DELIVERABLE

Project Acronym: **CARARE**

Grant Agreement number: **250445**

Project Title: ***Connecting ARchaeology and ARchitecture in Europeana***

D5.1 Functional specification of requirements for preparing 3D/VR for Europeana

Revision: final

Authors:

Daniel Pletinckx (Visual Dimension bvba)
David Haskiya (EDLF)

Project co-funded by the European Commission within the ICT Policy Support Programme		
Dissemination Level		
PU	**Public**	**X**
CO	**Confidential, only for members of the consortium and the Commission Services**	

Revision History

Revision	Date	Author	Organisation	Description
v. 0.1	01/09/10	DP	VisDim	First draft
v. 0.2	18/10/10	DP	Visdim	Second draft with images
v. 0.3	30/01/11	DP, DH	VisDim, EDLF	Full version
v. 1	05/03/11	DP	VisDim	Final version incorporating comments from Kate Fernie and Costis Dallas.
v.2	29/03/11	DP	VisDim	Minor addition in caption p.6

Statement of originality:

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

Contents

1. EXECUTIVE SUMMARY 4
2. INTRODUCTION 5
3. WHY 3D/VR IN EUROPEANA? 5
4. WHAT IS 3D/VR IN EUROPEANA? 9
5. 3D/VR REQUIREMENTS 10
6. PDF AS THE PROPOSED 3D FORMAT 10
7. EXAMPLES OF 3D DATA WITHIN CARARE 13
8. 3D/VR PUBLISHING WORKFLOW 16
9. VISUALISING COMPLEX AND LARGE 3D MODELS 23
10. METADATA 25
11. USER INTERFACE 27
12. QUALITY IN 3D 29
13. EVOLVING MARKETPLACE 30
14. CONCLUSIONS 31

1. *Executive Summary*

CARARE will make 3D accessible as a new type of content for Europeana users from 2012 onwards. This report sets out the functional specification of requirements for both content providers preparing to make their 3D resources accessible and Europeana on the delivery of such resources. The resulting document provides a workflow for implementation by CARARE.

While people are familiar with seeing 3D effects (in commercials, TV, film footage and as images, etc.) most have little or no experience of interacting with a 3D environment. A few Europeana users will have experience of using interactive 3D in games or other 3D environments on the internet. But with the exception of experts, very few users are likely to have had experience of interacting with cultural heritage data in 3D. So an important aspect of this preparing specification has been to propose ways that allow *all* users of Europeana to interact in a natural way with 3D to explore, appreciate and enjoy European culture.

Chapter 3 focuses on why 3D and VR (virtual reality) are important in cultural heritage through the creation of *added value* and *interactivity*. Chapter 4 looks at *quality and exploration* as primary goals of 3D resources in Europeana.

Chapter 5 outlines the technical and functional requirements concerning 3D/VR and proposes *PDF* as a 3D carrier. Chapter 6 outlines how the capabilities and functionality of PDF implement nicely the requirements and goals for 3D in Europeana.

Chapter 7 gives a brief overview of the 3D data that CARARE content providers plan to deliver. An important part of the 3D data represents spaces (sites, landscapes and cityscapes).

Chapter 8 outlines a 3D workflow, suggesting that for 3D spaces a part of the exploration needs to be implemented inside the 3D PDF resource. It notes that most 3D data within cultural heritage organisations is created for internal use (documentation, restoration, etc.) and that publication online for access via the Europeana portal is an additional process on top of the normal 3D production.

Chapter 9 discusses which 3D cannot be covered by PDF and how to solve that. It suggests that all 3D can be covered by PDF and video files.

Chapter 10 provides a first discussion of the metadata that goes with the 3D resources that CARARE will make available by 2012, showing that in terms of their metadata requirement 3D objects within Europeana do not differ that much from other objects.

Chapter 11 shows a first draft of the Europeana user interface for 3D, which is very much in line with the user interface for other media types. Chapter 12 elaborates a bit more on the marketing and quality aspects, concluding that 3D in Europeana needs to differentiate itself from other 3D repositories through quality. Chapter 13 looks into the potential evolution that 3D will go through in the near future, suggesting that HTML5 can play an important role but probably outside the lifetime of this project.

Chapter 14 summarises the conclusions.

2. Introduction

CARARE brings together heritage agencies and organisations, archaeological museums and research institutions and specialist digital archives from all over Europe to establish a service that will make digital content for Europe's unique archaeological monuments and historic sites interoperable with Europeana.

One of the objectives of the CARARE project is to give Europeana users access to 3D representations and VR (virtual reality) of monuments, historical buildings and archaeology. It aims to make the first steps for Europeana towards integration of a wide range of high quality, validated 3D/VR. This text describes why 3D/VR is of interest to the Europeana audience, what it should do and look like, which technical, conceptual and practical issues need to be overcome and how the content providers can fit it within their current 3D activity. This text aims at outlining a methodology for making 3D/VR accessible through Europeana, and to implement the cost-efficient and sustainable integration in existing and future workflows for 3D/VR.

CARARE and Europeana plan to make this new content type available to Europeana users as 3D visualisations adds value and offer users with new opportunities to understand, enjoy and appreciate archaeology, monuments and the cultural heritage in comparison to simple 2D resources. For example, a 3D model of a cathedral offers users something new and different in comparison with photographs or movies of the same building.

3. Why 3D/VR in Europeana?

Providing 3D/VR in Europeana is not a technology driven choice, nor it has to do with the 3D hype of film and TV. It rather has to do with the added value that 3D visualisation can bring to the Europeana user for better understanding, enjoyment and appreciation of European archaeology and monuments. In other words, 3D resources in Europeana need to add value. For example, a cathedral shown in 3D should offer more than some photographs or a movie of that cathedral. In other words, if the job can be done with photographs or movies there is no reason to provide a 3D model, as these media are much easier and cheaper to make.

CARARE focuses on digital resources related to *archaeological* and *architectural* objects, so 3D/VR within CARARE refers to 3D representations of such objects. This includes 3D models of a monument or landscape or archaeological object as it survives in the present day (through 3D digitisation by laser scanning, image modelling[1] or other techniques), reconstructions of such monuments[2] or landscapes[3] as they appeared at various times in the past (through a manual virtual reconstruction process), or digital restorations of archaeological objects or monuments (through editing of 3D digitised models[4]). Each of these three forms of 3D has its own specific requirements and properties, which play an important role when we want to make these 3D models available to a general public. It is worth noting that most of these 3D models are made for specialist purposes such as conservation or monument protection and the content creators are *repurposing* them for use by general public audiences.

---

[1] http://media.digitalheritage.se/2010/07/ARC_3D_TII.pdf
[2] http://media.digitalheritage.se/2010/07/Interpretation_Managment_TII.pdf
[3] http://media.digitalheritage.se/2010/07/Interactive_Landscapes_TII.pdf
[4] http://www.vision.ee.ethz.ch/~pmueller/wiki/Nymphaeum/PicturesMakingOf/

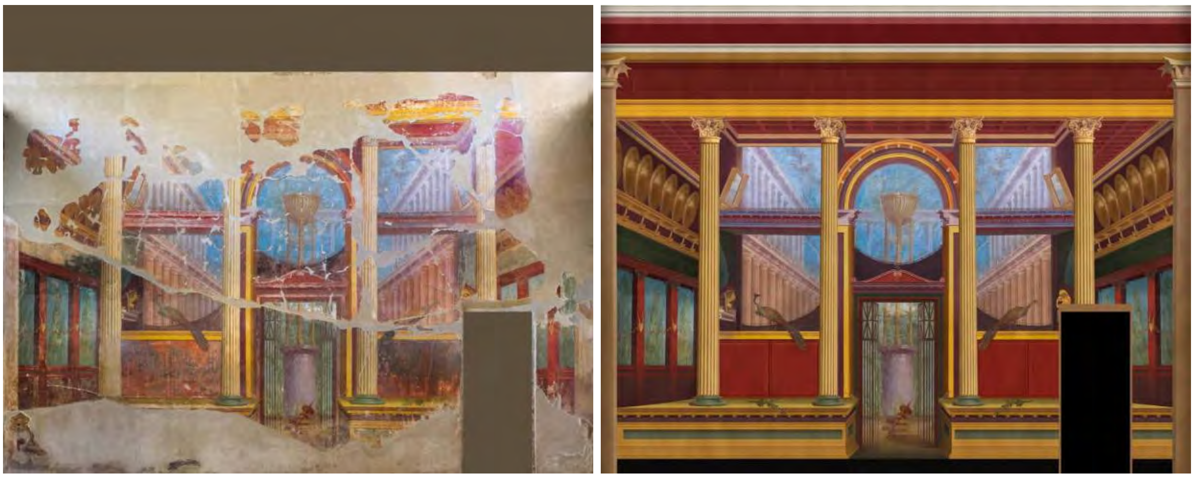
Handmade 3D model of Notre Dame cathedral in Paris (Christopher Snow - http://www.snowfall-cg.com/)

3D digitisation of the Seu Vella cathedral in Lleida, Spain (point cloud of 40 mio points), Visual Dimension

Providing a 3D model instead of an image or movie of an object can offer clear advantages for users. 3D can be an aid to understanding the complex structure of the building or object better, can provide viewpoints or cross sections which would otherwise be difficult or impossible to see. For example, a 3D model of Notre Dame cathedral (see image above) shows its structure better as in reality it is obscured by buildings and trees. 3D can be used to visualise and experience spaces that are difficult to access such as caves, or to reconstruct places which simply don't exist anymore such as destroyed buildings or ancient landscapes.

3D can be more than just a visualisation medium alone. 3D models can provide an interactive user interface to explore and discover information which has been attached to objects. For example in a virtual reconstruction of a Roman villa, users may click on a wall painting to see how it looks today, or to find out how that room was used and by whom.

