

<b>Institution: University of Brighton</b>	
<b>Unit of Assessment: D36 Communication, Cultural and Media Studies, Library and Information Management</b>	
<b>Title of case study: Shaping 3D Digital Cultural Heritage</b>	<b>ICS [1]</b>
<b>1. Summary of the impact</b>	

Through digital cultural heritage research the Brighton-led EPOCH project changed professional practice in the museums sector and shaped public discourse. Working with 609 researchers and 97 partner organisations it created new digital cultural heritage communities, produced a research agenda and a trust network of ten centres of expertise over 3 continents. Developed from EPOCH, the 3D-COFORM project, with >100 technologists and heritage professionals, co-created unique technologies and innovative cultural heritage research methods. The project produced innovative ICT tools combined with 'ground breaking' methodologies to evaluate socio-economic impact and strategies for sustainable enterprises that have been deployed by major heritage institutions in Belgium, Egypt, France, Germany, Italy and the UK.

## 2. Underpinning research

Established by ARNOLD in 2002, the founding vision of the Cultural Informatics Research Group at Brighton (CIRG) was that co-creation between heritage professionals and technologists would produce innovative ICT tools and create a knowledge exchange community that would advance the professional practices of both groups. The underpinning research in this study realised by establishing EPOCH, the European Network of Excellence in Open Cultural Heritage, (EU FP6 2004-08) a pan-European interdisciplinary research community. It produced an agenda for research that brought together intelligent ICT systems to develop a 'workflow' model through which to explore how their integration could be utilised for technical and scientific analysis, conservation, preservation, interpretation and display across the museum and heritage sectors.

Led by ARNOLD, EPOCH included a network of over 600 specialists whose expertise spanned research, practice and policy. It addressed key research questions at the intersection of ICT and cultural heritage, socio-economic impact evaluation and the development of planning tools for sustainable enterprises [reference 3.1]. In the summative paper ARNOLD reframed the conventional model of knowledge transfer to one of co-creation and knowledge exchange within the theoretical framework of 'Pasteur's Quadrant' [3.2]. This paper recognised that bringing together these fields generated new methods and models: 1) in computer science exploring knowledge representation, capture, manipulation and the use of 3D digital objects; 2) in professional practice; and 3) in digitally-transformed cultural heritage applications. EPOCH created a trust network of centres of expertise sharing integrated multi-disciplinary working methods and a common vocabulary (source 5.5); an agenda for future research [3.1] and tools for planning and socio-economic impact evaluation [3.6]. These tools were identified in the EU's final review as making 'ground-breaking progress in developing innovative methods and theory in the economics of cultural heritage'.

EPOCH demonstrated the value of developing interlinked and re-useable digital assets supported in multiple contexts by the parallel development of interoperable digital tools. It devised an integrated workflow that extended from documentation and investigation of cultural heritage data through to scholarly communication, and the shaping of innovative, real-time experiences, engagement of new audiences with cultural heritage and creating added-value and new enterprise opportunities [3.3]. It made the case for investment in systematic data collection through envisaging contexts in which data could be reused.

After EPOCH, ARNOLD led 3D-COFORM (EU FP7) a large scale integrating research project with 19 partners to advance the 'workflow' from tangible cultural heritage in its many and diverse contexts, through to the development of tools and expertise for 3D collection formation, and a distributed repository for 3D digital assets and their metadata.

The core aim of 3D-COFORM was to make 3D documentation a practical and sustainable proposition for Cultural Heritage institutions and accommodate mass 3D-acquisition by cultural heritage organisations [3.6]. Central to 3D-COFORM was the creation of a distributed 3D

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repository designed to manage the digital provenance of artefacts, ensure long-term data preservation and maintain its referential integrity. The repository underpinned the EPOCH ‘workflow’ model and held the results from ~20 tools, predominantly, developed as a result of 3D-COFORM research. These 3D-capture and associated processing tools included: laser and structured-light scanners; photogrammetry systems; annotation; fragment reassembly, and; modelling based on shape grammars. A viewer-browser, user interface was developed to support conventional searches, augmented by material and novel shape-based searching capabilities. Brighton developed the graphic system integrating assets from the range of tools.

