D5.2: Report on Publication

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Contents

1   Executive Summary

The publication of 3D digital assets by 3D-ICONS has focused on two main approaches: HTML5/WebGL and 3DPDF.

The introduction and use of 3DPDF in the CARARE project has been very successful, so 3DPDF was seen as one of the best ways to publish 3D online.

However, as already pointed out in the CARARE deliverables, newer publishing techniques based upon HTML5 and WebGL were in the making, promising powerful but easy to use 3D visualisation online.

For this reason, we proposed to use HTML5/WebGL as a second channel to publish 3D online in 3D-ICONS, especially because resources published through HTML5/WebGL will most probably have a long lifecycle and still will be usable in 5 and 10 years from now.

We can conclude that this promise has materialised completely in the last year, and that the decision to focus also on HTML5/WebGL as an additional publishing channel within 3D-ICONS has been rewarding.

The other reason to focus on an alternative for 3DPDF is the fact that Adobe has jeopardised significantly the future of 3DPDF by failing to deal swiftly and appropriately with security issues that were discovered in the online delivery of PDF. This has prompted the browser vendors to integrate low-end PDF viewers (based on Open Source libraries for visualising PDFs) into their browsers and banning plugins from Adobe. Unfortunately, these low-end viewers don't deal properly with the advanced features of PDF, such as 3D. In this way, the nice online delivery of 3DPDF has become impossible, destroying the simplicity of the CARARE solution.

3DPDF remains a great tool which has been used extensively in 3D-ICONS. By forcing people to download the 3DPDF and opening it local through Adobe Acrobat Reader, most of the problems could, however, be solved. The lack of 3DPDF visualisation on mobile platforms (which will produce by the end of 2015 more web traffic than the desktop platforms) undermines the importance of 3DPDF in the longer term.

At this moment, it becomes clear that HTML5/WebGL will be the stable solution that will last the longest and will provide all required functionality in the near future. Several 3D-ICONS partners have demonstrated the potential of this technology by adding, for example, automatic selection of 3D model complexity depending on the display device or collision detection to create a better walk-through experience. Other functionality that is currently available in 3DPDF (such as measuring, cross sections, animation, …) will become available soon in HTML5/WebGL.

D5.2 Report on Publication

2   The current context for publishing 3D online

In deliverable D5.1, we made some recommendations concerning suitable technologies and workflows to publish the 3D-ICONS content, which covers a wide range of data formats, types of 3D assets and interactivity. This deliverable reflects the choices made by the content providers

Although versatile and easy to use, we pointed out that some additional issues got linked to using **PDF** as a publication format. These issues can be situated on two levels. On one hand, there are a series of issues concerning the visualisation of online PDF files, that have resulted from security issues in which loopholes in the PDF delivery mechanism have been exploited to install viruses and malware. On the other hand, 3DPDF visualisation on mobile devices remains limited, as nearly all developments for 3D display on mobile platforms focus on HTML5 based solutions. As many cultural heritage organisations have implemented a 3DPDF workflow recently, a part of the 3D assets within 3D-ICONS have been produced in PDF format. Through some small adaptions of the delivery mechanisms, most of the issues have been solved however.

As predicted in the D5.1 deliverable, the major change that occurred in the past two years is the massive adoption of **HTML5**[1] and **WebGL**[2]. HTML 5.0 has reached the W3C Recommendation status in October 2014 as standard for the language for building websites. W3C[3] is the main international standards organisation for the World Wide Web. Although WebGL is not a W3C standard, it is the industry standard for displaying 3D content within a browser (WebGL uses the HTML5 *canvas element*, and relies transparently on the available graphics capabilities of the graphics card of a computer or mobile device). WebGL has a stable 1.0 version since the start of 2014, development of the 2.0 version started in 2013.

The big advantages of WebGL are that:

- there is no need to install any software or plugin to visualise 3D
- it is implemented by all major computer and browser companies
- it is available on all major platforms and browsers (from iOS8 onwards, WebGL is supported, but only by the Mobile Safari browser)
- it uses transparently the maximum of the 3D capabilities of the graphics card

In other words, 3D has become a natural element in a browser. By installing a modern browser, you have all you need to visualise 3D on any desktop or mobile platform. It is expected that WebGL will remain a natural, long-term partner of HTML5, with virtually

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[1] HTML5 http://en.wikipedia.org/wiki/HTML5
[2] WebGL http://en.wikipedia.org/wiki/WebGL

no competition or alternative technologies in place to supersede it. The most important alternative (Adobe Flash Player, containing Stage3D as a similar technology) has been discarded by all major players, including Adobe itself (at least when it comes to new developments for mobile platforms).

On the other hand, the combination of HTML5/WebGL is very flexible and provides a range of different solutions. One of the most remarkable and promising systems, developed by CNR-ISTI as one of the 3D-ICONS partners, is 3D streaming of complex 3D objects, through an application called 3DHOP (3D Heritage Online Presenter).

As a result, HTML5 and WebGL have played a major role in the publication process of 3D-ICONS. So most of this deliverable will deal with the use of these two technologies in different solutions for publishing 3D-ICONS content.

This is, in fact, very good news as the current situation never has been so complex, both in terms of which web browsers are used, as well as in the number of operating systems that are currently around (Windows, OS X, Linux, Android, iOS, Blackberry, Windows Phone, Firefox OS, Tizen, …), most of them in a variety of versions and flavours. Hence, WebGL provides native integration of 3D with the web. This reflects in the fact that in 2014, already 3 billion devices were capable of visualising 3D through WebGL.

This is also reflected in a number of tools that help visualising 3D online and that can be integrated easily in other webpages. We discuss **SketchFab** in detail in this deliverable as it has been used extensively by the 3D-ICONS team, but there are many others such as PinShape[4], p3D[5], the Digital Epigraphy Toolbox[6] or tools[7] based upon the *three.js* library.

Concerning web browsers, the trends that were highlighted in the D5.1 deliverable are still present: Internet Explorer and Firefox continue to lose share, while Chrome and Safari continue to win share. Opera has a small but loyal user base. Currently, those five browsers cover virtually the online domain, and should be taken into account for any analysis concerning online delivery of data. Note that browsing on mobile devices is growing exponentially, with a share currently above 30%, predicted to reach 50% by the end of 2015. Many websites however are not ready for this disruptive change[8].

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[4] PinShape https://pinshape.com/items/4500-3d-printed-crouching-woman-by-auguste-rodin

[5] p3D https://p3d.in/O4Xyo

[6] Digital Epigraphy Toolbox http://www.digitalepigraphy.org/museum/embed.html

[7] Three.js tools http://www.webgljobs.com/

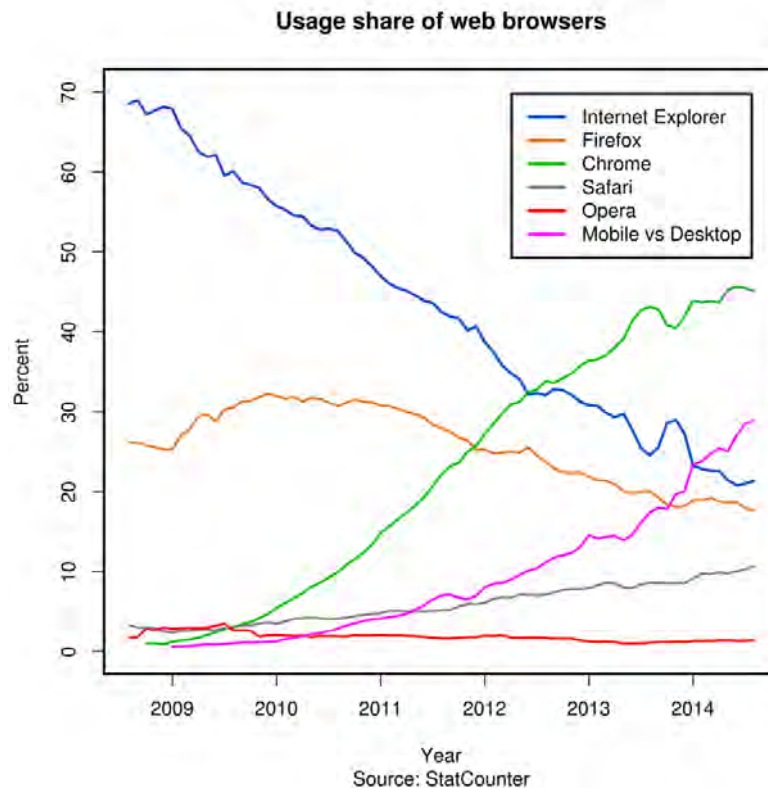**Usage share of web browsers**

Fig. 1: Evolution of the usage share of the major browsers through the last 7 years

Other technologies, mentioned in the D5.1 deliverable, were only used in a few special cases, which we will mention briefly in the next chapter of this deliverable.

The 3D content, published within the 3D-ICONS project, is quite diverse in terms of 3D data type (point clouds vs. meshes, textures vs. coloured vertices, …), size and complexity, interactivity and added interactive content. As a result, a range of solutions have been adapted, which will be discussed in the next chapter.

3   Publishing the 3D-ICONS content online

The choice of the right technology for publishing 3D content depends on several data parameters but also on the capabilities of the organisation. In CARARE, the choice had been made to use 3DPDF as a major publication channel. One of the main reasons for this choice was that the 3DPDF workflow integrated very well in cultural heritage organisations. In 3D-ICONS however, some partners have software development capabilities and are able to select more technical solutions that require the integration of JavaScript developments into the created webpages, fine-tuning in this way the technical 3D visualisation capabilities to the specific needs of the 3D data, based upon WebGL.