Virtual landscape reconstruction of the medieval portus of Ename, Belgium, around 1020 AD, Visual Dimension

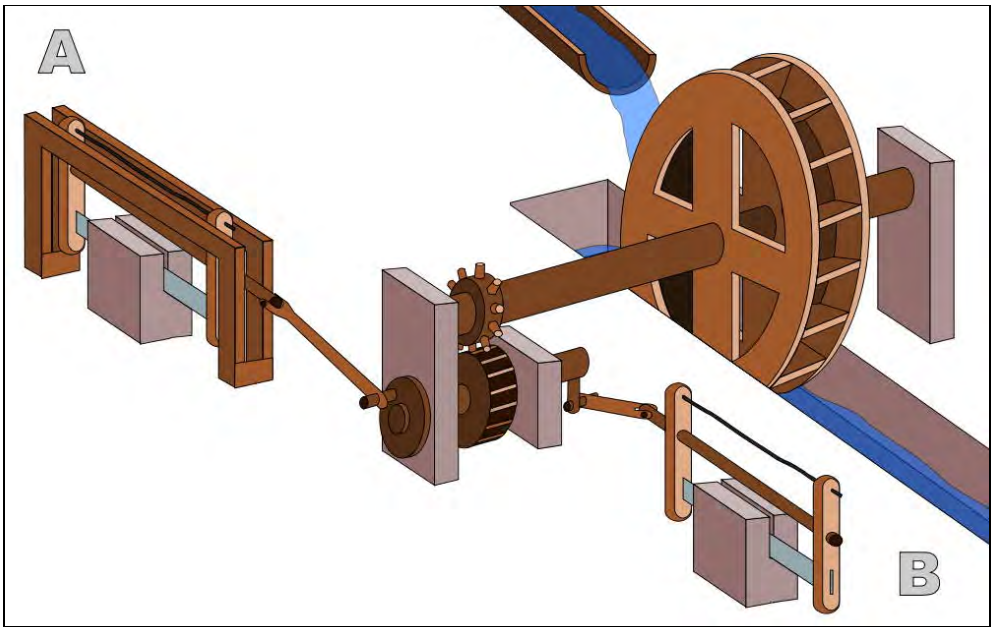


Wall painting in Roman villa in Oplontis, Italy (left) and its digital restoration (right), KVL, King's College London

3D can be used to show how a Roman saw mill worked allowing users to see it in motion and understand it better through a cutaway or exploded view. Users of 3D can walk through a Roman villa, open the doors and find their way through the building. Experts can use 3D to show how the siege of a medieval castle developed, how the attacking party breached or undermined walls and how the defending party could cope with attacks from the siege towers. 3D can also be used to know how archaeologists discover the past through analysing and comparing archaeological remains.

Virtual reconstruction of a room of a Roman villa in Oplontis, Italy (KVL, King's College London)

Studies have shown that learning happens faster and better, with more persistent results, if it is based upon personal decisions and interaction at a personal pace. The richness of a 3D model allows storing much more information inside than an image, so that personal interaction creates a closer psychological bond with the subject than other media.



Roman water-powered stone saw mill at Hierapolis, Asia Minor (Wikipedia)

In other words, we need to use 3D when the visualisation, animation and exploration capabilities of 3D help us to create added value through better understanding, better memorising or being more appealing. *It is exactly this added value that makes interactive 3D outperform the current multimedia tools in tourism, education and research, hence make 3D visualisation worthwhile using in Europeana.*

4. What is 3D/VR in Europeana?

3D is a term that covers a very wide range of applications and uses of 3D models. 3D ranges from simple sketchy designs (as made for example in SketchUp) to Hollywood movies where the virtual scenes and actors cannot be distinguished from the real scenes and actors, due to their photorealism and realistic behaviour. 3D ranges from applications on mobile devices (such as GPS car navigation in 3D[5]) and simple PCs (such as the Google Earth application) to molecule design and real time photorealistic rendering[6] that requires supercomputers and specialised hardware.

This report defines VR (virtual reality) as *3D that has embedded behaviour*. In other words, the user can do more than just look at a 3D object from all sides, the object contains information to be explored and behaviours which can be either autonomous (not triggered by users) or interactive (triggered by users). Autonomous behaviours include animations that show how an object functions (a water mill in operation) or behaves (a Roman ship sailing against the wind). Interactive behaviours include opening doors as well as more complex actions such as loading and firing a medieval cannon or 18th century rifle.

For Europeana users, 3D models which support exploration are likely to be the most interesting and important. The linking of information to a 3D model is also a most important feature. But extensive autonomous and interactive behaviours are probably too difficult to achieve in this start-up phase of 3D in Europeana. While photorealism or a high degree of detail are valuable, we consider content, interactivity and linking to be probably more important for general users now. It is however important to be sure that the choices made now allow for further evolution and richer functionality in the future.

The CARARE project aims to make a batch of about 3000 high quality 3D objects accessible to Europeana users to enable user testing and to establish the workflow and methodology for content providers. The workflow that is established should enable content providers to prepare 3D objects for Europeana in a coordinated and uniform way, without going too far into the functionality and sophistication of 3D objects. The proposed approach has potential outside the CARARE project and will allow for the deployment of extra functionality in the near future by any cultural heritage organisation wishing to publish 3D resources online for access via Europeana.

3D in Europeana should mean high quality data that allows *a certain degree of interactivity and exploration capabilities* (through different techniques), or that is provided as a linear movie. The difference with other repositories such as Google 3D Warehouse is the *quality of the data* (see chapter 12) *and especially metadata* (see chapter 10) that is guaranteed by the cultural heritage organisation that has created the 3D data. The metadata of the 3D model provides a rich context that helps the user to understand, assess and explore the object, and situate it within a larger historical and cultural framework. By comparison examples seen in Google Earth may be professionally modelled and yet be very simple with little resemblance to the real world structure and lack any description of the age, style, current function or ownership. Its location becomes only known through visualisation in Google Earth.

[5] http://www.pcworld.com/article/157215/garmin_gps_adds_3d_building_views.html
[6] http://www.romereborn.virginia.edu/gallery-archive.php#videos_1_1

5. 3D/VR requirements

Europeana requires content formats which are *open and standardised*, and which can be *sustained in the long term.* This means in practice a stable and well-known format but also that the format at least must be used by a sufficient number of users for the market to provide the necessary tools to maintain the format or migrate to other formats). Europeana also requires *full support of all European languages* if text is involved (this is the case as text can be integrated in 3D, for example as annotation).

But 3D is more than a content format. Visualising 3D requires a software application or plug-in and the following requirements for 3D viewers also need to be considered:

- To maximise the number of users that can be served, the 3D viewer must be *available on all major platforms* (Windows, Mac OS, Linux) and be *free* (and remain so in the foreseeable future).
- To minimise the number of people who will need to install software or plugins, the 3D viewer should be *present on nearly all computers* (in other words, have a high market penetration).
- For maximum sustainability, the 3D viewer should have a *proven track record* and be provided by *multiple companies*.

In addition to this, 3D objects made accessible to Europeana users should support resource exploration. This means that the 3D viewer needs to *support URLs and links to other documents*. Ideally, the 3D viewer should enable ways of *embedding text and images* to allow users to understand the object that they are visualising and exploring and should be *available within all major browsers*.

As Europeana aims to support education, tourism and research, the recommended 3D viewer should be widely accepted in these fields.

Finally, it is important that the solution proposed for publishing 3D data resources, which will sit on the content providers' own servers, is capable of being widely adopted by Europeana providers so that its users are offered a *standardised and uniform* experience and are not required to download a confusing array of different software and plug-ins to view 3D content.

6. PDF as the proposed 3D format

After analysing all the currently available 3D viewers, only one technology available at this moment that matches nearly all of the requirements described above. This technology is PDF which since 2005 (Acrobat version 7) has been extended to offer 3D capabilities. The current version 10 is based on 6 years of maturing 3D technology.

PDF has a proven track record. PDF (Portable Document Format[7]) was developed in 1993 and is the de facto standard for exchange of digital documents and forms. It is an open format since the full PDF format (version 1.7) was accepted in 2008 by the International Organisation for Standardisation as standard ISO 32000-1. This ISO standard does include the 3D capabilities of PDF and its extensions are open and published. An update of the ISO standard (i.e. ISO 32000-2, also known as PDF version 2.0) that includes these extensions has been accepted.

By PDF becoming an ISO standard has meant that *third parties can develop applications that read or write PDF without having to pay royalties to Adobe*. Several companies are already providing such applications, with 2010 seeing several new companies and applications emerging, which is very good news for the long-term support of PDF as a format and a technology.

[7] http://en.wikipedia.org/wiki/Portable_Document_Format

PDF readers are available on all major platforms (Windows, Mac OS, Linux) and are available *for free*. They always have been free from the start and will most probably remain free in the future.

Adobe, the company that created PDF, claims that its *Acrobat PDF reader is present on 89 % of all computers*. This number is considered by experts to be accurate. The reason that this number is not higher is probably that Apple provides an alternative image and PDF viewer (called Preview) that is preinstalled. For Windows, most computers come with the Acrobat PDF reader preinstalled, so most people don't have to install a PDF reader to view a 3D model published in this format. Mac users, as Preview does not visualise the 3D parts of a PDF file, will need to install the free Acrobat Reader for Mac. Preview does offer functionality to visualise Collada 3D files (for example from Google 3D Warehouse) directly.

As 3D PDF functionality has been integrated in Acrobat Reader since version 7 (released in 2005), even older computers, that haven't been updated in years, are capable of displaying 3D PDF with the basic functionality supported by that version (PDF version 1.6). To deal with older computers, content providers could create Acrobat version 7 compatible 3D PDF files. *However, to comply with the ISO 32000-1 standard, content providers are recommended to create PDFs that are compatible with Acrobat version 8 (PDF version 1.7) released in 2006.*

3D PDF can be visualised in most browsers on most platforms. The recent PDF plug-in for Mac OS X Intel for Mozilla Firefox on the other hand does not support 3D yet, so PDF fails this requirement to a certain extent. But as most people download PDF files instead of opening them in their browser, there is a work around which means this non-compliance to this Europeana requirement is not a serious drawback.

PDF supports all European languages and many more. The language support of most 3D applications has always been very weak, which has frequently resulted in strange behaviour or bugs occurring when non-ASCII texts, part names or descriptions are used.

Since the end of 2010, Adobe has moved its 3D development to a separate company, called Tetra 4D[8]. As this company is a co-operation with Tech Soft 3D, a specialised 3D company with a long track record, this move allows a much more focused development for and support of the different market segments that use 3D PDF. This needs to be seen as a very positive move and marks a transition for 3D PDF from "early adopter phase" to "mainstream product". The appearance in 2010 of good third party software for the authoring of 3D PDF also can be seen as a positive sign of a *maturing technology*. Assigning 3D PDF as the platform for 3D in Europeana should fit perfectly in this evolution.

