

3D Models of Historical Buildings created from Archival Drawings

A Best Practice Guide

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I. Executive Summary

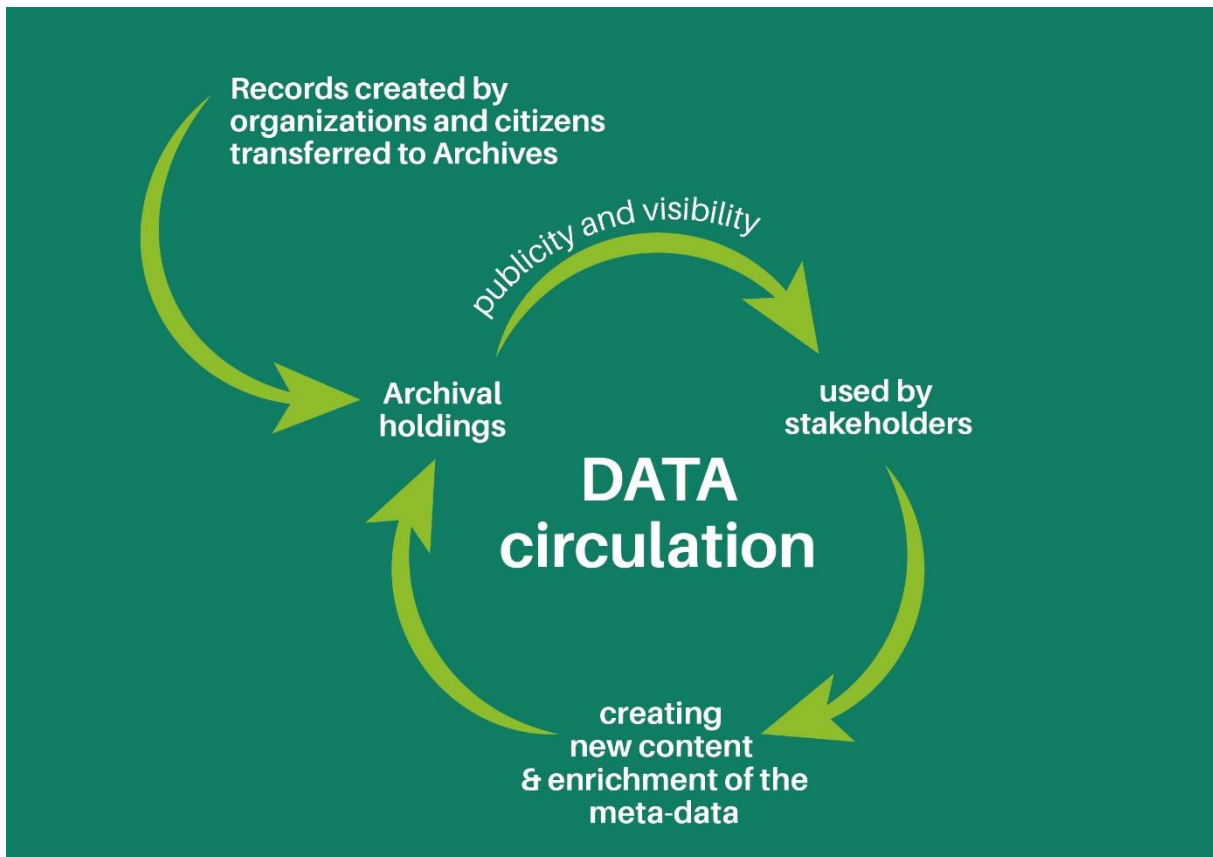
The main objectives of the *City memories: visualizing change in three European capitals* project are to develop new ways of serving demands and usages for historical building drawings preserved in archival collections, in order to make them more available, well interpretable and enjoyable for different kind of users. By developing innovative methods for interpretation, communication and presentation of building drawings, the City Archives of Stockholm, Copenhagen and Budapest contribute to the CULTURE strand Objective 2- Innovation: to enhance the capacity of European cultural and creative sectors. In the project, innovation is understood in a broad way and includes the development and experimentation of new practices and/or new models, also transfer and dissemination of good practices. In the project archive professionals and researchers to learn from each other, but also from their audiences and stakeholders. City Archives of Stockholm, Copenhagen and Budapest work with different target groups using different methodologies, but with an overall outside-in perspective on the collections and a focus on how to serve the needs of users.

Budapest City Archives (BCA) built on the already well established cooperations in pilot projects with Óbuda University, Ybl Miklós Faculty of Architecture and Civil Engineering (YBL) in the framework of which digitized plans are used in the training of 3D Digital Modelling of Historic Buildings and also with Hungarian Contemporary Architecture Centre (KÉK) which is the main organizer of Budapest 100, a yearly recurring urban community festival of built heritage, an integral part of which is archival research (a special form of citizen science) and usage and presentation of the drawings in on-site public events.

City Memories gave the opportunity and incentive to think over the methodology of cooperations with these two highly different types of user groups in a systematic way, analyse and summarize the tracks of user scenarios and the potentials embedded in the outcome products. Owing to this analysis it became apparent that both projects are occurrences of the same phenomenon from Archives' point of view, which phenomenon can be labelled as "Data Circulation".

Thanks to digitization archives provide massive amounts of data and documents to different user groups. Some of these usage projects result in new databases, publications, digital reconstructions, newly created digital content and various types of metadata. These results and products can be reused or repurposed, that's why it is a recently occurrent task to build up

tracks for acquiring them into the archival holdings and making them accessible and reusable for other stakeholders. This sort of Data Circulation is a new way of enriching and exploiting archival material specific to the digital age.



Model of Data Circulation at Budapest City Archives

In this Best Practice Guide we handle the cooperation between BCA and YBL as a case study of Data Circulation. YBL curate courses on digital historical building reconstructions, based on archival drawings. Student-modellers use exclusively drawings as sources (regardless of the existing building) and they create their models by CAD software. The main goal of cooperation between BCA and Ybl is the development of student-architects' competences and serving through this the protection, conservation and interpretation of built heritage. The products are 3D born-digital reconstruction objects, which are associated indirectly with the buildings as physical objects but not "digital copies" neither of the original drawings nor of the existing buildings. From archival point of view these are born-digital records which may

be positions in archival order as separate archival units and they are in connection with original drawing as related units of description (ISAD(G) 3.5.3).¹

This being a new and experimental way of usage of archival drawings, lots of questions rose, and in the following we handle the ones we regarded most important for transferring the findings for future cooperations.

