual Reality (VR) Experience
- Conclusions and Next Steps



What are the objectives of this study?

- At the start of the project the objective was
  - To capture and and generate a 3D model of Trausch's Library containing the building and bookshelves which clearly show the book spines of each book to allow identification
- As the project progressed the idea for the creation of a subsequent "virtual experience" of Trausch's Library arose. This required us
  - To carry out a study to investigate pathways from the 3D model of Trausch's Library to a public virtual experience
    - Linking of books (via spines) to scans of the pages
    - …

What are the steps/methods used to achieve these objectives?

To carry out a/an

- 3D survey of the building and bookshelves using various geospatial technologies
- 3D modelling of the building and its bookshelves using approaches such as Scan2BIM and Historic Building Information Modeling (HBIM)
- Investigation of the generation of photorealistic representations and virtual reality (VR) experiences from the 3D model
- Work with a commercial service provider to generate a publically accessible VR experience

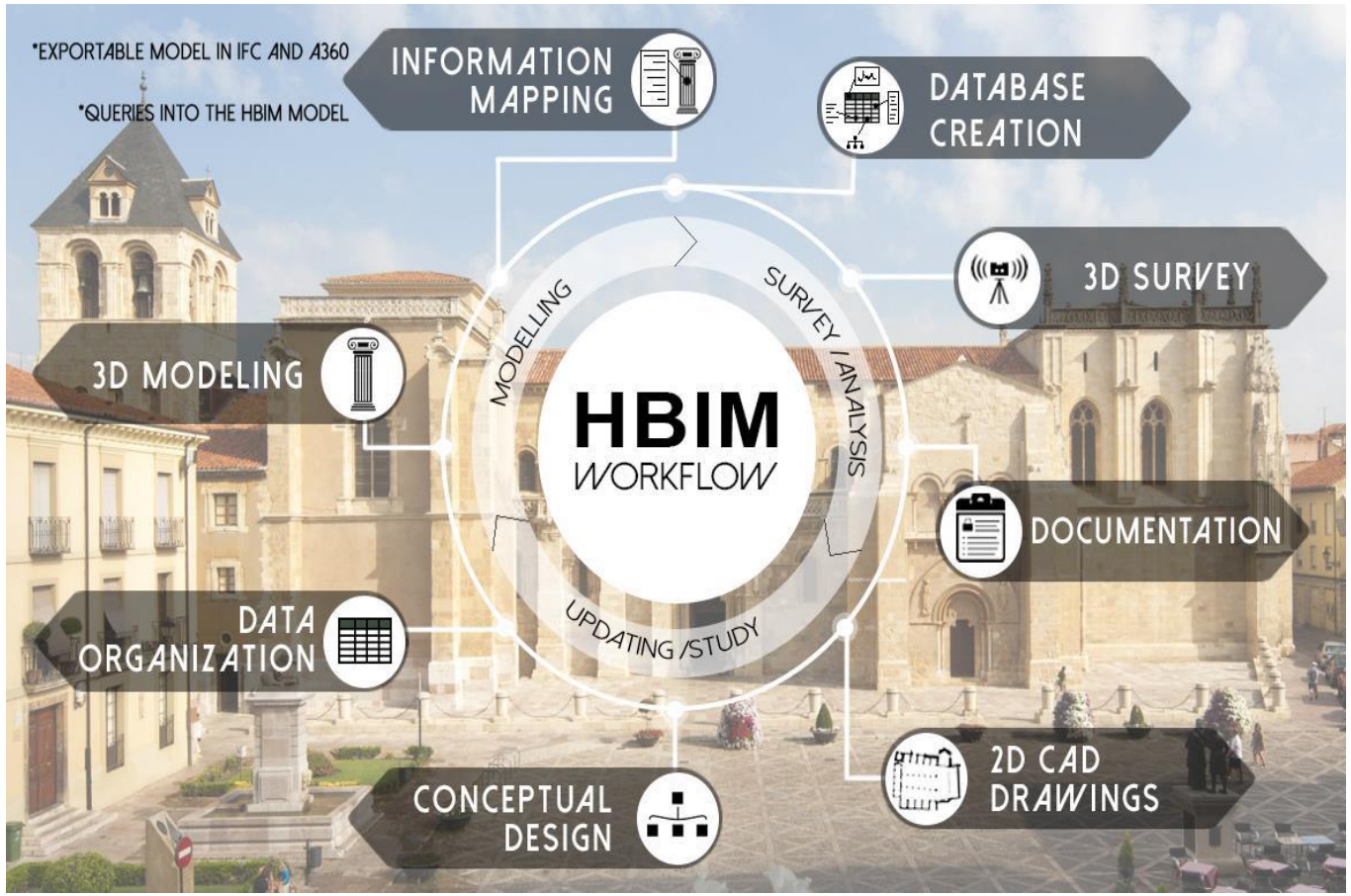
Geospatial Capturing Technologies and Building Information Modelling for Digital Cultural Heritage

- Geospatial capturing technologies allow to
  - collect highly detailed information about Cultural Heritage objects
  - complete accurate 3D models
  - safeguard and preserve many Cultural Heritage sites

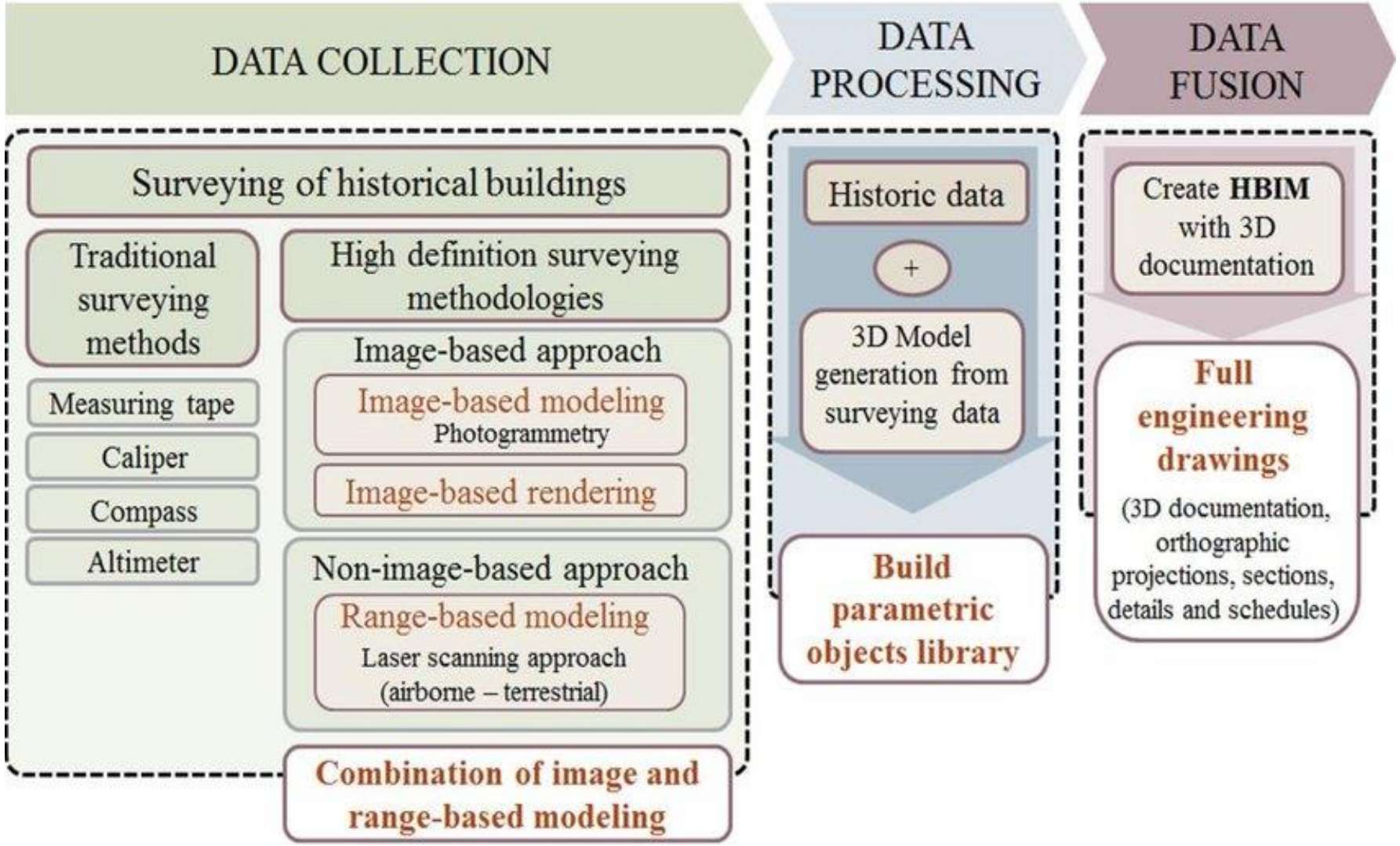
- Building Information Modelling (BIM)
  - provides an information system at architectural scale
  - facilitates the management of semantically enriched 3D models
  - unique database for all data of the building
  - support for Augmented Reality (AR) or VR applications
  - web sharing
  - …

What is Historic Building Information Modelling (HBIM) and what is it used for?

- Application of BIM principles to cultural heritage objects
- Focusses on a comparison between existing buildings and well-known architectural grammar
- HBIM applications are manifold: e.g. conservation, restoration planning, construction simulation, disaster preparedness



Which components are contained in the HBIM process?



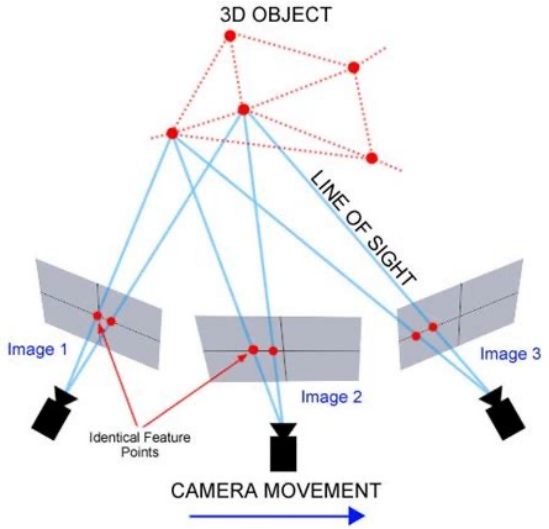
3D Survey

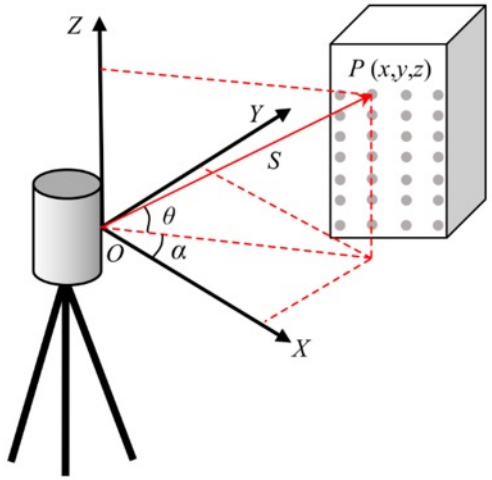
Establishing a coordinate reference and capturing the building and bookshelves

What are the main 3D reality capturing technologies for cultural heritage objects?