The 3D PDF creation process basically consists of two major steps: file conversion of existing 3D files and integration of the resulting 3D model into a context (see workflow in chapter 8). The file conversion step deals with most available 3D file formats resulting from both digitisation and virtual reconstruction processes. Internally in the PDF file, the 3D model is stored in a U3D or PRC format. U3D is the Universal 3D file format, standardised as ECMA-363 by ECMA International, the (American) industry association founded in 1961 dedicated to the standardization of Information and Communication Technology and Consumer Electronics. PRC (Product Representation Compact) has been developed by Adobe to provide a compact and versatile format for CAD/CAM/CAE data (for the domains of computer aided design, manufacturing and engineering). PRC is an open format that realises high compression rates for CAD/CAM/CAE data and is in the process of becoming an ISO standard for such data.

For cultural heritage purposes, *U3D however is the best choice*. Tests on many cultural heritage 3D files have shown that the compression capabilities of U3D typically better than PRC (over 4 case studies, U3D yielded a file reduction of 46,2% against 77,2% for PRC), while U3D provides better possibilities for animation. Currently, 3D PDF uses U3D version 3 (U3D version 4 is available since June 2007).

[8] http://www.tetra4d.com/

In the new Acrobat X version, the 3D import tool is installed as a plug-in (called "3D PDF Converter") to Acrobat Pro. Although Acrobat X is available for both Windows and Mac platforms, this plug-in is only available for Windows. Together with the plug-in, an application (called "3D Reviewer") is provided that helps to prepare the 3D data (it merges, edits, animates 3D, puts lights, …). In the current version, that was released at the end of Dec 2010, some useful formats, such as Autodesk 3D Studio, Collada, Google Earth .kmz and Wavefront .obj, will only be supported from Spring 2011 onwards. In other words, Adobe has separated 3D conversion and editing tools from the document creation process, which still incorporates integration of 3D (as long as the 3D is in U3D or PRC format).

However, there are other providers of good 3D PDF authoring tools. SimLab[9], a new Jordanian company, provides a powerful authoring and animation tool for 3D PDF. PDF3D[10] provides a large set of publishing solutions and a 3DPDF library for automation of 3D PDF generation. PDFTron[11], AccuSoft[12] and Tech Soft 3D[13] provide software development kits (SDKs) to integrate 3D PDF creation capabilities in new software.

Please note that these authoring tools are not free, but they are not expensive, compared to other 3D software. Note also that conversion to U3D is supported by all third party applications, as it is a long-standing and open format. Note also that there are other ways to create 3D data in U3D format, or to convert 3D files to U3D format (for example through the high end free OpenSource application MeshLab[14]), which mean 3D conversion software is not required as 3D PDF can be authored directly in Acrobat from U3D files. For example, a 3D PDF authoring environment on Mac can be set up, as both MeshLab and Acrobat are available on Mac.

PDF does support links to other parts of a document, to other documents and to URLs, and *provides simple ways to mix text, images and 3D* into something that looks very much like a normal publication, except that the image window in fact appears to be a live window on a 3D world that can be manipulated from the text. 3D PDF also includes animation that can be triggered and influenced from the text too (is based on Java scripts). 3D PDF also supports text annotation in the 3D model itself.

More specifically for research purposes, *PDF has excellent collaboration tools* that allow scholars to discuss their work and publications, including 3D models, and implement review and consensus mechanisms. The 3D annotation tool in PDF comes in very handy to attach remarks or ideas to certain parts of a 3D model. PDF also supports measurements, visibility analysis and multiple alternatives, which are essential for research based use of 3D in cultural heritage.

PDF as the file format for 3D within Europeana has been proposed to the CARARE 3D Working Group at meetings in Pisa and Brussels and to the Project Board meetings in Athens and London, and has been accepted at these meetings by the majority of the participants and by Europeana.

In other words, 3D PDF complies very well with the above mentioned technical, functional and digital preservation requirements, is supported by simple, cheap and versatile authoring systems from different providers and provides a wide range of tools and functionalities that allow versatile resource exploration and potential professional use in the near future by cultural heritage experts. The fact *that most people have this intelligent 3D visualisation tool on their computer without even knowing it* is instrumental in an easy take up by the Europeana users.

---

9 http://www.simlab-soft.com/
10 http://www.pdf3d.com/
11 http://www.pdftron.com/
12 http://www.accusoft.com/pdf.htm
13 http://www.techsoft3d.com/
14 http://meshlab.sourceforge.net/

7. Examples of 3D data within CARARE

This chapter gives a brief overview of the nature of the 3D data available from CARARE content partners. Through this overview, CARARE has aimed to find a common approach for the metadata, workflow and interactivity of the 3D resources that will be delivered to Europeana.

The *Ministry of Culture of Greece* offers 3D virtual reconstructions of parts of the archaeological site of Dion. Most of these virtual reconstructions are partial and show the structure of the excavated remains without fully reconstructing them (as many archaeologists are reluctant to fill in the unknown third dimension). A large number of 2D resources, a part of them related to the 3D models, are available to document this large and multi-phased archaeological site.

Virtual reconstructions of the sanctuaries of Demeter (left) and Isis (middle) and the praetorium (right) at Dion

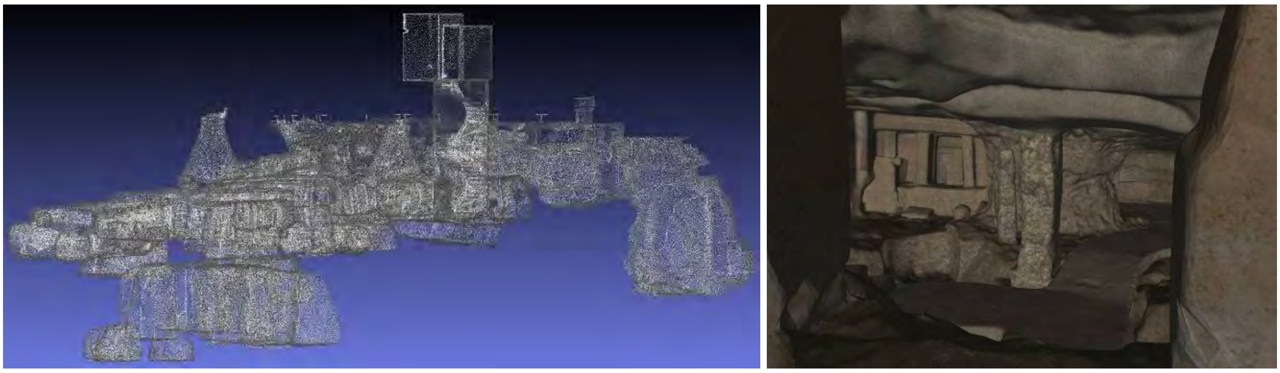
SNS offers the 3D model of the Forum of Pompeii, which has been digitised by a large team of specialists for restoration and documentation purposes. SNS also plans to make available a large database of illustrations and archaeological reports that document the earlier phases of excavation at Pompeii. Many people think everything is known about Pompeii, as all the evidence was preserved under the volcanic ash. The 3D models offer an explanation of the history of the excavations at Pompeii and the process of understanding the function and structure of the public and private buildings that are present in the Forum. The 3D models were made to document the current state of the archaeological site and are available in VRML format.

3D Model of the Forum of Pompeii (full) and north-east corner (right) with an arch, shops and the Lares sanctuary

Heritage Malta offers 3D models of prehistoric temples and the hypogeum at Hal Saflieni[15], a remarkable prehistoric underground temple. Heritage Malta also plans to provide 3D models of the archaeological objects

[15] http://en.wikipedia.org/wiki/Hypogeum_of_Hal-Saflieni

that have been found at these sites. For example, this hypogeum (UNESCO World Heritage) is a very complex underground structure for burials and rites. Although these underground spaces are accessible for the public, a virtual 3D model in Europeana should provide some understanding of the structure, function and history of the hypogeum but also allow appreciation of the beauty, atmosphere and importance of these underground spaces. Due to strict control of humidity and temperature, the number of visitors is limited to 80 people per day (as there has been damage to the wall paintings through humidity and algae), so virtual access to this unique monument is quite useful. The 3D models were made to document the site for restoration and site management and are available as X3D or VRML or OBJ or MDL files (from different providers).



Orthographic view of the 3D model of the Hal Saflieni Hypogeum (left) and inside view on the Middle Level (right)

KoBiDZ (Poland) offers 3D models of buildings (churches, castles, …), man-made structures (viaducts, factories, …) and landscapes (hill fort, gardens, …). Landscapes were digitised from balloon and kite. The 3D models were made as documentation for site management and restoration and are available as VRML files.

The hill fort and surrounding landscape in Calosc (left) and a traditional house in Bogatynia (right)

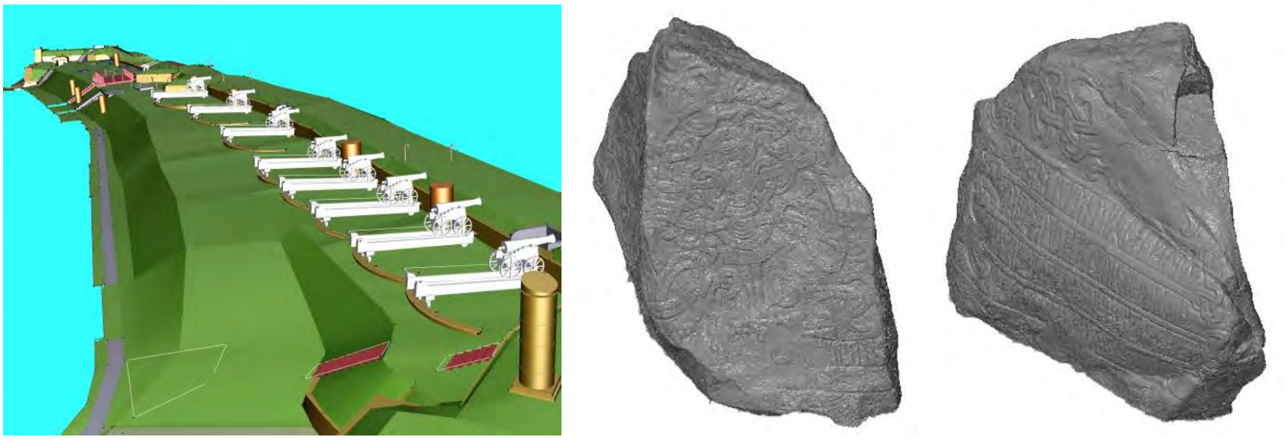
DCU/CETI offers 3D models of parts of Greek towns such as Agrostoli, Drama, Xanthi and the castle of Kavala. The 3D models are made as part of research projects on heritage digitisation, for example, the Xanthi model demonstrates a VRML based 3D search engine.

