Representation of Meta-Paradata for H-BIM Models in WebGIS: Paving the Way Towards '3D Scientific Models'

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Representation of Meta-Paradata for H-BIM Models in WebGIS: Paving the Way Towards '3D Scientific Models'

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Abstract

Ensuring authenticity and reliability of 3D models of Cultural Heritage (CH) data is increasingly critical, especially considering the increasing adoption of Artificial Intelligence (AI) in generating content. This paper highlights the importance of metadata and paradata to ensure transparency, authorship, and scientific rigor and considers challenges in creating meta-paradata information and its visualization on the web alongside 3D content. The study proposes a new meta-paradata schema for document-based Historic-BIM (H-BIM) models. It explores the integration of this schema into WebGIS platforms through tests on models from the Turin 1911 project. The goal is to promote best practices for accessible, georeferenced, and verifiable '3D scientific models', while preserving CH narratives in virtual 'scrollytelling' environments.

CCS Concepts

· ***Applied computing*** *→Document metadata; Architecture (buildings);* · ***Information systems*** *→Document representation; Geographic information systems;*

1.Introduction

In the era of emerging Artificial Intelligence (AI)-created content, the risk of finding misleading data on the web is high. Fraudulent data, like news, images or videos, are common nowadays, providing imaginary or distorted realities, even in the Cultural Heritage (CH) domain [Haz20]. Today AI can generate also 3D models, this further expands the potential for creating 3D content, a potential that is already growing thanks to the falling costs of software and sensors. Many professionals base their work and study on 3D content while people encounter 3D models in everyday life (videogames, films, online shopping, museums, online maps, etc.). The risk of using false data could increase exponentially, even because 3D data creators rarely declare who generated the content and how. In the field of 3D digital documentation of CH, how can we distinguish if the digital data we found in repositories or we produce, and share is phony or not? If it represents the real world or a reconstruction? If it is AI-generated or human generated? Even without considering the possibility of encountering data generated with AI or by humans, the question about reliability persists. Reliable data is essential for both professionals and people to base their work and lives and to trust data we encounter online. When dealing with 3D digital reconstructions of what is no longer visible today, more attention is due because we cannot compare the digital content with the real object. The aim of this paper is to begin a discussion on best practices for representing meta-paradata for Historic-Building Information Modelling (H-BIM) models visualized on webGIS platforms. Informed by literature, we defined a new schema for meta-paradata and its usage through some tests on 3D digitally recreated architecture of the Turin 1911 project (italyworldsfairs.org [DCS23]).

1.1. 3D scientific models

3D digital models perfectly reply to the non-experts' need to visualize existing CH and, above all, tridimensional visualizations render better what is drawn on traditional 'paper architectures' than a bidimensional representation [BAC22]. 3D virtual reconstructions of CH can be based on two types of sources, they can be generated starting from the real object or using sources documenting it [GFL07]. Reality-based modeling can rely on manual measurements, digital measurements through topographic equipment, laser-based or image-based sensors. Document-based modeling can be based on several kinds of documents, such as maps, photographs, depictions, and technical drawings. 3D modeling can implement what is preserved in digital archives, especially when architecture remains documented only on paper, and can reveal more than the papers themselves, providing new meanings [BAC22]. Creating a H-BIM model based on archival documents is becoming a common process to give life to architecture of the past [AFF23], but human intervention can highly influence the way of selecting and interpreting documents, hence, also the final shape of the building, its colors, dimensions, location, etc. Considering this, do these models adhere to reality and can we trust them? A 3D model cannot speak by itself; additional information is essential to tell 3D models history and its veracity. When descriptions are connected to 3D models, users gain a deeper comprehension of what reality is, nevertheless, when H-BIM models are created using archival material, documentation about soma data – for example who, when and how the model is achieved, which are the consulted original sources - are rarely declared [AWF*25]. Digital 3D reconstructing the architecture of the past (architectures that today are not visible or past phases) poses new issues related to its documentation [CR20], such as reference system, materials, temporal correspondence, type of reconstruction (hypothesis or reconstruction state), grade of reliability, models ownership, documentation about how technically the model is generated, long-term preservation and online data stability. All these aspects should be considered when creating a document-based H-BIM model, especially when the real object does not exist anymore and cannot be used as reference of trustiness. This is a scientific process that should culminate in the publishing of what should be called a '3D scientific model', like the writing and publishing of a scientific paper whose results are supported by proper documentation and reference. According to Hermon [HN07] a 3D scientific model relies on Galileo's principle of reproducibility obtaining the same results, it should be based on a predefined aim and should provide primary data and procedure description that enable achieving the same result and critical evaluation. The 3D scientific model concept is later developed by

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Apollonio [Apo24] who provides a definition entailing how a 3D scientific model should be generated:

<*A 3D model (or three-dimensional model) resulting from a 3D digitization or a 3D reconstruction is meant as a mathematical representation of a three-dimensional object, in which the information contained is structured and linked together according to a particular logical model (semantic structure). To be submitted for evaluation, it must present recognizable elements of specificity concerning pre-existing (reality-based) 3D models or the results of a logical-deductive procedure that, through the interpretation of data, creates a hypothesis of a past object, can be linked to publications, or can be accompanied by documentation that is suitable for adequate evaluation. It must also be uniquely identifiable and unambiguously referable to the author(s)/creator(s) who created the 3D model to be evaluated.*>

In this context, the provision of meta-paradata complying with FAIR principles of Findability, Accessibility, Interoperability and Reusability is essential to explain how digital data is generated, providing the right authors' attribution and rigor to the 3D scientific model'. Scientific models should be equal to scientific publications; a citation should be provided with a Digital Object Identifier (DOI) to uniquely identify the model and retrieve meta-paradata. Very few studies and projects are considering how to reference a scientific model and provide DOIs, two good examples are the Purdue University Research Repository [Pur25] which contains BIM models among different dataset types, and OpenHeritage3D [MTS*24 and Ope25] platform which stores CH-related primary datasets and not processed data, hence not H-BIM.