- Digital close-range photogrammetry
- Laser scanning
- and combinations of these in mobile mapping systems

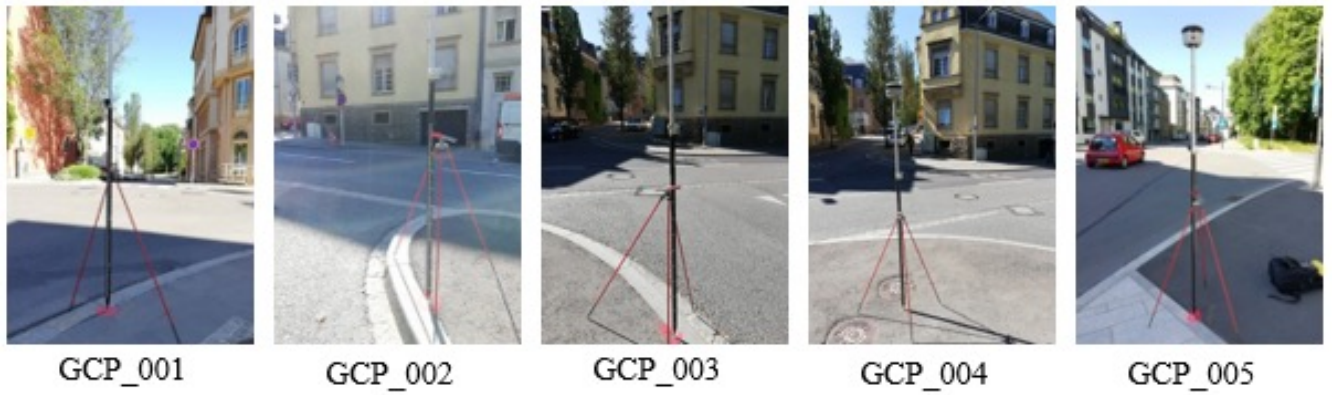
- Both technologies have pros/cons but have complementary features
- But, they need external information to merge their coordinate results

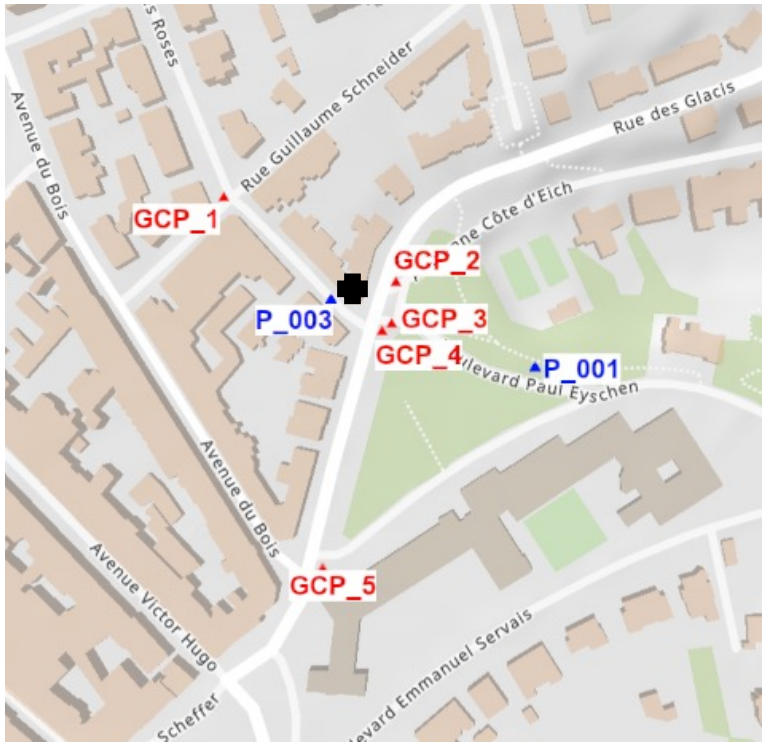




Geodetic framework for providing a coordinate reference for the Villa Trausch

- Real-Time Kinematik (RTK) GNSS Measurements
- Total station measurements



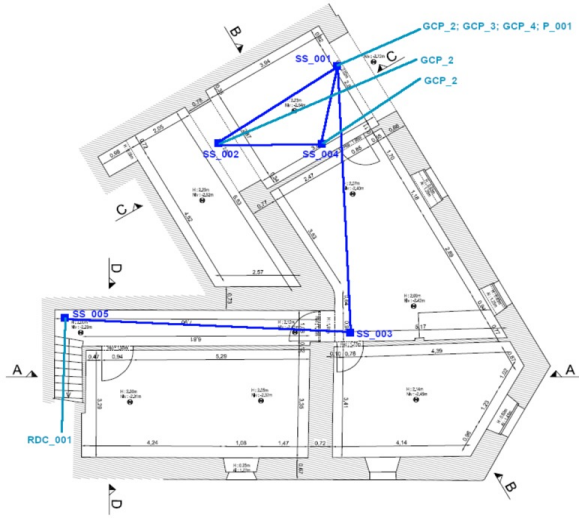


The coordinate frame inside the building in support of the reality capturing technologies

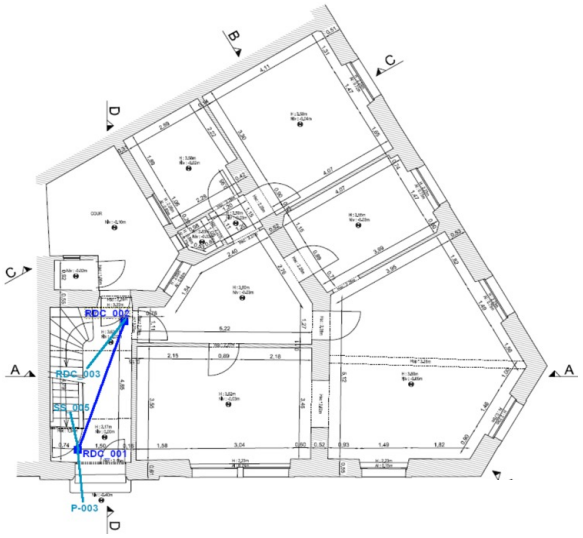
- Topographic survey inside the building using a total station
- Creation of a rigid coordinate frame as reference system for all measurements
  - Use of temporary targets
- Observations were adjusted with the least square adjustment method to estimate coordinates and quantify errors (LisCAD software)

The surveying campaign inside the building was an overdetermined control network

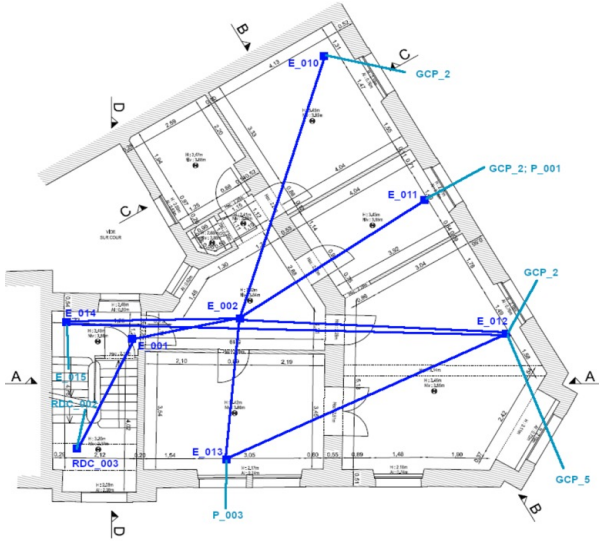
Basement



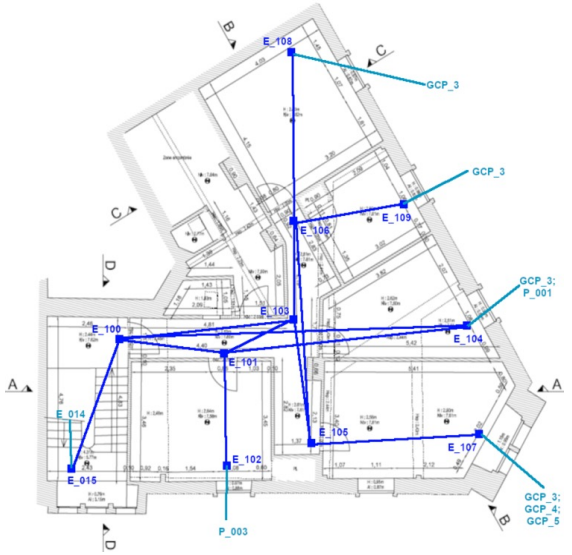
Ground Floor



1st Floor



2nd Floor



We used a laser scanner and a mobile mapping system to capture the outside and inside of the Villa

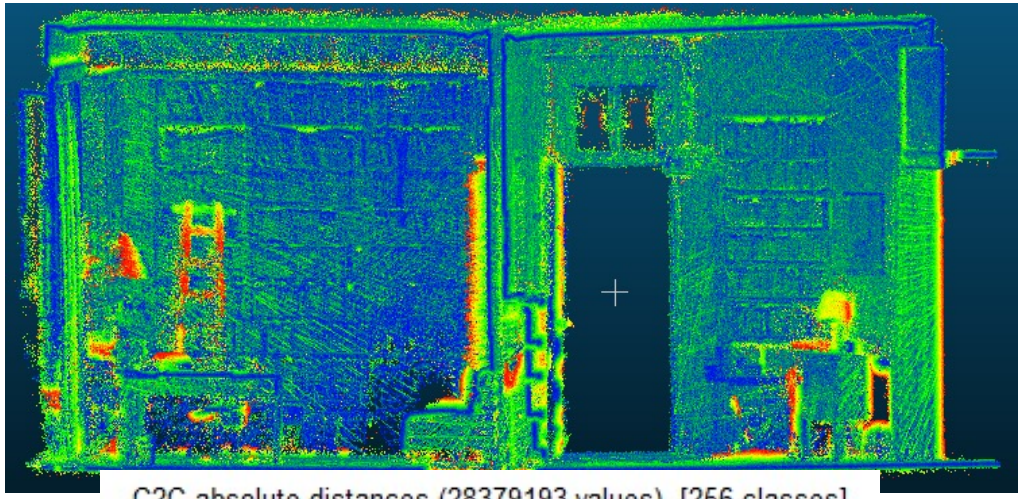
- Faro Focus S350
  - room scans with 1/5 resolution and 3x quality
  - bookshelves with 1/4 resolution and 4x quality parameters
- Zeb Horizon handheld mobile mapping system

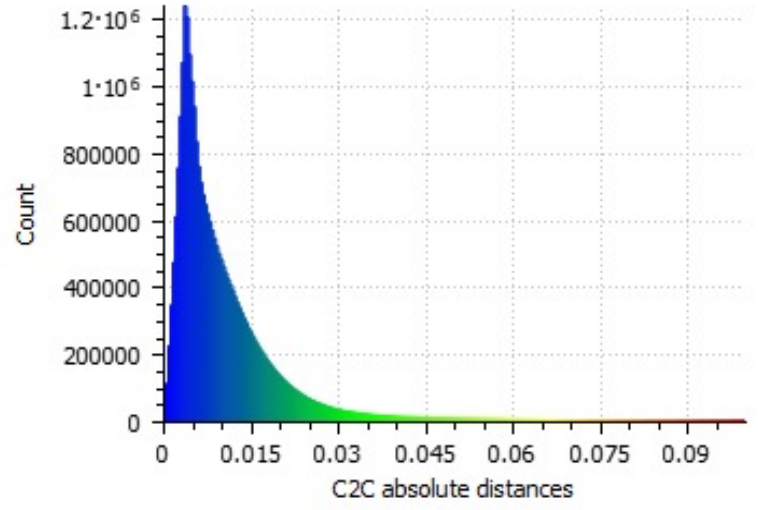
The results of the laser scanner capture were more than adequate for the application