3D models of Drama (left), Xanthi (middle) and Kavala castle (right)

STARC (Cyprus) offers a wide variety of 3D models of archaeological sites and structures but also of archaeological objects, such as vases, statues, … One of the planned 3D implementations is a 4D model of an excavation, in other words a 3D visualisation of the evolution of an excavation in Nicosia through time. The 3D models are part of documentation and research projects for archaeology and are available as PLY files.

The Roman amphitheatre in Paphos (left) and the excavations at the Agios Georgeos Hill in Nicosia (right)

KUAS offers several sites with ruins of Danish medieval castles, 3D digitisation of the Jelling stones (that mark the creation of Denmark as a country) and also a virtual reconstruction of a gun battery. The 3D models were made for documentation and research purposes and are available as DWG, U3D, DGN and STL files.



The Sixtus gun battery (left) and one (Store) of the Jelling stones (middle and right)

CAAI (Spain) offers a large (1300) collection of Iberian pottery from the CATA reference collection[16], which have been created internally as MAX files.

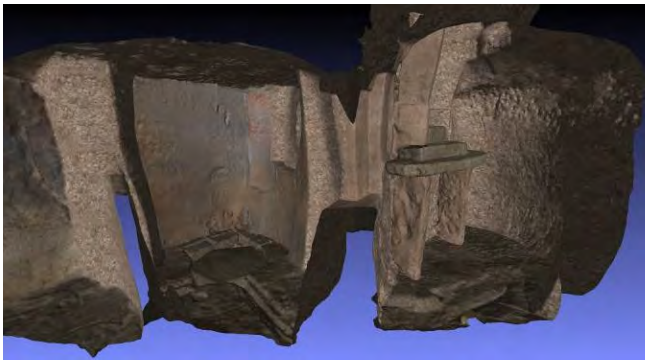
3D models of Iberian pottery from the CATA reference collection

8. 3D/VR publishing workflow

The 3D resources that are created within the context of cultural heritage organisations are relatively complex in comparison to most objects which are currently accessible via Europeana, where a published item resides as a single object, armed with the appropriate metadata to be discovered and semantically linked to related objects. The Hal Saflieni Hypogeum in Malta (see chapter 7) illustrates the issues.

A first issue is that a 3D resource *can be explored in itself*. Exploration is a natural, intuitive thing to do with 3D sites and buildings and when providing a 3D model of the underground Hal Saflieni Hypogeum, it would be counterintuitive to not provide ways to explore its amazing spaces.

16 http://cata.cica.es/

Views on the Upper (left) and Lower Level (right – in cross section) of the Hal Saflieni Hypogeum

A second issue is that most 3D have a high 'information load', in other words, a lot of information is connected to the 3D resource. Ideally creators of 3D models aim to provide easy and intuitive ways to find this information, linked to the natural exploration possibilities that a 3D resource provides.

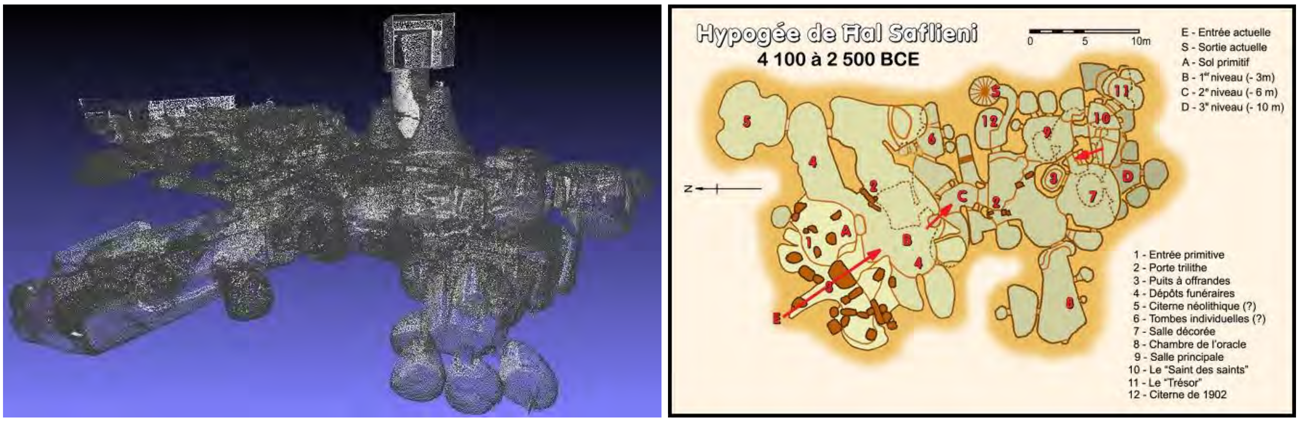
View inside the 3D model of the Painted Room with burial chamber (shaft on the left)

For example, for each of the underground chambers of the Hal Saflieni Hypogeum, some background information is needed to explain what the user is actually seeing, or to link objects that have be found at the site. In the so-called Painted Room in the Hal Saflieni Hypogeum, unique ochre mural paintings are still visible and one of the most appealing prehistoric funeral statues, the Sleeping Lady, was found in the burial chamber within this Painted Room. Exploration of this space needs at least to give information on the mural paintings, on the function as sanctuary and necropolis, on the position of the burial chamber and the link to the Sleeping Lady and its interpretation as prehistoric depiction of a deceased princess.

Sleeping Lady (Museum of Archaeology, Valletta) was found in the Painted Room burial chamber (cross section, left)

A third issue is that most 3D resources of archaeological or architectural sites are in fact not one object but a collection of interconnected parts that each has specific information. Even if the object is perceived as one single object, the technical framework within Europeana does not allow information to be attached to different spatial regions of the 3D resource (this would require the object to be divided into different components each with specific metadata).

For aesthetical and conceptual reasons, it is not effective to divide the 3D resource into its components. From the images of the Hypogeum example above, it should be clear that dividing the 3D model in separate rooms would not only be very difficult and would jeopardise the appreciation of this unique underground space but would also require a lot of manual work to separate the 3D model into its different components. So rather than dividing, it is better for content providers to establish mechanisms that allow resource exploration within the 3D model.



Overview of the Hal Saflieni Hypogeum as a 3D point cloud (left) and map (right)

In other words, when content providers design 3D objects, especially if they represent buildings and landscapes, it is best to do so in a way that *allows a part of the resource exploration to happen within the 3D resource itself* or more precisely, *a small part of the descriptive metadata needs to be integrated internally within the resource to allow an intuitive exploration that preserves the nature of the 3D resource*. In addition, most of the metadata is present external to the object to support resource discovery.

The balance between the external and internal metadata depends on the nature of the 3D resource and on the skills of the creating organisation to integrate some of the metadata in the interaction design. For most archaeological museum objects, the 3D resource only requires interactive visualisation from all sides to give users the impression of having the object in their hand, and all of the metadata can be external to the 3D resource. For buildings, archaeological sites, man-made structures and landscapes, a small part of the content metadata needs to be integrated into the 3D PDF resource to support resource exploration within the 3D resource.

In other words, there is scope to produce *two types of 3D PDF:*

- The first one can be seen as a pure file format conversion in which the original 3D file is converted into a PDF file with external metadata being provided to support resource discovery, describe the object, learn about it and find related objects or context information.
- The second uses all the possibilities of PDF to shows spaces (buildings, archaeological sites, man-made structures, landscapes) in a structured document, containing one or more 3D windows plus some text, images or URLs that help to explore and understand the 3D data.

In the first case, the visualisation capabilities of PDF are in most cases sufficient for interacting with such objects. On creation of the PDF file, standard views such as front, left, right, top, back, … can be added automatically for easier evaluation of the object. The added value of the 3D is the ability to interactively visualise the object from all sides, as if you are holding it in your hand. This is certainly an added value as most archaeological objects cannot be viewed like this, and some are even not on display at all. The example below shows a museum object, when clicked, the object can be inspected from all sides, while the toolbar allows to visualise (orthographic) standard views (top, left, front,…) that have been created automatically at file import.

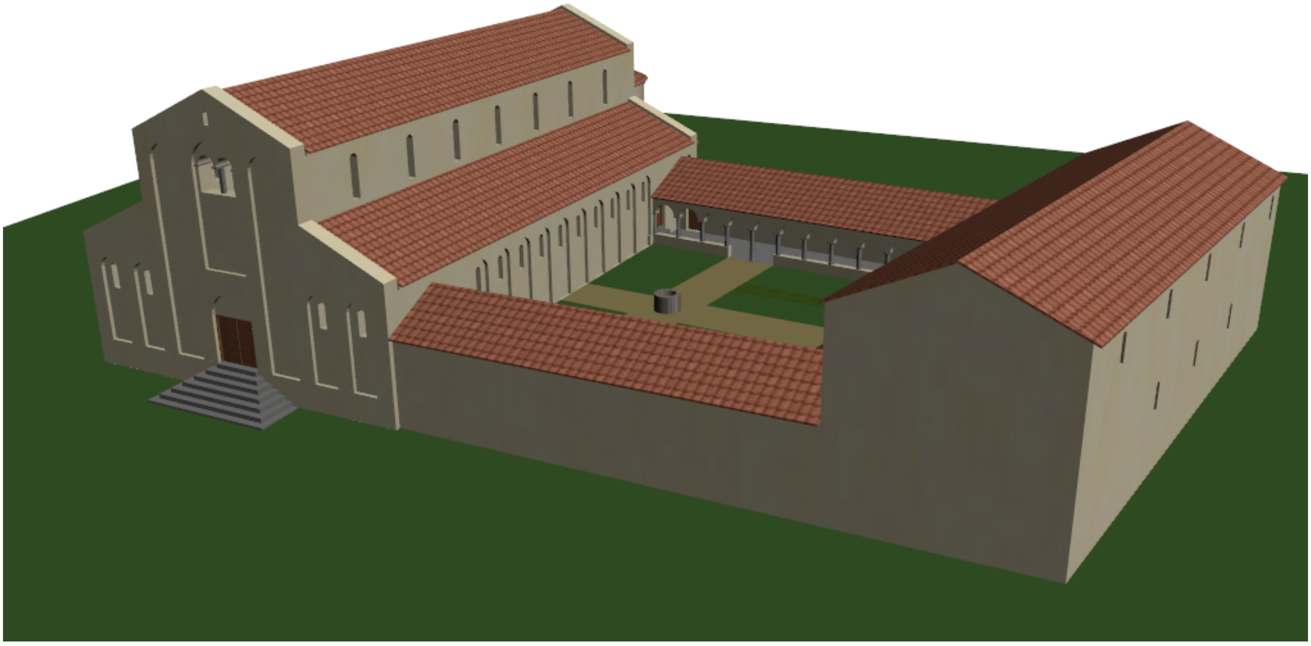
Head of pharao Tutmoses III, Allard Pierson museum, Amsterdam

In the case of museum objects, content providers can – when appropriate – also use the available 3D PDF authoring tools in the form of software libraries (see chapter 6) to add some metadata (title, short description, basic parameters or information) automatically in the PDF. In this way, the PDF is not only a nice 3D visualisation tool but the PDF file also becomes a useful standalone resource that can be printed, shared for educational use amongst students or taken to field on a laptop by archaeologists. For example, the CATA archaeological reference collection of Iberian pottery, provided by the CAAI (see chapter 7) can be automatically turned into a set of one page PDFs, each containing a 3D model of a certain vessel, together with some basic information that is taken automatically from the database. The collection of 3D models of

Greek and Roman vases held by STARC can be turned automatically into one page PDFs containing the 3D model and some basic information that can be used for example in an educational context.

