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Marinos Ioannides (Ed.)

Digital Cultural Heritage

Final Conference of the Marie Skłodowska-Curie Initial Training Network for Digital Cultural Heritage, ITN-DCH 2017

Olimje, Slovenia, May 23–25, 2017, Revised Selected Papers

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Editor
Marinos Ioannides
Cyprus University of Technology
Limassol
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Cover illustration: The images on the cover are taken from the paper "Rapid Reconstruction and Simulation of Real Characters in Mixed Reality Environments" by M. Papaefthimiou et al. on page 275. They represent the reconstructed monument of ASINOU, which belongs to the UNESCO WHL (http://whc.unesco.org/en/list/351). The upper image illustrates the monument and the lower one the virtual reality representation of the Priest and the frescos of the monument. The church is located on the southern part of Nikitari village on the foothills of the Troodos Mountains in Cyprus (https://www.byzantinecyprus.com/).
The ASINOU monument has been used as the first case study during the research training activities of all the ITN-DCH fellows (http://www.itn-dch.eu/index.php/case-studies/asinou/).

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Preface

The Marie Skłodowska-Curie Initial Training Network for Digital Cultural Heritage: Projecting Our Past to the Future (acronym, ITN-DCH) was the first and one of the largest fellowship projects in the area of the e-documentation/e-preservation and CH protection funded by the European Union under the EU FP7 PEOPLE research framework (www.itn-dch.eu). The project started on October 1, 2013, and its consortium comprises 14 full partners and 10 associate members covering the entire spectrum of European CH actors, ranging from academia, research institutions, industry, museums, archives, and libraries. The project aimed to train 20 fellows (16 ESRs and 4 ERs – 500 person months) in the area of CH digital documentation, preservation, and protection in order to provide them with a strong academic profile and market-oriented skills, which will significantly contribute to their career prospects. The consortium and the fellows training program were supported by a prestigious advisory board.

ITN-DCH aimed—for the first time worldwide—to analyze, design, research, develop, and validate an innovative multidisciplinary and intersectorial research training framework that covers the entire lifecycle of digital CH (DCH) research for a cost-effective preservation, documentation, protection, and presentation of cultural heritage. CH is an integral element of Europe and vital for the creation of a common European identity and one of the greatest assets for steering Europe's social and economic development as well as job creation. However, the current research training activities in CH are fragmented and mostly designed to be of a single discipline, failing to cover the whole lifecycle of DCH research, which is by nature multidisciplinary and intersectorial. The training targeted all aspects of CH ranging from tangible (books, newspapers, images, drawings, manuscripts, uniforms, maps, artifacts, archaeological sites, monuments) to intangible content (e.g., music, performing arts, folklore, theatrical performances) and their inter-relationships. The project aimed to boost the added value of CH assets by re-using them in real application environments (protection of CH, education, tourism industry, advertising, fashion, films, music, publishing, video games, and TV) through research on (a) new personalized, interactive, mixed, and augmented reality-enabled e-services, (b) new recommendations in data acquisition, (c) new forms of representations (3D/4D) of both tangible/intangible assets, and (d) interoperable metadata forms that allow for easy data exchange and archiving.

The project was structured in training modules and had as a milestone event a public final conference open to the public. The ITN-DCH fellows as well as other researchers from outside our project had to present their latest research results. The ITN-DCH fellows were responsible for the planning and organization of this unique event, which took place at Olimje in Slovenia in May 2017.

The presented papers were reviewed by the majority of the fellows and their supervisors and illustrate the state of the art in research and development in the area of DCH.

Here, we present 29 papers, selected from more than 100 submissions, which focus on interdisciplinary and multidisciplinary research concerning cutting-edge CH informatics, physics, chemistry, and engineering and the use of technology for the representation, documentation, archiving, protection, preservation, and communication of CH knowledge.

Our keynote speakers Eleanor E. Fink, Alex Yen, and Pavlos Chatzigrigoriou are not only experts in their fields but also visionaries for the future of CH protection and preservation. They promote the e-documentation and protection of the past in such a way for its preservation for the generations to come.

We extend our thanks to all authors, speakers, and everyone whose labor and encouragement made the ITN-DCH final event possible. The Organizing Committee, whose members represent a cross-section of archaeology, physics, chemistry, civil engineering, computer science, graphics and design, library, archive, and information science, architecture, surveying, history and museology, worked tenaciously and finished their work on time.

We express our thanks and appreciation to all the project advisors for their enthusiasm, commitment, free-of-charge work and support for the success of this project and the event. Most of all we would like to thank all the ITN-DCH fellows and the European Commission, CIPA, ISPRS and ICOMOS that entrusted us with the task of organizing and undertaking this unique event.

