Review of EDM to support 3D

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1. Introduction

This report presents an analysis of the Europeana Data Model (EDM) from the perspective of enhancing representation of 3D in Europeana, both in terms of accommodating a larger quantity of items and representations, and higher quality of information.

This document is the product of a working group gathering representatives from the Europeana Initiative, most of whom are also involved in data space projects currently ongoing on 3D (5D Culture[1] and EUreka3D[2]).

In the process, we have looked at relevant related work - some of which involving the members of the group producing this report:

- EC 3D studies[3]
- Deliverables of the 4CH initiative[4]
- Other past Europeana outcomes and work, like the report of the EuropeanaTech task force on 3D content in Europeana[5].
- Concrete examples of metadata coming from projects like Share3D[6] and WEAVE[7]

As of February 2024 we expect that this document is sufficiently advanced to guide us towards a future extension or refinement of the Europeana Data Model. But some more iterations may be produced during that process. In any case this report is to be seen as a base for discussion.

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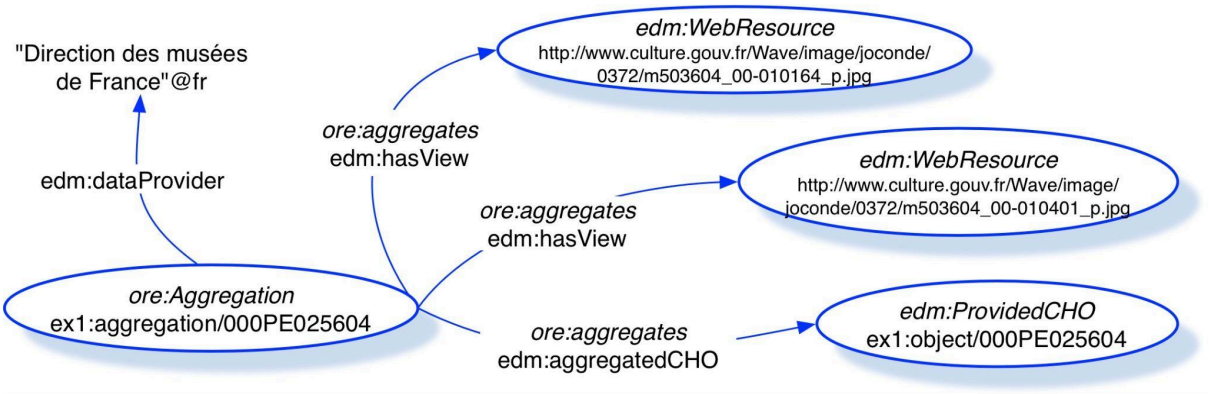
[1] https://5dculture.eu/
[2] https://eureka3d.eu/
[3] https://digital-strategy.ec.europa.eu/en/library/study-quality-3d-digitisation-tangible-cultural-heritage
[4] https://www.4ch-project.eu/
[5] https://pro.europeana.eu/post/3d-content-in-europeana-task-force-review . In a sense this report acts on one of the recommendations from this task force, which was that "guardians of [...] EDM are recommended to collaborate with the 3D community to develop the extensions needed to support the 3D workflow and the rich description of 3D content".
[6] https://share3d.eu/
[7] https://weave-culture.eu/

2. Basic modelling principles for 3D in EDM

Modelling distinctions that matter: cultural objects, digital representations and the one-to-one principle

The basis of EDM's modelling approach is the distinction between a cultural heritage object (edm:ProvidedCHO), digital representations of that object (edm:WebResource) and the "package" that brings them together (ore:Aggregation). The one-to-one principle is then applied with the aim that each resource "carries" information that belongs to it and not to another resource. This means, for example, that the date of when a "real-world" object was digitised, which resulted in the creation of some media (an image, an audio file...), is attached to the WebResource that stands for the resulting media file, while the date of creation of the original object is attached to the ProvidedCHO, even though both are expressed using a same property (dcterms:created).



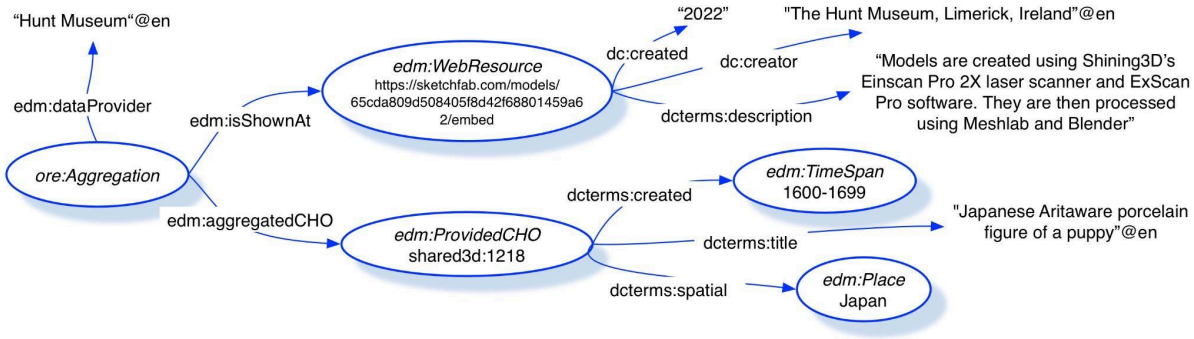
Basic EDM pattern representing an aggregation of a cultural object together with digital representations.

There are some known issues with the application of the one-to-one principle in EDM. Especially, there is a long-standing issue in that the ProvidedCHO carries the edm:type attribute that belongs on the WebResource (cf. Section 3).