But for more complex archaeological monuments or historic buildings, content providers may wish to add text and a few images to the PDF document to create the appropriate exploration mechanisms for the 3D object, which involves more authoring than the simple import described above. One of the benefits of PDF authoring is that it allows content providers to link keywords in the text to specific views in the 3D resource, so that clicking on those keywords produces the right view in the 3D window. This *simple VR behaviour* is easy to author but provides a very powerful navigation tool with a very low user threshold, as demonstrated in the example below (click the words in bold).

The example shows a virtual reconstruction of the **church and abbey of Saint John Evangelist** in Biograd, Croatia. This Benedictine abbey consisted of a **large church in Italian early Romanesque style** with an **extended choir** for the monks and some abbey buildings around a **cloister garden**: an **upstairs dormitory**, the **chapter room** in which daily meetings were organised, the **kitchen** with adjacent storage room and the **refectory** where the monks took their meals after washing their hands at the **well**.



Church and abbey of Saint John Evangelist, around 1070 AD, Biograd na Moru, Croatia.

The paragraph above provides a fully guided tour through the 3D virtual reconstruction, without any further user interaction with the 3D, giving direct information about the structure of the abbey and the daily life of the monks. The user can also explore the 3D model at free will (choose first ‘walking’ as interaction mode in the toolbar for easy navigation) or use different rendering modes or illumination. For example, changing the rendering mode to ‘shaded illustration’ reveals the layered structure of the **church** and the **abbey buildings** and the way they were constructed layer by layer (through medieval scaffolding).

By showing only some parts of the 3D model, 3D PDF can also highlight structure or evolution. 3D PDF also has an interactive cutaway tool that allows you to see how objects or buildings are structured, which is a great tool to improve understanding and to support learning processes and definitely creates added value through the 3D nature of the data. The authoring of such functionality is very simple and straightforward.

3D PDF has much more capabilities, for example to provide animation (a water mill in action) or user triggered interactivity (a door that opens when clicked). Such *advanced behaviour* needs to be created as Java scripts. CARARE content providers do not currently plan to add advanced behaviour to their 3D resources, but it is useful to know the capabilities of 3D PDF include this. It means that cultural heritage organisations still have many more options to create rich 3D content in the near future. As noted in chapter 6 above some third party 3D PDF authoring systems have good support for animation, avoiding the need to program in Java.

Currently, the 3D workflow that is proposed includes file conversion to PDF (in an automated way where necessary) or simple authoring that allows better understanding and exploration of 3D spaces and large structures. File conversion requires only a few parameters to be set and takes a few minutes. The simple authoring proposed takes about 10 minutes to half an hour per object when starting from an existing text or descriptive metadata. The use of a template PDF document helps in speeding up the process.

If one analyses why 3D is used in cultural heritage, one sees a range of applications such documentation, conservation[17], physical and digital restoration[18], research and virtual reconstruction and visualisation. Only a small part of that is focused on public outreach, nearly always deeply embedded in museum exhibitions, educational movies or scholarly publications that provide the necessary context for the 3D model.

A survey within the group of CARARE data providers showed that only 6 % of the 3D data is currently in 3D PDF format, with the majority of the 3D models having been created for internal, non-public uses using a variety of different formats (see chapter 7). This means that in most cases, CARARE content providers would need to convert the 'internal files' to 3D PDF , linked to a specific authoring and validation process (see below), to improve their accessibility by Europeana users and to avoid the issue of legacy data.

It is important for the proposed 3D publishing workflow to piggyback on the existing 3D workflows as a simple additional process, and be both sustainable and easy to implement within the structures of existing data providers. There should be no need for cultural heritage data providers to create a separate workflow for the creation of 3D PDF. It is important to avoid the duplication of files and efforts, which could jeopardise the long-term preservation process of the data.

Creating 3D PDF files for publication online for access via Europeana is proposed to be a small, additional process that uses the 'internal 3D files' and outputs them as 3D and VR objects that have a meaning and added value for the typical Europeana user.

The creation of 3D PDF files is relatively simple and can be provided as training for archaeologists and other cultural heritage experts. This training needs to focus on the general 3D PDF authoring workflow, on its integration within the 3D workflow of the organisation, on the creation of metadata (see chapter 9) on interaction design (as described above in this chapter) and on a few specific technical issues that needs to be mastered.

An important technical aspect is the file conversion to 3D PDF. Here it is important to distinguish between the file format in which the 3D data has been originally made, the open file format for long-term preservation of this 3D data, the metadata and the 3D PDF file.

It is good news that the 3D PDF authoring process can accept a large variety of file formats, both from the 3D digitisation, the 3D design and the 3D digital restoration domains. The content provider needs to decide which format is available and most suited to convert to 3D PDF. There are however some issues here.

First of all, a few important file formats are currently missing from the list of potential input formats, such as X3D (which is a quite popular open format for 3D files). This has no technical background but has everything

[17] http://www.sprecomah.eu/
[18] http://www.vision.ee.ethz.ch/~pmueller/wiki/Nymphaeum/Front

to do with the ongoing strategy game and alliances between the major 3D players. Good news is that 3D files can be imported from digitisation processes (which typically use vertex colours, and can be inputted through VRML) and creation processes (which typically use texture mapping, and can be inputted through formats such as Collada, OBJ, 3D Studio, …). It is useful to test the conversion process before starting major 3D projects to get optimal results and easy workflows.

A second issue that is related to the choice of file format to convert from is the differences in coordinate system. 3D systems that originate in the domain of surveying and CAD/CAM/CAE use the convention that the horizontal plane is parallel to the XY-plane (in other words, the positive Z-direction is up). 3D systems that originate in computer graphics on the other hand consider the XZ-plane as horizontal (in other words, the positive Y-direction is up). PDF uses the first system, so the latter formats need a simple 90 degrees rotation around the X-axis before conversion to PDF. It is important to observe the correct vertical direction in 3D PDF as some interactions modes (such as the 'walking' mode) only move the camera in the horizontal plane.

A third issue is the completeness of the 3D data when doing conversion to PDF. PDF does package all required information in the file itself, while most other 3D file formats do not store the required information in a single file but in a set of files: the shape information, the material information (which are sets of parameters for material definition, colour image files for texturing, gray scale images for bump mapping or displacement mapping), font files, …. Having such a set of files is fine in a production environment that generates images as output (stills, video, …) but this system is very vulnerable (for example, some 3D packages use absolute path names for material files, which is a problem when transporting the files to another environment). As the conversion of the 3D data to PDF can happen on another computer than the one that generated the 3D data, it is necessary to check and validate the available 3D data. Once successfully converted to PDF, the user does not have to worry as PDF encapsulates all required information in the PDF file itself to ensure portability. Also, each PDF file does behave exactly the same on every computer, also for 3D, as this is the key element of the portability concept that PDF realises.

Another important technical aspect is the spatial resolution (number of polygons) of the 'internal 3D file', which can be too high for use by the general public, as it exceeds their requirements and the capabilities of their computers and becomes too large to be transferred easily over the internet. So the 3D resolution of the 'internal files' from digitisation efforts needs to be reduced to a level that is much smaller but still remains aesthetical and functional. More and more, this functionality is integrated in the 3D digitisation production workflow, as reduction of the number of polygons is one of the standard features of professional digitisation software, and it helps the 'professional' users at the cultural heritage organisation to use the 3D data, for example on their laptop. On the other hand, free open source solutions (such as MeshLab) are becoming available that have high-end texture fitting and polygon reduction algorithms that can do the job. For Europeana 3D resources, a minimal polygon count with a high quality texture map is ideal.

A final technical aspect is the security of the 3D data. In most cases, cultural heritage organisations don't want the 3D data that is stored in the 3D PDF to be used for other purposes than viewing by Europeana users. 3D data can be exported from the 3D PDF (this feature is used a lot in the engineering applications of PDF), but this can be prohibited explicitly by setting the 3D status to "read only" when creating the file.

Once PDF files have been made for publishing online and delivery at Europeana, it may be important to look into an efficient update process of these files. No major issues are anticipated but this aspect will be researched and reported on in later deliverables.

3D PDF is proposed as the common and most suitable format for 3D resources in Europeana. All 3D content providers in CARARE are planning to produce 3D PDFs. Where useful, other 3D formats can complement this, providing specific functionality where needed. For example, DCU has a VRML based 3D search engine for some Greek city centres, linked to a database of cultural heritage resources. While an interactive3D model of the city centres can be provided in 3D PDF for the general public, DCU may also make the 3D search engine discoverable via Europeana for interested people to use.

9. Visualising complex and large 3D models

3D PDF is however not the solution for all the 3D models that might be made available to Europeana. There are some cases in which this solution falls short: when the object is *too large or too complex*, when a *higher quality of 3D visualisation* is required than is provided by the typical PDF reader software, when *special rendering software* is used such as ray-tracers (to visualise glass, reflections, gems, …), volume renderers (to show for example tomography data of museum objects) or landscape renderers (that show terrain, vegetation, bathymetry, …), when content providers want to *show evolution over long periods of time* of building complexes, sites or landscapes, or when *advanced animation techniques* such as the use of avatars or particle systems are used.

For example, a reconstructed landscapes or large cityscapes (such as Rome Reborn 2.1[19], showing Rome in 320 AD, containing 7000 highly detailed buildings and visualised with shadow), the amount of 3D data being visualised exceeds by far the capabilities of the computer of the average Europeana user.