The 3D-COFORM exhibition [3.4] was curated to show each stage of the integrated workflow with examples of cultural heritage research questions illustrated with iconic heritage content. It was designed to inspire and communicate to heritage and ICT professionals and to the public, the value, potential and necessity of 3D computing within cultural heritage.

### Key researchers:

David Arnold:	Dean (Faculty of MIS) (Sept 2002–Dec 2009), Director of Research Initiatives/Dean of the Brighton Doctoral College (Jan 2010–to date).
Andrew Grantham:	Research Fellow (Dec 1998–July 2006), Senior Research Fellow (Aug 2006–Aug 2011), Senior Lecturer (Sept 2011–to date).
James McLoughlin:	Senior Lecturer (Jan 1988–Nov 2003), Principal Lecturer (Dec 2003–to date).
Despina Kanellou:	Research Fellow (Mar 2000–to date).
Karina Rodriguez-Echavarría:	Research Fellow (Aug 2004–Oct 2009), Lecturer (Nov 2009–to date).
Jaime Kaminski:	Research Officer (Dec 2004–July 2006), Research Fellow (Aug 2006–Oct 2009), Lecturer (Nov 2009–to date).
Roger Evans:	Senior Research Fellow (Dec 1993–Sept 1994), Principal Research Fellow (Dec 1994–July 1997), Reader (Aug 1997–to date).

## 3. References to the research

- [3.1] ARNOLD, D.B. and GESER, G. (2008) *Research Agenda for the Applications of ICT to Cultural Heritage*, EPOCH, through Archaeolingua, Hungary. ISBN 978-963-9911-03-01. [Quality validation: co-authored research report/book of agenda-setting import. An independent reviewer for the European Commission commented on the 104-page 2007 preliminary report’s impressive scale of consultation with stakeholders, calling it ‘truly a multi-cultural cross-disciplinary endeavour’. This 253-page 2008 full report/book is an Arnold output in REF2014. It has been downloaded in full around 10,000 times.]
- [3.2] ARNOLD, D. B. (2008a, conference contribution 2007) Cultural heritage as a vehicle for basic research in computing science: Pasteur’s Quadrant and a use-inspired basic research agenda, *Computer Graphics Forum*, 27(8), pp.2188–2196. [Quality validation: paper selected from the cultural heritage stream of *Eurographics 2007*. A journal referee called the article ‘a seminal analysis of cultural heritage ICT research frameworks’. ARNOLD output in RAE2008.]
- [3.3] ARNOLD, D.B. (2008b) Digital artefacts: possibilities and purpose, in Mark Greengrass and Lorna M. Hughes eds, *The virtual representation of the past*, (Aldershot: Ashgate), pp.159–170. [Quality validation: this is a chapter in a book based on an invited presentation at an expert seminar held in Sheffield in April 2006, part of the AHRC ICT Methods Network].
- [3.4] ARNOLD, D.B., SPEARMAN, M., STORK, A. and NICCOLUCCI, N. (2012) *Reshaping History: A Future for our Past*, Exhibition, Brighton, 27 July–25 August 2012. [Quality validation: curated by ARNOLD, Spearman, Stork and Niccolucci, It is one of Arnold’s outputs in REF2014.]
- [3.5] KAMINSKI, J., RODRIGUEZ-ECHAVARRIA, K., ARNOLD, D. B., PALMA, G., SCOPIGNO, R., PROESMANS, M., and STEVENSON, J. (2012) Insourcing, outsourcing and crowdsourcing 3D collection formation: perspectives for cultural heritage sites. *VAST 2012*: pp.81–88.

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[Quality validation: this is a refereed conference paper published in a volume based on ~30% acceptance rate. It is one of Kaminski's outputs in REF2014.]