We argue that a better application of the one-to-one principle can be the basis for handling the case of 3D representations of cultural objects in EDM. Our approach takes into account relevant work such as (1) 4CH's analysis of 3D data generation and creation for Cultural Heritage[8] and (2) previous experiments in preparing for Europeana objects that have been represented by 3D models, notably in the Share3D project[9]. Let us exemplify it with the example of a Japanese Aritaware porcelain figure from the Hunt Museum, whose 3D model has been published on Sketchfab[10]. This case corresponds to a "reality-captured" 3D model in the 4CH report, as "the source data are directly coming from the original assets". We propose to represent the "real world" porcelain figure as an instance of edm:ProvidedCHO, whose metadata can include a title like "Japanese Arita Ware porcelain figure of a puppy" and "17th century" as date of creation. The 3D model itself can be represented as an instance of edm:WebResource carrying metadata statements like "Models are created using Shining3D's Einscan Pro 2X laser scanner and ExScan Pro software. They are then processed using Meshlab and Blender" as description and "2022" as

[8] See section 2 of 4CH D3.1 Design of the CH Cloud and 4CH platform.
[9] https://docs.google.com/document/d/1ZGemrFiTvIXibznKBcfkL-sTJorapCPA-tww9QlT_nU/
[10] https://sketchfab.com/models/65cda809d508405f8d42f68801459a62/embed

date of creation. The different metadata statements for the date of creation, especially, exemplify the application of the one-to-one principle, as they use the same property dcterms:created but with different values when they are used for different resources.



Distribution of some metadata values onto the main EDM classes.

A main motivation for following the one-to-one approach strictly is its consistency: the same pattern can be employed for various types of 3D model, and it is compatlbe with the approach undertaken in the Europeana Data Model for non-3D representations. As a matter of fact it also allows for "mixed" situations where an object would be provided with 3D representations and non-3D ones[11]. It also seamlessly enables the representation of objects that are provided with different 3D models, or versions of a 3D model (for example with different numbers of polygons or points, and different rights).

Note that the distribution of (meta)data onto the various resources brought together in the EDM Aggregation, and with descriptions of digital representations separate from the description of an heritage asset, is very much in line with ontological approaches to the emerging notion of *digital twin*, as "the digital representation of the complex of knowledge about that heritage asset"[12]

From reality-captured 3D models to born-digital objects.

In addition, the pattern can extend to the process of creating a 3D reconstruction of a heritage asset at a moment in time in the past.

In the case of 3D, as the 4CH report elaborates, some 3D models include elements that are not directly extracted from reality but instead come from interpretations of cultural objects, for example based on historical documentation (see Appendix "Sample metadata for 3D reconstruction"). In this case we speak of 3D reconstructions or "born-digital-reconstructions". Reconstruction drawing in archaeology/architecture can be used in two main ways. Either as a way of visualising scenes from the past (story-telling) or in a more technical way to reconstruct how a site or building looked at a point in time in the past.

These models are very different in terms of their provenance and sometimes technical aspects, for example when a 3D reality capture based on surviving CHOs is visually enhanced during data processing to reconstruct the elevation of a building that survives today as ruins, based on plans

[11] For example when a building is provided both with a 3D model and "traditional" 2D photographs.
[12] Cf *Populating the Data Space for Cultural Heritage with Heritage Digital Twins* (https://www.mdpi.com/2306-5729/7/8/105), which proposes a model in which the "digital twin" resource includes various documents, including 3D models and visual imagery and points to an heritage asset.

or drawings showing the building at a former time. In such cases there is still some cultural object that underpins them: a reconstruction remains a representation of the object, albeit dimensions of the model are derived (or calculated) from information available in historical sources.

Here is for example a digital reconstruction of the Wojsławice town in the 1930s: https://www.europeana.eu/en/item/814/https___biblioteka_teatrnn_pl_dlibra_publication_edition_139444_content

A first EDM interpretation of this case would be to claim that the historical town itself is the CHO, and the 3D model is a digital web resource that is directly associated with it, using the Aggregation pattern (i.e., linking an instance of Aggregation to the 3D model via edm:isShownBy, edm:isShownAt or edm:hasView). However, the nature of the reconstruction (i.e. not purely based on captured reality) would argue for not only focusing on the "original" real-world object as the CHO. The representation of the original object – as an "information object" created following research and interpretation – could also be treated as CHO. I.e., there would be a CHO for the representation/reconstruction of the town and both of them could be related via the edm:isRepresentationOf property, or the more general property dc:subject. The edm:ProvidedCHO resource would carry metadata that applies to the representation (information object), i.e., the creator would be the creator of the model, not the founder of the town. Note that this still does not mean that the ProvidedCHO resource should have metadata that belongs to the level of a specific WebResource: for example mentioning "Sketchfab" is a more likely fit as metadata for the web page that is the object of the edm:isShownAt statement.

Note that the representation may not be entirely born digital, nor entirely 3D: there might be analog sketches that were employed during the process of creating the (3D) representation, that are also contributed as web resources for the representation. In this case, the "representation CHO" should not have metadata statements that hint that it is only a 3D representation. For that to happen, a provider would have to distinguish between distinct "representation CHOs" for the 3D representation and the analog sketches.

Variants for reconstructions of an object: A PCHO for the town, a PCHO for the reconstruction, PCHOs for the 3D reconstruction and 2D sketches.

The same approach applies similarly to other important cases where the object itself is born digital, as for an abstraction of a design or the work of an artist's imagination that does not represent any pre-existing real world object[13]. This can happen, among others, for architectural (and other) design drawings. For example, in the case of a competition to design a major public building[14], only one of the designs is built. The other designs are proposals which do not represent a real-world object but which may be preserved as part of an architect's archive - ideas that may be reused and re-interpreted in future buildings. In the past the designs would have been done on paper[15]. Today more and more are born-digital.

In this case of a born-digital object the CHO is also described at a conceptual level and the digital representation is the "materialisation" of it e.g. as a file. One object/concept/intention may have different representations and different media files - for example providing different views, offering different types of 3D modelling, different quality, different rights.