1.2. Collecting meta-paradata

In the CH domain, clearance about data, metadata and paradata definitions is essential because literature collects slightly different concepts and how they should be conveyed [SBH22]. In 3D digital reconstruction, data is the 3D model itself, metadata is commonly defined as <*data about data*>, while paradata is <*information about human processes of understanding and interpretation of data objects*> [Den09]. While metadata provides information about technical details, model's origin and authorship, paradata describes the modelling steps to generate the model and the adopted choices and interpretations. These basic definitions provide a general understanding of the concepts but, in case we need to define which are the specifications of metadata and paradata for our data, they leave space for uncertainty. Amico [AF24] provides some practical examples of metadata entries (identifier, author, name, format, size, type, license, unit) and paradata (software name and version, creation date, modification date), while the London Charter [Den09] details a list of contents to be included in digital reconstruction paradata documentation: what sources are considered, how they are deployed for the digital visualization, the goal of the digital reconstruction, which state is represented – existing, hypothetical reconstruction, evidence-based restoration, design phase –, and declaration of its uncertainty. Besides, the Charter highlights the need to provide a complete list of the research resources deployed for digital visualization and their provenance. It also recognizes the relevance of the description of the adopted and rejected methods. However, some information – as creation date – could be ascribed to both metadata and paradata leaving a not clear distinction; besides, paradata cannot exist without the existence of fundamental metadata as a model's name. Hence in this paper we prefer to use the term meta-paradata when we address the concept of providing documentation to 3D models. Meta-paradata documentation could be very minimal or extensive, and finding the right balance between enough and complete meta-paradata is fundamental. The CAPTURE project [Huv24] raises the question about 'complete paradata' meaning: how much information should we include in meta-paradata in a way that is enough in quantity and quality? Besides, meta-paradata should be conceived for all type of re-users of our model that have situational and subjective needs. The fact is that meta-paradata itself is an indicator of the model's usability rather than model's quality. Meta-paradata should be useful in the sense that it should represent the model's transparency guaranteeing the model's understandability, reproducibility and reusability. CAPTURE project identifies 4 paradata categories of needs (scope of visualization, provenance, methods, and knowledge representation and organization) that can assist model's creator in providing useful meta-paradata for all users. For survey-based H-BIM models, literature reports some tests in creating meta-paradata schemas where some entries can be automatically recorded by sensors [MB20 and MKM*24]. In the case of BIM models, the modelling process for obtaining document-based models is greatly different from survey-based models where experts often derive the BIM model from a point cloud and can take advantage of a fast acquisition of the point cloud, semi-automatic steps for processing the data and plug-ins easing the parametric extraction [GFL07]. Document-based modelling requires preliminary material discovery, analysis and interpretation and, in this process, humans can hardly be substituted or assisted by AI, especially in the case of historical and no longer visible architectures that are unique and peculiar as their historical documentation. Due to this limitation, the digital reconstruction step is a time-consuming process, requires expertise and brings to the creation of a model that is influenced by the operator sensibility and ability in analysis and converting the paper material into H-BIM models, requesting to produce documentation about the decision made by each individual modeler, the technical steps and criticalities encountered, providing trustiness and authorship to the generated models. Documenting all this information requests human intervention and, depending on the amount of data desired to create meta-paradata documentation, this can be expensive and time-consuming. Creating overabundant documentation risks to be not only a time-consuming task but also a waste of time because this lengthy documentation will be rarely consulted [Huv24]. In creating meta-paradata schemas and defining rules for filling out them, information redundancy among different fields should be avoided because this can lead to contradictory information. Looking at meta-paradatra usage in CH, metadata is in the same cases applied, while paradata is rarely used. Even if paradata is recognized as fundamental, practical approaches for collecting and transmitting it to users are still underdeveloped [Huv24].

1.3. Representing meta-paradata

After having collected useful information for our model, the question about how to share and show the 3D models and their meta-paradata arises. Local storage of 3D data prevents their visualization to the public, limiting the dissemination of knowledge, while openness and unrestricted use maximize public access, as promoted by the London Charter [Den09]. Besides, enhancement of access to CH through digital technologies is also promoted by the Faro Convention. In data science, the best practices in creating and sharing data are the FAIR principles of Findability, Accessibility, Interoperability and Reusability. FAIR Principles are domain and standard independent and thus can be applied to many fields. Nevertheless, 3D models like point clouds, BIM models, Digital Elevation Models (DEM)s, and mesh models are not always shared with the public, as into web repositories of CH, for ephemeral or still-standing architecture. Rather than in

