USE OF DIGITAL AND 3D VISUALISATION TECHNOLOGY IN PLANNING FOR NEW DEVELOPMENT

Report for Scottish Government

David Miller, Jane Morrice, Margaret McKeen, Gillian Donaldson-Selby, Chen Wang, Jose Munoz-Rojas

James Hutton Institute, Craigiebuckler, Aberdeen

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Executive Summary

The independent review of the Scottish planning system (Empowering Planning to Deliver Great Places), published in 2016 focused on six key themes: development planning; housing delivery; planning for infrastructure; development management; leadership, resourcing and skills; and community engagement. Its recommendations could lead to a step-change in the planning process. One aspect of those is in the use of digital innovation (**Recommendation 10**) which is the focus of an IT Task Force to focus on the use of big data, Geographic Information Systems and 3D visualisations. This theme is supported by recommendations on the quality and effectiveness of pre-application discussions (**R28**); use of information technology to improve accessibility and allow for more real-time data to inform decisions (**R33**); establishment of shared services by local authorities (**R41**); commitment to early engagement in planning and improved practice (**R43**); and empowering communities to bring forward their own local place plans as part of the development plan (**R44**).

In supporting the six outcomes of the review, the Scottish Government response stated its aim of simplifying and strengthening the planning system and serving all of Scotland's communities. The IT Task Force will focus on 'on more effective methods of engaging people, including the use of innovative techniques such as 3D visualisation, at an earlier stage in the planning process.'

To inform discussions of the IT Task Force this study reviews the role and potential of digital imagery and 3D visualisations in the planning process in Scotland. The overall aim was to provide information, and examples through case studies, to aid understanding of the potential for how digital imagery and 3D visualisations could inform decision-making, and how the associated technology can improve community engagement, understanding and acceptance of development proposals at different stages in the planning process.

The desk-top study identified a wide range of visualisation technologies currently available and used in Scotland, with different levels of sophistication and associated requirements for hardware, software, data, and developer and user training. Key findings are:

1. Visualisation tools are used throughout the planning process, from eliciting initial ideas from stakeholders, including the public, through to final decision-making.
2. Preparation of 3D imagery is generally by, or on behalf of, the proposer of a development, with its use aligned to the stage in the planning process.
3. Evidence of the value of exchanging 3D models between stakeholders is emerging, but the practice is rare, and licencing can inhibit data sharing.
4. Key benefits and challenges differ for different types of stakeholder, but are linked, with overarching concerns over accuracy and reliability of 3D visualisation products.
5. Key benefits for developers are in the efficiency of planning processes, consistency in the basis for decision-making, and scope for imaginative approaches to design. This is similar for decision-makers. For communities, greater input to discussions about proposals is already evident, with a concomitant expectation for the acceptance and impact of 3D materials.

6. Key challenges for all stakeholders are for reliable information throughout the process. Specific challenges for decision-makers are the provision of materials to a known standard, which can be trusted and applied consistently. The challenge to developers is to provide materials to the required standard, and use tools for better communication of key aspects and more imaginative and effective engagement. Reliability and trust will be aided by development of standards for 3D visualisations and their use at different stages in the planning process.

7. For communities, difficulties arise due to limitations in internet bandwidth, and access to contemporary versions of software and data. This includes training and professional expertise, in particular with respect to limitations and weaknesses of some tools or data and thus where their use may be inappropriate. There is a clear requirement of increasing capacity of communities to make effective use of digital imagery and 3D data and tools in relation to planning.

8. 3D tools already have a role in empowerment of communities, with early adopters of technology having increased capabilities and prices increasingly affordable.

9. Increasing availability of digital geospatial imagery, with associated metadata on accuracy, means there is more data of appropriate quality for use at each stage in planning processes, and to all types of stakeholder.

10. Development of software for mobile devices is evolving rapidly, with Apps enabling visualisation of proposals *in situ* are being used in stakeholder engagement prior to submission of a proposal.

11. The use of low-cost Virtual Reality headsets with 3D models is providing new means of communication and early engagement with stakeholders.

12. An increase in the use of tools by all types of stakeholder can be expected, particularly of products for which there is almost universal access (e.g. online platforms of Google, Bing), with new online tools such as storymaps helping the interpretation of information such as Local Development Plans.

13. Increasing the uptake and practice of 3D visualisation tools in the planning process would be aided by: (i) providing examples of effective use of digital imagery and 3D tools in different stages in the planning process; (ii) providing examples of where the use of 3D tools contributes to best practice in principles of public policy and planning; (iii) presentations to CPD events for planners through the RTPI, and articles to journals of professional bodies.

A set of recommendations emerge for consideration in the work programme of the Task Force, which are:

1. To identify an approach to the development of standards for the use of digital imagery, 3D visualisations and models within the planning process. It should recognise the need to match the types of imagery, data and tools to the different steps in the planning process, and the differences between types of stakeholder at each step.

2. To identify means of enabling access to data and tools for generating 3D visualisations by all relevant types of stakeholder. It should include identification of the types of training in the use of 3D imagery, and tools for its

creation, inequalities of access to relevant data and tools (e.g. socio-economic and geographic).

3. To consider how to improve and broaden access to digital spatial data of relevance to different stages in the planning process, its maintenance and update cycles. This could include consideration of digital data as an element of national infrastructure, accessible via a cloud-type capability.

4. To identify the limitations to the effective use of mobile tools which can generate or use digital imagery and 3D visualisations. Such limitations may be infrastructural (e.g. gaps in coverage of mobile data communications of appropriate high speeds), or social (e.g. lack of access to contemporary mobile technologies across all groups in society).

5. To coordinate a short series of information events on existing digital imagery, tools and approaches to 3D visualisation used in planning in Scotland, and emerging tools (e.g. Virtual reality, citizen science). Such events would target civic society and communities; local authorities, Scottish Government and public agencies; and, developers and consultants.

1 Aims and Objectives

1.1 The aim of this study is to provide information, and examples through case studies, to aid understanding of the potential for how digital imagery and 3D visualisations could inform decision-making, and how the associated technology can improve community engagement, understanding and acceptance of development proposals at different stages in the planning process.

1.2 It aims to inform discussion post publication in May 2016 of a review of planning, “Empowering Planning to Deliver Great Places” (Beveridge et al., 2016). Specifically, Recommendation 10 of the report was that “an IT Task Force should be established to explore how information technology can make development plans more accessible and responsive to ‘live’ information”.

1.3 The specific objectives are to:

1. Identify what digital imagery and visualisation technology is currently available and in use in planning

2. Identify how it is used with respect to planning by local and central government, using case studies of different types of development and stage in the planning process

3. Assess likely financial and technological benefits and challenges to developers, decision-makers and community engagement

4. Identify the potential technology likely to be available in the near future and how it might best be used to positively improve stakeholder interaction and engagement with the planning system in Scotland to inform good practice

5. Recommend how digital imagery and 3D visualisation technology can become used or common practice within the planning system with respect to the recommendations of the review of planning (Beveridge et al., 2016), and inform discussions of the IT Task Force set up by Scottish Government.

2 Methods

2.1 The methods used are in three parts:

1. A high-level desktop review of scientific and technical literature of the current range of digital imagery and visualisation technology available and used within Scotland, the UK and overseas. This informs the subsequent interviews with stakeholders and identification of case studies.

2. Emailed questionnaires and telephone interviews with different types of stakeholder to identify current uses, experiences, and feedback on strengths and weaknesses of visualisation, and 3D visualisation technology, and inform the identification of case studies.

3. The development of case studies to consider the uses, benefits, limitations, required improvements and feedback from stakeholders related to each case study. These are drawn from different types of development and uses of digital imagery and 3D visualisation tools.

3 Introduction

3.1 BACKGROUND TO POLICIES FOR PUBLIC ENGAGEMENT

3.1.1 The Brundtland Commission (WCED, 1987) recognised the importance of developing suitable tools that exploit links between social organisation and state of the art in technology. It recognised the importance of information and participation in relation to the management and planning of change. Supporting policies, such as United Nations (UN) Decade of Education for Sustainable Development (2005 – 2014), emphasised education and capacity-building for increasing public and professional engagement in environmental challenges and decisions.

3.1.2 Brundtland's principles of sustainable development were the focus of UN 'Rio Earth Summit' (1992), which led to conventions on climate change (United Nations, 1992a) and biological diversity (United Nations 1992b). It was the development of 'Agenda 21' which centred sustainable development around people, and stressed the need for participation and partnership in delivering the objectives of these conventions. It noted that "… education is critical for promoting sustainable development and improving capacity of the people to address environment and development issues".

3.1.3 Local Agenda 21 ('Information for Decision-Making') refers to the emphasis which should be placed on the "transformation of existing information into forms more useful for decision-making and on targeting information at different user groups." This included technical assessments into forms suitable for planning and public information (United Nations Department of Economic and Social Affairs 2003:336). It also noted that "new technology should be developed and its use encouraged to permit participation of those not served at present by existing infrastructure and methods." (United Nations Department of Economic and Social Affairs 2003:337).

3.1.4 The importance of engaging the public in environmental issues is also at the core of the Aarhus Declaration on access to information and public participation in decision-making (European Commission, 1998). Its General Provisions noted that governments should take the necessary legislative and regulatory steps to:

1. …"ensure that officials and authorities assist and provide guidance to the public in seeking access to information, in facilitating participation in decision-making and in seeking access to justice in environmental matters."

2. …" promote environmental education and environmental awareness among the public, especially on how to obtain access to information, to participate in decision-making and to obtain access to justice in environmental matters."

3.1.5 The United Nations Decade of Education for Sustainable Development (2005 – 2014) (United Nations, 2005), notes that "promoting the goals of a transition to sustainability is a major challenge for science and technology." UNESCO also note that "… education for sustainable development must continue to highlight the importance of addressing the issues of natural resources …, and to raise the level of ‘environmental literacy’.”

3.1.6 To be effective in raising awareness and engagement, and understanding of issues associated with the trade-offs between development and natural resources, strategies and implementation plans for public and private sector development are required. Understanding such issues helps to identify the purpose and audiences for programmes of engagement, and consider the best options for delivery mechanisms. Such plans should consider the rationale for the selection of materials and media, and measures to monitor effectiveness.

3.2 SCOTTISH CONTEXT

3.2.1 Consistent with the evolution of international agreements and commitments, policies in Scotland recognise public engagement and participation relating to decision-making as principles, good practice, or requirements in the Land Use Strategy, Scottish Planning Policy, Scottish Biodiversity Strategy, and Creating Places.

