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DIGITAL 3D RECONSTRUCTIONS OF SYNAGOGUES FOR AN INNOVATIVE APPROACH ON JEWISH ARCHITECTURAL HERITAGE IN EAST CENTRAL EUROPE

RECONSTRUCCIONES DIGITALES EN 3D DE SINAGOGAS CON UN ENFOQUE INNOVADOR SOBRE EL PATRIMONIO ARQUITECTÓNICO JUDÍO EN EUROPA CENTRAL Y ORIENTAL

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Highlights:

- The article describes the concept of a Scientific Reference Model (SRM) and its specific workflow and guidelines exemplified for a hypothetical 3D reconstruction of architectural cultural heritage.
- The article gives new insights and questions concerning the former synagogue in Ashmyany (Belarus) as a Case Study for testing the SRM concept.
- The article gives an insight into the market for infrastructures for publication and preservation of 3D models of cultural heritage using the example of the presented case study.

Abstract:

This article examines the application of the Scientific Reference Model (SRM) concept in hypothetical three-dimensional (3D) reconstructions of architectural heritage, focusing on the synagogue in Ashmyany, Belarus. The SRM approach, tested in courses at the Hochschule Mainz, allows for transparent documentation of digital reconstructions to support further scholarly research and community engagement. Using historical source material, the 3D model of the synagogue in Ashmyany, serves as a case study for testing this methodology. The reconstruction process highlights the complexity of preserving Jewish architectural heritage in East Central Europe, where shifting political borders and a lack of comprehensive documentation complicate efforts. The synagogue's architecture, including significant elements such as the Bima and Torah ark, was modelled using Building Information Modelling (BIM)-compliant software. However, certain elements had to be approximated due to limited historical sources, illustrating the challenge of reconstructing lost heritage with accuracy. The integration of historical photographs and surveys into the modelling phase not only enriched the digital reconstruction but also led to further questions about the building's history and modifications over time. In addition to creating 3D models, the SRM emphasizes the importance of detailed documentation, following the FAIR principles to ensure that reconstructions are traceable and reusable for future research. Platforms like the CoVHer Repository facilitate the publication and accessibility of these models, alongside their metadata and source documentation. The Ashmyany synagogue case study demonstrates how 3D reconstructions can help visualize lost architectural heritage, offering new insights into its historical context and emphasizing the need for continued research on open repositories and digital preservation efforts. This approach showcases the potential of HBIM-modelling to contribute to the study and preservation of Jewish architectural heritage, while underscoring the ongoing need for community engagement and scholarly collaboration.

Keywords: source-based hypothetical 3D reconstruction; Heritage Building Information Modelling (HBIM); augmented reality (AR) postcards; cultural heritage; documentation; data preservation

Resumen:

Este artículo examina la aplicación del concepto del modelo científico de referencia (SRM) en hipotéticas reconstrucciones tridimensionales (3D) del patrimonio arquitectónico, centrándose en la sinagoga de Ashmyany, Bielorrusia. El enfoque SRM, probado en cursos de la Universidad de Ciencias Aplicadas de Maguncia, permite una documentación transparente de las reconstrucciones digitales para apoyar más investigación académica y la participación de la comunidad. Utilizando material de fuentes históricas, el modelo 3D de la sinagoga de Ashmyany, sirve como estudio de caso para probar esta

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metodología. El proceso de reconstrucción pone de relieve la complejidad de preservar el patrimonio arquitectónico judío en Europa Central y Oriental, donde las fronteras políticas cambiantes y la falta de documentación exhaustiva complican los esfuerzos. La arquitectura de la sinagoga, que incluye elementos importantes como el arca de Bima y la Torá, se modeló utilizando un software compatible con el '*Building Information Modelling*' (BIM). Sin embargo, ciertos elementos tuvieron que ser aproximados debido a la limitada fuente histórica, que ilustra el reto de reconstruir con precisión el patrimonio perdido. La integración de fotografías históricas y encuestas en la fase de modelado no solo enriqueció la reconstrucción digital, sino que también generó más preguntas sobre la historia del edificio y las modificaciones a lo largo del tiempo. Además de crear modelos 3D, el SRM hace hincapié en la importancia de la documentación detallada, siguiendo los principios FAIR para garantizar que las reconstrucciones sean trazables y reutilizables en futuras investigaciones. Las plataformas como el repositorio CoVHer facilitan la publicación y la accesibilidad de estos modelos, junto con sus metadatos y documentación de origen. El estudio de caso de la sinagoga Ashmyany demuestra cómo las reconstrucciones en 3D pueden ayudar a visualizar el patrimonio arquitectónico perdido, ofreciendo nuevas perspectivas sobre su contexto histórico y enfatizando la necesidad de continuar la investigación sobre los repositorios abiertos y los esfuerzos de preservación digital. Este enfoque muestra el potencial de la modelización HBIM para contribuir al estudio y la preservación del patrimonio arquitectónico judío, al tiempo que subraya la necesidad continua de participación comunitaria y colaboración académica.

Palabras clave: reconstrucción 3D hipotética basada en la fuente; HBIM; postales de realidad aumentada (RA); patrimonio cultural; documentación; preservación de datos

1. Use case and methodology

1.1. Course description

The course "CAD2 – Digital 3D Modelling" offers second-semester architecture students at the Hochschule Mainz – University of Applied Sciences a practical introduction to a widely used CAD (Computer-Aided Design) software for architects. It covers the basics of CAD, advanced principles of Building Information Modelling (BIM) (ISO 19650-1:2018), and provides a hands-on introduction to methods for documenting and publishing digital 3D reconstructions of architectural cultural heritage. During the Erasmus+ Project Computer-based Visualization of Architectural Cultural Heritage (CoVHer, 2022), this course served as the primary platform for examining, testing and refining the developed methodology. The course is divided into two main assignments: the digital 3D reconstruction of an architectural heritage object and the digital 3D conversion of the same building. Using examples of architectural heritage from the Jewish cultural sphere in East-Central Europe, the course also introduces fundamental concepts related to architectural cultural heritage, critical source analysis, and the process of creating digital 3D reconstructions using Heritage Building Information Modelling (HBIM) (Arayici et al., 2017) principles and the Scientific Reference Model (SRM) concept (Kuroczyński, Apollonio, Bajena & Cazzaro, 2023), developed at the Institute for Architecture (AI MAINZ).

1.2. Heritage Building Information Modelling (HBIM)

Since the course deals with architectural cultural heritage, one fundamental principle of the digital 3D reconstruction process is the implementation of HBIM. Traditional BIM, used for example in modern architectural planning and building processes, creates "semi-intelligent" 3D models containing additional information that extends their basic 3D geometry data. These 3D models can include information from the planning, designing, managing, and processing phases of a construction site and incorporate them into a single model (Single Source of Truth) for more efficient, interoperable, and sustainable access for all key players involved, thus connecting surveyors, architects, and engineers and bringing them together in a coordinated process (Autodesk, 2014). HBIM uses the principle of a single model by enriching it with additional information on the historical aspects of the architectural cultural heritage object, which usually do not play a role in modern construction sites. This additional information is provided by building surveyors, cultural protection agencies, or architectural historians and must be attached individually to the 3D model (Arayici et al., 2017).

A crucial benefit of using BIM/HBIM is its compatibility with the ISO-Standard Industry Foundation Classes (IFC) (ISO 16739-1:2024), which allows global data interchange without loss of information during data exchange between different 3D software (McPartland, 2017). IFC not only provides the necessary 3D geometry data but also alphanumeric information about classifications and properties of individual object parts. Since IFC was originally established for the modern construction process, some information related to the digital 3D reconstruction of architectural cultural heritage, like e.g. textures, are not displayed, but the standard still provides the lowest common denominator for 3D data interoperability.

1.3. Scientific Reference Model (SRM)

The concept of the SRM, represented in Fig. 1, reflects many years of engagement with source-based hypothetical 3D reconstructions of no longer existing, altered, or unrealized architecture for educational and research purposes. Its focus is on a low-threshold, application-oriented method for creating documented and openly published digital 3D models as the basis for further data usability. A structured SRM represents a crucial working and knowledge state that clarifies essential information about the research object, its components, its credibility, the extent of hypotheses, as well as its copyrights. The SRM is made available for further research, edits, and refinement of the 3D model, as well as for the creation of derivatives for use in special applications. Therefore, the SRM stands as a findable and citable result of a scholarly investigation into a material object that no longer physically exists in its original state.

In order to be used in scholarly practice and dissemination, 3D models, as products of source-based hypothetical 3D reconstructions of historical objects, should follow the basic principles of scientific work (Kuyper, 1991), which include, most importantly, the documentation of the adopted criteria for the reconstruction and visualization process of the 3D model in the most transparent and transmissible way.