- [3.6] MCLOUGHLIN, J., SODAGAR, B. AND KAMINSKI, J. (2006) Dynamic socio-economic impact: a holistic analytical framework for cultural heritage sites. In: *Heritage impact 2005: Proceedings of the First International Symposium on the Socio-economic Impact of Cultural Heritage*. Archaeolingua, Budapest, Hungary, pp.43–56. ISBN 963804666X. [Quality validation: this presents the first work described as 'ground-breaking' by the EC reviewers and was one of McLoughlin's outputs in RAE2008.]

**Key research grants/awards:**

ARNOLD, EPOCH: 'Network of Excellence in Processing Open Cultural Heritage', EU project with 97 partners, March 2004–March 2008: Total funding: €7.88m, contract no. IST-2002-507382. UoB allocation: €1.8m.

ARNOLD, 3D-COFORM: 'Tools and Expertise for 3D Collection FORMation', EU FP7-funded 'Large Scale Integrating Research Project', with 19 partners over 4 years, 2008–2012: Total funding: €8.45m, grant agreement no. 231809. UoB allocation: €1.1m.

**Partnerships:**

V-MUST (Virtual Museum Transnational Network), EU FP-7 funded network of excellence, 2011–2015, Total funding: €4.55m. UoB allocation: €78,400.

**4. Details of the impact**

The research underpinning this case study has changed professional practices in the museums sector and shaped public discourse. At its height EPOCH involved 609 researchers and 3DCOFORM ran over 30 deployment experiments, combining tools to address curatorial challenges, test technologies and integration, raise awareness and train a new generation of heritage professionals. The former Head of the V&A's Photographic Studio confirmed that 3D-COFORM 'brought the V&A Photographic Studio into a new realm of expertise' absorbing new skills and creating 'a whole new form of imaging media'. (5.8) In Egypt, the National Centre for Digitisation and the Egyptian Museum are collaborating to implement tools and techniques that build on the 3D-COFORM project for the museum conservation laboratory' and The Royal Belgian Museum of Art and History has said 'the 3D-Coform project was the first to adapt an integral approach' (5.9). The research has had a 'cutting-edge' impact on the creation of collaborative international cross-organizational networks and had a 'joined-up' effect on cultural institutions (5.8).

Specific tools developed under EPOCH and/or 3D-COFORM such as, for example, the KU-Leuven Minidome now are in regular use. The Minidome employs 198 lights and 1 camera to produce 3D relief-models of physical artefacts. It is now in daily use in 'the capture of digital simulations of inscriptions on Near-Eastern clay tablets (5.9). Additionally, the Minidome integrates with MeshLab which is an advanced 3D mesh processing open-source software system developed and maintained by 3D-COFORM partner CNR-ISTI. Downloads of MeshLab have increased sevenfold as a result of the redesign originated by 3D-COFORM to over 250,000 per annum and viewers for iPad, iPhone and Android are all being released in 2012-13.

3D-COFORM partner ICS-FORTH has provided the secretariat for development of ISO standard 21127:2006 CIDOC-CRM, which is a reference ontology for the interchange of cultural heritage information. 3D-COFORM's description of provenance-related entities contributed to this activity by drawing together the workflow from initial data capture to the communication of results. The take-up of 3D-COFORM's metadata handling system is being integrated within infrastructure projects, such as repositories, with direct bearing on professional practice and standards.

The former Technical and Operations Director of Europeana (formerly the European Digital Library) confirmed that 3D-COFORM was 'instrumental' in bringing the new content category of 3D models to Europeana being 'one of the first data suppliers to use the new...Data Model, and working through the intricacies of 3D metadata [which] helped shape both the model and the workflows around it' (5.10) In testing the workflow 3D-COFORM became the first data provider to upload ~50 virtual objects to Europeana.