3.2.2 The Scottish Land Use Strategy (LUS 1) set out a Vision to 2050 with Objectives relating to economic prosperity, environmental quality and communities. Core to the Strategy is a set of ten Principles and thirteen Proposals. Of relevance here is that the Principles “… are relevant for everybody involved in planning the future use of land or in taking significant decisions about changes in land use.” Principle ‘I’ states: “People should have opportunities to contribute to debates and decisions about land use and management decisions which affect their lives and their future.”

3.2.3 Proposal 12 of the LUS (“Identify and publicise effective ways for communities to contribute to land-use debates and decision-making”) envisages that opportunities are available for communities to better understand issues associated with land uses and change (e.g. development), and to contribute to relevant forums and debates. In the Land Use Strategy Delivery Evaluation Project, extensive references were made to the use of maps, visuals and other more novel techniques to engage the public and affected communities in land use/management decision-making. However, ‘visuals’ do not refer to 3D visualisation tools. Nonetheless, this shows a potential for the use of computer and 3D visualisations as means of enabling the future delivery of Principle I.

3.2.4 The Land Use Strategy 2 (2016-2021) builds on the framework and principals and sets out the next steps under the three themes of the contemporary policy context, informed decision-making, and applying the Principles and associated proposals, thus continuing to improve the means of operationalising Principle I, and Proposal 12.

3.2.5 Scottish Planning Policy (SPP) (Scottish Government, 2014) identifies how the planning system can deliver high-quality places for Scotland, taking a positive approach to enabling high-quality development, making efficient use of land for long-term benefits, and protecting and enhancing natural and cultural resources. Consistent with aspirations of the Aarhus Declaration, the SPP includes “… opportunities are available for everyone to engage in the development decisions which affect them.”

3.2.6 SPP also notes that "Effective engagement can lead to better plans, better decisions and more satisfactory outcomes and can help to avoid delays in the planning process", noting the importance of engagement with stakeholders under enabling the delivery of new homes. For example, under Placemaking, achieving a pleasant and positive sense of place includes the promotion of visual quality, alongside other factors, for which visualisation tools could play a role in communicating options and designs for development. Similarly, visualisation tools could aid community participation in relation to co-construction in design and planning environments, as articulated in Creating Places (Scottish Government, 2013) and the Scottish Government Town Centre Toolkit (Vision the future; Scottish Government, 2015).

3.2.7 In response to development proposals, such as for wind turbines, digital data and computer visualisations form a key part of the materials used in assessing visual impacts. Guidance on the visual representation of wind farms (SNH, 2014), sets out requirements for the preparation of visualisations. However, these are restricted to the use of photomontages and wireframe images to illustrate locations proposed for wind farms and interpretation of visual effects of developments. The consultation on the draft guidance (SNH, 2013) contained a question on the visualisation or other for representing wind farms. Responses published by SNH noted that 'fly-throughs have been found useful for sequential effects on routes', '3d interactive models can be useful' and 'animation useful' (principally from practitioners). Most contributions to this question were from practitioners. In response, SNH noted "that other techniques are available and can be used in addition to the visualisation required."

3.2.8 In parallel to the development of guidelines of best practice for visualising wind turbine developments, a range of tools have emerged in research and practice to support pre-application discussions about potential renewable energy developments, community engagement about options (e.g. siting), potential visual impacts, and cumulative visual impacts.

3.2.9 Such 3D visualisations and associated tools may have benefits which could support delivery of the types of aspirations or regulatory requirements in public policies which relate to planning and development. The framework for reviewing the opportunities and limitations is developed in the following sections, and their assessment with respect to potential and limitations follow the stakeholder interviews and case studies.

3.2.10 In September 2015, Scottish Ministers appointed an independent panel to undertake a review of the Scottish planning system. The panel's report, "Empowering Planning to Deliver Great Places" (Beveridge et al., 2016; www.gov.scot/Topics/Built-Environment/planning/Review-of-Planning) was published on 31 May 2016 (referred to as the "Planning Review" in this report).

3.2.11 The Planning Review focused on six key themes - development planning; housing delivery; planning for infrastructure; development management; leadership, resourcing and skills; and community engagement. Of the 48 recommendations, Number 10 proposes that …

> 'An IT task force should be established to explore how information technology can make development plans more accessible and responsive to 'live' information. The recommendation is that "digital innovation, such as the use

of big data, specialist systems (such as for minerals and aggregates), Geographic Information Systems and 3D visualisations, should be actively rolled out across all authorities. We strongly recommend that we start a co-ordinated investment in technology now to ensure we are responsive to future advances".

3.2.12 Several other recommendations are closely associated with the proposal of a step-change in use of digital information and 3D visualisations. Most notable of these recommendations are:

28 – The quality and effectiveness of pre-application discussions with planning authorities and consultation by developers should be significantly improved;

33 - As with development planning, the use of information technology to improve accessibility and allow for more real-time data to inform decisions;

41 - Local authorities should pursue the establishment of shared services;

43 – There should be a continuing commitment to early engagement in planning, but practice needs to improve significantly;

44 – Communities should be empowered to bring forward their own local place plans, and these should form part of the development plan.

3.2.13 Combined, implementation of this set of recommendations would represent a significant change in the capabilities of the planning process to draw on the latest technological opportunities, and reinforce the evolution of community empowerment in Scotland.

3.2.14 The Scottish Government, in July 2016 (Scottish Government, 2016), responded to the Planning Review, noting 'We want to simplify and strengthen the planning system to ensure it better serves all of Scotland's communities', and that it 'strongly support the six outcomes proposed by the review'. In the immediate actions, Scottish Government is establishing an IT Task Force, and focusing 'on more effective methods of engaging people, including the use of innovative techniques such as 3D visualisation, at an earlier stage in the planning process.'

3.2.15 This report reviews the use of digital imagery and 3D visualisations in the planning process in Scotland, informed by examples from other areas of the UK, and concludes with recommendations for consideration by the IT Task Force in taking forward Recommendation 10.

4 Engagement and Participation

4.1 BACKGROUND

4.1.1 In 1969, Arnstein defined a multi-level participatory classification, comprising eight levels of involvement, clustered under three main categories: non-participation; tokenism; and citizen power. Non-participation embraces levels where citizens' involvement is at largely at an educational level, meaning they are informed and educated on a subject, but where only one-way communication exists. Tokenism involves active participation from citizens, but their opinions will not significantly influence final decisions. Citizen power provides, to different degrees, direct influence of citizens on the decision-making process.

4.1.2 This classification has been adopted and adapted by many authors working in different participation processes (e.g. Dorcey et al., 1994). Whilst Arnstein (1969) focused on power, Dorcey et al. (1994) focus on functions, and the UNDP (1997) definition focuses on decision aspects of participation (Table 1). The last column in Table 1 shows an integrated view of the landscape management process concerning these typologies.

Table 1. Typologies of participation (adapted from Green and Hunton-Clarke, 2003).

Arnstein (1969)	Dorcey et al. (1994)	UNDP (1997)	Environmental management	
Non-participation	Manipulation	Inform	Manipulation	Misinformation
	Therapy	Educate	Information	Informing the public
Tokenism	Informing	Gather information and perspectives	Consultation	Restricted participation
	Consultation	Consult on reactions	Consensus-building	Discussing risks and alternatives
	Placation	Define issues	Decision-making	Assessing risks and recommending solutions
Citizen Power	Partnership	Test ideas, seek advice	Risk-sharing	Defining interests, actors and determining agenda
	Delegated power	Seek consensus	Partnership	Final decisions
	Citizen control	Ongoing involvement	Self-management	

4.1.3 The degree of impact of public participation on decision-making processes is related to the extent of the involvement of the public which, in practice, falls into three main levels: 1) *information*, dissemination or direct participation (where information is communicated primarily in one direction to the public); 2) *consultation*, where public opinions are sought and considered in expert or managerial decision-making; 3) *collaboration*, where representatives of the public are involved actively in developing solutions and directly influencing decisions to some degree (Sheppard, 2005a). Authors such as Ravetz (2004) and Mayumi and Giampietro (2005) argue that public opinion is an important aspect in legitimising policy-making requiring effective two-way exchange of knowledge, building trust and learning processes.

4.1.4 Knowledge exchange is a two-way process which recognises that engagement with stakeholders is tailored to local circumstances, and may stretch across different types of participation, as summarised in Table 1. To this end consideration is required of the purpose, audiences and delivery mechanisms. In the choice of mechanisms 3D visualisations provide one option at different stages of development of a proposal. Table 2 provides an overview of the stages for engagement.

Table 2. Stages in a strategy for engagement and awareness raising.

Stage	Subject	Question to address
Identification	Purpose	Why are we communicating?
	Audience	Who are we communicating with?
	Geography	Where are the audiences?
Design and Selection	Materials	What materials are best suited to the purposes?
	Media	How are the messages best conveyed?
Implementation	Mechanisms	What are the mechanisms for delivery of messages?
	Schedule	What is the schedule of delivery?
Feedback	Evaluation	How effective were the communications?

4.1.5 Increasingly, materials are being developed for knowledge exchange that are designed to aid engagement and communications with specific types of stakeholder. Such materials are developed with the aims of:

1. Increasing the accessibility of plans such as those of strategic or specific developments, in a format and language tailored to different types of stakeholder (e.g. statutory consultees, developers, planners and other practitioners, and the wider public).
2. Providing mechanisms for feedback and inputs from specific types of stakeholder to highlight areas where assessments are lacking, and to enable different types of stakeholders to have opportunities to interact and discuss key issues.
3. Raising awareness of key messages amongst stakeholders (e.g. planning teams, developers, practitioners, public) benefitting from participatory activities.
4. Building capacity amongst stakeholders to undertake their developing business needs (e.g. engagement activities of developers, designers and architects, practitioners in Environmental Impact Assessments and Strategic Environmental Assessments).

4.1.6 However, the choice of materials and mechanisms should be those which are most appropriate for delivering to the aims of a given initiative or development. Local infrastructure may be significant in deciding upon the choice of media and methods.

For example, availability of a suitable signal (e.g. wifi, GPRS or 3G) may influence the use of online tools.

4.2 INFORMATION AND COMMUNICATION TECHNOLOGY TOOLS

4.2.1 The evolution of visualisation and mapping tools has contributed to their uptake in relation to assessing consequences of drivers of land-use change in urban and rural areas, such as renewable energy, housing and transport. Of these, 3D visualisations, associated tools, and their application in the context of public participation in environmental decision making, is steadily increasing in use. This is due to continued reductions in price, capability and availability of computer hardware, visualisation software, and spatial databases. However, there are certain requirements for the effective use of such tools. These include their role in the process of scenario development (e.g. participatory approaches), or assessment of implications (e.g. access routes to new housing, design of street furniture).