Accordingly, the results of a digital 3D reconstruction, such as 3D models, should be enriched with information allowing the identification of the model accuracy and its classification, especially in terms of its constructive aspects. (Re-)construction is also subject to historical rigour, which requires ensuring the traceability of the research process by the documentation of the used sources and their interpretation by the author or a third party.

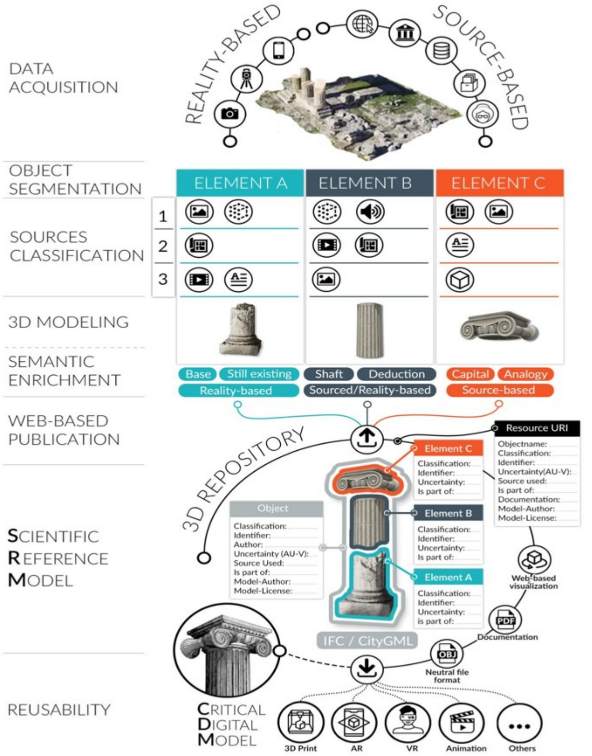


Figure 1: Data-driven SRM and its derivatives. An overview (Kuroczyński, Apollonio, Bajena & Cazzaro, 2023).

With this background in mind, the SRM proposes a traceable scholarly method for hypothetical 3D reconstructions implemented within an accessible 3D reference model (Kuroczyński, Bajena & Cazzaro, 2024). The impact of the SRM is based on presenting a low-threshold, complete process chain, from the analysis of sources to the web-based publication of the 3D model, offering applicable guidelines for the "3D community", including professionals and non-experts.

The overarching idea behind the SRM is, on the one hand, ensuring accessibility and reusability, following the FAIR Principles (Wilkinson et al., 2016). On the other hand, the SRM ensures the documentation of knowledge and the assessment of the cognitive value of a reference 3D model, produced following the fundamental principles of scientific and subject-specific methods. Therefore, the SRM constitutes an applicable methodology to offer heritage scholars a potentially useful 3D reference tool (Kuroczyński et al., 2023).

The SRM concept was tested in the hypothetical 3D reconstruction of the former synagogue of Ashmyany using the BIM-compatible 3D software ArchiCAD 27 (AC), as a best-practice example and will be used here to explain the numerous steps from the beginning of the course to its various outcomes.

2. Case study

2.1. The former Synagogue of Ashmyany

The case study of the synagogue in Ashmyany (Eng.) / Oszmiana (Pol.), a small town in present-day northern Belarus, served as an example of the practical application of the SRM concept in higher education. At the same time, this example illustrates how a hypothetical 3D reconstruction of architectural cultural heritage can significantly enrich the knowledge, visibility, and accessibility of a historical building through the SRM concept.

The great synagogue in Ashmyany[1] (Figure 2) may have been constructed in the mid-19th century but was partially rebuilt or expanded by 1902, when it was re-inaugurated in August of that year.[2] The reason for this significant intervention remains unknown. At least by World War II (WWII), the building had been partially destroyed and repurposed. In the post-war period, improper treatment of the building continued: it was used as a bakery, leading to minor alterations in the roof area, and at times as a liquor store, a warehouse, and later as an auto repair shop. This explains the raising of the floor level in the main prayer hall by approximately 1 m and the destruction of parts of the eastern wall for direct vehicle access.

Figure 2: The former synagogue in Ashmyany (Belarus) (Klimovich, 2023).

In the 1980s, plans to demolish the entire building were discussed, but recent efforts indicate hopes for its restoration and reuse as a museum or conference centre. Since 2018, experts from the International Council on Monuments and Sites (ICOMOS)-Belarus National

[1] Wikidata-Object: Synagogue in Ašmiany Q9349975: https://www.wikidata.org/wiki/Q9349975; the Bezalel Narkiss Indes of Jewish Art: Object ID: 104 Jewish Architecture: https://cja.huji.ac.il/browser.php?mode=set&id=104.

[2] The terminus ante quem of August 1902 is derived from the Hebrew newspaper Hamelitz (No. 179, 12[25].8.1902, pp. 2-3). According to the Bezalel Narkiss Index of Jewish Art (Object ID: 104, Jewish architecture), the ceiling of the main prayer hall may have been vaulted, with a Bima in the center supporting the stone structure. This hypothesis is based on the placement of the inner central pilasters. The repair work, undertaken under the supervision of the warden (gabbai) named Horovitz, may have involved the complete destruction of the original vaulting and the replacement of the entire roof structure. This massive intervention likely also led to the enlargement of the main windows and the addition of a round window above the Torah ark, as the capitals of the pilasters now end beneath the windows.

Committee and the European Humanities University of Vilnius have conducted several public events to raise awareness and develop community-based solutions for the conservation of the site. The Scientific-Methodological Council later adopted these conservation concepts under the Ministry of Culture of Belarus. Today, the building is managed by the Local History Museum of Ashmyany. Its most recent activity, in August 2023, was dedicated to the conservation and restoration of some parts of the internal wall paintings from the early 20^{th} century.

2.2. Data collection

The hypothetical 3D reconstruction of the synagogue in Ashmyany was entirely based on historical 2D source material, mainly a set of plans from the 1990s (Fig. 3). These architectural drawings were based on an older building survey from 1929, documenting the synagogue's condition before its partial destruction during WWII. The original plans and the redrawn versions from the 1990s are currently archived at the Polish Architecture Department at the Architecture Faculty of Warsaw University of Technology (ZAP)[3] and the Institute of Art of the Polish Academy of Sciences (IS PAN)[4]. Consequently, the reconstruction essentially depicts the state of the building around 1929. In addition, modern and historical photographs were used as comparative sources. Architecturally noteworthy is the main prayer hall, which extends over the building's two floors and features a wooden dome that reaches far into the roof structure. The main prayer hall, which was also visibly accessible from the first-floor women's prayer room through five open arches, stands out due to its remaining wall and ceiling paintings. A modern data acquisition using digital survey methods such as laser scanning was not possible and not required as part of the course's case study.

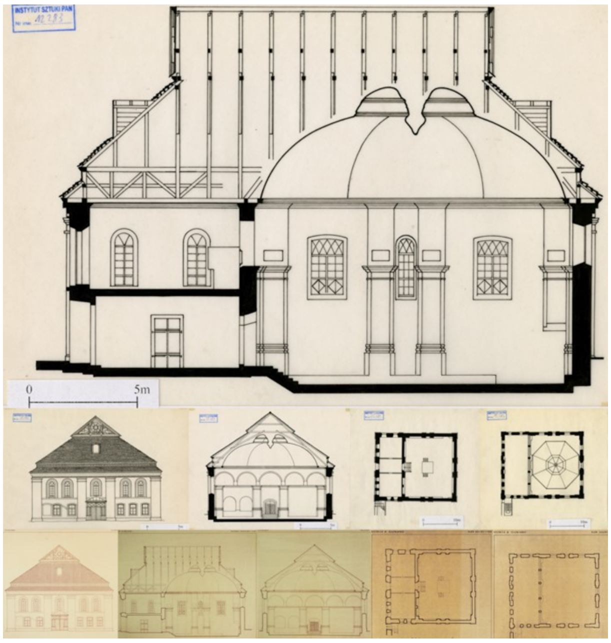


Figure 3: Main sources of the synagogue in Ashmyany, original building survey from 1929 and re-drawings from the 1990s, (Instytut Sztuki PAN, 1929, 2023a-2023h).

During the course, each team, consisting of 2-3 students, is given a similar set of architectural drawings of a synagogue in East-Central Europe. For the first assignment of the course, the hypothetical 3D reconstruction of a synagogue, the team is encouraged to follow the steps of the hypothetical 3D reconstruction process from the Ashmyany case study, applying them to their individual object and becoming familiar with the BIM-conform software ArchiCAD 27 (from now on referred to as AC) step by step. The second assignment of the course, the digital 3D conversion, is not part of this article.

