Institution: The Glasgow School of Art
Unit of Assessment: 34 Art and Design: History, Practice and Theory
Title of case study: The Scottish Ten

1. Summary of the impact (indicative maximum 100 words)

The Scottish Ten is an ambitious five-year project using cutting edge technology to create exceptionally accurate digital models of Scotland's five UNESCO designated World Heritage Sites (WHS) and five other international heritage sites in order to better conserve and manage them. It has had global impact in terms of both its outputs and the process of research activity including forging intellectual and diplomatic links with our international partners, increasing access to digital surrogates of heritage sites, raising awareness of technological approaches to conservation of world heritage, and contributing to the policies of major heritage organisations across the world.

2. Underpinning research (indicative maximum 500 words)

Large scale recording and scanning of World Heritage sites and the creation of digital outputs appropriate for multiple modes of delivery and long-term secure preservation has required the Scottish Ten project to engage in the research and development of numerous novel processes for data-acquisition, processing and management. These have included the development of custom scanning rigs, the integration of multiple scanning technologies in a single record set, the deployment of advanced modelling techniques and the development of management processes for multiple terabyte scale datasets each containing multiple open and/or proprietary file formats. The Scottish Ten project has drawn together the most advanced technologies available, pioneered their integration and applied them to sites challenging in terms of access, material and condition to develop a sound methodology for digital recording of major cultural heritage sites.

In 2004 a new research post of Urban Cities Development Officer was created between DDS and the Mackintosh Environmental Architecture Research Unit (MEARU) (also at Glasgow School of Art). The work of Douglas Pritchard in this role initiated several research projects alongside commercial visualisation activity and helped to build up a critical mass of 3D visualisation expertise within the department. In parallel to DDS academic research, commercial R&D activity led to a successful bid to produce the Glasgow Urban Model (from a public European tender). This project was the first of its kind in the world [8] and won multiple awards for technical innovation [7]. This commercial activity considerably developed the DDS' technical expertise and digital documentation methodology, moving from photogrammetric modelling approaches to the extensive use of high definition 3D laser scanning for dimensional accuracy (at the time, 3D laser scanning was a relatively new technique, usually applied to one building or city block). Methodological research arising from the Glasgow Urban Model focussed on High Definition ground-based laser scanning to derive highly accurate 3D building facades and provided a sound rationale and justification for selecting particular technical approaches. [2] As a result of these interleaving research strands, the DDS developed a thriving Visualisation team and was, by 2008, producing technically outstanding 3D models that were both academically rigorous and visually stunning leading to a growing reputation as a world-class centre of digital documentation and visualisation expertise.

As a result of the innovation and impact of the Glasgow Urban Model, the first direct link between DDS and Historic Scotland was established and through demonstrations of earlier research activity, and a commissioned scan of the Bute Canopy as a visualisation pilot, the DDS established itself as a highly credible partner for this executive agency of the Scottish Government. This led to a series of joint projects of increasing size and complexity including scans of Rosslyn Chapel and Stirling Castle, building trust and expertise between the two organisations as well as driving knowledge exchange on the needs and opportunities for using visualisation technologies in a real-world, conservation context [3] [4]. Over the course of this activity the relationship between DDS, Historic Scotland, and the Scottish Government developed and matured, leading to the signing of a Minute of Agreement with Historic Scotland on 18th March 2008 [1] and the commitment of £1.5m to fund the Scottish Ten project in 2009, followed by the creation of a partnership between DDS and Historic Scotland, the Centre for Digital Documentation and Visualisation (CDDV), in March 2010 as a vehicle to deliver the Scottish Ten.