December 2017 Marinos Ioannides

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Acknowledgment and Disclaimer

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However, the content of this publication reflects only the authors' views and the European Commission, the CIPA, ICOMOS, Cyprus University of Technology, all the ITN-DCH partners/institutions, supervisors and associated partners/institutions, the Slovenian Association for Earthquake Engineering (SAEE) and the EU projects FP7 PEOPLE ITN2013 ITN-DCH and IAPP2012 4D-CH-WORLD, the DARIAH-EU ERIC, the EU DARIAH-CY, the EU H2020 INCEPTION, the EU H2020 CSA ViMM, the CIP ICT-PSP Europeana-Space, the CIP ICT-PSP LoCloud and the EU COST Action TD1406 projects are not liable for any use that may be made of the information contained herein.

Contents

Digital Cultural Heritage: Semantic Enrichment and Modelling in BIM Environment

Federica Maietti[1(✉)], Marco Medici[1], Federico Ferrari[1], Anna Elisabetta Ziri[2], and Peter Bonsma[3]

[1] Department of Architecture, University of Ferrara, Via Ghiara 36, 44121 Ferrara, Italy
{federica.maietti,marco.medici, federico.ferrari}@unife.it
[2] Nemoris s.r.l, Via Decumana 67, 40133 Bologna, Italy
annaelisabetta.ziri@nemoris.it
[3] RDF Ltd., 25 Iskar str., Sofia, Bulgaria
peter.bonsma@rdf.bg

Abstract. The ongoing EU funded INCEPTION project proposes a significant improvement in the 3D modelling for the enhancement of Cultural Heritage knowledge by the use of a BIM approach for the semantic enrichment and management of models. Indeed, when used in the CH field, semantic BIM will be able to connect different users (e.g. scholars, technicians, citizens, governments), supporting the need for interpretation of the cultural heritage model.

The expectations on this are quite broad, but the architectural differences make the task quite difficult. Since every building is the final result of different influences and combinations in order to solve practical problems, as well as further additions and changes during time, the INCEPTION project is developing common parameters, setting a nomenclature or "glossary of names" as a starting point to semantic enrichment and modelling in BIM environment.

One of the main issues in creating a nomenclature is that there are many different active sources that all have very valuable information that would be interesting to be reused. Furthermore, this means both valuable but potentially competing information needs to be connected. Semantic Web technology and Linked Open Data principles make it possible to define an open H-BIM ontology. This state-of-the-art technology is developed by members of the W3C organization and is at the moment, a mature technology. INCEPTION makes use of the tools available, supporting these standards.

Keywords: Heritage buildings · Semantic modelling · Linked open data
Heritage documentation · H-BIM

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1 Introduction

One of the main challenges in 3D modelling is related to an effective BIM approach for cultural heritage knowledge, semantic enrichment and model management. The ongoing EU funded INCEPTION project proposes an improvement in this methodology by recognizing that buildings are a set of elements, named by an architectural style nomenclature and organized by spatial relationships. Now, a shared library for historical elements does not exist. Starting from the so-called Heritage Building Information Modelling (H-BIM) approach the necessity of the libraries' implementation will be reached by INCEPTION, avoiding the oversimplification of the shapes. When used in models of cultural heritage, semantic BIM [1] will be able to connect different users (e.g. scholars, technicians, citizens, governments), supporting the need for interpretation of the cultural heritage model, in addition to the common BIM features of 3D visualization, technical specification and dataset [2].

Starting from a definition of concepts and their relationships, we can state that the first step in creating semantic BIM for cultural heritage is by defining the ontology: a formal representation of knowledge as a hierarchy of concepts within the cultural heritage domain. The linguistic definitions related to the ontology concepts can also be used as shared vocabulary to denote the types, properties and interrelationships of cultural heritage aspects [3].

The expectations on this are quite broad, but the architectural differences make the task quite difficult. Naming each architectural element that composes a building is not an easy task. If we look at classical architecture, we can find several books that deeply analyze and summarize rules which were fundamentally adopted in classical buildings. When mainly based on classical orders, ancient architecture is easier to understand and name, even if the building practice often differs from the theory. For instance, to list some of the most known theoretical books from the past, we can mention *De architectura (On architecture, published as Ten Books on Architecture)* by Vitruvio; *De re aedificatoria (On the Art of Building)* by Leon Battista Alberti; and *I quattro libri dell'architettura (The Four Books of Architecture)* by Andrea Palladio.

These are only some of the major treatises that influenced architectures all over the world for centuries. Nevertheless, local practices introduced several variations, including, many different constructive techniques, shapes and decorations that were not standardized. Every building is the final result of different influences and combinations in order to solve practical problems, as well as further additions and changes over time.

For this reason, aiming at the standardization in heritage documentation data handling and management, the INCEPTION project is developing common parameters, setting a nomenclature or "glossary of names" as a starting point to semantic enrichment and modelling in BIM environment [4]. The recognition of shapes, either manually or automatically performed, is possible only if single architectural elements (or their variations) are identified and univocally classified following a shared procedure.