In general, we can say that 3D has seen a real tipping point in 2014, in which the integration of WebGL and HTML5 into all browsers on all platforms has made 3D visualisation a natural and easy thing to do.

The WebGL visualisation tools have significantly matured during 2014 and 2015, and provide richer interactivity (for example walking a site instead of visualising the site as an object, see SketchFab) and tools to add value (adding points of interest in a 3D model that provide some information or tell a story).

Although the low end devices that are currently used for browsing (smart phones and tablets) have improved significantly in terms of graphical display capabilities, working memory and storage capabilities, it has been perceived by some data providers as a must to publish the 3D data in multiple resolutions.

On the other hand, most 3D-ICONS data is provided also in high resolution for use by researchers. In this way, there is a clear distinction between the low-resolution 3D data for visualisation purposes and the high-resolution 3D data for professional use, which is much wider than visualisation only.

In total five different technologies have been used in 3D-ICONS to publish the 3D assets. We provide an overview of these technologies, and their specific implementations.

3.1 WebGL

Most of the 3D-ICONS 3D data is visualised through WebGL (under HTML5), with nearly full support[9] on nearly all browsers on nearly all platforms. However several different WebGL viewers are used, depending on the complexity and kind of the 3D data, but also depending on the capabilities of the partners to program web applications or rather to use predefined tools that only require data entry.

Several partners have used the **three.js** Javascript library[10] for creating a custom WebGL based 3D viewer, for the different types of 3D data at hand (point cloud, coloured vertex mesh, textured mesh, …). This library is one of the most popular and most powerful but freely available and Open Source, with a large community of developers using it and sharing their experiences and code. For example, Potree[11] is a three.js based viewer for large point clouds.

Other 3D viewers based upon *three.js* are used frequently for online 3D museum object libraries such as the 3D Petrie museum[12] or the Naturalis Biodiversity Centre[13]. FBK

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[9] Status of WebGL http://caniuse.com/#feat=webgl

[10] Three.js library http://threejs.org/

[11] Potree point cloud viewer http://potree.org/

[12] 3D Petrie museum http://www.ucl.ac.uk/3dpetriemuseum

has used the *jsc3D*[14] library (see below). Similar libraries are used for the Google Art Project[15] in 3D.

Other partners have used the **X3DOM**[16] framework. X3DOM is an open source JavaScript framework, used to create *declarative 3D scenes in Web pages*. Since it is based on standard browser technology, the browser does not need any plugin to display X3DOM scenes. The name X3DOM is composed of two well-known abbreviations. The first one is X3D, which denotes a royalty-free ISO standard for declarative 3D graphics. The second abbreviation is DOM ("Document Object Model"), which describes the interaction concepts and hierarchical representations that are associated with the content of HTML documents. The Smithsonian Institute is using X3D[17] for its 3D objects website.

Another popular 3D visualisation tool is **SketchFab**. This tool allows to visualise 28 different 3D formats through WebGL, with support for physically based rendering[18] (better representation of physical materials, which is very important for cultural heritage) and real-time shadows (important for buildings and spaces). SketchFab has both an object mode (called *viewer mode*, to look at an object from all sides) and a walk through mode (called *first person*, to explore spaces) which unfortunately has no collision detection or definition of a terrain to walk on, so it's elementary. SketchFab is mostly used for textured objects but can also handle vertex colours (through file formats that support vertex colours such as .fbx or .ply).

SketchFab converts the uploaded 3D file and stores the results on its central server. In D5.1, it was recommended not to use SketchFab because of the IPR rules at that moment, where SketchFab basically took possession of the file. Now, the IPR rules[19] have be drastically altered, respecting the rights of the owner of the 3D assets.

SketchFab is available on all desktop computers through virtually any browser, and on recent versions of Android, Blackberry and iOS. Other similar tools such as 3DSOM are used in 3D online repositories such as the one from Carnuntum[20].

3.2 3D Streaming with WebGL

The most sophisticated WebGL viewer is **3DHOP** (3D Heritage Online Presenter), developed by CNR-ISTI. All CNR-ISTI assets for Europeana are provided through this viewer, that uses 3D streaming, so that in a very short time (seconds) the form of the object is visible while the details of the 3D objects appear gradually, by preference in the visible parts of the object. The object can be annotated through clickable zones,

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[14] Jsc3D library https://code.google.com/p/jsc3d/

[15] Google CI 3D https://www.google.com/culturalinstitute/browse/?f.media_type=3d

[16] X3DOM http://www.x3dom.org/

[17] Smithsonian Institute 3D online repository http://3d.si.edu/

[18] Physically based rendering in SketchFab https://sketchfab.com/pbr

[19] SketchFab IPR https://sketchfab.com/terms

providing information about specific parts of the object[21]. Also, multiple versions of an object can be provided, showing for example the original and digitally restored version of an object [22]. Typically, 3DHOP is used for objects (which can be seen from all sides) but it can be used also for scenes, in which the camera can move around in a predefined way, providing a kind of guided tour[23]. The object resides on the server, defined by the creator of the visualisation, not on a central server.

The advantages of this viewer are quite important. Not only can it visualise very high-resolution files without making the user wait for the full download of the model, but this streaming of 3D content is also intelligent as it loads those details first that are being visualised. In practice, this means that digitised objects can be visualised instantly without simplification, which is a major advantage for cultural heritage objects. The annotation, controlled camera and support for multiple versions of an object are essential for publication of 3D digital heritage assets. The tools to produce such a 3DHOP asset (created by conversion to the Nexus format[24] and the use of some style sheets) are free.

The major disadvantage, however, of the application is that only colour per vertex 3D data (or 3D data without colour information) can be shown, not textured 3D models. In practice, this is no severe problem as 3D models with high complexity consist nearly always of coloured vertices.

3.3 HTML5

Several HTML5 based visualisation techniques, that are not using WebGL, have been applied to visualise **panoramas and ObjectVR visualisations**. In a panorama mode, the (virtual) camera remains in one point and shows the (virtual) environment (which is implemented as an interactive visualisation of a cylindrical image or a set of six square images arranged as a cube). In ObjectVR mode, the camera moves around a fixed point in one or more circles (which is implemented as an interactive visualisation of a matrix of images with one or more rows). Panoramas are used to visualise real and virtual spaces, ObjectVR visualisations are used to show real and virtual objects, sites and landscapes.

HTML5 allows this interactivity to be implemented within a browser without any plugins, through programs such as *krpano* and *object2vr*. Such panorama and ObjectVR visualisation of virtual environments and objects allows to show things that are too complex to visualise in real time, for example the light refraction of glass objects or the vegetation of landscapes with shadowing applied.

In this 3D-ICONS project, panoramic and ObjectVR HTML5 visualisations have been used for historical landscape reconstruction, in which the procedural vegetation can

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[21] Annotation in 3DHOP http://vcg.isti.cnr.it/3dhop/demos/tut/index_tut.html

[22] Sigliano helm http://vcg.isti.cnr.it/3dhop/demos/helm/index_helm.html

[23] http://vcg.isti.cnr.it/europeana/san_gimignano/landing/san_gimignano_piazza_cisterna.html

make scenes as heavy as 30-60 billion polygons with render times (for full HD images) in the order of 20-30 minutes per image on a powerful computer.

Other uses that can be envisioned for ObjectVR visualisation is showing interactively *gems or glass objects* (as good rendering of transparent objects still requires high-end ray tracing which cannot be implemented in real time on normal computers) or *4D visualisation* in which a 3D displacement and an evolution through time is visualised in one ObjectVR file. Fig. 2 below shows an example of a 3D object (the German Imperial Crown, preserved in the Hofburg Museum in Vienna) that cannot be visualised in real time, as it is full of gems and special precious stones. It took 6 months to make the 3D model.

Fig. 2: Interactive application using an ObjectVR visualisation of the German Imperial Crown as user interface (by Henning Kleist and Visual Dimension, 2014)

3.4   PDF

Another format that has been used extensively in 3D-ICONS is **3DPDF**. Although 3DPDF does not exist as a model format, we use 3DPDF to indicate PDF files that contain 3D content that can be visualised by Adobe Acrobat Reader, which is installed on more than 90 % of the desktop computers. 3DPDF was used extensively in the CARARE project for five main reasons:

- the use of WebGL/HTML5 was too early at that time
- 3DPDF could be visualised offline and online, providing maximum flexibility
- 3D capable PDF readers were installed on more than 90 % of the computers
- the 3DPDF workflow could be integrated easily in cultural heritage organisations
- PDF is a file type that is available in most document archiving applications

Today however, this situation has changed significantly:

- WebGL/HTML5 works on all major platforms on all major browsers
- No further investments have been made in visualising 3DPDF on mobile devices, while mobile browsing will become bigger than desktop browsing by the end of 2015
- Visualising PDF online has become a mess as most major browsers have integrated low end PDF viewers (without 3D capabilities) for security reasons (PDF has even been put on the blacklist by some governmental organisations as a potential source of virus and trojan horse infections)
- 3DPDF has seen nice further developments (animations[25], versioning, security, …) but only focused on the technical CAD market[26], not on mainstream use

Still, PDF is a great platform for visualising 3D through the ubiquitous Adobe Acrobat Reader, but should no longer be considered as a 3D publishing channel in future 3D online projects.