3. Identifying and addressing basic limitations for 3D in EDM

When we started discussing the approach above, we knew that there are discrepancies between the current EDM - and especially, the way it is documented and often applied - and the theoretical approach. To further identify limitations, we have applied the above principles to an example from the Share3D project (see appendix). The metadata shown there tries to respect the one-to-one principle and the distinction between the original object and the 3D representation. It also represents some data that we believe is important, either present in the original example or mentioned in the literature.

First, we observe that some important information like description or file format are already supported in EDM.

Other requirements would be met by relatively straightforward additions to the current EDM WebResource class:

- allowing the representation of types of model by high-level categorisation between "reality captured" models and "3D reconstruction"
- allowing the representation of types of model by technical aspect of the representation[16]: point cloud, mesh with higher or lower polygon count, with or without textures, BIM and parametric models, etc. (from a controlled list of types, preferably)
- (maybe) enabling dc:title and dcterms:provenance

For the first two requirements, the example in the appendix uses dc:type. However, we have made this choice merely to illustrate the matter at hand. Both could be addressed by using a different property, either reused from an existing namespace or newly created in the EDM

[13] This may also include AI-generated objects.
[14] E.g., this competition, which mentions 3D visualisations among the media that can be submitted: https://www.archdaily.com/999941/open-call-re-imagining-cappadocia-as-an-eco-district-architecture-competition
[15] Analogue example of a room design: https://www.europeana.eu/en/item/15514/KI_14388_38
[16] Cf slide 13 of Sharing with Europeana: depositing and publishing 3D datasets for preservation and future access at https://europeana.atlassian.net/wiki/spaces/EF/pages/2407170152/Twin+it+3D+for+Europe+s+culture+webinar+series#Webinar-5:-Storing,-managing-and-visualising-the-3D-models

vocabulary (similarly to edm:type). This will have to be discussed in the next steps of our work. In any case, both requirements probably require establishing a controlled vocabulary of possible values. Such endeavour relates to a more general effort to inspect whether existing EDM properties need to be provided with recommendations on using controlled vocabularies that are specific to the 3D context - for example on foreseen file formats.

We have then identified a fundamental issue with the usage of the existing property edm:type, , which is meant to reflect the general media category of an object, like "TEXT" or "IMAGE", for Europeana purposes. This type should not be attached to ProvidedCHO as it is currently. For example, in the case of a statue that has some digital images, edm:type is set to "IMAGE". But if the same statue in a different context would have been provided with a 3D model, edm:type should be set to "3D". It would be more appropriate to attach the type of media to the resource that stands for the media representation of the cultural object, i.e. the edm:WebResource.

As an alternative (or in addition), the property could be attached to the ore:Aggregation[17]. But we should probably allow for multiple edm:type statements on the ore:Aggregation class then, to cater for the cases where an object has representations of different types (say, a 3D model and some more classical photographs that dictate using "IMAGE" as value for edm:type). However, even though this option meets simple user information needs like "retrieve objects that have at least one 3D representation", it would complicate rather than improve the model. If edm:type is moved to the level of edm:WebResource, the type of each representation for an object is clear. If it is moved to the ore:Aggregation and we allow multiple types, the type of each representation is not clear.

4. Advanced 3D requirements for EDM

The elements discussed in the previous section seek to address common, basic needs of characterization of 3D objects. In our group's discussions, we identified more advanced requirements that can play a crucial role.

The first category regards the intended usage of representations available on the web for 3D objects. Especially, when sharing 3D models in a context like that of the data space, it makes a big difference whether a representation is meant for a specific (technical) purpose, such as preservation or for viewing. This distinction could be made explicit in EDM. A specific case is that of content that is accessed via a viewer, for example Sketchfab's, which can be embedded in another page, for example on a portal like europeana.eu. Another example is when a provider would like to give a link to the raw/full version of a 3D model instead of relying on re-users asking for it via another process. From a user perspective it would be useful to have access to information about how such - often very large - resources may be consumed (e.g., the software, media bundles, contexts etc). We do not know yet from the perspective of the data space, how best to support this access. These requirements are not specific to 3D but they can play a significant role in the 3D context.

The second category of desirable extension of EDM regards context and especially the paradata that informs on the provenance of 3D content. Information about the digitization process can be crucial to data space users for research or re-use.

[17] This case would be similar to what happens for edm:rights, which must be attached to the Aggregation in order to apply as a "default" to the WebResources attached to it, when these do not have a specific edm:rights statement.

We do not foresee that EDM should be extended to cope with all the possible categories of paradata that is collected at source, which can be very rich and specific. Yet, we expect that a subset of this information can be very useful even for basic access and re-use scenarios in the data space, especially to inform about the authenticity of the model, re-use conditions, and relevant technical aspects of the model's creation process. For example information of motivation (e.g. "research") and limitations of digitisation projects could give hints about the quality and trustworthiness of the 3D model. Examples of such provenance aspects could include the indication that a model results from a general "research" (project) motivation, that it is generated from AI training datasets and has not been curated, or that it was created photogrammetrically from user-generated images.

When identified, this "core" shall be considered for inclusion in an EDM extension for 3D for easier consumption. And in any case, EDM shall be extended with a mechanism that allows the data re-users that need it to access the full paradata provided by the creators of the 3D content, by means of a relation leading to the information expressed in the relevant standards (or more specific formats).

Note that some "simple" provenance requirements such as capturing the roles of the people or organisations involved in the life cycle of 3D models[18] may need significant extensions of EDM. The issue of representing roles of agents, for instance, has been identified for a long time as a general limitation of EDM, and it requires non-lightweight solutions such as introducing events[19].

5. Supporting work needed

This section gathers issues that are not about data modelling proper, but, which should be addressed so that providers are encouraged to follow best practices.