Over the years, several architectural dictionaries have been produced. Thousands of architectural names have been collected and managed following a specific sorting. For instance, a traditional thematic dictionary collects names in alphabetical order, for a specific language, describing every single name and without the requirement of conceptually linking them together. Conversely, an architectural treatise explained by graphics gives more consistency to the nomenclature, setting up specific relation between elements (Fig. 1).

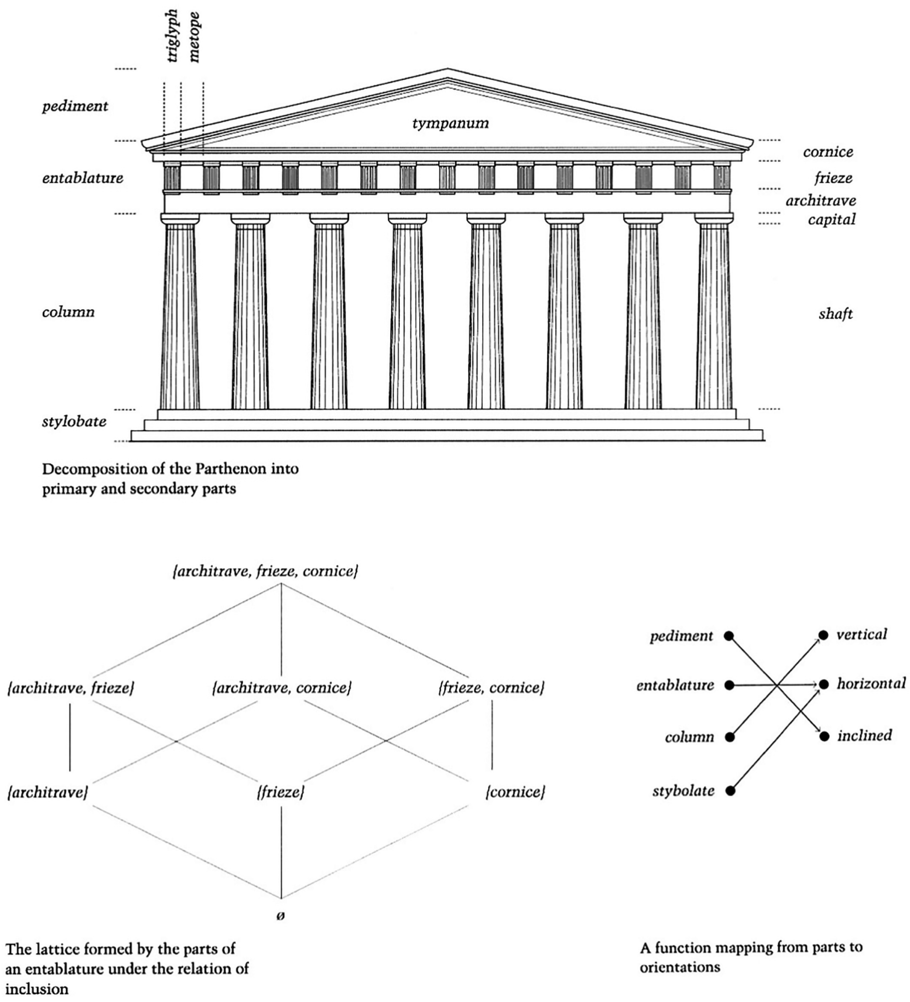

Fig. 1. Example of "storage of values and proprieties" in data structure through the decomposition of the Perthenon into parts (source: W.J. Mitchel [5]).

This defines two different kind of issues within INCEPTION:

- setting up of a common glossary of names for all Demonstration Cases by involving scholars and experts;
- organizing names following a structure that could ensure the linking between elements which could be re-used in the IT development phase.

2 State of the Art in Heritage Nomenclature and Linked Open Data

The need for the definition of an international "glossary" for architectural heritage and by extension, for cultural heritage has arose. This need has originated from the fact that there are various methodologies regarding heritage documentation. Various vocabularies and thesauri are used in the field of conservation, while the variety of "uniqueness" of each cultural artefact turns its categorization into a difficult endeavor. In addition, not only spatial information needs to be standardized, but also the related metadata. Multilingualism, the translation of terms and the existence of many local words for the description of the same object, are the most important challenges when structuring vocabularies. Therefore, the attempt to describe an object with terms understandable to every culture and the adoption of a common "linguistic ground" meets a number of difficulties (Table 1).