4.2.2 Several authors discuss the role of Information and Communications Technology (ICT) tools in the context of landscape planning and management. These have covered advances made in approaches to issues such as awareness raising (Pedroli and Van Mansvelt, 2006; Miller et al., 2013), education (Pedroli and Van Mansvelt, 2006; Castiglioni, 2012; Sarlov-Herlin, 2012), innovation (de Montmollin, 2006; Jones, 2007; Klinar, 2013), public participation in decision-making (Prieur and Durousseau, 2006; Jones, 2007; Scott, 2011; Noguera, 2013), and public engagement in engaging communities in developing scenarios of development in the local area (e.g. Wang et al., 2015).

4.2.3 Pettit et al. (2011) and Donaldson-Selby et al. (2012), describe the roles, strengths and weaknesses of the use of visualisation tools in communications about alternative landscapes. Tobias et al. (2016) discuss the role of real-time visualisation in support of developing landscape visions, and Schroth et al. (2011) describe the use of visualisation tools in the context of facilitating stakeholder planning workshops. Portman et al. (2015) describe the roles of virtual reality in architecture, landscape architecture and environmental planning, noting the differences in requirements of accuracy and nature of representation for different types of application.

4.2.4 Drawing from the summaries of such authors, the requirements of 3D visualisation tools, often linked to wider ICT tools, are to:

- Provide access to up-to date information about a site or development.
- Support inputs to discussion from the perspectives of different types of stakeholders (i.e. visually).
- Visualise multi-dimensional environmental issues relating to different aspects of development (e.g. aesthetics, noise, water quality), often from different viewing perspectives.
- Enable stakeholders to interact with or modify plans.

4.2.5 De Montmollin (2006) classified ICT tools according to their nature, capacities and potential uses. The same classification can be used when considering 3D visualisation tools, with some modifications to the details, as follows:

Design and development

- To design the components and layout of a development (e.g. buildings, street design, wind farm layout)
- To present the concept and specific plans for a development.

Participatory tools

- To facilitate community input to and participation in the protection, management and planning of urban and rural landscapes (e.g. Charrettes, 'Planning for Real')
- To work at local levels to help communities to identify and understand the characteristics, value and vulnerability of the landscapes in which they live, and to describe their aspirations for an area.

Tools for awareness raising and training

- To enable planning and training by public agencies (e.g. emergency responders)
- To inform and train groups and agencies concerned with landscape about issues relevant to a specific development
- To inform and train those involved in the decision-making process (e.g. elected representatives, advisors)
- To inform public and younger people about landscape and trade-offs between different types of development and other related land-use changes, and environmental impacts (e.g. climate change and renewable energy; timescales for development and environmental change).

Technical tools

- To assess and discuss the economic importance of landscapes
- To monitor changes in landscapes
- To enable the assessment and evaluation of restoration of landscapes in peri-urban, industrial and commercial areas.

4.2.6 The requirements of visualisation tools will not be the same for all the purposes listed. The fitness to purpose of tools will differ in terms of level of detail in a model (e.g. representation as schematic or photorealistic), interactivity (e.g. capability to walk, drive or fly through an area, introduce or move individual features, switch on or off the representation of a development to illustrate change), represent environmental conditions (e.g. viewing under different weather conditions or times of day or year), viewing (e.g. as individuals or in groups).

4.2.7 MacEarchren and Kraak (2001) present a 'geovisualisation cube' (**Figure 1**) to describe the characteristics associated with visualisation materials with respect to the nature of the user and the implied level of expertise (here, assuming that experts and public are at opposite ends of that dimension), interaction (i.e. the level of interaction required), and information to be communicated.

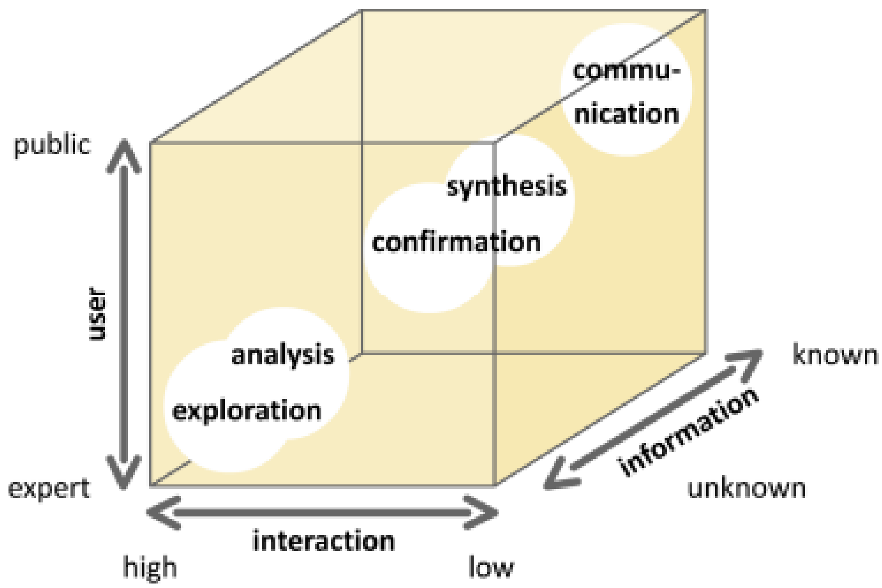


Figure 1. The purposes of geovisualisation, from exploration to communication, illustrated in a geovisualisation cube (from MacEarchren and Kraak, 2001).

4.2.8 The identification of purpose and use of the visualisation will inform the specification of its development, and thus the software and data requirements.

4.2.9 As noted in Section 3.1, an aim of the Aarhus Declaration (European Commission, 1998) is to obtain "… access to justice in environmental matters". Therefore, the potential for the use of 3D visualisation tools is tempered by recognition of the importance of the responsibilities associated with decision making or education. Sheppard (2005b) provides a Code of Ethics for visualisation outlining the importance of factors such as authenticity when using tools to communicate issues such as land use or climate change. Therefore, the functions of the tools set out by de Montmollin (2006), and the specification and implementation of a 3D visualisation, should be informed by guidelines such as those provided by Sheppard (2005b).

4.2.10 The frameworks described above provide means of discussing the uses of computer visualisations in general, and 3D visualisation in particular. They provide means of discussing roles of such tools with stakeholders in the interviews, and for structuring the interpretation of use, function, impact in the case studies.

5 Visualisation and 3D Modelling

5.1 DEFINITIONS

5.1.1 In this study, a **3D model** is one for which there is representation of an object which has width, depth and height. The use of such a model for the design of components of a development need not be georeferenced, particularly if they are not going to be combined with any other features which are in a geographically specific location.

5.1.2 The emphasis of this study is on geospecific visualisations, which represent current and future urban and rural landscapes with different types of development. These include 3D models which can be used directly, or from which visualisations can be derived (e.g. as images from pre-set viewpoints).

5.1.3 In the United Kingdom georeferencing is typically to the Ordnance Survey National Grid. However, for some specific applications other referencing systems may be used, most commonly a Geographic projection (i.e. latitude and longitude), or Universal Transverse Mercator (UTM), the latter particularly marine environments.

5.1.4 Proprietary software packages are available which enable conversions between references systems for most forms of models, and between different formats of 3D model.

5.2 APPROACHES

Compilation of a basic model

5.2.1 The essential elements for the creation of a landscape visualisation are a representation of the terrain, surface textures (e.g. of land cover or vegetation), features (e.g. animals and humans, water, built structures), and environmental conditions (e.g. weather conditions, lighting) in different combinations of some or all of them (Ervin, 2001).

5.2.2 **Figure 2** shows an overview of the basic process for producing a geospecific visualisation of the landscape.

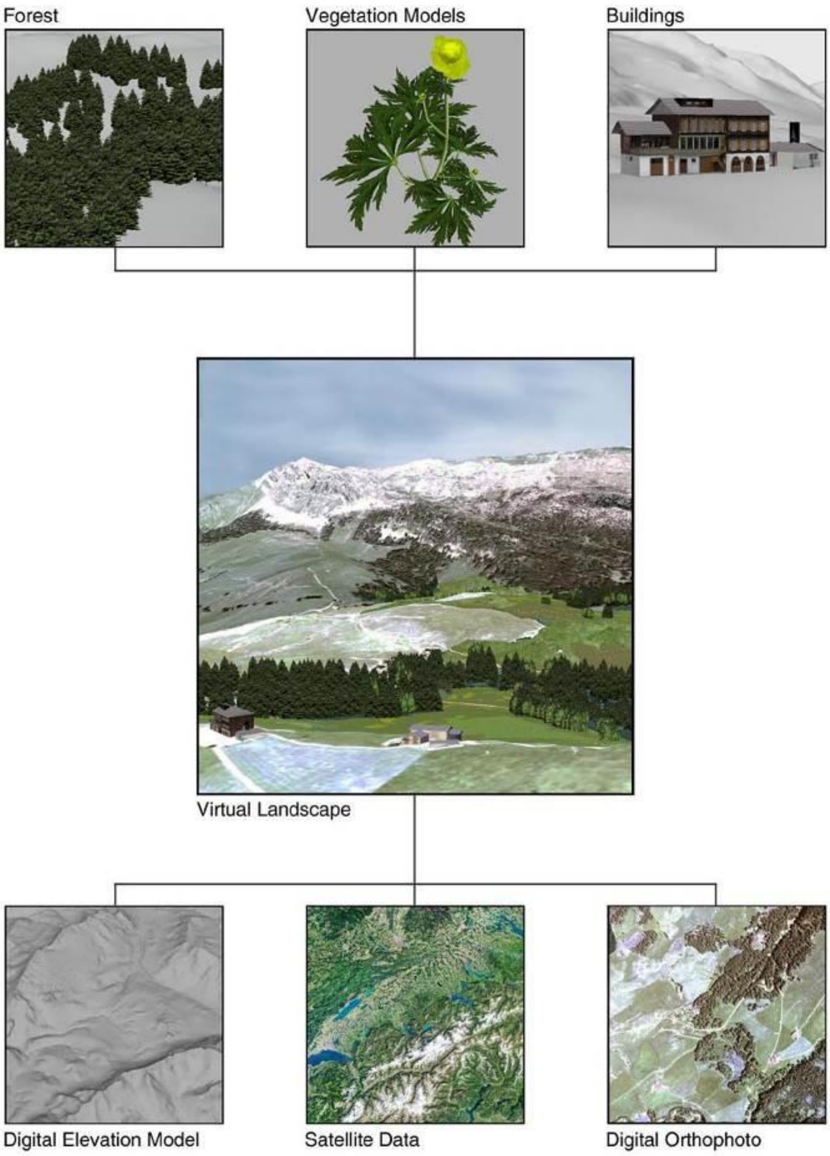


Figure 2. Compilation of a basic landscape visualisation (Source: Lange et al., 2005).

