



## Metadata Schemas



## Abstract

A document that describes a series of metadata schemas such as bibliographic documentation or geoinformatics, that are required to be added to the BIM model in order to meet the specifications of a CIDOC CRM based on ISO standards ISO 21127:2014.

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## Metadata Schemas - Matching of elements

In building our approach as a matter of good practice, the first step was to map the common meaningful fields of metadata attributes between three relevant schemata: the IFC standard which addresses the needs of the building construction; the MIDAS schema of the English Heritage, which covers the needs of built heritage, monuments and historic sites' enquiries, and finally, the CityJSON schema which introduces the relevant attributes of the city scale. This helped us creating the appropriate vocabulary and links between the attributes for the semantic structuring of the metadata.

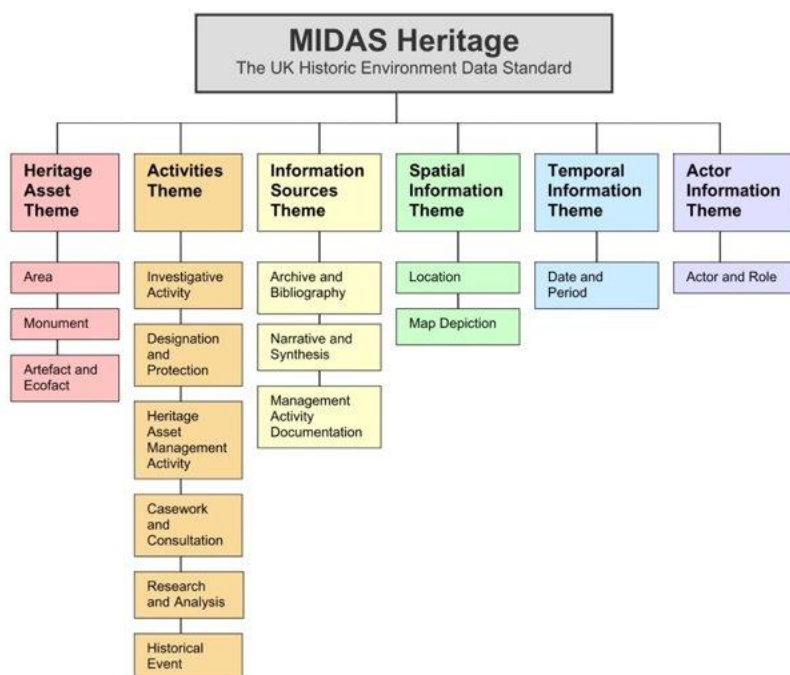


Figure 1. MIDAS schema for built heritage and monuments.

The CARARE schema is an application profile of the Europeana Data Model (EDM). It is based on MIDAS Heritage, LIDO and EDM, and compatible with the CIDOC CRM. The strength of the schema lies with its ability to support the full range of descriptive information about monuments, building, landscape areas and their representations in both 2D and 3D. The CARARE schema's main information classes are:

- Heritage asset – this includes archaeological monuments, historic buildings, industrial monuments, archaeological landscape areas, shipwreck, artefacts and ecofacts, as well as books, printed materials, printed maps, drawings, photographs, films and born-digital 3D models which relate to the archaeological and architectural heritage;
- Digital resource – these are online resources (image, text, video, audio, 3D model) being made accessible to the service environment (e.g. CARARE, Europeana);
- Collection information – this describes the collection which holds the content being provided;
- Activity – this includes both historical events which took place at the heritage assets (such as building, alternation, demolition, battles, etc) and archaeological events (such as excavations, surveys, etc.).

City Geographic Markup Language (CityGML) CityGML has developed the multiscale and multiview support. The CityGML approach to the multiscale modelling consists in a method of separating features founded on the relationship between the geometric and thematic component. For each LOD there is a specification for the generalization level, the absolute tolerance and the included thematic classes. The model allows to associate more than one instance of a geometric class to each instance of a thematic class through a specific relation for each LOD. In addition, the multiview support associates a set of visualization settings, including the photo-realistic rendering of the surface of geometric models, to each instance of a thematic class. Based on the CityGML specifications the correspondence between the LODs and the representation scales was defined as follows: LOD4 (1:100); LOD3 (1:200-1:500); LOD2(1:500-1:1000) LOD1 (1:1000-1:2000); LOD0 (1:5000- 1:10000).