Rome Reborn 2.1, a virtual reconstruction of Rome in 320 AD (VWHL, University of Virginia)

In most of these cases mentioned above, the content provider can fall back on image based visualisation techniques that allow the 3D content to be visualised interactively. In the past, one of the most popular applications to do this was QuickTime VR but this was discontinued by Apple in 2010. QuickTime VR provides in fact only 'pseudo 3D' as it can show only pre-rendered still images from predefined points of view (object mode) or a panorama of an environment (there are two modes, a cylindrical panorama relies on one long image, a cubic panorama or 'bubble' relies on 6 square images, organised as a cube). For a QuickTime VR object, smart organisation of the images can create great interactivity, with capabilities to link images,

[19] http://www.romereborn.virginia.edu/

URLs, text and other objects. Although such an object nearly feels like interactive 3D, it is simply based upon a large amount of pre-rendered images and is only pseudo-3D.

Currently, QuickTime VR functionality is being replaced by Flash and Java based solutions[20] that provide the same possibilities as QuickTime VR (panoramas and VR objects). In most cases, content producers will need VR object functionality to provide the interactive exploration they want to achieve. If they want to show for example a digital restoration of a glass object that has be found in an excavation, they need to use a VR object or animation to visualise the glass properly[21], 3D PDF does not even comes close to a decent visualisation of glass objects. If content producers want to create 4D exploration (space plus time to show evolution) of a site or landscape[22], they need to use a VR object as the amount of data will exceed by far the capabilities of 3D PDF. For example, the 4D visualisation of Ename, Belgium (see chapter 3), that shows the evolution of the complete village from 1020 until 2004 through 12 historical periods, represents in total over 1 GB of 3D data and 800 hours of rendering time (as vegetation and shadows are used), so a VR object with pre-rendered imagery is the only way to visualise this interactively.

Bottle with ivy decoration, excavated at Sidon, Lebanon, currently at Louvre museum (Wikipedia)

There are several possibilities to visualise such VR objects, one of the more recent possibilities is *to have such panoramas and VR objects integrated in a PDF file*. When visualising complex animations (for example with avatars), content producers currently need to fall back on animated sequences in the preferred video formats. Animations are always an alternative for visualising 3D but of course they lack interactivity. This means concretely *all 3D visualisation in Europeana can be covered through PDF and video files*.

Because QTVR is no longer offered as functionality within QuickTime, content producers are recommended not to create QTVR files anymore, but to use PDF and supported video-formats instead.

[20] http://www.easypano.com/modelweaver-gallery.html
[21] http://www.youtube.com/watch?v=IdhnRGOVYEM
[22] http://media.digitalheritage.se/2010/07/Interactive_Landscapes_TII.pdf

10. Metadata

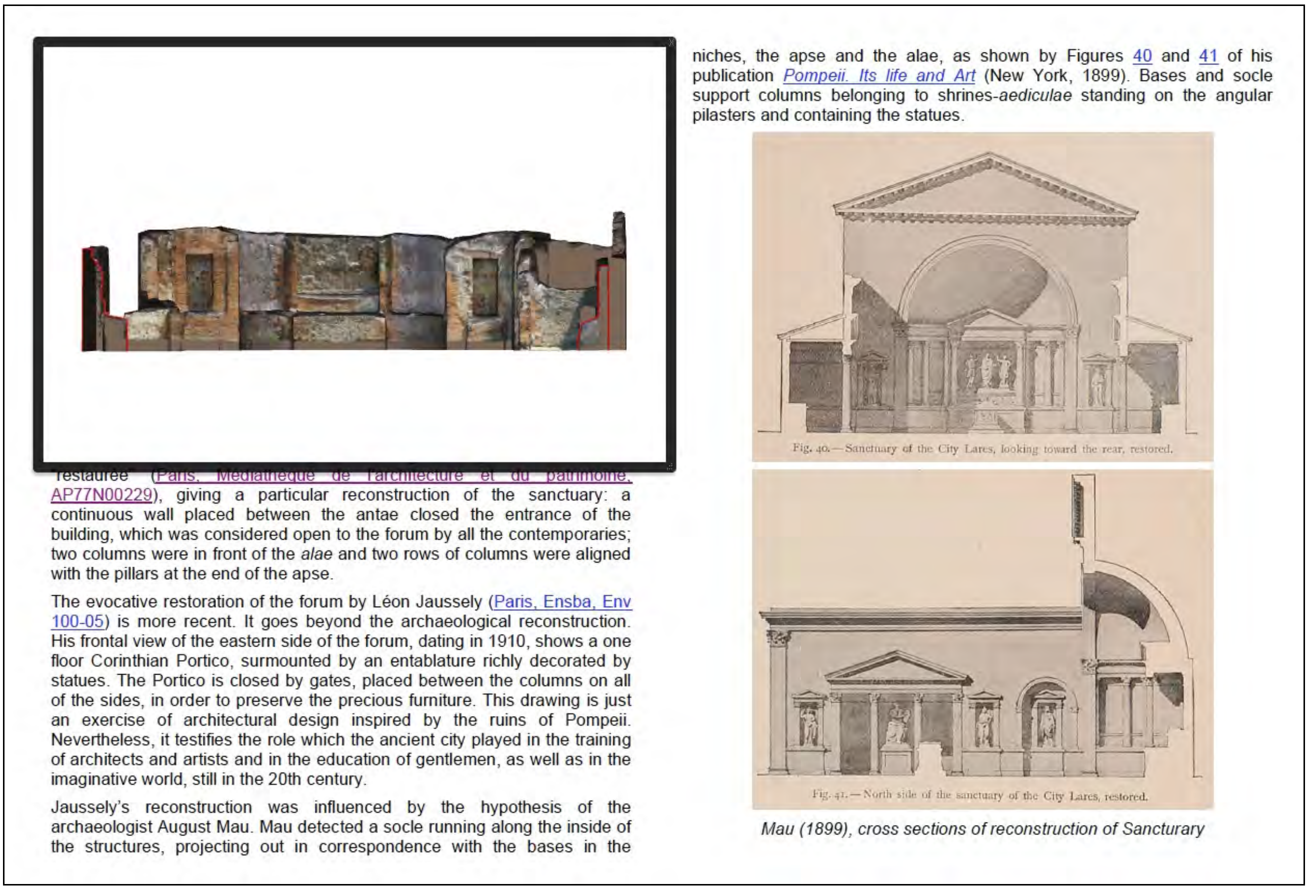
This report defines two types of metadata. On one hand, there is the *resource discovery metadata* attached to the 3D PDF file which will enable users to find the digital object via Europeana. On the other hand, there is descriptive metadata that can be incorporated in the 3D PDF resource itself as an aid to exploration (as explained in chapter 8).

Metadata for 3D is still very much a research domain, especially for virtual reconstructions. Also, cultural heritage resources in real 3D for a general public are brand new, so there is a need for a process of validating the current 3D metadata insights by creating/mapping the metadata for a set of 3D resources (created by the 3D content providers) that is representative for the data that 3D providers can make available. This validation and assessment will take place in the beginning of 2011.

The CARARE metadata schema, which has been developed in close consultation with the partners that are involved in the 3D strand of CARARE, distinguishes clearly between the metadata for the 'heritage asset' (object, building , landscape…) and for the 'digital resource' (the 3D PDF) which is linked to the heritage asset. Most 3D content providers not only deliver 3D data but also a lot of other resources, such as related images, video, excavation reports, … It is important that the right relationships are established between these elements so that old engravings of historical buildings or excavation photographs of its remains can be linked for example to a 3D virtual reconstruction, or that a museum object can be linked to the site where it has been found, with the archaeological site and the museum object are both represented as 3D model (see for example the case of the Sleeping Lady, found in the Painted Room in the Hal Saflieni Hypogeum in Malta, depicted in chapter 8). The CARARE metadata schema allows content providers to establish these relationships. The schema does not allow for links to be created for the exact place of certain information within 3D models, but this can be easily be solved by linking this information as images or text in a 3D PDF document to specific views in the 3D model (as explained in chapter 8).

It is also important to highlight that the concept of 'collection' is also present in 3D objects representing spaces. For example, the Forum of Pompeii (see chapter 7) will most probably be organised as an overview 3D object (probably not in 3D PDF as the amount of 3D data is too high, but as an interactive object, see chapter 9) plus a set of 3D PDF files, one per building. It is obvious that the overview 3D object needs to link to each of the 3D PDFs that show the buildings, but also to 2D historical iconography that depicts the ruins in the 18^{th} and 19^{th} century. The concept of the collection of objects relating to Pompeii can be represented in the CARARE metadata schema, and through relations between the overview 3D object and to the 3D resources that present the Forum buildings, but also by some links or compositions in the 3D objects themselves.

The image below shows a text page and a floating 3D window (another functionality of 3D PDF) where clicking on the right top image (a reconstruction drawing from 1899) produces exactly the same view with cross section on the 3D model in the 3D window. In this way, the user can study the archaeological remains of today and compare them with the reconstruction drawing of 1899 by August Mau, the archaeologist that excavated and studied Pompeii in great detail. The link between this image and the 3D model also can be made through the metadata, but the specific 3D cross-section view put next to the reconstruction image has a strong visual impact and clear advantage for public and educational use.



"restaurée" (Paris, Médiathèque de l'architecture et du patrimoine, AP77N00229), giving a particular reconstruction of the sanctuary: a continuous wall placed between the antae closed the entrance of the building, which was considered open to the forum by all the contemporaries; two columns were in front of the *alae* and two rows of columns were aligned with the pillars at the end of the apse.

The evocative restoration of the forum by Léon Jaussely (Paris, Ensba, Env 100-05) is more recent. It goes beyond the archaeological reconstruction. His frontal view of the eastern side of the forum, dating in 1910, shows a one floor Corinthian Portico, surmounted by an entablature richly decorated by statues. The Portico is closed by gates, placed between the columns on all of the sides, in order to preserve the precious furniture. This drawing is just an exercise of architectural design inspired by the ruins of Pompeii. Nevertheless, it testifies the role which the ancient city played in the training of architects and artists and in the education of gentlemen, as well as in the imaginative world, still in the 20th century.

Jaussely's reconstruction was influenced by the hypothesis of the archaeologist August Mau. Mau detected a socle running along the inside of the structures, projecting out in correspondence with the bases in the niches, the apse and the alae, as shown by Figures 40 and 41 of his publication *Pompeii. Its life and Art* (New York, 1899). Bases and socle support columns belonging to shrines-*aediculae* standing on the angular pilasters and containing the statues.