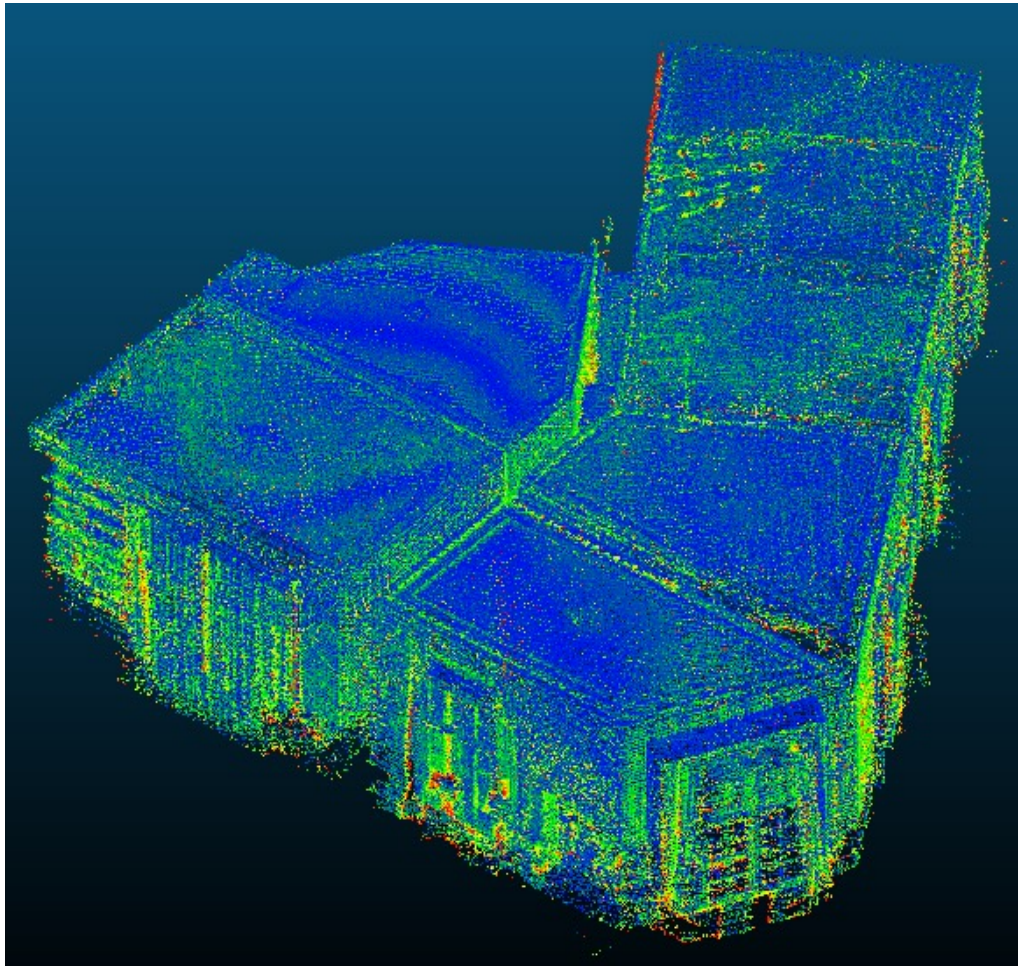
- Approx 7,000,000,000 points (billion)
- Mean point error of 1.5 mm
- A minimum overlap ratio of 12.9%
- Maximum point error of 48.9 mm

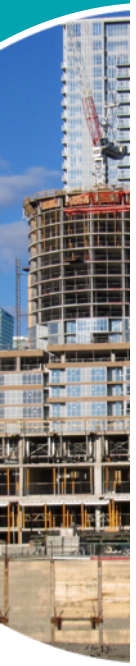
Co-registered point cloud of the building exterior

Cross-evaluation between laser scanner and mobile mapping results shows cloud-to-cloud distances of less than 15mm





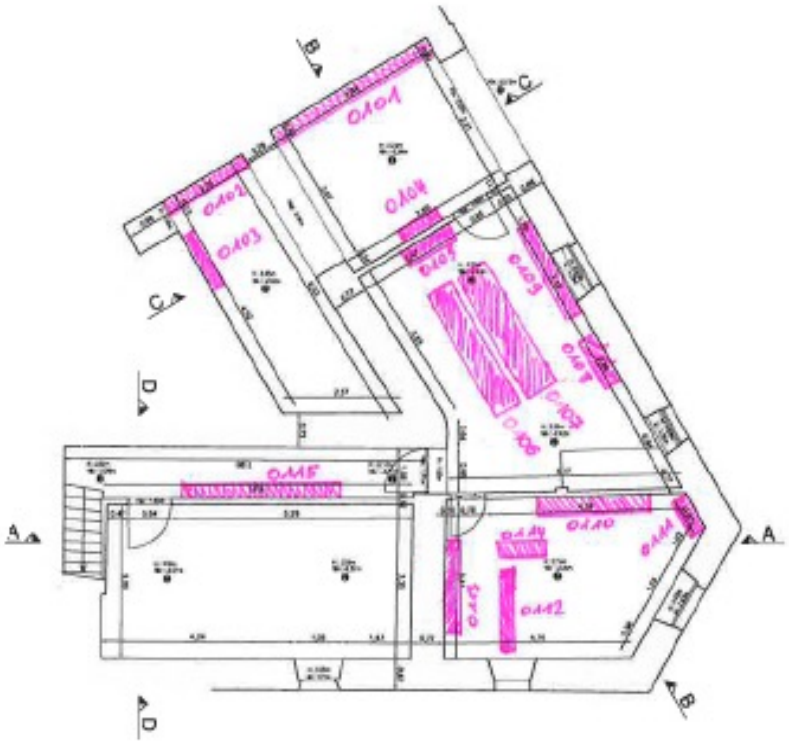




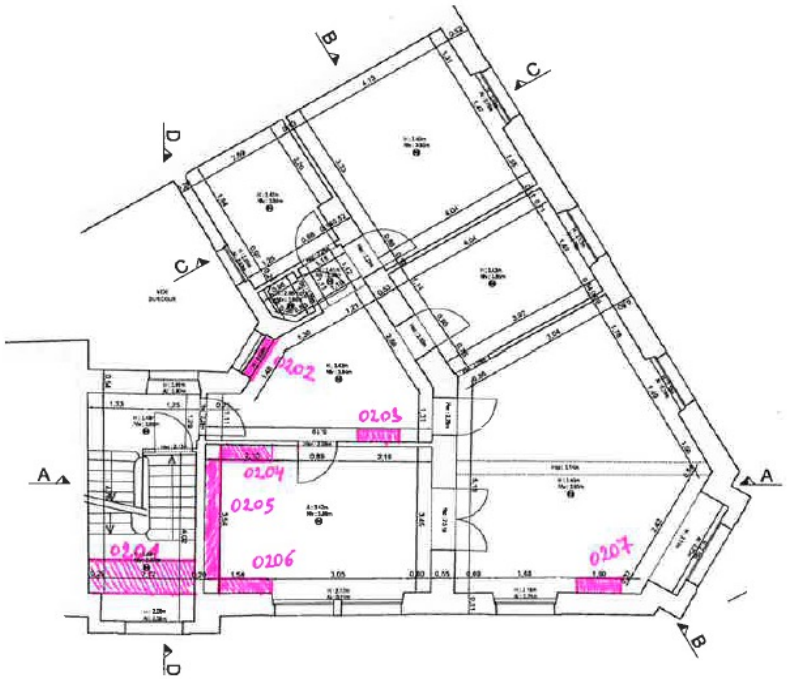
The photogrammetric survey of the bookshelves

- Nikon D800 (36.8 Mega-Pixel)
- Fixed focus around 60 centimetres. Parameters: ISO400 and F16

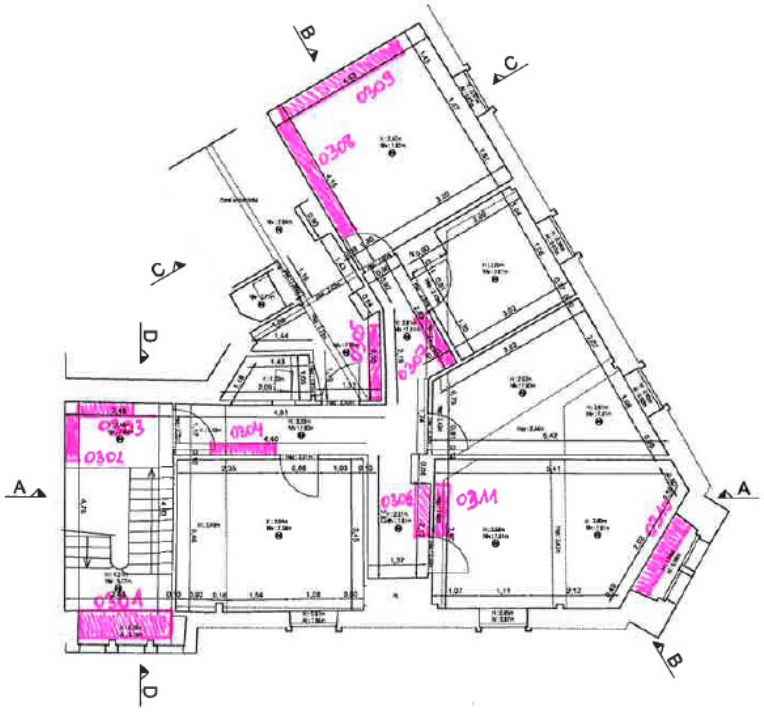
The 33 bookshelves on 3 floors of Trausch's Library