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digital DBs and repositories for study and research such as the Smithsonian, Open Heritage 3D, Google Arts and Culture, CyArk, and Europeana, 3D models find more success in repositories for commercial purposes, like the well-known Sketchfab, or Autodesk Online Gallery [CR20]. When they are part of 3D online portals there is a lack of meta-paradata [CR20], undermining data trustiness and reducing its reusage potential. Besides online repositories, 3D content can be loaded into immersive experience for scrollytelling. According to Ammirati et al. [AWF*25], <scrollytelling is a narrative technique that combines scrolling interactions with dynamic multimedia elements such as text, images, videos, and animations, further enriches these educational experiences>. More than one model can be loaded into a 3D scene, besides issues related to visualizing detailed and useful meta-paradata can conflict with clear and unclogged navigation. Focusing on H-BIM models, they are often heavy, some issues persist in format interoperability, georeferencing them to provide physical context, and in loading them in webGIS application for sharing [MB20, MCIV23, SCDc23].

2. Related work

Some CH-related projects and repositories are facing meta-paradata provisioning and visualization for different data types and formats of digital models and are here analyzed. The selection is not comprehensive and is focused only on large projects related to online visualization of 3D models on institutional websites related to CH and dealing with meta-paradata provisioning and, in some cases, with CH storytelling.

UNESCO Dive Into Heritage (DIH) project [AWF*25] aims to provide an online platform for immersive 3D scrollytelling experience to explore World Heritage Sites. The project addresses issues related to visualizing different data types (such as photographs, videos, maps, 3D models) to create the narrative, furthermore they are planning to insert Augmented Reality or Virtual Reality applications in the future. Besides, the project tested adaptability of 3D models for online visualization and reflects on providing scientific rigor to each item loaded in a single visualizer alongside many other items, without distracting the storytelling experience. Even if DIH is a huge and relevant project, the platform is not yet available to the public and cannot be evaluated deeper in this paper.

British Museum's Skecthfab page [The25] displays over 250 models online with standard metadata provided automatically by Sketchfab itself, besides additional information is offered with links to external webpages where the real object is described, and a CC license is defined. Even if information about software used and author is included in the descriptive note, these models are not enough documented regarding adherence to the real object and it is unclear what sources are used for the reconstruction.

OpenHeritage3D (OH3D) [MTS*24 and Ope25] is a platform - run by University of California San Diego in collaboration with other scientific institutions designed as repository for distribution and open access of raw data related to CH, the sharing is for scientific scopes and not for entertainment or promotion as Sketchfab is. Each dataset is complemented with metadata, a license, a DOI, external links for additional information, and a 3D viewer allows a preview of what is available for download. OH3D represents a good repository of primary data with all the needed metadata but for the moment lacks paradata about how this data are collected and its accuracy. Even if BIM models cannot be visualized online – because the visualization is based on Potree that renders only pointclouds, every raw data format can be submitted the file and is converted into a point cloud just for visualization, while the original files are stored and made available for downloading. Besides, the platform is conceived to be a repository for raw data obtained with a survey that is not the case of BIM.

Global Digital Heritage (GDH) [GDH25] is a not-for-profit education and research organization aiming to document CH and make data freely available on its website. Even if it has worldwide coverage of the CH they survey, not all the sites are accompanied by a 3D model with a report containing meta-paradata.

Google Arts and Culture (GA&C) [Goo25] is an online platform developed in 2011 to provide access to high-resolution images of works of art belonging to many museums. GA&C also offers online exhibitions of CH digital reproduction with images and narratives, authors' biographies, descriptions of artistic movements, historical events, and means of expression in a scrollytelling way. A 3D object section collects around 2000 3D models [G3D25] of many CH institutions providing a brief description for each and the quantity of metadata depends on who uploaded the content (sometimes the author is not even declared). Even if GA&C is a popular platform for promoting CH and the navigation is easy and captivating, the license is often unclearly stated, no paradata is available in general for all the models, no citation such as a DOI is provided and BIM formats are not supported and need to be converted for uploading.

In general, these projects attempt to make 3D data online available for free, but they miss providing proper paradata documentation that gives trustiness and helps reusability. These projects and related considerations are considered for developing a paradata schema and visualization modalities for the Turin 1911 project.

3. Turin 1911 Project

The digital research project "Turin 1911" led by University of California San Diego (USA) and Polytechnic University of Turin (Italy) aims to critically study the 1911 International Exposition held in Turin (Italy) by exploiting digital technologies. Settled in the fabulous stage of Valentino Park, the event lasted only 6 months and involved thousands of people in the design, construction and evolution of the Fair. More than 200 built environment objects located in 1 million m^2 fairground were specially built and later demolished or abandoned after the fair closure, leaving no physical traces of the grandiosity of an event that attracted 7.4 million visitors. Archival materials are the sole source witnessing an occasion of contamination of knowledge, where the most innovative technologies and histories of many cultures were put in show. These materials are stored in many private and public archives, institutions and collections worldwide, they are difficult to access and interpret, process that can be faced only by experts and is time-consuming. Turin 1911 project collects, digitize, catalogue and analyze the material identified and make it available online on a free dedicated website (italyworldsfairs.org [DCS23]) promoting understating of a complex historical event, as a World's Fair, and being a pioneer in extensively documenting, studying, and publishing material about a single World's Fair.