Below the comparison table, which comprised the first step in the process.

3D ICONS *	MIDAS XML Monument Schema **	IFC	CityGML	CityJSON
Record information: Unique ID assigned by the content provider.	Asset ID	Parcel: Unique code assigned by the public authorities.  <i>New Project information parameter: <b>Data - Parcel</b></i>		
Designation: The name of the spatial asset and the identifier (ID) and may be repeated if, for example, a building/spatial structure is known by more than one name or has more than one ID number.	Building name	Building name: The name of the cultural heritage building assigned by the UP team.  <i>Default Project information parameter: <b>Identity Data - Building Name</b></i>		
Description: Includes the features of the site, building, and the born-digital 2D or 3D models.		Description: Includes the typology of the cultural heritage building.  <i>New Project information parameter: <b>Construction - Description</b></i>		
General type: A broad classification of the general type of the physical asset or born-digital record intended to	Monument type	Historical style: A classification related to both general type and main features of a building that make the		

enable spaces, buildings and landscape sites to be distinguished from other objects.		<p>cultural heritage asset notable and historically identifiable.</p> <p>New Project information parameter: <b>Construction</b> - <b>Historical Style</b></p>		
<p><b>Actors:</b> Represents the actors involved with space; actors include for example creators, builders, owners, inhabitants and individual who are example creators, builders, owners, inhabitants and individual who are associated with the site or building.</p>	Associated people	<p><b>Actors:</b> People who are associated with the cultural heritage building, municipality, owner, engineers or organizations.</p> <p>Default Project information parameter: <b>Identity Data - Author Identity Data - Organization Name Identity Data - Organization Description</b> (Short Description of the organization role) New Project information parameter: <b>Phasing - Architect/ Engineering of Renovation Construction - First Owner</b> New Project information parameter: <b>General - Municipality General - Current Owner Other - Client Name Construction - Architect/ Engineering</b></p>		
<p><b>Listing:</b> Information about any designations for a site or building which provide it with protection in law.</p>	Grade	<p><b>Listing Status:</b> Information related to the land registry.</p> <p>New Project information parameter: <b>Data - Listing Status</b></p>		

		<p>Town Planning: Information related to the land registry.</p> <p>New Project information parameter: <b>Data</b> – <b>Sheet</b> <b>Data</b> – <b>Drawing</b> <b>Data</b> – <b>Parcel</b> <b>Data</b> – <b>Plot Number</b></p>		
<p>Conditions: About the condition of a site or building.</p>		<p>Conditions: A short statement about the conditions of the cultural heritage building.</p> <p>New Project information parameter: <b>Construction</b> – <b>Conditions</b></p>		
		<p>Occupation Status:</p> <p>New Project information parameter: <b>General</b> – <b>Occupation status</b></p>		
		<p>Current use:</p> <p>New Project information parameter: <b>General</b> – <b>Current Use</b></p>		
		<p>Original use:</p> <p>New Project information parameter: <b>Construction</b> – <b>Original Use</b></p>		
		<p>Entrance Orientation :</p> <p>New Project information parameter: <b>Construction</b> – <b>Entrance Orientation</b></p>		
		<p>Accessibility:</p>		



		New Project information parameter: <b>General –</b> <b>Accessibility</b>		
		Zone:  New Project information parameter: <b>Data –</b> <b>Zone</b>		
		Development plan:  New Project information parameter: <b>Data –</b> <b>Development plan</b>		

<b>Provenance:</b> A free-text statement of any changes in ownership and custody of the resource since its creation that are significant for its authenticity, integrity, and interpretation, e.g., transformations of the site of building as originally produced, the addition of auxiliary structures, or other changes; note that this 'administrative' provenance has nothing to do with the digital provenance concept, nor with construction material provenance.		<b>Historical Phasing:</b> Information related to any transformation of the building additions or other changes to the building structure.  <i>New Project information</i> parameter: <b>Phasing – Renovation Date</b> <b>Phasing – Description</b>		
<b>Structure asset type:</b> Classifies the site or building with respect to its function ore use e.g. house.				
<b>Temporal:</b> About time	<b>Period</b>	<b>Period:</b> Short description of the decades that the cultural heritage has been constructed.  <i>New Project information</i> parameter: <b>Construction - Period</b>		
	<b>Data range</b>	<b>Date:</b> <i>New Project information</i> parameter: <b>Construction - Date</b>		
<b>Materials:</b> About the basic materials of which a spatial asset is composed, e.g., brick, stone, tile, paper etc. Use of a controlled vocabulary is recommended, and the vocabulary used may be indicated using an attribute.	<b>Materials (Main)</b>	<b>Materials Main:</b> Information related to the construction materials of the building <i>New Project information</i> parameter: <b>Materials and Finishes - Material Main</b>		