Topographic data

5.2.3 For geospecific visualisations (**Figure 2**), some representation of the terrain is required. Generally, that is of the ground surface, i.e. the topography, and represented by a Digital Terrain Model (DTM). There is extensive coverage of such height data for Great Britain, which are widely used in different aspects of planning. These data include Digital Terrain Models provided by Ordnance Survey (e.g. Terrain 5) and from commercial vendors (e.g. GetMapping, Bluesky).

5.2.4 Data representing the ground surface and that of surface features (e.g. building, vegetation) is a Digital Elevation Model (DEM). There is increasing coverage of such digital imagery notably that obtained from Lidar (Light Detection & Ranging). In England and Wales, the Environmental Agency announced in June 2015 that it will be providing free access to Lidar to improve work on topics such as flood risk management. This may provide cover of some very small areas of

Scotland at the Scotland/ England border. As such data become available so the expectations may be raised about similar data being made available for parts of Scotland. If so, that in turn will increase the potential for its use in planning related applications, including supporting the use of 3D modelling and visualisation.

5.2.5 An example of the use of lidar data in a 3D viewer, presented in a video walk through is provided in the following link for an area of Carlisle, and illustrated in **Figure 3**. It does not include texturing rendering or other forms of representation of surface features. These data, typically at spatial resolutions of 1 to 3m, would support backdrops and content of terrain models over which are draped high resolution textural data (e.g. aerial imagery), and used for 3D models which enable navigation through relatively small geographic areas (e.g. housing estate, city centre, new build or brownfield site), to communicating information to public and expert audiences. It would support geospecific applications, albeit still likely to be overviews. Therefore the use in planning would be most likely aligned with the provision of information for initial scoping of development ideas of small geographic areas.

Figure 3. Image of elevation data (lidar from Environment Agency) and viewing in perspective, of area of Carlisle (Courtesy: A. Sage).

5.2.6 Publically available data are also available at lower spatial resolutions such as that from the global ASTER dataset (c. 90m x 90m), obtained from the Shuttle Radar Topography Mission, completed in 2014. Such data would support 3D visualisation and modelling for exploration by public audiences, and symbolic overviews of landscape. Therefore their use in planning would be most likely aligned with the provision of information for initial scoping of development ideas of large geographic areas (e.g. strategic planning, or large infrastructure developments of bridges and bypasses). The availability of such data to members of the public and enables wider uptake of digital imagery and visualisation as part of planning processes, but with a risk that the quality of the data may not match the requirements of the use.

5.2.7 Also notable is the use of photogrammetric methods for deriving digital data on urban areas, particularly the use of stereo aerial photography for deriving the heights of buildings and other features. Such data are increasingly available and used for major urban centres, providing a core dataset for managing, negotiating and consulting on proposed developments, and implementation of public policies. **Figure 4** shows an example of a building height dataset for the centre of City of Birmingham (see also Case Study 10).

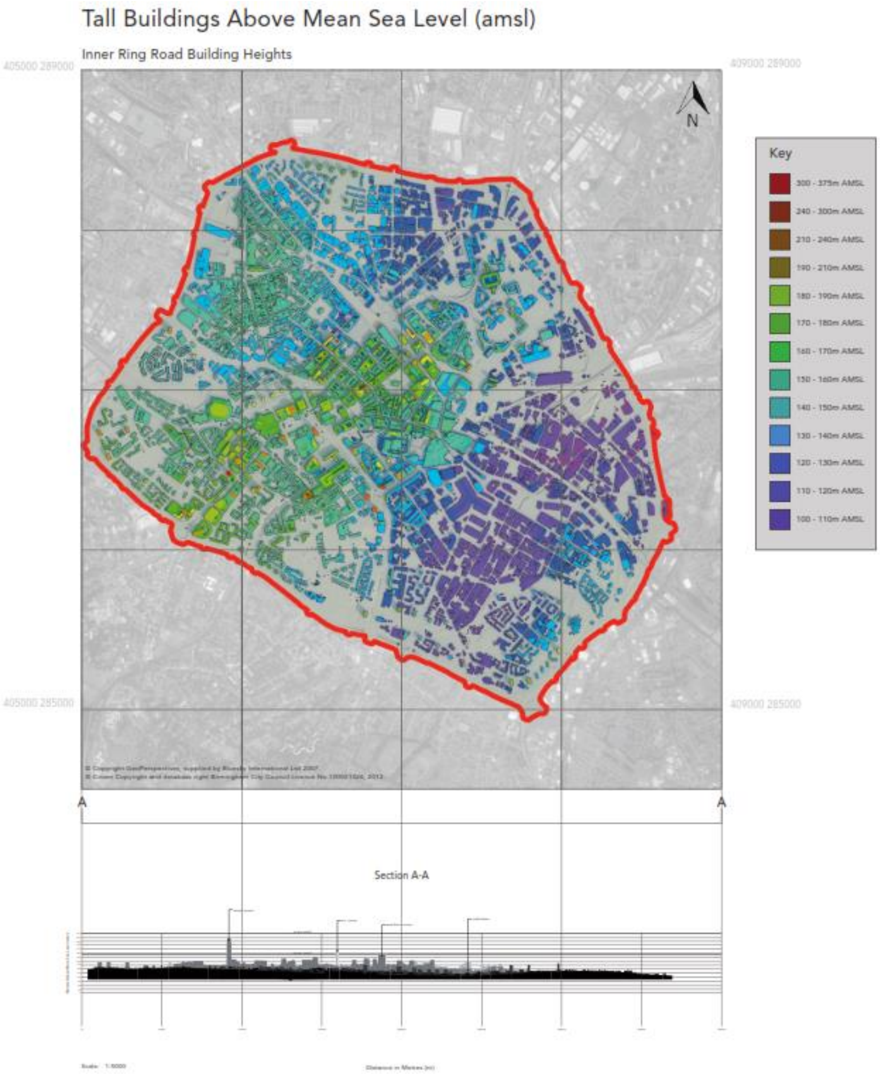


Figure 4. Map of building heights for central City of Birmingham (© Crown Copyright. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings. [Zmapping Ltd](), 2016; and Birmingham City Council. Licence number 100021326, 2016).

Surface textures and planimetric data

5.2.8   For interpretation of landscapes, for non-expert audiences, there is a requirement for some spatial cartographic or textural information (**Figure 2**). The 'draping' of geospecific textures across a DTM enables the simple representation of landscapes, with which people are increasingly familiar through online resources (e.g. Google Maps and Earth, Bing Maps). Sources of such geospatial information is commonly orthophotographs (i.e. georeferenced aerial imagery) or satellite imagery, or digital maps. Other approaches to the provision of textures include their generation using computer algorithms such as the use of fractals.

5.2.9 Feature specific data with buildings, vegetation types, transport infrastructure all represented explicitly by polygons, lines or points provide the basis of allocating textures or 3D models to the correct geographic locations. This is most clearly enabled by use of digital map data and information. Such data are extensively available for Scotland. The Ordnance Survey provide a broad range of scales of topographic information, from approximately 1:1,250 to 1:250,000. Much of these data are accessible to signatories of the OneScotland Mapping Agreement. Membership to the Agreement is available across the public sector in Scotland and those undertaking work on their behalf.

5.2.10 Ordnance Survey also makes available 'Open Data', free under the Open Government Licence. Several datasets have been updated and released over 2016 including terrain (50 metres), backdrops (1:250,000 colour raster), and features (e.g. roads, rail, rivers, watercourses, woodlands. Access to these data is online at www.ordnancesurvey.co.uk/opendatadownload/products.html. It's use in planning may be limited to strategic planning and visualisation of overviews of areas due to the geographic scales of the data (e.g. 1:50,000 and 1:250,000).

5.2.11 Another source of well-used, open source, data is the Open Streetmap, which has developed rapidly over the last few years, with some support from Ordnance Survey. Open Streetmap provides data of generally compatible accuracy and availability for all Scotland, as part of a global initiative. These data are available for downloading in formats (e.g. Shapefile) compatible with use in digital mapping and visualisation tools. The details of attributes enable the design of representation of features in visualisation tools. It provides access to spatial data of a resolution suitable for use in all stages of the planning process with no data specific financial barriers. An example of the detail is shown in **Figure 5**.

Figure 5. Extract of OpenStreemap, Edinburgh (Courtesy: OpenStreepMap Project).

5.2.12 A search of planning documents available online in Scotland has not identified reference to Open Streetmap. So, it may not yet be in use for formal planning applications, or not fully referenced. Software packages which can utilise information about type of features and associated their representation with specific textures or 3D models would be able to take advantage of such data (e.g. Unity 3D, CityEngine, see Annex 1).

5.2.13 Overall, the quality and availability of spatial data continues to improve in terms of availability, higher spatial resolutions, and access to a wider range of users in public and private sectors and members of the public. Such data continue to support the underpinning of increased use in relation to early stages in a planning process, and some through to final submissions of proposals.

5.2.14 Features are added to the scene to represent specific elements of relevance to the application (e.g. animals, human figures, vehicles, buildings). Such features may be in the form of billboards, or 3D objects, and represent landscape features which are characteristic of the area of interest (e.g. individual trees, buildings, street furniture). Such features are defined by their geometric characteristics of position, shape, size and orientation as well as by their graphic representations, colour, brightness and texture (Ervin, 2001). Grassi and Klein (2016) describe the use of lidar for capturing detailed information on building dimensions and subsequently in development of an augmented reality tool for use in discussing wind turbines.

5.2.15 Several visualisation packages were originally developed for applications that were not geospecific (e.g. Vega Prime), or required separate packages for to develop a model with conversion software for importing DTMs, textures (e.g. aerial imagery), and combining these with individual 3D models of features (e.g. buildings).

Level of detail

5.2.16 The level of detail will differ according to purpose or the model and representation of the area or scene. Depending on the objectives of visualisations, there are high demands on computing resources. In general, high levels of detail are important for the perception and recognition of foreground images (e.g. <400m), compared to middle and far distances (e.g. 400m and over) (Lange, 2001). However, several factors will influence the identification of features at different distances, including weather and lighting conditions, contrast and colour of the feature, whether the feature or the viewer is moving, and knowledge of what is being observed.

5.2.17 **Figure 6** shows three different representations of the same landscape in Switzerland. The top image is developed in software to produce a simulation with detail to the level of individual plants in the foreground, whereas the bottom image is a stylised representation of the same landscape.

Figure 6. Landscape with elements with high, middle and low levels of detail (Courtesy: O. Schroth, University of Sheffield).