3.5   Serious Games

The use of serious games for cultural heritage is currently dominated by Unity3D[27] as platform. Many universities use Unreal[28] as it is free for non-commercial use and has a specific programme for academic partners.

The advantages that serious games platforms provide over the other solutions can be summarised as follows:

- better interactivity for exploring buildings and sites: guided tours, collision detection, terrain following including stairs, automatic opening of doors, …
- optimised solutions for creating photorealistic visualisations of buildings and sites (indirect light, level of detail for vegetation, animated environments…)
- highly optimised viewers that deal better with complex scenes
- availability on all (for Unity3D[29]) or most (for Unreal[30]) of the platforms

Although both Unity3D and Unreal[31] export to HTML5/WebGL, there is still some performance difference between these web viewers and their native viewers. This difference however will fade away in the near future through better optimisation of the WebGL builds that are produced by Unity3D and Unreal. Although Unity3D and Unreal require additional installation of software, this installation happens automatically and is fast, so there is nearly no drawback for the user using such a serious game

[25] Animations in 3DPDF http://www.tetra4d.com/products/enrichment/3d-pdf-animate.html

[26] 3DPDF target markets http://www.tetra4d.com/showcase.html

[27] Unity3D http://unity3d.com/

[28] Unreal Game Engine http://www.unrealengine.com/

[29] Supported Unity3D platforms http://unity3d.com/unity/multiplatform

[30] Supported Unreal platforms https://www.unrealengine.com/faq

implementation instead of a HTM5/WebGL implementation, while the functional advantages can be quite important. However, such serious games implementation does require a set of technical and design skills that are not always present in cultural heritage institutions.

Unity3D is currently the most common platform for publishing 3D digital heritage assets, see for example this virtual reconstruction of the Castle of Couchy, France by Riches Heures[32]. Nevertheless, serious games do require a set of technical, 3D and programming skills that are not commonly found in cultural heritage organisations. Probably for this reason, there have been little serious games implementations in 3D-ICONS.

3.6   Remote rendering

Another technique for 3D visualisation that has been implemented to show very high resolution 3D models is remote rendering, where a low resolution model is manipulated interactively (through WebGL) and a rendering of the high resolution model is created on a remote server, replacing after a few seconds the low resolution visualisation[33]. This technique has several major advantages for cultural heritage organisations (see D5.1). Nevertheless, this technique is not been used widely, probably because of a lack of promotion and an unclear business model (for example, the rendering server needs to be powerful, so it should be central, while cultural heritage organisations want the high-resolution 3D models on their own server, which may be not powerful enough for such rendering jobs). The 3DHOP solution presented above is an excellent replacement for this technique and performs even better without requiring a dedicated rendering server. This technique has not been used in 3D-ICONS.

4   Lessons learnt from the 3D-ICONS publication process

This deliverable has the additional intention to help institutions that want to use online 3D publishing, so we briefly list here what we learned in the process.

4.1   WebGL

Since October 2014, there is full support for WebGL on all major platforms/browsers. This means that once a webpage has been designed and works on one platform, it should work on all other desktop and mobile platforms. We have tested successfully several of the implementations described below, that were designed and verified on desktop, on a mid range Android tablet (Nexus 7).

The major issue, however, is that not everybody is using the most recent version of the operating system and/or browser. Especially on Android, there is quite a latency as there is no general upgrade policy such as used by Apple (where all OS X and iOS users are pushed to upgrade as soon as possible). On the other hand, WebGL is already

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[32] Castle of Couchy in 3D http://www.richesheures.com/abonne/visite-3d/07coucy.htm

properly supported for some time on Android, so this compensates somewhat this latency. For iPads and iPhones, WebGL is only properly supported on iOS8, but mid April 2015 (7 months after the launch of iOS8), already 79% of the iOS users is running iOS8. So we can estimate that currently, about 70 to 80 % of the mobile device users and over 80 % of the desktop users should have a configuration that can display HTML5/WebGL without problems. We rely here on numbers that estimate the web traffic per browser and per computer platform, not on numbers that show the installed number of browsers (in which for example Internet Explorer has nearly a 60 % market share, compare with fig. 1).

Note that visualising 3D through WebGL is a new and still somewhat immature application. This does not show up as technical problems but as a certain lack of functionality. As demonstrated by CETI (see below), useful features such as collision detection and automatic selection of the complexity of the 3D model can be implemented in WebGL applications, but such features are still lacking in most 3D-ICONS implementations. It can be expected that standard tools (such as SketchFab) or libraries (such as three.js) will support such functionality soon.

For example, over the last year, SketchFab (currently containing over 300.000 objects) has seen a significant increase of 3D models representing monuments, buildings and landscapes. An important part of these 3D models can be considered as cultural heritage. To explore such 3D models, collision detection and walk through modes would be very useful. The current *first person* mode is too limited to provide a good walk through experience, although a clever use of the annotations capability[34] can give already a nice walkthrough in the 3D model. Seen the popularity and current developments in SketchFab, it is quite likely that better walkthrough tools will be developed soon.

In terms of complexity, most WebGL tools that we describe here are really doing well, even for large models (> 2M polygons). However, the 3DHOP viewer (see below) is beating everything by 3D streaming (see 4.3).

Annotation is already available in several tools and libraries, and has been used by several 3D-ICONS partners (see for example the Discovery Programme below).

The use of JavaScript libraries and tools such as SketchFab that can be integrated easily in webpages (mostly through iframes) has also enabled to embed the 3D in landing pages that also give access to for example the description, related images and videos, location and technical details (see for example fig. 14, 18 and 19).

4.2 HTML5 without WebGL

The use of non-WebGL HTML5 techniques for ObjectVR and panoramas to visualise 3D assets has been very successful, although only used by some 3D-ICONS partners. The main advantage is that the webpages using this technique do work immediately on any

platform and browser. A small disadvantage for ObjectVR visualisation is that the technique is image based so that the ObjectVR cannot be too extended as the load time for the images can become long on slow internet connections.

A major advantage of panorama and ObjectVR visualisation is that it works for both real and virtual scenes, and is easy to make.

4.3 3D Streaming

One of the most important contributions of 3D-ICONS to the visualisation of high-end 3D models is the development of 3DHOP[35] (3D Heritage Online Presenter) which is based upon streaming of 3D content from the general shape to the fine details through the Nexus file format. 3DHOP has been developed by CNR-ISTI, one of the 3D-ICONS partners.

The 3D streaming is intelligent, in this way that the details are loaded of those parts of the object that are visible. Changing the view or even zooming in makes other or more details to load immediately, while details that are not visible are loaded after loading the visible details first. While loading, the 3D object remains interactive all the time.

The functionalities to add annotations, to add multiple versions of an object and to define camera paths for buildings and landscapes makes this one of the most advanced 3D visualisation tools for the moment.

3DHOP has been used in all 3D assets that have been provided by CNR-ISTI. Testing on desktop computers has shown that the performance is stunning. Typically in 5 to 10 seconds, the object is already well defined while it can take several minutes to have the full object loaded.

The technique is in fact working perfectly for mobile devices, but there is some missing functionality for interacting with the 3D object on mobile devices that still needs to be added by CNR-ISTI. This should be done as soon as possible, as 3DHOP makes it possible to visualise even very complex 3D objects on low-end tablets and smart phones. Note that by the end of 2015, more online activity will take place through mobile devices than through desktop computers.

4.4 3DPDF

When using 3DPDF, it is annoying that most browsers try to visualise the PDF within the browser. This visualisation is based upon simple Open Source libraries that do not support 3D visualisation. This results in opening the 3DPDF file without displaying the 3D content, which is quite confusing for most people. Opening the same file in Acrobat Reader shows the 3D content properly.

To solve this, we have advised the 3D-CONS partners to make the users explicitly download the file and open it in Acrobat Reader. However, it depends on the local settings of the user if a file is downloaded or visualised through a certain programme.

To solve this, we use a feature of HTML5 that allows to specify explicitly that a file should be downloaded, through the download tag[36]. The file specification looks like this:

<a href="/HA/heritage_asset.pdf" download>

Together with a short description that the file needs to be downloaded and opened in Acrobat Reader, this has solved the issue.

The use of 3DPDF is still appreciated in cultural heritage by the more technical people that need dimensions (which can be measured in the PDF file itself) and cross sections (that can be defined and visualised in the PDF file itself).

However, we see that the 3DPDF community is focussing more and more on the niche markets of the CAD/CAM and AEC (architecture, engineering & construction) industry[37], where 3DPDF files are mostly used as standalone files, not as online documents.

Therefore, and because the developments in HTML5 and WebGL do provide better solutions and tools, we recommend not to use 3DPDF anymore in the near future. We are convinced that features such as measuring dimensions and creating cross sections will be provided soon in WebGL tools and libraries.

4.5   Carousel

Most 3D-ICONS partners considered that having a cultural heritage object (CHO) with multiple WebResources is a very useful feature, provided by Europeana.

Originally, the need to attach several digital representations to one CHO in the form of an image carousel, was described in the MIMO project[38]. In fig. 3, we can see such an implementation. EDM allows these different resources to be connected to each other and enriches the global context of the object aggregated. In the example below, the CHO is provided with three different digital representations. This situation results in the creation of three different 'edm:WebResources' pointing to three images (JPEG).