Throughout the project numerous research and technology application challenges have been addressed for the first time including the integration of LIDAR, laser scanning data (long and close-range), HDR photography, photogrammetric data and subsurface data (ex.BGS) into a single coherent digital model [5]. These integrated datasets have been developed with partners to meet

multiple needs such as site management, analysis, site-propsection, and public information [6]. The Scottish Ten project has been at the forefront of researching and developing large scale digital recording processes from the point of acquisition to the point of delivery including deposition for digital preservation purposes [16].Data acquisition techniques have been developed that are specific to non-standard materials and complex structures, e.g. ferrous metal structures [4] and structures previously inaccessible/un-recordable without the development of specialist, bespoke, scanning equipment. For each recording event extensive testing of acquisition technologies covering materials, weather conditions, range, surface finish, colour fidelity etc. have informed the development of the final recording methodology. The scale, quality, and reach of Scottish Ten research can been seen first hand by the selection of media and information available on the project website and youtube channel.[17]

3. References to the research (indicative maximum of six references)

[1] Minute of Agreement between Digital Design Studio and Historic Scotland (CONFIDENTIAL);

[2] Pritchard, D. (2007) "Capturing the City; The Development of the Virtual City of Glasgow" in *Proceedings of the 10th International Conference on Computers in Urban Planning and Urban Management*, Foz do Iguacu; Brazil July 2007

[3] Wilson L, Pritchard DK, McGregor HC and Mitchell DS (2012) "Two Avenues for Data: Rosslyn Chapel as a Terrestrial Scanning Case Study" in *Proceedings of the XXII Nordic Surveyors Congress*, Oslo 2012.

[4] Wilson L, Mitchell DS, Davey A and Pritchard D (2010). Digital Documentation of Historic Ferrous Metal Structures: 3D Laser Scanning as a Conservation Tool, in Mardikian P, Chemello C, Watters C and Hull P (editors). *Metal 10, International Conference on Metal Conservation.* October 2010, Charleston, USA, Clemson University Press: Charleston: 279-286.

[5] Wilson L, Rawlinson A, Mitchell DS, Pritchard DK, McGregor HC (2011) "3D Documentation of Global Historic Sites: The 'Scottish Ten' Project and its Applications for Cultural Heritage" in *Proceedings of 3D-ARCH 2011 Conference*, March 2011, Trento, Italy. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* Vol. 38-5.

[6] L. Wilson, A. Rawlinson, D.S. Mitchell, H.C. McGregor, R Parsons, "The Scottish Ten Project: Collaborative Heritage Documentation" in *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Volume XL-5/W2, 2013, *XXIV International CIPA Symposium* September 2013, Strasbourg, France

[7] Awards for technical research: Glasgow Urban Model: 2007 BAFTA Scotland Award for Technical Innovation, August 2007; Glasgow Urban Model: 2010 Scottish Award for Quality in Planning; Rosslyn Chapel: First Place, 2010 High Definition Surveying World Wide Users contest in heritage category.

[8] The Glasgow Urban Model was widely reported on by BBC News Scotland on Monday 14th May and by Science Scotland (a journal by the Royal Society of Edinburgh) Issue 6, Autumn 2007.

4. Details of the impact (indicative maximum 750 words)

Cultural diplomacy

The Scottish Ten project mobilised support at ministerial level in the Scottish government [10] and has (so far) resulted in the very high precision scanning of all five Scottish sites inscribed on the UNESCO list of World Heritage Sites, and four of the five international sites. Data from each site was gifted to international partners, creating diplomatic links between the Scottish Government and international organisations: the USA National Parks Service (NPS), the Archaeological Survey of India, the State Administration of Cultural Heritage (China) and Chinese Academy of Cultural Heritage, and Sydney Opera House Trust. As part of his trade mission to China, First Minister Alex Salmond said: *"The Scottish Ten is an excellent example of digital diplomacy and cultural exchange, helping enhance the mutual understanding between Scotland and China, creating an atmosphere of respect, trust and celebration. As a result of a cultural memorandum of understanding I signed on behalf of the people of Scotland with China we have seen a greater number of collaborations across the arts, creative industries, heritage and national collections allowing the people of both our countries to share some unique experiences. It's fantastic to be here in Beijing to personally handover the first set of Scottish Ten data to the State Administration of Cultural Heritage, which is a huge step in digital diplomacy"* [11]

Impact on organisational policies

Scottish Ten research has resulted in demonstrable changes in Historic Scotland policy and practice, most notably in their decision to embark on their own programme of high precision scanning intended to cover their entire estate, a core purpose made possible by the building up of a critical mass of expertise in 3D scanning as a result of this partnership.[9][10]