Table 1. Vocabularies/Thesauri

Thesaurus name	Primary relevance
Herein	Architecture, Monuments
UNESCO Thesaurus	General
UK Archival Thesaurus	Archives
Centre National d' Archaeologie Urbaine	Sites, Archaeology
Pactols Thesaurus by Frantiq	Archaeology
Getty, The Art & Architecture Thesaurus	Art, Architecture
The Getty Thesaurus of Geographic names	Sites
Getty, The Union List of Artists Names	Actors, artists
Getty, The Cultural Objects Name Authority	Museums

The above vocabularies and thesauri provide an extensive list of object terms in different thematic areas and relate each object term to others within a hierarchical taxonomy. Due to the fact that the needs of each institution are diverse, some of these standardized vocabularies provide controlled flexibility, by allowing the specialized user to add new terms within the vocabulary, in order to express finer points of distinction among similar but subtly different objects. It is clear that the vocabularies establish only a convention for object names, in order to facilitate data retrieval, and in many cases, do not substitute for fuller descriptions. Thesauri provide terminological tools for the identification of terms and concepts in various fields of science. For example, the HEREIN thesaurus (2014) provides the aforementioned service in the field of CH, TGN thesaurus does likewise in the field of geographic names, AAT in the field of art and architecture etc.

One of the main issues with creating a nomenclature in general is that there are many different active sources that all have very valuable information that would be interesting to be reused. Furthermore, this means both valuable but potentially competing information needs to be connected. Since this information is constantly in development, linking is preferable rather than copying a "static" version at a certain date. This is even more true for Heritage nomenclature.

Semantic Web technology and Linked Open Data principles make it possible to define an open H-BIM ontology without having the complexity of defining the complete schema as a copy of external sources. This state-of-the-art technology is developed by members of the W3C organization and is at the moment a mature technology with mature supporting tools. INCEPTION makes use of the tools available supporting these standards.

The above named state-of-the-art vocabularies/thesauri define a nomenclature for the Cultural Heritage domain. Before this valuable knowledge can be used as linked open data the following steps need to be defined:

- translate the vocabularies/thesauri in a technology that supports linked open data;
- interlink the different vocabularies/thesauri and link them together;
- filter what is relevant for the H-BIM ontology within INCEPTION.

2.1 The Choice of the Getty Vocabularies

Analyzing the state of the art, Cultural Heritage data dictionary related to "names" connected to architectures and sites, different sources were browsed, considering primarily European policies in managing and sharing information on cultural heritage. Such as the HEREIN Thesaurus, a multilingual thesaurus that enables the identification of terms and concepts relevant to the field of heritage in 14 languages.

The UNESCO Thesaurus, for example, is a controlled and structured list of terms used in subject analysis and retrieval of documents and publications in the fields of education, culture, natural sciences, social and human sciences, communication and information. Continuously enriched and updated, its multidisciplinary terminology reflects the evolution of UNESCO's programs and activities.

The starting point for semantic organization and glossary definitions for cultural heritage buildings is the integration of the glossary with ifcOWL (in order to start working on H-BIM modelling defining specific parts of the model), ifcOWL as Semantic Web serialization on schema level for IFC schemas will be followed where possible for BIM content stored/exchanged via IFC. No useful connections were found with HEREIN (this is more related with the GIS aggregation level and less on product definition) or other thesauri. Anyway, the analysis of available nomenclatures will go on, according to activities of WP3, by analyzing national and international resources.

For the Web service set up, the Getty Vocabularies were chosen as a starting point, including AAT - Art & Architecture Thesaurus, TGN - Getty Thesaurus of Geographic Names and ULAN - Union List of Artist Names.

The Getty vocabularies contain structured terminology for art, architecture, decorative arts, archival materials, visual surrogates, conservation, and bibliographic materials. Compliant with international IT standards, they provide authoritative information for cataloguers, researchers, and data providers. In the new linked, open environments, the vocabularies provide a powerful tool to be adopted within the INCEPTION project, even if a filtering activity is required in order to make them suitable. Furthermore, where an existing vocabulary will not correctly cover a specific definition, it will be integrated. Current work is creating an ontology as a valuable base for possible upgrading about what is expected/required in H-BIM.

The AAT, TGN and ULAN contain structured terminology for art and other material culture, archival materials, visual surrogates, and bibliographic materials. Compliant with international standards, they provide authoritative information for cataloguers and researchers, and can be used to enhance access to databases and web sites. The Getty Vocabularies are produced by the Getty Vocabulary Program (GVP) and grow through contributions.

UNIFE, NEMORIS and RDF are extending the H-BIM ontology based on the classification available in Getty and are integrating this with the 'BIM' classification generated from the IFC schemas.

3 The INCEPTION Approach

This section focuses on the methodological explanation of how to filter and select the nomenclature for Cultural Heritage starting from the chosen vocabularies. The creation of a shared semantic field for Cultural Heritage will be reached through a wiki-like 3D parametric modelling approach. Anyway, the simple definition of a vocabulary of architectural elements is not sufficient to describe the complex relationship present in a H-BIM model. Those concepts have to be organized in a hierarchy and related through properties that describe more complex relationships than parent/child, like composition or geolocation (ontology).