	Materials (Covering)	<p>Finishings: Information related to the finishings, materials which cover the floors, materials etc.</p> <p><i>New Project information</i> parameter: <b>Materials and Finishes</b> - <b>Finishings</b></p>		
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Dimensions extent: Part of the spatial asset being measured e.g. foundations.		Dimensions extent : Information related to the finishings, materials which cover the floors, materials etc.  <i>New Project information parameter:</i> <b>Dimensions</b> - <b>Dimensions extent</b>		
Dimensions measurement: Refers to height, length, width, depth, shape.		Dimensions measurement:  <i>New Project information parameter:</i> <b>Dimensions</b> - <b>Area</b> <b>Dimensions</b> - <b>Volume</b> <b>Dimensions</b> - <b>Height</b>		
Dimensions unit: e.g. metres, centimetres etc.		<i>Default project parameter</i>		
Dimension scale		<i>Default project parameter</i>		
Dimensions value: Attribute registering the accuracy of the measurement to be indicated e.g. exact, approximate.				
Spatial: Information about the place at which the spatial asset is located, including name places, postal address, the map coordinates and geometry of the asset.		Project Location: Specifies the geographic location of the project.  <i>Default Project Location parameter</i>		
	Statutory address	Address: <i>Default Project information parameter:</i> <b>Other – Project Address</b>		
	Grid reference (Absolute)			
	Grid reference (Traditional)			

	Alternate addresses (Postal addresses)			
	Locality	Quarter: New Project information parameter: <b>General - Quartet</b>		

	Parish			
	District			
	County			
	Ceremonial county			
	Various other location flags			
Repository location: Identifies the institution which custodies the artefact and possibly the current location.		Repository location: Identifies the institution which projects the current cultural heritage building.  <i>New Project information parameter: <b>General - Repository Location</b></i>		
Publication statement		Publication Statement :		
Rights: A statement about any rights associated with the asset.		<i>New Project information parameter: <b>General - Publication Statement</b></i>		
References appellation: The name was given to the information source				
References actors: Creator, author, contributor, editor etc.				
References type: Includes archive, file, record, book, chapter, article etc.				
References rights				
References publication statement				
References note				
References link: URL where users can find the reference online.				

References have representation: Relationship between an asset and a digital resource/repository in which it is represented.				
	List description test			
	Map, volume and item reference			
	Date listed/amended			
	National park			
	Record metadata			

## Autodesk Revit: Project Information Parameters.



Construction	
Architectural Style & Period	Vernacular (Urban)
Description	A traditional ground floor house. Built on a neoclassical style with influences from rural Cypriot architecture. Its main façade is along the street border. The main entrance, with a carved stone frame and a wrought iron skylight, leads directly to the sunroom.
Date	1920
Architect/ Engineer	Unknown
Entrance Orientation	North
Original use	Residential
First Owner	Paraskevas Paraskevopoulos
Condition	Conserved
Material and Finishes	
Material Main	Sandstone; adobe; timber
Finishings	Plaster
Dimensions	
Area	75.00m <sup>2</sup>
Volume	450m <sup>3</sup>
Height	6.00m
Identity Data	
Building Name	STR_217
Organization Description	
Organization Name	Urban Periscope
Phasing	
Renovation Date	2007
Description	Replacement of roof tiles by asbestos sheets, replacement of the original floors and window sills with mosaics, additions of cement plasters to the walls (unknown date); Restoration of the existing structure, addition of a two-storey extension, removal of incompatible plasters, demolition of subsequently added elements, removal of asbestos roof, reconstruction of original roof, repair of entrance gate (2007).
Architect/ Engineer of Renovation	Christos Theodorou
General	
Current Owner	Pavlos Pamporidis
Repository Location	
Publication statement	