Basement



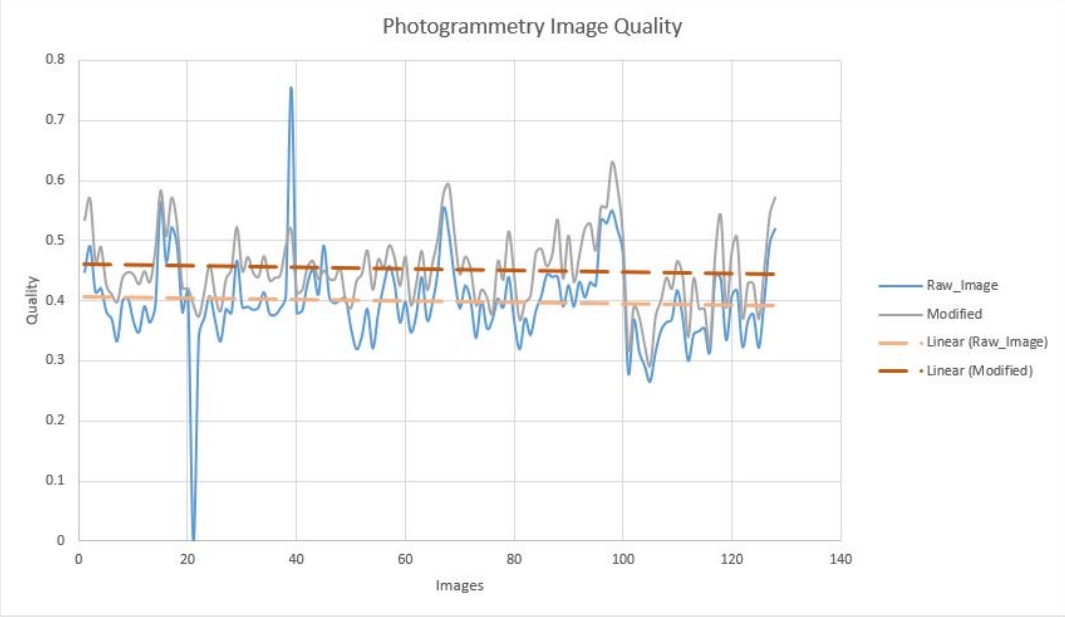
1st Floor



2nd Floor

An orthophoto was generated for each of the 33 bookshelves

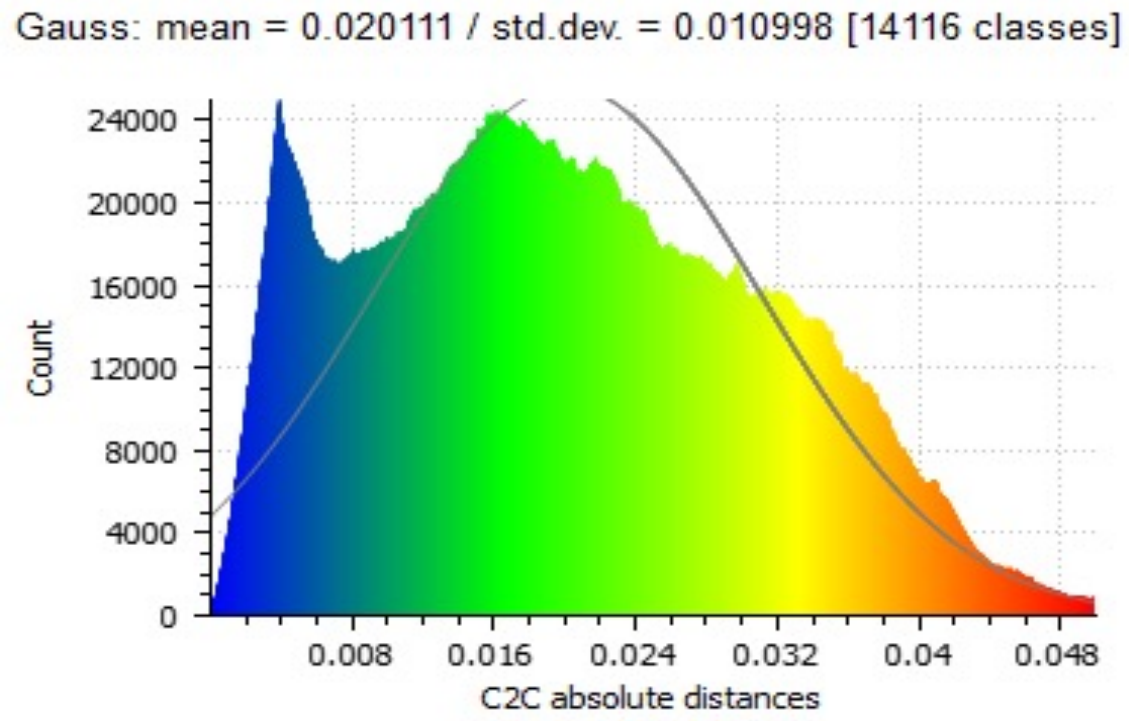
- Employ the Agisoft Metashape software
- An image enhancement step was introduced in order to reduce voids (mainly edge areas) in initial orthophotos
- However, only incremental improvements were achieved, many voids remain, probably due to coverage/quality issues

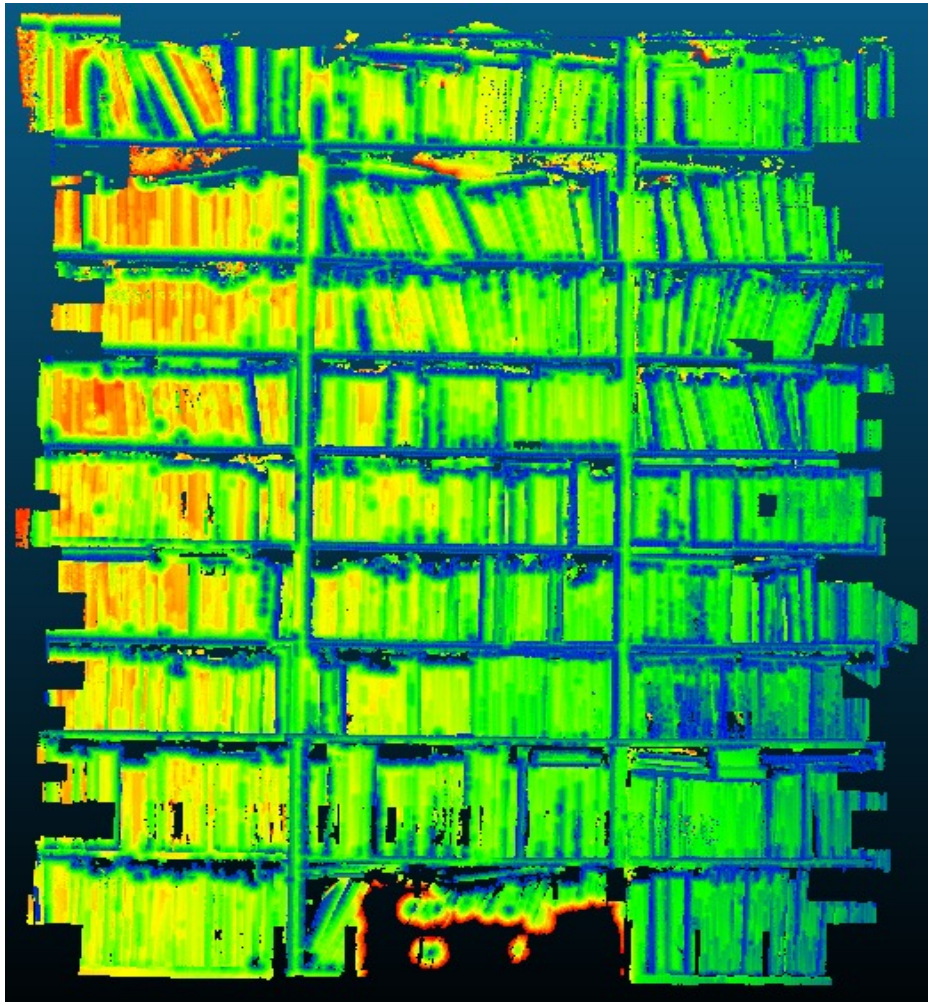


Using the generated orthophotos of the bookshelves a coordinate system for the location of books was derived

- i.e. $Book_{ID} = \mathbf{02\ 05\ 02\ 04\ 047}$
- **Alternative:** $Book_{ID} = \mathbf{02\ 05\ 02\ 06\ 047}$ **(matrix in database)**

The cross-evaluation between laser scanner survey and photogrammetry shows cloud-to-cloud distances with standard deviation of 1 cm



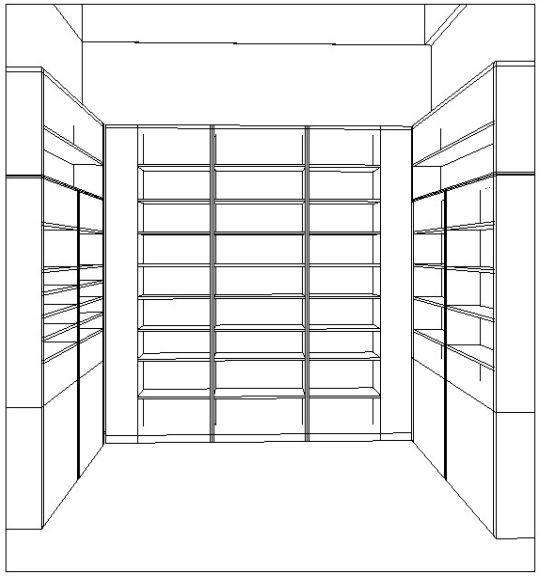


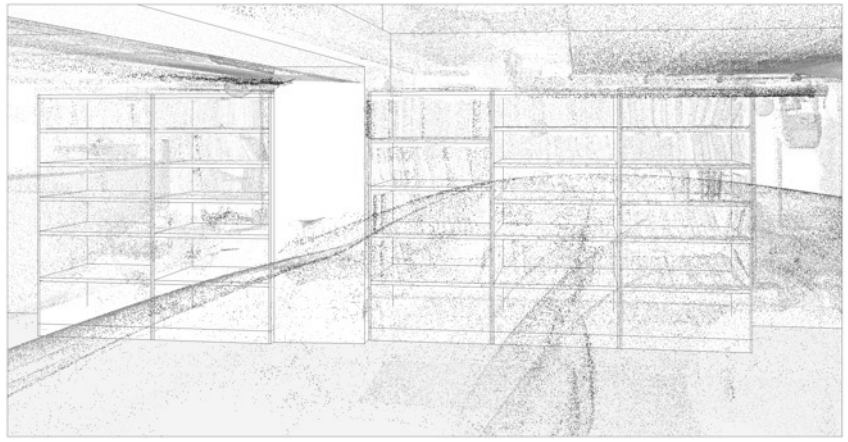
3D modelling

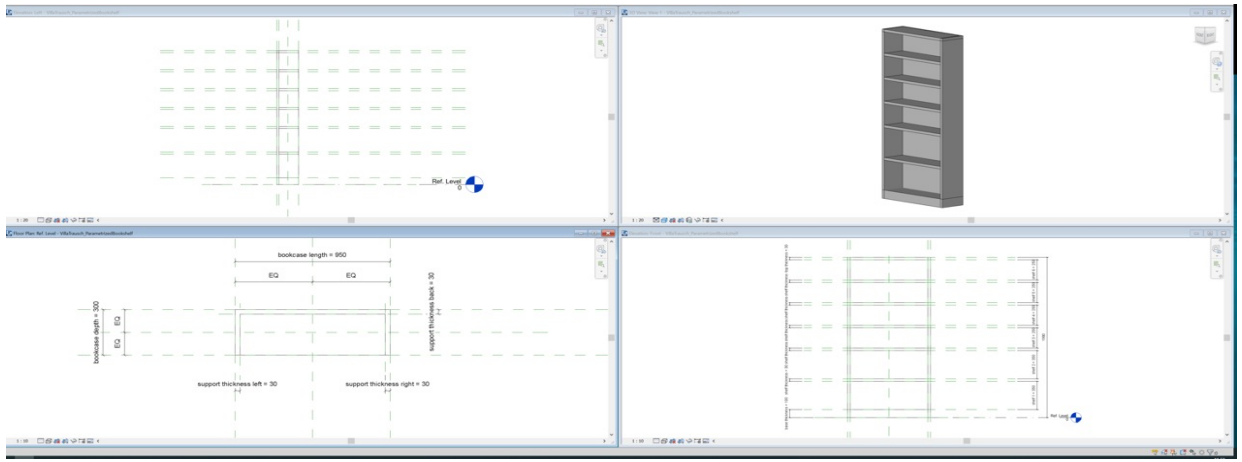
using the Autodesk Revit BIM software

The modelling phase required a hybrid solution including parametric and direct modelling