Review of documentation and guidelines

Our experience tells that more guidance on specific (mapping) points will be useful. Many issues relate to the one-to-one principle. EDM provides the ability to distinguish the PCHO as a cultural asset from its specific digital representations. Statements that apply to the asset or the digital representations should be attributed to the specific EDM resources that stand for it. It is crucial to decide whether the ProvidedCHO is the original object or a digital representation[20]. Metadata statements such as the creation date should follow that choice. Note that we do not claim that statements of one kind are more important than others. Of course, users will often benefit much from knowing the date of creation of the original CH asset. But some users will also need to know when the 3D model of that asset was created.

Consider an item that represents a real-world object/monument, as hinted by the use of "church" in the ProvidedCHO's dc:title (without any mention of a "3D model" in it) and a date like

[18] This is especially important to give indication on the authenticity and trustworthiness of the model, e.g., whether it is created by a research team based on data with high geometric accuracy, or by a project with other motivations and more limited resources.
[19] https://pro.europeana.eu/project/data-quality-committee#representing-events-in-edm
[20] Note that this concern already holds in the case of objects with non-3D representations, where attributes of the digital representation should not be mixed with those of the original cultural object.

"13th century" as the date of creation. Here are some examples of possible other statements that would raise a discrepancy issue:

- a dc:subject with "3D model": in this example the church is the subject of the PCHO, the format of the digital representation is best entered into the WebResource.
- a PCHO dcterms:extent statement describing the number of polygons in the 3D model: technical information about the model is best entered into the WebResource. A church's extent would rather consist of its physical dimensions.
- a PCHO dc:rights that mention the creator of the 3D model in some project, not the creators of the church. Here it is best to include rights information about the 3D model in the WebResource.

These metadata statements should be present on an instance of the WebResource class, not the ProvidedCHO, when that ProvidedCHO is meant to stand for an (analog) heritage asset[21]. These are not specific to the case of 3D, but for 3D their impact can be significant - especially as they could happen very often.

It is worth noting that the existing EDM guidelines can be confusing. Echoing the issue of edm:type mentioned in the previous section, the EDM mapping guidelines for dc:format on the edm:ProvidedCHO include the instruction "Use the value “3D-PDF” if appropriate". This is actually not compatible with following the one-to-one principle and should be removed.

Separating these elements of information would require creating a new instance of the EDM WebResource class when it is not present in the provided metadata. This is an extra effort, but it is very much in line with the needs to represent valuable, 3D-specific information (type of model, digital provenance) introduced in the earlier parts of this report. Guidelines should emphasise this.

Recommendations for the delivery of 3D

Specific care is needed to articulate recommendations on the web resources themselves, which are provided for an object. For example, it is sometimes not possible to give access to a "raw" 3D model, due to the size of these files. In any case, it is important to provide alternatives to the raw model, such as with an edm:isShownBy linking to an embeddable viewer which is supported by Europeana, and/or an edm:isShownAt pointing to a view of the objects at the data provider’s website. In case the provider wants to point to the raw model (e.g., to specific types of professional users who may need it, such as architects or conservators), this will always be possible via provider’s own workflows and procedures: such information should be made available in the provider’s website.

Exploitation of enhanced metadata on 3D representations

Several of the issues that we have observed for representing 3D objects can be traced back to concerns of display in the Europeana website. For example a record can have the dc:format and dc:type duplicated across a web resource and the ProvidedCHO. This is certainly not because these attributes cannot be used with WebResources. It is rather because they are not displayed on the europeana.eu portal when they are used only on the WebResource. Even the dc:creator field is not displayed when it is attached to the WebResource. This is a barrier for data providers

[21] The situation of a ProvidedCHO standing for a born-digital object would be different. There, for example, the dc:creator of the ProvidedCHO is likely to be also the creator of the model itself (which should still be also represented on the WebResource)

that seek to convey to users information that they feel is important. Adapting display and search (indexing) to better surface information about (3D) web resources should be implemented at the same time as the data model is deployed and documentation is updated. Note that this is in line with work started in the Europeana Data Quality Committee about enhancing discoverability of (general) web resources by users.

6. Roadmap for future work

As next steps, we will work on confirming the proposals in this document and progress on their implementation. The main elements of work are:

- Identify requirements for paradata and technical metadata on 3D models. These requirements will include the representation of
    - types of model by high-level categorisation ("reality captured" vs "3D reconstruction") and
    - types of model by technical aspect of the representation[22]: point cloud, mesh with higher or lower polygon count, with or without textures, etc. (from a controlled list of types, preferably)
    - types of model by project/motivation/limitations (especially provenance info that could give hints about the quality and trustworthiness of the 3D model)
    - intended usage of 3D models, especially, for links to embeddable viewers
    - any other context information (digital provenance) is relevant to capture for basic access and re-use scenarios in Europeana (including and beyond dcterms:provenance). This could focus on elements which are in existing established schema for paradata (e.g. CIDOC-CRM dig, CARARE 2.0 etc) or which can be detected automatically.

    We will seek to identify these requirements from studying (re-)user applications[23], earlier reports[24], more record examples[25], existing and coming metadata schema inventories and mappings[26] and relevant data space outcomes planned for the period[27]. Also, UNESCO is currently preparing updated "Principles for recording cultural heritage" that include a short section about metadata, which should be relevant. We will check whether additional requirements would arise from other data

[22] Cf slide 13 at https://docs.google.com/presentation/d/1AeG8mFWl1gzIhEkFO_glOCud5SJW8_OI/edit#slide=id.g297a7348da5_0_117

[23] We could use https://idovir.com/ as case study. The portal presents some structured data on 3D digitization projects and the software they use, but it seems that it also has a free-form description of paradata and a link to a fuller representation.

[24] We could draw an inventory of types of 3D content relevant for Europeana and a first analysis of digital provenance information from the report of the EuropeanaTech task force on 3D content (e.g. sections 2.2.1, 5.1, 5.2 and Appendix 1).