Current use	Residential
Occupation Status	Occupied
Accessibility	Accessible
Quarter	Chryseleousa
Municipality	Strovolos
Sheet	21
Drawing	1012V02
Development Plan	Nicosia Local Plan
Zone	Πα9
Listing Status	Listed
Plot Number	217
Parcel	217
Project Address (Default)	Megalou Alexandrou 21
Project Issue Date (Default)	090920
Project Status (Default)	SHR
Project Address (Default)	28is Oktobriou
Project Name (Default)	UP_STR_7D.01_CVI_ARC_217_M3_SHR
Project Number (Default)	217

## Work towards the development of metadata schema for Architecture Heritage

Historic urban environments are not given static formations disconnected from the contemporary fabric of a city, but rather a set of tangible and intangible assets subjected to dynamic pressures of economic, environmental, and social activities. The sustainable development of these environments is often threatened by urbanization, neglect and climate. The cross-disciplinary nature of the pressing challenges posed by these phenomena (Historic England 2020) requires the development of novel data-driven tools for agile safeguarding of our historic building stock. In an era of rapid technological developments due to digitization initiatives, state-of-the-art methods and data-driven tools dedicated to the protection and promotion of architectural heritage should be exploited and extensively employed in the sustainable management of built environment. The adoption of holistic, integrated, multi-disciplinary methods can bridge technological innovation with the conservation and restoration of heritage buildings. The next step in the development of built heritage digitisation methods should focus in expanding the scope of study beyond the single built heritage structure and allowing deeper understanding and interdisciplinary interpretation of its condition and performance within its topographical context and the surrounding built environment. This could become a reality today by means of the advancements in digital tools, remote sensing, algorithms and computation prowess of hardware available to researchers (Mohamed et al. 2020). Particularly, data interoperability and re-use, in the context of the FAIR principles, can only be achieved through the semantic description, using metadata and ontologies (Messaoudi et al. 2018).

Arguably, the penetration of Building Information Modelling software in the building industry is enabled by semantic tools, such as the Industry Foundation Classes (IFC) data model (2022) or the Green Building XML schema (gbXML). Acknowledging this, the research explored possible specifications and metadata schemas which facilitate interdisciplinary research for the study and reuse of built heritage in our cities, analysing and representing scales larger than the one of the building itself, including building blocks, streets, or even neighborhoods. First, we created the process graph that connects all metadata from the urban scale down to architectural-historical scale laid in order by LOD (100>400), as in Figure 2.