- Parametric modelling: for repetitive and geometrizable elements (some instance parameters for local editing)
- Direct modelling: extracting 2D profiles from the point cloud and modelling through functions such as extrusion, void and sweep

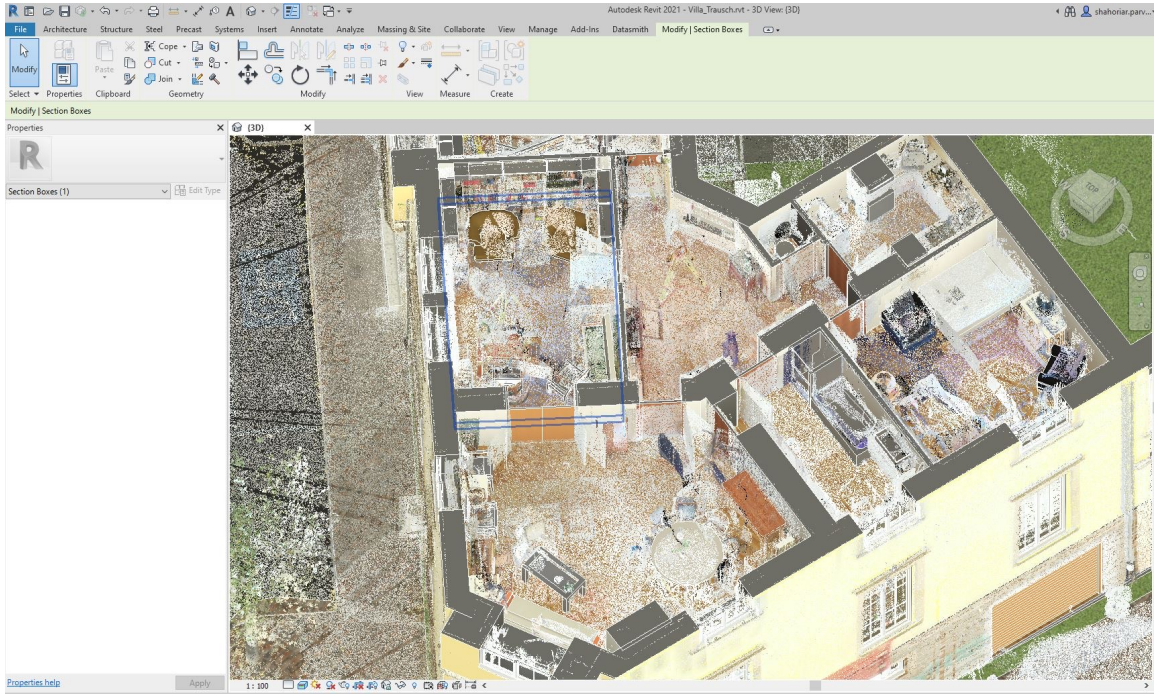


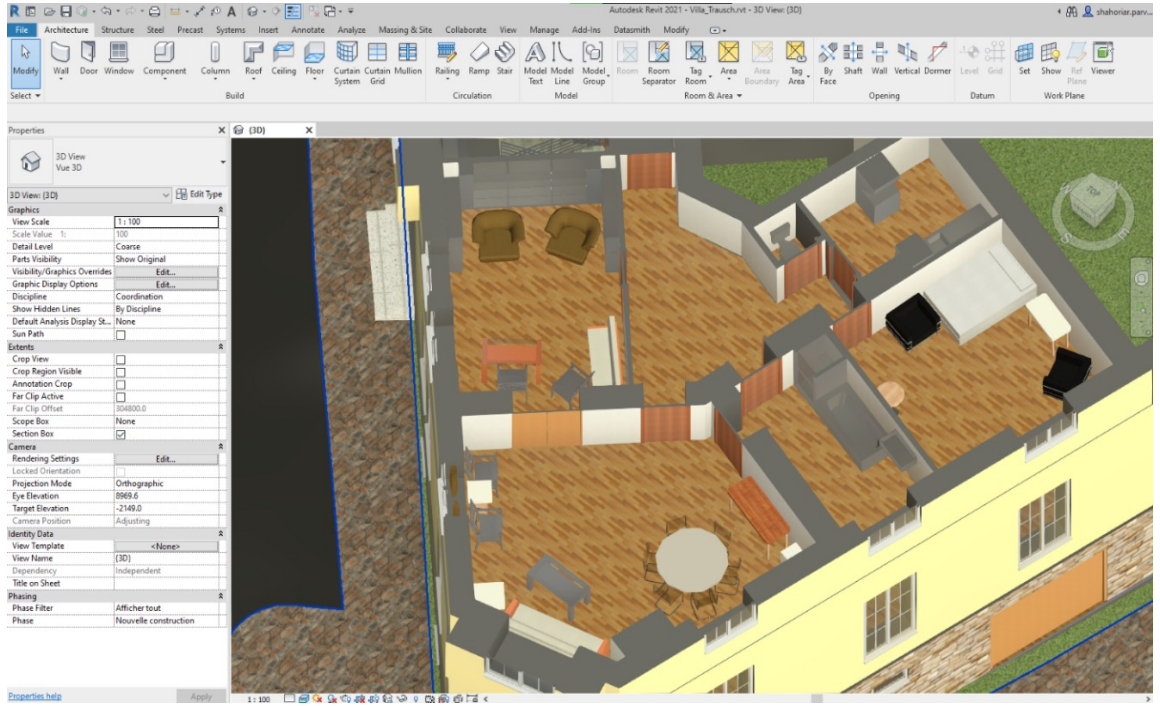




Interior Modelling was carried out using parametric and direct modeling within the BIM environment

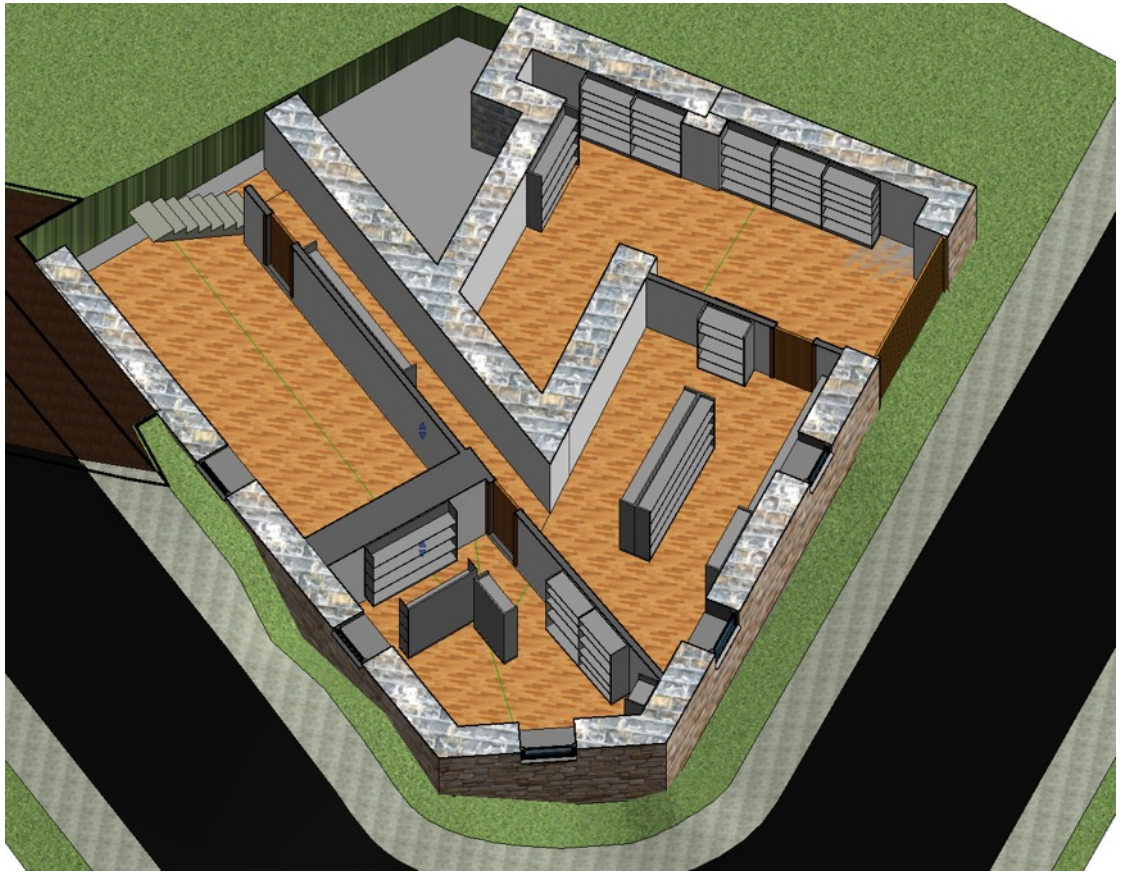
- The building structure would be based on direct modelling
- Bookshelves and furniture on parametric modelling





Example Model Views of Floors and Bookshelf Locations (1)