To ensure consistent documentation throughout all projects within the course – and to provide the necessary metadata for the documentation phase – the visual sources provided by IS PAN or other institutions are named, stored and organized according to the requirements of the internal work at AI MAINZ. Files with sources, for example, need to follow special naming conventions and are stored in dedicated folders, following a hierarchical folder structure. This naming convention is also followed in the image captions within the 3D modelling software. The same structure is applied to additional sources provided by third parties or found through online resources. This step may seem obvious, but its importance cannot be stressed enough, especially when dealing with first-time student work.

2.3. Data interpretation

Since the course is committed to educating architects in digital, collaborative, object-oriented, and BIM-conform 3D modelling, the two main assignments are to be carried out as group tasks and within the internal BIMcloud server. As with the naming convention and files organization system, it is important also to follow proper naming within the BIMcloud to ensure an efficient workflow. Before the 3D file is set up, the project is prepared by loading a prepared AC template, created for the current version of AC, to ensure smooth access within the BIMcloud and to support a proper workflow for corrections and communication. The template not only contains helpful guidelines and checklists for the students but also several features that are needed for a proper classification in HBIM. For example, the classification set for a "Bima" and "Torah ark" is already integrated into said template.

The next step is the localization and georeferencing of the project. Although one could use the software's internal localization tool to select the geo-coordinates, students are advised to select coordinates from a common global and decentralized platform to ensure consistent research data, using controlled standard datasets. The geo-data, as well as the object's URL and identifier number, should also be integrated into the top-level information within the AC project file, that also includes metadata like for example the name of the authors etc. to guarantee consistency during the subsequent documentation phase.

To acquire a visual overview of the environmental context, the course encourages the groups to gather open source vectorized plans of the location and integrate these visual sources alongside provided historical plan material within AC. The export typically requires an additional step through open-source Geographic Information System (GIS)

[3] More information about ZAP can be found online: https://nauka-polska.pl/#/profile/institution?id=9125&_k=eyyugs, last accessed 04 October 2024.

[4] Institute of Art of the Polish Academy of Sciences, Sig.: RP0000012281–12285, RPZ0000004957–4961.

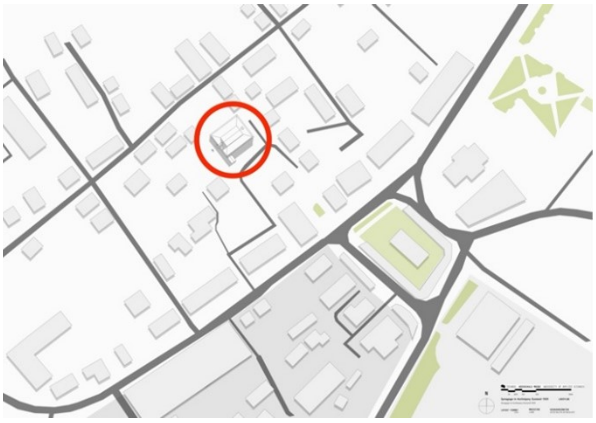
software to obtain clean vectorized plan material for the site in its current state. This step can also be further enhanced by comparing the site with the historical map material.

In the case of the synagogue in Ashmyany, the comparison with the existing historic plan material raised a series of questions that have not yet been satisfactorily answered. Its location is clarified based on the remaining building in situ in the centre of the village. However, the urban situation of this block between 1927, 1932, and 1935 is not definitively traceable on the preserved historical map segments (Fig. 4). The map from 1927 shows the block of houses entirely blacked out. During this period, it is possible that another building of the Jewish community existed, symbolized by the Star of David located east of the city near the Franciscan monastery. This indication could suggest a possible, though unlikely, dissolution of the synagogue before 1929, which may also be supported by the absence of the Torah ark in the original plan material from the 1929 building survey.

The most precise representation of the synagogue's block before its partial destruction is found on a map from 1932. However, the building itself does not appear to have been marked at this time, even though it must have still existed. Additionally, the connecting structure on the south façade, which included an external staircase leading to the women's prayer room, and an additional building that must have also belonged to the Jewish community, are not identifiable. The same issue applies to the map from 1935.

As with the historic building survey material, the historic map material and the modern vectorized plans of the surroundings, it is required to integrate all visual sources with separate AC worksheets. Worksheets are needed to perform 2D tasks within AC, that are later used as traces within the 3D workspace. This separation of 2D and 3D workspace is important to ensure data consistency and efficient workflows. Each visual source from the historic survey must be individually adjusted to the given measurement scale, which in our case is in the unit of meters in 1:100 or 1:200. The groups are recommended to work with the true dimensions of the building. Each geometrical object will differ according to the given sources and most likely be modelled not over a level of detail equivalent to the scale of 1:100. After the integration and scaling of the visual sources, the groups face their first step of interpretation within their hypothetical 3D reconstruction. Since a reconstruction usually consists of a variety of diverse visual sources – instead of a coherent digital building survey in the form of a consistent aligned point cloud – it is essential to select a user defined coordination system (UCS) as the origin of the 3D scene. A well placed UCS is also helpful to align each visual source (e.g., floor plans, sections, and elevations) properly.

What follows is the time-consuming process of aligning each scaled visual source from the historic building survey. Since the plan material is usually depicted in different scales, it is advisable to select the image with the best resolution and largest scale. In the case of Ashmyany, the "leading" image would be the longitudinal section, which was drawn at 1:100, rather than the 1:200 scale used for the floor plans. To properly align these sources, it is helpful to use the software's internal guideline system.



(a)

(b)

(c)

Figure 4: Maps of Ashmyany with the block of the synagogue. a) Today's urban situation. b) Map section from 1927 (Herder Institute for Historical Research on East Central Europe, 1927). c) Map section from 1932 (Herder Institute for Historical Research on East Central Europe, 1932).

In order to fully understand the building, the students first have to re-draw the 2D sources. As 2D plan material can automatically be derived on demand from the 3D model after the modelling phase in AC, this step might seem unnecessary. However, based on experience, it still makes sense that significant sources are being vectorized (re-drawn) on a separate worksheet. This step of producing clear vectorized drawings serves several purposes. First, it generates historical insights by fully comparing the given source material and detecting misalignments. Secondly, these vectorized drawings reveal symmetries within the building, which will aid during the 3D modelling phase through abstraction and unification. The results of this vectorization step can later be used in the dissemination phase.

Since, in most cases, an on-site visit is not possible, additional and more accurate sources, such as modern photographs of the existing building – particularly of the interior – should be researched and collected by each group. These images should be attached to a separate "overview" worksheet in AC, with the necessary metadata stored in captions of the images for each source, for the upcoming documentation phase.

2.4. 3D Modelling

The 3D modelling phase is typically the main working step within a hypothetical 3D reconstruction (Fig. 5). The entire process will not be meticulously explained in this case study. Instead, certain aspects will be highlighted for a digital reconstruction that is entirely based on image sources and reconstructed within BIM-compliant 3D software. Since the BIM-based approach is an object-oriented modelling process, it is recommended to identify and semantically divide the building into logical sub-objects. Much of this segmentation is already facilitated by the functionality, toolbar, and layer division within the software.

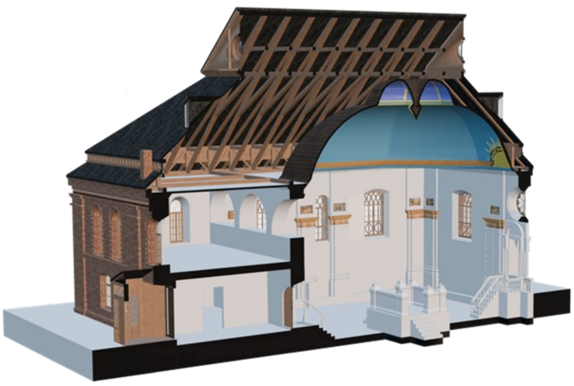


Figure 5: Perspective cutaway from the digital 3D model of the synagogue in Ashmyany around 1929 with additional texturing in the main prayer hall.

Aside from the UCS of the project, it is crucial to establish a logical story setting. To achieve this, it is recommended to generate a structural study of the building in the form of a single object based on the 2D drawings from the vectorization step. This helps familiarize the students with the building's structure, as well as with the alignment of sections and elevations to the ground floor plans. The stories should be set according to the ground floor plans and with straight values. During this step, which can still be considered preparation for the 3D modelling phase, the abstraction and unification of the source material will lead to an initial idealisation of the building that must be kept in mind for the documentation phase. For historical buildings – especially in sacred architecture – the division into uniform and identical stories usually does not apply and must be adapted individually per case.

