3D4Ever: why is it so hard to talk about the preservation of 3D data?

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Introduction

In December 2016 on behalf of the Digital Preservation Coalition (DPC) and with colleagues in the Wellcome Library, the author helped organise an invitational expert conference to review and discuss tools and techniques to preserve 3D data, especially real world data generated from scanning devices. [1] In this brief opinion piece the author describes the efforts made to bring that programme together and the unexpected challenges that arose. The article argues how all of those involved in the creation of 3D data sets – especially in the museums and cultural heritage sector – need to clarify their thinking in relation to the production and management of 3D data sets. In brief, the author believes that there is a contradiction at the heart of much 3D scanning in the cultural heritage sector as there is a surprising lack of evidence that those involved in producing 3D data sets for the sector have sufficient capacity – and in many cases no evident concern – to ensure the accessibility necessary for data preservation outside of often tightly constrained and poorly documented delivery mechanisms. Therefore, in relatively short order, and despite much rhetoric to the contrary, interactions degrade, effort is wasted and new kinds of cultural disenfranchisement are engineered. Preservation and access are mutually reinforcing. The undoubted opportunities for access that 3D data generates cannot be sustained without some attention to how such models are preserved. Conservators, who may be asked to comment on 3D scanning and who should be a major beneficiary of 3D condition monitoring, are well placed to ensure that 3D data avoids an imminent crisis of technical obsolescence, 'resource discovery' and corporate abandonment. Novel forms of preservation are urgently needed to support this novel form of access.

With this paper the author invites comment, correction, and contradiction on the assumption that there must be evidence available for any counter-argument that render its assumptions and conclusions incorrect. Furthermore, in suggesting this dialogue, the opportunity to collate, manage and share such evidence is also invited, thereby informing and enhancing the tremendous opportunities presented in using 3D models.

Why 3D data?

3D scanning - and subsequently 3D printing - has been the ‘next big thing’ for a long time. With origins in the 1960s it is an established technology and has enjoyed a prominent place in the imagination but has remained a rather niche concern in practice. [2] As scanning equipment has become cheaper and more 'user-friendly', and as ubiquitous processing power improves, so the barriers to creating, sharing and accessing highly detailed 3D models are gradually being eroded. Simultaneously, a fall in the price of personal immersive technologies means that digital outputs can be distributed more widely, while 3D printing is beginning to become increasingly disruptive of older technologies within many industrial and commercial sectors. [3] Furthermore, 2016 bore witness to the first widely reported incident involving appropriated 3D data when a team of artists claimed to have surreptitiously scanned the bust of Queen Nefertiti at the Neues Meseum in Berlin. [4] As the value and

utility of the 3D scanning is going up and the cost and barriers to production continue to fall 3D visualisation companies are being purchased by global tech firms eager to add 3D capabilities to their stable, [5] leading this author to conclude that 3D scanning is, finally, the next big thing.

Digitization creates, by default, a digital preservation challenge. [6] For decades, photographers and 2D imaging technicians have argued over the most appropriate formats for capture, preservation, and dissemination of their images. Complex metadata requirements have been specified and embedded into workflows; preservation modules have been integrated into image management systems; compression techniques have been devised, demonstrated, and sometimes denounced. [7] Perhaps because of the long heritage of analogue photography we implicitly value 2D images more when compared with the rapid evolution of 3D scanning, as it appears that we have not taken the time to consider the equivalent protocols that consolidate its value.

However, it would be false to assume that concerns about the long-term sustainability and preservation of 3D data have not been raised before. In 1996 Nick Ryan challenged the lack of transparency as a problem in the generation and use of 3D models,[8] and in 2002 the UK Archaeology Data Service (ADS) published a ‘Guide to Good Practice’ advising on creating and using 'virtual reality' and which explicitly discussed the steps necessary to ensure that sufficient attention is paid to data preservation and reuse.[9] Furthermore, while Principles Five and Six of the 2006 *London Charter* encouraged those public agencies developing 3D visualisations to act as good stewards of public investment by ensuring data sustainability, [10] the question remains as to whether such warnings and principles have been overlooked?