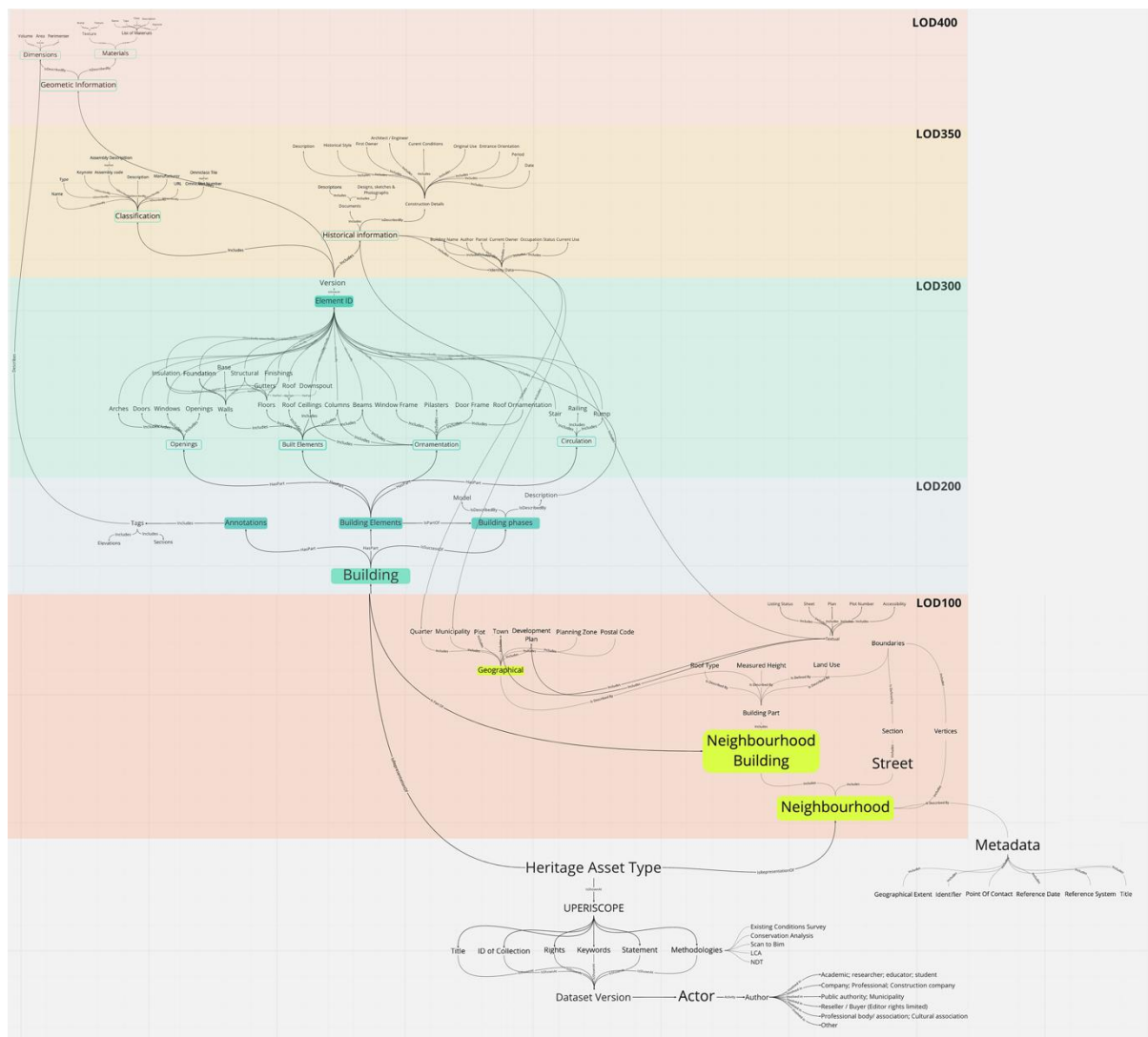


Figure 2. A process graph of the metadata structured by Level of Detail (LOD100-400). Aim of the development of this process graph is to structure and enable the integration of multiple datasets on the UP platform.

Particularly, the action focused on the creation of a new metadata schema that would enable linking the relevant to cultural heritage of our historic cities' multi-modal and multi-discipline datasets, e.g., 3D models, IFC classes, historical descriptions, and environmental data. That was done considering how this multiscale data-driven study can facilitate a more holistic, integrated application of digital methods, such as BIM, modelling & simulation to cities, and better contextualise cross-disciplinary enquiries (Cursi et al. 2022).

The work focused on assessing a series of existing metadata schemas such as bibliographic documentation or geoinformatics, which are required to be added to the BIM model in order to meet the specifications of a CIDOC-CRM based on ISO standards ISO 21127:2014 (Acierno et al. 2017). The result of this action is the description of a new metadata schema, CIDOC-CRM compatible, as an extension of the CARARE 2.0 metadata schema (Fernie et al. 2013), which in turn is based on MIDAS

metadata standard for built heritage and monuments (English Heritage 2012). The creation of such a data model contributes to the long-standing discourse in the field (Ronzino et al. 2013; Ronzino, Niccolucci and D’Andrea 2013), which will concur in the future to big data management for historic cities.

In this Project action, a further step in the description and standardization of architectural data has been carried out: the alignment of the proposed metadata schema to the CIDOC CRM ontology and its extensions (Figure 5). The semantic integration allows the holistic description of the different aspects of the Architectural Heritage and provide a multidisciplinary perspective to its study, including historical and landscape analysis, environmental investigations and climate change impact on its conservation and preservation.

The first step of the research consisted of the establishment of the methodology towards the development of such an inter-disciplinary ontological solution. This step required to first identify the best strategy for including all the different information embedded in the newly proposed metadata schema and the missing ones (Figure 3).