Mitigation of risk to cultural heritage

3D models resulting from the Scottish Ten are already being used by HS, NPS, and Cyark for documentation, conservation, management, research and public engagement. These activities allow the mitigation of risk to fragile heritage sites by enhancing conservation planning [9] [9] which has the potential to reduce the cost of managing the estate (for example, NPS are using the scan as a baseline to assess speed of environmental damage). The data from the Scottish Ten project have been added to the CyArk 500 collection of meaningful digital surrogates for 500 heritage sites at risk worldwide (along with previous Historic Scotland/DDS 3D scans e.g. Rosslyn Chapel).[12]

Public reach, impact and enhancing engagement

Scottish Ten and CDDV activities have been a significant factor in raising the profile, nationally and internationally, of Scottish cultural heritage and have been used extensively as a promotional tool for this purpose. For example there has been extensive media coverage of the Scottish Ten/Rosslyn Chapel/Stirling Castle projects, highlighting both the technologies used and significance of the selected heritage sites [13].The reach of the public interest in, and media coverage of this project is genuinely global, the television coverage of the Eastern Qing Tombs scanning alone was broadcast to over 1 billion people. The availability of high quality 3D representations allows publics to get a sense of a site from any Internet connected computer, anywhere in the world [17].Representations of St Kilda are particularly valuable as no public access is normally possible. Via close association with the scanned sites the project outputs have also been used to enrich the experience of physical site visitors through interactive visitor education tools at e.g. Rosslyn Chapel and, in the case of Mt Rushmore, a mobile application developed by CyArk.[18] Scottish Ten data has also been used in television programmes. [14] Scottish Ten has also run workshops with local schoolchildren to explain the 3D scanning methodology and necessity for cultural heritage management.

Economic impact

After the success of the Mount Rushmore scan, the NPS and CyArk committed further investment for the creation of educational materials, based on Scottish Ten digital assets, exploring the technology and cultural heritage for all education sectors from primary to HE [19].Historic Scotland offers HLF Skills for the Future learning bursaries (1/y for 4 years) attached to the Scottish Ten and its digitisation programmes [15]. Furthermore, the growth of the CDDV as a direct result of Scottish Ten activity has garnered additional investment and contributed to the commercial arm of the DDS, increasing the staff and equipment available.

The Scottish Ten has also contributed to the assets of international tourism, firstly by making representations of data publicly available in a form that can be accessed by potential visitors online (through images and rendered video) [17] and secondly by providing key content to visitor centres at Maeshowe and Skara Brae in Orkney, Nanjing Museum in China, Mount Rushmore in the USA (inclusion in other sites is currently under confidential discussion).

Contribution to academic field and knowledge exchange

The Scottish Ten project led directly to a conference series bringing together sector experts from industry, government and academia. Starting with a workshop on digital documentation in 2008 (c.50 delegates), this grew into the successful 'DigiDoc' conference convened annually from 2009, the most recent taking place in 2012 (c.230 delegates).[16] This conference series is the most public manifestation of the on-going knowledge exchange between CDDV partners, government, and industry partners such as CyArk. Governmental support is evidenced in the addresses given at DigiDoc conferences by Minister for Culture Michael Russell (2009), First Minister Alex Salmond (2011), and Cabinet Secretary for Culture and External Affairs Fiona Hyslop (2012). The innovation demonstrated by Scottish Ten collaboration also prompted UNESCO to convene a single topic two-day international conference "I Know Where I'm Going: Remote Access to World Heritage Sites from St Kilda to Uluru" held in Edinburgh in 2011.[16]

Knowledge Exchange was central to the Scottish Ten and on-site training in 3D laser scanning has been delivered to over 20 individuals (India:7; USA:4; China:1; Australia:4; Scotland:10 (including