3.1. The H-BIM Models

Considering the relevance of architecture in representing national identities and in the architectural history in general [Del06], built environment objects represent a particular focus of the Turin 1911 project and have a dedicated website section https://italyworldsfairs.org/explore. Each built heritage object (national pavilion, kiosk, recreation structure, etc.) has its own

features and characteristics, it needs expertise in architecture for studying its shapes, composition, dimension, style, and materials, and requests observing and comparing heterogeneous materials. The knowledge about these architectures can be shared with people without this expertise thanks to digital 3D reconstructions. However, if these digital files remain stored on local computers or hard disks, the reconstruction effort is lost, missing to guarantee the maximum benefits for the CH knowledge as was instead hoped for by the London Charter [Den09], while if the models are published online, these models are accessible to everyone with only a computer with an internet connection. Since 2018, many experts have been involved in this process of digital reconstructing those Turin 1911 architecture using non-parametric model first [ESCDc20] and moving to a BIM approach later. After generating BIM models, every model is contextualized by georeferencing it in the real world and uploaded online. This step was essential to locate each architecture in the location where it was built and expand the way of accessing history of the past in a new way. Many technical issues related to publishing BIM models into webGIS applications have been solved [SCDc23 and SC24], but less attention was paid to documenting the creation process. Who, how, when, and why these digital models are created can be easy to document, but how much these models adhere to the real object, how to store this information, and how to convey it online alongside the digital model in a 3D visualization is not straightforward. Besides, sometimes the models were improved for example by adding materials, or the georeferencing was adjusted and the online model was substituted with the new version, without leaving traces of what improvements were made and when.
For the Turin 1911 project, the possibility of digital reconstruction was limited to those architectures for which enough archival materials were available. At the time of writing, 13 built environment objects are visible on the website as BIM models inserted into webGIS applications and needs meta-paradata: Court of Honor and access to the Water Castle; Martell Cognac Kiosk; Modern City; Moët & Chandon Kiosk; Monumental Bridge; Monumental Waterfall; Pavilion of Belgium; Pavilion of France; Pavilion of Hungary; Pavilion of Siam; Pavilion of the Arts Applied to Industry, including China, Japan and Persia; Pavilion of the City of Turin; and Strega Liqueur Kiosk.

4. Proposal of a Paradata for BIM models

4.1. Meta-paradata Structure

According to literature [Huv24], some paradata structures are available today for different scopes related to CH, but no one is specific for document-based models. Informed by Huvila [Huv24] about major paradata categories and by the London Charter, in this paper a paradata schema is proposed tailored for document-based H-BIM models, focusing on useful information and aiming to provide synthetic but exhaustive documentation about the process to obtain the model, its visualization scope, the provenance of data, and relevant metadata information. Meta-paradata can be provided as descriptive text attached to the digital model - such as a text file or portable document file - that can be uploaded online, or as structured data - such as a spreadsheet file or a database - that can be organized, analyzed, and manipulated, or as linked data [BSH20]. Using structured data enables us to perform queries, filtering, and generate statistics about the digital models. In the case of BIM models, meta-paradata could be inserted into the project itself (for example in Revit or Archicad), but this data is attached to each single element alongside a ton of other specific data related to the single element. It is better to store together all the data related to the project in general and not have them nested with single-element data. We opted to provide meta-paradata in the form of structured data in a database to enable data analysis. In the following **Table 1** the proposed meta-paradata structure for Turin 1911 H-BIM models is reported, including field name, filed description, and field type. The structure is subdivided into 3 parts: scope of visualization, methods, reuse. The data structure is tailored to the Turin 1911 project needs, focusing on describing the overall modelling process from the document selection to the georeferencing step, and detailing aspects that are relevant for evaluating the trustiness of the created model. For example, the 'description of sources usage' field enables readers to understand which sources are used for modelling, which ones are excluded and why. Because BIM models are in general generated in BIM software that works with local coordinates, the georeferencing process requires to be explained in detail. The fields 'georeferencing process', 'images describing the georeferencing', 'coordinates and rotation of the point used for georeferencing' and 'reference system' report info about the georeferencing task and allow the reusability of the model and future updates of the model location. As 'LOD' we mean Level of Development and we rely on the LOD concept defined by the American Institute of Architect and which means <*completeness reliability of the building elements information*> [AB22]. Among the LOD standards available today and analyzed by [AB22], we opted for this LOD because it is a synthetic indicator commonly used in the BIM area to help users in understanding the geometrical detailing of objects. Even if designed to be applied to single elements, we use LOD field to provide a general indicator of each digital object as a whole to guide users understand the level of detail of the digital object. We followed the 6 levels defined by the BIMForum working group in 2024 [Bim24] that are: LOD 100 (conceptual model), LOD 200 (approximate geometry), LOD 300 (precise geometry), LOD 350 (construction documentation), LOD 400 (model and additional information), LOD 500 (as built). More information about missing or incomplete parts are reported in the free text field named 'Accuracy' where geometrical accuracy, adherence to reality and completeness are declared.