- To make this kind of cooperation mutually fruitful for archives and users it's of paramount importance to understand in detail the needs, questions and working methods of the specific user group and the hurdles which make them use and interpretation of archival material difficult. That's why we describe the cooperation process and work of YBL with the drawings in detail.
- The working methods of the specific user groups have great impact on the features of new digital contents created by these projects which are purposed to archival acquisition and reuse.
- The content and structure of the new digital content requires special examination. It can't be merely regarded as new representation of the original drawings and quite different from outcomes of standard record creation processes. Decisions on their position in archival order, preservation formats and metadata need to be made based on this special analysis, but much can be learned from solutions in akin projects. That's why we describe in detail the decisions made by BCA on archiving 3D models created at YBL. The main goal is to preserve models guaranteeing authenticity, interpretability, accessibility and reusability. Imagery and publication can be approached as by-products.

II. Archival drawings, 3D modelling and data circulation

II.1. Basic concepts and tools of cultural heritage in 3D

3D models which are “set of digital data that are linked to a single object of study and that are obtained after 3D acquisition or modelling”² can represent a great variety of objects. These models are synthetic digital documents having their own life-cycle evolving through several versions until a final version delivered for a specific purpose. Their distinguishing characteristic

¹ ISAD(G) International Standard of Archival Description <https://www.ica.org/resource/isadg-general-international-standard-archival-description-second-edition/>

² 3D Lexicon for Human and Social Sciences, p. 10.

is that they represent their object of study in three dimensions (x,y,z). 3D data can be described as the stored geometrical equations that are read by the software of a viewing platform to visualize the 3D model. 3D models are composed of vertices (x,y,z locations), edges (line connections between the vertices) and faces (a flat surface inside at least three edges).³ 3D models can provide dematerialised access to cultural heritage objects for variety of purposes: serving as analytic tool, synthesis of knowledge, bases of 3D Scholarly Editions,⁴ visual accessibility for a wide public and storytelling.

Digital 3D reconstruction of historical architecture has been a well-established and more and more widespread branch of 3D for humanities during the last decades methodological results and problems of which has already been synthetised in a Handbook.⁵ We can differentiate between reality-based modelling basic datasets of which are acquired via 3D digitization of tangible heritage objects and digital reconstruction or virtual-based modelling which requires human interpretation of data to create a hypothesis of a past object. “The model is then mostly created on the computer using manually controlled graphic modelling software originating from construction and engineering in the case of computer-aided design (CAD), or from design and creative industries in computer-generated imaging and graphics software (CGI).”⁶

- **3D models** are synthetic digital documents having their own life cycle evolving through several versions until a final version delivered for a specific purpose.
- A 3D digital model as a synthetic document can be composed of different **3D objects**. In the case of a 3D model of building models any parts of the model representing a real part of the building by geometric objects with meaningful attributes can be regarded as 3D objects.
- **3D data** can be described as the stored geometrical equations that are read by the software of a viewing platform to visualize the 3D model and may include beyond geometrical equations other information to translate the model, such as properties relating to material textures and their opacity, reflectiveness, shadow occlusion, or animation properties.

³ PURE3D Technical report, p. 6.

⁴ PURE3D Technical Report, p. 5.

⁵ Handbook of Digital 3D Reconstruction of Historical Architecture

⁶ Handbook of Digital 3D Reconstruction of Historical Architecture, p. 26.

To preserve and provide 3D models for further use means the preservation of the 3D datasets meeting FAIR data principles and requires different tools than visualizing and publishing models and enabling user interaction.

II.2. Problems of preserving and publishing 3D data in Archives

Solutions for archiving 3D content in humanities and social sciences are surveyed by PURE3D Technical Report (2021). This report examines Institutional Repository Systems, Digital Asset Management Systems and Repositories for Digital Humanities as possible solutions. The main stakeholders whose requirements are taken into consideration are the University/Higher Education sector and Research Labs. The focus of PURE3D project has been developing 3D Web Infrastructure for 3D Scholarly Editions to make accessible research-based academic 3D assets. In the framework of abovementioned Data Circulation concept, the task is not creating 3DSE, but acquisition, arrangement, description and long-term preservation of 3D models as archival records in ISAD(G)-based archival arrangement and description environment and ingestion of them into digital archival repository. PURE3D report doesn't deal with the specific needs of archives as organizations responsible for preserving records with permanent value. This being so, PURE3D report and other existing standards and protocols offered only poor guidance on archiving the 3D models in BCA's system, so roadmaps and methods had to be configured in *City Memories* project. The main goal is to preserve models guaranteeing authenticity, interpretability, accessibility and reusability. Imagery and publication can be approached as by-products.

The complete content of the models is delivered to BCA in .pla file format, which is the proprietary archive format of Archicad, so to open and reuse it requires special tools. Apart from this speciality it is accessible according to the general archival rules, but delivering to third parties and reuse for any purposes are restricted by copyright. The publication format is .obj which can be opened in 3D viewers and published on different web platforms.

II.3. BIM CAD software as tool of historical reconstruction

CAD software is a key tool in digital building modelling and reconstruction. Through their precise documentation, analysis, design and visualisation capabilities, these software tools can make a significant contribution to the preservation of historic buildings and the design and construction of their eventual reconstruction or rehabilitation. By supporting multi-disciplinary

collaboration and data sharing, CAD software is an effective tool for the successful delivery of complex projects.

For these reasons, the teaching of CAD software is also part of the architectural engineering training programme. Historical buildings provide a very good (out of the comfort zone) training ground for the acquisition of modelling skills. The aim of the course "Digital Modelling of Historical Buildings" is twofold: to provide students with knowledge of architectural history and 3D modelling by modelling from archival material. Architectural drawings (original plans in the case of historic buildings) are the most important source of authentic building reconstructions.

To the best of our knowledge, the creation of this elective course is unique in Hungarian universities, and according to our research, in international universities, 3D reconstruction of buildings is only found as an aspect of heritage conservation courses. The models produced therefore always represent the state of the plans and not the reality, since the modelling is based on the plans.

Students use Archicad software for modelling. This software was chosen firstly because Archicad is the most commonly used design software on the Hungarian market and it is a compulsory subject in the 4th semester of the BSc in Architecture, so students arrive to the course Digital Modelling of Historical Buildings with Archicad knowledge. Other benefits of Archicad include full BIM support⁷, an easy-to-learn, user-friendly interface, real-time collaboration capabilities (e.g. teamwork with other colleagues), a large number of pre-stored model elements and their customisability; excellent visualisation capabilities and automated documentation. A .pla file contains all the model elements (not just references to them) so that they can be opened on any computer). For visualizing and publishing purposes .obj format have been chosen among many possible outputs of Archicad, because it seems to be most appropriate for GIS web applications including Budapest Time Machine.