The December 2016 conference asked participants what, if anything, do we have to show from the last 50 years of 3D scanning? and what do we need to do to ensure that the next 50 years is better? [11] Speakers reviewed a range of case studies of good – and at times bad – practice and these case studies demonstrated not only the value of 3D data but the ways in which it could be preserved and the simple faults that inhibit such preservation. The conference ended with an extended roundtable discussion on ‘what should be done next’. Some of its recommendations became actions for the DPC, such as the provision of more case studies or technical reports so that its members can be better informed about the pitfalls in the preservation of 3D data. Others became actions aimed at enabling both the creators of 3D data and suppliers of tools and technologies to better protect the long-term value of their data, such as the standardization or automation of relevant metadata or attention to robust file formats.

An unlikely absence?

There is no shortage of interesting work in 3D data creation and distribution, with many different sectors, many different approaches and many different projects all looking at new technologies for 3D scanning. Similarly, there are numerous papers and experts who can talk on the topic of generating 3D data, [12] but in preparing the December 2016 conference it was striking how difficult it was to put together a programme on the preservation and re-use of data after its initial creation. [13] This impasse was widely echoed by other speakers at the event and was deemed all the more surprising since generally the agencies involved in creating 3D data do seem to understand and frequently articulate notions about the long-term value of the data. For example, recent efforts to scan world heritage sites in the Middle East,

including Palmyra, have been specifically endorsed as a welcome and necessary addition to the preservation of cultural sites placed at risk by war and hostile ideologies [14].

Such commitments to preservation, and repeated demonstration of technological capabilities, do not seem to have offered much in the way of practical digital preservation know-how. Arguably, the 3D data community appears not to have learned much from the wider digital preservation community and, conversely, it seems that the digital preservation community, noted for its habit of borrowing good ideas, has yet to scavenge approaches from the 3D data community. This might simply be a coincidence or perhaps the December 2016 event was held on the day that the world's 3D data preservation community was otherwise engaged. Or perhaps it's further anecdotal evidence to suggest that there is a disconnection between the 3D data community and the digital preservation community which is, perhaps, to our mutual disadvantage?

A confusion

It doesn't help that the language is sometimes misapplied or muddled. Digital preservation should be understood as a relatively challenging field concerned with the preservation of digital content. Formally, this means it is 'the series of managed activities necessary to ensure continued access to digital materials for as long as necessary' and it broadly refers to 'all of the actions required to maintain access to digital materials beyond the limits of media failure or technological and organisational change.'[15] This is not to be confused with laser scanning, computed tomography, photogrammetry, ground penetrating radar, LIDAR, side-sweeping sonar, ultrasound, digital x-ray nor any other of the digitizing techniques used to render, explore, or generate 3D images of real world objects and places. This misappropriation of 'digital preservation' for digitization is confusing and sometimes contrived. Digitization, particularly when undertaken to create point-in-time digital surrogates of at-risk cultural heritage objects, can reasonably be described as 'preservation by record'[16] and such 'preservation by record' creates an implied digital preservation requirement, especially when the real-world objects in question have since been lost, altered, or destroyed.

Moreover, digital preservation is not uniquely about data: it encompasses tools, paradata, metadata, and all the applications and technology stacks necessary to ensure a faithful, authentic and credible interaction with data. The boundaries between data and application are hard to discern and the dependencies so complicated that sometimes it can be hard to talk about data in any meaningful way. Digital preservation is also about much more than just data storage, and for the avoidance of doubt it does not mean we should try to save everything. On the contrary, we should be encouraged to dispose of the things we don't need and prioritise the parts that matter. Furthermore, the value of data is not inherent: it's the deployment that matters. So by extension, digital preservation is not concerned so much with meaningful preservation of data as with the purposeful transmission of the opportunities which digital technologies enable.