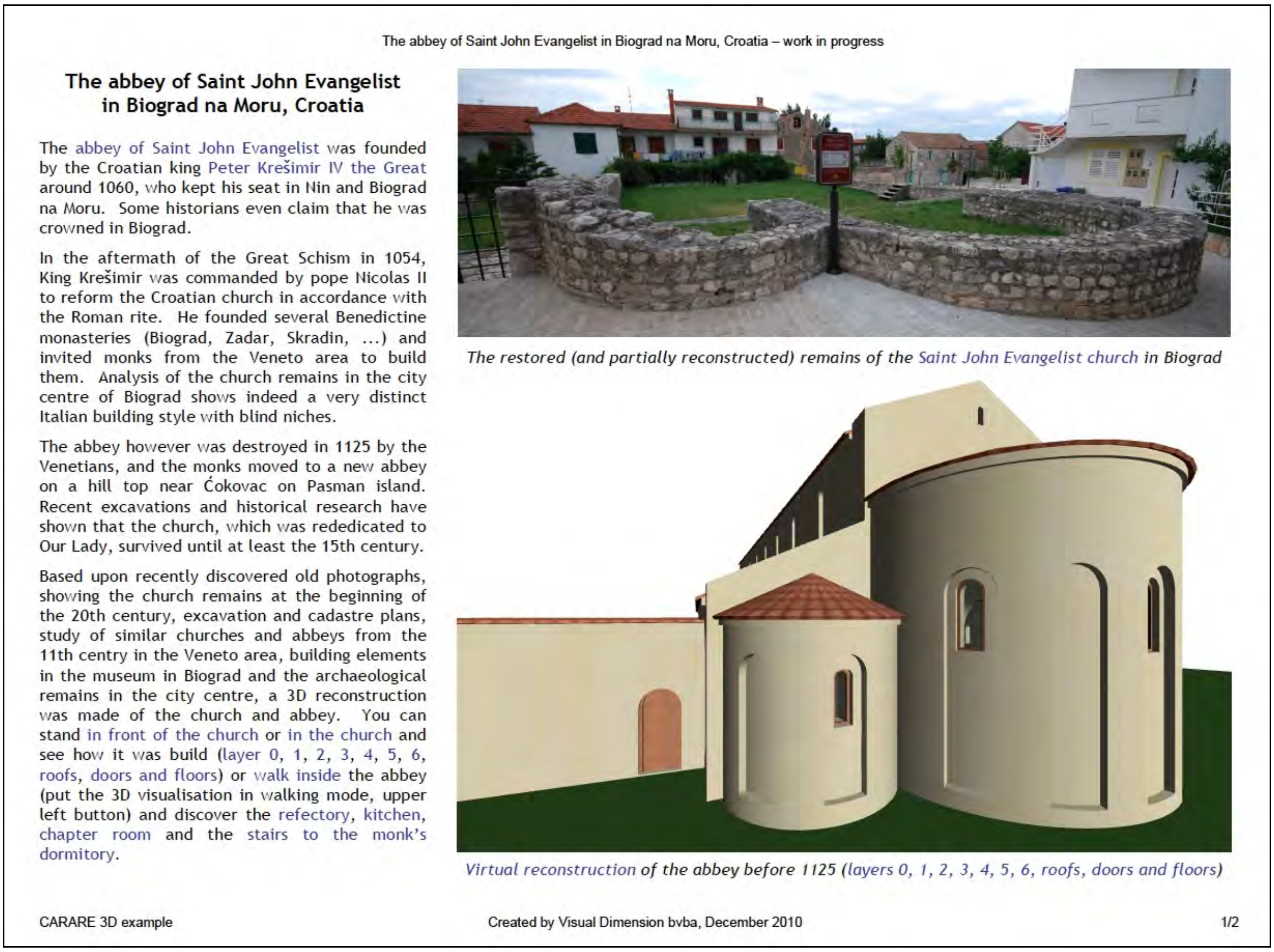
Fig. 40.—Sanctuary of the City Lares, looking toward the rear, restored.

Fig. 41.—North side of the sanctuary of the City Lares, restored.

Mau (1899), cross sections of reconstruction of Sancturary

One page of a prototype 3D resource on the Sanctuary of the Public Lares at the Forum in Pompeii

For the resource exploration of virtual reconstructions, it is even more important to link the different sources that were used to create the virtual 3D model, so that it becomes clear how the virtual model has been derived from the sources. In the image below, the visual link is created between the image of the archaeological remains and the 3D model by clicking on the caption of the image of the remains.



The abbey of Saint John Evangelist in Biograd na Moru, Croatia – work in progress

The abbey of Saint John Evangelist in Biograd na Moru, Croatia

The abbey of Saint John Evangelist was founded by the Croatian king Peter Krešimir IV the Great around 1060, who kept his seat in Nin and Biograd na Moru. Some historians even claim that he was crowned in Biograd.

In the aftermath of the Great Schism in 1054, King Krešimir was commanded by pope Nicolas II to reform the Croatian church in accordance with the Roman rite. He founded several Benedictine monasteries (Biograd, Zadar, Skradin, ...) and invited monks from the Veneto area to build them. Analysis of the church remains in the city centre of Biograd shows indeed a very distinct Italian building style with blind niches.

The abbey however was destroyed in 1125 by the Venetians, and the monks moved to a new abbey on a hill top near Ćokovac on Pasman island. Recent excavations and historical research have shown that the church, which was rededicated to Our Lady, survived until at least the 15th century.

Based upon recently discovered old photographs, showing the church remains at the beginning of the 20th century, excavation and cadastre plans, study of similar churches and abbeys from the 11th centry in the Veneto area, building elements in the museum in Biograd and the archaeological remains in the city centre, a 3D reconstruction was made of the church and abbey. You can stand in front of the church or in the church and see how it was build (layer 0, 1, 2, 3, 4, 5, 6, roofs, doors and floors) or walk inside the abbey (put the 3D visualisation in walking mode, upper left button) and discover the refectory, kitchen, chapter room and the stairs to the monk's dormitory.

The restored (and partially reconstructed) remains of the Saint John Evangelist church in Biograd

Virtual reconstruction of the abbey before 1125 (layers 0, 1, 2, 3, 4, 5, 6, roofs, doors and floors)

CARARE 3D example

Created by Visual Dimension bvba, December 2010

1/2

One page of a prototype 3D resource on the Saint John Evangelist church and abbey in Biograd, Croatia

Putting some descriptive metadata in the PDF itself could make the 3D resources more suitable for use as standalone resources (for example, a teacher providing 3D PDFs to the students for study and homework).

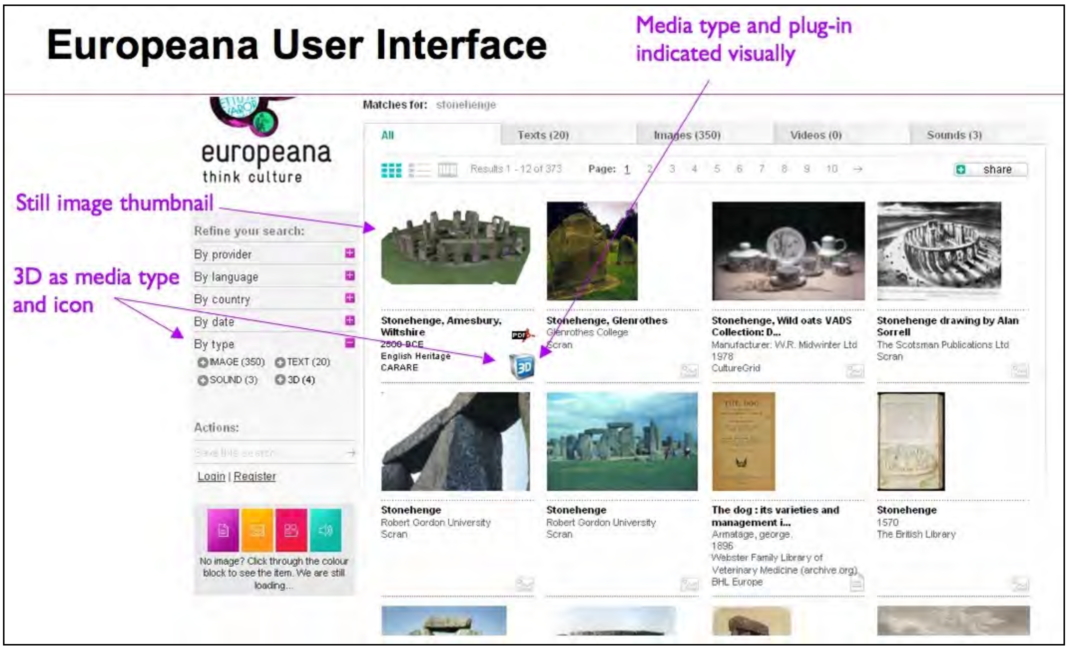
The creation of *metadata* needs to be part of the 3D data creation process within the cultural heritage organisation. This metadata is then published online and made accessible for harvesting by the CARARE aggregation service. As part of the harvesting process, content providers will map their native metadata to the CARARE schema and it will be transformed by the repository service to Europeana's current schema and exported for use in the Europeana service. In other words, it will be important for CARARE to give training and good practice guidance to data providers on the metadata as part of their 3D workflow, so that they can make sure that the metadata needed for Europeana users to discover their models is present at CARARE and Europeana level.

11. User interface

When searching for 3D in Europeana, the interaction must be as similar as possible to the search and display user interface of other media types in Europeana. When applying the approach of this text, there seem to be no reasons to make 3D behave in another way than other media types, so it is very useful to keep the Europeana user interface consistent for each media type.