⁷ Building Information Modelling (BIM) https://en.wikipedia.org/wiki/Building_information_modeling

III. Cooperation of BCA and YBL in teaching Digital Modelling of Historical Buildings

III.1. Concept of the teaching course and its function in the development of architecture students' competencies

The aim of creating the Digital Modelling of Historic Buildings course was therefore to enable BCA and YBL to develop a collaboration and a methodology for the digital reconstruction of historic buildings based on archival material.

According to the official description of the subject, its mission and teaching objective are:

“In this course, students will create digital models of historic buildings and architectural details. Throughout the semester, using archival planning documents and architectural “pattern books”, models of buildings and building construction details will be prepared in varying levels of detail to support pre-defined objectives: visualisation and preservation, analysis, decision preparation and decision support.

The aim of the course is to introduce students to methods that help document our built environment.”

Virtual modelling has many applications in the fields of architecture, engineering and construction. One such purpose is value preservation, which is particularly important for the protection of historic buildings and cultural heritage. As a result of the modelling work, a kind of “digital twin” of historic buildings can be created, detailing the geometric and optionally e.g. construction material properties of the building. The digital models of buildings can also include historical and current condition data to help with accurate documentation and tracking of changes. Models are created by “direct manual modelling” using Archicad's built-in modelling tools (walls, slabs, roofs, windows, etc.).⁸

In the context of this project, the aim was visualisation within the framework of conservation, showing the planned historic buildings based on archival material.

Based on several semesters of the Digital Modelling of Historic Buildings course, the following can be said about the development of students' competences:

- The students already have a partial theoretical knowledge of architectural history when they enrol for the course, but this is transformed into quasi-applied knowledge during

⁸ This modelling method is a subtype of classical 3D modelling. For more information, see Handbook of Digital 3D Reconstruction of Historical Architecture, p. 115-119.

the modelling. In the process of creating building decoration, students will discover the interrelationships between the different systems of decoration and their components. For example, how is the decoration scheme of the main façade of a historic house constructed? How do decoration systems change in different periods? What are the structural elements of the facades? What are the basic elements of each building decoration?

- In addition to learning about the formal characteristics of building decoration, students will develop their knowledge of building types and their construction: they will gain a better understanding of the function of buildings at ground and first floor level; the circulation system of buildings (main and secondary staircases, corridors); and although they will not model the interiors of buildings, only the external envelope, they will learn about the functional system of dwellings and its transformation over time.
- In terms of the continuity of architectural history, where archival documentation includes plans for the conversion of a building, part of the history of the building is known by the students. For example, how the café on the ground floor was transformed first into two small shops and later into a bookshop.
- In addition to the architectural history aspect, students will also gain 3D computer modelling skills, which they can use not only to create models of historic buildings, but also in their studies and work later on.

III.2. Detailed description of the method

The cooperation between BCA and YBL and its details in chronological order for each educational semester are as follows:

- 1) Before the start of each academic semester, YBL and BCA staff jointly agree on the theme for the next semester.

The choice of topic - and therefore the modelling - is typically based around a well-defined territorial unit. In recent semesters, these have been the following locations in Budapest: Grand Boulevard, Inner-Erzsébetváros, Outer-Erzsébetváros, Kálvin square and its surroundings. Once the area has been selected, BCA staff will check which buildings in the area are available in plan view and will pass them on to YBL. The material can be available in two forms: either already available on one of BCA's

online platforms, or BCA staff can search the plans of the building in the archives, digitise them and provide them to YBL as digitised images.

For the preparation of the models, the following minimum building plans are required: ground floor plan, at least one floor plan, at least one section, street facade. If any of these plans is missing, the building cannot be reconstructed. After handover, the YBL tutors will check in advance that the materials handed over are complete and actually suitable for modelling.

By the time the students start their semester work, the materials received are already organised and distributed to the students. (In some cases, several students work in the same building in preparation for possible student failures.)

- 2) Students receive a set of plans prepared by the BCA and their tutors and first familiarise themselves with the building: they study the plans, look at the building on various digital platforms (e.g. Google Maps, Apple Maps, archive photo library) and in most cases go to the site and take photographs of the building. Together with their instructors, they discuss the characteristics of the building, the differences between the design and the actual state (reminder: students always model the planned status, as the design materials are there to help them). (Sometimes there are several different design conditions in the documentation of a building.)

In addition to the data package, students will also receive a template file to create a model. This Archicad template file contains, among other things, a digital base map of the area of the semester (plot boundaries and building contours); it also contains pre-defined virtual building materials and surfaces to be used, as well as the structure used for the logical separation of building elements (e.g. walls, slabs, building ornaments). These pre-defined element properties contain fewer choices than the original set offered by the software and are tailored to the target task (e.g. the software offers the possibility to manage a large number of virtual building materials and surfaces, but since the aim of this project is not to analyse models based on material composition/appearance, the template file contains a reduced list.)



Example of the base map (Budapest, District VII.)

- 3) After learning the plans and the template file, students start modelling. Archicad software is used for modelling.

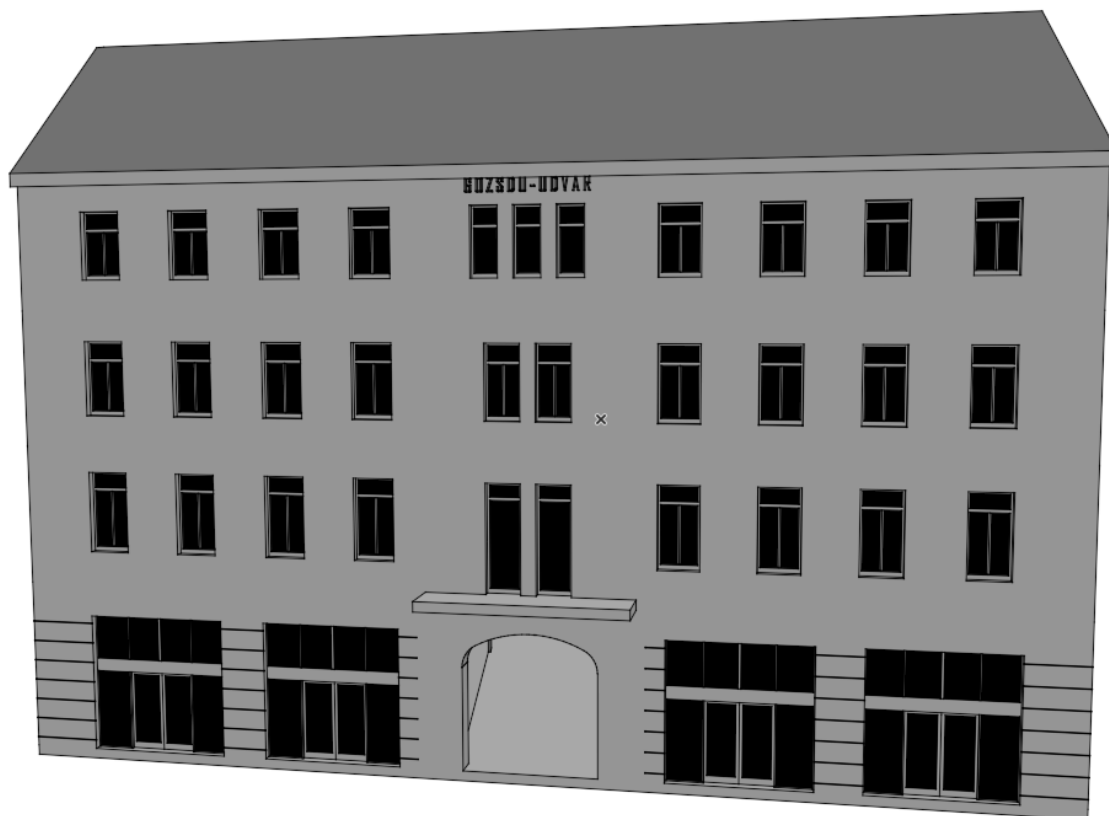
The base map mentioned in the previous section allows the building models to be geolocated, i.e. to include information on their geographical coordinates.