A recent exhibition of the 3D-COFORM research, *Reshaping History*, made it possible for ICT and Cultural Heritage professionals and members of the public to share, experience and explore

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stereoscopic digital reconstructions of cultural objects and heritage sites (5.6). Opening in Brighton (2012) the research has since travelled to Prato and to the Naples National Archaeological Museum with requests for it to be exhibited in Cairo, Berlin, London, Paris, Rio and Sao Paulo. In addition to a footfall of >10,000 exhibition visitors the research also has stimulated public discourse through the press and media. This has included a Euronews documentary broadcast in 121 countries to 193 million homes and a BBC Radio 4, *Today Programme*, interview broadcasts to circa 4 million listeners. Other coverage includes: BBC South East News; ITV Meridien News; Discovery Channel Canada; Italian regional TV channels; Al Jazeera; *The Telegraph*; *The Daily Mail*; *The Times* and *La Stampa*.

EPOCH has established new connected communities of practice and developed a significant and sustainable legacy including a network of ten centres of expertise (5.5). For example, the Norwich Forum Trust has cited its 'profound effect' in leveraging £2.5m of capital investment, funding for new projects and creating new forms of employment in the field of cultural heritage (5.7). Professional advice and guidance from EPOCH's Stockholm centre led directly to the formation of Digital Intangible Heritage Asia (DIHA), a new research and development cluster at NTU, Singapore. 3D-COFORM has subsequently furthered this legacy establishing a Virtual Competence Centre for 3D (Company No. 07912842) that will provide independent advice on 3D-technologies to cultural institutions in the next period. Current collaborations with cultural organisations provide further evidence of impact. During this period Brighton joined University College London and Oxford University winning an EPSRC Centre for Doctoral Training in Arts, Heritage and Archaeology, with Brighton leading the Digital strand. Over 45 partners, including V&A, British Museum, Tate, British Library, BBC, English Heritage, Natural History Museum and Historic Royal Palaces will all collaborate in the approved Centre.

**5. Sources to corroborate the impact**

- 5.1 (Fig 4, p14) 3D-COFORM D.5.4 – Final Report WP5 – 3D Artefact Processing Version 1.6.4 - FINAL 07 November 2012.
- 5.2 'Cultural heritage – a new dimension', *euronews TV*, Broadcast around six times, starting 08/09/10. Available at: <http://www.euronews.com/2010/09/08/cultural-heritage-a-new-dimension/> [Accessed: 8 November 2013].
- 5.3 'Secrets of Rubens and Michaelangelo revealed by 3D Scans', by Richard Gray (Science Correspondent), *the Daily Telegraph*, September 9 2012, p.18.
- 5.4 'A Napoli arriva la storia rimodellata in 3D'. Available at: <http://www.lastampa.it/2012/10/31/cultura/a-napoli-arriva-la-storia-rimodellata-in-d-SiHcsIsJufMqC0zMyg2Q4H/pagina.html> [Accessed: 8 November 2013].
- 5.5 KANELLOU, D., GRANTHAM, A., KARINA RODRIGUEZ-ECHAVARRIA, PLETINCKX, D., and GOTTLIEB, H., (2010) EPOCH Network of Expertise Centres as a mechanism for bridging the knowledge gap between cultural institutions and information and communication technologies professionals. Open Digital Cultural Heritage Systems, EPOCH Conference, Archaeolingua, Hungary, ISBN 978-963-9911-25-3.
- 5.6 Visitors' responses to the exhibition *Reshaping History*: included 'An absolutely brilliant undertaking and a refreshing exhibit explaining why 3D technology has the potential to completely change the way we create, incorporate and explore archaeological finds/archives' (PAS Liaison Officer).
- 5.7 Testimonial available from Norwich Forum Trust (Head of Strategic Development), EPOCH's Norwich Expertise Centre, confirming how this led to capital investment, jobs and a new study centre in digital heritage.
- 5.8 Testimonial available from the former Head of Photographic Studio, V&A about the collaboration on deployment experiments, leading to new skills and ongoing 3D work (eg the Meissen fountain project).
- 5.9 Testimonial from Royal Belgian Museums, ICT dept. Has taken on 3D-COFORM technologies and integrated approach and is now using them on a 'day-to-day basis' .
- 5.10 Testimonial from the former Technical and Operations Director, Europeana, that credits 3D-COFORM with establishing new 3D content type. Led collaboration on metadata mapping and workflows.