Another crucial decision, which should be made in advance, concerns the main wall elements. Based on the source material and the information available, the main walls should be modelled from the beginning as either basic or composite wall elements, with the reference line for the exterior walls facing outward and toward the core of the wall. The benefit of basic wall elements is clear. These elements are not only easier to handle within the AC but also do not require insight into the actual wall structure and building materials. If no information can be gathered on this subject, it is recommended to use the software's internal generic material settings, typically in drafting white, for further adjustment in the visualization phase. The same approach can be applied to other structural elements such as slabs, stairs, roofing, etc.

A different approach needs to be followed after the decision is made to use composite wall elements. These elements specifically require information about the building materials used during the construction of the site. While this step will lead to a more accurate SRM, it also demands more insight and research time.

For the entire modelling phase, it is recommended to adhere to the worksheets as traces and references, and to work with symmetries and straight values for both distance and angle to avoid complicating this already time-consuming step. After all, a digital 3D reconstruction based on historic visual sources is always an abstraction of reality.

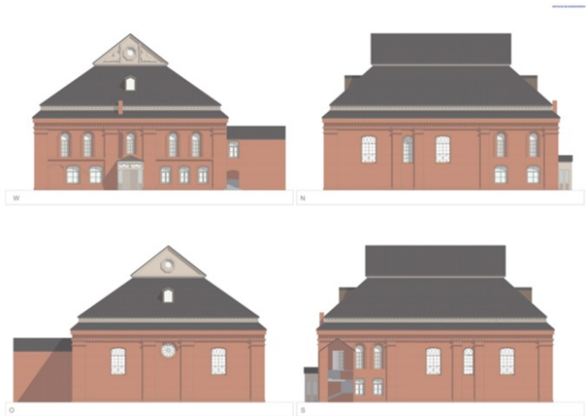
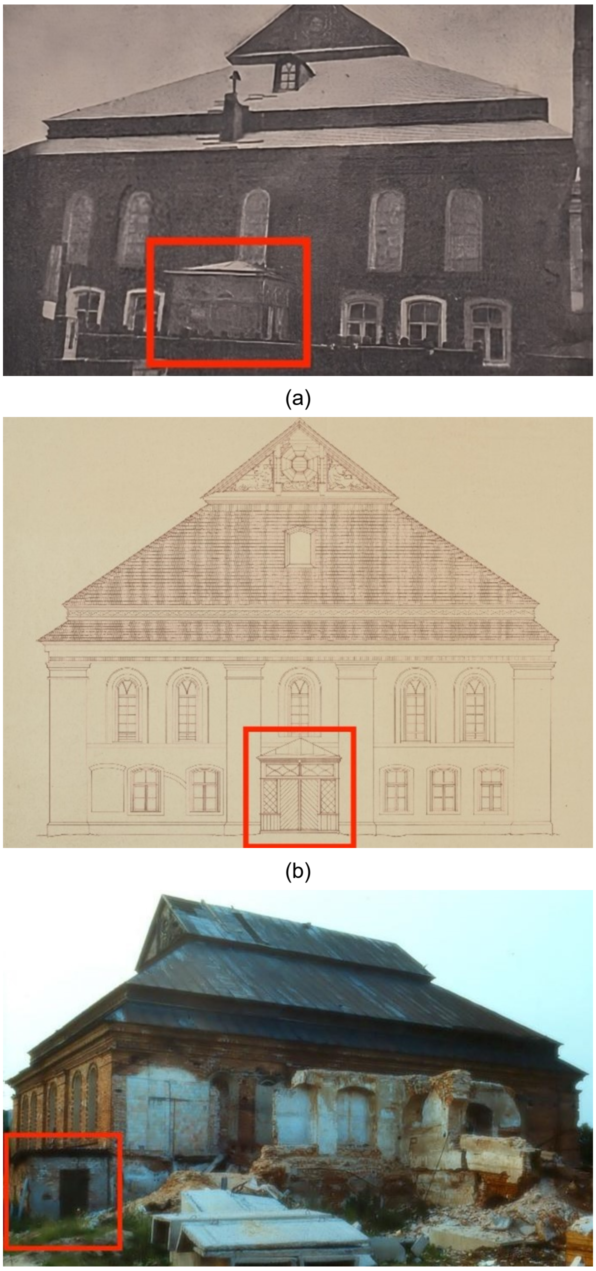


Figure 6: Elevations from the digital 3D model of the synagogue in Ashmyany around 1929.

The first real challenge when dealing with historic architecture in object-based, BIM-conform software is typically the windows. Many other structural objects can be managed effectively with the predefined elements in the software's internal object library, but for historic windows – especially in sacred architecture – there will rarely be a predefined object that accurately represents the given information. From experience, it is wise – particularly for beginners – to approach this task in stages. To avoid time-consuming trial and error, it is best to start by working with the historic window openings available in the internal object library. This helps beginners to approach the modelling of historic windows with bevelled window reveals. A more advanced step would be to replace these window openings with hand-generated custom windows and more elaborate window bars that follow the source material more accurately. The same applies to historic door openings, etc.

Another time-consuming task can be the modelling of the historic roof truss. Although the automatic roof generator works well for modern buildings, this tool should only be used for a quick overview of how the roof truss might have been shaped. To accurately reconstruct the historic truss system, it is recommended to follow the available sources and model the historic roof using the beam and column tools, which still allow adjustments during this step. The same approach applies to the historic roof covering.

During the 3D modelling phase of the synagogue in Ashmyany, some newly developed insights were already drawn for further investigation on-site. The building naturally underwent numerous renovations throughout its history, which can still be traced on its façades today (Fig. 6). Although a more detailed and precise investigation of these changes needs to be carried out on-site, some observations can be made from the visual sources at hand. Initially, both modern and historical photographs provide no reason to assume a completely plastered façade, even in historic times. Currently, only the main windows of the main prayer hall exhibit plastered window frames. The decorative elements of the upper-floor windows on the west facade, along with the continuous cornice above the outer pilasters adorned with angled bricks, suggest that the structure was likely entirely made of exposed brickwork.



(a)

(b)

(c)

Figure 7: The entrance porches of the synagogue: a) Historical photography with depiction of the first wooden porch, 1915-1918; b) West elevation from the building survey from 1929 (Instytut Sztuki PAN, 2023b); c) Construction site in 1990ies (Wikimedia Commons, 2007).

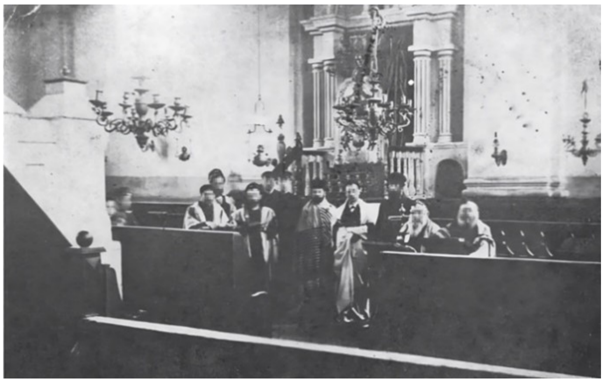
The main façade of the synagogue is, as usual, located to the west. Unfortunately, an early wooden porch, which can only be traced via the elevation of 1929 (Fig. 7b) and is missing on both the ground floor plan and the longitudinal section, is depicted in only one historical photograph from the period between 1915-1918 (Fig. 7a).

In the post-war period, presumably replacing this early wooden porch, a low brick structure was attached to the west façade. This second porch no longer exists and can only be seen in photographs (Fig. 7c) taken during deconstruction works on the second southern building in the 1990s. Again, a more precise dating of this building phase and the adjacent southern building was not possible and will require additional research that could not be conducted at this stage.

The current state of the east façade displays several changes in the building structure. In particular, the ground floor area underwent significant alterations, likely after 1929. Originally, this area, like the north and south façades, would have consisted of continuous wall zones without any openings on the ground level. Later, the upper part of the wall was supported by massive rectangular frames to create new openings on the ground floor as additional access to the main hall. In the middle of the east façade, where there is now a rectangular door, there would have been the niche for the Torah ark. However, the 1929 ground floor plan does not show any evidence of this, suggesting that the Torah ark may have been removed before 1929. Still, as was the case with the wooden porch, the survey may simply have omitted this detail. Above the former Torah ark, there remains a large oculus today, a so-called "Misrah window", enclosed by a brick frame similar to the upper-floor windows on the main west façade. As is the case for the wall and ceiling paintings, the exact date of these significant alterations is not definitively documented at present. It is thought that they occurred during the raising of the floor when the room was converted into a car repair shop.