- 4) In a first step, students will build a low-detail (LoD2.5)⁹ model. This model includes the building's envelope structures: walls, slabs, roofs; and windows and doors. At this stage, the model does not include building ornaments. The purpose of this model is to allow the geometries to be checked before the students start to create the final, decorated model.

At this stage, in our experience, it is easier to detect possible mis-modellings and to correct them than if the model already includes the building decorations. Examples of mis-modelling include: students misinterpreting or ignoring the dimensions on the plans; misinterpreting the relationship between the openings and the surrounding ornamentation, so that they model openings of the wrong proportion; forgetting to include the interior courtyards; modelling the wrong roof pitch.

⁹ LoD levels in detail: see Handbook of Digital 3D Reconstruction of Historical Architecture, p. 123-124. The name LoD2.5 indicates that the model already includes the openings (doors and windows).

The LoD2.5 model is typically not a problem for students, and based on their previous studies they can easily do it.

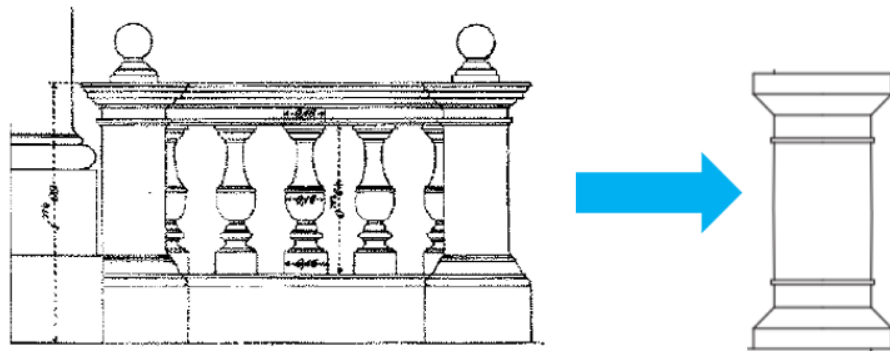


Example of the low-detail (LoD2⁺) model

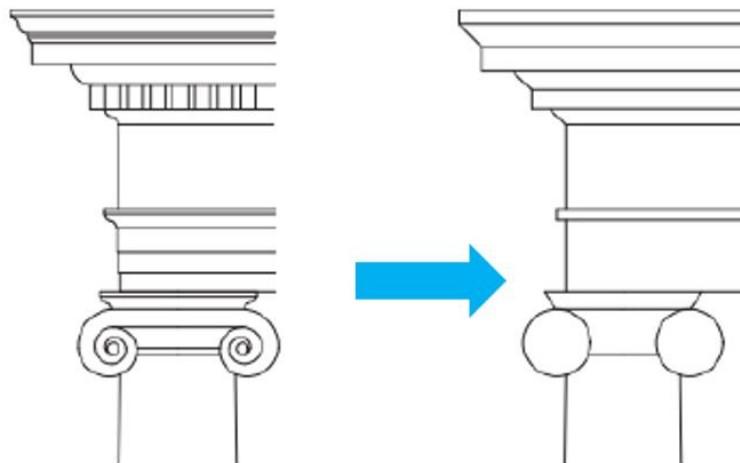
- 5) In the next step, the students will make the building decorations and place them on the building. This will create the LoD3-level model.¹⁰

This step is where most student consultations take place. Simplifying and modelling building ornamentation is the biggest challenge for students. Basically, we simplify building decoration according to the so-called "main-line representation". There are two reasons for this simplification: firstly, it reduces the number of polygons in the final model; secondly, the elements that can be modelled in the design software are limited, for example, single or even double curved surfaces can be complex to model.

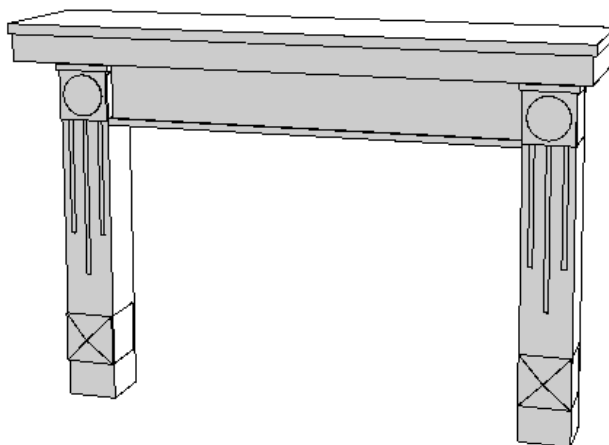
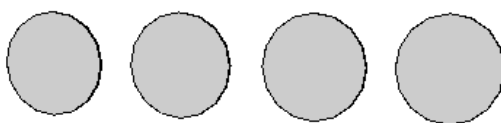
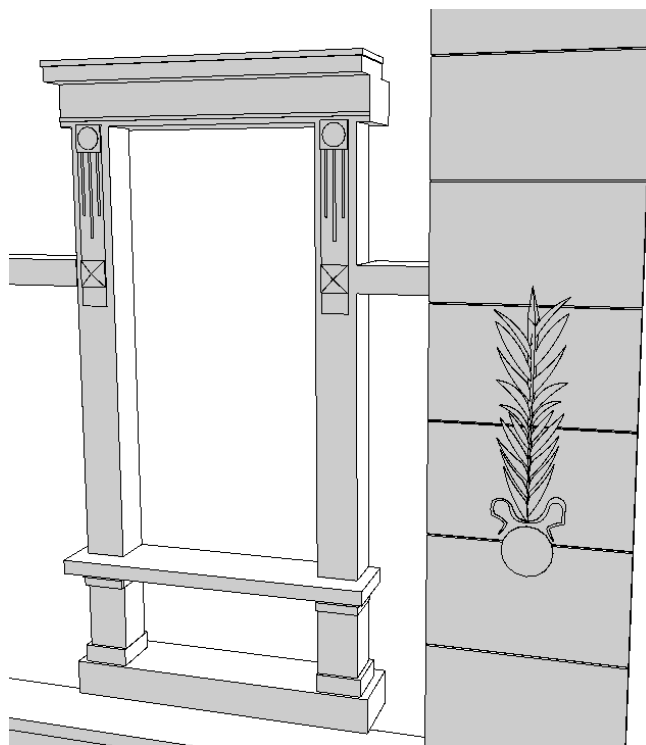
¹⁰ LoD levels in detail: see Handbook of Digital 3D Reconstruction of Historical Architecture, p. 123-124.