Therefore, a specific hierarchical organization of European Cultural Heritage information about buildings is under development, based on a sematic approach to prevent restricted access to the knowledge. With a top-down approach, information about the target of the model will be organized in a semantic structure, adding to geometric information attributes such as architectural style, time frame, author, location, etc.

Semantic 3D reconstruction of heritage buildings and sites needs a multidisciplinary approach based on the collaboration of various experts towards the development of 3D models integrating semantic data [6]. The first step requires the identification of the Cultural Heritage buildings semantic ontology and data structure for information catalogue in order to integrate semantic attributes with 3D digital geometric models for management of heritage information. The ultimate goal of this process is the development of semantic 3D reconstructions of heritage buildings and sites, integrated with intangible information and social environment, to create models more accessible and implementable. Collection of semantic data associated to the models, enables the semantic information enrichment by users, sharing knowledge and allowing new interpretation and understanding of European cultural assets (Fig. 2).

The issue of semantic enrichment has been split into "how to retrieve the data" and "how to aggregate the data". If 3D data can be captured following a more commonly shared procedure. Terminology and interpretation have a large variety when looking at semantics, due to different competencies, skills and languages. On the other hand, making data aggregable asks for a Semantic Web structure [7] in order to give back to different users a new way to look at the information in a heritage context. A Semantic Web structure also means that the relations, properties and composition of the "nodes"

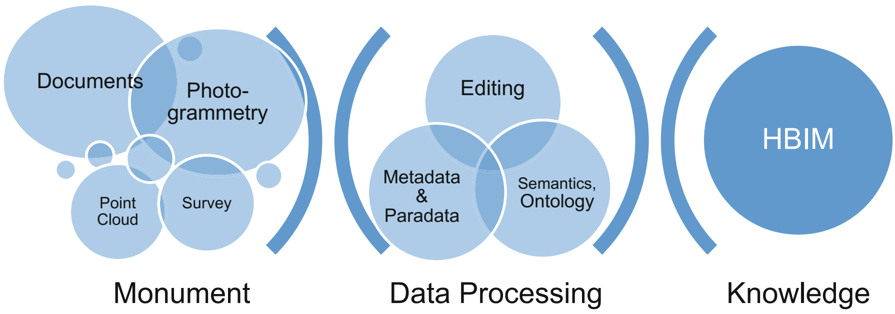

Fig. 2. The phase of *Data Processing* is the bond that ensures the successful development of H-BIM.

of information give a new insight which is different from a list of the same concepts or a database structure. At present, consistent structured data is missing for cultural heritage architectures.

The INCEPTION approach in the selection of the nomenclature for Cultural Heritage starts from classical architectural sources: the project is focused on historical architectures and sites, and the activities accomplished during the first year of the project defined the common framework for catalogue methodology. The outcomes from this work led to comprehensive considerations related to possible classifications of individual buildings and sites [8] according to international charts, recommendations and conventions.

The work done so far regarding the "taxonomy of monuments" according to holistic e-documentation needs, is the base to understand the approach on "names" to start a classification in Semantic Web in order to connect terms with H-BIM ontology. Additional future steps will allow adding further terms, definitions and different translations by means of automatic procedures. Therefore, the common glossary of names crossing all Demonstration Cases is under development. Names have been organized following a structure that could ensure the linking between elements and could be re-used in the IT development phase. In the new linked, open environments, the vocabularies provide a powerful tool to be adopted within the INCEPTION project, even if a filtering of activities is required in order to make them suitable. Current work is creating an ontology as a valuable base for possible upgrading about what is expected/required in H-BIM.

3.1 Filtering Getty Vocabularies

Focusing in particular on the AAT - Art & Architecture Thesaurus, a lot of names are unnecessary for our purposes and the complete and unfiltered adoption could result in being wasteful. By the use of SPARQL queries, it is possible to extract relevant information from Getty sources [9]. The query allowed extracting 2041 names from the concept of "architectural elements", asking for narrower concepts. The query goes in depth by seven levels, where we decided to stop because of too detailed object names.

The choice was made due to the results but could be easily extended in other directions (broader or narrower or including other types of classification if applicable).

The Getty Vocabularies approach was intended to identify a universal architectural approach, whilst a cross check with case studies was performed. Indeed, within the INCEPTION project, several historical Demonstration Cases were identified in order to achieve a significant variation in terms of size, location and historical period. On each building or architectural space, a modelling segmentation was carried out, identifying architectural components to be matched with their names (Table 2).