[25] It will be interesting to present cases where different versions of a 3D model are available and hierarchical objects where an object is embedded in another object.

[26] See ongoing work on this Miro board: https://miro.com/app/board/uXjVP9vAkWk=/ and data space outcomes Mapping of national and sectoral repositories handling 3D data completed (Apr 2024), Overview of standards and fields used to describe 3D delivered (June 2024)

[27] Especially, Strategy for content embedding is designed and implemented as a MVP (Jul 2024)

space outcomes that are not specific to 3D but may have a relation, such as the work on enrichment and provenance[28] as well as annotations.

- Identify which new elements should be included in the EDM model, trying to re-use as much as possible existing metadata standards used in the domain. E.g., for context/provenance, re-using Dublin Core's dcterms:provenance[29] (for more EDM classes), the proposed extension for events in EDM and/or specific modelling support for software processes, like dcterms:Software. Emphasis should be given on use of Linked Open Data data models and vocabularies. This task should be aligned with the work needed for the data space outcome *Interoperability between EDM and models to describe 3D established* (Jul 2024)
- Identify first 3D-centred quality criteria for metadata on 3D objects, especially identifying mandatory or recommended metadata elements. These could be included in the Europeana Publishing Framework. For instance we can include information about 3D objects such as file format, number of vertices, etc, in the calculation of EPF Metadata tiers. The type/motivation for 3D models as discussed in section 4 could also be relevant with regards to setting up quality requirements on the provenance metadata. For this effort it will be useful to re-use works that seek to define completeness of 3D information, such as the 4CH report mentioned above and the Study on quality in 3D digitisation of tangible cultural heritage[30].
- Discuss with the designers of the europeana.eu website, how the new metadata and content could be accessed and displayed. This includes how to download and display different versions of a 3D model, embeddable viewers[31] as well as provenance information represented via the corresponding WebResources.
- Review documentation and guidelines to properly reflect adherence to the one-to-one principle and avoid problematic mappings mentioned in section 4.

In the meantime, we will share the recommendations here with the Member States working group on 3D (CEDCHE[32]) and with the 4CH initiative. We will also seek feedback from any other expert that expresses interest in doing so. This would allow more interested stakeholders to be involved, for example from the EuropeanaTech community - we will especially target the experts involved in the earlier EuropeanaTech task force on 3D. We could also engage the IIIF 3D Technical Specification Group[33].

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[28] Especially in the data space outcome Provenance mechanism in EDM are refined to accommodate new needs (May 2024)

[29] Note that the current dcterms:provenance is focused on "ownership and custody" while we need to represent paradata

[30] https://digital-strategy.ec.europa.eu/en/library/study-quality-3d-digitisation-tangible-cultural-heritage A lot of this work being focused on the quality of (3D) content, it is likely that concrete quality requirements based on it would rather be fit for inclusion in the computation of the EPF Content tiers, not the Metadata ones.

[31] The report of the EuropeanaTech task force on 3D content includes a list of viewers (Section 5.2 and Appendix 1)

[32] https://digital-strategy.ec.europa.eu/en/news/expert-group-common-european-data-space-cultural-heritage

[33] https://iiif.io/community/groups/3d/tsg/

Appendix - Sample metadata for a reality-captured 3D model

This section presents an example of an EDM metadata record for a 3D model Japanese Arita Ware porcelain figure of a puppy, which follows the findings in this first review. In this case, the provider has chosen to have the ProvidedCHO stand for the (reality-captured) 3D model and not the original object.