Example of „main-line representation”



Example of „main-line representation”

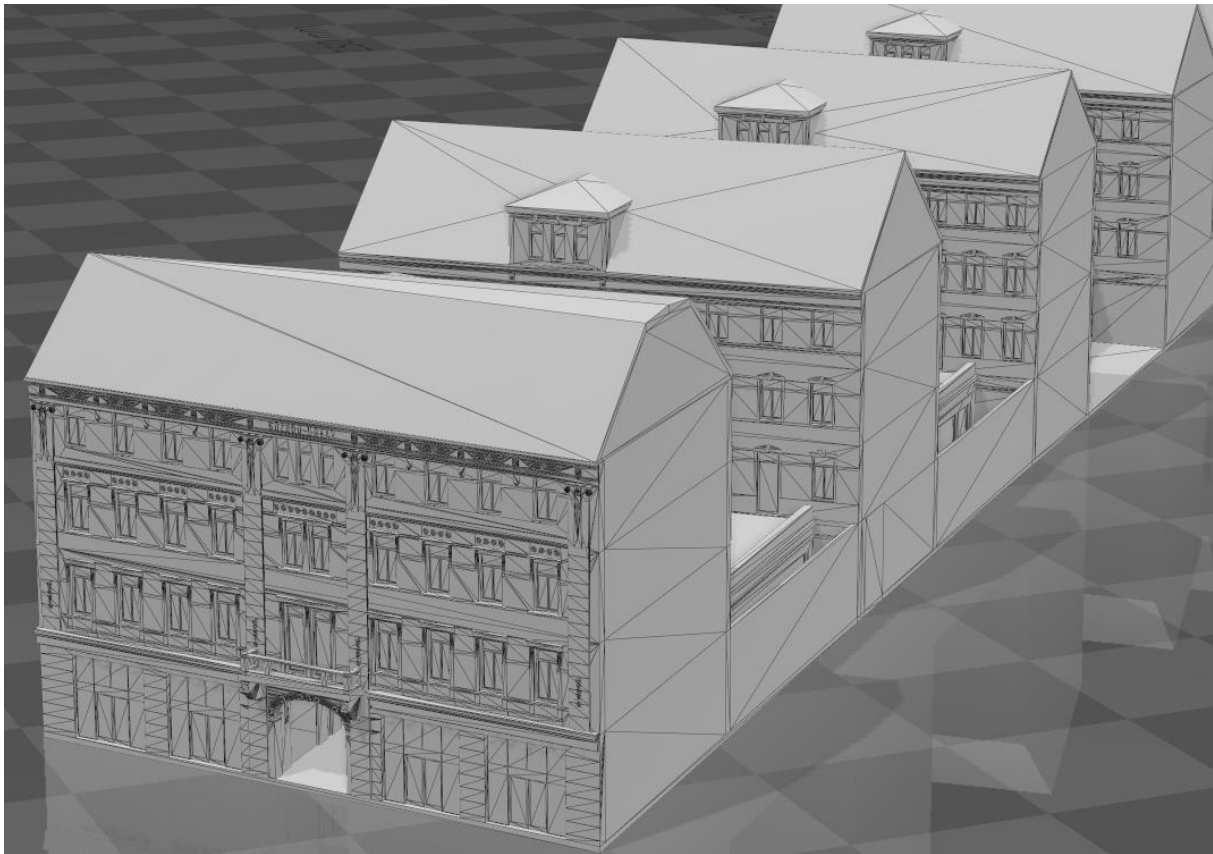


Example of completed building decorations



Example of the finished model (LoD3)

- 6) In the last step (after the instructor's approval), students prepare the models for archiving. They save them in Archicad's own archive format (.pla - which contains all the model elements (not just references to them) so that they can be opened later on any computer) and export the models in a format suitable for import into the Budapest Time Machine (.obj).



Example of .obj exported model

III.3 Limitations of the methodology and possible improvements

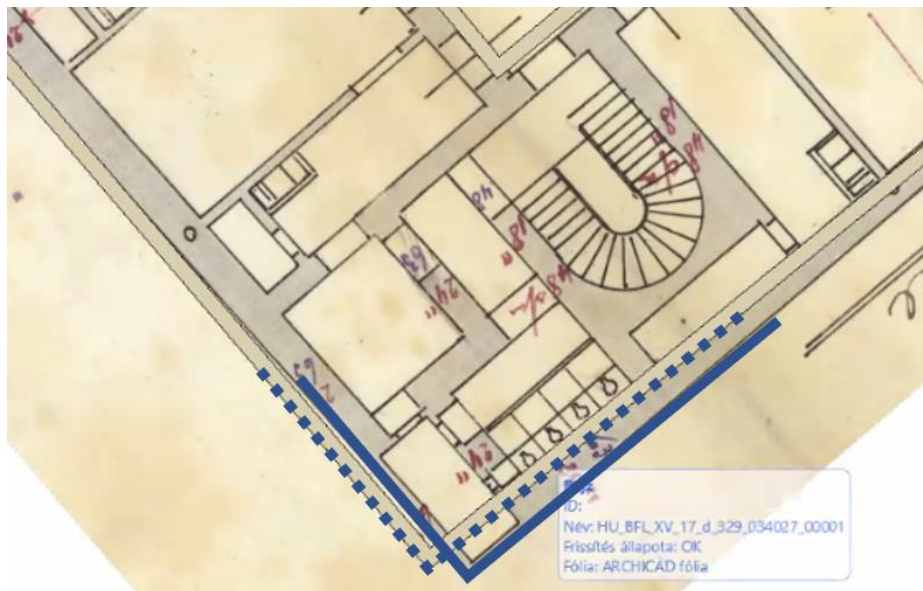
The limitations and problems that have emerged during the preparation of the methodology and pilot models, which require further research and development, are the following:

- The courtyards of the buildings were modelled only schematically (without ornamentation), the reason being that most archival plans do not include any guidelines for courtyard decoration.
- The details of openings (e.g. windows, doors, gates) is usually not shown on the plans, so they are either schematically modelled or as they are in the today's status.
- Given that in most cases the plans do not provide information on the use of facade materials, the models were prepared without surfaces (textures).

