Ontology for Preservation of Cultural Heritage 3D Models (OntPreHer3D)

Version 2.1.1

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Contents

1. Introduction 5
   1.1. Scope 5
   1.2. Status 6
   1.3. Naming convention 6
2. Classes and properties hierarchy 7
   2.1. External Ontologies 7
   2.2. Classes declaration 7
      M1 3D Object 7
      M5 Digital Publication Event 8
      M6 Digital Record 8
      M14 Research Project 9
      M15 Digital Feature 10
      M16 Digital Material 10
      M17 Digital Environment 11
      M18 Digital Position 11
      M19 Simulation 12
      M20 Digital Property 12
      M21 Shape 13
      M22 Digital Shape 13
      M23 3D Modelling Technique 14
      M24 Texture Mapping 14
      M25 Digital Reconstruction 14
      M26 Cultural Heritage Thing 15
      M27 Accuracy Value 16
      M28 Uncertainty Value 16
      M29 Reliability Value 17
      M30 Raw Data 17
      M31 Raw Model 18
      M32 Informative Model 18
      M33 Website 19
      M34 Paradata 20
      M35 File 20
      M36 Conceptual Modification 21
      M37 Serial Number 21
      M38 Segmentation 22
      M39 Feature 22

M40 Derivative 23
M41 Preview File 24
M42 Render 24
M43 Screenshot 25
M44 License 25
M45 File Format 26
M46 Affiliation Assignment 26
M47 Classification Assignment 27
M48 Relation Assignment 27
M49 Method 27
M50 Spatial Configuration 28
M51 Geometric Continuity 28
M52 Level of Development 29
M53 Weather Condition 29
M54 Abbreviation 30
M55 Technology 30
M56 Collection 31
M57 Inventory Number 31
M58 Bibliographic Reference 32
M59 Readability Assessment 32
M60 Consistency Assessment 33
M61 Readability Value 33
M62 Consistency Value 34
M63 Reliability Assessment 34
M64 Source Assignment 35
M65 Uncertainty Assessment 35
M66 Relevance Assessment 36
M67 Relevance Value 36
M68 Country 37
M69 Phase 37
2.3. Properties declaration 39
R1 published (was published by) 39
R4 is preceding version of (has preceding version) 39
R5 is following version of (has following version) 39
R6 is alternation of (has alternation) 40
R7 has position (is position of) 40
R8 digitally created (was digitally created through) 41

R10 simulates (is simulated by) ... 41
R11 simulates thing (is thing simulated by) ... 42
R12 embeds (is embedded in) ... 42
R13 consists of (is incorporated in) ... 42
R14 has reconstructed (is reconstructed by) ... 43
R15 simulates time (is time simulated by) ... 43
R16 has shape (is shape of) ... 44
R17 has representation type (is representation type of) ... 44
R18 has accuracy value (is accuracy value of) ... 45
R19 has digital carrier (is digital carrier of) ... 45
R20 has file format (is file format of) ... 46
R21 has version number ... 46
R22 supports (is supported by) ... 46
R23 has custody of (is currently in the custody of) ... 47
R24 segments (is segmented by) ... 47
R25 identifies (is identified by) ... 48
R26 has variant number ... 48
R27 has object (is part of) ... 49
R28 can be referred as (is bibliographic reference of) ... 49
R29 has results incorporated in (incorporated results of) ... 49
R30 has scale ratio (is scale ratio of) ... 50
R31 generated digital representation (is digital representation generated by) ... 50
R32 has property (is property of) ... 51
R33 used as texture (is texture used for) ... 51
R34 has occurrence count ... 52
R35 met technological requirements of (is technological requirement of) ... 52
R36 covers (is covered by) ... 53
R37 has model number ... 53
R38 refers to coordinate system within (has coordinate system referred to) ... 54
R39 simulates (is simulated by) ... 54
R40 has phase (is phase of) ... 54
3. Deprecated classes and properties ... 56
Deprecated Class Migration Instructions ... 56
Deprecated Properties Migration Instructions ... 56
4. Cited Work ... 57

1. Introduction

3D models of cultural heritage are invaluable resources. They enable detailed analysis without compromising the physical integrity of artefacts (Bossema et al., 2021) and provide virtual access to objects that are typically inaccessible to both site visitors and researchers (Efkleidou et al., 2022). In addition, 3D models can be used to virtually reconstruct lost cultural heritage (Kuroczyński et al., 2021) or digitally visualise architectural projects that were never built (Apollonio et al., 2023). The academic community has also acknowledged the importance of 3D models as digital documentation for archaeological (Brandolini et al., 2021) and architectural research (Argasiński & Kuroczyński, 2023). Despite their growing importance, a standardised approach for the long-term storage and preservation of 3D models has yet to be established (Golubiewski-Davis et al., 2021). The rapid obsolescence of digital data poses a serious risk, potentially resulting in so-called "digital graveyards" where all knowledge invested in 3D representation of the past becomes inaccessible (Kuroczyński, 2017).

Ontology for Preservation of Cultural Heritage 3D Models (OntPreHer3D) addresses these challenges by introducing tools for the semantic description and documentation of 3D models of cultural heritage, with a special emphasis on the introduction of classes enabling the preservation of 3D data and the knowledge behind it.

1.1. Scope

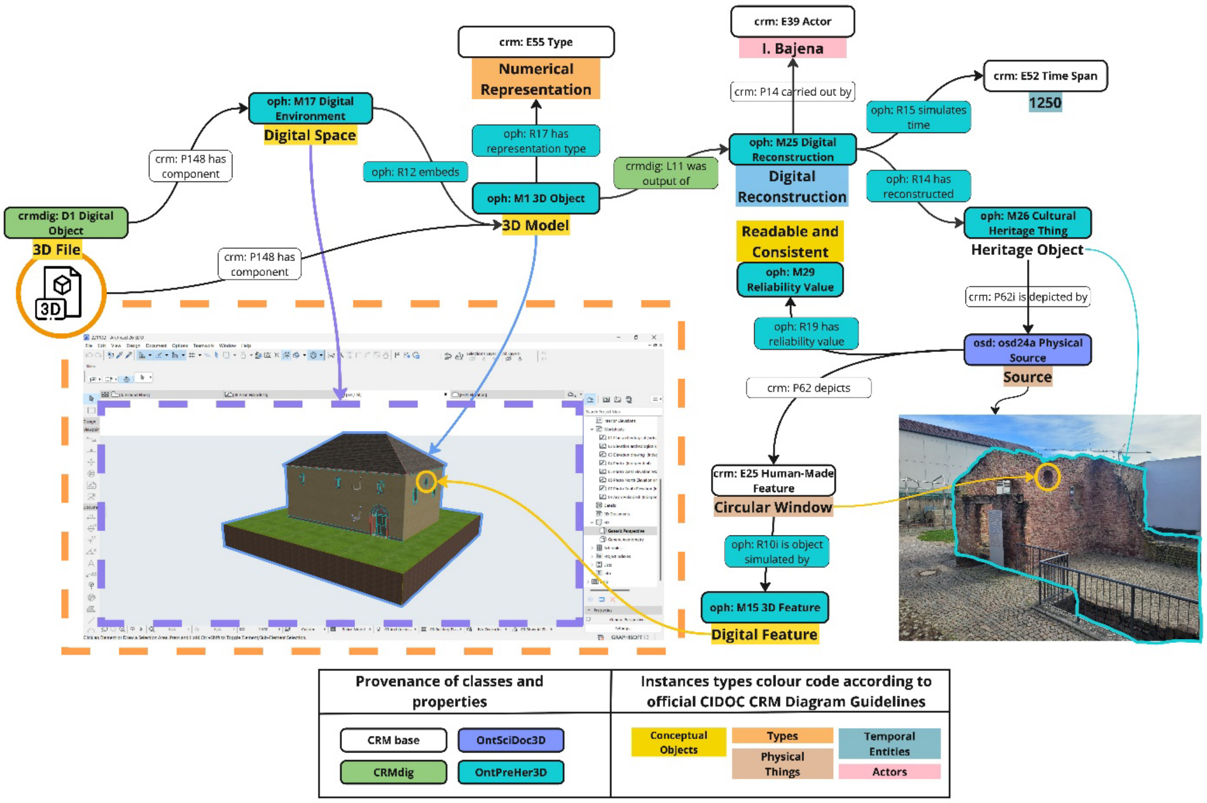

Figure 1 The OntPreHer3D conceptual model

OntPreHer3D is an application ontology built as an extension of CIDOC-CRM, and OntSciDoc3D designed to support the comprehensive preservation of cultural heritage 3D models. It semantically maps the intricate relationships between 3D models, their features, real-world counterparts, and the metadata needed to document both digital and hypothetical reconstructions—from photogrammetric point clouds to interpretive reconstructions and never-realized architectural concepts. Ontology enables 3D models to be treated as scientific work with identifiable versions and variants, introduces the process of object segmentation into parts as the basis for documenting hypotheses entered in 3D, enables the classification of source materials and the assessment of uncertainty in the result of the virtual reconstruction process. Classes and properties are also introduced to enable the documentation of computer techniques used to create models and the accurate recording of digital simulations of materials and geometry.

The model is built on the same principles of the CIDOC CRM. As in CRM, indeed, the semantics of the building are rendered as properties between two classes. The model reuses, when appropriate, parts of the CIDOC CRM classes and properties, and refers to other CRM extensions that were developed to ensure the completeness of documentation. In particular, it explicitly incorporates extensions from the CRM ecosystem—including CRMdig (Doerr et al., 2022), CRMinf (Doerr et al., 2023), and LRMoo (Bekiari et al., 2023) — to address specialised need, but also it extends the functionality of the OntSciDoc3D (Kuroczyński & Große, 2020), a complementary ontology from the former research group team.

1.2. Status

The OntPreHer3D is the result of research carried out in the framework of the CoVHer project and is part of the outcome of the PhD thesis by Igor Piotr Bajena with title "Digital 3D reconstruction as a research environment in art and architecture history. Infrastructure for documentation and publication" (Bajena, 2025). The ontology is **actively under development**, with the latest version (v2) published in July 2025 on GitHub.

1.3. Naming convention

All the classes declared were given both a name and an identifier constructed according to the conventions used in the CIDOC CRM model. For classes that identifier consists of the letter M followed by a number. Resulting properties were also given a name and an identifier, constructed according to the same conventions. That identifier consists of the letters R followed by a number, which in turn is followed by the letter "i" every time the property is mentioned "backwards", i.e., from target to domain (inverse link). 'M' denotes from "3D Model" and "R" from "Relationship". They correspond respectively to letters "E" and "P" in the CIDOC CRM naming conventions, where "E" originally meant "entity" (although the CIDOC CRM "entities" are now consistently called "classes"), and "P" means "property". Whenever CIDOC CRM classes are used in our model, they are named by the name they have in the original CIDOC CRM. CRMinf classes and properties are referred with their respective names, classes denoted by I and properties by J, CRMdig classes and properties are referred with their respective names, classes denoted by D and properties by L. LRMoo classes and properties are referred with their respective names, classes denoted by F and properties by R. OntSciDoc3D classes are denoted by osd and properties by P and added underscore at the end of property followed by additional number.

2.Classes and properties hierarchy

2.1. External Ontologies

List of external ontologies used for data model:

- CIDOC CRM v 7.1.3.
- OntSciDoc3D v 2.0
- CRMdig v 4.0
- CRMinf v 1.0

List of external ontologies used for class hierarchy reference:

- LRMoo v 0.9.6

2.2. Classes declaration

Status 23.07.2025

M1 3D Object

Subclass of:

D1 Digital Object

E26 Visual Item

Scope note:

This class comprises a virtual three-dimensional simulation of E70 Thing of a conceptual or physical nature that can be considered as a single digital unit. M1 3D Object can be described through a set of M15 Digital Features, which simulates their physical equivalents of E26 Physical Feature observed directly on the E70 Thing or its carrier of information (osd31b Source). This class can constitute a collection of points in a virtual space unconnected to each other (point cloud) or connected through lines, curves or planes, which form a specific M23 Digital Shape consisting of M16 Digital Material.