The example represents an "ideal" representation, which may differ from the current metadata for the object. For readability, namespace declarations are omitted.

```
<rdf:RDF>
  <edm:ProvidedCHO rdf:about="share3d:1218">
    <dc:identifier>share3d:1218</dc:identifier>
    <dc:title xml:lang="en">3D model of Japanese Aritaware porcelain figure
of a puppy</dc:title>
    <dc:description xml:lang="en">A porcelain dog, white with black spots and
wearing a red collar with a bell [?]. His tail is curled behind him and he
looks upward.  Puppies are associated with good luck and protection from
evil. They are usually given to newborn baby boys to keep them safe from
harm. Arita ware from the Arita province, Japan.
</dc:description>
    <dc:subject xml:lang="en">Animals &amp;amp; Pets</dc:subject>
    <dc:subject xml:lang="en">Cultural Heritage &amp;amp; History</dc:subject>
    <dc:subject xml:lang="en">Aritaware</dc:subject>
    <dc:subject xml:lang="en">Japanese porcelain</dc:subject>
    <dc:subject rdf:resource="http://vocab.getty.edu/aat/300010662"/>
    <dc:subject rdf:resource="http://vocab.getty.edu/aat/300256050"/>
    <dcterms:spatial rdf:resource="#edmPlace_share3d:1218/SP.1"/>
    <dcterms:temporal rdf:resource="share3d:1218/TMP.1"/>
    <dc:relation
rdf:resource="https://www.huntmuseum.com/explore/item/43e62130-d57e-321b-a787
-3d9ebf448d71/?s%3Dpuppy&amp;amp;pos=1"/>
    <dcterms:provenance xml:lang="en">Models are created using Shining3D's
Einscan Pro 2X laser scanner and ExScan Pro software. They are then processed
using Meshlab and Blender. ; Laser scanning; Mesh cleaning; Mesh
processing</dcterms:provenance>
    <dc:type xml:lang="en">3D</dc:type>
    <dc:type rdf:resource="http://example.org/realitycapturedmodel"/>
    <dc:type rdf:resource="http://example.org/mesh"/>
    <dcterms:isPartOf xml:lang="en">Share3D</dcterms:isPartOf>
    <edm:type>3D</edm:type>
  </edm:ProvidedCHO>

  <edm:Place rdf:about="#edmPlace_share3d:1218/SP.1">
    <wgs84_pos:lat>36.5748</wgs84_pos:lat>
    <wgs84_pos:long>139.239</wgs84_pos:long>
    <skos:prefLabel>Japan</skos:prefLabel>
  </edm:Place>

  <edm:TimeSpan rdf:about="share3d:1218/TMP.1">
```

```
    <skos:prefLabel xml:lang="en">17th century CE</skos:prefLabel>
    <edm:begin>1600</edm:begin>
    <edm:end>1699</edm:end>
    <owl:sameAs rdf:resource="http://vocab.getty.edu/page/aat/300404511"/>
    <owl:sameAs rdf:resource="https://www.wikidata.org/wiki/Q7016"/>
  </edm:TimeSpan>

  <edm:WebResource
rdf:about="https://sketchfab.com/models/65cda809d508405f8d42f68801459a62/embe
d">
    <dc:creator>The Hunt Museum, Limerick, Ireland</dc:creator>
    <dc:language>en</dc:language>
    <dcterms:created>2022</dcterms:created>
    <edm:rights
rdf:resource="http://creativecommons.org/publicdomain/mark/1.0/"/>
    <dcterms:provenance xml:lang="en">Models are created using Shining3D's
Einscan Pro 2X laser scanner and ExScan Pro software. They are then processed
using Meshlab and Blender. </dcterms:provenance>
    <dc:format xml:lang="en">glTF</dc:format>
    <edm:type>3D</edm:type>
    <dc:type xml:lang="en">3D</dc:type>
    <dc:type rdf:resource="http://example.org/realitycapturedmodel"/>
    <dc:type rdf:resource="http://example.org/mesh"/>
  </edm:WebResource>

  <ore:Aggregation rdf:about="share3d:1218#aggregation">
    <edm:aggregatedCHO rdf:resource="share3d:1218"/>
    <edm:dataProvider>The Hunt Museum</edm:dataProvider>
    <edm:provider>CARARE</edm:provider>
    <edm:isShownAt
rdf:resource="https://sketchfab.com/models/65cda809d508405f8d42f68801459a62/e
mbed"/>
    <edm:isShownBy
rdf:resource="https://sketchfab.com/models/65cda809d508405f8d42f68801459a62"/
>
    <edm:rights
rdf:resource="http://creativecommons.org/publicdomain/mark/1.0/"/>
    <edm:object
rdf:resource="https://media.sketchfab.com/models/65cda809d508405f8d42f6880145
9a62/thumbnails/3bf41dbfdcd44704be9b20708ba83e2e/0c1dae5da92f4387bd2a6ae39760
cbfc.jpeg"/>
  </ore:Aggregation>
</rdf:RDF>
```

Discussion of example:

`dc:relation | https://www.huntmuseum.com/explore/item/43e62130-d57e[...]`
It was kept here because the ProvidedCHO stands for a 3D model. But if it was standing for the original asset, then this statement could be better with the other properties of Aggregation (as edm:hasView or even edm:isShownAt)

`dcterms:provenance | Models are created using [...]`
This choice is not ideal: in Dublin Core, dcterms:provenance is "A statement of any changes in ownership and custody of the resource since its creation that are significant for its authenticity, integrity, and interpretation."
Also, what is mapped in this element is repeated in the WebResource. This is a side effect of having the ProvidedCHO stand for the 3D model.

`dc:type | 3D`
Mapping '3D' in this element is not very useful. It is better to use a more specific typology, e.g. 'reality captured 3D model', as in the other dc:type statements in this example.
Also, having '3D' mapped in both dc:type and edm:type creates unnecessary redundancy.

`dcterms:isPartOf | Share3D`
Mapping the name of the project in this element has been a way to track data submissions for GS projects. However, there may be cases that require a more optimal use of the element, e.g., representing objects that are part of a hierarchy.

`dc:creator | The Hunt Museum, Limerick, Ireland`
`dc:language | en`
`dcterms:created | 2022`
If the ProvidedCHO is the model, then, these statements can also be copied to the ProvidedCHO resource in the record. It would create redundancy, however, as for the dcterms:provenance statement discussed above.

Appendix: Sample metadata for 3D reconstruction

This section presents an example of an EDM metadata record for a 3D reconstruction[34]. The choices made for this representation are quite similar to those made for the porcelain figure above. Especially, the provider has chosen to have the ProvidedCHO stand for the 3D model and not the original object.
For readability, namespace declarations are omitted.

```
<rdf:RDF>
  <edm:ProvidedCHO rdf:about="share3d:58">
    <dc:identifier>share3d:58</dc:identifier>
    <dc:title xml:lang="en">Ename abbey guest quarters and carillon
tower</dc:title>
    <dc:description xml:lang="en">Virtual reconstruction with guided tour
through the entrance, carillon tower and prison of the Benedictine abbey of
Ename, Belgium around 1665.  A carillon tower, indicating time every quarter
of an hour in an auditive way, was essential in organising a society that
barely had any personal watches or timepieces yet.
```