5.2.18 Visual communication can be described with a sign classification going from abstract meaning to physical reality (Sherman and Craig 2003). Using graphic semiology of Bertin (1983) and the realism axis of Sherman (2003), **Figure 7** illustrates four levels of detail of individual features (trees).

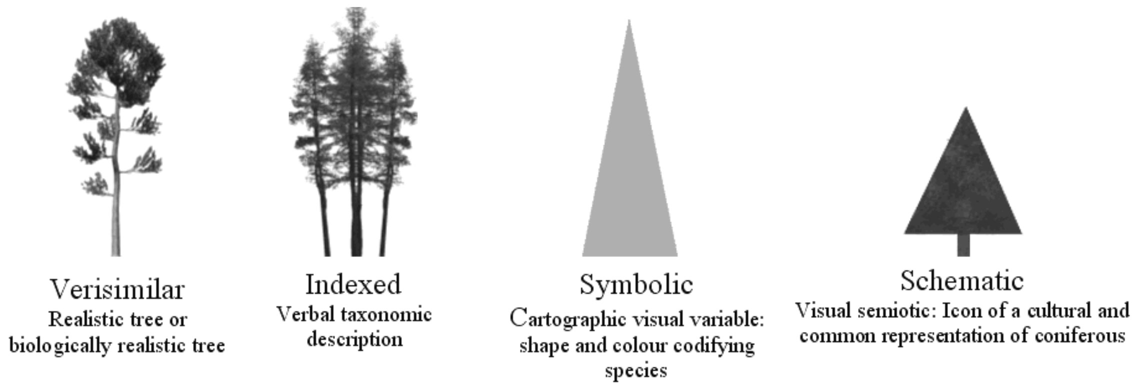


Figure 7. Visual semiology of the Caledonian Pine, using an adaptation of the Sherman realism axis (Sherman, 2003).

5.2.19 **Figure 8** shows a representation of levels of detail in a landscape view described as symbolic or specific (i.e. feature textures included), and views from above or ground level. The bottom right image illustrates a view from eye-level with 3D features representing individual plants in the foreground. This compares to a representation of the land uses from an oblique view (top right).

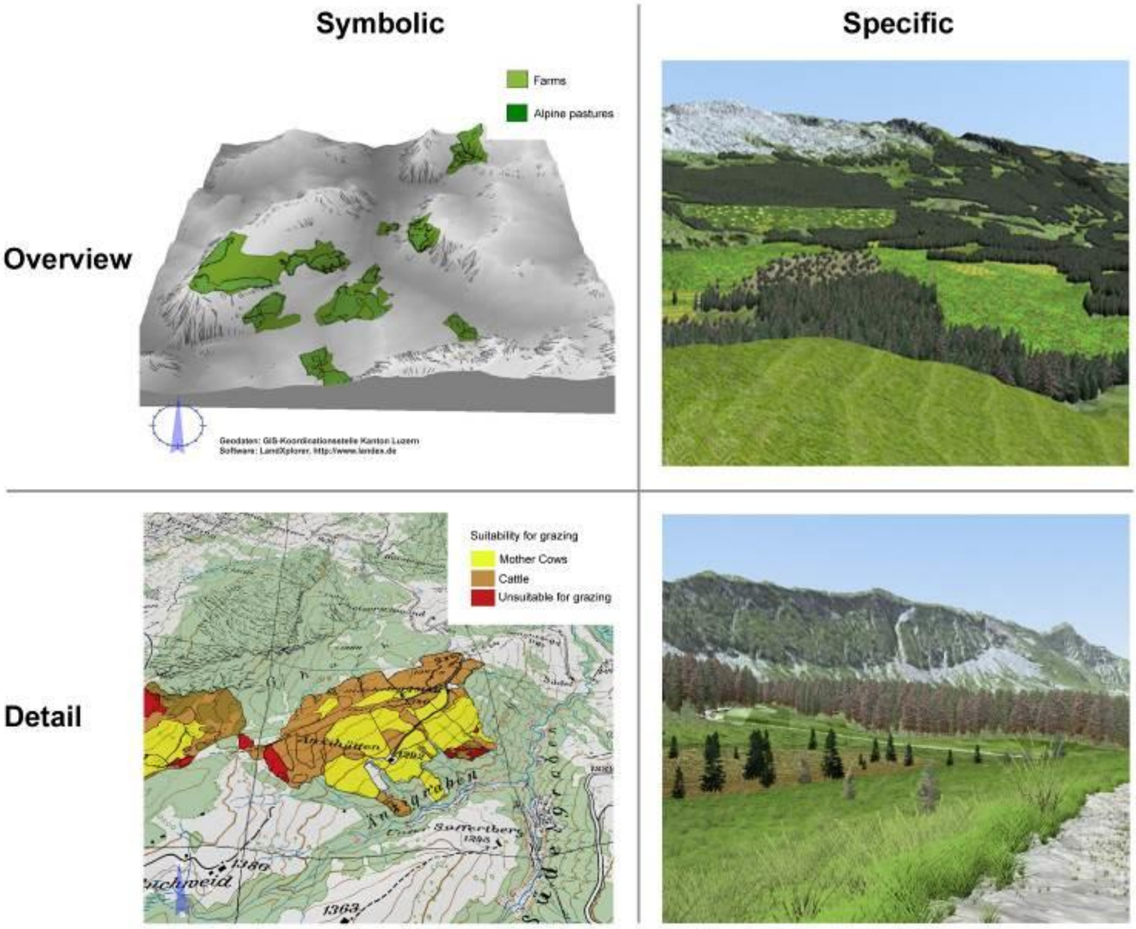


Figure 8. Examples of levels of detail of different types of 3D visualisation with respect to a classification of the representation of a landscape (Courtesy: O. Schroth and U Wissen, EU VisuLands project).

5.2.20 Generally, there is a trade-off between the level of realism and resources required for the representation of features in a visualisation. The choice of approach (i.e. software, hardware, data) can only be made once there is a clear specification of the objectives of the visualisation, *i.e*. the planning task, and the character of the landscape that is visualised (Lange and Bishop, 2005).

5.2.21 The findings from studies into levels of detail and people's interpretation or perceptions of landscapes, suggests that the coherence of the combination of image components influences the reading of an image. Visual mismatches in the combination of features and ground textures are a limiting factor in the acceptability of a picture's content. This has implications for the design of visualisation materials, the development of 3D visualisation models, and to which uses they are most appropriately applied. Significant mismatches in levels of detail may be interpreted by the user (viewer) as incomplete information, misinterpreted in relation to gaps in content, or misleading, either deliberately or unintentionally.

5.2.22 With respect to levels of detail and the approaches taken to representation of a landscape, one implication of the issues raised is that the easiest option is to use a photograph and the details captured therein, which removes any requirement to model the contents of the view. However, this loses the flexibility associated with 3D models and their uses in visualisations of manipulation and representation under different viewing conditions.

5.2.23 As developments emerge in software and data so the differences between photographs and 3D visualisations will reduce and the limitations of such visualisations for some types of applications can be expected to be overcome.

6 Visualisation Tools

6.1 VISUALISATION SOFTWARE AND USES

6.1.1 A review of software packages and systems available as of September 2016 has been carried out, listed in Annex 1, Table A1. With rapidly evolving technology and applications, it is recognised that such a review will not be comprehensive. The review has drawn on publicly available information about software used by public agencies, private consultancies, and research organisations. No recommendations of software are implied by their inclusion.

6.1.2 The listing of software includes an indication of the types of application for which it is used, the computer operating system, an indication of cost, and relevant web links. This information provides a basis for analysing and summarising the types of software and hardware available, and for use in discussions with interviewees and expansion in the case studies.

6.1.3 **Table A2** lists packages, or tools, which are used to provide inputs to the visualisation software, or pre-processing materials, such as photographs for use in producing textures on 3D models. The table represents a sample of known programmes, applications and technologies but is not exhaustive of all such examples.

6.2 TECHNOLOGIES: HARDWARE

6.2.1 Most of the digital imagery and visualisation tools in operational use are based on high specification desktop or equivalent hardware such as high Macs or PCs, equipped with appropriate graphics cards, memory and processing capabilities. Examples of communication using digital imagery and visualisation tools which utilise specialist hardware are those of large format touchtables, and virtual reality.

6.2.2 *Touchtables.* Large format touchtables and touchscreens have become increasingly available, principally due to an increase in the range of models available, and reductions in their costs (e.g. £2,000 to £5,000 depending upon specification). Such facilities are supporting the presentation and engagement with audiences of topics which can use geospatial data as well as other forms of information and media (e.g. videos). The example in **Figure 9** shows the use of such a facility, using digital map data for the Edinburgh area with a public audience identifying woodlands and recording their uses using a map interface.

Figure 9. Touchtable being used by public audience in discussing woodlands at John Hope Gateway, Royal Botanic Garden Edinburgh, September 2016 (Courtesy: D Miller, James Hutton Institute).

6.2.3 They do not of themselves offer anything new in terms of 3D modelling or visualisation. However, they do provide capabilities for engaging with public and professional audiences with use of any digital imagery for which there are suitable software players or means of presentation (e.g. Multi-date aerial imagery, digital maps or development plans, static or video walk-throughs of 3D models). They are mobile to varying extents and thus can be used in venues in close proximity to a development proposal, a planning office or council chamber. Recent examples of their use in planning related applications in Scotland include: (i) Adaptation Scotland to link adaptation with engagement on flood risk management and wider land use planning, tested in Aberdeen; and (ii) in marine spatial planning (e.g. Marine Scotland).

6.2.4 *Head mounted displays (HMD).* Head Mounted Displays for representing areas with geospecific data are becoming more accessible, and progressively as marketed for public or retail audiences. Facebook bought an early start-up project, Oculus Rift, providing greater access to financial capital and support for marketing, and the launch of 3rd generation versions of the headsets. As a consequence, content for representation and exploration in the Oculus Rift is rapidly becoming available. Examples include design plans for site development, using a wide range of imagery (e.g. video, 3D models).

6.2.5 HMDs provide fully immersive experiences of environments, as recorded in video or photographic panoramas, of 3D representations of existing or new build sites. The use in planning is likely to be in gathering information, consulting on potential developments, informing stakeholders (e.g. Birmingham City Smithfield market, Case Study 10), and assessing potential visual impacts of developments. An example of a headset and the scene being viewed redisplayed on a PC screen is shown in **Figure 10**.

Figure 10. View of an Oculus Rift headset and images of scene being viewed (video board) (Courtesy: D Miller, James Hutton Institute).