Table 2. Example table of collected names – the Spanish Demonstration Case of Castle of Torrelobatón, Spain

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Torre del homenaje (Tower keep)	Defensas (Forebuilding)	Garitón (Bartizan)	Balcón (Balcony)	Tronera (Embrasure)	Saetera (Arrow slit/Loophole)	Ladronera (Parapet)
Torre prismática (Square tower)	Cara (Face)	Flanco (Flank)	Tronera (Embrasure)	Saetera (Arrow slit/Loophole)	Ladronera (Parapet)	
Torre cilíndrica (Cubo) (Round tower)	Tronera (Embrasure)	Saetera (Arrow slit/Loophole)	Ladronera (Parapet)			
Baluarte (Bastion)	Tronera (Embrasure)	Saetera (Arrow slit/Loophole)	Ladronera (Parapet)			
Barbacana (Barbican)	Tronera (Embrasure)	Saetera (Arrow slit/Loophole)				
Muro (lienzo de muralla) (Curtain wall)	Barrera (Barrier)	Alambor (Scarp)	Contrafuerte/Espolón (Buttress)	Garita (Hut)	Tronera (Embrasure)	Saetera (Arrow slit/Loophole)
Columna (Column)	Base (Base)	Fuste (Shaft)	Capitel (Capital)			
Habitación/Dependencia (Room)	Espacio expositivo/Museo (Museum)					
Ventana (Window)	Reja (Bar iron/ Wrought iron)					

In order to proceed with the Glossary of Names, each partner responsible for a Demonstration Case was asked for the filtering of the extracted list of names by matching with names of architectural elements that could be identified in their Demonstration Case (Table 3).

3.2 Demonstration Cases Analysis

Nine Demonstration Cases are under development within the INCEPTION project, chosen in significant heritage sites, and are representative of different kinds of Cultural Heritage (archaeological sites, monumental complexes, castles, museums, etc.).

Starting from the holistic e-documentation and integrated 3D data capturing, each Demonstration Case is thoroughly defined in terms of semantics, including the glossary of names, in order to define the nomenclatures as the starting point for advanced

Table 3. Example table of links to AAT dictionary– the Spanish Demonstration Case of Castle of Torrelobatón, Spain

Names	AAT dictionary URL	Query depth level
arch, dome or vault components	http://vocab.getty.edu/aat/300076608	2
<floors and floor components>	http://vocab.getty.edu/aat/300052265	2
fencing (barriers)	http://vocab.getty.edu/aat/300299221	2
<bastions and bastion components>	http://vocab.getty.edu/aat/300100130	2
keeps	http://vocab.getty.edu/aat/300003694	2
buttresses	http://vocab.getty.edu/aat/300000891	3
corbels	http://vocab.getty.edu/aat/300003610	3
<coffered ceilings and coffered ceiling components>	http://vocab.getty.edu/aat/300076213	3
<windows and window components>	http://vocab.getty.edu/aat/300052375	3
loopholes	http://vocab.getty.edu/aat/300003018	3
moats	http://vocab.getty.edu/aat/300003716	3
barbicans	http://vocab.getty.edu/aat/300003628	3
scarps (fortification elements)	http://vocab.getty.edu/aat/300003713	3
columns (architectural elements)	http://vocab.getty.edu/aat/300001571	4
roofs	http://vocab.getty.edu/aat/300002098	4
<bases for columns>	http://vocab.getty.edu/aat/300233843	4
shafts (column components)	http://vocab.getty.edu/aat/300001754	4
parapets	http://vocab.getty.edu/aat/300002717	4
curtain walls (fortification elements)	http://vocab.getty.edu/aat/300002504	4
bartizans	http://vocab.getty.edu/aat/300003636	4

(*continued*)

Table 3. (*continued*)

Names	AAT dictionary URL	Query depth level
machicolations	http://vocab.getty.edu/aat/300002695	4
<capitals and capital components>	http://vocab.getty.edu/aat/300065036	5
<doors and door components>	http://vocab.getty.edu/aat/300052371	5
embrasures (battlement components)	http://vocab.getty.edu/aat/300002597	6
merlons	http://vocab.getty.edu/aat/300002601	6

modelling in Heritage BIM environment and the development of tailored tools and applications for a wide and inclusive access to European Cultural Heritage.

Demonstration Cases under analysis are:

- Istituto degli Innocenti in Florence, Italy;
- Saint Nicholas Chapel of the Church of Obergum, the Netherlands;
- Stone Villages in Croatia;
- Technical Museum "Nikola Tesla" in Zagreb, Croatia;
- Castle of Torrelobatón, Spain;
- Church of Panayia (The Virgin) Phorviotissa (Asinou), Cyprus;
- Acropolis of Erimokastro in Rhode, Greece;
- Villa Klonaridi in Athens, Greece;
- Historical Museum of Hydra, Greece.

Morphologies of buildings and sites have been described by listing descriptive terms hierarchically related. The morphological description of elements will allow advancements in H-BIM modelling starting from geometries up to the link of different semantic attributes and related contents. Therefore, how to name building descriptions was the preliminary step to link heritage digital documentation and representation toward semantic modelling.