Problems:

- It has been mentioned earlier that the buildings are modelled into a base map due to geolocation. The geometry of the buildings has also been adopted to the base map in order to achieve the future goal of having multiple building models side by side to create a gap-free and not-overlapping street scene (i.e. no gaps between buildings and no overlapping buildings).

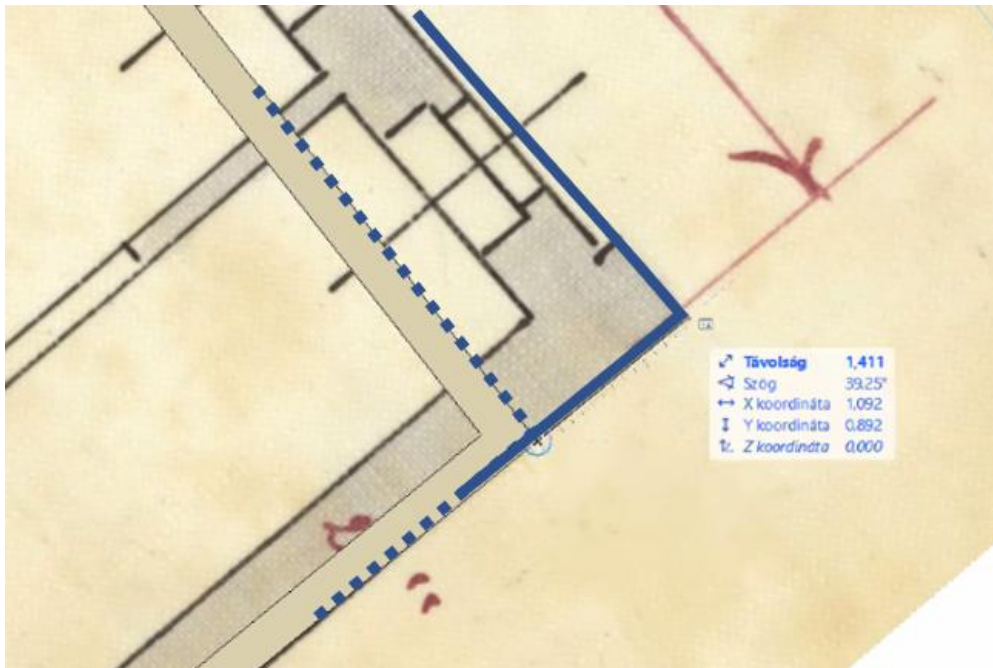
During the fitting process, the fitting inaccuracy between the archival floor plan/site plan and the present-day site plan was typically ≤ 50 cm, which can be eliminated by minor distortions (e.g. reducing the length of the building by 25-25 cm on both sides) for buildings of this size.



Example of a general fit (error ≤ 50 cm)

The figure shows the building contour according to the plan with a solid line, the building contour according to the cadastral map with a dashed line

In some glaring cases, the misalignment was greater than 50 cm. In these cases, the modeller was challenged to either (a) use the design geometry or (b) use the existing cadastral map as a reference. In these cases, a consultant's decision was usually taken to adjust the building to the cadastral map, still aiming for a gap- and overlap-free fitting.

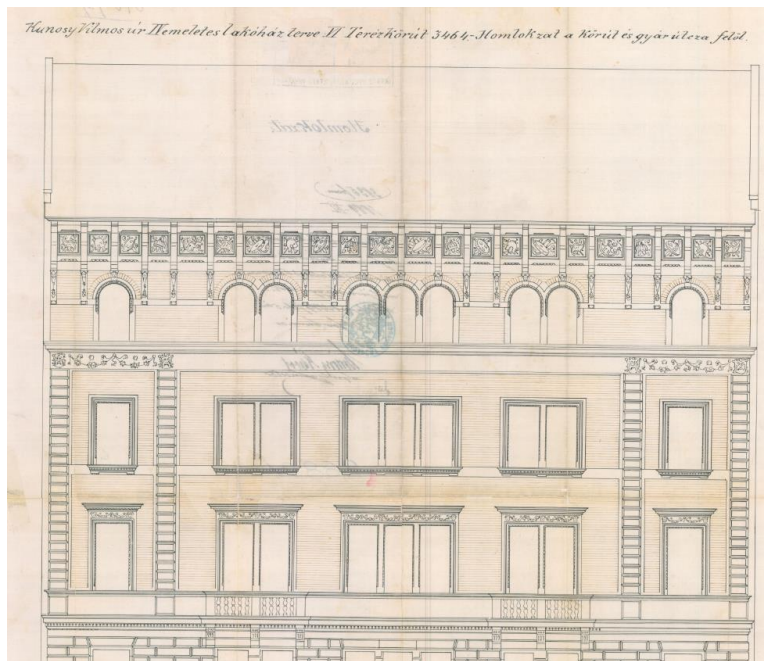


Example of "non-general" fit (error > 50 cm, ~ 1.5 m)

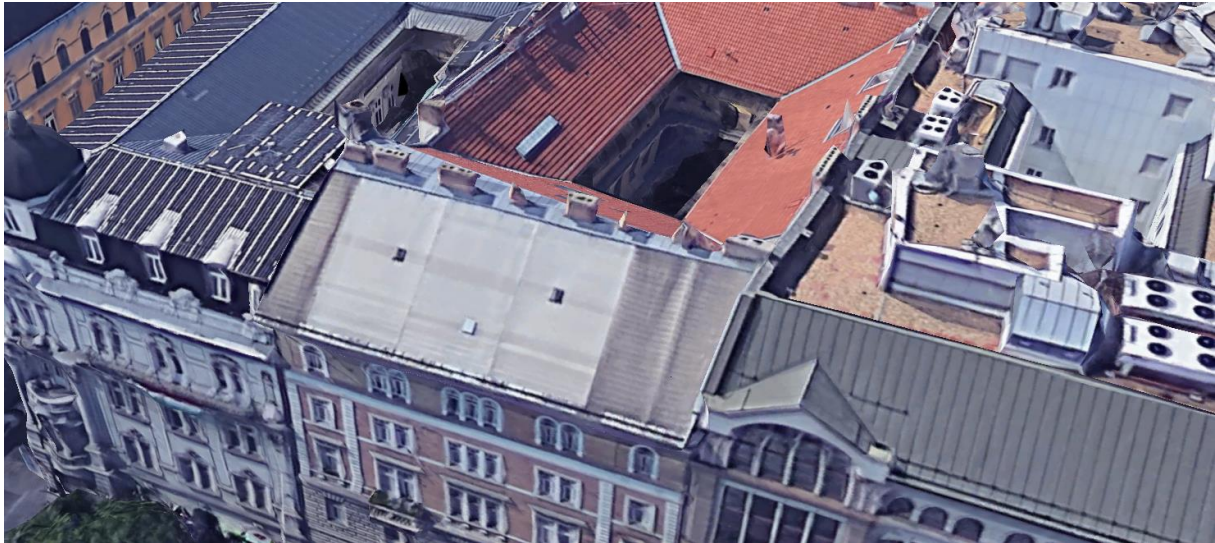
The figure shows the building contour according to the plan with a solid line, the building contour according to the cadastral map with a dashed line