HS survey teams, HLF bursary holders, and PhD students)) and working with a variety of commercial scanning and survey companies.
Scottish Ten data is being used by the University of the Highlands and Islands Orkney College to identify new archaeological sites and was a central part of the PhD work of Alice Watterson, resulting in multiple publications, presentations and exhibitions at the Universities of York and Glasgow, and onsite at Skara Brae itself.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[9] **Policy documents:** Historic Scotland Annual Report and Accounts 2011-12 (http://www.historic-scotland.gov.uk/publicationsresultsdetail.htm?id=5271288e9); Scotland's Digital Future: a strategy for Scotland – The Scottish Government www.scotland.gov.uk/Resource/Doc/981/0114237.pdf
[10] Testimonials from First Minister Alex Salmond, Michael Russell MSP (previously Minister for Culture, External Affairs and the Constitution) and Fiona Hyslop (Cabinet Secretary for Culture and External Affairs). "*The First Minister said Scotland will be the first country in the world to digitally document its national collection of monuments, and that Historic Scotland was embarking on the Rae project to record all of its 345 sites using the scanning technology.*" http://www.historic-scotland.gov.uk/news_search_results.htm/news_article.htm?articleid=34243
[11] Diplomatic event in China focussed on Scottish Ten outputs as part of trade mission http://www.scottishten.org/index/news/news-detail.htm?id=41721
[12] CyArk 500 Digital Preservation Archive: http://archive.cyark.org/scottish-ten-partner
[13] **Very small selection of media/public debate:** TED talk: *Ben Kacyra: Ancient wonders captured in 3D*, TED Global, Edinburgh, July 2011 (http://www.ted.com/talks/ben_kacyra_ancient_wonders_captured_in_3d.html); *Sky News* (12th May 2013) and website: http://news.sky.com/story/1089850/sydney-opera-house-preserved-for-the-future; *BBC News*: http://www.bbc.co.uk/news/uk-scotland-16048752 (6th Dec 2011), http://www.bbc.co.uk/news/uk-scotland-glasgow-west-18490402 (18th June 2012), two-minute evening slot on BBC TV "Reporting Scotland" (22nd Oct 2012), http://www.bbc.co.uk/news/uk-scotland-edinburgh-east-fife-20027135 (22nd Oct 2012). Articles in international press include *The Times of India* (readership of 7million): http://articles.timesofindia.indiatimes.com/2011-10-19/ahmedabad/30297183_1_monument-kc-nauriyal-vav (front page, Oct 19th 2011) and http://articles.timesofindia.indiatimes.com/2011-11-07/ahmedabad/30368881_1_monuments-digital-preservation-asi-s-vadodara (Nov 7th 2011), *The Australian*: http://www.theaustralian.com.au/arts/opera-house-to-be-3-d-scanned/story-e6frg8n6-1226500969263 (Oct 23rd 2012), *China People's Daily*: http://www.china.org.cn/travel/2012-11/13/content_27099526.htm (Nov 13th 2012), Scottish 10 Orkney image published in *New Scientist Magazine* and featured as image of the day (*New Scientist*, Issue 2862, 28th April 2012)
[14] Scan activity, animations, and interviews used *The History of Ancient Briton: Orkney's Stone Age Temple* (BBC, Jan 1st 2010, http://www.bbc.co.uk/programmes/b01971gm)
[15] Historic Scotland learning bursaries: http://tinyurl.com/o3w9qgm
[16] **Selected academic/industrial events and publications:** DigiDoc conference http://digitaldocumentation.co.uk/; Ruth Parsons *Keynote Presentation: Scottish Ten* at SPAR International conference, March 20-26 2011: http://www.sparpointgroup.com/spar-2011-presentations.aspx; *"3D Digital Technologies for Remote Access and Sustainability"* at *I Know Where I'm Going: Remote Access to World Heritage Sites from St Kilda to Uluru,* 23rd - 24th November 2011 http://iknowwhereimgoing.eventbrite.co.uk/?ebtv=F
[17] **Multimedia:** http://www.scottishten.org; http://www.youtube.com/user/historicscotlandtv/videos
[18] Commercial app for Rosslyn Chapel: http://www.pixelstag.com/blogs/blog1.php/a-new-rosslyn-chapel-multimedia; iTunes Rushmore App http://itunes.apple.com/us/app/mount-rushmore-virtual-tour/id534020138?mt=8
[19] Lesson plans (17-26) http://archive.cyark.org/education-lesson-plans