M1 3D Object can only be visually perceived by E39 Actor within the context of E17 Digital Environment. M1 3D Object, together with M17 Digital Environment, creates a digital spatial or spatiotemporal simulation saved as a file with a specific format (D1 Digital Object). M1 3D Object does not depend on a specific physical carrier and can exist simultaneously on one or more carriers. It can also be transferred to another instance of M17 Digital Environment through a process of D7 Digital Machine Event. However, this process can change its perception due to the differences in geometrical, morphological and materials simulations specifications, which are highly dependent on characteristics of M17 Digital Environment.

Examples:

Manually created (M23) digital 3D model (M1) of hypothetical reconstruction (M25) of heritage object (M26)

Raw point cloud (M1) acquired from laser scanning (osd7a)

Processed 3D mesh (M1) acquired from the photogrammetry process (osd7a)

Properties:

R4 is preceding version of (has preceding version): M1 3D Object

R5 is following version of (has following): M1 3D Object

R6 is alternation of (has alternation): M1 3D Object

R7 has position (is position of): M18 Digital Position

R12 is located within (locates): M17 Digital Environment

Same as:

CRMvr: V8 3D Object (https://github.com/elisabettacaterina/CRMvr)

M5 Digital Publication Event

Subclass of:

D7 Digital Machine Event

Scope note:

This class comprises the activities of selecting, arranging and presenting one or more instances of D1 Digital Object available in electronic form on a public network to communicate it to some public audience. This event happens on physical digital devices following a human activity that intentionally caused its immediate or delayed initiation. This results in the creation of an instance of an M6 Digital Record with published instances of a D1 Digital Object on behalf of the human actor.

Examples:

Process of publication of a video (D1) titled “Digital Reconstruction – New Synagogue in Breslau” on the Vimeo (https://vimeo.com/417172262)

Process of uploading a 3D model of the “Central Part Dome Part (CPDP)” (M1) of the digital reconstruction (M25) of the Synagogue in Breslau (M26) to the public viewer in the Sketchfab Repository (https://sketchfab.com/3d-models/cpdp-4a180e83961147b2bda7541b50ec8a2e)

Process of publication of the article "Digital Reconstruction of the New Synagogue in Breslau: New Approaches to Object-Oriented Research" (E73) by Springer publisher (E39) on the website (https://doi.org/10.1007/978-3-030-93186-5_2)

Properties:

R1 published (was published by): D1 Digital Object

R8 digitally created (was digitally created through): M5 Digital Publication Event

M6 Digital Record

Subclass of:

D1 Digital Object

E31 Document

E33 Linguistic Object

F3 Manifestation

Scope note:

This class comprises a publicly available and identifiable digital set of items that make propositions about part of reality, constituting a specific subject. M6 Digital Record can be created only as a result of the M5 Digital Publication Event conducted by E39 Actor. Each M6 Digital Record has its own E42 Identifier as a URI web address of a digital resource on the web. The M6 Digital Record includes the published set of D1 Digital Object instances with any metadata, allowing a better understanding of the published resource. The M6 Digital Record is intended to disseminate the resource with first-hand information in a linguistic manner that humans understand. Therefore, it also constitutes an instance of the E33 Linguistic Object.

Examples:

Wikipedia Article titled "Nowa Synagoga we Wrocławiu" (E35) in Polish (E56) translation by Wikipedia Editors Community (E39) available at https://pl.wikipedia.org/wiki/Nowa_Synagoga_we_Wroc%C5%82awiu (E42)

Record of a protected area "ShUM Sites of Speyer, Worms and Mainz" (E35) on the UNESCO (E39) list in English (E56) available at https://whc.unesco.org/en/list/1636 (E42)

Entry "Mainz – Worms – Speyer. Drei mittelalterliche Städte im ZentrumEuropas als Linked Data" (E35) in German (E56) on the AI MAINZ (E39) website available at https://architekturinstitut.hs-mainz.de/projects/mainz-worms-speyer (E42)

YouTube Video "What was the Role of Synagogues during the Second Temple Period? | Spotlight on History | Synagogues" (E35) in English (E56), published by Bible Discovery TV (E39) available at https://www.youtube.com/watch?v=M_44yS_Fgj4 (E42)

M14 Research Project

Subclass of:

E7 Activity

Scope note:

This class comprises a series of activities to find answers to scientific questions conducted by instances of E39 Actor, which are most often research institutions or universities. It commonly requires external funding and interdisciplinary consultation. It involves the preparation of adequate documentation of conducted instances of E7 Activities following academic work ethics and their discipline's internal requirements. The M14 Research Project is always motivated by specific objectives and has predetermined goals to be achieved in a defined E52 Time Span.

Examples:

Project (M14) of hypothetical source-based digital 3D reconstruction (M25) of the New Synagogue in Breslau (M26) by AI MAINZ (E39) (https://www.new-synagogue-breslau-3d.hs-mainz.de/)

Project (M14) "Computer-based Visualization of Architectural Cultural Heritage (CoVHer)" (E35) co-funded by the Erasmus+ Programme of the European Union (E74) (https://covher.eu/project/)

Student seminar (M14) on digital reconstruction (M25) of wooden synagogues (M26) held at the Faculty of Architecture of Warsaw University of Technology (E39) in the summer semester of the academic year 2022/23 (E52)

M15 Digital Feature

Subclass of:

M1 3D Object

Scope note:

This class comprises identifiable features that are digitally attached in an integral way to particular digital objects. M15 Digital Feature refers only to the specific part of an M1 3D Object, which the physical equivalent would not constitute a separate physical unit. Instances of M15 Digital Feature share many of the attributes of instances of M1 3D Object. They may have a one-, two- or three-dimensional geometric extent. The instances of M15 Digital Feature represent instances of the M39 Feature, which could be observed directly on the E71 Man-Made Thing or its carrier of information (osd31b Source) and which are transferred to the M17 Digital Environment in the process of M25 Digital Reconstruction.

The M15 Digital Feature consists of two components that simulate the shape of an object (M22 Digital Shape) and a surface finish that simulates reactions of materials to light (M16 Digital Material). In the vast majority of cases, both components have their counterparts, instances of which can exist in the physical world and are defined as E57 Material for surface finishes and M21 Shape for geometric shapes that can be measured and expressed in mathematical coordinates and functions.

Examples:

CAD drawing of the profile of the cornice crowning (E26) St. Peter's Basilica in Rome (M26)

Digitally reconstructed proportions of the dome (E26) of the demolished (E3) New Synagogue in Wroclaw (M26)

Digital reconstruction of the rosette (E26) of Notre Dame Cathedral (M26)

Properties:

R13 consists of (is incorporated in): M16 Digital Material

M16 Digital Material

Subclass of:

E55 Type

Scope note:

This class is a specialisation of E55 Type and comprises the concepts of digital representations of E57 Materials. It consists of attributes encoded in a 3D file containing information about the material's colour, roughness, light emission, reflexivity, or transparency. The material can also be simulated by applying an image (E36, D1) to the surface of an M1 3D Object through an M24 Texture Mapping. Images can affect the surface's colour and pattern or create the illusion of depth or irregularity. Connecting several images to represent the same material is possible, but each image will be responsible for simulating a different property of the material's surface.

This type is used categorically in the model without reference to instances of it, i.e., the model does not foresee the description of instances of M16 Digital Material, e.g., “instances of gold”.

Examples:

Old Abandoned Building Wood Plank Flooring PBR Material (M16) #3 for Blender (D14) (https://freepbr.com/materials/old-wooden-flooring-3/)

Seamless (tileable) Dirty Glass PBR Texture (M16) with eight maps (M20): albedo/diffuse, reflection, glossiness, height/displacement, roughness, metalness, ambient occlusion and normal map (https://cgaxis.com/product/dirty-glass-pbr-texture/)

M17 Digital Environment

Subclass of:

D1 Digital Object

E92 Spacetime Volume

Scope note:

This class comprises a 4-dimensional environment in digital spacetime simulation in D14 Software, programmed for creating and displaying instances of M1 3D Objects. The program associated with 3D models always has an individual coordination system to locate the position of M1 3D Object in digital space. The fourth dimension is a characteristic of animated models only and, in most cases, is not considered. M17 Digital Environment has individual features that affect the perception of the placed M1 3D Object, such as the light or the camera through which the object is observed.

The central point (0,0,0) is an integral part of the M17 Digital Environment. Each M1 3D Object placed in the space has its own M18 Digital Position, which is described in relation to the central point of the space. The object's position is determined by its pivot, the relative point to which all operations on the 3D object are performed. The pivot should be approximately at the centre of gravity of the object.

Examples:

Modelling space (M17) inside the scene of the Blender program (D14)

Interaction space (M17) with 3D model (M1) in Sketchfab online repository

Properties:

R10 is simulated by (simulates): D13 Software

M18 Digital Position

Subclass of:

D1 Digital Object

E53 Place

Scope note:

This class comprises the location of M1 3D Object in digital space expressed by set of E59 Primitive Values that should be implemented with appropriate validation, precision and references to spatial coordinate or relative to central point of M17 Digital Environment. In the same time, it serves as a declaration of E53 Place, but in digital world for M1 3D Object. M18 Digital Position of M1 3D Object may not have anything to do with the location of the actual equivalent of the 3D object in the real world expressed by E53 Place.

Examples:

x = 4.07625 m, y = 1.00545 m, z = 6.35832 m (in Blender coordination metric system)

Properties:

R11 refers to coordinate system within (has coordinate system referred to): M17 Digital Environment

M19 Simulation

Subclass of:

D10 Software Execution

E13 Attribute Assignemnt

Scope note:

This class comprises events that happen on physical digital devices following a human activity that intentionally caused its immediate or delayed initiation and results in the creation of a virtual 3D representation simulating a certain E3 Condition State of instance of M26 Cultural Heritage Thing.

The input of a D7 Digital Machine Event is a three-dimensional digital model, an instance of an M1 3D Object in a specified M17 Digital Environment. Due to technological limitations or lack of sufficient source material, it should be borne in mind that M19 Simulation most often does not represent a perfect copy of the simulated object state but is rather an attempt to interpret the output, the end result of which is subject to a certain level of guesswork expressed by the M28 Uncertainty Value. Assumptions regarding the technology limitation can be expressed by the M27 Accuracy Value and limitations to the source material by the M29 Reliability Value.

Examples:

Hypothetical realistic simulation (M19) of the reconstruction (M25) of the destroyed (E3) New Synagogue in Wroclaw (M26) via the Sketchfab viewer (M17) (Kuroczyński et al., 2021)

Non-photorealistic visualisation (M19) Maison d'un employè, Cité idéale de Chaux by Ledoux with use of texture projection and procedural mapping based on original architect drawings (Apollonio et al., 2021)

Properties:

R10 simulates (is simulated by): M26 Cultural Heritage Thing
R18 has accuracy value (is accuracy value of): M27 Accuracy Value
R31 generated digital representation (is digital representation generated by): M1 3D Object

M20 Digital Property

Subclass of:

E89 Propositional Object

Scope note:

This class comprises the intrinsic knowledge about how M16 Digital Material representing instances of E57 Material are simulated on surfaces of M1 3D Object. It consists of attributes encoded in a 3D file about the colour, roughness, light emission, reflexivity, transparency or any other property of the material. The material can also be simulated by applying an image (E36, D1) to the surface of a M1 3D Object through a texturing process. Images can affect the colour and pattern of the surface or create the illusion of depth or irregularity on the surface. The method of mapping images to the M15 Digital Feature surface is determined by M24 Texture Mapping.