Field name	**Field description**	**Field type**
SCOPE OF VISUALIZATION		
Model title	Name of the model describing the format and what it represents	Free text
Model representative image	Representative image of the model	Image
Model scope	Text describing why the model was created. This would help people who see the model to understand why it has been generated, the level of detail and lacks that the model has	Free text
Type of model	Term defining if the model is survey-based or document-based or other. If other, please specify	Structured term
Real object title	Name for the real object which is represented by the digital model	Free text
Real object existence	Term defining if the real object exists today or not	Structured term
Object date	Year to which the model refers	Integer
Location	Nation, Municipality, Location of the real object	Free text
METHOD		
Sources used	Insert 1 to 99 images for sources used for creating the model	Image
Sources not-used	Insert 1 to 99 images for sources not used for creating the model	Image
Sources usage description	Description of why a document is preferred over another (this could	Free text

	be simply more detailed drawing because of the scale), stress missing sources, where you found additional information regarding materials, elevations, etc.	
Materials	List of materials	Structured terms
Materials Description	Description of how the materials are selected and the sources on which the choice is based	Free text
Reference system	Name of the reference system, the EPSG code between brackets and the type of height referred to the georeferencing coordinates and rotation and to the model	Free text
Georeferencing coordinates and rotation	Cartesian coordinates and elevation in meter, and angle in degree minutes and seconds for the point used for georeferencing the model	Structured term
Georeferencing images	Insert 1 to 5 images documenting the point used for georeferencing and a schema for the rotation	Free text
Georeferencing process	Describe which source and software is used for georeferencing, and strategies applied by the modeler to achieve georeferencing or any other info related to georeferencing useful to reproduce the process or for reuse the model	Free text
Georeferencing software and version	List of all the software used for georeferencing and their related versions	Free text
Technical process	Description of the overall process to achieve the model and online uploading	Free text
Modelling software and version	List all the software used for modelling and their related versions	Free text
REUSE		
Author	Name and Surname of the final creator of the model. Previous authors are available under previous versions	Free text
First online uploading date	Uploading date of the version 1 of the model	Date
Modification date	Uploading date of the latest version of the model	Date
Model Version	Version of the model in integer numbers and notes about what is updated	Free text
LOD	Level of Development concept defined by the American Institute of Architect and which means *<completeness reliability of the building elements information>*	Structured term
Accuracy	Description of the evaluation of metrical accuracy in respect to the real object, adherence to reality, definition of lacks in the digital model and why	Free text
File format	List of all the file formats generated from the BIM modelling till the uploading on the web	Structured terms
File size	List of file size for each format	Free text
Licensing	Type of license under which the digital model is released, and which defines the reusability condition	Structured term
DOI	Digital Object Identifier for the available datasets	Free text
Additional information	URL where further information can be retrieved, as information about the real built object and where the H-BIM model is visible	Free text
Models' online availability	Description of the websites where the model is just visible and where it is downloadable for re-use	Free text
Report	Link to the full report in .pdf format or where it can be downloaded	Free text
Notes	Additional information can be reported here	Free text

Table 1. *Meta-paradata structure proposal*

4.2. Example for Turin 1911

We opted to create an online survey (Survey123 by ESRI) to ease the collection of meta-paradata for each H-BIM model and to have it in a database structure. Collected data can be linked to the model or a PDF can be generated and linked, these options save time for web application development for visualizing the meta-paradata alongside the models. Quality of submitted data is verified by a supervisor who requests integration and modification, if needed, to providers. The supervisor can edit the text to balance entries submitted by different team members, since descriptions are subject to personal writing interpretations in terms of text length and level of detail. An example of the collected data is reported below for the Moët and Chandon Kiosk. This kiosk is relevant due to the usage of different software for modelling and georeferencing, and because some decorative elements are generated with AI.

4.2.1. The Moët and Chandon Kiosk

Model title: H-BIM of the Moët & Chandon Kiosk

Model representative image:

Figure 1. *Representative image for Moët and Chandon Kiosk*

Model scope: The model was created to allow a better understanding of what the Turin 1911 International Exhibition (Italy) was and how the Kiosk of Moët & Chandon looked like. Reconstructing this now lost heritage and making the models visible allows us to preserve the historical memory and revive the experience of that important event.

Type of model: document-based

Real object title: Moët & Chandon Kiosk at the Turin 1911 World's Fair

Real object existence: Does not exist

Object date: 1911

Location: Italy, Turin, Valentino Park

Sources used:

Figure 2. *Sources used for Moët and Chandon Kiosk*

Sources not-used: not available

Sources usage description: For the Moët & Chandon model, in the absence of both project drawings and technical drawings, photographs taken during the event were considered. Two photographs were found in the private archive of the Maison Moët & Chandon, while others are commemorative postcards of the Exhibition made during the event and available on italyworldsfairs.org website. Another type of source used are the articles of magazines in which there are two photographs, namely: L'Esposizione di Torino Giornale ufficiale illustrato p.572 and La Guida ufficiale dell'Esposizione Internazionale - Torino 1911 p.137. The two black-and-white photographs were used to better recognize some details compared to the photographs of the Maison's archive in sepia tones. However, most of the time it is more or less the same photograph or at least the same point of view. The interesting part is the accompanying text, although these texts are not extremely in-depth and prefer to talk about the company in general, you can still find useful data. This is the case of the magazine L'illustrazione italiana, year 38 n.40 1 October 1911 which describes the length of 100 feet of the pavilion (about 30 meters). Finally, the data of the general shape of the plan was extracted from the general plan at 1:3000 scale of the Exhibition: Esposizione internazionale di Torino 1911. Planimetria Generale (Grand Didier) is available on italyworldsfairs.org website.