Basement

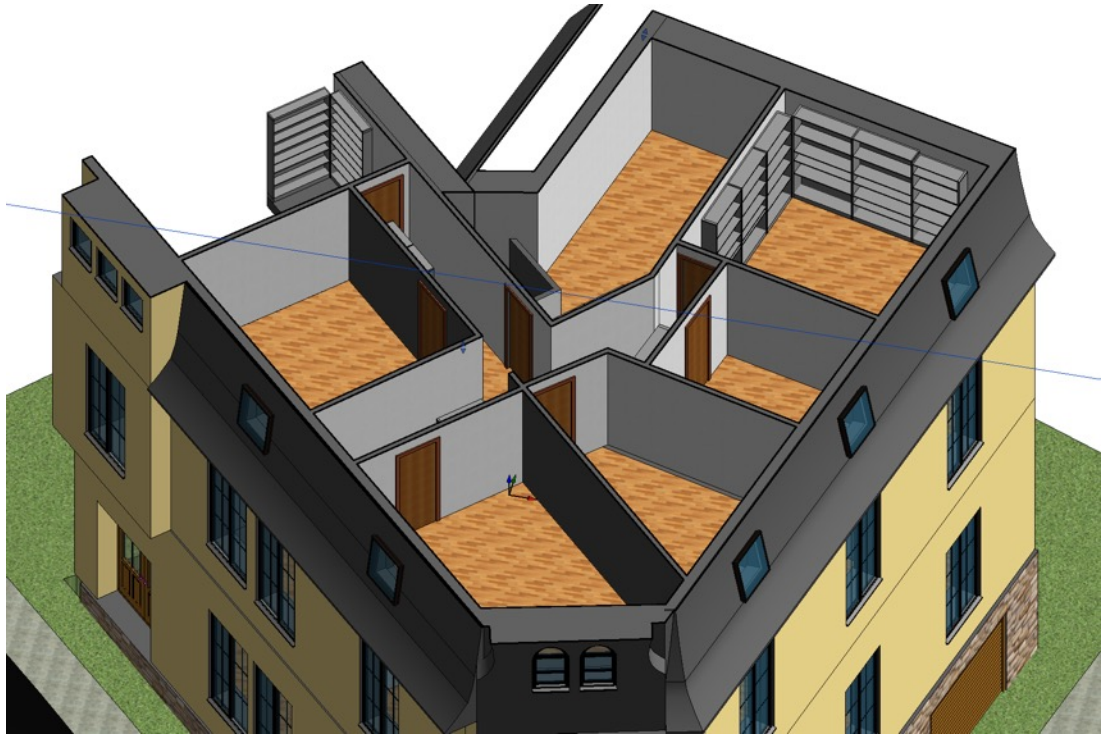


First Floor

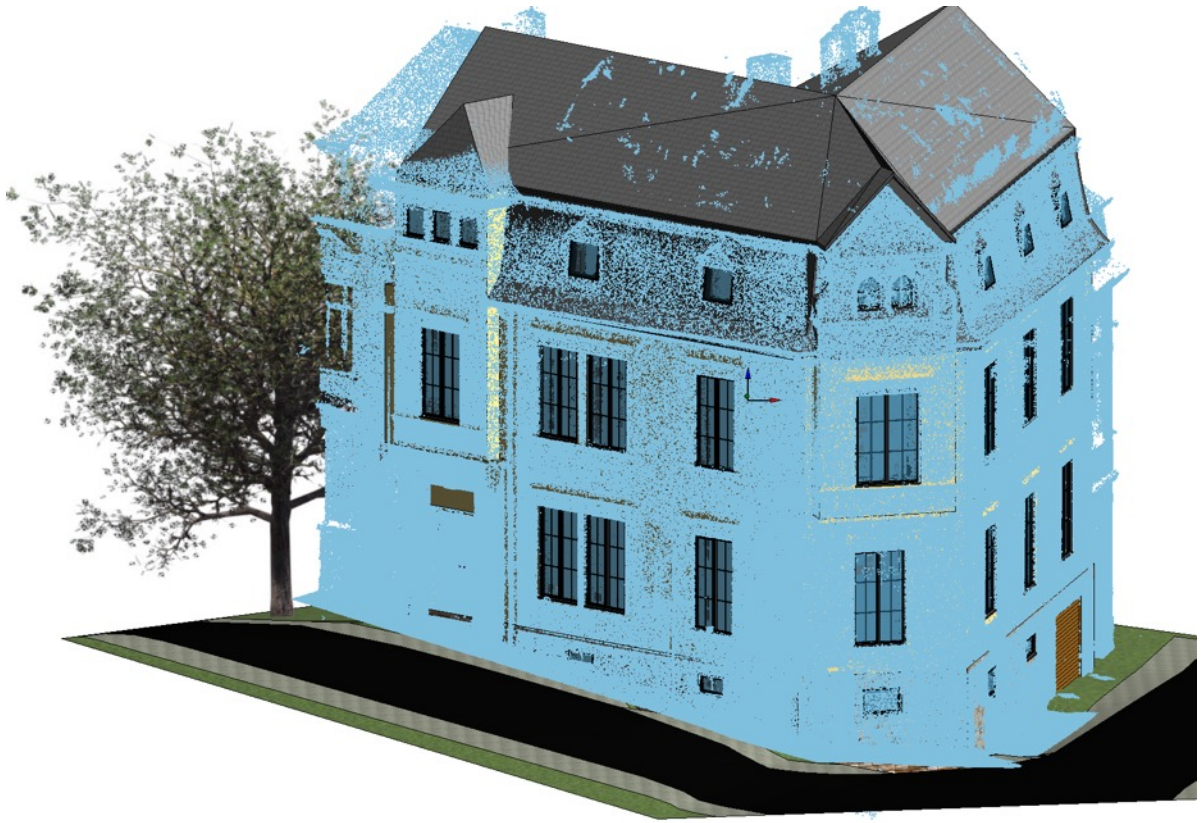
Example Model Views of Floors and Bookshelf Locations (2)

Second Floor

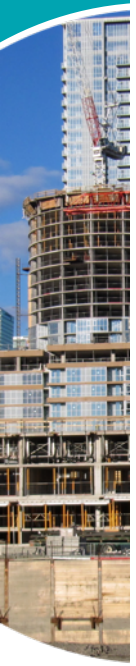
Third Floor



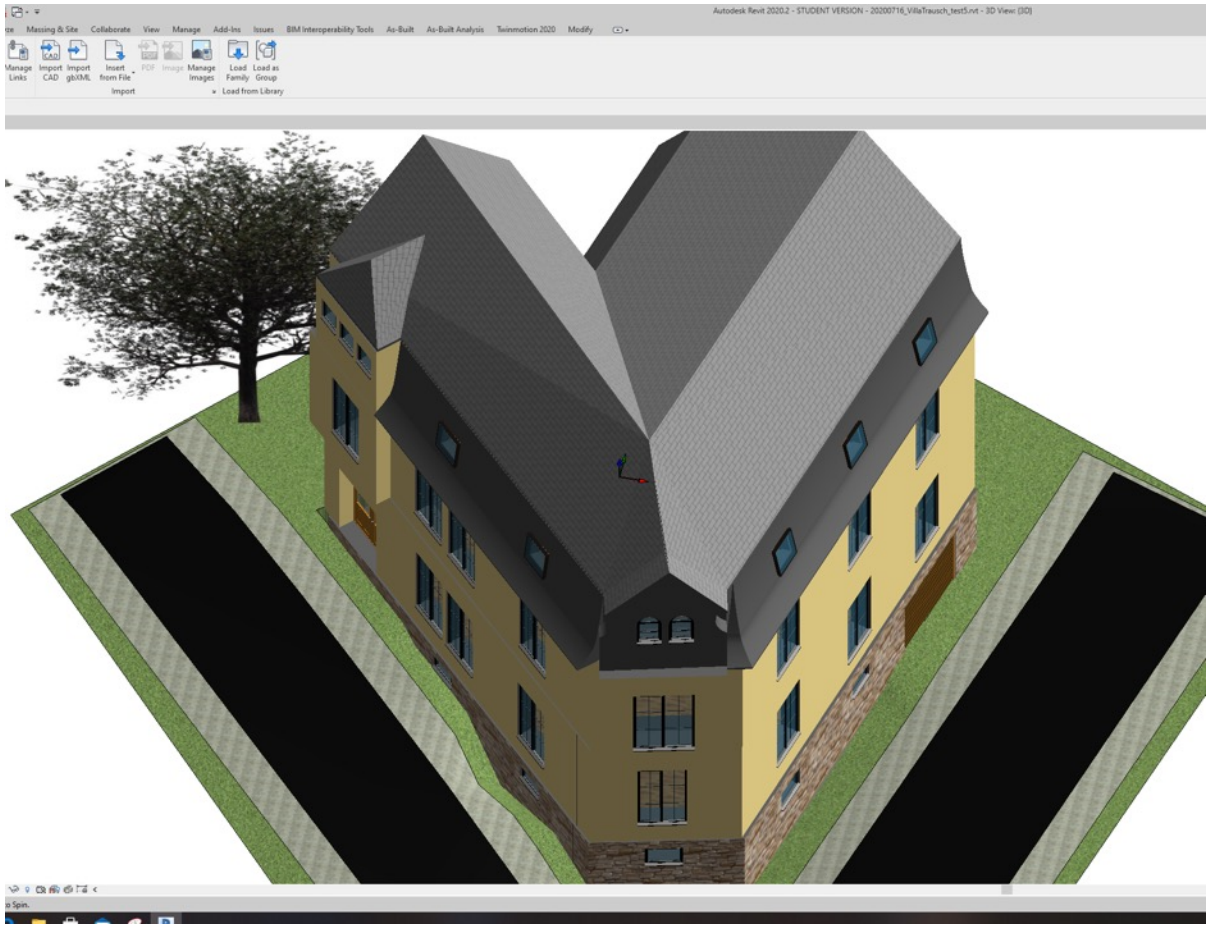
Linking the 3D model with the point cloud allows an assessment of the accuracy of the model