Notable alterations on the southern façade can be observed around the entrance hall and the women's prayer room, likely associated with its access via a staircase extension and possible connection to the second building south of the synagogue. Currently, no information is available about this adjacent southern building.

The supposedly new roof structure of the synagogue, with its wooden decorations on the exterior and the massive wooden dome above the main prayer hall, stands out as a prominent architectural feature, especially in contrast to the plain brick façade. It consists of a double-broken hipped roof with a broad wooden cornice, creating a three-layered roof construction by adding another gabled roof on top. Originally, the roof was covered with shingles until at least 1925. At some point, presumably after 1945, it was re-covered with metal sheets, possibly tin or copper. Today, it is covered with simpler corrugated metal sheets. Within the triangular gable of the roof, elaborately carved lion reliefs, slender wooden pilasters, and an octagonal skylight adorn the west side, while these decorative elements are absent on the east side. These carvings are the only remaining figurative embellishments on the exterior of the entire synagogue.



(a)

(b)

Figure 8: Interior of the main prayer hall: a) Historical photography, before 1939 b) Visualization of the main prayer hall.

The interior of the main prayer hall, the most significant room of the building, could only be approached in abstraction due to the limited preserved sources. The geometry of fixed elements, such as the pilasters, Bima, and Torah ark, had to be roughly approximated. Unlike movable items like chandeliers or benches, which played no role in this reconstruction, the fixed elements were modelled as complete as possible. However, only a single historical photograph of the interior has been preserved, offering merely a partial representation of the room and allowing for limited accuracy in the reconstruction process (Fig. 8a).

Regarding the fixed interior elements, the preserved historical depiction gives us at least an idea of the form of the Torah ark. Typically situated between the two central pilasters on the east wall, the Torah ark was accessed via a staircase with wooden railings, reaching approximately the height of the pilaster base. The Torah ark extended over two semi-circular niches to the left and right of the staircase. A simple arrangement of double columns with a moulded beam separated the curtains covering the niche behind. The exact form of the upper part directly beneath the Misrah window could only be vaguely estimated. At this point, the reconstruction had to leave secure ground, hypothesizing the completion of the object by adding a possibly semi-circular tympanum.

Similarly uncertain is the shape of the Bima in the centre of the prayer room. The ground floor plan (1929) only depicts the Bima as a square measuring approximately 3 m x 3 m on each side, with two staircases to the north and south. This may have been the base remains of the first Bima, which could have been the main support of the possible stone-vaulted interior. The historical depiction only shows the southeast corner of these remains, providing a rudimentary insight into the geometric form of it. Therefore, it is likely that the remains of the Bima were crafted from stone and, at least after the renovation of 1902, no longer served as a supporting structure (Fig. 8b).

2.5. Semantic enrichment

The advantage of using AC is object-oriented modelling, which provides predefined semantics and properties to the objects, which are encoded in an IFC-conform way. According to the standard, the software recognizes basic architectural elements such as walls, beams, ceilings, windows, doors, and roofs. The modeler can use pre-made parametric library elements for modelling and adjust them by changing specific parameters, such as height, length, or width. More complex objects offer a higher level of customization, with additional parameters available for control (Murphy, McGovern & Pavia., 2009). However, historic buildings have a more complex and sophisticated form than most architectural elements used in contemporary design. Consequently, the built-in library elements in BIM software are often insufficient to create a 3D model of a historic building (Aubin, 2013).

Most notably, for our set of example objects, there are the main defining elements of Jewish sacred architecture, which are naturally not predefined within the AC library. Objects such as the Bima or the Torah ark have to be modelled from scratch as custom objects. Additionally, they must be subsequently defined with individual classification and property settings.

The software – as mentioned earlier – works with BIM-compliant identification sets (classification and properties) and predefined layers, mainly according to the toolbar. Thus, the organization of the objects within AC reflects a logical segmentation of the building based on the element type. However, entering the final modelling phase requires some necessary alternations in the default classification of semantic model elements, the default classification of the properties of objects should be revised, particularly in the case of non-standard objects, as demonstrated with the example of the Torah ark in the synagogue of Ashmyany. The verification includes such properties as position within the building (e.g., exterior or interior), structural function (e.g., load-bearing or non-load-bearing), and status within the construction process. For the reconstruction assignment in the course, construction status should always be set to "existing". The objects should also be classified according to the IFC Standard (ISO 16739-1:2024). If no predefined classification can be found, a new classification should be set up using the Getty-AAT controlled vocabulary (The Getty Research Institute, 2017), which for some cases like the Bima is already integrated into the template as mentioned before.

These classifications and properties should be verified by the groups using the graphical overrides[5] before exporting the final results in the 3D data interchange format (IFC). This is a key aspect of the SRM, which aims the dissemination of reconstructions in a standardized, but also in an informative format, which can communicate information about the objects as a set of properties assigned directly to semantic segments of the 3D model.

[5] The feature "graphical override" in AC is able to make quality assessments by checking the 3D data according to its properties. This is done visually in the 3D viewer by means of a predefined color set assigned to these properties.

2.6. Visualization

Figure 9: Perspective cutaway from the digital 3D model of the synagogue in Ashmyany around 1929 with a detail of the northeastern wall corner and the original photo material from the remaining wall painting.

The surface finish materials were selected based on an analysis of photographs from the site and an interpretation of the source materials. Their representation is mainly based on AC's built-in material library. The AC provides a predefined set of textures that is preset by the selection of material for each object from the toolbar. Thus, a full texturing of the 3D model can be achieved simply by selecting the appropriate material. AC automatically maps embedded textures to object surfaces using tiled planar mapping. However, this step is merely the beginning of a complete texturing and visualization of the reconstruction. Some elements were decorated with detailed paintings, which are not covered in material library of the software. Their implementation in the model requires prior extraction from the source materials, following the concept of the Critical Digital Model (CDM) (Apollonio, Fallavollita & Foschi, 2021). This method focuses on conveying the reconstruction content by applying materials extracted directly from the source. Its main application is for objects preserved only in design drawings. The materials are often represented symbolically through drawing and painting techniques. Their extraction and application to the model allow the author's ideas about the materials to be conveyed without unnecessary over-interpretation. The use of CDM for preserved objects focuses more on extracting the textures of the materials directly from the preserved substance of the object. From the technical point of view of the course, this method mainly applies to exceptional cases, as it requires the acquisition of high-resolution, deformation-free textures and their subsequent mapping to the desired surface. Due to the complexity of this task, it is recommended to switch to different 3D software, which gives greater control over materials and their mapping.

In this case study, full texturing has not been applied to the entire model. Texturing of the exterior part was done with the use of library materials, and most of the interior part was left in white, due to the lack of clear evidence of the interior materials and colour. Textures were applied according to the CDM method only in highly endangered areas containing the most prominent features of historical significance or associated with the symbolism of the Jewish religion (Fig. 9). The dome, likely part of the second construction phase until 1902, was painted dark blue with stars scattered across the surface, while the flat parts of the wooden ceiling were coloured light blue. These flat parts, as well as the lower rim of the dome, were decorated with foliage, but this decoration was not integrated into the texturing process due to its damaged condition.[6]

Above the Torah ark is a rising sun, which is inscribed: “ממזרח שמש עד מבואו נהלל שמי״” ("From the rising of the sun to its setting, the name of the Lord is to be praised", Ps. 113:3) (Center for Jewish Art, 2016a). Above the capitals of the pilasters are 12 small rectangular niches that were painted with the 12 zodiac signs: "The order of the signs starts with Aries, the sign of Nisan, depicted on the pilaster to the north of the Torah ark. Most of the paintings were used as target practice and damaged by bullets, probably during WWII (Center for Jewish Art, 2016b).