Examples:

Node graph (E73) for material (M16) setup with parameters (E59) in Blender (D14)

Material (M16) property manager (E73) setup with parameters (E59) in ArchiCAD (D14)

M21 Shape

Subclass of:

E55 Type

Scope note:

This class is a specialisation of E55 Type. It comprises the concepts of shapes and forms of conceptual and physical in two- and three-dimensional space. According to Getty Art&Architecture Thesaurus it is the outline, form, or characteristic configuration of an object, including its contours, which define the external form or outer boundary of the object.

Examples:

Biforia window shape

Cylinder

Outline of the city’s skyline

M22 Digital Shape

Subclass of:

E55 Type

Scope note:

This class is a specialisation of E55 Type. It comprises the concept of digital interpretations of the M22 Shape. M22 Digital Shape most often does not accurately reflect the actual form of the M21 Shape. Its digital representation adopting certain simplifications allowing an appropriate perception of the target form or shape.

Examples:

triangulated mesh of building model

segmented arc

idealised plan of a historical building based on right angles

NURBS-based ideal semisphere

M23 3D Modelling Technique

Subclass of:

osd75p Technique

Scope note:

This class is a specialisation of osd75p Technique. It comprises the classification of activities of constructing the M22 Digital Shape of M1 3D Object (e.g., algorithmic 3D modelling can be used to generate 3D models that are defined with NURBS or mesh representation methods).

Examples:

algorithmic modelling

digital sculpting

direct hand-made 3D modelling

semi-automatic reality-based 3D modelling

M24 Texture Mapping

Subclass of:

D10 Software Execution

Scope note:

This class comprises events by which a digital device runs a series of computing operations on an M1 3D Object as a single task to apply an image to the surfaces of the 3D object to simulate a material. M24 Texture Mapping is predefined by a series of decisions regarding the material properties, texture image selection, and mapping method selection by the human.

Examples:

UV Mapping

Planar Mapping

Box Mapping

Cylinder Mapping

Sphere Mapping

Node Mapping

Source:

https://manual.keyshot.com/manual/textures/mapping-types/

M25 Digital Reconstruction

Subclass of:

osd7a Research Activity

D7 Digital Machine Event

Scope note:

This class comprises actions intentionally carried out by instances of E39 Actor that result in digital reconstruction of a specific E3 Condition State of M26 Cultural Heritage Thing as a new instance of M1 3D Object. The reconstruction of a cultural object's past states is always subject to a certain degree of uncertainty, so M25 Digital Reconstruction can result in multiple instances of the M1 3D Object showing different stages of the reconstruction work or different versions of the final reconstruction.

This class encompasses not only the process of creating the model itself but all instances of E7 Activities that support this process, such as collecting source materials, digitising source materials, critically analysing the collected materials, or searching for analogies to fill gaps in building knowledge.

Examples:

Hypothetical source-based digital 3D reconstruction (M25) of the New Synagogue in Breslau (M26) as it looked in 1872 (E3) by AI MAINZ (E39) (https://www.new-synagogue-breslau-3d.hs-mainz.de/wisski/navigate/1164/view)

Hypothetical reconstruction (M25) of the church of Santa Margherita in Bologna (M26) by University of Bologna - Department of Architecture (E39), variant as designed by Angelo Venturoli in 1792 (E3) (https://doi.org/10.1007/s00004-023-00707-2)

Digital documentation (M25) of Synagogue in Przysucha (M26) through laser scanning (osd7a) in 2022 (E3)

M26 Cultural Heritage Thing

Subclass of:

E71 Human-Made Thing

Superclasss of:

E24 Physical Human-Made Thing

E28 Conceptual Object

Scope note:

This class comprises discrete, identifiable human-made items that hold the legacy of the past generation and are documented as single units. These items are either intellectual products (intangible heritage) or human-made physical things (tangible heritage), characterised by relative stability. M26 Cultural Heritage Thing offers a bridge between the past and the future by applying particular approaches in the present. Due to its attached values for groups or societies inherited from the past, cultural heritage is maintained in the present and bestowed for the benefit of future generations.

Examples:

Michelangelo’s David sculpture (E22)

Destroyed (E3) New Synagogue in Wroclaw (E22)

Design of never-realized (E3) Volkshalle by Albert Speer (E39)

Ruins (E3) of Acropolis of Athens (E22)

Treatise on Architecture by Vitruvius (E89)

M27 Accuracy Value

Subclass of:

E89 Propositional Object

Scope note:

This class is a specialisation of E89 Propositional Object and comprises the precision of the representation of the M1 3D Object in relation to the collected source materials (osd31b Source) and their provenance used in the M25 Digital Reconstruction process. It can also be understood as the level of detail of the reconstruction and explains what margin of error was assumed by the E39 Actor performing the M25 Digital Reconstruction. It can be expressed in terms of scale (e.g., 1:500). In the case of digital reconstructions based on the process of digitisation, the model's accuracy corresponds to the measurement accuracy of the M8 Digital Device.

Examples:

1:50

1 cm

0,5 mm

M28 Uncertainty Value

Subclass of:

E89 Propositional Object

Scope note:

This class is a specialisation of E89 Propositional Object and comprises reconstructed parts of M1 3D Object that are historically uncertain in comparison to its equivalent of M26 Cultural Heritage Thing in certain E3 Condition State that they represent. The more hypothetical the reconstitution, the more its level of uncertainty increases. Due to the subjective value and hypothesis burden, the M28 Uncertainty Value instance should be assigned by using I5 Inference Making expressing fuzziness of logic statements. M28 Uncertainty Value can be expressed as numerical or string value on a specific Uncertainty Scale (I3 Inference Logic) or be calculated by a mathematical formula (I3 Inference Logic) that takes into account the values estimated for different semantic parts of the object. as a percentage value, or through a string indicating the level of uncertainty.

Examples:

“03” (E60) in 5-level uncertainty scale of Irene Cazzaro (I3) for portal reconstruction (M25) of the Speyer Synagogue (M26) which stands for deduction (E55) (2025, https://doi.org/10.11588/arthistoricum.1440)

28% (E60) of uncertainty in digital reconstruction (I5) of Piazza delle Erbe calculated with formula of Average Uncertainty Weighted on the Volume with Relevance factor (AU_VR) (I3) published by Apollonio et al. (2023, https://doi.org/10.3390/heritage7010023) “low” (E59) uncertainty value of the reconstruction (I5) of the dome of the New Synagogue in Wroclaw (M26) in a 3-level scale (low-medium-high) (I3) by Kuroczyński et al. (2021, https://doi.org/10.1007/978-3-030-93186-5_2)

Same as:

CRMvr: V21 Uncertainty Grade (https://github.com/elisabettacaterina/CRMvr)

M29 Reliability Value

Subclass of:

E89 Propositional Object

Scope note:

This class captures the outcome of a M63 Reliability Assessment, expressing the overall degree of confidence in a source (osd_31b_Source). Reliability is derived from multiple dimensions—including provenance and source type, readability (as measured by M61 Readability Value), consistency across sources (via M62 Consistency Value), physical condition such as damage or distortion, and contextual fidelity (e.g., perspective or scale accuracy). The Reliability Value may be expressed as a percentage (0–100 %) or as a qualitative grade such as “high,” “moderate,” or “low.” By integrating these factors, it enables transparent and reproducible evaluation, aligning with uncertainty-reduction principles in digital heritage.

Examples:

85% reliability for a well-documented archival photograph with consistent readings and good provenance.

“Moderate” reliability for mixed-quality drawings with partial contradictions and unclear origins.

60% reliability for a damaged manuscript with uncertain authorship but consistent detail where legible.

Same as:

CRMvr: V22 Accuracy Grade (https://github.com/elisabettacaterina/CRMvr)

M30 Raw Data

Subclass of:

M1 3D Object

D9 Data Object

Scope note:

This class is a specialisation of M1 3D Object. It comprises the unprocessed information instrumentally acquired from reality (e.g., from the preserved remains of built heritage through laser scanning or photogrammetry) necessary to create the instance of M31 Raw model (e.g., the photos for a photogrammetric campaign).

The M30 Raw Data is independent of the user's subjective influence by definition, namely, it only represents metric and colourimetric information (that is, objective up to the accuracy of the acquisition technology used) and does not contain any interpretative or creative additions by any author. If two different users acquire the same physical object through the same instrument with the same input settings and environmental/boundary conditions, the data from the two campaigns would be analogous. The difference between classes M30 Raw Data and M31 Raw Model is that the M30 Raw Data does not necessarily have to be three-dimensional (e.g., the photographic set for photogrammetry before processing is raw data).

Examples:

Point Cloud acquired through laser scan

Photographs set prepared for photogrammetry

M31 Raw Model

Subclass of:

M1 3D Object

Scope note:

This class is a specialisation of the M1 3D Object and comprises digital 3D models obtained through quasi-automatic procedures. These models are generated from M30 Raw Data captured from physical sources (osd24a Physical Source) with minimal subjective interpretation by the operator (E21 Person) (e.g., digital photogrammetry, laser scanning). Potential sources may include archaeological remains (e.g., the ruins of a Roman theatre), in which case the M31 Raw Model could take the form of a point cloud or a textured mesh model.

The M31 Raw Model is one of the two main categories of M1 3D Object, alongside the M32 Informative Model. The key difference between these two categories is conceptual: the raw model represents only dimensional data (and, in some cases, colorimetric data) acquired from an E19 Physical Object. In contrast, the M32 Informative Model represents the outcome of a complex interpretation process involving various sources (E73 Information Object). The M32 Informative Model is typically produced through a reverse-engineering process. There is also a technical distinction between these two categories. The M31 Raw Model always contains discrete data (numerical or polygonal). On the other hand, the M32 Informative Model can be represented using a variety of digital methods (both continuous and discrete) and created using diverse modelling techniques (M23 3D Modelling Technique) (e.g., parametric modelling, direct handmade modelling, or polygonal modelling).

Examples:

A textured mesh model obtained through photogrammetry after processing conducted by humans

A combined point cloud file created from multiple laser scans

M32 Informative Model

Subclass of:

M1 3D Object

Scope note:

This class is a specialisation of the M1 3D Object and comprises digital 3D models that are the result of informed interpretation processes. These models are generated through reverse-engineering procedures, typically executed by computational systems, in which an E21 Person uses digital tools to transform M30 Raw Data or an M31 Raw Model into a new 3D representation enriched with interpretative, geometric, and semantic content. Alternatively, M32 Informative Models can also be created entirely through manual modelling workflows—without relying on raw data—particularly when reconstructing historical, hypothetical, or never-built M26 Cultural Heritage Thing. In such cases, the model is constructed based solely on one or more E73 Information Objects (e.g., archival documents, architectural drawings, historical narratives, or visual sources).

Unlike M31 Raw Models, which aim to preserve the dimensional characteristics of an E19 Physical Object with minimal interference, M32 Informative Models are the outcome of modelling decisions and interpretative reasoning. These decisions are guided by a variety of information sources and can be realised through diverse M23 3D Modelling Techniques (e.g., parametric modelling, CAD-based manual modelling, or hybrid workflows). The resulting models may involve both discrete and continuous digital representations (e.g., polygonal meshes, NURBS surfaces, BIM elements).