In order to be compliant to the INCEPTION inclusive approach (forever, for everybody, from everywhere) the semantic H-BIM will allow interactions with the 3D models, advanced representations, integration of semantic metadata, and the management of changes undergone by buildings overtime (time-machine).

The adopted methodological workflow included the integration of different contributions from several sources, from the expertise by INCEPTION partners and stakeholders, to the literature review, with a specific focus on the most significant texts explaining the relation between architectural elements, their shape and their nomenclature.

Aiming at the creation of H-BIM models, the generic list of names of architectural elements were hierarchically organized, mapping a significant subset of the ifcOWL ontology whilst, at the same time, the matching with the Getty vocabulary was preserved. Thus, each identified element into a Demonstration Case was double connected, from one side to its possible geometrical description, as well as on the other side, to a wide linguistic resource providing an unambiguous description (Fig. 3).

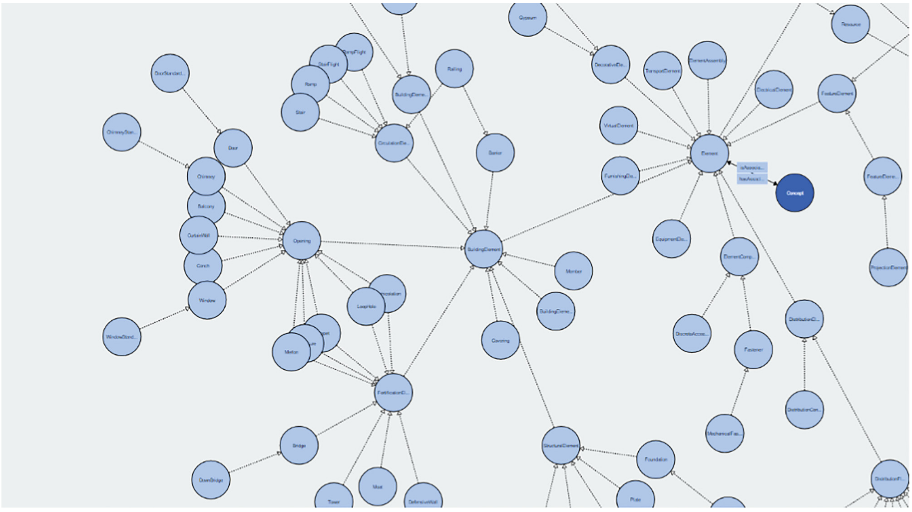

Fig. 3. Graphical representation of the INCEPTION H-BIM ontology.

Nevertheless, this approach allows forecasting the inclusive possibility of giving wide access to Cultural Heritage: the two-way connection between linguistic resources and the geometrical appearance opens, indeed, to the development of a platform and several applications where the user can enjoy a CH asset and its complexity both with technical or non-technical expertise.

3.3 Semantic Organization and Data Management Toward H-BIM Modelling

The 3D semantic models in the INCEPTION project will contain geometric information for 3D visualization, historical information for narration, and geo-technical as well as structural information for material conservation, maintenance and refurbishment. The 'intelligent' 3D models generated will be accessible for all types of users for multiple purposes depending on the needs and level of knowledge of the end-users.

Since 1994, the currently named IFC standard has been in development. While the actual roots point back towards 1985, the Building & Construction specific development started 10 years later. IFC is often seen as the reference open BIM standard and it is safe to say it is the most mature and widely adopted open standard for exchange of information about BIM in the broadest sense of the word. Many people see IFC as a geometry format. However, IFC is able to handle a large variety of geometrical representations, so it is much more than just geometry. It contains many structures, grouping mechanisms as well as a lot of semantics. Over the years, a lot of semantics has been integrated in the IFC schema definition in many different layers. Within the INCEPTION project, a tool has been developed in order to convert both the semantic information from the IFC schema into parts of the H-BIM ontology as well as being able to convert real data files (tested up to 500 Mb files) towards project content according to the H-BIM ontology.

The tool is able to convert the schema IFC 2x3 TC1 (the mainstream version), IFC 4 ADD2 (latest version of the latest official schema) and IFC 4x1 (latest IFC version with integrated infra structure elements).

The tool creates part of the H-BIM ontology on request (as soon as a revision is released this can be adapted automatically). Any instance of files created/available for a specific project can also be converted and the content is correctly defined against the defined H-BIM Ontology. It is possible to integrate any other ontology like Getty without losing correct links with the generated project content.

At the moment, mainly the IFC object classification (entities inheriting from IfcObject) is converted together with some small other parts from the IFC schema for non-geometrical data. Within INCEPTION, H-BIM uses for geometry a geometric ontology independent from IFC with ± 100 classes where conversion from all IFC geometry as well as from Collada will be available as a service. Based on what is needed by projects this can be extended or reduced in a generic way (Fig. 4).