6.2.6 *Virtual Reality Theatres*. A theatre environment enables a shared experience of a digital representation of an environment, supporting group discussion amongst participants (Portman et al., 2015; Wang et al., 2015). As in most workshop settings, the use of theatre-style facilities requires facilitators to run the engagement, using the 3D model and tools as support for the task in hand (e.g. eliciting public opinions on issues, ideas for new development, raising public awareness in pre-application consultations, assessing public and stakeholder responses to proposed change, elected representatives and planning officers discussing change). The levels of detail can be overview and schematic, or photo-realistic and immersive. They are increasing available in research environments, and in use in real applications (e.g. Case Study 3). **Figure 11** illustrates the representation of proposal for a windfarm offshore Aberdeen.

Figure 11. Public discussion about proposal for windfarm in Aberdeen Bay, using a virtual reality theatre (Courtesy: D Riley, Macaulay Land Use Research Institute).

6.3 TECHNOLOGIES: SOFTWARE

6.3.1 The representation of documentation and plans relating to planning can take advantage of new tools and media. An example applied in Scotland is the use of ESRI 'story maps', part of the ArcGIS / ArcMap software suite. South Ayrshire Council produced an interactive 'story map' to present and explain the Local Development Plan (LDP) and policy areas, supported by all associated spatial data such as constraints, current land uses, and proposals for development (Case study 7).

6.3.2 The interface is based on interactive maps, photographs and text, with extensive hyperlinking to other relevant materials. Data showing a significant increase in access to the LDP reports 56% more views of the new means of presenting the LDP in two months than over the previous 12 months with the equivalent document. **Figure 12** shows an extract of the 'story map' for South Ayrshire.

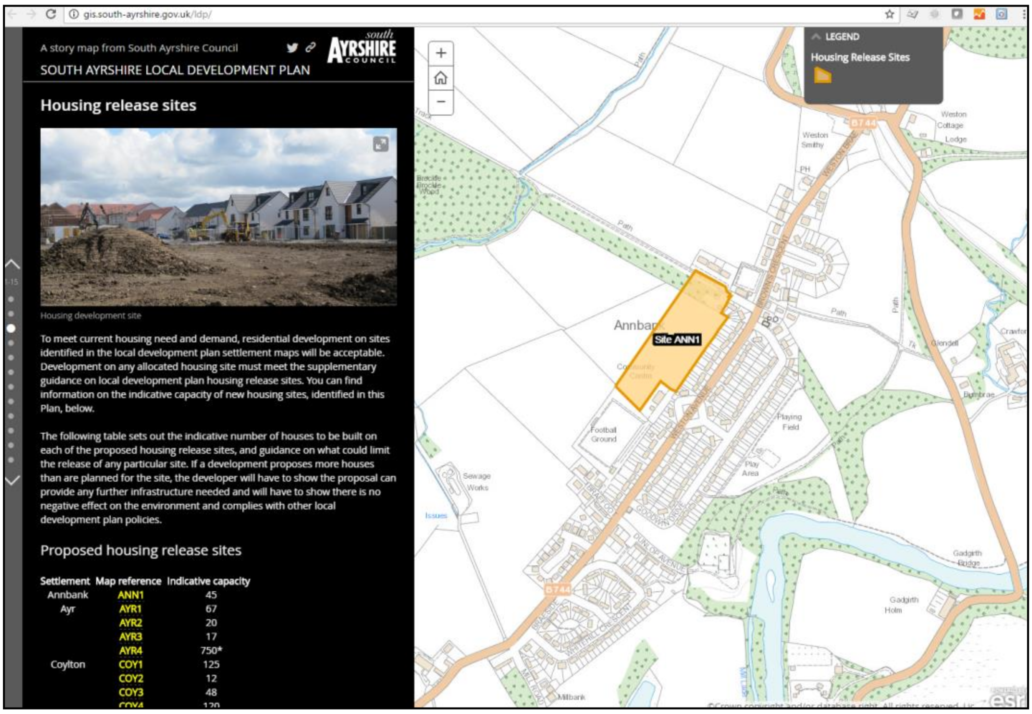


Figure 12. View of 'story map' for South Ayrshire Local Development Plan (http://gis.south-ayrshire.gov.uk/ldp/)

6.3.3 No new forms of functionality in 3D visualisation have been developed which are likely to be used in practice in different phases of the planning process. Functionality such as overlaying map, development plans or other spatially defined imagery on terrain or other backdrop images (e.g. aerial imagery), is consistent with requirements of identification, interpretation or modification. However, means of accessing such materials are changing. The ongoing uptake of mobile devices has been accompanied by an increase in the range of applications. These include the accessibility, and thus likely use, of online spatial data referred to above.

6.4 SOFTWARE AND DATA INFRASTRUCTURE

6.4.1 Combining developments of online data warehouses and supply, ongoing improvement in data transfer speeds (in general), software tools are becoming available and used which enable the creation of 3D models of user specified areas, almost in real time. Purchase of a licence enables user access to online data resources (e.g. Bing) for terrain and aerial imagery, with no requirement for the user to locate, purchase or load. Packages such as Autodesk Infraworks 360 enable the creation of 3D models for anywhere in Scotland (i.e. rural and urban), with the representation of features such as buildings, field boundaries and transport infrastructure using pre-set parameters (e.g. colour, texture). Such tools can be used by expert or public audiences with relatively low levels of technical expertise, guiding the appropriate scales and resolution of spatial data to produce a coherent representation of an area.

6.4.2 **Figure 13** shows an area around Dalkeith, Midlothian, representing changes in built area with 3D building against a backdrop of aerial imagery and boundaries of land classes from the Land Capability for Agriculture for Scotland.

Figure 13. Perspective view of Dalkeith showing new housing since 2008, with backdrop of aerial imagery and boundaries from the Land Capability for Agriculture for Scotland (ClimateXChange).

6.4.3 Similar capabilities are emerging which are directed at city environments. An example is the ESRI CityEngine (www.esri.com/software/cityengine). The types of uses to which this is put suggest that it is aimed at communication with professional and public audiences at early stages of a proposal, and in presentation of a Masterplan. An example application is of 10km^2 of Marseille for Effiage, a French civil engineering company. An example of this application is shown in **Figure 14**.

Figure 14. Perspective view of Masterplan of Marseille waterfront represented in ESRI CityEngine (Source: ESRI).

6.4.5 The application of such tools in the UK, include representing proposed developments and existing built areas can draw on increased web-based and online materials. **Figure 15** shows an example of use of ‘Carto3D by Swindon Council, linking OS MasterMap data with information in submitted to the planning portal enabling the visualisation of new proposals in the context of the existing built environment.

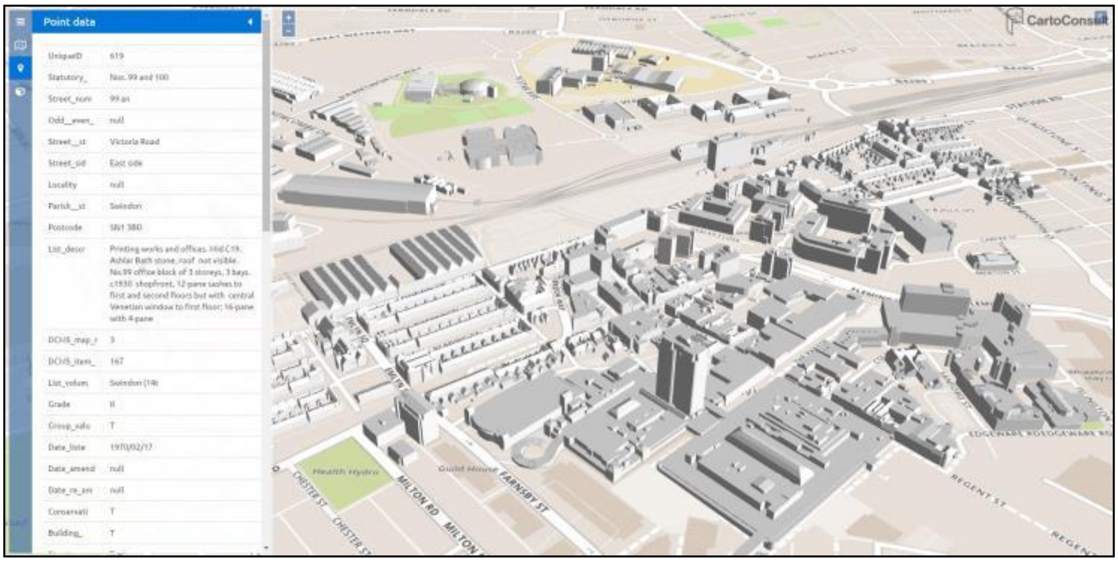


Figure 15. Perspective overview of proposed developments and existing built environment (Source: Carto3D).

6.4.6   Digital infrastructure which integrates software and data for its presentation and use in planning or related activities is evolving rapidly. There is a significant increase in accessibility to publicly available data via web mapping services (e.g. via Scotland’s Environment Web), and databases compiled for use with commercial products (e.g. Bing, LinkNode Ltd.). The use of cloud-based infrastructure will support this evolution and the services it will be able to support in relation to planning.

6.5 PHOTO-REALISTIC 3D MODELLING

6.5.1 Photorealistic, high resolution representation of environments, particularly of natural and semi-natural environments with detailed information on plants, has been available for some years, with updates to products continually becoming available. Such products are used to illustrate environments which predominantly comprise vegetation, with outputs as videos and walk-throughs as well as still images.

6.5.2 Significant impact is created by the coherence of the components of the imagery notably in consistency between the ecology of the site, plants and prevailing conditions (e.g. season, time of day). However, this requires investment to ensure the level of quality is achieved as anything less is likely to underline the effectiveness of the outputs.

6.5.3 An example, created in Lenne 3D to communicate content and features in the Sanssouci Palace Park in Potsdam is shown in in **Figure 16**. A video can be accessed at http://lenne3D.com/portfolio/spaziergang-in-einem-verlorenen-garten/). The speciality of this type of product is the accurate representation of botanic features in terms of individual species, form and colour evolving consistent with the season of the year, and the coherence of the movement of features (e.g. leaf, branch, trunk).

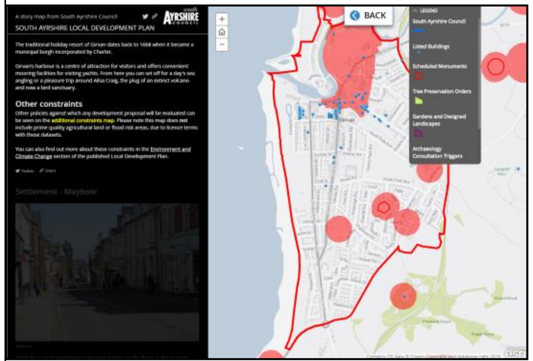
Figure 16. Scene of walk-through of Sanssouci Palace Park, created in Lenne 3D (Source: Lenne 3D).