[34] https://www.europeana.eu/en/item/181/share3d_58

```
Work in progress [background
information](https://enameabbey.wordpress.com/2019/06/20/the-world-of-abbot-d
e-loose/)</dc:description>
    <dc:language>English</dc:language>
    <dc:creator>visualdimension</dc:creator>
    <dcterms:created>2019</dcterms:created>
    <dc:rights xml:lang="en">Visual Dimension bvba</dc:rights>
    <dc:subject rdf:resource="http://vocab.getty.edu/aat/300000642"/>
    <dc:subject rdf:resource="http://vocab.getty.edu/aat/300195449"/>
    <dc:subject rdf:resource="http://vocab.getty.edu/aat/300006460"/>
    <dc:subject rdf:resource="http://vocab.getty.edu/aat/300148044"/>
    <dcterms:spatial rdf:resource="#edmPlace_share3d:58/SP.1"/>
    <dcterms:temporal xml:lang="en">1665</dcterms:temporal>
    <dcterms:temporal rdf:resource="share3d:58/TMP.1"/>
    <dc:relation
rdf:resource="https://enameabbey.wordpress.com/2019/06/20/the-world-of-abbot-
de-loose/"/>
    <dcterms:provenance xml:lang="en">The 3D model was created based upon a
map and a drawing by surveyor Jan Bale in 1661, in addition to excavation
data of the building; Building Information Modeling</dcterms:provenance>
    <dc:format xml:lang="en">glTF</dc:format>
    <dc:type xml:lang="en">3D</dc:type>
    <dcterms:isPartOf xml:lang="en">Share3D</dcterms:isPartOf>
    <dcterms:isPartOf xml:lang="en">Belgium</dcterms:isPartOf>
    <edm:type>3D</edm:type>
  </edm:ProvidedCHO>
  <edm:Place rdf:about="#edmPlace_share3d:58/SP.1">
    <wgs84_pos:lat>50.8578</wgs84_pos:lat>
    <wgs84_pos:long>3.62914</wgs84_pos:long>
    <skos:prefLabel>Ename, Oudenaarde</skos:prefLabel>
  </edm:Place>
  <edm:TimeSpan rdf:about="share3d:58/TMP.1">
    <skos:prefLabel xml:lang="en">17th century CE</skos:prefLabel>
    <edm:begin>1600</edm:begin>
    <edm:end>1699</edm:end>
    <owl:sameAs rdf:resource="http://vocab.getty.edu/page/aat/300404511"/>
    <owl:sameAs rdf:resource="https://www.wikidata.org/wiki/Q7016"/>
  </edm:TimeSpan>
  <edm:WebResource
rdf:about="https://sketchfab.com/models/1f60850f4ac248b18b6a0c83ed560878/embe
d">
    <dc:creator>visualdimension</dc:creator>
    <dc:description xml:lang="en">The 3D model was created based upon a map
and a drawing by surveyor Jan Bale in 1661, in addition to excavation data of
the building</dc:description>
    <dc:format xml:lang="en">glTF</dc:format>
    <dc:type xml:lang="en">3D</dc:type>
    <dcterms:created>2019</dcterms:created>
  </edm:WebResource>
  <ore:Aggregation rdf:about="share3d:58#aggregation">
    <edm:aggregatedCHO rdf:resource="share3d:58"/>
    <edm:dataProvider>visualdimension</edm:dataProvider>
    <edm:provider>CARARE</edm:provider>
```

```
    <edm:isShownAt
rdf:resource="https://sketchfab.com/models/1f60850f4ac248b18b6a0c83ed560878/e
mbed"/>
    <edm:isShownBy
rdf:resource="https://sketchfab.com/models/1f60850f4ac248b18b6a0c83ed560878"/
>
    <edm:rights
rdf:resource="http://rightsstatements.org/vocab/NoC-NC/1.0/"/>
    <edm:object
rdf:resource="https://media.sketchfab.com/models/1f60850f4ac248b18b6a0c83ed56
0878/thumbnails/73da0a6f0fb34a65b2389508ae2cd7b9/d939efd3be6342a4b6129cc5ae3e
1b47.jpeg"/>
  </ore:Aggregation>
</rdf:RDF>
```

Appendix - Sample metadata for a reality-captured 3D model (2)

```
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF>
      <edm:ProvidedCHO rdf:about="urn:nbn:sk:cair-ko2g9e6">
      <dcterms:created xml:lang="sk">13. storočie</dcterms:created>
      <dcterms:created xml:lang="en">13th century</dcterms:created>
      <dc:description xml:lang="sk">Rotunda - neskororománska tehlová
rotunda s vnútornou apsidou z druhej štvrtiny 13. storočia. Zachovaná
románska stavba kostola s minimom neskorších stavebných úprav je jednou z
najvýznamnejších pamiatok tohto obdobia na Slovensku. S vnútorným priemerom
11m patrí Kostol zasvätený sv. Margite Antiochijskej medzi najväčšie románske
stavby kruhového pôdorysu v strednej Európe.
Pôvodne románske nástenné maľby, ktoré zobrazovali výjavy z legendy o sv.
Margite, boli prekryté gotickými maľbami s rovnakou tematikou a doplnené
výjavmi pašiového cyklu. Najcennejšou je románska výmaľba svätyne s výjavmi o
živote a umučení sv. Margity. Tieto etapy sú zobrazené v hornom páse malieb
na monumentálnom lomenom oblúku.
V 18. storočí bola do starej kamennej ohrady vstavaná zvonica so vstupnou
bránou. V tesnom susedstve sa dodnes nachádza cintorín.
Dvanásť z kostolov Gotickej cesty bolo v roku 2022 zapísaných do zoznamu
Európskeho dedičstva ako súbor lokalít s názvom Stredoveké nástenné maľby na
Gemeri a v Malohonte. Jedným z nich je aj rotunda v
Šiveticiach.</dc:description>
      <dc:description xml:lang="en">Rotunda - a late Romanesque brick
rotunda with an inner apse from the second quarter of the 13th century. A
preserved Romanesque building with a minimum of later construction
modifications and one of the most important monuments of this period in
Slovakia.
With an internal diameter of 11 meters, the church dedicated to St. Margaret
of Antioch in Šivetice is one of the largest circular-shaped Romanesque
structures in Central Europe.
Originally adorned with Romanesque frescoes portraying scenes from the legend
of St. Margaret, the church underwent a transformation with the addition of
```