Materials: wood, stone, tiles, stucco

Materials description: Given their ephemeral existence, almost all the pavilions were built with a wooden structure that was subsequently covered. Hence, it is plausible that this strategy was adopted also for Moët & Chandon Kiosk. As regards the covering materials, thanks to a description of the pavilion in a magazine (L'illustrazione italiana, year 38 n.40, 1 October 1911) and photographs, we tried to hypothesize them: stone wall covering since the construction refers to a part of the Abbey of Hautevillers (stone masonry), tile covering and white stucco decorations clearly visible in the photographs.

Reference system: WGS 1984 UTM Zone 32N (EPGS: 32632), orthometric height

Georeferencing coordinates and rotation: 4989439.17N 396479.41E Elevation: 222.72 m. Angle from Project North to True North: 95° 51' 46" to Est

Georeferencing images:

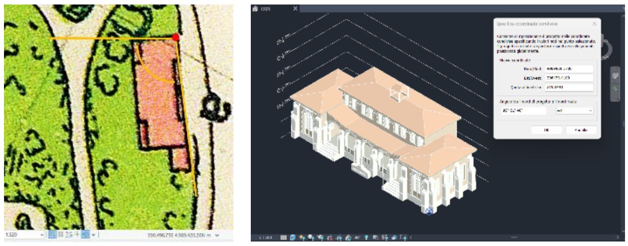

Figure 3. *Georeferencing images for Moët and Chandon Kiosk*

Georeferencing process: The Esposizione internazionale di Torino 1911. Planimetria Generale (Grand Didier) is georeferenced in ArcGIS Pro. A point on a specific corner of the desired pavilion is created. The coordinates of this point are copied and pasted in the Revit project, on the exact same corner of the Moët & Chandon kiosk. The angle is measured in ArcGIS Pro considering the main facade of the Kiosk as reference. The angle is inserted in Revit. The .rvt file is saved and a .prj file with the same name of the .rvt file is located in the same folder. The prj. file stores the information for the 32632 EPSG reference system and it is necessary to proper locate the .rvt file in ArcGIS Pro.

Georeferencing software and version: Autodesk Revit 2025, ArcGIS Pro 3.4

Technical process: As a first step, given the presence of a frontal photograph, it was decided to apply a photographic rectification to this photograph. The second step was to scale this photograph to be able to extract measurements, these measures are used to reconstruct the kiosk in Archicad. The third step was drawing guidelines for the main elevation and the plan by using the photographs in comparison to the 1:3000 fairground map. Then the elements are modelled as parametric following the sources and the guidelines.

Once these steps were completed, we moved on to modeling the main elevation and the two lateral ones but leaving out the fourth front, given the absence of sources illustrating it.

As for the decorative elements, the statue at the entrance depicting Dom Pérignon was created using the Meshy website (https://www.meshy.ai/discover), a website dedicated to the reconstruction of 3D models through Artificial Intelligence approach. Meshy website reconstructed the statue based on a photograph of the original Dom Pérignon statue still standing in Épernay (France). The same method was used for the modeling of the two bells, for which, however, a specific photograph was not available; consequently, a general description of the object to be modeled was transmitted to Meshy for generating the model. The .fbx files generated by Meshy are converted into .3ds and then loaded in Archicad. The .pln project file is saved in .rvt for georeferencing. After the georeferencing step in Revit, the .rvt file is loaded in ArcGIS Pro, then the .slpk file is generated and is loaded on ArcGIS Online.

Modelling software and version: Graphisoft Archicad27, Meshy website

Author: Erica Casareto

First online uploading date: 27.03.2025

Modification date: 07.04.2025

Model Version: Version 2 (the elevation is adjusted for a better georeferencing)

LOD: 300

Accuracy: Regarding metric accuracy, it is not possible to evaluate it without a real object. Concerning the adherence to reality, this is a digital reconstruction according to the available sources at the time of modelling. The interiors of the built object are almost missing due to a lack of sources.

File format: pln, rvt, prj, slpk

File size: 173 MB .rtv, 1 KB .prj, 166 MB .pln, 30.3 MB .slpk

Licensing: CC BY-NC-SA

DOI: not yet available

Additional information: https://italyworldsfairs.org/built-environment-objects/exhibition-kiosks/moet-and-chandon-kiosk

Models' online availability: The model is available for re-use on ArcGIS Online. This model is part of the web scene integrated into an Experience Builder application available on ArcGIS Online. The web app is integrated into the italyworldsfairs.org website at the Moët & Chandon Kiosk webpage. The raw files (.rvt + .prj, .slpk) are not yet available for download.

Report:
https://ucsdonline.maps.arcgis.com/sharing/rest/content/items/9a5fdac515a84e8 3ac7ebe27fce04374/data

Notes: nothing else to report.

5. Meta-paradata visualization in webGIS

Once meta-paradata are retrieved and stored in a structured way, the problem related to how to visualize them in a web platform persists. The risk of disrupting the storytelling and overloading the web application is high. Best practices of paradara representation on scrollytelling web platforms are introduced by Ammirati et al. [AWF*25], this paper proposes 4 visualization methods and for each pro and cons are discussed, also considering its usability in relation to the user device type (computer, tablet, smartphone). The 4 proposed solutions and considerations are here summarized:

1. Information panels placed alongside each model with meta and meta-paradata summaries. This option is not feasible on small screens because it occupies a large amount of space.