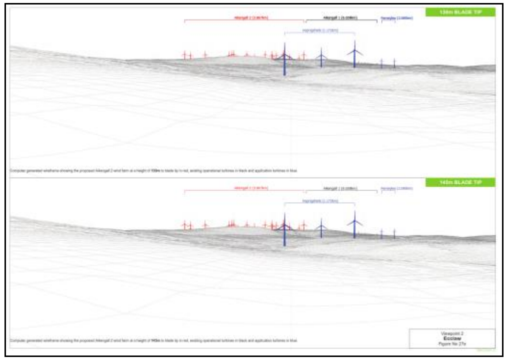
6.6 AUGMENTED REALITY

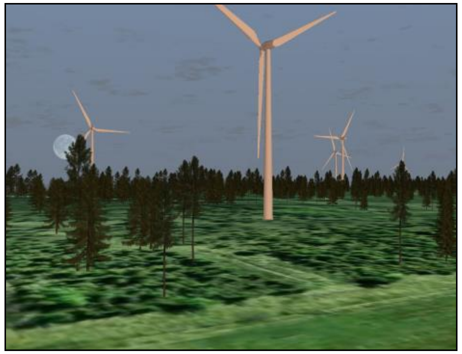
6.6.1 *Imagery* The use of digital video and 360^o imagery is an increasingly practical capability. Cameras such as the Ricoh 360' S, launched in 2015, and other cameras with similar capabilities, means that the creation of 360^o still and video imagery for relatively low cost is increasingly feasible. Video imagery from such sources can be inspected using standard image tools with functions of pan and zoom, and linked to WWW-based geographic tools (e.g. Google Maps and StreetView). This enables easy access for public exploration and interpretation of environments. Such imagery can be used as backdrops for video with animated 3D models incorporated, examples of which are of use in Germany for assessing impacts of wind turbine developments (e.g. Biosphere3D).

6.6.2 *Mobile capability* As noted above, online access to information is enabling new opportunities for using tools in planning related activities, including uses on-site. An example of such tools on mobile devices are those of Linknode Ltd. (www.linknode.co.uk/), and Eyesee (www.pinnaclevl.com/). The Linknode tools (e.g. VentusAR) are being used by renewable energy developers for on site visualisation of developments. Examples include above-ground photo-voltaic (http://ventusar.com/wp-content/uploads/2015/07/GreenCat_VAR_CaseStudy.pdf), and discussion of cumulative visual impacts of wind turbines, drawing on a database of existing, approved and proposed wind energy projects. In planning processes, the approach can add valuable capability for pre-development discussion and exploration of options with stakeholders (e.g. statutory authorities, local authorities, and public).

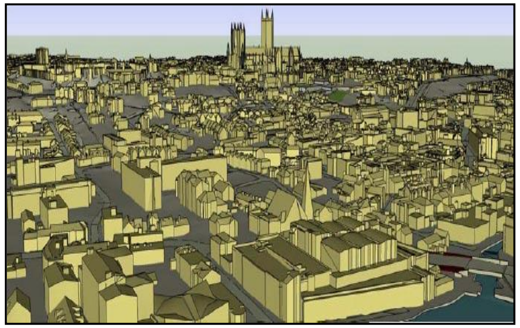
Table 3. Examples of the presentation of digital imagery and 3D visualisation in planning and development proposals.

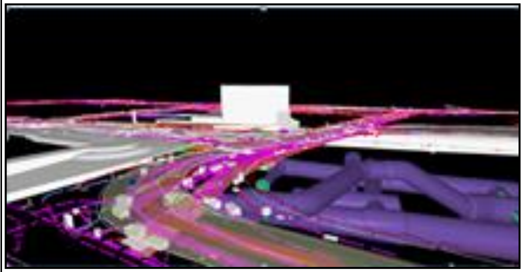
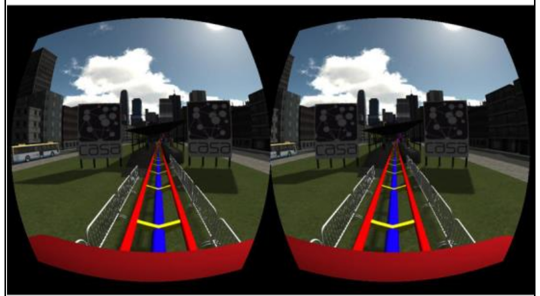
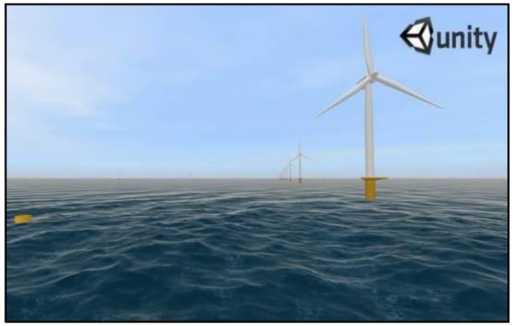
Application	3D visualisation tool	Description visualisation	Purpose/use, referring to Tables 1 and 2	Example image	Accessibility/ availability of tool/ usability/ limitations (e.g. data)
Communicating Local Development Plan for South Ayrshire	None	Raising public awareness	Informing, consulting and educating about LDP and prospective developments.		Free availability of output online (http://gis.south-ayrshire.gov.uk/ldp/). Data: OS backdrops (One Scotland Mapping), local authority plans and maps overlaid via WebMapping Services.
Kirkcaldy Town Centres Planning Pilots Programme	3D modelling tools; software 3DS (awaiting confirmation)	Representing outputs of workshops on visions of future town centres, following Scottish Government Town Centre Toolkit (Vision the future). www.gov.scot/Resource/0048/00489261.pdf	Gathering information and perspectives, consulting, representation of plans to test ideas and seek advice	 	Imagery produced for reporting on outputs of visioning exercises. Data: project specific, designed to represent options for development of centre of Kirkcaldy.

Windfarm Proposal (Aikengall II, www.communitywindpower.co.uk/projects/aikengall-ii/3.htm).	Wireframe; software: ReSoft	Representation of the cumulative visual impact of turbines upon the landscape of a proposed extension to an existing wind farm. (https://pa.eastlothian.gov.uk/online-applications/applicationDetails.do?activeTab=documents&keyVal=MQR3LOGN01500).	Public and Stakeholder consultation as part of the Landscape and Visual Impact Assessment section of the EIA. (Comparing varying turbine heights).		Easily accessible, widely used software for public and expert use. Geospecific models.
Windfarm proposal (Aberdeen Bay)	Photomontage; software: ReSoft	Representation of seascape with wind turbines in place	Public consultations for Aberdeen Bay windfarm	 (extract from original photomontage)	Easily accessible, widely used software for public and expert use. Geospecific models. Data used: OS DTM (10 m x 10 m), ground photographs for selected viewpoints.
Windfarm proposal (Aberdeen Bay)	3D model, virtual reality; software: Octaga and Vega Prime	Representation of alterative scenarios of wind turbine layout, and viewing under different environmental conditions	Raising public awareness of windfarm, pre-proposal		Specialist hardware, publically available software, group engagement. Geospecific models. Data used: OS DTM (10 m x 10 m), aerial imagery for textures, ground photographs for textures of buildings

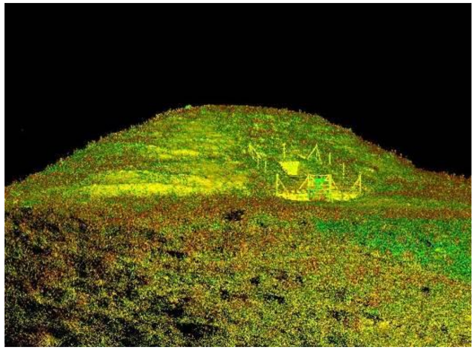
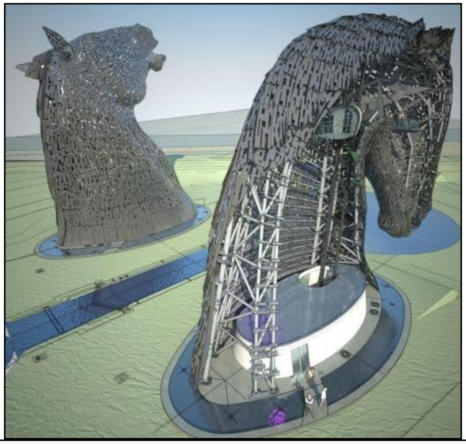
Windfarm proposal	3D model; software: Octaga	3D model, interactive visualisation of windfarm proposal	Formal public consultation of windfarm proposal		Easily accessible software, non-specialist hardware, data from public sources. Geospecific models. Data used: OS DTM (10 m x 10 m), aerial imagery for textures, ground photographs for textures of buildings
Urban development of offices and shopping: Marischal Square Development by Aberdeen City Council and Muse Developments	Eyesee Visualisation software www.pinnaclevl.com/index.html	An interpretation by software firm Pinnacle Visualisation, based on public documents submitted as part of the planning application.	Community engagement, public exhibitions		Geospecific models. Data used: Ground photographs for textures of buildings, and data on building dimensions for 3D model.
Above ground PV – in field assessment	3D models superimposed on imagery viewed on mobile devices	Visual assessment and communicating plans for above-ground PV	Gather information and perspectives, and test ideas, seek advice.		Imagery produced for communicating plan and support visual impact assessment; in0field background – live view on mobile device, with 3D model overlaid (Image permission being sought – GreenCat and LinkNode).