It is not unusual to find different, and at times competing, expectations and opportunities mapped over data, and thus it is not entirely clear as to what the long-term use case for data will be. In some cases, 3D scanning is presented as a novel means of access to collections, where this access might be for research, for environmental monitoring or the impact of material decay processes. In other cases, the drive to 3D scanning is for the production of

missing parts for integration in restoration or simply for the sale of replicas. There are also, as indicated, high-profile and genuine efforts to deploy 3D scanning techniques to create point-in-time records of cultural objects that face destruction. [17]

These and other many different use cases mean that there may not be a single digital preservation solution that can meet all such demands simultaneously. Instead it presents the opportunity for the wider 3D data community to lead a debate on which techniques work best for different requirements and how preservation actions might be optimised in multiple use cases - arguably this is a debate the digital preservation community badly needs and one in which both communities are missing important opportunities.

A complication

Why does the digital preservation community find it hard to engage with the 3D data 'creation community'? The obvious answer is that there really is no such thing as while in describing such a ‘creation community’ the argument in this paper can be mobilised, in reality it reduces a dynamic and diverse set of approaches and agencies that are themselves quite distinct. As 3D creation is a fast-changing topic that is technically complex and produces large quantities of data, it is unsurprising that the digital preservation community finds it hard to engage, focus and resolve such a manifest complexity into practical advice.

While these different barriers to dialogue are not imagined, they are not insurmountable. Other sectors with large volumes of data – larger in many cases than those produced by 3D technologies – appear able to engage coherently with the challenge of digital preservation. For example, the audio-visual preservation community, one that increasingly intersects with the digital preservation community, has a sizeable digital preservation challenge but also a sizeable output of digital preservation literature. Similarly, there is probably no digital theme more dynamic, commercially sensitive or diverse than the aggregation and interrogation of social media data, [18] and yet the digital preservation community manages to have meaningful discussions about, for example, how to preserve Twitter data. Digital preservation can bring incredibly detailed expertise to bear and the digital preservation community has used this ability to learn from and contribute to most of the sectors orthogonal to 3D data generation such as AV, CAD, geo-sciences, and every aspect of data visualisation. While this doesn’t imply that in any particular case the preservation challenges have been resolved it does suggest that there is at least some elementary understanding of the issue and practical know-how that gives confidence [19]. In terms of building bridges, it is hard to believe that the 3D data creation community is so exceptional or so fiercely competitive as to be able to ignore the pressing challenge of preservation, a challenge of its own making.

A prize

It may seem by now that the author is making 3D digitization and its data preservation problematic through some kind of 2D recalcitrance but that would be wrong. In fact, this article was drafted precisely because the author believes that the opportunities and impending impact of 3D are very real and that 3D data and its associated technologies will be immensely disruptive and transformative. To illustrate the point, anyone who doubts this should consider what might be termed a three-fold bonanza for those involved in 3D data. Firstly, although 3D printing remains expensive as a consumer technology, it is within reach of many small businesses, geeks and devotees in the way that PCs were in the mid-1980s. Secondly, high

quality 3D headsets, developed mostly thanks to the gaming industry, are now commonplace in many parts of the world, just at the point when the high-speed internet infrastructure necessary to deliver content has become widespread. Finally, scanning technology is now almost as ubiquitous as the smartphone as so many 'phones now incorporate its technology.

Thus these new technologies present opportunities for a new kinds of engagement with cultural heritage with new kinds of access and new ways of putting cultural objects into hard-to-reach communities. But unless we proceed with some concern for their sustainability these means of access will be abandoned and the promise of engagement will turn into a form of disenfranchisement.