The conceptual difference between M31 and M32 lies in the nature of their content: while the M31 Raw Model conveys only metric and colorimetric information directly acquired from physical reality, the M32 Informative Model introduces additional levels of meaning, such as inferred geometry, structural logic, or historical conjecture. Technically, the M32 Informative Model is not constrained to a discrete format and can incorporate both structured and free-form representations, depending on the modelling goals and techniques.

Examples:

A 3D reconstruction of a medieval church created based on archaeological remains, historical engravings, and scholarly hypotheses, modelled using CAD software.

A segmented and idealised 3D model of a Roman theatre derived from a laser-scanned mesh, where missing architectural elements are digitally reconstructed.

A 3D model of an unbuilt 18th-century theatre, reconstructed entirely from historical architectural drawings and textual descriptions.

M33 Website

Subclass of:

D1 Digital Object

Scope note:

This class comprises structured digital resources accessible via the web (e.g., HTML pages, scripts, media) that serve as platforms for presenting, documenting, or disseminating cultural heritage content. An M33 Website may include or represent instances of E31 Document (e.g., research reports), or function as an interface to access entities such as M1 3D Object or M32 Informative Model. It may consist of multiple digital components and is considered a composite digital object. M33 Website may carry scholarly information, support interaction with 3D content, or document the creation and interpretation of heritage-related resources. It can be associated with E21 Person or E40 Legal Body as its creator or maintainer.

Examples:

An online catalogue of digital heritage assets with interactive access (Europeana, https://www.europeana.eu/)

3D Repository of CoVHer project (https://repository.covher.eu/)

M34 Paradata

Subclass of:

D1 Digital Object

Scope note:

This class comprises information that documents the evaluative, analytical, interpretative, and creative decisions made during the creation of digital representations, particularly in the context of M25 Digital Reconstruction of M24 Cultural Heritage Thing. Paradata provides transparency regarding the methodologies, assumptions, and sources used during the modelling process, facilitating scholarly evaluation, reproducibility, and reuse.

Paradata may include details about source selection, modelling techniques, interpretative choices, and the rationale behind reconstructive decisions. It can be conveyed through various forms, such as textual documents (e.g., reports, annotations), embedded metadata within 3D models, or structured data formats like IFC or CityGML.

The importance of paradata is emphasized in Principle 4.6 of the London Charter (2009), which states that documentation of the evaluative, analytical, deductive, interpretative, and creative decisions made in the course of computer-based visualisation should be disseminated in such a way that the relationship between research sources, implicit knowledge, explicit reasoning, and visualisation-based outcomes can be understood.

Examples:

A report detailing the interpretative choices made during the 3D reconstruction of an ancient temple.

Annotations embedded within a 3D model explaining the sources and assumptions for specific architectural elements.

A metadata file accompanying a digital reconstruction, outlining the modelling techniques and historical references used.

M35 File

Subclass of:

D1 Digital Object

D13 Digital Information Carrier

Scope note:

This class comprises individual digital files that serve both as discrete digital objects and as carriers of digital content. Each M35 File represents a specific, structured sequence of bits, typically stored on a digital medium, and is identifiable by a filename and a file extension.

In the context of the ontology, every instance of D1 Digital Object is stored on a D13 Digital Information Carrier, with M35 File representing the most granular level of such carriers. The relationship between a digital object and its file carrier is expressed through the property L19 stores (is stored on), linking D13 Digital Information Carrier to D1 Digital Object.

Furthermore, each M35 File is associated with a specific file format, denoted by its file extension (e.g., .pdf, .obj, .tiff). This association is captured by the property R20 has file format (is file format of), which links M35 File to M45 File Format, specifying the encoding and structure of the file's content.

Examples:

A “model.obj” file containing a 3D architectural reconstruction.

A “report.pdf” file documenting the methodology of a heritage project.

Properties:

R20 has file format (is file format of): M45 File Format

M36 Conceptual Modification

Subclass of:

E7 Activity

Scope note:

This class comprises activities that result in changes to instances of E28 Conceptual Object, particularly those representing unrealised cultural heritage concepts (e.g., architectural designs, artistic plans). M36 Conceptual Modification captures the evolution of such conceptual entities over time, reflecting alterations in their content, structure, or interpretation. Unlike physical modifications, conceptual modifications occur within the realm of ideas and are often documented through various carriers, such as sketches, drafts, or digital files. These modifications may arise from iterative design processes, discussions, or reinterpretations, leading to new versions or states of the conceptual object. In the context of cultural heritage, M36 Conceptual Modification is essential for documenting the developmental history of conceptual works, especially those that were never physically realised. It provides a framework for understanding the intellectual processes behind the creation and transformation of cultural concepts.

Examples:

The revision of an architectural blueprint following client feedback, resulting in a new design version.

M37 Serial Number

Subclass of:

E42 Identifier

Scope note:

This class comprises unique identifiers assigned to individual instances of D8 Digital Device to distinguish them from other similar devices. A serial number is typically a combination of numbers and/or letters, assigned by the manufacturer, and serves as a means of identification, asset tracking, warranty verification, and quality control. Serial numbers are crucial for managing and tracking devices throughout their lifecycle, including manufacturing, distribution, maintenance, and decommissioning. They enable precise identification of devices, facilitating processes such as inventory management, technical support, and recall operations. While serial numbers are often physically affixed to devices (e.g., labels, engravings), they can also be stored digitally within the device's firmware or software. The format and structure of serial numbers may vary depending on the manufacturer's standards and the device type.

Examples:

The serial number "XYZ-987654321" designated for an individual digital camera.

The serial number "A1B2C3D4E5" associated with a particular smartphone.

The serial number "LLPDS2301234" assigned to a FARO Laser Line Probe (LLP) device.

M38 Segmentation

Subclass of:

osd7a Research Activity

D7 Digital Machine Event

Scope note:

This class comprises activities that involve the subdivision of an M26 Cultural Heritage Thing into distinct components, referred to as M39 Features. Segmentation facilitates the identification and classification of meaningful parts within cultural heritage objects, enhancing analysis, documentation, and interpretation. In the context of M25 Digital Reconstruction of hypothetical cultural heritage objects, segmentation is performed by identifying semantic elements (M39 Features) based on historical sources (osd_31b_Source). For existing physical objects, segmentation is conducted on their digitized representations, such as point clouds or 3D models.

Segmentation can be applied to various digital representations, such as M1 3D Objects (e.g., point clouds, meshes), and may utilize manual methods, semi-automated processes, or automated techniques. The process often involves assigning specific identifiers (E15 Identifier Assignment), classifications, or attributes to each feature (E13 Attribute Assignment), and establishing their spatial and hierarchical relationships within the whole.

Examples:

Semantic division of the building into parts regarding storeys

Semantic division of a building into semantic elements in the form of walls, floors, ceilings, windows, doors, stairs, and roofs.

Properties:

R24 segments (is segmented by): M26 Cultural Heritage Thing

R25 identifies (is identified by): M39 Feature

M39 Feature

Subclass of:

E28 Conceptual Object

Scope note:

This class comprises identifiable features that are integrally connected to instances of M26 Cultural Heritage Thing. Unlike E26 Physical Feature, which pertains solely to physical objects, M39 Feature extends to conceptual elements observed in design documents, architectural plans, or other sources (osd31b Source) representing unrealised or hypothetical cultural heritage entities. M39 Features may include architectural components such as windows, arches, or decorative motifs that are part of the conceptual design of a structure. These features are often identified through the process of M38 Segmentation and can be documented for analysis, interpretation, or digital reconstruction purposes. When an M39 Feature is digitally reconstructed, it results in an instance of M15 Digital Feature, representing the virtual manifestation of the conceptual or physical feature within a digital environment.

Examples:

The circular window depicted in the architectural drawing of an unbuilt Renaissance church.

The ornamental frieze design found in the conceptual plans of a historical palace.

The layout of a hypothetical courtyard identified in ancient manuscripts.

Properties:

R24 segments (is segmented by): M26 Cultural Heritage Thing

R25 identifies (is identified by): M39 Feature

M40 Derivative

Subclass of:

D1 Digital Object

Scope note:

This class comprises digital objects that are derived from pre-existing digital objects through a process of formal transformation. An M40 Derivative is typically created to adapt the original digital object for specific applications or purposes, such as augmented reality (AR), virtual reality (VR), 3D printing, or animation.

The derivation process is documented as an instance of D3 Formal Derivation, which records the transformation from the source digital object to the derivative. This process may involve changes in format, resolution, geometry, or other attributes to meet the requirements of the intended application.

In the context of digital reconstructions (M25 Digital Reconstruction), an M40 Derivative may be produced by modifying an existing M32 Informative Model to create a version optimized for a particular use case. These derivatives maintain a representational relationship to the original cultural heritage object but are tailored to specific functional or technical needs.

Examples:

A simplified 3D model derived from a detailed M32 Informative Model, optimized for real-time rendering in a VR application.

A high-resolution mesh generated from an M31 Raw Model, prepared for 3D printing.

An animated sequence created by deriving motion data from a static M1 3D Model.

M41 Preview File

Subclass of:

M35 File

E36 Visual Item

Scope note:

This class comprises digital files that serve as visual previews of other digital objects, typically to facilitate quick identification, selection, or browsing. Instances of M41 Preview File are derived from existing digital objects (D1 Digital Object) and provide a visual representation without encompassing the full content or functionality of the source object.

Preview files are commonly generated through formal derivation processes (D3 Formal Derivation) and are used in various contexts, such as displaying thumbnails of images, cover images of books, or simplified versions of 3D models for quick rendering in viewers. They are integral in digital asset management, user interfaces, and content delivery systems where visual cues enhance user interaction and navigation.

Examples:

A JPEG image depicting the cover of a digitized manuscript, serving as a thumbnail in a digital library catalogue.

A low-resolution PNG snapshot of a high-resolution 3D model, used as a preview in a 3D asset repository.

A GIF animation showing a rotating view of a 3D artifact model, providing a quick visual summary in an online exhibition platform.

M42 Render

Subclass of:

M41 Preview File

Scope note:

This class comprises digital visual representations generated through rendering processes that convert 3D models (M1 3D Object) into 2D images or animations (E38 Visual Item). These renders are produced using specialized rendering software that simulates lighting, shading, texture, and perspective to create realistic or stylized visuals from a specific viewpoint.

Renders serve as visual previews or illustrative representations of digital reconstructions (M25 Digital Reconstruction), informative models (M32 Informative Model), or other 3D assets. They are commonly used in documentation, presentations, publications, and digital exhibitions to convey the appearance or design of cultural heritage objects.

Examples:

A photorealistic image of a reconstructed ancient temple generated from a 3D model using ray tracing techniques.

An animation showcasing the interior of a historical building, created through rendering software for a virtual tour.

A stylized render of a medieval castle used in an educational publication to illustrate architectural features.

M43 Screenshot

Subclass of:

M41 Preview File

Scope note:

This class comprises digital images captured directly from a computer or device screen, representing the visual output displayed at a specific moment. Screenshots are typically used to document the current state of digital objects, such as 3D models (M1 3D Object), during various stages of development or analysis.

In the context of hypothetical 3D digital reconstructions (M25 Digital Reconstruction), screenshots serve as quick documentation tools to capture progress, illustrate issues, or record specific views without the need for formal rendering processes.

Examples:

A screenshot capturing the wireframe view of a 3D model during the modelling process.

An image showing the user interface of a 3D modelling software with the current project open.

A captured screen displaying the results of a simulation or analysis performed on a digital reconstruction.

M44 License

Subclass of:

osd30a Copyright

Scope note:

This class comprises legal documents that specify the terms and conditions under which a digital object (D1 Digital Object) can be accessed, used, modified, or redistributed. Licenses serve as formal agreements between the rights holder (licensor) and the user (licensee), delineating the permissions granted and any associated restrictions.