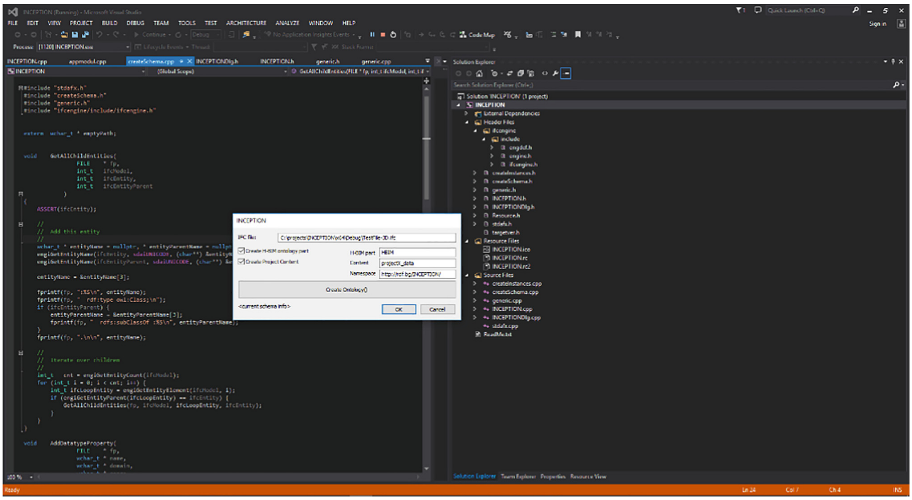

Fig. 4. Screenshot of the software tool for IFC schema conversion and H-BIM ontology creation.

3.4 Next Steps

The bsddOWL development is definitely something to keep an eye on, but seems to be less mainstream. A good reusable first step could be the development of a SPARQL end-point on top of the current bSDD solution.

Within the IFC world, two of the main items of development at the moment are the linked data/Semantic Web approach and the infra extensions. The linked data/Semantic Web approach is followed as much as possible and covered by the developed application. The infra extensions also cover local roads and therefore could be relevant for INCEPTION also. The solution as developed for INCEPTION is generic, this means H-BIM ontology parts coming from IFC could directly contain newly proposed extensions, the proposed extensions for IFC 4x1 (currently Release Candidate 3) is already working and part of the H-BIM ontology.

The major challenges and areas of research to be faced are:

- The automation of data capture and H-BIM creation.
- The update and maintenance of information in H-BIM.
- The handling and modelling of uncertain data, objects and relations occurring in historic buildings.

The approach of the INCEPTION project on data management in H-BIM models should help to solve some of these challenges by adding semantic information (intelligence) to raw data and providing a platform able to effectively manage all available information. The main objective is the sharing and the portability of H-BIM models from different people and different capacities, to a wider user community with different purposes.

4 Achieved Results

The current work is to create an ontology as a valuable base for possible upgrading about what is expected/required in H-BIM [10]. However, it is important to understand the difference between BIM standards and the Semantic Web technologies. Indeed, the ifcOWL is defined as a serialization of an IFC schema definition [11], in order to enable the use of contents semantically managed. For this reason, within INCEPTION, H-BIM is meant to be an ontology to support storage of semantic knowledge available for Cultural Heritage buildings and architectural complexes, as well as their related information [12]. The integration of Getty vocabularies and ifcOWL is a complex but feasible task, focusing on the actual queries, communications and current H-BIM work. Furthermore, within INCEPTION, we have the chance to test such integration, achieving positive results as well as beginning an implementation, thanks to the use of a “glossary of names” gathered by the Demonstration Cases analysis.

5 Conclusions

Developing an H-BIM is a complicated "reverse engineering" process. According to the INCEPTION workflow, it starts with documenting user needs, including and engaging not only experts but also non-experts. The demand is leading us to "how" and "what" surveying information we should include in H-BIM. The surveying produces a variety of different data, formats and outputs. It is essential to process the data without losing important information like metadata and paradata while editing and developing the digital elements of the H-BIM. A methodology of archiving digital data and linking them to the final product is one of the main outcomes. Before and during the creation of H-BIM, semantics and ontologies must be defined. In that phase, nomenclature (vocabularies, thesauri, etc.) are critical to maintain a common typology and to support interoperability.

Starting from the standardization for H-BIM modelling, the methodology for merging IFC models and semantic data has been defined. The identification of the Cultural Heritage buildings semantic ontology and data structure for information catalogue will allow the integration of semantic attributes with hierarchically and mutually aggregated 3D digital geometric models for management of heritage information. The development of a semantic 3D reconstruction, integrated with intangible information and social environment, structuring digital representation of buildings and sites will lead to the creation of models more accessible and implementable in a Heritage-BIM environment, based on Open BIM standard (IFC, IFD, etc.).

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