A problem and a proposal

The cultural heritage sector has remarkable treasures to share and remarkable opportunities to explore and exploit. However if there is going to be a meaningful and productive interaction which adds value to the 'memory institutions' that look after the real world and from which 3D data is derived, then those institutions need to consider the long-term implication of this new dependency. The suggestion here is that that this should start with some relevant and credible thinking about digital preservation such that there needs to be a much more robust and straightforward questioning about the long-term viability of the digital materials that are being generated. More generally, if we have a vision of such disruptive technologies evolving structural changes in the economy, but have not discussed how those technologies will sustain their own outputs, then we risk envisioning an economy built on sand. This might not sound like it has much to do with conservation or digital preservation but on the contrary it means that preservation becomes a pressing concern for our time. Preservation of 3D data is a relevant and sizeable exemplar of the challenge associated with delivering lasting value from disruptive technologies: and conservators in the cultural heritage sector are directly involved, whether as guarantors to the physical integrity of collections or consumers of the condition monitoring that it enables.

In brief, there are at least three parts of this challenge: technical obsolescence, resource discovery and corporate abandonment. Technical obsolescence occurs when some element of the technology stack becomes out of date and is not replaced. It is visualised most easily as the problem of old media and the difficulty of finding contemporary devices to read them, but it is more pervasive than this since any internal system or process can be deprecated. Resource discovery is a challenge because, even if an object avoids obsolescence it still needs to be found to be used. A fortuitous example of resource discovery was cited at the December 2016 conference: an architectural scan of a building was found shortly after fire destroyed a world heritage site and just before what appeared to be an unsafe wall was pulled down. The 3D scan showed that the wall had always bulged and so was most likely safe. But that the evidence only came to light by chance emphasises how serendipity may not always be so favourable. But where one might propose online public fora like *SketchFab* as a potential remedy to resource discovery, the internet is littered with once high-value services that have suffered from corporate abandonment, also known as the volatility of ever-evolving business strategies.[20] It seems that 3D data, as for all digital technologies, is in an endemic crisis of obsolescence, resource discovery, and corporate abandonment.

It was exactly from such fears of impending digital obsolescence that the Digital Preservation Coalition, for which the author works, came into being. The DPC has since matured as a platform and partner for all those involved in 3D data and its preservation and can potentially progress the necessary discussion. However, the author is acutely aware that the argument set out here might provoke one of two responses:

1. that the description of the problem and the lack of solution is entirely wrong, in which case the invitation is to assemble the necessary evidence and facilitate a better and more effective discussion around the lessons learned;

2. that the description is broadly accurate, in which case there is a need to prioritise relevant developments such as the codification of good practice as standards, the agreement on metadata requirements, the development of tools to simplify and automate workflows, and the dissemination of thoughtful case studies of re-use.

Both responses point in the same direction: that it is time to develop a roadmap for the development of digital preservation solutions for 3D outputs and to ensure how they can be incorporated early into object or project lifecycles. Pragmatically, this could be achieved through partnerships where collaborating bodies select from current 3D projects those they would like to be able to use in ten years' time and begin experimenting and refining how best to preserve them. For this work the author suggests that the DPC could be active as both partner and platform for debate, acting as a conduit for constructive engagement and creative thinking about digital preservation for participants both within the 3D and digital preservation communities.

Two messages

In planning the December 2016 conference on how to preserve 3D data, two key messages emerged for those who generate 3D models and the many companies, developers and engineers that support them.

Firstly, 3D data and associated technologies have to be understood from the context of the enormous challenge the digital preservation community has in handling the massive quantities of data coming its way, even the types which are well known and clearly within the current scope of archives and libraries. These quantities of data are only going to increase in size, complexity and importance so the task faced becomes ever more challenging. Entropy dictates that something will be left behind - although the digital preservation community would like to ensure 3D data can be managed through the challenges of media failure, technical obsolescence, or organisational change, archivists and records managers alone cannot sort out such a data mess that is exotic in form and liminal to institutional missions.

Secondly, and perhaps more fundamentally, it behoves the 3D data community to show the world that it values its own outputs. If those creating 3D models and the tools to construct them don't take those outputs seriously so that they don't think they are of long-term value, then it's going to be hard to persuade archivists and conservators to take them seriously, too.

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along with those of the Journal's reviewers and Editor, have encouraged and improved this article.