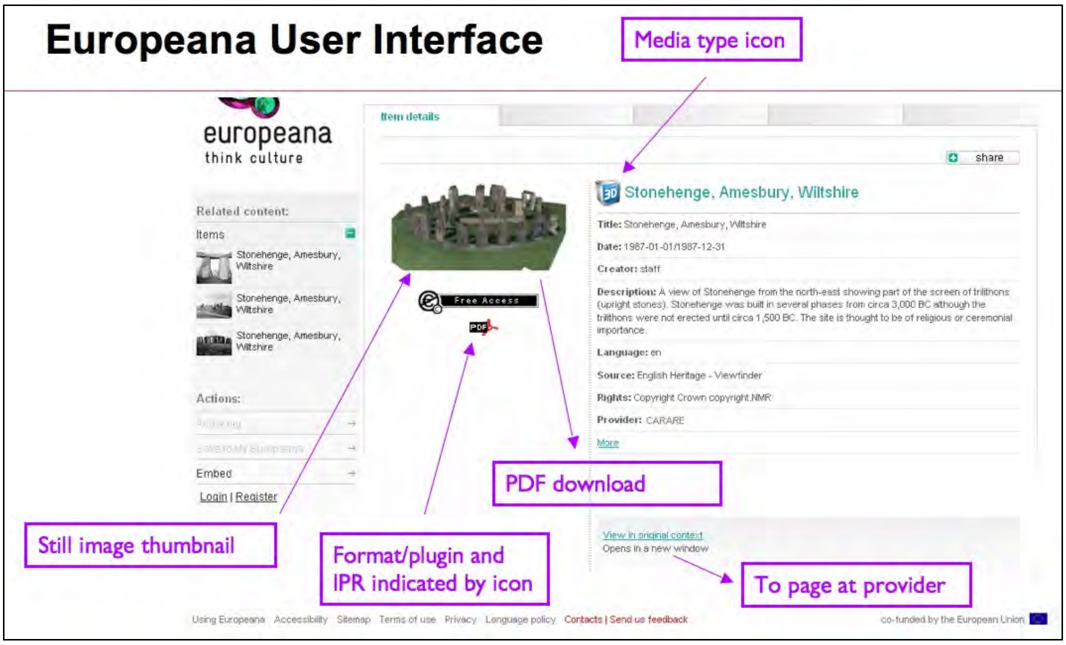
It is important to note that the user interface of Europeana probably will change in the near future. Chances are high that the brief result tabs will disappear and that the interface will indicate more clearly what the media type and required display software for each search result is. The introduction of 3D fits in this general development of the user interface. Below a mock up of the Europeana user interface for 3D is shown in a way that already reflects this new generation of user interface. Currently, a release date of January 2012 is proposed for the addition of 3D as a content type to Europeana and the adaption of the user interface.

The mock ups shown below need to be seen as conceptual models, the specific layout and graphical look of the final user interface can differ from what is shown below. When a user makes a free text search for content in Europeana, 3D objects in the brief search result have a unique icon that indicates 3D as media type (other media type icons are image, audio, video, text) and 3D is also shown as a media type so the user can use that facet to limit results to 3D objects only. The 3D object is represented by a still thumbnail image. Currently, the thumbnail image is not provided as result of the harvesting process but is calculated automatically at Europeana. For 3D resources, this is however not obvious. There are two solutions for this. One solution is that the ‘poster image’, which is included for each 3D object in a 3D PDF file, and which represents that 3D object before the 3D is activated, is extracted automatically from 3D PDF file and scaled to the required thumbnail size. If there is more than one 3D object in the PDF file, the first one could be taken. Another solution is providing the thumbnail image explicitly. This makes sense in the context of this overall user interface redesign as other media types, such as sound, also should have an explicit thumbnail image (see for example iTunes). This needs further elaboration by the Europeana team. Note in the mock up below that tabs are still shown (the intention is that these will disappear, if not a 3D tab should be provided).



Mock up of a brief search result of a free text search in the future version of Europeana

When selecting a certain 3D object from the brief search result window, the object display shows again the unique 3D icon and also an icon symbolising the plug-in or software necessary to view the 3D object. Clicking the plug-in icon will bring the user to the Europeana help page about that plug-in or software. For 3D PDF, the help page will explain both the use of the PDF plug-in in a browser and the stand-alone use as a PDF reader, and will highlight where to download one of the multiple readers available. As noted above, 3D can also be represented by other file formats than PDF, so other plug-in icons than PDF may be required when showing 3D objects.



Mock up of a 3D object display in the future version of Europeana

In line with the standard Europeana interaction pattern, the actual viewing of the digital object is done on the original data provider's site by the user clicking either the thumbnail or the 'view in original context' link (so-called 'landing page'). Depending on how the future user interface will be defined for the other media types, when clicking the thumbnail a user could go to the landing page on the data provider's site where the file will be presented for display or download (if such differentiation is implemented, it needs to be implemented for all other media types too).

Note that the behaviour of a PDF-file in a browser (if the file will be downloaded or displayed) depends on the user settings, so it would be a good idea to implement a download and a landing page separately.

Note also that on the object display (see image above), the IPR status is shown through an icon.

Until HTML5 matures, plug-ins are required to visualise 3D objects (also video, sound and some types of image file formats) via web browsers. PDF was chosen by CARARE and Europeana as a display format that their providers are already making available. In the original context (landing page) there might be links to other formats requiring other plug-ins (e.g. VRML, QTVR). The reason for choosing one format for Europeana is largely to not force users to download and install various plug-ins and to provide users with a consistent experience.

12. Quality in 3D

One of the characteristics that sets Europeana apart from other resources is *quality*. 3D should be seen not as technological gimmick but as an opportunity to deliver content in a better and more effective way. This means that, like in many innovative creation processes, content should be put first and the focus kept on the quality and effectiveness of the 3D resources being created. Studies have shown that in many cases, photorealism and nice visualisation are only secondary to the perceived quality, which has more to do with 'presence', 'learning processes' and 'enjoyment'.

This means that content producers need to build in *validation* processes into the 3D creation workflow to safeguard the *scientific accuracy* of the 3D data and the provided context information, and the *completeness of the required files* to ensure a *correct and optimal visualisation and interactivity* and to *maximise the opportunities for exploration, education and enjoyment*. Further validation procedures needs to be performed on *correctness and completeness of the associated metadata* and on translations of the resource in different languages, if provided.

It is important to realise that an important part of the 3D data, that will be made available through Europeana, is legacy data, existing data that has been archived and in which the link with the creators can be broken or for which no funding is available to update the data. Therefore content producers need a *validation procedure* that checks the 3D data, that verifies if the data (as a whole or parts of it) have the required quality level, that defines the actions to be taken if the quality level is insufficient, and that plans the additional processing of the data before harvesting (making it multilingual, translating it in up to date file formats, establishing long-term digital preservation, …).

In other words, there is a preparation and quality assurance phase to be implemented by the content provider, before 3D data is published online and its metadata is created ready for harvesting. This phase needs further study but is outside the scope of the CARARE project.

Finally, there is also the marketing side of the story. 3D in Europeana can differentiate itself from Google 3D Warehouse and many other free 3D repositories by the quality and depth of content, which are assured through this validation process and the know-how of the content provider.

13. Evolving marketplace

It also needs to be clear that the current 3D hype will produce new visualisation opportunities in the near future that will comply with the requirements stated above (in section 5).

HTML5, that is expected to reach W3C (World Wide Web Consortium) Candidate Recommendation in 2012 does promise much better 3D rendering within browsers, the 3D part would be based upon the ISO-standard X3D. As the games world is very interested to have this[23], there is quite a pressure on the market to get this up and running. On the other hand, other players are trying not to lose their market share. Adobe is currently extending its Flash technology with 3D capabilities, but also announced t support for HTML5. Time will tell where the market will go to. The battle has definitely started, for example Apple refusing Flash technology on its platforms for many years could result from this HTML5 battle behind the scenes. Within one year, the situation probably will be much clearer. Currently, there are already good solutions on the market (for example Unity3D[24]) that are multiplatform (including mobile devices) and provide great functionality, even including avatars, but they do not have the open and standard character that Europeana requires.

It would be great to see Europeana data providers making accessible interactive, intelligent walk-throughs of virtual scenes or digitised buildings, as an avatar with other non-player characters showing how people lived and worked (see for example the Via Flaminia application[25] that is working since 2007 in the National museum in Rome). However, the only fully reliable and deployed 3D environment available today is 3D

[23] http://web.appstorm.net/roundups/browsers/10-html5-games-paving-the-way/
[24] http://unity3d.com/
[25] http://www.vhlab.itabc.cnr.it/flaminia/

PDF. More sophisticated 3D visualisation tools will soon become available and maybe they will mean that such content can be made accessible to Europeana users.

Another major evolution that can be seen happening today is that the use of digital files in digital form is finally maturing. The availability of platforms such as the iPad and iPhone has dramatically improved the way people deal with digital data. A few years ago, a PDF file was still seen as suitable for printing only, but now people are starting to learn how to use it in a digital form, to read, discuss, exchange ideas and remarks, present, learn… The use of PDF files in for example education will dramatically change once teachers and students learn to use them in a digital form, including new capabilities such as 3D.

PDF (and especially its 3D capability) has already carved out some interesting digital niches such as training, digital manuals, engineering. PDF resources have a major future in a wide range of domains such as education, tourism and cultural heritage research. In other words, the choice of PDF as a cultural heritage data resource is a valid choice with long-term potential. CARARE plans to create several case studies to demonstrate how domains such as education, tourism and cultural heritage research can be supported by the capabilities of 3D PDF. The evolution of the marketplace and the technology will show which other kind of resources will also appear that have the same potential.

14. Conclusions

Images of 3D models are used frequently in all domains, including cultural heritage. Providing 3D models to a general public however is new and cannot be done without clear goals and methodology.

This report recommends encapsulating 3D models in a PDF file, as this format is known by nearly every Internet user, a large majority of the Internet users has a PDF reader already installed and it is available and stable on all major platforms. PDF is a standardised and open format, with several software companies providing authoring systems and readers. 3D models from a large variety of formats can be translated easily into PDF, with all required information and files (shape information, textures, materials, …) encapsulated inside the PDF file, which provides a robust and easy way of delivering 3D data.

PDF also provides a large set of possibilities to create VR (3D plus behaviour) to improve the exploration and learning capabilities of the 3D data. It provides also tools for collaboration and knowledge exchange. This makes PDF a suitable platform for education and tourism, but allows also professional applications in 3D to be developed for research, training, restoration, site management in cultural heritage.

3D in Europeana, as provided by CARARE, has the opportunity of distinguishing itself from other 3D repositories by the quality of the 3D data and its metadata, providing a reliable source of information and allowing a much better resource exploration. 3D PDF files can incorporate additional information to the 3D (such as text, photographs, iconography, URLs, …) improving the exploration of the 3D resource and producing unique resources for education, tourism and research. The link between text and 3D model (as demonstrated by the examples above) provides a VR behaviour that is easy to create but also yields interactive 3D with a near to zero learning curve that will appeal to all users of Europeana. In this way, the uptake of 3D cultural resources through Europeana will be easy and smooth for all users, from children to experts.