Gothic paintings featuring the same themes. These were complemented by depictions from the Passion cycle. The most valuable part is the Romanesque frescoes in the sanctuary, vividly illustrating the life and martyrdom of St. Margaret. These stages are portrayed in the upper band of paintings on the grand pointed arch.
In the 18th century, a bell tower with an entrance gate was incorporated into the old stone enclosure. To this day, a cemetery is situated in close proximity.
Twelve of churches of the Gothic Route were inscribed on the European Heritage List in 2022 as a set of sites called Medieval Wall Paintings of Gemer and Malohont. Rotunda of St. Margaret is one of them.</dc:description>
<dc:identifier>urn:nbn:sk:cair-ko2g9e6</dc:identifier>
<dcterms:spatial rdf:resource="https://sws.geonames.org/3057568/"/>
<dc:title xml:lang="sk">Rotunda sv. Margity Antiochijskej</dc:title>
<dc:title xml:lang="en">Rotunda of St. Margaret of Antioch</dc:title>
<dc:type xml:lang="sk">architektonické pamiatky</dc:type>
<dc:type xml:lang="en">monuments</dc:type>
<edm:type>3D</edm:type>
<dc:rights xml:lang="sk">Pamiatkový úrad Slovenskej republiky</dc:rights>
<dc:rights xml:lang="en">The Monuments Board of Slovak republic</dc:rights>
<dc:subject xml:lang="sk">rotunda</dc:subject>
<dc:subject xml:lang="sk">architektúra a pamiatky</dc:subject>
<dc:subject xml:lang="sk">sakrálna stavba</dc:subject>
<dc:subject xml:lang="sk">románska stavba</dc:subject>
<dc:subject xml:lang="sk">kultúrne dedičstvo</dc:subject>
<dc:subject xml:lang="en">architecture</dc:subject>
<dc:subject xml:lang="en">cultural heritage</dc:subject>
<dc:subject xml:lang="en">history</dc:subject>
<dc:subject rdf:resource="http://vocab.getty.edu/aat/300177433"/>
<dc:subject rdf:resource="http://vocab.getty.edu/aat/300004842"/>
<dc:subject rdf:resource="http://vocab.getty.edu/aat/300020768"/>
<dc:subject rdf:resource="http://vocab.getty.edu/aat/300004559"/>
<dc:subject rdf:resource="http://vocab.getty.edu/aat/300007391"/>
<dcterms:spatial>Banskobystrický samosprávny kraj</dcterms:spatial>
<dcterms:spatial>Gemer</dcterms:spatial>
<dcterms:spatial>Šivetice</dcterms:spatial>
</edm:ProvidedCHO>
<edm:WebResource rdf:about="https://sketchfab.com/3d-models/sivetice-rotunda-of-st-margaret-of-antioch-307bb162a0924276a04a1f4d39a8e04a/embed">
<dc:description xml:lang="sk">3D model rotundy s kamennou ohradou a zvonicou so vstupnou bránou</dc:description>
<dc:description xml:lang="en">3D model of Rotunda and the stone enclosure with bell tower and entrance gate</dc:description>
<dcterms:created>2023</dcterms:created>
<edm:rights rdf:resource="http://creativecommons.org/licenses/by-nc-sa/4.0/"/>
</edm:WebResource>
<edm:WebResource rdf:about="https://sketchfab.com/models/56c6ac95be654c2f8494b862c1320fa8/embed">

```
      <dc:description xml:lang="sk">3D model Rotunda - interiér - vnútorná
apsida s freskami</dc:description>
      <dc:description xml:lang="en">3D model Rotunda - interior - inner apse
with frescoes</dc:description>
      <dcterms:created>2023</dcterms:created>
      <edm:rights
rdf:resource="http://creativecommons.org/licenses/by-nc-sa/4.0/"/>
      </edm:WebResource>
      <edm:WebResource
rdf:about="https://sketchfab.com/3d-models/sivetice-entrance-portal-of-the-ro
tunda-ab112f8a534d4d73bcbe0e3b8abea16e/embed">
      <dc:description xml:lang="sk">3D model Rotunda - vstupná brána
rotundy</dc:description>
      <dc:description xml:lang="en">3D model Rotunda - entrance portal of
the rotunda</dc:description>
      <dcterms:created>2023</dcterms:created>
      <edm:rights
rdf:resource="http://creativecommons.org/licenses/by-nc-sa/4.0/"/>
      </edm:WebResource>
      <ore:Aggregation
rdf:about="https://www.slovakiana.sk/kulturne-objekty/cair-ko2g9e6">
      <edm:aggregatedCHO
rdf:resource="https://sketchfab.com/3d-models/sivetice-rotunda-of-st-margaret
-of-antioch-c7c37dd7945140748a889250e381dcf7"/>
      <edm:dataProvider xml:lang="sk">PÚ SR</edm:dataProvider>
      <dc:date>2023</dc:date>
      <edm:isShownAt
rdf:resource="https://www.slovakiana.sk/kulturne-objekty/cair-ko2g9e6"/>
      <edm:isShownBy
rdf:resource="https://sketchfab.com/3d-models/sivetice-rotunda-of-st-margaret
-of-antioch-c7c37dd7945140748a889250e381dcf7"/>
      <edm:hasView
rdf:resource="https://sketchfab.com/3d-models/sivetice-rotunda-of-st-margaret
-of-antioch-307bb162a0924276a04a1f4d39a8e04a"/>
      <edm:hasView
rdf:resource="https://sketchfab.com/3d-models/sivetice-rotunda-interior-56c6a
c95be654c2f8494b862c1320fa8"/>
      <edm:hasView
rdf:resource="https://sketchfab.com/3d-models/sivetice-entrance-portal-of-the
-rotunda-ab112f8a534d4d73bcbe0e3b8abea16e"/>
      <edm:rights
rdf:resource="http://creativecommons.org/licenses/by-nc-sa/4.0/"/>
      <edm:object
rdf:resource="https://media.sketchfab.com/models/c7c37dd7945140748a889250e381
dcf7/thumbnails/3a530e25a5d447ecb46dee661f7f1bb1/02189a99fce4403f94d44c010759
3320.jpeg"/>
      <edm:provider>Slovakiana</edm:provider>
      </ore:Aggregation>
</rdf:RDF>
```