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[36] HTML5 download tag http://www.w3schools.com/tags/att_a_download.asp
[37] PDF in AEC industry https://www.youtube.com/watch?v=rvFNla18tuQ
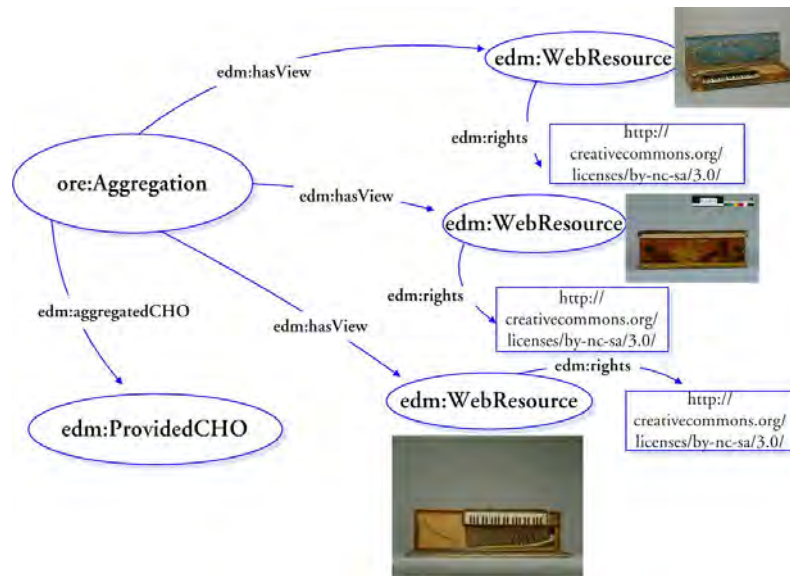
Fig. 3: Clavicorde lié dit de Lépante from Cité de la Musique[39]

Unfortunately, the EDM carousel was designed only for images. However, it is important to be generally useful that this carousel can handle different types of digital representations properly, such as video, sound, 3D, etc. Even in the above example, an additional WebResource was added during an update, where the digital representation was a sound file (.mp3) and not a .jpg image file.

Several 3D-ICONS partners felt the need to use this carousel with WebResources of different types (such as 3D) attached to one CHO. The issue was raised a few times to the Europeana personnel that was responsible for the 3D-ICONS harvesting.

EDM in its current implementation records for an additional WebRresource the following fields:

edm:hasView:
> *dc:description:*
> *dc:format:*
> *dcterms:extent:*
> *dc:rights:*
> *dc:source:*
> *edm:rights:*

If the *edm:hasView* points to an image, then a thumbnail is created and it is placed in the carousel (fig. 4a) and when we select the large thumbnail, an image stored in the Europeana portal is displayed (fig. 4b)[40]

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[39] Clavicorde http://www.europeana.eu/portal/record/09102/_CM_0161358.html

Fig. 4 a (left) and b (right): Europeana carousel with images

Unfortunately, when the *edm:hasView* does not point to an image, then the thumbnail is replaced with a thumbnail indicating just the type of the digital representation.

3D	Sound	Video	Text

In fig. 5, we have two examples, one with only 3Ds and the second with images and sound simultaneously. The first thumbnail is the thumbnail of the CHO defined in the *edb:object* . The functionality is now different. If we select the thumbnail in the upper row, we go to the object where its URL points to.
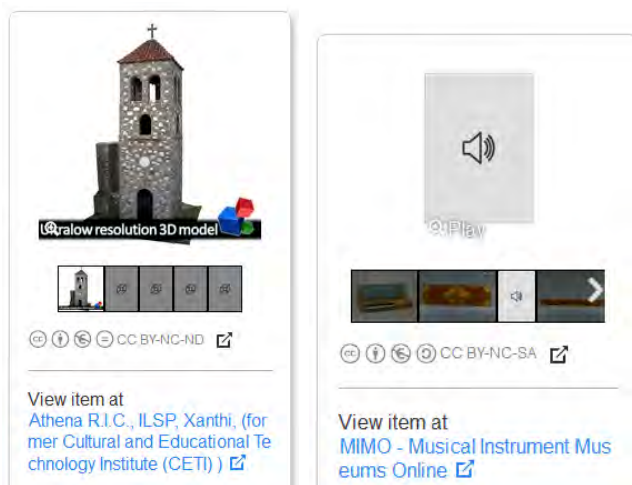
Fig. 5 a (left) and b (right): Europeana carousels with no image DR

To solve this issue, we propose the following: allow for one more field *dc:object* in the WebResource, pointing to the thumbnail of the object

Even if you can find the type of the DR from the dc:format, we can have one more field *dc:type* defining the type of digital representation

This way, you can have thumbnails in the carousel, and you can also place a marker indicating the type of the DR. Since, 3Ds usually are very large files, it could be informative if you can also put the size of the file under its thumbnail.

4.6 Rights statements

Concerning rights statements, a potential conflict is perceived between the Europeana statements and the Italian law, that regulates the reproductions of cultural heritage and their publication.

The relevant law is the Legislative Decree 22/01/2004, no. 42 – Code of cultural heritage and landscape, according to art. 10 of Law no. 137 of 6/7/2002. Art. 107 and 108 concern the reproduction of objects.

Art. 108 has been recently modified by the Decree no.83 of 31/05/2014 "Urgent measures for the protection of cultural heritage, the promotion of culture and the relaunch of tourism", converted as Law 106 of 29/07/2014, with modifications.

The resulting version, currently in force, states the following (subsection 3-bis):

"In any case, as concerns the due controls, the following activities are free if performed as no-profit, even indirect, and for the purpose of study, research, free expression of thought and creativity, and promotion of the knowledge of cultural heritage:

1) the reproduction of cultural heritage using procedures not involving any physical contact with the objects, nor the exposure of the same to light sources, or the use of tripods;

2) the dissemination with any system of images of cultural heritage, rightfully obtained, in a way that prevents further reproduction by the user except, possibly, at low digital resolution."

If the case envisaged by art. 108 does not occur (image capture using laser/tripods, and high-resolution images), the provision of art. 107 and 108 are in force, requiring an authorization, which is free of charge if for personal use or study reasons, and any profit, even indirect, is excluded.

Summarised:

- the dissemination of reproductions of cultural heritage is free (no authorisation) if for personal/study use and at low resolution
- if this is not the case (i.e. at high resolution), it is subject to an authorisation, at no charge, if for personal/study use
- if it is not for personal/study use or involves profit, it is subject to authorisation and is at a charge.

In other words, there is a discrepancy between the Italian law and what Europeana imposes. In any case, partners of EU projects cannot be held responsible of the consequences of a national law entered into force after the contract was signed; they must comply with the law in any case.

5   Overview by partner

5.1   CNR-ISTI

ISTI CNR has published in the 3D ICONS database:

- 166 3D models
- 1798 photos
- 9 videos

All 3D models have been generated by 3D scanning (laser triangulation, structured light, TOF (time-of-flight), TOF Interference), apart from 9 objects, which have been hand-modelled based on archaeological data, and 3 objects, which have been generated by 3D-from-photos. All 3D models are triangulated meshes, except for 10 models in point-cloud.

Roughly 70% of the models contain only shape information, around 30% are colour-mapped from photos. The complexity of the 3D models varies from 1 to 180 million triangles (5 to 300 million of points for point-clouds).

The size of the objects, represented in the 3D models, vary a lot, from few centimetres for the smallest statues and artefacts (Aphrodite statue: 20 cm tall, Capsella Samagher: 20 by 30 cm) to hundred of meters for very large buildings (Pompeii Insula: 100 by 50 m, Pisa cathedral: 120 by 80 m, city centre of San Gimignano: 350 by 180 m).

The 3DHOP viewer has been used to create the online interactive preview for all these 3D models (3D meshes, 3D point clouds and hand modelled objects), with streaming of the 3D data from the coarse shape to the fine detail.

The standard interaction used in all models is a simple "trackball interface" with rotation, zoom and pan capabilities, except for:

- 1 room, viewed from the inside, only rotation and panning, no zoom
- 3 urban areas, where a predefined path is used to navigate the environment

The light direction may be changed and the viewer may be brought to full-screen. 3DHOP works on all up-to-date major browsers (Firefox, Chrome, Internet Explorer) on Windows, Linux and Mac. Mobile platform support (more precisely the interaction part) is coming soon (the WebGL 3D streaming is working).

In addition to the 166 3D models, there are also 1798 photos and 9 videos. All the photos are available online, each one in its own landing page, as subsampled previews. All the videos are available in YouTube

All the landing pages, photo thumbnails and online viewable 3D models are hosted on the ISTI server, for a total size of 24 GB of data.

David di Donatello - Museo del Bargello (FI)

3D Model: master model

LEFT MOUSE BUTTON + MOVE: rotate model
LEFT MOUSE BUTTON + MOVE: pan model
MOUSE WHEEL: zoom

click HERE to go to the main project page

Fig. 6: an example of a landing page provided by CNR-ISTI, through 3DHOP

5.2 POLIMI

POLIMI used the 3DPDF technology to visualise the low-resolution models. Each 3DPDF file is automatically downloadable through the landing pages of each model. High resolution models have their own landing pages but are available only on request due to IPR limitations imposed by the heritage asset owners. POLIMI started also to use SketchFab for showing online a selection of the best high-resolution models produced[41].