2. Annex is a dedicated section on the web for collecting all the meta-paradata for all the available models, separating the 3D models visualization from their documentation. This requires an identifier - for example a unique ID or a DOI - for linking the documentation to the digital model. Data in an annex could be searched and filtered, but the owner of the website where models are visualized is not always the same owner of the models and cannot provide DOI for all of them. With an annex, meta-paradata can be searched and, if stored in a structured way, can be filtered and statistics can be calculated.

3. Buttons for each model opening a pop-up window or leading to another page with full meta-paradata can be inserted similarly to the "I" icon on many platforms. The problem of distraction due to many icons can be avoided by limiting the icon visualization to a certain level of zoom.

4. Reference section or credits screen can be visualized at the end of the experience displaying full documentation.

Ammirati et al. [AWF*25] did not test these solutions with the UNESCO DIH platform, nor provide example images. Hence, we tested the 4 methods with the Turin 1911 project, considering some relevant H-BIM models. Besides these 4 ways, hybrid solutions by integrating 2 or more solutions in a single visualization could be applied.

5.1 Examples for Turin 1911: information panels

An information panel could be a 3D object in the shape of a panel such as in the real world located next to each model or a digital information panel that can be displayed in the web application near the model, in a specific window. In the first case, a 3D panel should be large enough to display a textual recap of meta-paradata, in this case it could be hard to insert text on it, and this could highly distract users from enjoying the digital 3D reconstruction, hence, this solution is not tested here. The second option could be a fixed window that can be shown or hidden, could contain a complete information text with images or a meta-paradata summary with a link to an external document or webpage reporting all the information. This solution can be easily applied where only one model is loaded into a web application. In the case of more than one model - hence more than one information panel - a dynamic panel showing the meta-paradata related to the visualized model should be set, but this can require more expertise in configuring dynamic entries.

The solution with a single H-BIM model is tested for the Moët and Chandon Kiosk (**Figure 4**): a digital information panel is visible on the right side of the web app, all the entries are visible by scrolling down, a link permits the pdf report download (the pdf includes also the field description), a button let users decide to hide or show the panel.

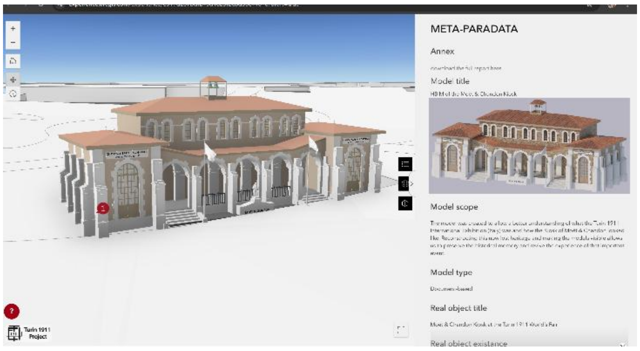

Figure 4. *Digital information panel for the Moët and Chandon Kiosk. The panel can be scrolled and hidden/shown by users.*

5.2 Examples for Turin 1911: annex

An annex could be a simple webpage with text and images or a simple link to a downloadable file (as a pdf). For Turin 1911, an annex as a downloadable file is already included in the information panel (**Paragraph 5.1**). This solution is optimal in the case of a single model but does not provide an overall summary of all the available documentation in the case of multiple models and related meta-paradata.

5.3 Examples for Turin 1911: buttons

The issue of multiple models nested in a single environment can be easily solved by using a button for each model. The button can be inserted as a 3D point or as 2D point with the Z value stored in a field. The preferred icon can be rendered as an image instead of a point. Point visibility can be set according to the desired minimum and maximum scales of visualization to avoid disrupting users' navigation or overloading the scene with too many icons. In the Turin 1911 project there are buildings of different dimensions, in case of small pavilions as the Moët and Chandon and Martell Cognac Kiosks (**Figure 5**), the icon can be easily found by users, while in case of large architecture - as for the Monumental Complex (**Figure 6**) - setting the visibility scale can help users in identifying the meta-paradata icon before reaching an high scale of visualization (for example 1:500).

Figure 5. *Button solution, visualization of more than one architecture: the Martell Cognac and Moët and Chandon Kiosk.*

Figure 6. *Button solution, identification of the meta-paradata icon with a large architecture: the Monumental Complex.*

5.4 Examples for Turin 1911: reference section

Reference section or credits screen cannot be not inserted as it is proposed at the end of the experience because there is no scheduled end for Turin 1911 web applications, the user is free to move in the 3D scene as it prefers and ending when and where it wants. However, this solution is adapted to Turin 1911 by adding a credit button. The credit button could redirect to an index.

5.5 Examples for Turin 1911: index

Instead of a simple annex, an interactive index could provide a more efficient way in collecting and displaying meta-paradata for multiple models. This index could be a simple list of texts - reporting for example only the Model title – or could be accompanied by an image of the digital model and other relevant data. For each model, this index could include a button for downloading the annex or a link to the single webpage where full documentation is reported. Besides, if the meta-paradata is associated with a location in the space, each entry could be linked to the 2D location of the represented model. Navigation across meta-paradata could be achieved by searching by a selected field, for example by Model title. For Turin 1911 (**Figure 7**) we tested an index with only a representative image, Model title, modification date, author, and a button to download the annex file. The search is based on the Model title and once the model box is selected, the map automatically zooms and pans to the corresponding icon on the map.