The reasons for the high degree of inaccuracy of the alignment are assumed to be: the archival cadastral map / site plan was not accurate enough; the construction was not exactly on the site boundary and the subsequent alignment of the site boundary was already aligned with these building contours.

- In the course of modelling and following the plans, many students have encountered that our architect predecessors have in many cases treated the plans "generously" (certain delicate details were not shown). This was most often manifested in the following two cases:
 - Roof shape: the architectural plans showed a perfect roof shape without defects, but it was not possible to construct it from the ground plan geometry (truncation, plane breaking had to be done on the roof);
 - in the case of buildings facing two streets, the plans mostly ignored the different height of the two streets.



Example of a roof truncated by a near-horizontal plane that does not appear on the façade



The as-built condition is also truncated (source: Google Earth)

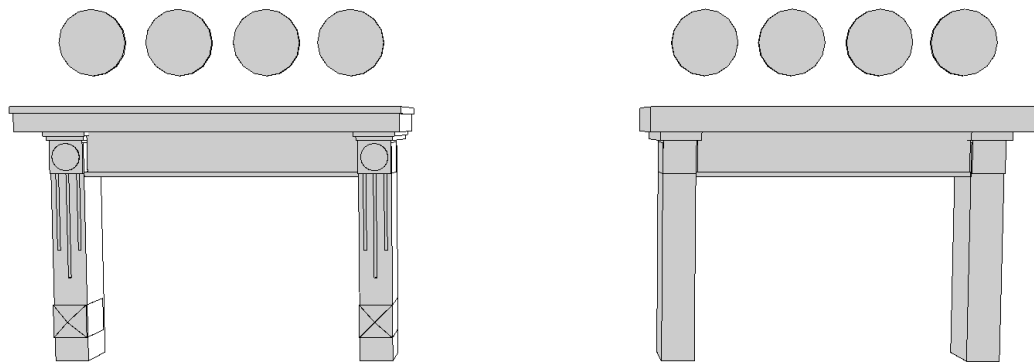
- One of the main difficulties in developing a modelling methodology is the issue of detail. A building model will undoubtedly be more beautiful the more building detail it contains. However, a large number of building decorations and their high level of detail will result in a large number of polygons, and thus the size of the exported file formats (.pla and .obj) will be large. For the Archicad format (.pla) this is less of a problem, but for the .obj format for web publishing we have encountered that web browsers cannot display certain models, or only with great difficulty.

The modelling methodology in this area certainly needs further research and development. Our goal is to develop a modelling methodology that does not compromise the previously stated student competence development goals but makes the models suitable for web visualisation.

Regarding the level of detail, it is important to note that once a building decoration or the model itself has been created (and the file size is too large), automatic geometry reduction in Archicad is no longer possible: model elements cannot be linearly reduced. In this case, re-modelling is necessary with simplified geometry.

The task of the students (as also mentioned earlier) was to simplify the main lines of the building ornamentation in the modelling. However, this method does not have a fully defined set of rules. The students and their tutors tried to ensure that the building

ornaments did not lose their character during the simplification. However, this is a rather subjective formulation. When does a building decoration lose its character?



Example of simplifying building decorations. Has the one on the right lost its character?

- Digital Modelling of Historic Buildings is an elective course, which students take in addition to their compulsory courses in the given semester. Since there is no sanction for "not taking" elective courses at the University of Óbuda, we often face the situation that students do not finish their models because other subjects take up their time. In personal conversations, they say that they found the subject interesting, useful and not demanding, but they unfortunately still did not have the time to do it. Owing to these circumstances paradata are usually not documented during the modelling process and not provided with the transfer of the finished models to BCA. One solution to this problem could be, for example, to split the subject into blocks, or to advertise an intensive "modelling week". This would allow students to complete the models in one week of an intensive course (either during the exam period or in the first week of the semester), so that they would not have to do this during the semester.

IV. Archiving the 3D digital reconstruction objects

The task of arrangement, description and long-term preservation of 3D models as archival records requires definition of their position in archival order and describe them according to the principle of provenance and the rules of multilevel description. Digital 3D building reconstructions are based on original drawings, but they are not copies of them but special representations which are connected to them as related units of description as defined by ISAD(G) 3.5.3.

IV.1 Preservation format

Decision on preservation format is highly dependent on the preservation strategy of the respective Archives or – where national preservation strategy exists – of the country. All the known strategies have serious limitations and risks. Public archives in Hungary including BCA follow the migration strategy which typically means to achieve future accessibility, usability and interpretability of the digital object by the conversation of files considering current program availability and working environment. Migration strategy entails that the formats accepted for archiving should be limited to keep future migration costs and workload in reasonable limits. A strictly regulated migration strategy allows the acquisition of only a few widespread, application-independent “archival formats” from record creators. Among partners in *City Memories* the national strategy of Denmark follows this way. Limitation reveals itself in the fact that Danish strategy cannot handle CAD formats. The Hungarian version of migration strategy is “softer”: the National Archives of Hungary proclaims the list of formats, which public archives are obliged to accept or recommended to accept but it doesn’t mean the total exclusion of other formats. Specific formats for 3D objects are presently not on this shortlist and for databases it recommends only SIARD which is optimized for relational databases.

This being so BCA had to consider limitations and possible risks of different solutions regarding the goal and environment of the project. The archive file format produced by Archicad software is the above mentioned .pla which is a complex database in itself relating 3D coordinates, polygon structures, information on architectural elements, building materials etc. to each other and can’t be represented in standard formats for image or textual content or for relational databases. We suppose that a “solution-based” strategy can work that means, if a format is widespread enough the acquisition is less risky because the preservation of .pla format will be a shared problem of the planning and building industry and housing sector, and according to

our experiences the vendors of planning software really invest in usability of planning objects in different software environments. On the other hand, it would be technically feasible to convert the content of a 3D model (3D data and attributes) into really usual software-independent formats like .xml or .csv but it would serve only long-term preservation; to restore usability of the database would require extra resources in this case. Following the above described Data Circulation principles an emphasized goal of archiving these models is to offer usable products for new potential user groups and user scenarios and not in the far future but in foreseeable future. That's why the decision was made to archive the models in. pla.