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Biography
As Executive Director of the not-for-profit Digital Preservation Coalition, William supports the digital preservation activities of more than 60 members worldwide, providing him with a comprehensive understanding of current practice. William began his career as an archaeologist in the early 1990s when the discipline's enthusiasm for new technology outstripped its capacity to preserve the resulting data. Since then, he has spent 20 years working at the intersection of the digital and cultural heritage sectors, previously holding positions at Glasgow Museums and the Archaeology Data Service. Before that he was a lecturer in archaeology at the University of Glasgow where he is now a Senior Research Fellow.

Abstract
This brief opinion piece reflects on the author's experience planning the programme for a conference on 3D data: '3D4ever: building three dimensional models to last'. The development of 3D laser scanning and printing technology in recent years is described and the author laments the apparent lack of attention to the long-term preservation of the resulting data. While the agencies involved in creating 3D data do seem to understand the long-term value of the data, they have not taken sufficient action to ensure its value is maintained. In this article a challenge is posed to address the gap between the communities who create 3D data and those with the expertise to manage and preserve it for the long-term.

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Notes

1 For information about past Digital Preservation Coalition (DPC) expert and training events, see http://www.dpconline.org/knowledge-base/training (accessed 14 March 2017).

2 For a review of the history and development of 3D scanning and printing see: Mostafa Abdel-Bary Ebrahim, '3D Laser Scanners: History, Applications, And Future' (2011) https://www.researchgate.net/publication/267037683_3D_LASER_SCANNERS_HISTORY_APPLICATIONS_AND_FUTURE (accessed 14 March 2017).

[3] With reference to the increase in personal immersive technology cf. 'Matterport Surpasses 70 Million Global Visits and Celebrates Explosive Growth of 3D and Virtual Reality Spaces', *Market Watch*, September 20, 2016, http://www.marketwatch.com/story/matterport-surpasses-70-million-global-visits-and-celebrates-explosive-growth-of-3d-and-virtual-reality-spaces-2016-09-20-10160559 (accessed 14 march 2017).

[4] See, for example, Charly Wilder, 'Swiping a Priceless Antiquity … With a Scanner and a 3D Printer', *The New York Times*, March 1, 2016, https://www.nytimes.com/2016/03/02/arts/design/other-nefertiti-3d-printer.html?_r=0 (accessed 14 March 2017).

[5] See, for example, Sophie Curtis, 'Oculus VR: the $2bn virtual reality company that is revolutionising gaming', *The Telegraph*, 26 March 2014, http://www.telegraph.co.uk/technology/video-games/video-game-news/10723562/Oculus-VR-the-2bn-virtual-reality-company-that-is-revolutionising-gaming.html; in early 2017 the US company CBRE, 'the largest commercial real estate company in the world' acquired a small 3D imaging technology firm, see Nav Athwal, 'CBRE Acquires Floored: Real Estate Tech Poised For A Big 2017', *Forbes*, January 10, 2017, http://www.forbes.com/sites/navathwal/2017/01/10/cbre-acquires-floored-real-estate-tech-poised-for-a-big-2017/#6ae5da6c77af (accessed 14 March 2017).

[6] For example, the challenge is discussed in a blog post published by the **Chartered Institute of Library and Information Professionals** (CILIP): Jenny O'Neill, 'Is digitisation the answer or is digital preservation the question?', December 1, 2014, http://www.cilip.org.uk/blog/digitisation-answer-or-digital-preservation-question (accessed 14 March 2017).

[7] See for example Rob Buckley, 'JPEG 2000 - a Practical Digital Preservation Standard?', *DPC Technology Watch Report*, February 2008, http://www.dpconline.org/component/docman/?task=doc_download&gid=87 (accessed 14 March 2017).

[8] N.S. Ryan, 'Computer-based visualisation of the past: Technical "realism" and historical credibility' in *Imaging the Past: Electronic Imaging and Computer Graphics in Museums and Archaeology*, ed. Peter Main, Tony Higgins and Janet Lang, British Museum Occasional Papers 114 (1996), 95-108.