The zodiac signs include – starting from the north of the Torah ark, moving counterclockwise:

- **Aries** is represented as a lamb, inscribed: "מזל ניסן" (Zodiac Sign of Nisan).
- **Taurus** is represented as a cow (notice the udder), inscribed: "מזל איר" (Zodiac Sign of Iyyar).
- **Gemini** is represented as two doves, one white and one black, inscribed: "מזל סיון" (Zodiac Sign of Sivan).
- **Cancer** is represented as a beetle, inscribed: "מזל תמוז" (Zodiac Sign of Tammuz).
- **Leo** is represented as a lion in a desert, inscribed: "מזל אב" (Zodiac Sign of Av).
- **Virgo** is represented by a dove with a harp, inscribed: "מזל אלול" (Zodiac Sign of Elul).
- **Libra** is represented as a scale, inscribed: "מזל תשרי" (Zodiac Sign of Tishrei).
- **Scorpio** is represented as a crawfish, inscribed: "מזל מרחשון" (Zodiac Sign of Marheshvan).
- **Sagittarius** is represented as a bow with an arrow, inscribed: "מזל כסלו" (Zodiac Sign of Kislev).
- **Capricorn** is represented as a goat in a field, inscribed: "מזל טבת" (Zodiac Sign of Tevet).
- **Aquarius** is represented as a well in a field, inscribed: "מזל שבט" (Zodiac Sign of Shevat).
- **Pisces** is represented as two fish, inscribed: "מזל אדר" (Zodiac Sign of Adar).

The depiction of the zodiac signs in connection with Jewish sacred architecture can be traced back to late antiquity, as evidenced by preserved floor mosaics from the 4th and 6th centuries. Even during this period, the depiction is interpreted as a symbolic "journey" from the earthly world into the heavenly spheres. In general, the

[6] According to the Bezalel Narkiss Index of Jewish Art (Object ID: 104 Jewish architecture), the foliage decorations are part of the initial decoration phase around 1902, whereas the more figurative paintings, such as the zodiac signs and the rising sun, were added around 1920. All following information was taken from the Bezalel Narkiss Index of Jewish Art: (Object ID: 104 Jewish architecture). The author(s) would like to express sincere gratitude to Valdimir Levin from the Center for Jewish Art at the Hebrew University of Jerusalem for his valuable contribution in providing additional information and material about the site.

use of such symbolism can be linked to early forms of Jewish mysticism (Schäfer, 2024, pp. 81-84), a form of Jewish belief that – simply put – spread through Ashkenazi Judaism in Eastern Europe and survived as Hasidism until its forced demise during WWII.[7]

The outcome of the visualization enables the experience of the main prayer hall as it may have been intended, for the first time since the significant alterations and the destruction during and after WWII. Currently, this space is no longer possible to experience on-site due to the state of the paintings and the raised ground floor. However, this experience is conceived, saturated with a relatively high rate of uncertainty. it is important to note that it represents just one of several possible reconstruction versions The perception of reconstitution is also dependent on the used visualization and dissemination techniques. The key idea behind the SRM concept is that all forms of visualization – whether 2D renderings or other versions of the 3D model – are considered derivatives of the SRM and can be traced back to the core research activity.[8]

2.7. Documentation

The work on the 3D reconstruction concludes the documentation phase. It is a crucial stage of work for scientific activity, as only through proper documentation the decisions and their reasoning can be traced for critical analysis by a third party. However, thorough documentation of the scientific project of a hypothetical 3D reconstruction can be extremely time-consuming and is not within the scope of the course. For this reason, it was decided to use the emerging, innovative web-based tool designed to document hypothetical reconstructions, IDOVIR, developed by the Digital Design Unit of the Faculty of Architecture at the Technical University of Darmstadt (IDOVIR, 2022).

IDOVIR is based on the Reconstruction - Argumentation - Method. The method requires segmenting a building into semantic elements, to which visual triples are assigned, consisting of a visualization of the reconstructed element, the historical source used, and a brief textual argumentation (Grellert, Wacker, Bruschke, Stille & Beck, 2023). In the courses, a built-in template with predefined building segmentation within IDOVIR is used to keep the documentation phase as coherent as possible and to establish a clear reading flow for the generated documentation file. Each object of the building structure – predefined in the IDOVIR template – should be reflected by appropriate visualizations generated from the 3D model, and visual sources depicting the object. These documentation bundles are enriched with a brief, descriptive argumentation explaining the modelling decisions and possible reconstruction variants, if necessary. The granularity of the documentation should be kept simple but at a sufficient complexity level to allow understanding of the reasoning behind the reconstruction process. The platform permits enriching all visual sources with the necessary metadata, such as classification (e.g. historical photography, design drawings, building survey, etc.), provenance and copyright.

The platform is quite intuitive and allows not only quick documentation, which can be done even using screenshots but also a quick ability to verify the reconstruction by visually juxtaposing the visualization of the reconstruction with the sources on which it is based. An additional advantage is the ability to export all documentation to a structured PDF file. The generated documentation file is one of the compulsory elements affecting the course completion and is attached to the project's final publication in the online 3D repository.

An additional requirement of the project documentation has become the evaluation of the obtained result, what was introduced to the course at the Hochschule Mainz through an exchange with the Department of Architecture at the University of Bologna. In this approach, the documentation of the results is captured synthetically by evaluating the level of the uncertainty of each semantic segment of the model. This method uses a predefined colour scale (Fig. 10a), developed by the research team of the University of Bologna, to categorize building elements according to different levels of uncertainty based on used types of sources (Apollonio, 2016). An extension of this method was the development of an algorithm that calculates the averaged value of uncertainty for the entire reconstruction based on building volume and assigned levels of uncertainty (Foschi, Fallavollita & Apollonio, 2024). This algorithm was implemented in the 3D mathematical modelling program Rhinoceros 8 using a built-in plug-in for parametric modelling based on the visual programming language Grasshopper. It is a completely different form of modelling that is rule-based, not object-based like BIM (Costantino, Grimaldi & Pepe, 2022). The authors of the algorithm used this workflow to also develop a plug-in for the open-source 3D modelling software Blender. Due to its free license, and the simple process of transferring the 3D model by exporting to OBJ format from AC, it was possible to use the algorithm in this case study as well, to obtaining a visualization in false colours according to the uncertainty scale (Fig. 10b).

In the case of the synagogue in Ashmyany, since all sources were more or less unambiguous – stemming from the same survey – the result was an almost monochromatic visualization. Only the Bima, particularly the construction on top of the rectangular base, as well as the top part of the Torah ark, were reconstructed without conclusive source material and must therefore be considered hypothetical variants of these elements. Visualization of uncertainty using false colours may be used to asses materials, constructive systems and/or positional uncertainty, however, in this case the analysis only considers the geometric form of the object.

[7] Whether or not the Jewish community in Ashmyany could at some point in history be considered as part of the Hasidic movement could not be established in this article.

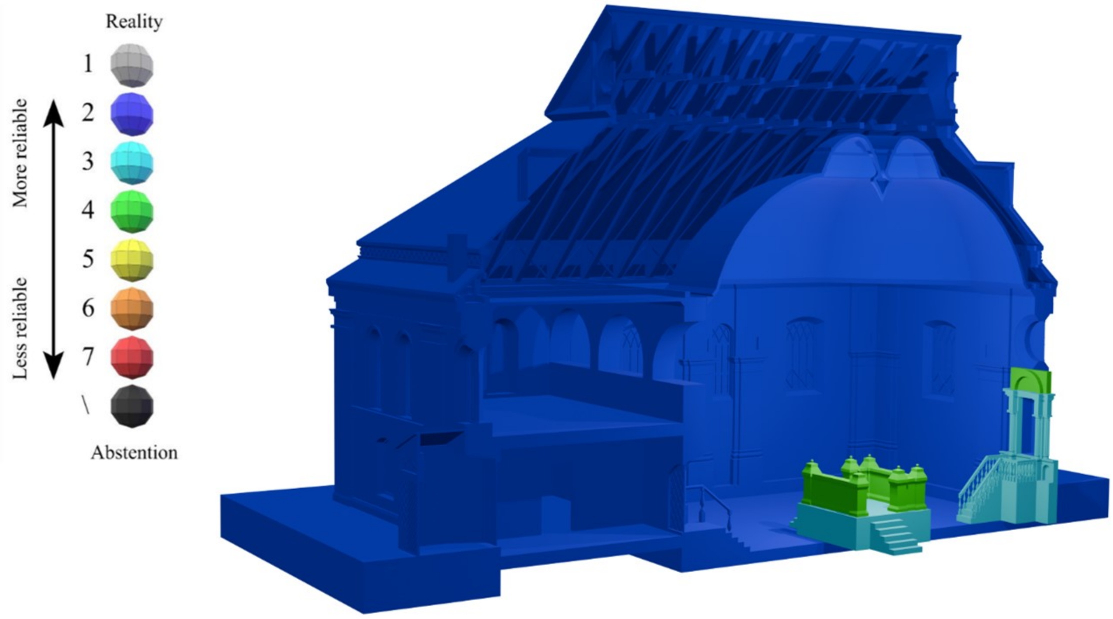
[8] Tracing the connections between derivatives and the main model is possible thanks to the documentation of the project in the online repository based on a virtual research environment, using semantic relationships. More details about this can be found in Section 3.2.