	A	B	C
1	FIELDS/CLASSES	IFC CLASS	IFC CLASSE SCOPE NOTE
2	Periscope	<a href="#">IfcContext</a>	Is the generalization of a project context in which objects, type objects, property sets, and properties are defined
3	Title	<a href="#">IfcLabel</a>	Is the term by which something may be referred to. It is a string which represents the human-interpretable name of something and shall have a natural-language meaning
4	Actor	<a href="#">IfcActor</a>	Defines all actors or human agents involved in a project during its full life cycle. It facilitates the use of person and organization definitions in the resource part of the IFC object model. This includes name, address, telecommunication addresses, and roles
5	Activity	<a href="#">IfcTask</a>	Is an identifiable unit of work to be carried out
6	Author	<a href="#">IfcActorRole</a>	Indicates a role which is performed by an actor, either a person, an organization or a person related to an organization
7	ID of collection		
8	Rights	<a href="#">IfcOwnerHistory</a>	Defines all history and identification related information. In order to provide fast access it is directly attached to all independent objects, relationships and properties

Figure 3. More specifically, this step required to first identify the best strategy for including all the different information embedded in the newly proposed metadata schema and the missing attributes. To do so, the fields of the new metadata schema were listed. This allowed to clarify their structure and relations and the existence of hierarchies between them, and to identify repetitions of concepts, possible inconsistencies and lacks of classes useful to the description of the Architectural Heritage in its broader sense. In parallel, the classes have been analysed one by one in order to understand the meaning of each field. An explicit attribution and the scope note were needed, therefore the analysis of the terms also

involved the meaning attribution to them. In some cases, this exercise allowed to identify some superimposition of fields/meanings or lack of concepts.

To do so, the fields of the new metadata schema have been listed. This allowed to clarify their structure and relations and the existence of hierarchies between them, and to identify repetitions of concepts, possible inconsistencies and lacks of classes useful to the description of the Architectural Heritage in its broader sense. In parallel, the classes have been analysed one by one in order to understand the meaning of each field. Some of the fields are borrowed from the Industry Foundation Classes (IFC) data model, for which a reference is provided. Others are taken from other metadata schema or newly created. An explicit attribution and the scope note were needed, therefore the analysis of the terms also involved the meaning attribution to them. In some cases, this exercise allowed to identify some superimposition of fields/meanings or lack of concepts of the terms.

	A	B	C	D	E	F	G
1	FIELDS/CLASSES	IFC CLASS	IFC CLASSE SCOPE NOTE	PROPERTY	CIDOC CRM		
2	Periscope	<a href="#">IfcContext</a>	Is the generalization of a project context in which objects, type objects, property sets, and properties are defined		D13 Digital Information Carrier	D1 Digital Object	
3	Title	<a href="#">IfcLabel</a>	Is the term by which something may be referred to. It is a string which represents the human-interpretable name of something and shall have a natural-language meaning	P132 has title	E35 Title		
4	Actor	<a href="#">IfcActor</a>	Defines all actors or human agents involved in a project during its full life cycle. It facilitates the use of person and organization definitions in the resource part of the IFC object model. This includes name, address, telecommunication addresses, and roles	P94 has created by	E39 Actor	Vocabulary	
5	Activity	<a href="#">IfcTask</a>	Is an identifiable unit of work to be carried out				
6	Author	<a href="#">IfcActorRole</a>	Indicates a role which is performed by an actor, either a person, an organization or a person related to an organization				
7	ID of collection						
8	Rights	<a href="#">IfcOwnerHistory</a>	Defines all history and identification related information. In order to provide fast access it is directly attached to all independent objects, relationships and properties	P104 is subjected to	E30 Right		
9	Is a resource						

Figure 4. Finally, the last step consisted of the alignment of the metadata fields to the ontology. The selected one was the CIDOC CRM ontology. That choice is due to the fact that is an ISO standard and because of specific extensions dedicated to buildings, specifically CRMba (Building Archaeology), therefore taking into consideration also the heritage aspect of Architectural assets.

Finally, the last step of the action consisted of the alignment of the metadata fields to the ontology. The selected one was the CIDOC CRM ontology. That choice is due to the fact that is an ISO standard and because of specific extensions dedicated to the description of build structures, specifically CRMba (Building Archaeology), therefore taking into consideration also the heritage aspect of Architecture (Figure 4). Moreover, the ontology has several extensions covering different disciplines and aspects of the research and therefore covering a broad range of concepts related with the inter-disciplinarity of the subject studied. Specifically, beyond the core CRM, and the extension dedicated to buildings, further extensions such as CRMdig (dedicated to the digital version of the cultural/architectural heritage) and the CRMsci (dedicated to the scientific observation and analysis) have been considered. This allowed the authors to cover several aspects of the Architectural research, including documentation, digitization, analysis of the state of conservation and of the landscape (Figure 5).