[9] Kate Fernie and Julian Richards *Creating and Using Virtual Reality: A Guide for the Arts and Humanities*, AHDS Guides to Good Practice, (Oxford: Oxbow Books 2003). For more up to date guidance see Archaeology Data Service, 'Guides to Good Practice', http://guides.archaeologydataservice.ac.uk/g2gp/GuideAim (accessed 31 January 2017).

[10] *The London Charter* is a 2006 initiative to establish 'internationally-recognised principles for the use of computer-based visualisation by researchers, educators and cultural heritage organisations'. For the current version referred to, see http://www.londoncharter.org/ (accessed 31 January 2017).

[11] For details on the joint DPC and Wellcome Library Conference, 9 December 2016, see http://www.dpconline.org/events/past-events/3d4ever-building-three-dimensional-models-to-last (accessed 31 January 2017).

[12] For an impressive local example with global connections see 'The Scottish Ten' project set up to digitally document Scotland's international heritage sites 'to create accurate 3D data to help with their conservation and management, their interpretation and virtual access': https://www.engineshed.org/about-us/the-scottish-ten/ (accessed 31 January 2017).

[13] In addition to the works cited in notes 8, 9, and 10 that address this topic, see also *Preserving Complex Digital Objects* ed. Janet Delve and David Anderson, (London: Facet Publishing, 2014) and Alex Ball, 'Preserving Computer Aided Design', *DPC Technology Watch Report*, April 2013, http://dx.doi.org/10.7207/twr13-02 (accessed 14 March 2017).

[14] For example, in 2016 the Institute for Digital Archaeology (IDA) used 3D technologies to produce a scaled version of the destroyed Palmyra Arch in an effort to exhibit the possibilities of using 3D techniques for long term heritage preservation http://digitalarchaeology.org.uk/building-the-arch/. See also Emma Cunliffe, 'After ISIS storms Palmyra, race is on to log global heritage' New Scientist (May 2015) https://www.newscientist.com/article/dn27590-after-isis-storms-palmyra-race-is-on-to-log-global-heritage/ in which Cunliffe reports on the aims of the CyArk project to digitally preserve world heritage at risk http://www.cyark.org/ (all accessed 29 March 2017).

[15] cf. the Digital Preservation Handbook, Glossary, 'Digital Preservation': http://dpconline.org/handbook/glossary#D (accessed 14 March 2017).

[16] For discussion of 'preservation by record' and the efficacy of the approach see, for example, Peter Hinton, 'The National Planning Policy Framework and Archaeology: A Response – How did the Profession come to this?' in *Papers from the Institute of Archaeology* 22 (2012): 13-18 http://www.pia-journal.co.uk/articles/10.5334/pia.392/ (accessed 14 March 2017).

[17] See, for example, Elizabeth England, 'The Signal: Using Three-Dimensional Modeling to Preserve Cultural Heritage ', Library of Congress blog, 24 January 2017, http://blogs.loc.gov/thesignal/2017/01/using-three-dimensional-modeling-to-preserve-cultural-heritage/?loclr=eadpb (accessed 14 March 2017).

[18] For a discussion on some of the issues around long-term preservation and social media see Sara Day Thomson, 'Preserving Social Media', *DPC Technology Watch Report* , February 2016, http://dx.doi.org/10.7207/twr16-01 (accessed 14 March 2017).

[19] For example, as evidenced in publication outputs by the author's institution in its DPC Technology Watch Series: http://dpconline.org/knowledge-base/tech-watch-reports (accessed 29 March 2017).

[20] Sketchfab is an online community where 3D models can be published, shared and discovered. https://sketchfab.com/ MySpace is often cited as the model example of a service that was once the most popular social network on the internet and now is no longer - see, for example, https://www.theguardian.com/technology/2015/mar/06/myspace-what-went-wrong-sean-percival-spotify (both accessed 31 March 2017).