A large majority of the 3D models, created by the POLIMI unit, represent archaeological artefacts provided by the two surveyed museums (Archaeological Museum and Ancient Art museum at Castello Sforzesco, both in Milan) and are textured meshes. A fraction of the models (around 10%) refer to architectural structures, representing the current state of each building by point cloud (some with colours, some without), while the 3D reconstructions of these buildings (some representing historical phases, others referring to the current state) have been made with CAD modelling. Here is an overview:

- Low-resolution textured meshes exported as 3DPDF: 501
- High-resolution textured meshes exported as .obj files (with related .mtl and .jpg): 472
- High-resolution 3D point clouds: 15
- 3D CAD models: 14
- full HD MPEG-4 video sequences: 31
- JPEG images: 1176

The visitor has the 3D interaction features provided by the Adobe PDF viewer, such as 3D navigation, 3D examination with zooming, panning and rotating functionalities, representation of the model with or without texture, representation with transparent walls for looking inside architectural structures, sections with planes and point-to-point measurements, that gives a number expressed in meters and make sense since each model has been metrically scaled. On the small selection of the SketchFab assets, POLIMI started to use hotspots and local annotations.

POLIMI has provided two different levels of resolution, a low-resolution 3DPDF for web visualisation and a high-resolution model for study and analysis (for which permission needs to be granted by the POLIMI coordinator). The high-resolution models of the museum artworks are fixed to a maximum of 2 million polygons, while the low resolution ones are around 10 times smaller. For the architectural structures, the number of 3D points per high-resolution object is generally much higher (10 to 40 Mpoints) than for museum artworks (1 Mpoints, approximately corresponding to 2 Mpolygons), but it can vary a lot from case to case.

The main issue in the publication process is related to Italian IPR constraints, that should be all ruled of course by the same law, but that are applied very differently

depending on the availability of each superintendent in charge of signing the papers. This has been a great waste of time.

Fig. 7: an example of a landing page for 3D content provided by POLIMI

5.3 CNRS-MAP

CNRS-MAP developed a specific HTML5 meta-viewer, based on WebGL and JavaScript, able to visualise 3D models (Collada, .obj, .ply), images (.jpg, .bmp, …) and videos (.avi, .mov, …). The meta-viewer changes the visualisation properties and the interaction behaviours according to the type of media to be visualised and handled.

The CNRS-MAP meta-viewer allows visualising 3D representations based on:

- dense and coloured 3D point clouds structured in octrees (by using the Potree visualisation tool) downloaded dynamically according to the observation point
- regular and dense 3D meshes with (or without) vertex colours for visualising complex artefacts (e.g. architectural details and archaeological findings) obtained by an automatic 3D geometric reconstruction
- CAD-like 3D models with (or without) image-based textures for visualising large and complex architectural scenes obtained by interactive 3D modelling/texturing techniques
- hybrid 3D representations based on 'transfer map' techniques allowing to embed the high definition geometric and visual information into low resolution polygonal representations enriched by colour, displacement, normal, bump, ambient occlusion and light maps

The meta-viewer and the NUBES web platform (developed at CNRS-MAP) will be linked in the near future, allowing the semantic annotation of 3D models as well as the structuring of heterogeneous data (documents, images, videos, etc..) around a 3D model.

Fig. 8: an example of a landing page for 3D content provided by CNRS-MAP

The CNRS-MAP corpus contains:

- Large and dense 3D point clouds of archaeological and monumental sites obtained by UAV-based acquisition and multi-view stereo photogrammetry;
- Large and dense 3D point clouds of heritage buildings obtained by laser scanning and/or multi-view stereo photogrammetry;
- Complex architectural 3D scenes of the current state of the buildings integrating several terrestrial acquisitions and geometric modelling techniques;
- Virtual reconstructions of architectural 3D scenes integrating current and hypothetical state of the buildings;
- Relevant architectural elements and details (columns, capitals, furniture etc..) as well as archaeological fragments represented by high resolution and textured 3D models.

All the content (3D models, images and video) elaborated by CNRS-MAP is provided in two versions:

- low resolution for real-time visualisation on the web;
- high resolution for research purposes, available on demand.

5.4 Archeotransfert

Archeotransfert has used a 3D WebGL viewer based upon the *three.js* library. In total 107 3D objects have been made available, of which 60 are also available in high resolution. The 3D assets represent archaeological objects and buildings. Both point clouds (with colours per vertex) and textured meshes (for the low resolution objects) are used. The interaction is always in object mode (rotate, pan and zoom), no annotation has been applied. The 3D files and their metadata are hosted on the Archeotransfer/Archeovision server and duplicated on the CNRS server.
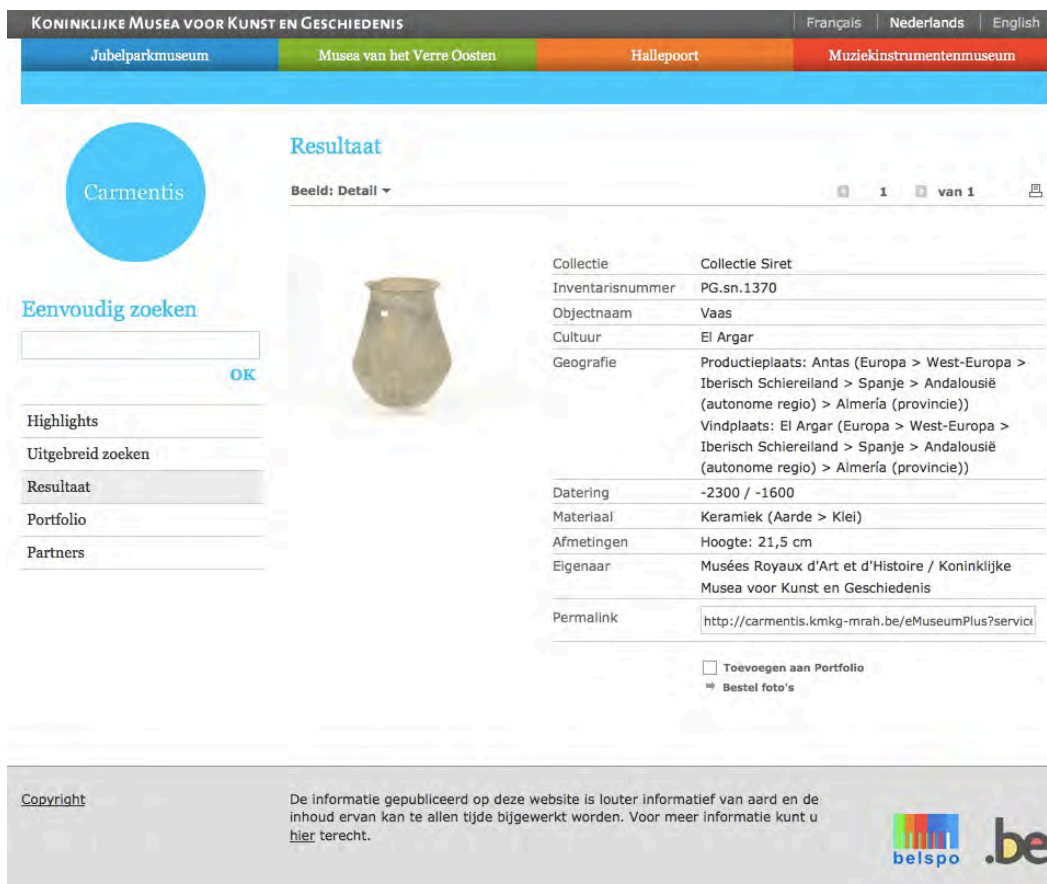
Fig. 9: an example of a landing page for 3D content provided by Archeotransfert

5.5 KMKG

The digitised objects are burial remains of the El Argar culture, i.e. pottery and grave goods. All objects have been produced through structure-from-motion software (AgiSoft). In total there are 457 3D objects.

The medium resolution 3D models that KMKG produced are available in 3DPDF and can be downloaded for visualisation through Adobe Acrobat Reader. High-resolution models are available on request in .obj format through the portal.

Fig. 10: an example of a landing page for 3D content provided by KMKG

5.6 CAAI

CAAI has previous experience in using 3DPDF in CARARE and has used the same workflow in this project. The resulting 3DPDFs have to be downloaded explicitly to be opened in Adobe Acrobat Reader. In total 590 3D models have been provided, depicting archaeological sites and objects, some of them residing in museums. The object depicted below is on display in the museum of Jaén.

Fig. 11: an example of a landing page for 3D content provided by CAAI

Fig. 12: an example of 3D content provided by CAAI as 3DPDF

5.7 CETI (Athena RC)

Athena RC has provided 170 3D models in X3D [42] format, visualised through WebGL/HTML5. From some 3D models, 11 MPEG4 video sequences have been made in full HD resolution[43]. These video sequences have been created in Blender including the post-processing effects. In addition, 347 images have been provided.

The objects are ranging from movable pottery up over man-made structures to complete monuments with surrounding landscapes. For monuments, a drone has been used to make aerial photography for creating the 3D model through photogrammetry.

Fig. 13: the drone used by CETI to digitise buildings

Athena RC has based its online 3D visualisation approach on a customised version of the X3DOM JavaScript framework (WebGL/HTML5). The landing page dynamically changes its content visualisation if the device is a mobile device (tablet, smart phone, etc.) or a desktop device (desktop computer, laptop, etc.). In addition, the option is offered of stereoscopic visualisation on a Google Cardboard viewer for mobile devices.

The models are offered in five different resolutions while there is an option for wireframe or colour point cloud visualisation. A loading progress bar informs the visitor of the remaining downloading time. The models are offered as textured mapped meshes but the X3DOM framework offers the additional visualisation of coloured point clouds and wireframes.