Highlights differences between reality and model



Comparison of Roof Model and Google Earth

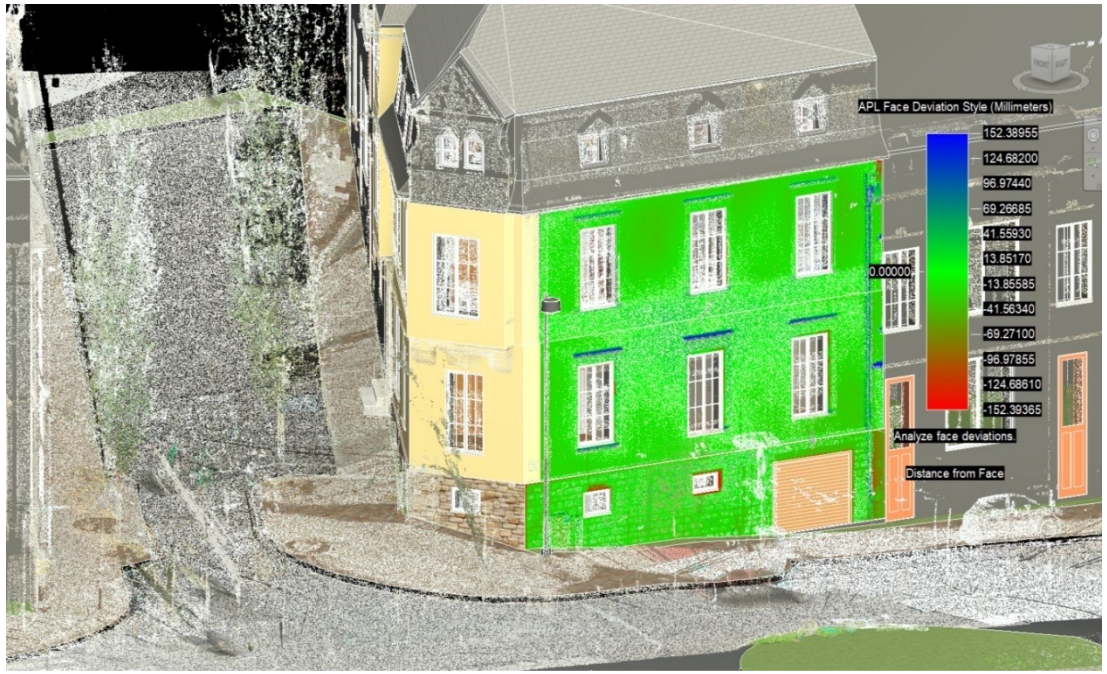


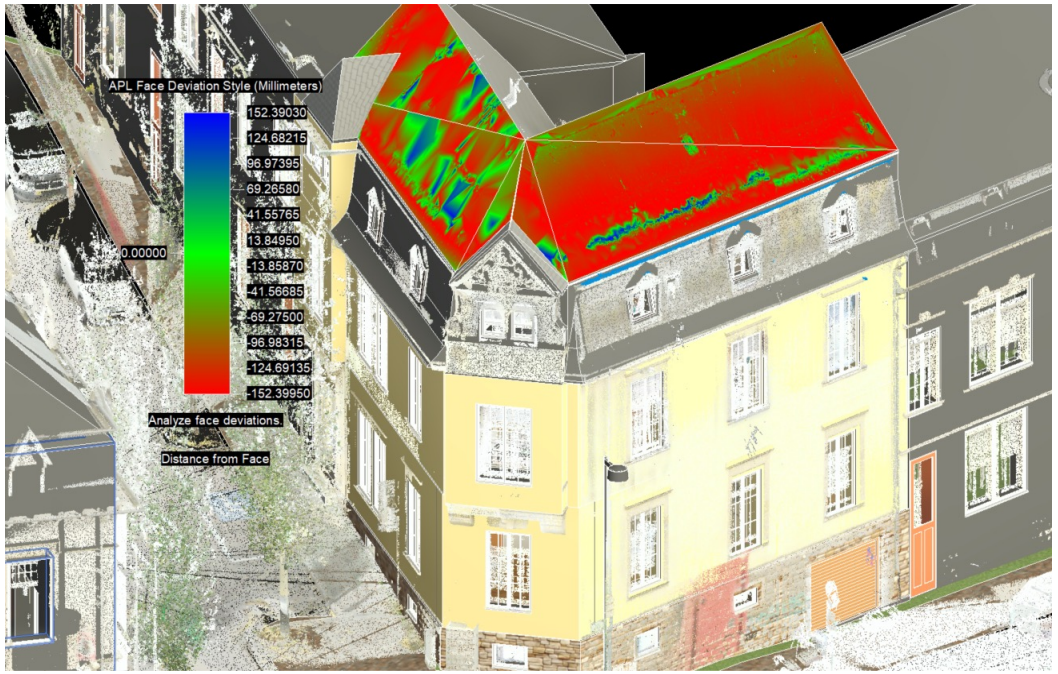
- The current surveys were all ground based and do not capture the roof adequately
- Difficulties in modelling the roof and of its features

How accurate is the 3D building model?

A metric comparison between the 3D virtual model and point cloud was designed within Point Layout to evaluate the geometric model reliability.

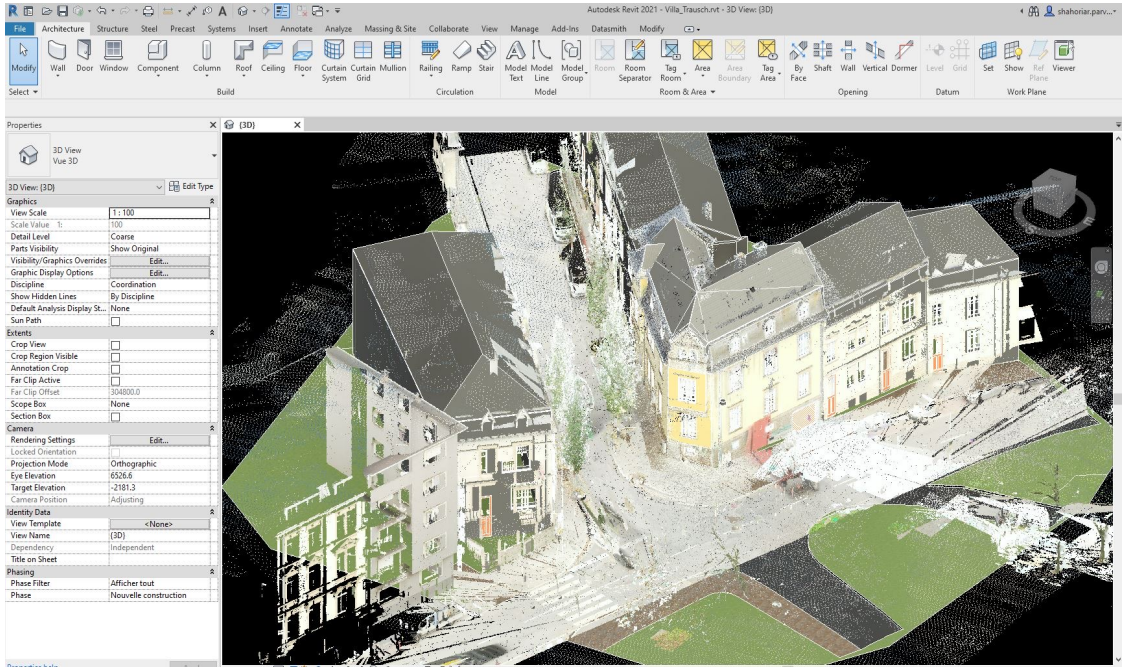
- For facades the differences range from 0 – 1 cm
- For roof areas the differences range form 10 - 15 cm

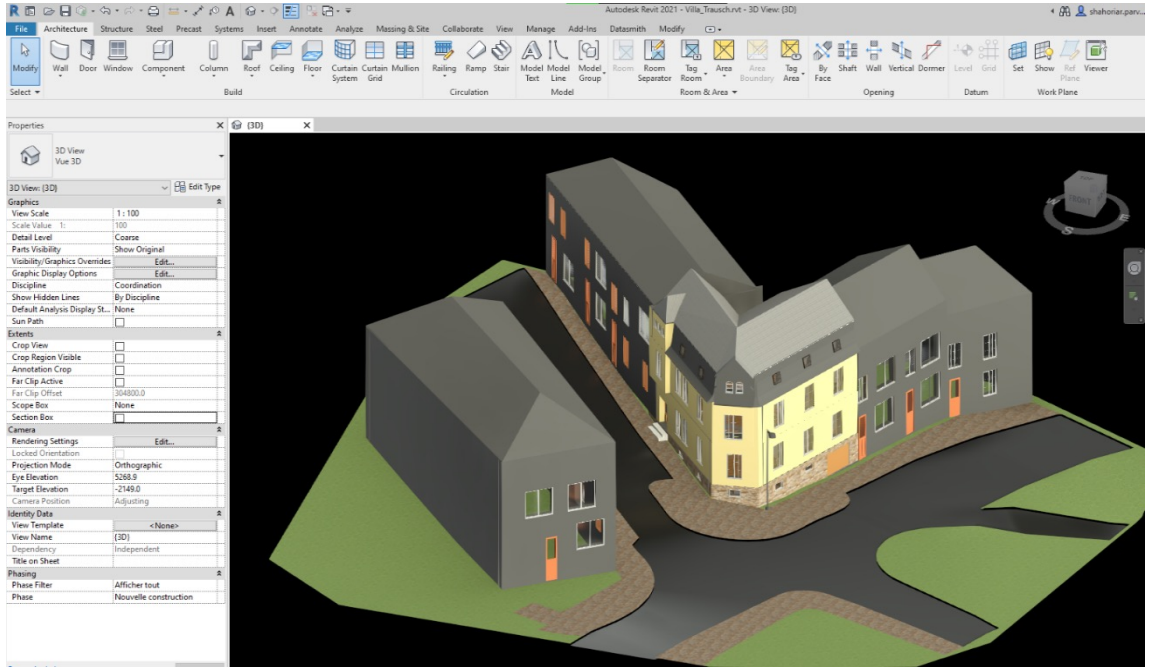




Improving the exterior modelling by adding other buildings and a local terrain model

- To generate a more realistic building model, it was not enough to model the Villa Trausch alone
- Additional buildings had to be included as well as a terrain model based on additional laser scanner data



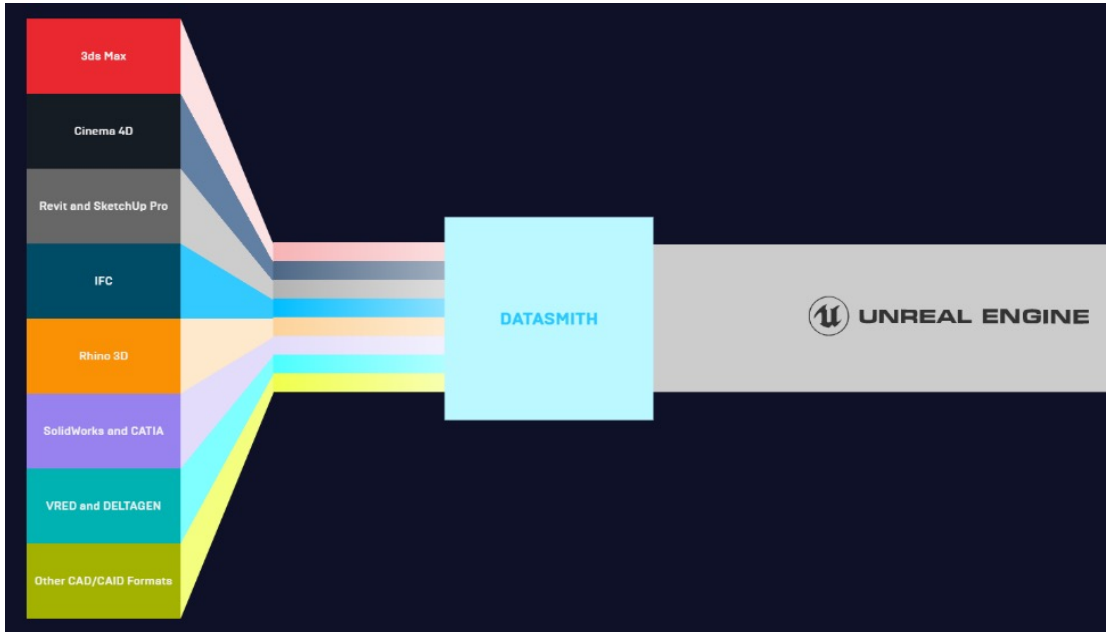


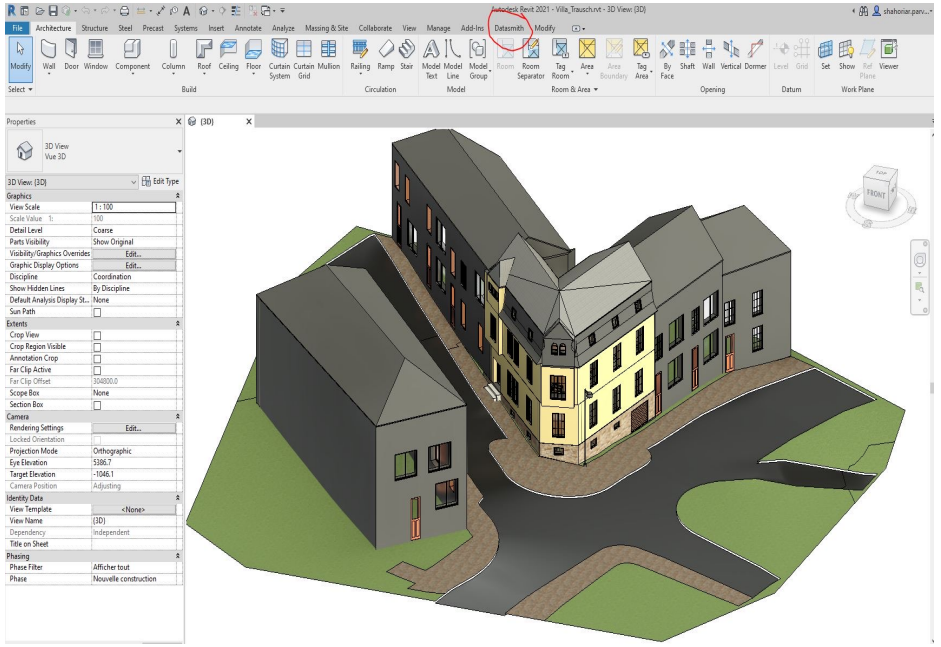
The VR Experience

Investigating pathways to move from the 3D building model to a VR experience

Investigating the software Twinmotion and the Datasmith plugin for generating a photorealistic representation

- Twinmotion is an incredibly simple-to-use real-time visualization tool built on the Unreal Engine from Epic Games, this platform enables users to create, modify, and apply materials to objects in a scene
- Datasmith is designed to solve the specific challenges faced by people outside of the game industry who want to use the Unreal Engine for real-time rendering and visualizations.