In the context of digital cultural heritage, licenses are essential for clarifying the allowable uses of digital assets, such as 3D models, images, texts, and datasets. They ensure that users understand their rights and obligations, facilitating the responsible sharing and reuse of digital content.

Examples:

A Creative Commons Attribution 4.0 International (CC BY 4.0) license applied to a digital photograph of a historical artifact.

A GNU General Public License (GPL) applied to the source code of an open-source 3D modeling software.

A custom license agreement specifying the terms of use for a digitized manuscript in an online archive.

M45 File Format

Subclass of:

E55 Type

Scope note:

This class comprises standardized designations that specify the format in which a digital file (M35 File) is encoded. File formats determine how data is structured and stored, influencing the compatibility, usability, and preservation of digital content. Common file formats include extensions such as .3dm for 3D models, .jpeg for images, .pdf for documents, and .mp4 for videos. Understanding the file format is essential for selecting appropriate software tools for rendering, editing, or converting digital files. In the context of digital cultural heritage, documenting the file format ensures long-term accessibility and interoperability of digital assets across various platforms and systems.

Examples:

.3dm – Rhino 3D Model

.jpeg – JPEG Image

.pdf – Portable Document Format

.mp4 – MPEG-4 Video

M46 Affiliation Assignment

Subclass of:

E13 Attribute Assignment

Scope note:

This class comprises events in which an affiliation between an actor (E39 Actor) and a group or institution (E74 Group) is established, modified, or terminated. Such affiliations can include employment, membership, collaboration, or any formal association relevant to the documentation and interpretation of cultural heritage.

The M46 Affiliation Assignment records the nature of the relationship, the parties involved, the time-span during which the affiliation is or was valid, and any relevant roles or responsibilities assigned. This information is crucial for understanding the provenance of cultural heritage documentation, the context of data creation, and the network of contributors involved in cultural heritage projects.

Examples:

The assignment of Dr. Jane Smith (E21 Person) to the role of Chief Curator at the National Museum (E74 Group) from 2015 to 2020.

The affiliation of the Archaeological Institute (E74 Group) with the University of Bologna (E74 Group) for a collaborative excavation project initiated in 2018.

The termination of membership of John Doe (E21 Person) from the Historical Preservation Society (E74 Group) in 2022.

M47 Classification Assignment

Subclass of:

E13 Attribute Assignment

Scope note:

This class comprises activities in which an instance of E39 Actor assigns one or more classifications (E55 Type) to an instance of E1 CRM Entity within a specific context or scope. Such classifications serve to categorize, describe, or qualify the entity based on defined criteria, facilitating organization, analysis, and retrieval.

Examples:

Assigning the classification "point cloud" to a 3D model based on its data structure.

Attributing the classification "numerical" to a model reflecting its geometric continuity.

M48 Relation Assignment

Subclass of:

E13 Attribute Assignment

Scope note:

This class comprises activities in which an instance of E39 Actor assigns a specific relationship between two instances of E1 CRM Entity. The nature of the relationship is defined by an instance of E55 Type, indicating the kind of association established between the entities. M48 Relation Assignment is utilized to explicitly document the presence of a relationship, such as "is part of," "is similar to," or "is derived from," between two entities. This assignment facilitates the representation of complex inter-entity connections, enabling nuanced documentation and analysis within cultural heritage information systems.

Examples:

Assigning the relation "is part of" between a digital reconstruction of a cathedral nave (M1 3D Object) and the overall cathedral model (M1 3D Object).

Documenting the relation "is based on" between a scholarly article (E31 Document) and a historical manuscript (E22 Man-Made Object).

M49 Method

Subclass of:

E29 Design or Procedure

Scope note:

This class comprises documented, repeatable procedures or systematic approaches employed to achieve specific objectives, particularly within scientific, technical, or scholarly contexts. Instances of M49 Method encapsulate the organized sequences of actions, techniques, or rules designed to conduct research, perform analyses, or execute tasks in a consistent and reproducible manner.

In the cultural heritage and digital humanities, M49 Method is instrumental in detailing the methodologies applied during processes such as 3D digital reconstruction (M25 Digital Reconstruction), data acquisition, analysis, and interpretation. Documenting these methods enhances transparency, facilitates peer evaluation, and supports the reproducibility of results, aligning with best practices in scientific research.

An instance of M49 Method can be associated with specific activities (E7 Activity) through the property P33 used specific technique, indicating the application of the method within a particular context. This association aids in understanding the procedural aspects that underpin the creation or analysis of cultural heritage objects and their digital representations.

Examples:

The methodology for photogrammetric documentation of archaeological sites.

A standardized procedure for classifying architectural elements in historical buildings.

M50 Spatial Configuration

Subclass of:

E55 Type

Scope note:

This class comprises classifications that describe the spatial structure of a 3D model (M1 3D Object) based on its geometric representation. It is one of the possible taxonomies for classification of 3D models in terms of digital representation method. Spatial configurations provide insights into how a 3D model is constructed and visualized, which is essential for understanding its intended use, and compatibility with various applications such as simulation, analysis, or visualization. Assigning a spatial configuration to a 3D model aids in determining its suitability for specific tasks and ensures proper handling in various computational processes.

Examples:

Classifying a 3D architectural model as "Solid" for structural analysis.

Designating a scanned artifact model as "Surface" for visualization in a virtual museum.

M51 Geometric Continuity

Subclass of:

E55 Type

Scope note:

This class comprises classifications that describe the smoothness and continuity of a 3D model's (M1 3D Object) geometry, focusing on the seamless connection between surfaces or curves. It is one of the possible taxonomies for classification of 3D models in terms of digital representation method. Geometric continuity is typically categorized into levels, denoted as G^n, where higher values of "n" indicate smoother transitions between surfaces. For instance, G^0 continuity ensures that surfaces meet at a point, G^1 continuity ensures that surfaces share a common tangent direction at the junction, and G^2 continuity ensures that surfaces have matching curvature at the junction.

Assigning a geometric continuity classification to a 3D model aids in understanding its suitability for specific applications, such as simulation, manufacturing, or visual rendering.

Examples:

Mathematical representation of geometry in a NURBS-based 3D model.

Numerical representation of geometry in point cloud model.

M52 Level of Development

Subclass of:

E55 Type

Scope note:

This class comprises classifications that describe the extent to which a M25 Digital Reconstruction has been developed in terms of its geometric detail, informational content, and the reliability of the represented data. The Level of Development (LoD) provides an agreed framework to articulate the maturity and usability of a model at various stages of its lifecycle. Assigning a Level of Development to a 3D model ensures clear communication among project participants regarding the model's current state and its suitability for specific purposes.

Examples:

Defining 3D geometry shape representations as cubes in city model with white material instead of textures

Defining usage of BIM models with geometry representation on level of LOD400, symbolic materials as ready assets identified from historical sources and assignment to each object properties related to uncertainty level, material and used sources for reconstruction.

Defining usage of BIM models with geometry representation on level of LOD300, symbolic materials as ready assets identified from historical sources and assignment to each object properties related to uncertainty level, material and used sources for reconstruction.

M53 Weather Condition

Subclass of:

E3 Condition State

Scope note:

This class comprises the prevailing atmospheric conditions observed during a specific time-span, particularly in the context of digitization activities such as photogrammetry or 3D scanning. Weather conditions—including factors like cloud cover, temperature, humidity, wind, precipitation, and ambient light—can significantly influence the quality and accuracy of data captured during these processes.

Understanding and documenting the weather conditions at the time of data acquisition is crucial for assessing the reliability of the resulting digital representations. For instance, overcast skies can provide diffuse lighting that minimizes shadows, enhancing image consistency for photogrammetry.

By recording the weather conditions during digitization events, practitioners can better interpret the quality of the digital outputs and make informed decisions regarding data processing and analysis.

Examples:

A cloudy day with mild temperatures and low wind.

Temperature around 23°C, Humidity 53%, southwest wind at 6 km/h, partially cloudy.

M54 Abbreviation

Subclass of:

E41 Appellation

Scope note:

This class comprises shortened forms of words or phrases—such as acronyms, initialisms, contractions, or clipped terms—that are used to represent longer expressions more concisely. Abbreviations serve both functional and communicative roles, enabling efficient referencing of complex concepts (e.g., “LOD” for “Level of Development,” “CRM” for “Conceptual Reference Model”).

In digital heritage contexts, abbreviations frequently appear in metadata, documentation, and user interfaces. Properly identifying and documenting abbreviations enhances clarity, supports interoperability, and ensures that both human users and automated systems interpret terminologies consistently.

Examples:

“CIDOC CRM” for CIDOC Conceptual Reference Model

“VR” for Virtual Reality

“3D” for Three-Dimensional

M55 Technology

Subclass of:

E29 Design or Procedure

Scope note:

This class comprises technology-use categories that define the intended technical requirements and applications for which a digital object—typically an M1 3D Object or D1 Digital Object—has been adapted. Each M55 Technology designation reflects the expectations that influenced the creation of the derivative through D3 Formal Derivation, ensuring that the generated object meets specific performance or format criteria for that technology. (e.g., 3D printing, augmented reality, virtual simulations). By assigning a M55 Technology to a digital object, stakeholders can readily understand its applicability and technical readiness for specific workflows or platforms.

Examples:

“Augmented Reality” – requires simplified mesh, limited vertex count, exportable in compatible real-time formats

"3D printing" – requires closed/watertight mesh

M56 Collection

Subclass of:

E78 Curated Holding

Scope note:

This class comprises curated assemblies of cultural heritage items (instances of E18 Physical Thing or M1 Digital Object) that are acquired, organized, and managed by a museum or similar institution according to a collecting policy or purpose. A Collection reflects intentional stewardship, where items are accessioned, catalogued, preserved, and potentially exhibited or researched.

Collections support curatorial, educational, research, and public engagement functions—ranging from permanent, specialized thematic groups (e.g., medieval manuscripts, archaeological ceramics) to rotating or donated assortments. The formal inclusion of an object into a collection is typically recorded through accessioning, which confers legal ownership and institutional responsibility.

Examples:

The medieval sculpture collection in a national art museum curated for exhibition and research.

An archaeological pottery assemblage accessioned by a regional history museum.

The digital 3D assets of a heritage reconstruction project held within an online institutional repository.

M57 Inventory Number

Subclass of:

E42 Identifier

Scope note:

This class comprises unique identification codes assigned to individual items—typically within museums, archives, or digital collections—to facilitate systematic tracking, documentation, and management. An inventory number is part of a structured registration system (e.g., accession or inventory book) that links an item to its metadata, provenance, and administrative records.

Museums often format inventory numbers with prefixes denoting the institution or collection and a sequential identifier. These identifiers are essential for inventory control, security, insurance, and scholarly reference.

Examples:

"MNW/M/123" (museum and collection prefix + object number) (de Rosset, 2017)

"2018.14.315" (year, collection batch, object sequence) (American Alliance of Museums)

"Des 207 d" (collection prefix, object number, suffix) (Hohmann, 2010).

M58 Bibliographic Reference

Subclass of:

E73 Information Object

Scope note:

This class comprises formal citations that provide complete bibliographic information for published or unpublished works, enabling precise referencing and attribution. A M58 Bibliographic Reference may include elements such as authors, publication year, title, series or journal name, editor(s), DOI or URL, publisher, volume, issue, and page range. By structuring this information, the class supports reproducibility, scholarly communication, and linkage between digital resources and their documented intellectual sources.