7(+1) steps scale

	UNCERTAINTY	DESCRIPTION
1	Lowest uncertainty (~0 to 14% uncertain[1])	The analyzed feature[2] of the 3D model is derived mainly from good quality reality-based data, which reaches the target LoD.
2	Low uncertainty (~14 to 28% uncertain)	Reliable conjecture based mainly on clear and accurate direct[3] / primary[4] sources, which reach the target LoD. When reality-based data is unavailable, or available but unusable, or which does not reach the target LoD.
3	Average-low uncertainty (~28 to 43% uncertain)	Conjecture based mainly on indirect / secondary sources, by the SAME AUTHOR/S, which reach the target LoD. Or logic deduction / selection of variants. When direct / primary sources are available, but minimally unclear / damaged / inconsistent / inaccurate / which do not reach the target LoD.
4	Average uncertainty (~43 to 57% uncertain)	Conjecture based mainly on indirect / secondary sources by DIFFERENT AUTHOR/S (or unknown authors), which reach the target LoD. When direct / primary sources are available, but minimally unclear / damaged / inconsistent / inaccurate / which do not reach the target LoD.
5	Average-high uncertainty (~57 to 71% uncertain)	Conjecture based mainly on indirect / secondary sources by the SAME AUTHOR/S, which reach the target LoD. When direct / primary sources are not available or unusable.
6	High uncertainty (~71 to 86% uncertain)	Conjecture based mainly on indirect / secondary sources by DIFFERENT AUTHOR/S (or unknown authors), which reach the target LoD. When direct / primary sources are not available or unusable.
7	Highest uncertainty (~86 to 100% uncertain)	Conjecture based mainly on personal knowledge due to missing or unreferenced sources.
\	Abstention	Not relevant / not considered / left unsolved / missing data and missing conjecture

[1] The % is calculated dividing 100 for the number of steps of the scale.
[2] The feature are: shape, constructive material or surface appearance.
[3] Direct sources: all the sources where the object is directly represented, reported, recorded with any level of accuracy and detail
[4] Primary sources: first hand sources of a specific object.

(a)



(b)

Figure 10: Level of uncertainty according to the color scale by the University of Bologna: a) Scale of uncertainty (Foschi, Fallavollita, & Apollonio, 2024); b) Visualization.

3. Dissemination of research

3.1. Repositories and infrastructures for 3D data

The critical point of the SRM concept is the open publication of the 3D data with its documentation, which allows for the creation of a reference to the reconstruction process for other researchers. This is not a scientific publication in the traditional sense, which relies on the written word, but the sharing of the 3D data with the necessary attachments. Although methods for reviewing published data in a scientific context have yet to be developed, guidelines on how to prepare data for publication have already been established. Currently, the most followed rules for data publication are the FAIR Principles, which describe the requirements for easy use and the integration with other data by the scientific community (Wilkinson et al., 2016). The accessibility of data is increasingly becoming a required practice for researchers, as it provides transparency and allows for the verification of raw material. While open data repositories for researchers have been emerging for years (Hansson & Dahlgren, 2022), most do not offer the ability to view 3D data directly in a browser. This is a crucial feature, as it enables initial verification of the 3D model without investigation of the data file itself, which can be challenging due to the wide variety of 3D file formats. The publication of 3D models has also become a hot topic in institutions responsible for data preservation, such as libraries and archives, where there is a lack of adequate infrastructure for the publication of such data sets (Koller, Firscher & Humphrey, 2010).

A growing number of researchers as well as cultural institutions are shifting their interest towards commercial repositories for web-visualization of 3D models, such as Sketchfab[9], which also offers free publishing services. The platform practically dominates the cultural heritage market, already reaching more than 100.000 3D models just in the cultural heritage category by 2019 (Bajena & Kuroczyński, 2023). As a result, the platform is now being used as one of the main methods of disseminating 3D models in one of the largest cultural repositories for all of Europe, the Europeana (Europeana Foundation, 2008; Fernie, 2024). However, Sketchfab is not a reliable platform due to its lack of policy towards data preservation. These concerns were confirmed after the commercial takeover by Epic Games, which announced the closure of the portal in 2025, and its replacement by marketplace Fab. It is unclear at this point what will happen to content that was uploaded under Creative Commons licenses and to non-downloadable content.

These concerning changes have imposed the emergence of further projects proposing alternative infrastructure solutions for the publication and preservation of 3D data. In recent years, Germany alone has seen the development of several infrastructure projects funded by the German Research Foundation (DFG). New infrastructures include projects such as the digital portal for historical building research, baureka.online (Naujokat, Glitsch, Martin & Schlimme, 2020), the Specialised Information Service BAUdigital (Arndt et al., 2022), and the free and open-source toolchain for viewing and annotating 3D models, Semantic Kompakkt (Rossenova et al., 2023), which is being developed as part of the Consortium for Research Data on Material and Immaterial Cultural Heritage, the NFDI4Culture. AI MAINZ has also become involved in the infrastructural project developments through participation in the project of 3D Infrastructure for Digital Reconstructions – DFG 3D-Viewer. This project will create a public web service for visualizing digital 3D objects from different remote repositories using international standards and enabling data aggregation for state libraries based on a standardized metadata documentation scheme (Bajena & Beck, 2024). The first phase of the project, completed in June 2023, saw the introduction of the developed solutions in a prototype open repository for 3D models of cultural heritage based on the Scientific Communication Infrastructure – WissKI. The repository provides the possibility to document both hypothetical 3D reconstructions and 3D models of digitized cultural heritage objects (Bajena & Kuroczyński, 2024). It uses the ability to create semantic links between the data based on the Linked Open Data technology (Berners-Lee & O'Hara, 2013). However, all semantic links have been predefined between the fields of the metadata form, making the documentation process much easier for the user and comparable to traditional methods of creating semantic data (Georgieva-Trifonova & Galabov, 2023). Due to its intuitive use, the 3D repository was tested in courses related to hypothetical digital 3D reconstruction to evaluate whether this type of tool would be effective in higher education (Bajena & Kuroczyński, 2024).

Students using the 3D repository were surveyed to assess indicators such as intuitiveness, functionality, guidelines, and difficulty of the form (Fig. 11).

They had to rate each category on a scale from 1 (very bad) to 5 (very good). The average scores for the intuitiveness and functionality categories gave an average result, giving room for improvement, but providing a stable basis for further use of the platform. The guidelines were well received and the difficulty of the form was considered the hardest task, suggesting a need to improve the system in terms of user experience for further use in education.

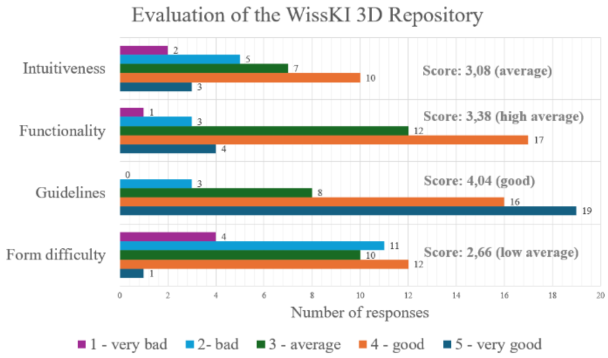


Figure 11: The evaluation of the WissKI 3D Repository by respondents, ratings were given on a scale from 1 to 5, with 1 being the most negative and 5 the most positive. (Bajena, Kuroczyński, 2024).

3.2. Publication process

The positive feedback from students led to the development of a new WissKI-based open platform (CoVHer, 2024). Several significant changes were made to the documentation scheme of the new repository to meet the requirements of hypothetical digital restoration projects while maintaining a simple and user-friendly interface. Five main documentation units were introduced: people, organizations, projects, cultural heritage objects, and digital reconstructions, which users can cross-reference semantically. The platform supports the publication of 3D models at different documentation complexity levels. The minimal requirement for the metadata verification denominator addresses the information about cultural heritage object name and type, reconstructed time phase of the 3D model, license type for the dataset, and authorship and rights holder to 3D Data.

The 3D Repository records can be enriched with metadata and files about characteristics of the hypothetical reconstruction, including analytical, interpretative and deductive processes carried out (paradata). Following the guidelines of the London Charter (2009) for documentation of computer-based visualization of cultural heritage, the 3D repository allows the documentation of analysed source materials, hand sketches, and other multimedia data that helps viewers to better understand the reconstruction process (Fig. 12). Users can also document the model's development history by recording the different versions and variants of the reconstruction.