IV.2 Transfer of the models into OAIS-based preservation system

BCA preserves digital records in a digital repository system which is managed by Preservica Digital Preservation software, compliant with Reference Model for an Open Archives Information System (OAIS).¹¹ Preservica requires a workflow the first phase of which is transformation of the digital asset and metadata into Submission Information Package (SIP) according to OAIS, ingest into the Preservica system, where it is connected to the archival structure from the Archival Information System (AIS), so the archival description can be created by transferring the metadata into AIS.

Metadata are encoded for ingest and storage by Encoded Archival Description (EAD) 2002.

On model level the following EAD elements are used:

<unitid> HU BFL XV.17.i.2. – [property plot number]

<unittitle> 3D building reconstruction – [property plot number]

<unitdate> year of creation of the model

<scopecontent> Creator of the model; Tutor and instructor; University and course; Academic year and semester

<note> files (number and format); Software used for the 3D reconstruction

<addressline> Property plot number; Adress; Address or location at the time of the creation of the archival plan;

<userrestrict> information on copyright and proprietary issues

<relatedmaterial> reference code of the related original archival material

¹¹ Reference Model For an Open Archival Information System (OAIS) <http://www.oais.info/>

IV.3 Archival order and description

As mentioned above 3D digital reconstruction models have to be handled as independent archival units related to, but not representations of the original drawings. Positioning them in the archival order depends highly on institutional systems and policies.

The Collection of Architectural Drawings in BCA is arranged to sub-collections and series based on the record creators, so the principle of provenance is “built in” the collection of this special record type. Probable user scenarios of 3D models suppose that main line of search and access will be the search of the modelled building, so it seemed to be the most reasonable solution to integrate the models into the Drawing Collection. One of the sub-collections contain digital objects, which have no paper-based originals in BCA. The decision has been made to create a series for 3D models within this sub-collection, handling the models related to, but not as copies of the originals.

The purpose of archival description is to identify and explain the context and content of archival material in order to promote its accessibility. The models in .pla contain a huge amount of metadata on the drawing, the building and the planning. As possible user scenarios are supposed to search models of specific buildings or specific locations, it seemed to be the most reasonable solution to map these metadata with the basic metadata of our Archival Information System used to describe the drawings themselves.

Providing searchability and findability of metadata in AIS are crucial. PURE3D 2.1.2 summarizes the known metadata schemas which may be considered for describing 3D models. It highlights the recommendations of PARTHENOS White paper on "Digital 3D Objects in Arts and Humanities: challenges of creation, interoperability and preservation" (2017) according to which the necessary information elements should include¹²:

Actors – The agents involved in the creation, modification, maintenance, enrichment and critique of 3D models play a crucial role in the understanding of a 3D object as they provide the original knowledge of its creation and may hold valuable additional data for the interpretation and reuse of the model.

Objects – Aside from the digital object itself, the objects of which the 3D object is a model and their aspects are of key importance in order to be able to understand and evaluate the information delivered by a 3D model

¹² PARTHENOS - Digital 3D Objects in Art and Humanities: challenges of creation, interoperability and preservation. White paper, p. 46–48.

Goals – 3D models are elaborated towards some end. They do not form and cannot be seen as digital replacements of the actual objects of which they are models. Rather a 3D model plays a functional purpose in a scientific process to understand some aspect of an object. Explicitly documenting such goals of creation/modification/use of models is crucial to their scientific evaluation.

Tools – Playing an effective causal role in the produced model are the sampling devices and the digital tools adopted for the digitization, as well as their use at certain moments in certain environments using specific variables. Linking 3D models to the causal processes that created them is crucial in supporting their interpretation and reuse.

To adapt this recommendation to archival needs it's necessary to map these information elements with the metadata structure of AIS used in BCA. The special schema used for describing drawing seems to contain all elements which are essential to find and interpret the 3D building reconstructions:

Reference code	
Title	Object
Date (of creation of the model)	Object
Creator	Actor
Scope and content/Student who created the model	Actor
Scope and content/Tutor and instructor	Actor
Scope and content/University and subject; Academic year and semester	Goal
Property plot number	Object
Address	Object
Address or location at the time of the creation of the archival plan	Object
Files	Object
Other technical characteristics/Type and version of software used for modelling	Tool
Related material/Original drawings from which the model was created	Object

IV.4. Publishing via Budapest Time Machine

The output format of modelling for publication is .obj file. Beyond making individual models accessible, they are suitable also for integrating into (H)GIS systems, as they contain geolocated information. A relatively new but rapidly developing family of these systems is “Time Machine” which is a brand of a European-wide international initiative aiming to develop the

Big Data of the Past, creating a huge distributed digital information system. Local Time Machines are the representation of the collected Big Data of the Past of a geographic place, created by the sum of information provided by different projects and initiatives connected to this place.¹³ *Budapest Time Machine* is a part and partner of this initiative coordinated by Time Machine Organization. It can be regarded as a new generation of archival databases which makes search for archival data and digitized records based not only on “traditional” keywords and data fields, but by navigating on interactive historical maps and finding the sources relating to one site (building, property plot, address, public place) by one click. By publishing 3D building reconstructions on Budapest Time Machine online platform in visualised format they can be connected easily with other sources relating to the same building (e.g. scanned drawings, land registers, flat data sheets, notarial records, postcards and photos).

V. Possibilities and recommendations for further development

The methodology presented here could be improved by assessing the actual state of the buildings (either by conventional methods or by photogrammetric or laser scanning methods), modelling it and comparing it with the planned state. However, it should be noted that the survey of existing buildings would require significant financial and human resources.

It may be a future goal to “build” the model of the processed quarters and neighbourhoods of the city having multiple building models side by side creating gap-free and not-overlapping street scenes. By publishing 3D building reconstructions on Budapest Time Machine online platform¹⁴ in visualised format they can be connected easily with other sources relating to the same building (e.g. scanned drawings, land registers, flat data sheets, notarial records, postcards and photos).

The future of architectural records in archives depends on the solving of the long-term archiving problem of CAD and BIM software outputs. Different countries have different strategies on long term digital preservation. The strategies have advantages and disadvantages. None of them are flawless. A next step of high priority in international archival cooperation should be working out suggestions regarding the use for formats which could result in redeeming some of the flaws of these strategies and address these challenges.

¹³ <https://www.timemachine.eu/>

¹⁴ <https://www.hungaricana.hu/en/databases/budapest-time-machine/?>

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