Examples:

Kuroczyński, P., Apollonio, F. I., Bajena, I. P., & Cazzaro, I. (2023). SCIENTIFIC REFERENCE MODEL – DEFINING STANDARDS, METHODOLOGY AND IMPLEMENTATION OF SERIOUS 3D MODELS IN ARCHAEOLOGY, ART AND ARCHITECTURAL HISTORY. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLVIII-M-2–2023*, 895–902. 3. https://doi.org/10.5194/isprs-archives-XLVIII-M-2-2023-895-2023

Foschi, R., Fallavollita, F., & Apollonio, F. I. (2024). Quantifying Uncertainty in Hypothetical 3D Reconstruction—A User-Independent Methodology for the Calculation of Average Uncertainty. *Heritage*, *7*(8), Article 8. https://doi.org/10.3390/heritage7080209

Franczuk, J. (2025). Information processes in Virtual 3D reconstruction of Roman Three-Bay Double Arch of Musti (Tunisia). *Virtual Archaeology Review*, *16*(32), Article 32. https://doi.org/10.4995/var.2024.22543

M59 Readability Assessment

Subclass of:

osd7a Research Activity

I5 Inference Making

Scope note:

This class comprises evaluative activities aimed at determining the legibility and interpretability of source materials—such as images, drawings, photographs, manuscripts, or texts—used in heritage documentation. Readability assessment considers factors such as visual clarity, graphical scale, textual clarity, physical deterioration, distortion, and recording conditions, which may affect the user's ability to accurately interpret depicted information.

The result of an assessment is formalized in an instance of M61 Readability Value, typically expressed as a percentage or score indicating the degree to which the source is legible. By recording this value alongside metadata about the editable geometry of digital reconstructions, professionals can make informed decisions regarding the usability and reliability of the source material.

Examples:

Evaluating how clearly inscriptions on a carved stone appear in a high-resolution photograph, and assigning a readability value of 85%.

Assessing schematic clarity of a 17th-century architectural drawing to determine if proportions are decipherable, yielding a readability value of 70%.

Determining intelligibility of faint sketches in archival documents after scanning, resulting in a 60% readability score due to partial erosion and ink fading.

M60 Consistency Assessment

Subclass of:

osd7a Research Activity

I5 Inference Making

Scope note:

This class comprises evaluative activities that analyze coherence, agreement, or discrepancies among multiple source materials (e.g., architectural drawings, paintings, textual records) describing the same object or element. A M60 Consistency Assessment examines whether information across sources aligns or contradicts—by evaluating details such as shapes, features, descriptions, measurements, or qualitative statements. For example, if an elevation drawing shows a rectangular window but a section drawing and a written description indicate a rounded top, the assessment identifies such inconsistencies and supports the decision-making process for reconstruction or interpretation. The result is recorded as an instance of M62 Consistency Value, expressed as a percentage of consistent information across sources.

Examples:

Comparing two drawings: elevation shows rectangular windows, but the section drawing implies arched tops → inconsistency in window shape.

Comparing written text and sketch: text describes “three columns,” but the sketch depicts “four” → counting mismatch.

Evaluating multiple paintings: facade ornament differing subtly between sources → partial agreement/inconsistency.

M61 Readability Value

Subclass of:

E89 Propositional Object

Scope note:

This class represents the outcome of a M59 Readability Assessment, capturing how legible or interpretable a source document is. A Readability Value may be expressed quantitatively—such as a percentage score (0–100%)—or qualitatively as a descriptive assessment (e.g., "high", "moderate", "poor readability"). The flexible format acknowledges that readability encompasses factors beyond simply measurable metrics (e.g., layout, clarity, context) and aligns with best practices in readability evaluation. In digital heritage workflows, documenting the M61 Readability Value helps users understand the usability of sources (e.g., architectural drawings, manuscripts) and informs decisions about their suitability for tasks like transcription, interpretation, or digital reconstruction.

Examples:

75 % indicating high readability in a clear, well-preserved photograph.

"Moderate" for a faded archival document with partially illegible handwriting.

50 % for a damaged ink drawing where portions are ambiguous or lost.

M62 Consistency Value

Subclass of:

E89 Propositional Object

Scope note:

This class represents the result of an M60 Consistency Assessment, indicating the degree of agreement or discrepancy among multiple sources that describe the same aspect of a cultural heritage object. A Consistency Value can be expressed quantitatively—as a percentage of consistent items—or qualitatively—as a descriptive rating (e.g., "high consistency," "conflicting"). The concept aligns with evidence-consistency frameworks such as those used by environmental agencies, where agreement across independent data increases confidence (a concept formalized in causal analysis). A structured Consistency Value provides clear documentation of how much sources concur, supporting decision-making during reconstruction, interpretation, or documentation.

Examples:

80 % consistency between two architectural drawings (elevation vs. plan) regarding window count and placement, but a discrepancy in window shape.

"Moderate" consistency across three written descriptions: two describe round arches, one mentions pointed arches.

40 % consistency in depicted ornamentation across surviving sketches and textual accounts, indicating low agreement.

M63 Reliability Assessment

Subclass of:

osd7a Research Activity

I5 Inference Making

Scope note:

This class represents a comprehensive evaluative process in which an assessor examines a source's provenance and origin, physical condition, and contextual fidelity. Crucially, it also includes formal sub-assessments—M59 Readability Assessment and M60 Consistency Assessment—to measure legibility and agreement with other sources, respectively. The purpose is to integrate all these dimensions—provenance, readability, consistency, condition, and fidelity—into a holistic judgment expressed as M29 Reliability Value, which may be quantified or described qualitatively. This approach ensures a transparent, reproducible methodology for establishing the trustworthiness of source materials used in digital reconstruction and heritage documentation.

Examples:

A well-documented 19th-century photograph is found to be highly legible (via M59), consistent with drawings (via M60), and reliably sourced → High reliability.

A faded manuscript is moderately legible, shows inconsistencies with other accounts, has uncertain origin, and damage → Moderate reliability.

A damaged, unsigned map with conflicting data yields → Low reliability.

M64 Source Assignment

Subclass of:

osd7a Research Activity

I5 Inference Making

Scope note:

This class represents the event in which a source (osd_31b_Source) is purposefully linked to a specific instance of M25 Digital Reconstruction, indicating that the source was formally considered in the reconstruction process—even if not ultimately used. This assignment also records the nature of the source's coverage in relation to the reconstruction through the property R31 covers, which qualifies how the source aligns (for example, sharing author, geographic origin, time period, or thematic relevance).

Examples:

A preparatory sketch by the original architect assigned to a Renaissance façade reconstruction with *R31 covers = "Same author"*.

A site map from the same historical period attached to an ancient church model with *R31 covers = "Same period"*.

A regional survey drawing linked to a chapel reconstruction with *R31 covers = "Same location"*.

Properties:

R36 covers (is covered by): E55 Type

M65 Uncertainty Assessment

Subclass of:

osd7a Research Activity

I5 Inference Making

Scope note:

This class represents the evaluative event during which an assessor examines the degree of uncertainty inherent in the interpretation of semantic element (M15 3D Feature) or attributes within a digital reconstruction (like shape (M21 Shape/M22 Digital Shape), or material E57 Material/M16 Digital Material), based on the source evidence. It does **not** assess the technical execution of the modelling process or simplifications introduced by the modeller. Instead, it evaluates how confidently the attribute can be discerned from the sources, taking into account factors such as source readability, consistency across sources, provenance, and type. The method often employs a documented methodology—such as the user-independent average uncertainty calculation by Foschi et al. (2024)—which computes an overall uncertainty score derived solely from source-derived premises for the shape of the object. The assessment results in an instance of M28 Uncertainty Value, which may be expressed either as a percentage or a qualitative descriptor, reflecting uncertainty in premises, not modelling fidelity.

This class represents an evaluative event during which an assessor examines the degree of uncertainty.

Examples:

A reconstructed vault, interpreted from partial source data, yields an Uncertainty Value of 22% using the Foschi et al. methodology.

A column whose shape is deduced from inconsistent plans obtains a rating of "high uncertainty" in its premised reconstruction.

A robust arch with clear source agreements receives a "low uncertainty" descriptor.

Same as:

CRMvr: V19 Uncertainty Evaluation (https://github.com/elisabettacaterina/CRMvr)

M66 Relevance Assessment

Subclass of:

osd7a Research Activity

I5 Inference Making

Scope note:

This class represents an evaluative activity during which an assessor assigns relevance factors to semantic elements (M15 3D Feature)This class represents the evaluative event during which an assessor examines the degree of uncertainty inherent in the interpretation of particular attributes within a digital reconstruction (like shape M21 Shape/M22 Digital Shape, or material E57 Material/M16 Digital Material), in order to weight their impact on the overall uncertainty. The process is informed by the methodology "Average Uncertainty Weighted on the Volume and Relevance" (AU_VR) developed by Foschi et al (2024). Through this event, each element's volume is combined with a subjective yet documented relevance rating, reflecting its critical importance within the reconstruction context. The output is captured as M67 Relevance Value, which may be numeric or descriptive.

Examples:

In a basilica model, architectural ornaments are assigned a high relevance factor of 20 to reflect their cultural significance, impacting the overall uncertainty weighting.

Structural walls are given a relevance factor of 1, reflecting their lower interpretative sensitivity but high volume.

Decorative capitals are rated with moderate relevance (e.g., 5) due to their detailed historical value, affecting the AU_VR calculation.

M67 Relevance Value

Subclass of:

E89 Propositional Object

Scope note:

This class represents an evaluative activity during which an assessor assigns relevance factors to semantic elements (M15 3D Feature)This class represents the evaluative event during which an assessor examines the degree of uncertainty inherent in the interpretation of particular attributes within a digital reconstruction (like shape M21 Shape/M22 Digital Shape, or material E57 Material/ M16 Digital Material), in order to weight their impact on the overall uncertainty. The process is informed by the methodology "Average Uncertainty Weighted on the Volume and Relevance" (AU_VR) developed by Foschi et al (2024). Through this event, each element's volume is combined with a subjective yet documented relevance rating, reflecting its critical importance within the reconstruction context. The output is captured as M67 Relevance Value, which may be numeric or descriptive.

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M68 Country

Subclass of:

E53 Place

Scope note:

This class comprises geopolitical entities with defined borders, recognized sovereignty, and shared governance structures. M68 Country instances are characterized by geographically bounded territories, resident populations, official languages, and government systems. They may also possess unique identifiers (e.g., ISO 3166 codes). In cultural heritage contexts, countries serve as locations for events, repositories, and origins of artifacts, making them important for documenting provenance, heritage site context, and digital reconstructions.

Examples:

Italy – territory in Southern Europe with multiple official languages (Italian, German, Slovene), borders with France, Switzerland, Austria, Slovenia, and the Mediterranean Sea.

Japan – island country in East Asia with recognized sovereignty, known for distinct cultural heritage objects and digital museums.

Poland – country in Central Europe, with official language Polish, borders Germany, Czechia, Slovakia, Ukraine, Belarus, Lithuania, and Russia's Kaliningrad, and the Baltic Sea.

M69 Phase

Subclass of:

E4 Period

Scope note:

This class represents a time-bounded phase in the life of a cultural heritage thing during which the thing exhibits a particular condition state and/or physical form (for example, a building's Romanesque phase or Gothic phase). Phases are used in reconstruction workflows to contextualize which temporal–physical state a reconstruction portrays. They may be qualified by descriptions akin to E3 Condition State and be related to events/activities (e.g., renovations) that cause transitions between phases.

Examples:

The Gothic phase of a cathedral following a 13th-century expansion.

The Restoration phase 1950–1960 when a façade was re-plastered.