The visitor has the option of free walk or fly through 3D navigation with collision detection, or can do 3D examination with zooming, panning and rotating functionality. The initial start viewpoint can be restored at any point. Interactive tours are offered as full HD (1080p) video

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[42] X3D http://en.wikipedia.org/wiki/X3D

sequences depicting the 3D asset from different angles. Photo galleries are also offered along with references lists for additional information regarding the 3D asset. The landing pages offer rich textual information enriched with Google Maps-based location visualisation.

Each model is provided in multiple resolutions. Each resolution is intended for a system with a specific level of computational power and network access bandwidth. There are five different resolution levels:

- ultra low: 35k polygons, 1024x1024 texture map resolution
- low: 75k polygons, 2048x2048 texture map resolution
- medium: 350k polygons, 4096x4096 texture map resolution
- high: 1M polygons, 8192x8192 texture map resolution
- RAW: without any simplification, uncompressed

Fig. 14: an example of a landing page for 3D content provided by CETI

RAW models can be provided upon request as a special permission has to be acquired based on the proposed use of the data. Recently, the RAW 3D model of the Rotunda has been used

for the design and installation of a new lighting set-up in the yard of the monument. A special permission has been given by the Ephorate in charge.

The lack of downloading times in the current version of the X3DOM framework was solved by creating a customised version of the JavaScript source code.

5.8   MNIR

MNIR offers a wide range of 3D assets, varying from small pottery cups, bronze statuettes, marble statues, large architectural monuments and archaeological landscapes.   The 3D models have been generated from images through photogrammetry.

Fig. 15: The head of Dionysos in 3D, content provided by MNIR

These 3D models are available as textured meshes in 3DPDF format for download, while high-resolution versions are available on request depending on the user criteria (MNIR is able to offer point cloud and wireframe models, as well as high resolution textured models).

PROJECT 3D-ICONS // MNIR

project description   high resolution models   3d models   twitter   3D ICONS

3D model of Dionysos ID 18701

22/11/2014   Posted in 3D MNIR

Appelation Name: 3D model of Dionysos ID 18701
Description: The sculpture represents the head of young Dionysos. A wreath of fruits and ivy leafs is represented on the head of the god.
Type: 3D
Format: 3D-PDF
Language: English
Copyright Credit Line: Muzeul Naţional de Istorie a României
Europeana Rights: The Creative Commons CC0 1.0 Universal Public Domain Dedication (CC0)
Spatial: Collections of the Romanian National History Museum, Bucharest
Source: Muzeul Naţional de Istorie a României
Country: Romania
Metadata Rights: The Creative Commons CC0 1.0 Universal Public Domain Dedication (CC0)
Download (Save As): Download 3D PDF Model

Fig. 16: an example of a landing page for 3D content provided by MNIR

5.9   CNR-ITABC

CNR-ITABC used an HTML5/WebGL approach based on X3DOM. The data (150 3D objects) is visualised as plain textured meshes. The models are shown with their shadows and local colour at the moment of recording, so only a simple diffuse shader is used. The 3D models are mainly large and small buildings with a fewer presence of objects. The interaction is limited to orbiting around the object and zooming. There is a predefined point of view for each object that is the first view opening the corresponding web page of the 3D asset.

In the case of the Mausoleum of Romulus at Rome both a range-based 3D model (laser scanning) and an image-based one are provided. All other models are created through image-based photogrammetry or hand modelled virtual reconstruction. Almost all objects have also a high-resolution version in addition to the low-resolution 3D model (implemented as a 50k polygons model intended to be compatible with the typical hardware configuration of the mid-end computers).

CNR ITABC Collection

Room 39 at Villa of Livia

Keywords:

Physical object specifications:

Object:
Room

Period:
Late Republic until the middle Empire (from 100 BC to 299 AD)

Material:
Opus latericium

Measures:
8.2 x 4 x 1 meters (lenght, width, height)

This object is part of the following collection:

Name:
Villa of Livia at Prima Porta (Rome)

Credits:
Soprintendenza Archeologica di Roma

Time span of the collection:
Roman times (from 753 a.C. to 476 d.C.)

Fig. 17: an example of a landing page for 3D content provided by CNR-ITABC

5.10 Discovery Programme

The Discovery Programme has used HTML5/WebGL technology for the majority of the presentation of 3D content, with some 3D PDF models created for the models early on in the project, complemented by models hosted on the SketchFab platform (which are subsequently embedded using an iframe into a dedicated site[44] for all media and descriptive content).

For point cloud visualisation, several different methods were investigated during the project. Initially, Potree was utilized for the online viewing of point-cloud data, however, the load times where too long for users to effectively use this solution and the final aesthetics of the model were not total fulfilling. As no real-time solution to display high volume point cloud data was evident, a pseudo-3D, ObjectVR approach was employed (Object2VR). However, the rendering of point-cloud data within specific orbit paths was not without problems. Finally, after a chance discovery, a workflow was defined to load highly decimated point-cloud .obj files into SketchFab which provided the solution closely matching the ability to dynamically view point-cloud data.

In addition videos where rendered to enable those without WebGL capabilities to view the model.

Three type of videos have been generated:

1. HD Turntable models of all 3D assets to enable 360 degrees view of heritage objects around a singular orbit
2. For decorated stone objects where the rear face was inaccessible for recording a dynamic lighting video was created to enables the viewer to perceive the different decorative detail which is displayed in the shadows as the light direction alters.
3. Fly through models of point-cloud data, as presently there is no other way to enable users to view a full point cloud dataset dynamically through a web interface, therefore this is the best alternative

There are two primary methods utilised for visualisation:

1. Re-topologised low-poly mesh model (.obj) utilising an additional normal map for the visualisation of detailed morphology. These models are then presented either using:
    a. An ambient occlusion layer, which accentuated the morphological detail of the object. This is especially good when visualising carved stone as often the colour of the object masks the detail.
    b. A photo texture layer derived from Gigapan imagery and projected and painted onto the model using Mari software
2. Highly decimated (approximately 1% of full model) colourised (RGB) point-cloud data stored within an .obj file

For both visualisation processes environmental lighting and imaging effects (e.g. sharpen filters) were utilised to enhance the visualisation of the 3D model.

Three types of assets have been created during the course of the project:

1. 3D models of archaeological landscapes, generated using airborne laser scanning, ranging in size from 75km^2 to 2km^2
2. 3D models of buildings, upstanding monuments and archaeological remains. These have been captured utilising terrestrial phased based laser scanning and have ranged in size from complete city walls (approximately 1,7 km in length) to smaller structures (approximately 2 m by 3 m)
3. 3D models of carved stone structures (e.g. high crosses) or architectural detail of larger monuments. This data was captured using a structured light close range scanner

In total 152 Models (90%) have been published though WebGL solutions, while 16 Models (10%) are using 3D PDF.

Within SketchFab, users can navigate around the object primarily using an orbit, pan and zoom system. Where required, they can switch their viewing mode to first person. This is essential where 3D models of buildings are created to enable exploration of the internal space. No collision detection is available in this platform, so it is hoped to utilise the models built within the project within a Unity 5 environment in the future.

For some models annotations have been embedded within the model. These provide the user with information on a specific part of the model. These are useful where lots of detail and potential associated narratives exist. Predefined views can also be used to provide a tour around a complex monument. In addition these can be used to create a link to a detailed model if the site has multiple representations (for example a URL link going from a landscape model into a model of a building within that landscape).

Some models (18) have been provided in both coloured texture and ambient occlusion texture. The effort required to texture every model derived through terrestrial laser scanning with high-resolution imagery would have been too great for the project. This effort will continue beyond the project as all imagery has been captured. Therefore all re-topologised models (98) have been created with ambient occlusion textures to enhance their morphological features and allow viewers to visualise their form and structure, which is especially useful in visualising carved stone detail.

Several models have been provided at different resolutions. This is method has been used where several digitisation methods have been utilised on the same site but at different scales (for example aerial LIDAR was utilised to model the complete island of Skellig Michael, whilst terrestrial laser scanning was utilised to model individual structures on the island, annotation points are used to dynamically link the two models as explained above).

Some models when provided in their decimated point cloud form have been segmented into individual models to allow for more detailed display of the data (for example Knowth Passage Tomb mound point cloud model also has separate point cloud models created of the individual passage tombs enclosed within its structure).

Sixteen models also have 3DPDF representations as these allow users to measure detail and cross section the models. These models were created at the start of the project before the HTML5/WebGL solution was available.