Deligiorgi, Marissia; Vassallo, Valentina; Tsagka, Anastasia; Artopoulos, Georgios A new metadata schema about “Architectural Heritage in the Built Environment”, DARIAH Annual Event 2023, Cultural Heritage Data as Humanities Research Data? June 7 - 9, Budapest. DARIAH ERIC.

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## References

- Acierno, M., Cursi, S., Simeone, D., Fiorani, D. (2017). Architectural heritage knowledge modelling: An ontology-based framework for conservation process. *Journal of Cultural Heritage*, 24, 124–133.
- Artopoulos, G.. (2020, December 2). Schemas for BIM interoperability: a case for linked urban data. Scholarly Primitives - DARIAH Annual Event 2020, Zagreb, Croatia. <https://doi.org/10.5281/zenodo.4302146>
- CityGML & CityJSON metadata schema for building <http://schemas.opengis.net/citygml/building/2.0/>
- Cursi, S., Martinelli, L., Paraciani, N., Calcerano, F., Gigliarelli, E. (2022) Linking external knowledge to heritage BIM. *Automation in Construction*, 141, 104444.
- English Heritage (2012), MIDAS Heritage – The UK Historic Environment Data Standard, v1.1. [https://historicengland.org.uk/images-books/publications/midas-heritage/midas-heritage-2012-v1\\_1/](https://historicengland.org.uk/images-books/publications/midas-heritage/midas-heritage-2012-v1_1/); [https://www.jiscmail.ac.uk/cgi-bin/filearea.cgi?LMGT1=FISH&a=get&f=/MIDASXMLCaseStudy\\_LBS.htm](https://www.jiscmail.ac.uk/cgi-bin/filearea.cgi?LMGT1=FISH&a=get&f=/MIDASXMLCaseStudy_LBS.htm)
- Fernie, K., Gavrili, D., & Angelis, S. (2013). The CARARE metadata schema, v.2.0. Zenodo. <https://doi.org/10.5281/zenodo.495365>; [https://pro.carare.eu/documents/8/the\\_carare\\_metadata\\_schema2.pdf](https://pro.carare.eu/documents/8/the_carare_metadata_schema2.pdf)
- Green Building XML (2023). [https://www.gbxml.org/About\\_GreenBuildingXML\\_gbXML](https://www.gbxml.org/About_GreenBuildingXML_gbXML), accessed 12 January 2023.
- Historic England (2020). Architectural Investigation, <https://historicengland.org.uk/research/methods/architectural-investigation>, accessed 10 March 2021.



- Industry Foundation Classes (IFC)–BuildingSMART International. Available online: <https://www.buildingsmart.org/standards/bsi-standards/industry-foundation-classes/>, accessed 20 April 2022. <https://technical.buildingsmart.org/standards/ifc/ifc-schema-specifications/>
- Messaoudi, T., Véron, P., Halin, G., De Luca, L. (2018). An ontological model for the reality-based 3D annotation of heritage building conservation state. *Journal of Cultural Heritage*, 29, 100–112.
- Mohamed, A.G., Abdallah, M.R., Marzouk, M. (2020). BIM and semantic web-based maintenance information for existing buildings. *Automation in Construction*, 116, 103209.
- Ronzino, P., Amico, N., Felicetti, A., Niccolucci, F. (2013). European standards for the documentation of historic buildings and their relationship with CIDOC-CRM. CRMEX@ TPDL, 2013. Online: 257765377\_Workshop\_Practical\_Experiences\_with\_CIDOC\_CRM\_and\_its\_Extensions\_CRMEX\_2013\_17th\_International\_Conference\_on\_Theory\_and\_Practice\_of\_Digital\_Libraries\_TPDL\_2013
- Ronzino, P., Niccolucci, F. and D’Andrea, A., (2013). Built Heritage metadata schemas and the integration of architectural datasets using CIDOC-CRM. *Built Heritage 2013, proceedings*: [http://www.bh2013.polimi.it/papers/bh2013\\_paper\\_318.pdf](http://www.bh2013.polimi.it/papers/bh2013_paper_318.pdf)