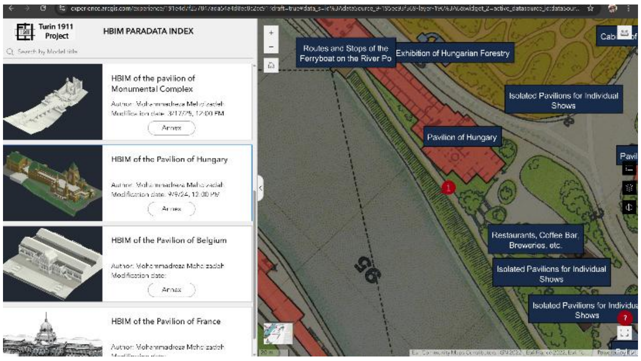

Figure 7. *Index with location on the map for the Turin 1911 project*

5.6 Examples for Turin 1911: hybrid solution

Applying more than one way (informative panels, annex, buttons, reference section) into a single environment can give users multiple ways of discovering meta-paradata but in this case the graphic design and navigation must be carefully designed to avoid overloading the web app. For the Turin 1911 project we developed a dedicated web app for discovering meta-paradata of multiple 3D models with a hybrid solution (**Figure 8**). The app is mainly based on a 3D scene where all the H-BIM models are loaded in the reconstructed Valentino Park terrain and a meta-paradata button is provided for each model. Considering the vastity of the area (physically around 1.2 million m^2) and the large dimensions of some pavilions (as for example the Monumental Complex), an index – containing only the Model title and the representative image – is located on the left of the 3D scene. When users click on the representative image, the 3D view goes to a specific point of the 3D scene. This option guides users in the digital Valentino Park and brings to each pavilion where its meta-paradata button is clearly visible. By clicking on the desired button, full meta-paradata is displayed in the informative panel on the right side. Besides, in the informative panel the pdf annex is downloadable with a click.

Figure 8. *Hybrid solution: a web app dedicated to H-BIM models and their paradata*

6. Discussion and conclusions

This paper illustrates the relevance of meta-paradata for H-BIM models representing no-more-visible architecture for generating 3D scientific models. Considering the vastity of information that creators can collect for documenting the modelling process and the model itself, we hope that the proposed meta-paradata schema can reply to the principle of usefulness introduced by Huvila [Huv24], to the London Charter aim of documentation and that can be a good compromise between essentiality and detail. By providing dedicated fields (‘source used’, ‘source not used’, sources usage description’, ‘accuracy’) we help users in understanding on which bases models are created and what are the lacking parts. By providing meta-paradata we provide documentation also for replicating the model or improving it and we generate authenticity and trustiness for declaring it a 3D scientific model. To fully achieve this objective, DOI will be assigned to each H-BIM model, also allowing free data download for reuse purposes. In the future reuse by humans and machines will be addressed. By referencing models, as authors do for scientific papers, we increase the reconstruction of history, we expand knowledge, and we help people in visualizing this history that in many cases is not visible, such as in the case of Turin 1911.

The meta-paradata structure is tailored to document-based 3D models, but in the future the schema could be applied to other types of 3D reconstructions. In fact, the field ‘sources used’, ‘sources not-used’, and ‘description of sources usage’ are generic and can fit with other types of sources, for example photogrammetric or laser scanner surveys. We hope this study can provide the basis for a unified meta-paradata schema for document-based H-BIM models, but also for survey-based models as well as for other type digital objects and, more in general, for models not related to CH. In case of adoption of this schema, some fields request additional specification according to the specific project. For example, in our case the ‘author’ field considers only the modeler of the uploaded version. For Turin 1911 the author is responsible for both modelling and checking the sources, even if the modeler inherits a previous model. However, authorship can include multiple people covering different tasks and this deserves detailed attributions.

Structuring meta-paradata, as for Turin 1911, is beneficial because data can be filtered, and dashboard can be created. This option is favorable for large 3D repositories where searching can be performed based on fields (authors, type of model, etc.) and a dashboard helps users in having a glimpse onto the repository. We are considering mapping our meta-paradata schema to standards (e.g. CIDOC-CRM and Prov data model by W3C) to improve findability and exchange across different platforms and in the next future the recently introduced Level of Information Need (LOIN) (ISO 7817-1:2024) will be considered.

Regarding meta-paradata online visualization, 5 modalities are tested by using Turin 1911 H-BIM models discussing pro and cons. Projects can take advantage of these examples and apply what fits better with their scopes, repositories or scrollytelling. For the Turin 1911 project, the hybrid solution will be further developed and integrated into the Turin 1911 website to represent a scrollytelling platform based on ‘3D scientific models’. User feedback will be considered to refine the proposed system, to assess its maintainability and scalability.

The digital revolution, today supported by AI, has massively produced digital products too fast, and different actors are not able to follow the speed of this evolution with adequate conservation strategies, as stressed by the 2003 UNESCO Charter on the Preservation of Digital Heritage. Today, digital heritage is at risk and its preservation is an urgent issue. If properly trained, could AI generate the same document-based H-BIM models that our modelers created? Does the training effort and cost worth the result? How can the quality and trustworthiness of these models be assessed? In the era of AI, transparency in model creation and the recognition of authorship for modelers are both relevant and urgent issues.

We hope that this paper can contribute to providing useful information to create digital repositories or scrollytelling experiences with the aim of long-term preservation and communication of trusted ‘3D scientific models’. In the future we expect that other case studies will be presented in literature to transport the theorical notion of ‘3D scientific model’ into practice.

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