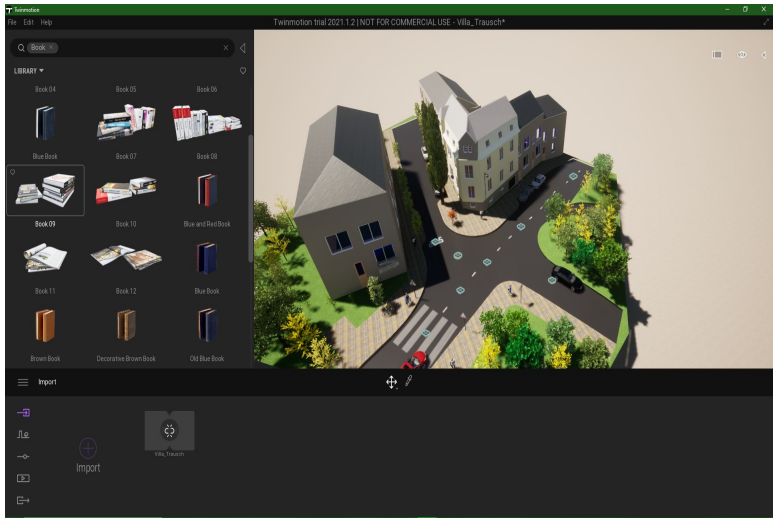




Rendered Model in Twinmotion

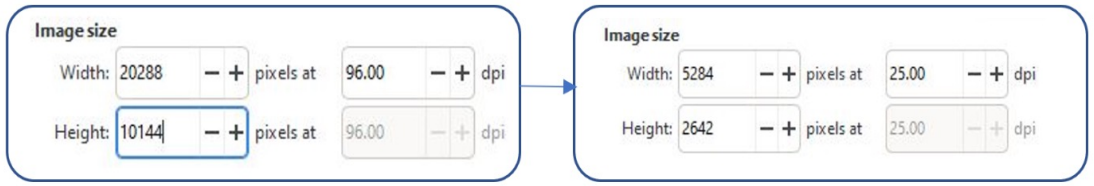
Rendering the 3D model inside Twinmotion is the same as in another Unreal Engine. Twinmotion has a considerable number of indoor and outdoor objects that are beneficial to making more realistic environments and terrain, e.g.,

- Animated doors
- Parametric objects (books)



Investigating panoramic images for generating a VR experience

- The 3DVista VR software allows users to input panoramas from various 360° and DSLR cameras
- During the laser scanning also images were collected that are used to provide colour for the scan points
- Using the scanner software full-colour resolution panoramic images were exported
- The VR experience had to be based on reduced size images (from 96dpi to 25dpi) to run smoothly



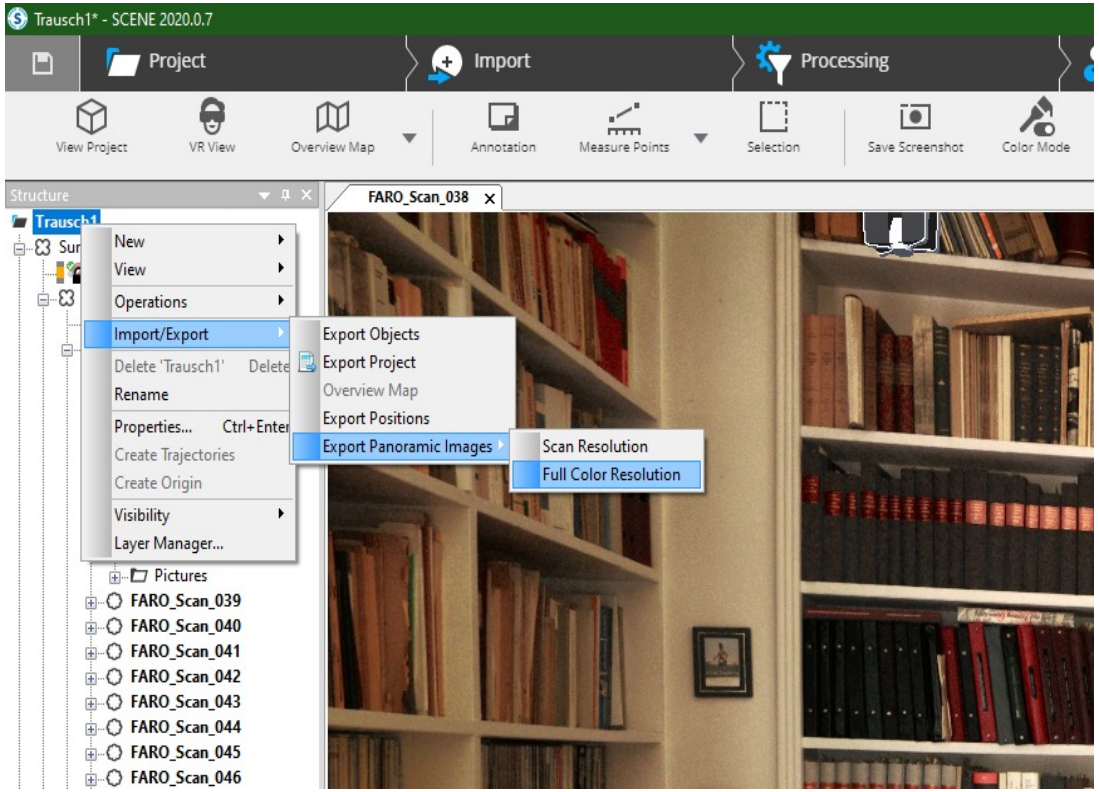
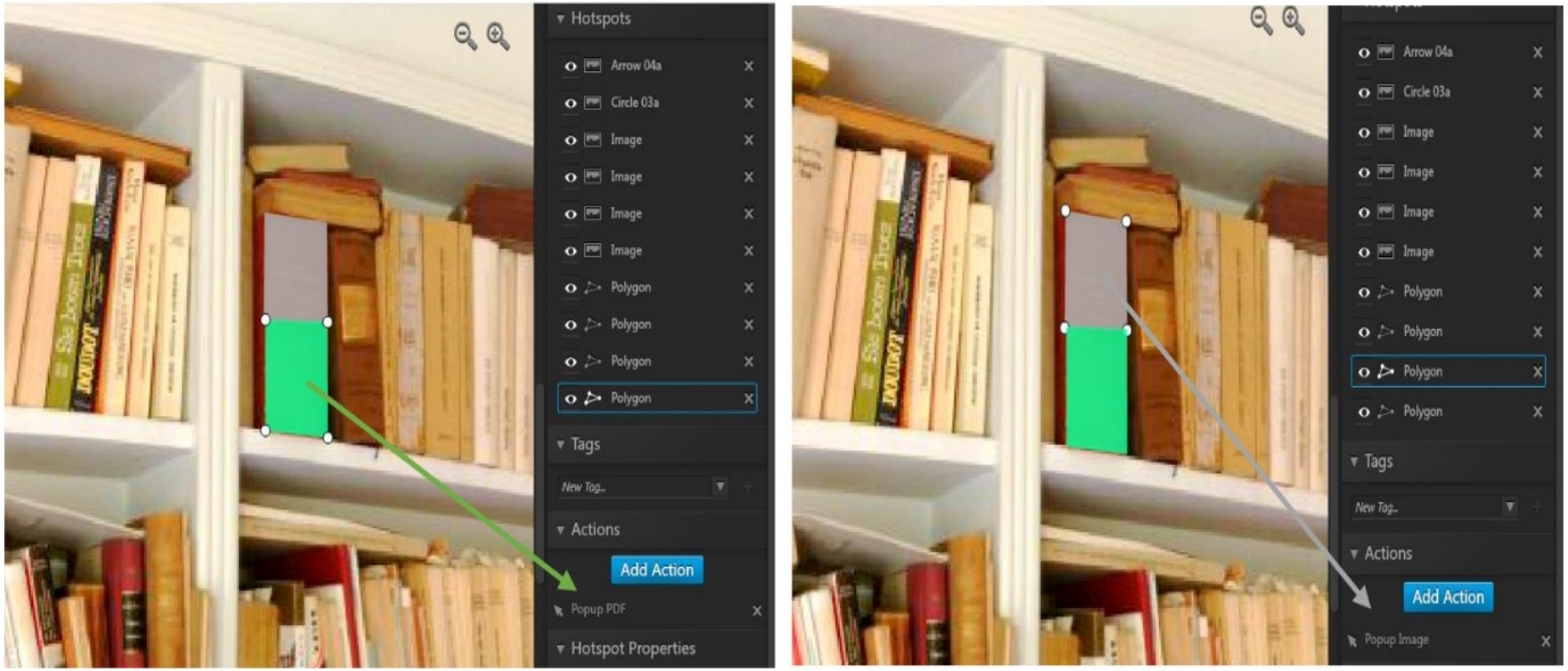


Image Enhancements within VR Software

- To generate the best possible VR experience the panoramic images required an enhancement step
- To improve contrast and brightness, image modifications were performed inside the VR software

Investigating a polygonal hotspot to link book scans to the VR experience

Book spines can be divided into two polygonal hotspots; the upper one is linked with a high-resolution image; lower hotspot is linked with the scan (PDF) of this book.



The 3D model and VR experience of the Villa Trausch are hosted on GitHub for test purposes (https://shahoriar3254.github.io/villa_trausch/)

Virtual tour of Villa Trausch

3D models of Villa Trausch

Conclusions

- The exterior and interior (mainly bookshelves) of Trausch's Library were captured using modern 3D reality capturing technologies
- The cross-evaluations of the different technologies demonstrate the high accuracies achieved.
- Derived products (orthophotos and 3D models) were provided to the project team in support of the historic analysis
- Pathways for generating a VR experience of Trausch's Library have been investigated and results were demonstrated

Next steps

1. Creation of a full high-fidelity model ready for web and VR consumption
2. Exploitation of this model for
    1. A general public outreach application to engage audiences with the life and work of Gilbert Trausch
    2. A facility to interlink the spatial configuration of Trausch's library with his thinking and oeuvre

Goals

- Provide a critical insight into the life and work of G Trausch
- Enable understanding into how historians work
- Contextualize the exploration of the virtual space through oral history interviews

Interlinking Trausch's library with his work

- Enabling access to the Zauberhefte
- Mapping the content of the Zauberhefte with the physical distribution of the library
- Facilitating "spatial search" that matches full-text search on the content of books and the Zauberhefte with their physical locatin in space

Thank you for your attention and check out https://shahoriar3254.github.io/villa_trausch/

- Acknowledgments
  - Addisu Hunegnaw, Eshetu Erkihune, Arghavan Akbarieh, Saif Hassani and Cedric Bruyere