Properties:

R39 simulates (is simulated by): M25 Digital Reconstruction

2.3. Properties declaration

Status 23.07.2025

R1 published (was published by)

Domain:

M5 Digital Publication Event

Range:

D1 Digital Object

Subproperty of:

dig: D7 Digital Machine Event -> dig: L11 had output (was output of) -> dig: D1 Digital Object

Quantification:

one to many, necessary, dependent (1,n:1,1)

Scope note:

This property describes the process of a publication of a digital object (picture, document, video, 3D model, etc.) on the web resulting in creation of URI.

R4 is preceding version of (has preceding version)

Domain:

D1 Digital Object

Range:

D1 Digital Object

Subproperty of:

crm: E70 Thing -> crm: P130 shows features of (features are also found on)-> crm: E70 Thing

Quantification:

one to one, necessary (1,1:0,1)

Scope note:

This property associates two instances of D1 Digital Object, indicating the progression of the state of work on the content they contain. The property allows the progression of work on versions to be tracked in the order in which they occur, pointing to the preceding working state. It can assign only one version the D1 Digital Object, which was a record of the previous work state.

R5 is following version of (has following version)

Domain:

D1 Digital Object

Range:

D1 Digital Object

Subproperty of:

crm: E70 Thing -> crm: P130 shows features of (features are also found on)-> crm: E70 Thing

Quantification:

one to one, necessary (1,1:0,1)

Scope note:

This property associates two instances of D1 Digital Object, indicating the progression of the state of work on the content they contain. The property allows the progression of work on versions to be tracked in the order in which they occur, pointing directly to the following working state. It can assign only one version preceding it to the D1 Digital Object, which was a record of the following work state.

R6 is alternation of (has alternation)

Domain:

M1 3D Object

Range:

M1 3D Object

Subproperty of:

crm: E70 Thing -> crm: P130 shows features of (features are also found on)-> crm: E70 Thing

Quantification:

many to many (0,n:0,n)

Scope note:

This property associates an instance of M1 3D Object with another instance of M1 3D Object that constitutes a variant of the former and that may also be used for identifying results of M25 Digital Reconstruction identified by the former, in suitable contexts, independent from the particular item to be identified. It is important to note that both M1 3D Object depict the same M26 Cultural Heritage Thing in the same E3 Condition State and were prepared based on the same body of knowledge. If the research on the object is progressing and the scope of the starting material for reconstruction has been changed, this should be expressed not by a variant but by creating an entirely new instance of M25 Digital Reconstruction.

It is a directed relationship where the range expresses the variant and the domain is the source of original form of variation if such a direction can be established. Otherwise, the relationship is symmetric. This property is not transitive. This property is irreflexive.

R7 has position (is position of)

Domain:

M1 3D Object

Range:

M18 Digital Position

Quantification:

many to many (0,n:0,n)

Scope note:

This property identifies an instance of M18 Digital Position, which determines the position of an M1 3D Object through a set of coordinates between the centre point of the M17 Digital Environment and the reference point of the 3D object.

R8 digitally created (was digitally created through)

Domain:

M5 Digital Publication Event

Range:

M6 Digital Record

Subproperty of:

lrmoo: F30 Manifestation Creation -> lrmoo: R24 created (was created through) -> lrmoo: F3 Manifestation

Quantification:

one to many, necessary, dependent (1,n:1,1)

Scope note:

This property associates the instance of M6 Digital Record that was created digitally during a particular instance of M5 Digital Publication Event.

R10 simulates (is simulated by)

Domain:

M19 Simulation

Range:

M26 Cultural Heritage Thing

Subproperty of:

crm: E7 Activity -> crm: P16 used specific object (was used for) -> crm: E70 Thing

Quantification:

one to one, necessary (1,1:0,1)

Scope note:

This property associates the instance of M19 Simulation with the simulated object represented by the instance of M26 Cultural Heritage Thing, which is digitally reconstructed on the M1 3D

Object. Property can be used also for property associates the instance of M19 Simulation with the feature represented by the material (E56 Material) or shape (M21 Shape).

R11 simulates thing (is thing simulated by)

Domain:

M1 3D Object

Range:

M26 Cultural Heritage Thing

Subproperty of:

crm: E70 Thing -> crm: P130 shows features of (features are also found on) -> crm: E70 Thing

Quantification:

many to one, necessary (1,1:0,n)

Scope note:

This property identifies an instance of M26 Cultural Heritage Thing that is simulated by M1 3D Object. Simulating is meant in the sense that an instance of M26 Cultural Heritage Thing intentionally shows, through its optical qualities or form, a representation of the entity simulated. Digital 3D scans are, by default, regarded as being intentional in this sense.

This property is a shortcut of the more fully developed path from M26 Cultural Heritage Thing through *R10 is simulated by,* M19 Simulation, L11 had an *output* to M1 3D Object.

R12 embeds (is embedded in)

Domain:

M17 Digital Environment

Range:

M1 3D Object

Quantification:

many to many (0,n:0,n)

Scope note:

This property associates the instance of M1 3D Object with an instance of M17 Digital Environment, where the 3D model is embedded. Creating a derived 3D Object by exporting to other file formats (D1 Digital Object) also creates new instances of D17 Digital Environment based on the specification of the exported file format, where the M1 3D Object is embedded.

R13 consists of (is incorporated in)

Domain:

M1 3D Object

Range:

M16 Digital Material, M23 Digital Shape

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property identifies the instance of M1 3D Object or M15 Digital Feature with its attributes of shape (M22 Digital Shape) and material (M16 Digital Material). All digital 3D things simulate visually 2D or 3D shapes and volumes with a surface-specific perception expressed by digital materials. R12 consists of (is incorporated in) allows the different digital materials and different shapes to be recorded.

R14 has reconstructed (is reconstructed by)

Domain:

M25 Digital Reconstruction

Range:

M26 Cultural Heritage Thing

Subproperty of:

crm: E13 Attribute Assignment -> crm: P140 assigned attribute to (was attributed by) -> crm: E1 CRM Entity

Quantification:

many to many (0,n:0,n)

Scope note:

This property associates an instance of M25 Digital Reconstruction with the instance of M26 Cultural Heritage Thing about which it made a reconstruction. One cultural object can be the subject of multiple instances of digital reconstructions conducted by different actors in different times and environments.

R15 simulates time (is time simulated by)

Domain:

M25 Digital Reconstruction

Range:

E52 Time Span

Quantification:

one to one, necessary (1,1:0,1)

Scope note:

This property associates an instance of M25 Digital Reconstruction with the instance of E52 Time Span about which it made a reconstruction. Each digital reconstruction of an object matches only a certain time span from the object's lifespan, which this property allows to document.

R16 has shape (is shape of)

Domain:

M26 Cultural Heritage Thing

Range:

M21 Shape

Subproperty of:

crm: E1 CRM Entity -> crm: P2 has type (is type of) -> crm: E55 Type

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property identifies the instances of M21 Shape that match the outline of an instance of M26 Cultural Heritage Thing. In the case of physical things, this property describes the physical boundaries of the object. In the case of conceptual objects, this property refers to the boundaries deduced from the interpretation of the carriers of a given concept.

R17 has representation type (is representation type of)

Domain:

M1 3D Object

Range:

E55 Type

Subproperty of:

crm: E1 CRM Entity -> crm: P2 has type (is type of) -> crm: E55 Type

Quantification:

many to many (0,n:0,n)

Scope note:

This property allows the categorisation of M1 3D Object instances according to the type of 3D model representation, which should be understood as the intrinsic mathematical/geometrical digital representation. Possible classifications are continuous representation (e.g., NURBS, Bézier, spline) and discrete representation (e.g., mesh, point clouds, voxels), mathematical representation (equations with parameters) and the numerical representation (coordinates), or implicit representation and explicit representation. It should be kept in mind that this class refers to general categories defining the geometric representation method.

R18 has accuracy value (is accuracy value of)

Domain:

M19 Simulation

Range:

M27 Accuracy Value

Subproperty of:

crm: E13 Attribute Assignment -> crm: P141 assigned (was assigned by)-> crm: E1 CRM Entity

Quantification:

many to many (0,n:0,n)

Scope note:

This property indicates the value of accuracy of object simulation in digital space that was assigned to M19 Simulation event.

R19 has digital carrier (is digital carrier of)

Domain:

D1 Digital Object

Range:

M35 File

Subproperty of:

crm:E70 Thing → crm:P130 shows features of (features are also found on) → crm:E70 Thing

Quantification:

one to many, necessary (1,n;0,n)

Scope note:

This property links a D1 Digital Object—the abstract bitstream or immaterial content—to its M35 File carrier(s), which are digital encodings (e.g., .jpg, .obj, .pdf) stored in a file system or cloud location. It does not refer to physical media like CDs or hard drives, which are instances of D13 Digital Information Carrier. A single digital object may be stored across multiple files: identical copies (e.g., backups) or different file formats. While these files may represent the same logical object, subtle differences can arise—such as loss of transparency when saving an image as .jpg instead of .png—highlighting that format choice can affect fidelity despite preserving the object's conceptual identity.

R20 has file format (is file format of)

Domain:

M35 File

Range:

M45 File Format

Subproperty of:

crm:E70 Thing → crm:P130 shows features of (features are also found on) → crm:E70 Thing

Quantification:

many to one, necessary (1,1:0,n)

Scope note:

This property links a D1 Digital Object—the abstract bitstream or immaterial content—to its specific M35 File carriers, which are digital encodings (e.g., .jpg, .obj, .pdf) held in a file system or cloud location. It does *not* refer to physical storage media such as CDs or hard drives (these are D13 Digital Information Carriers). Instead, the file is the digital artifact that, once decoded or rendered by software, presents the digital object to users or systems.

R21 has version number

Domain:

D1 Digital Object

Range:

E62 String

Subproperty of:

crm:E1 CRM Entity → crm:P3 has note → crm:E62 String

Quantification:

one to one (1,1:1,1)

Scope note:

This property records the version identifier assigned to digital artefacts—typically software applications or digital models—according to accepted versioning schemes such as Semantic Versioning or Calendar Versioning. Property can be used to track evolutionary changes, updates, and compatibility over time (e.g., version “2.0.1” or “2025-06-09”).

R22 supports (is supported by)

Domain:

D8 Digital Device

Range:

D1 Digital Object

Quantification:

many to many (0,n:0,n)

Scope note:

This property expresses compatibility between a D8 Digital Device and the digital object types it is designed to handle—such as specific file formats, applications, or 3D model types. For example, an AR application may be compatible only with iOS devices supporting ARKit, while a Formlabs Form 2 3D printer supports files in STL and OBJ formats for 3D printing.

R23 has custody of (is currently in the custody of)

Domain:

D1 Digital Object

Range:

E39 Actor

Subproperty of:

crm:E18 Physical Thing → crm:P52 has current owner (is current owner of) → crm:E39 Actor

Quantification:

many to many(0,n:0,n)

Scope note:

This property denotes which actor currently holds and is responsible for the preservation, management, or stewardship of a D1 Digital Object. It captures the notion of digital custody, indicating who controls the file access, backup protocols, or long-term preservation.

R24 segments (is segmented by)

Domain:

M38 Segmentation

Range:

M26 Cultural Heritage Thing

Subproperty of:

crm:E7 Activity → crm:P16 used specific object (was used for) → crm:E70 Thing

Quantification:

one to many, dependent (0,n:1,1)

Scope note:

This property links an M38 Segmentation event—where semantic units such as windows, doors, walls, or floors are identified—to the specific M26 Cultural Heritage Thing being segmented. The process is conceptual and does not alter the physical object Rather, it identifies meaningful semantic features (M39 Feature) that serve as documentation units for digital reconstruction.