Some point-cloud datasets, which have been utilised to derive the re-topologised online models, are also available. However, these are under a more restrictive license and can be accessed through a separate arrangement with the Discovery Programme.
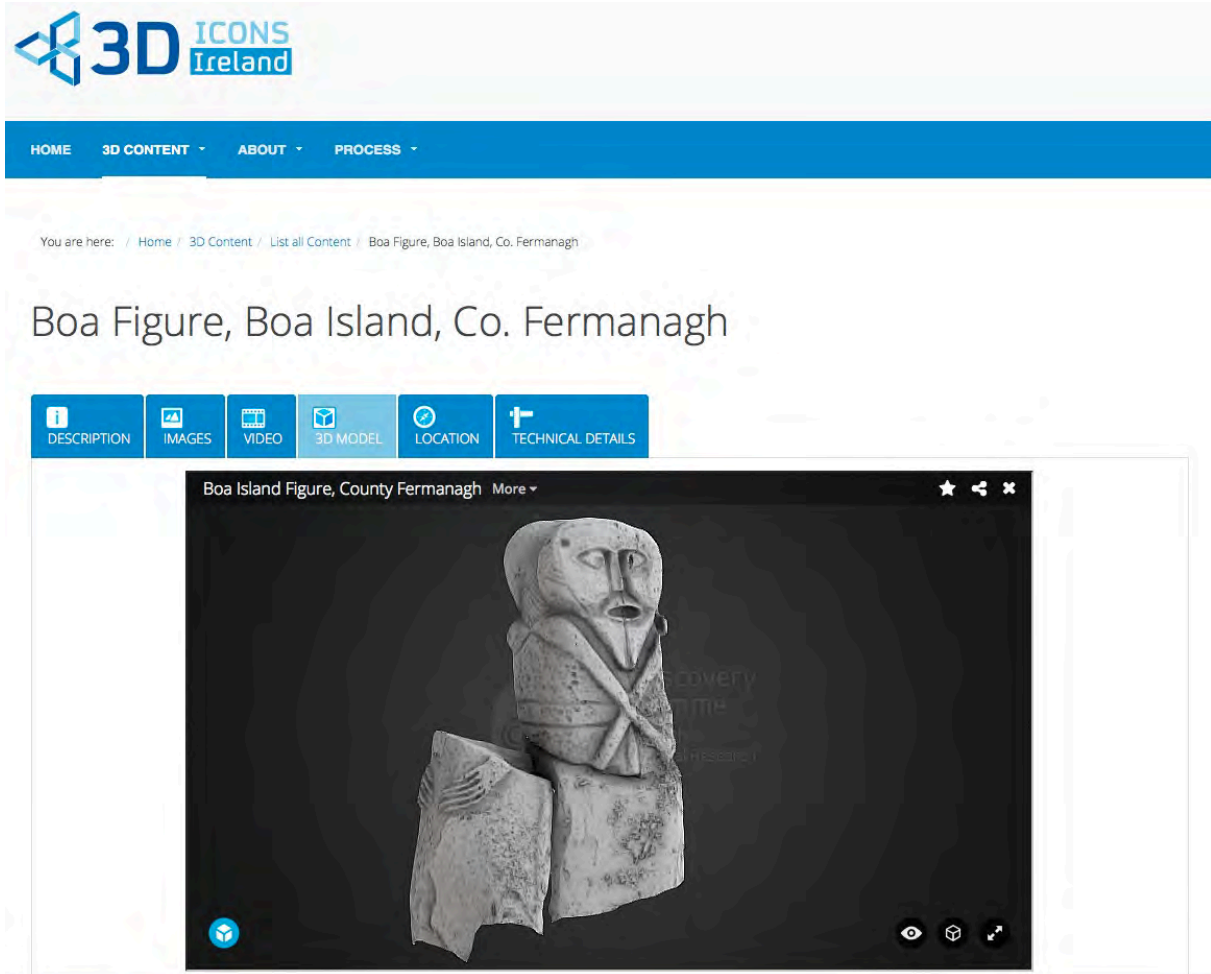
Fig. 18: an example of a landing page for 3D content provided by the Discovery Programme

5.11 FBK

FBK has used WebGL (75%), video animation (10%) and navigable panoramic view such as krpano (15%). The WebGL visualisation has been built on top of the *jsc3d* JavaScript library.

The 3D models provided represent objects, small and large buildings, sites and landscapes. They are provided as polygonal mesh models with external textures.

The objects and buildings are visualised through the typical object representation (rotation around centre, zoom) while the high-resolution panoramic images allow zoom and pan.

3D models have been provided usually at both high and low resolution. High-resolution models are mainly intended for research purposes, as they are suitable for in-depth analyses and studies, but are not suitable for web visualisation and interaction. To solve these issues, low-resolution models have been derived from the high-resolution

models through an optimisation process where the geometry, i.e. the number of polygons, has been reduced, but the texture has been maintained at the high resolution of the original model.

Hence, the low-resolution version of the models is freely available for visualisation on the web. All the digital resources (both low and high resolution) can be provided upon request and with the permission of the related Superintendence.

Fig. 19: an example of a landing page with WebGL viewer of a museum object provided by FBK

Fig. 20: an example of a landing page for panoramic content provided by FBK
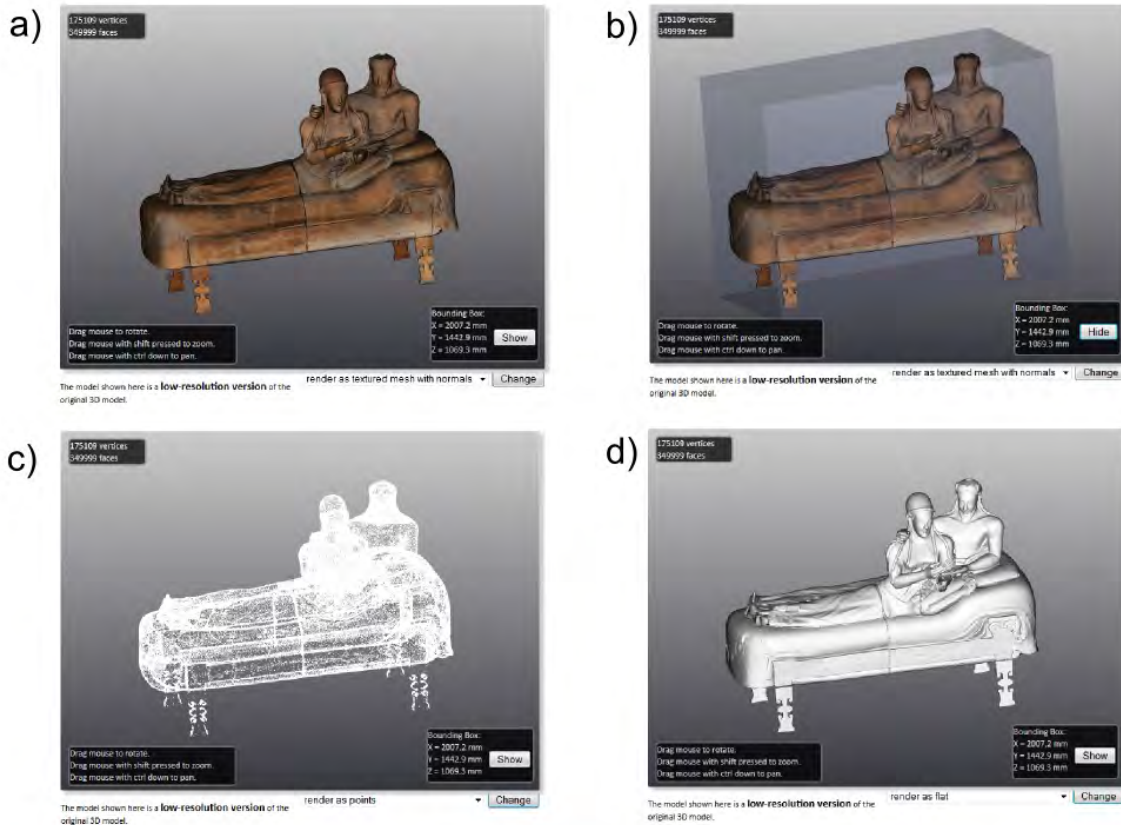
Fig. 22: Details of the implemented WebGL viewer:
a) 3D model rendered as textured polygonal mesh with normals;
b) 3D model rendered as textured polygonal mesh with normals and bounding box;
c) 3D model rendered as point cloud;
d) 3D model rendered as flat polygonal mesh without texture

5.12 Visual Dimension

Visual Dimension has provided HTML5 based ObjectVR and SketchFab visualisations[45] of virtual reconstructions of the Saint-Laurentius church and the archaeological site in Ename, Belgium.
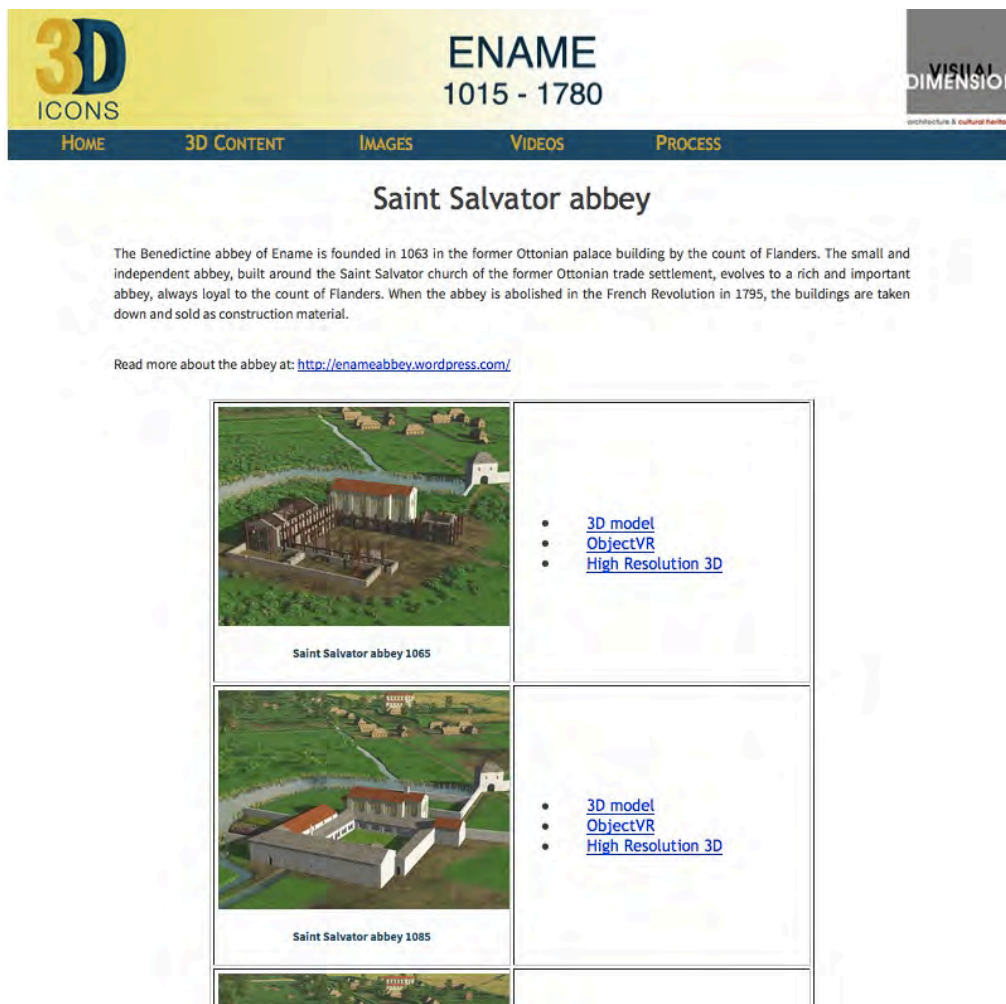
Visual Dimension has provided 3D and 4D ObjectVR visualisations. 3D ObjectVR visualisations show the reconstructed buildings and landscape for each of the 9 periods in the evolution of the site. 4D Object VR shows the evolution of the site through time, still maintaining the 3D aspect of the visualisation. One of the ObjectVR visualisations has been implemented as an interactive 4D movie[46] that allows to fly over the landscape (horizontal movement of the cursor) but also to evolve through time (vertical movement of the cursor).