Other researchers can verify published data by including decision documentation from the IDOVIR system or by downloading and manually checking the native reconstruction files. Another advantage of the CoVHer Repository is its visual access to the 3D model via the integrated 3D Viewer, which allows for a detailed examination of the geometry and texture data. This

[9] https://sketchfab.com/, last accessed 03 October 2024.

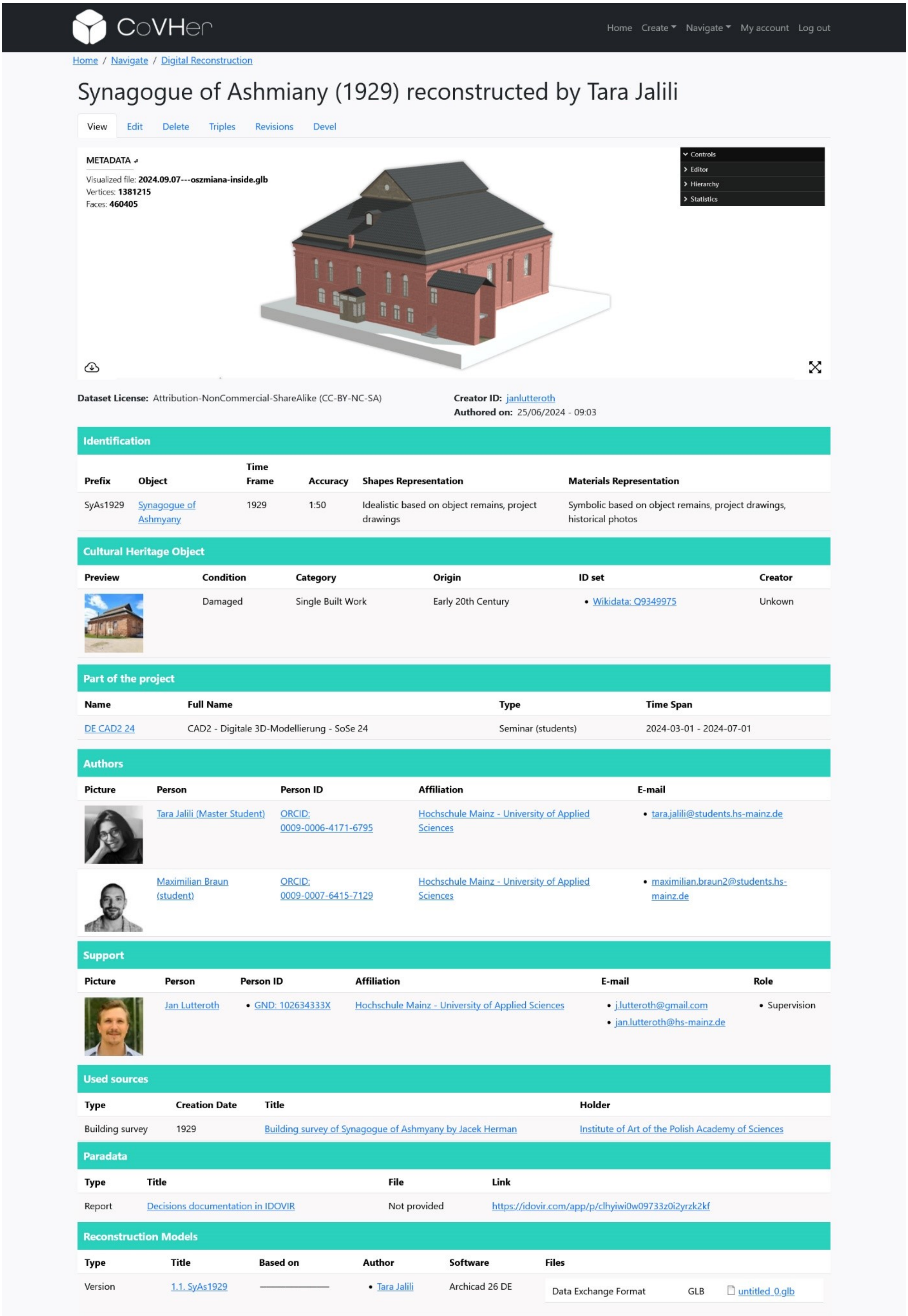


Figure 12: Record of the digital reconstruction of the synagogue of Ashmyany in the CoVHer Repository (CoVHer, 2024).

provides an initial impression of the model's reusability (Fig. 12). The platform's guidelines also include core export rules from various 3D modelling software. Ideally, the SRM should be provided in its native format and data exchange formats such as IFC or CityGML, with an appropriately defined Creative Commons license.

3.3. Derivatives

The concept of the SRM does not include a final step. Its aim is to describe the knowledge behind the 3D model and to share the 3D data set for further investigations. As most experts in the scientific 3D community know all too well, most digital 3D reconstructions are never truly final. There will always be a need for alterations, variants, and new versions of new software with more powerful rendering engines, etc. Often, more elaborate versions of certain models are simply not realized due to time constraints. The concept of an SRM takes this into consideration and allows the community to further develop the process through access to the 3D data and transparent documentation, without the loss of previous work.

Figure 13: Augmented reality Postcard of the synagogue in Ashmyany around 1929.

For example, one potential finalising step could be the production of a dissemination asset. The augmented reality postcard developed at AI MAINZ conveys basic information about the heritage object in a short paragraph and delivers a reduced version of the SRM in the form of a reduced and textured 3D model, visible by scanning a tracker on the postcard via a mobile device (Fig. 13). In a way, this form of dissemination reverses the digital process by reapplying it to the analogue world. Other derivatives of the SRM could include a 3D-printable version of the 3D model. What is important is that these derivatives maintain a semantic connection with the SRM within the CoVHer repository and are accessible for reuse by the community.

4. Discussion

The synagogue in Ashmyany around 1929 is just one of several examples used as case studies at AI MAINZ to test the concept of the SRM with architecture students focusing on Jewish architectural heritage in East Central Europe. A holistic survey of East Central Europe's Jewish architectural heritage poses a significant challenge. Since the Jewish population and culture constituted a pivotal element in this region from the early modern period at least until WWII, a simple categorization of objects according to modern state borders, as practised in heritage preservation, is helpful for an initial overview. However, it contradicts the actual conditions under which these buildings were originally constructed, considering the significant shifts in borders across East Central Europe during the early modern period and again after WWII.

For instance, the remarkable research conducted by Maria and Kazimierz Piechotka (2017), which serves as the primary source for the course workflow, focused on the historical boundaries of the former Polish-Lithuanian Commonwealth, encompassing parts of present-day Ukraine and Belarus. However, this classification did not include the former German provinces of the Second Imperial Realm despite the cultural exchange between Jewish communities in these regions and the core areas of Poland. Including these territories raises the count of existing and lost synagogues to over 1800 objects, with additional buildings of central importance to former Jewish communities – such as ritual baths (Mikva'ot), mortuary halls, ritual slaughterhouses, and bathhouses – yet to be considered. Consequently, a holistic survey of the entire Jewish architectural heritage becomes even more complex. Such an endeavour requires time and experts who may not possess skills in working with digital 3D models. The provided workflow within the course, however, aims to offer easy access to the core data for further research into this topic and to draw attention to these endangered buildings, emphasizing the remarkable richness of Jewish architectural heritage across these regions.

5. Conclusion and further steps

The Ashmyany synagogue serves merely as one example among many, showcasing the advantages offered by 3D models in preserving neglected Jewish architectural heritage. It became evident that the thorough exploration of the building in the virtual realm primarily leads to further inquiries regarding the synagogue's history and solidifies the current state of knowledge on the subject. The SRM methodology recognizes the value of this work, even in student deliberations, and offers the opportunity to not only document the invested reconstruction efforts but also to disseminate the data in a way that is based on scientific rules.

Consistent with these results, the continued teaching of these practices can contribute to the preservation of knowledge from the study of lost cultural heritage. The very method of effective publication of these datasets is still unstandardized. However, attempts are being made to find divisible methods of documentation, as exemplified by the activities of German infrastructure projects, whose combined efforts have contributed to the first approaches in mapping documentation schemes and developing a minimum standard of metadata. Within the framework of the DFG 3D-Viewer project, two workshops on metadata for the documentation of digital 3D models of cultural heritage have already been held in Mainz (December 2022) and Munich (April 2023) (Bajena & Kuroczyński, 2023). The obtained results serve as the basis for further development in the second phase of the DFG 3D-Viewer project aimed at creating a network of institutions that undertake the preservation of 3D data in accordance with the proposed standard. All these activities influence the further development of the CoVHer Repository, for storing and sharing the results of hypothetical 3D reconstruction projects, creating serious 3D in research, education and dissemination of cultural heritage.

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