R25 identifies (is identified by)

Domain:

M38 Segmentation

Range:

M39 Feature

Subproperty of:

crm:E7 Activity → crm:P16 used specific object (was used for) → crm:E70 Thing

Quantification:

many to many, necessary, dependent (1,n:1,n)

Scope note:

This property links a M38 Segmentation event—which semantically partitions a cultural heritage object into meaningful units—to the M39 Feature that is recognized or extracted during that event. It captures the act of conceptual identification of architectural or cultural segments (e.g., windows, doors, walls, floors) that serve as base documentation units for digital reconstruction and analysis.

R26 has variant number

Domain:

M1 3D Object

Range:

E62 String

Subproperty of:

crm:E1 CRM Entity → crm:P3 has note → crm:E62 String

Quantification:

one to one (1,1:1,1)

Scope note:

This property assigns a variant identifier to a specific 3D object instance representing an alternative interpretation derived from the same stage of research. These variants are uniquely numbered or labelled (e.g., "Variant A", "Variant 1") and each number corresponds to a single model. They differ from versions tracked via R21 has version number, which represent revisions following new research or changes in evidence. R26 has variant number should be used to maintain clarity on alternative interpretations explored in parallel, ensuring each variant has its own distinct identifier.

R27 has object (is part of)

Domain:

M56 Collection

Range:

M26 Cultural Heritage Thing

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property links a M56 Collection—understood as a thematic grouping of cultural heritage resources held by an institution—with the individual M26 Cultural Heritage Thing instances that are part of that collection. The objects may be physical items or digital representations and are included to reflect their thematic or curatorial relevance. Use this property to document the composition of collections, supporting discovery, management, and analysis of grouped heritage assets.

R28 can be referred as (is bibliographic reference of)

Domain:

E73 Information Object

Range:

M58 Bibliographic Reference

Subproperty of:

crm:E89 Propositional Object → crm:P67 refers to (is referred to by) → crm:E1 CRM Entity

Quantification:

one to many, dependent (0,n:1,1)

Scope note:

This property identifies the link between an E73 Information Object (such as a dataset, article, or digital model) and formally structured M58 Bibliographic Reference instances. Bibliographic references provide full citation details—authors, title, publication year, DOI, URLs, etc.—following international standards like APA or Chicago. These structured references are especially valuable when documenting osd_31b_Source usage, ensuring precise attribution, reproducibility, and scholarly rigor.

R29 has results incorporated in (incorporated results of)

Domain:

M64 Source Assignment

Range:

osd7a Research Activity

Subproperty of:

crm:E13 Attribute Assignment → crm:P141 assigned (was assigned by) → crm:E1 CRM Entity

Quantification:

one to one (1,1:1,1)

Scope note:

This property associates the outcome of a M64 Source Assignment—the formal linking of a source to a digital reconstruction or research event—with the broader osd7a Research Activity in which it is embedded. It ensures that the use or consideration of a source is explicitly recorded as part of a specific activity, even if the source was not ultimately utilized. This property maintains clear provenance of inference-making, tracing which sources were assessed and in which context, enhancing transparency and traceability across reconstruction or investigative workflows.

R30 has scale ratio (is scale ratio of)

Domain:

osd31b Source

Range:

E54 Dimension

Subproperty of:

crm:E70 Thing → crm:P43 has dimension (is dimension of) → crm: E54 Dimension

Quantification:

many to one (0,1:0,n)

Scope note:

This property identifies the scale ratio specified in a source document—typically expressed as “1:50,” “1 cm = 1 m,” or “1/100”—capturing the proportional relationship between the representation and real-world dimensions. Since scale is a measurement characteristic, it ì uses E54 Dimension. R30 applies only to sources where scale is defined—such as technical drawings or physical scale models—and not to photographs, texts, videos, or other unscaled materials.

R31 generated digital representation (is digital representation generated by)

Domain:

M19 Simulation

Range:

M1 3D Object

Subproperty of:

crmdig:D7 Digital Machine Event → crmdig:L11 had output (was output of) → crmdig:D1 Digital Object

Quantification:

one to one (1,1:1,1)

Scope note:

This property links each M19 Simulation event—which occurs on a digital device and simulates a particular E3 Condition State of a cultural heritage object—to the resulting M1 3D Object (the simulated digital representation). It captures the fact that simulations are creative digital events transforming source models into new visualizations. Since simulations typically rely on available source data and tools, the output may not perfectly mirror reality. Instead, simulation assumptions and technological limitations introduce a level of guesswork. simulation parameters or conditions change—resulting in a different digital model—a new M19 Simulation event should be documented with a separate R31 link.

R32 has property (is property of)

Domain:

M16 Digital Material

Range:

M20 Digital Property

Subproperty of:

crm:E1 CRM Entity → crm:P129i is subject of (is about) → crm:E89 Propositional Object

Quantification:

many to many (0,n:0,n)

Scope note:

This property associates an M16 Digital Material—the layer defining visual and physical surface qualities of a 3D object—with one or more M20 Digital Property instances that describe key material attributes such as transparency, glossiness, roughness, metalness, emissiveness, and opacity. These properties reflect physically based rendering (PBR) standards—where attributes like albedo, normal, gloss/roughness maps, and metalness affect how a surface interacts with light—ensuring realistic simulations and perceivable behaviours in digital environments.

R33 used as texture (is texture used for)

Domain:

M24 Texture Mapping

Range:

D9 Data Object

Subproperty of:

crmdig:D10 Software Execution → crmdig:L2 used as source (was source for) → crmdig:D1 Digital Object

Quantification:

many to many (0,n:0,n)

Scope note:

This property identifies the 2D image or data file (a D9 Data Object, such as a JPEG, PNG, or TIFF) used during an instance of M24 Texture Mapping to visually texture a 3D surface. Texture images are projected onto geometry via UV coordinates to simulate material appearance (e.g., brick patterns, wood grain, color detail). A single mapping event may involve several texture files (e.g., base color, normal map, specular map), and a particular texture file can be reused in different mapping contexts.

R34 has occurrence count

Domain:

M15 3D Feature

Range:

E60 Number

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property assigns a numeric count indicating how many times a particular M15 3D Feature appears within its parent M1 3D Object. It quantifies repeated occurrences of semantic elements—such as the number of windows, pillars, or decorative motifs—on a digital model. This property supports feature-based analysis, volumetric enumeration, or architectural assessment methods that rely on counting repeated features within digital representations.

R35 met technological requirements of (is technological requirement of)

Domain:

D3 Formal Derivation Event

Range:

M55 Technology

Subproperty of:

crm:E7 Activity-> crm:P19 was intended use of (was made for)-> crm:E71 Human-Made Thing

Quantification:

many to many (0,n:0,n)

Scope note:

This property identifies the link between a D3 Formal Derivation Event—such as adapting a 3D model to a format or standard—and the target M55 Technology requirements it was intended to fulfil. Examples include preparing a model to be watertight and manifold for 3D printing, simplifying geometry and reducing polygons for augmented reality, or converting textures and meshes for virtual simulation. This property documents which technological contexts the derivative model was explicitly designed for, ensuring transparent traceability of design intentions, performance constraints, and cross-platform adaptations.

R36 covers (is covered by)

Domain:

M64 Source Assignment

Range:

E55 Type

Subproperty of:

crm: E13 Attribute Assignment -> crm: P141 assigned (was assigned by) -> crm: E1 CRM Entity

Quantification:

many to many (0,n:0,n)

Scope note:

This property specifies the aspect of overlap between the source and the digital reconstruction, such as authorial identity, temporal provenance, geographic context, or conceptual relation. Its values are instances of E55 Type, serving to clarify the nature of the source's relevance within the reconstruction event.

R37 has model number

Domain:

D8 Digital Device

Range:

E62 String

Subproperty of:

crm:E1 CRM Entity → crm:P1 is identified by (identifies) → crm:E41 Appellation

Quantification:

many to one (0,1:1,n)

Scope note:

This property captures the manufacturer's model number for a physical digital device (for example, "BLK360" in Leica BLK360 Imaging Laser Scanner, or "Focus S 150" in FARO Focus 3D S150). This identifier denotes the commercial product family and hardware version. It is distinct from the serial number, which uniquely identifies individual units. Model numbers categorize multiple units under the same design specification, while serial numbers differentiate each physical instance.

R38 refers to coordinate system within (has coordinate system referred to)

Domain:

M18 Digital Position

Range:

M17 Digital Environment

Subproperty of:

crm: E89 Propositional Object -> crm: P67 refers to (is referred to) -> crm: E1 CRM Entity

Quantification:

many to one, necessary (1,1:0,n)

Scope note:

This property associates the instance of M18 Digital Position in relation to the coordinate system of the instance of M1 Digital Environment to which it refers to.

R39 simulates (is simulated by)

Domain:

M25 Digital Reconstruction

Range:

M69 Phase

Quantification:

many to one (0,n : 0,1)

Scope note:

This property links a digital reconstruction to the specific phase of the cultural heritage thing it presents. While R15 simulates time connects reconstructions to an abstract E52 Time-Span, R39 simulates anchors them in a domain concept of phase that captures both the temporal extent and the characteristic condition/physical form of the object.

R40 has phase (is phase of)

Domain:

E22 Human-Made Object

Range:

M69 Phase

Quantification:

many to many (0,n : 0,n)

Scope note:

This property associates an instance of E22 Human-Made Object with an instance of M69 Phase that defines its stylistic, chronological, or developmental stage. A phase represents a coherent period or stylistic manifestation in the object's physical evolution — for example, the Romanesque, Gothic, or Baroque phases of a building — which may differ in structure, form, ornamentation, or materials.

The property enables documentation of distinct cultural or historical phases observable in the same physical object, whether through physical stratigraphy, stylistic analysis, or archival evidence. When an object has undergone multiple transformations, each phase should be represented as a separate instance of M69 Phase, allowing reconstructions or analyses to be linked to the corresponding phase.

3. Deprecated classes and properties

The following is a list of classes and/or properties that have been deprecated between the version 1.0.1 of OntPreHer3D and this release (2.0.0). As OntPreHer3D is actively maintained, certain classes and properties may become outdated as the model evolves to better represent emerging needs in documenting digital heritage workflows. In such cases, older constructs are deprecated to preserve backward compatibility, but knowledge graphs built with earlier versions should be updated to align with the latest ontology version. Below you'll find a Deprecated Class Migration table listing outdated entities alongside their recommended replacements. A separate Deprecated Property Migration table details how to replace deprecated properties and establish correct new semantic connections. If the range of a property is narrowed to a subclass of its former type, migration notes will clarify how to adjust affected triples. Tracking these deprecations ensures that your datasets remain consistent with OntPreHer3D's evolving structure and semantic rigor.

Deprecated Class Migration Instructions

Deprecated Class	**Migration Instruction**
M2 Versioning	use *M1 3D Object* with property *R5 is following version of*
M3 Variation	use *M1 3D Object* with property *R6 is alternation of*
M4 Division	use *M38 Segmentation*
M7 Visualization	use *M41 Preview File*
M8 Web Document	use *M33 Website*
M9 Research Publication	use *E31 Document*
M10 Area	use *M26 Cultural Heritage Thing , P2 has type: "Area"*
M11 Single Built Work	use *M26 Cultural Heritage Thing , P2 has type: "Single Built Work"*
M13 Component	use *M15 Digital Feature*

Deprecated Properties Migration Instructions

Deprecated Property	**Migration Instruction**
R2 has name (is name of)	use *P1 identified by (identifies): E41 Appellation*
R3 has surname (is surname of)	use *P1 identified by (identifies): E41 Appellation*
R9 simulates feature (is feature simulated by)	use *R10 simulates (is simulated by): M15 Digital Feature*
R12 refers to coordinate system within (has coordinate system referred to)	use *R38 refers to coordinate system within (has coordinate system referred to)*

CHNAGES LOG:

- Introducing new property R40 has phase (is phase of)

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