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[45] Ename 1015-1780 http://www.visualdimension.be/europeana/

A number of 3D models has been provided through SketchFab. In addition, fly through movies of the reconstructed site for the different periods and an additional movie for the 1015 period has been made. Some images of the restoration and excavation of the Saint-Laurentius church are provided as reference for the virtual reconstructions.

Most 3D models that are visualised through ObjectVR or decimated in SketchFab are also available upon request in high resolution for research and personal use. This includes also full reconstructions in Unity3D, including landscape and integrated museum objects.

The reconstruction process is documented in two blogs, one on the trade settlement[47] and one on the abbey[48].

Fig. 23: example of an overview page of 3D assets by Visual Dimension

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[47] Ename trade settlement https://enamearound1000.wordpress.com/

6 Publishing 3D online in the near future

In this paragraph, we provide some ideas and trends about publishing of 3D content and how it could evolve in the next years.

6.1 3D becomes mainstream

In many ways, 3D is becoming mainstream. This not only can be seen from the large amount of articles that appear in newspapers and magazines (hence address the general public, not a technical or specialised audience), but can be seen also from the investments that companies as Intel and Apple are doing for the moment. Both companies have bought technologies and companies that provide instant 3D digitisation. For example, Apple has bought PrimeSense, that makes the 3D sensor technology inside the Kinect camera.

Another sign is the appearance of 3D on Facebook (see fig. 24). As SketchFab is very easy to integrate in other pages, also in Facebook pages, people start to share their 3D models just like they share photos.
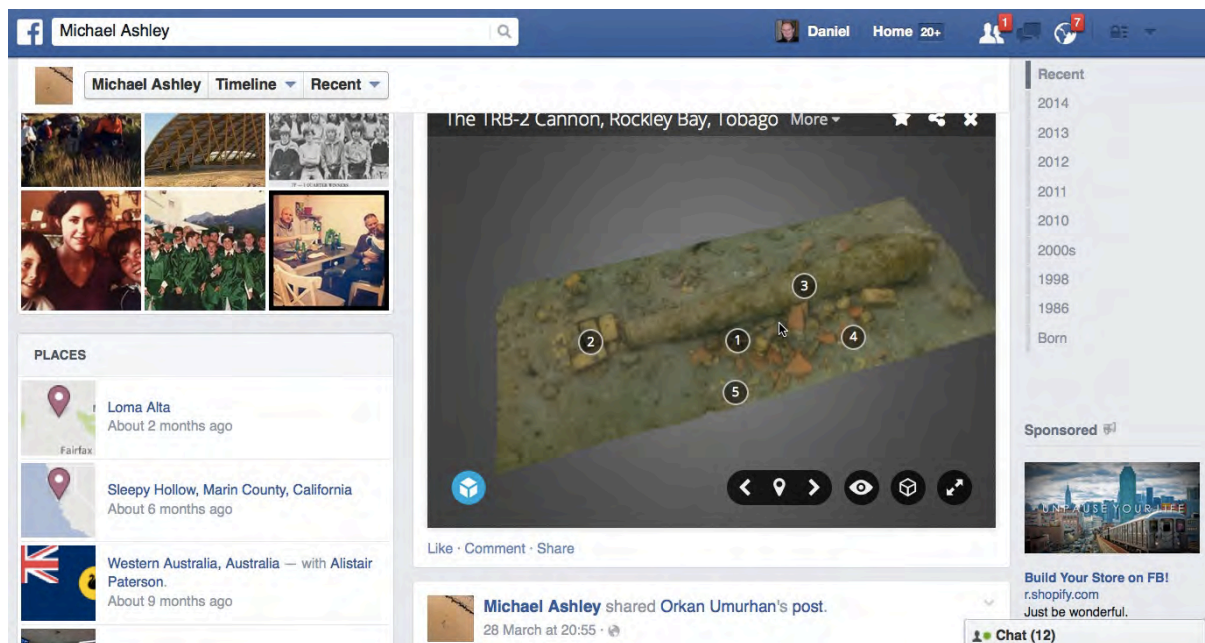
Fig. 24: an example of a Facebook page with integrated 3D content

The 3D path is not always paved with gold, however. In 2012, Unity3D had invested a lot of effort and money in integrating their 3D game technology in Facebook. Besides some simple 2D games, this never materialised, probably because there is simply no need to play a 3D game inside a Facebook page. Showing, on the other hand, a 3D object on your Facebook page could work out much better as the tools to create and design 3D are becoming mainstream too.

Although 3D printing is very much hyped, we see in practice that 3D printing of non-technical things, such as 3D models of humans, is really taking off. Giving a 3D print of your mum as a present starts to be reality, not hype.

Cultural heritage organisations can use this to have their objects 3D printed, creating a much closer bond between the visitor and the museum[49].

6.2   WebGL-based object viewers

With the advent of WebGL based 3D object viewers, it has become much easier to visualise and deliver 3D models to a wider public. We can certainly expect that the functionality of these viewers will expand in the very near future. For example, SketchFab (but also Unity3D) has added recently physically based rendering[50] to its capabilities, boosting significantly the photorealism of its objects.

As CETI has demonstrated in this project, collision detection can be added easily to 3D online viewers, providing a better feeling for the space, while CNR-ISTI has added camera paths for virtual tours to its 3DHOP viewer. These are functionalities that we certainly can expect soon in online 3D viewers.

The drawbacks are mostly on the side of the serious games vendors. It will depend mostly in which market segments the HTML5/WebGL implementations will be used in the near future that will determine if serious games applications for cultural heritage will remain important. It can be expected that the technical threshold of serious games will remain too high for cultural heritage organisations to adopt them as a visualisation tool.

However, the recent 2+3D Photography Conference[51] at the Rijksmuseum shows that the interest of the cultural heritage domain for 3D is high and that we will see in the near future much more 3D heritage assets online.

7   Conclusions

3D-ICONS has published a wide range of 3D assets on Europeana and has explored in this way the possibilities, efforts and drawbacks of 3DPDF, WebGL, HTML5 and Unity3D.

3DPDF has been used in a basic way in this project, but turns out to have an efficient and versatile workflow to publish a wide range of 3D models (point clouds, coloured vertex meshes and textured meshes). It provides a nice set of tools (measuring, annotation, cross sections, animation, …) and can be used online and offline. The lack of investments in visualisation of 3DPDF on mobile platforms however is a serious drawback, that undermines the long-term use of 3DPDF for cultural heritage. In

[49] 3D ArcheoLab http://3dprintingindustry.com/2015/05/14/3d-archeolab-shows-italy-truly-appreciate-cultural-history/

[50] SketchFab Physically Based Rendering https://sketchfab.com/pbr

addition, the messy situation created by embedding low-end PDF viewers in browsers has undermined the beauty and simplicity of 3DPDF as a 3D publishing platform.

So we have seen several partners in 3D-ICONS switching from 3DPDF to WebGL, or producing WebGL versions in addition to 3DPDF versions of their resources.

We also see that a lot of the functionality that is present in other visualisation methods (such as collision detection that is used in serious games) is being implemented in WebGL, and it can be expected that other useful functionality such as measuring, cross sections and animation will get implemented soon in popular WebGL tools (such as SketchFab) or libraries (such as three.js). Other functionalities such as annotation or point cloud visualisation have been implemented already in standard tools such as SketchFab.

The introduction of the brand new 3DHOP system that provides 3D streaming under WebGL is a major breakthrough in the publishing of 3D data as it allows complex models to visualised immediately and interactively. The fact that the 3D streaming format (Nexus format) makes it difficult to recreate the original 3D model provides an additional protection of the 3D data. The implementation of annotations, camera paths for scenes (sites, buildings) and multiple versions of an object (for example to show digital restoration) make this tool an excellent choice for publishing cultural heritage assets.