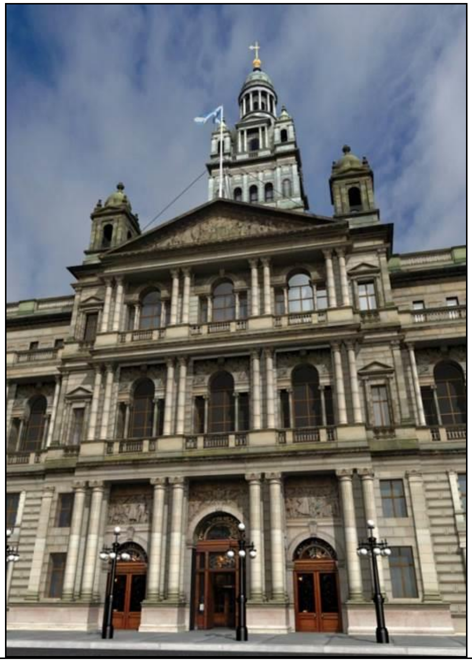
Forth Road Bridge – Queensferry Crossing	Bentley MX Autodesk Civil 3D Autodesk 3Ds Max Design Autodesk Civil View Autodesk Autocad Adobe Photoshop Adobe Premiere Unity	Computer-generated flythrough and images of the replacement bridge.	Community engagement and publicity for the project		Videos of various fly through showing the replacement bridge. The images and some videos are also contained within Transport Scotland and Jacob/ ARUP websites.
Aberdeen Western Periphery Road	Vega Prime	Computer-generated flythrough of the Aberdeen Western Peripheral Route	Community engagement, public exhibitions		Software easy to use with multiple functions; design plugs-ins for road infrastructure and signage; allows for rapid application prototyping and modification. Geospecific models. Data used: OS DTM (10m x 10m), textures from mix of aerial imagery and a pallet of textures. Models of trees from model collection.
Dundee waterfront, V&A by Live Visualisation	Information not provided	Application of gaming technology to create a detailed photo-realistic 3D visualisation	Awareness raising		The software gives an accurate representation of physical spaces, and can be used by companies interactively for a wide range of purposes, from promotional to training and education.

City of Lincoln Council: 3D Model for Proposed Development	SketchUp	The model was created using photogrammetric software, delivered in Google SketchUp and draped with high-resolution aerial photography to provide a realistic view of the city that can be observed and assessed from any viewpoint.	Increases the efficiency of the overall development management process, in particular: - Public consultation - Planning committee meetings - Consideration of planning applications		Offers flexibility so that new buildings can easily be added and new views modelled. Presents a simple solution from which all users and abilities can benefit. Provides an accurate and consistent model for measurement and line of sight views. Geospecific models. Data used: Building outlines from OS MasterMap. Source of height data not known.
Aberdeen – Golden Square	3dStudio Max and Vega Prime	Creation of model in 3DSMax for use in a virtual reality theatre using Vega Prime display software	Public consultation for the local authority of scenarios of future designs		3D model creation software widely available. Depiction in Vega Prime and Virtual Reality environment (Virtual Landscape Theatre) requires conversion and use of specialist hardware. Not geospecific model. Terrain assumed level. Building dimensions and textures from ground photographs.

London Transport Crossrail project is the largest civil engineering project in the UK. Joint venture by Atkins and Arup.	ESRI ArcGIS, along with Bentley Geo Web Publisher, FME for data export into 3D CAD	ESRI ArcGIS, along with Bentley Geo Web Publisher, FME for data export into 3D CAD	Awareness raising		Topographic information from Ordnance Survey.
Raising awareness of urban development	Immersive representation of 3D models, digital imagery, video	Representation of site-level environments (urban and rural; pre-and post-development)	Consulting on reactions and gathering information and perspectives		Oculus Rift available for retail price c.£300. Models available for free-download for demonstration and some games. Cost of models for operational use in planning depend upon purpose and application. Data: 3D models and building textures specific to site.
Dogger Bank Offshore Windfarm	Unity 3D	Viewing of different scenarios of wind turbine size and layout, types of foundation used, and infrastructure	Stakeholder meetings, facilitated constructive discussion		Easy to use with multiple functions; users of the simulator can control time of day (night/day), sea state, and weather conditions (e.g. fog, haze and wave heights). Detailed model not required to be geospecific. Textures of sea surface generated by software.

Appenzell Innerrhoden, Switzerland: Visualising and analysing future growth	Autodesk Infraworks	Create a 3D model of the canton based on GIS and geospatial terrain data, enabling officials to visualize the different growth strategies against the backdrop of Appenzell's existing buildings and landscape.	Stakeholder meetings, Municipal planning, Decision making		Easy to use with multi functions: easy to manage and evaluate multiple development plans within a single model, ability to visualise impact of different strategies for increasing building densities. Geospecific models. Data used: Textures from aerial imagery and a palette of textures. Models of trees from model collection. Building outlines from mapping agency, textures from photographs.
3D Battle of Bannockburn Game Simulation. www.designweek.co.uk/news/simulating-the-battle-of-bannockburn/3038070.article	Autodesk 3DS Max, MOCAP, 3D Scanning, 3D Printing.	Automatic Life-size 3D show presentation systems have been designed. It is blending real and virtual with interactive characters and 3D Battle Map.	Community engagement, public exhibitions		Easy to use with multi functions: 3D Immersive space; battle room, Interactive CGI characters; good quality AV and Control Systems.

Scottish Ten: The Heart of Neolithic Orkney World Heritage Site. www.scottishten.org/property3	Laser scanning, CyArk 3D Viewer	Record the 3D surface geometry of Orkney's Maeshowe chambered tomb in a digital form. A large amount of 3D data was collected within a short period of time and produced in a 3D Model.	Digital heritage preservation, Community engagement, public exhibitions,		Easy to use with multi functions: develop a new interactive 3D viewer, which can be used to explore the 3D point clouds and models we produce from the laser scanning projects. Source of data: laser scanning, with textures from photographs captured at same time as scanning.
The Kelpies sculptures/boat lock	CATIA > Rhinoceros > Autocad >Tekla	Representation of Kelpies	Design of the large sculptures, and engineering details		CATIA and Rhinoceros are 3D Cad / modelling softwares. Autocad is a widely used CAD software. Tekla is modelling software for the construction industry.

Glasgow Urban Model www.glasgow.gov.uk/urbanmodel	3D Studio Max	Glasgow City Chambers	High resolution 3D digital Models for citizens, development industry and City Council		Widely used modelling/visualisation software. Building details provided by ground photographs.
Regeneration of Maryhill, Glasgow www.williemiller.co.uk/portfolio-items/maryhill-town-centre-action-plan-2	Google Streetview, Photoshop, 3d Studio Max	Proposed Maryhill regeneration	Town Centre Action Plan. Visualisation of proposed urban regeneration		Widely used 3D modelling and visualisation software. Imagery extracted for geospecific locations and merged into photographic images for context

7 Stakeholder Interviews

7.1 Engagement with different types of stakeholders was used to explore the awareness, perceptions, actual experiences, and plans for use of 3D visualisation tools. The types of stakeholder included Scottish Government planners, strategic planning authorities, local planning authorities, public agencies, consultants for developers, and representatives of planning advisors for the public. A provisional list of interviewees was discussed with the project Steering Group from which a selection was made.

7.2 A questionnaire was developed to guide interviews with stakeholders. These were to elicit opinions on specific aspects of 3D visualisation tools and provide scope for more general comments. Questions were informed by previous studies and scientific literature to elicit information from stakeholder experiences using other means of achieving current requirements for tasks such as visual and cumulative visual impact assessments, awareness raising, and community engagement. The wording of the questionnaire was agreed with the Steering Group.

7.3 Contact was made with those on the initial stakeholder list, with follow-up emails and telephone calls. Several organisations nominated alternative personnel to lead their response to the surveys, with some providing a response collated from the perspective of a team from across the organisation (e.g. two local authorities). To obtain the perspective of communities, contact was made with Planning Aid for Scotland (PAS) which circulated the questionnaire amongst its volunteers, all qualified planners, from which three responses were received from around Scotland.

7.4 Follow-up telephone calls were conducted with respondents except those of the PAS volunteers. The background of relevant policies and associated regulations and guidance provided a context for the discussions with stakeholders regarding the use of 3D visualisations and tools. These calls enabled further details to be obtained on specific topics and issues to be clarified by respondents, including comments on candidate case studies of 3D visualisations and technology.

7.5 A summary of strengths, weaknesses, opportunities and threats was compiled from stakeholder responses to the surveys, which are summarised in Table 4 at the end of this section. They are discussed together with the responses to the interviews below.

7.6 Of the 15 interviewees, 14 considered themselves to be familiar or very familiar with 3D visualisation tools. In discussion, their comments were informed by experience of the use of a range of 3D models or visualisation materials. The organisations represented comprised public bodies (e.g. local authorities and agencies; NGOs, consultants, and planning advisors to communities).

7.7 Amongst interviewees in public bodies, familiarity with 3D models and visualisation technology was with receiving and using materials submitted by developers such as CAD products, Sketchup, maps and hard copy printouts. However, consultants and some PAS volunteers reported familiarity with specific 3D visualisation and spatial data handling and analysis packages, and specialist forms of data capture (e.g. laser scanning, 3D Topos, ReSoft Windfarm, etc.).

7.8 Of the types of interviewee, the functions of the organisation generally matched the level of in-house capabilities for developing or using 3D models and visualisations. Consultants had capabilities, experience and skills in the development and use of 3D models. The response from most other types of organisation reflected that of:

> "Not in-house. All visualisation materials are provided by developers or designers." [Interviewee 5]

7.9 Of those which do have in-house capabilities these were restricted to Sketch-up (2 local authorities), and Photoshop. One noted that:

> "Yes, we have Windfarm software but have never had any training on it, and there is no IT support for it so it is not as useful as it could be." [Interviewee 18]

7.10 When asked about the current uses of computer visualisations to consider development proposals, by their organisations, several respondees noted that they did not use such tools directly. However, most people referred to different roles for visualisation tools and imagery within their organisation as part of their operational processes. For example, wireframe imagery (for an example, see entry on Aikengall II windfarm proposal in Table 2) derived for selected viewpoints aided the interpretation in the field for undertaking landscape assessments of wind turbine proposals. Others have a responsibility for reviewing visualisations submitted as part of a development proposal.

7.11 The organisations surveyed had experience of successful and unsuccessful uses of visualisation tools and materials. Successful uses were where the levels of detail, medium and functionality fitted the purpose to which they were contributing.

> "Yes. We often find that visualisation of proposals in the Design Forum setting are helpful to understand the massing and design rationale of buildings. At the scale of places, we find that both layered mapping and scenario mapping are helpful to understand the possibilities of investment, leverage and impact. The visualisations are a tool to use as a 'what if' rather than a factual description of 'what will'." [Interviewee 10]
>
> "…to record and understand the juxtaposition of historical features in their landscapes, and of the sequence of the process…The whole industrial processing area has now been demolished, so this is the only surviving 3D evidence for the site" [Interviewee 11]

7.12 Indicators of success included where materials provided to public bodies adhered to guidance or standards provided. The aspect of success varied with some examples relating to the technology and media (e.g. the positive impacts of fly-throughs and animations of model features for promotional and working at the conceptual stage of a proposal.

7.13 Successful uses of computer visualisations need not be technologically sophisticated, such as that provided by Interviewee 8:

> "During community charrettes where it is important that proposals are easily understood by a non-professional audience. It is important in these situations that material is generated very quickly, and visualisations are often basic in their presentation or are used as a framework over which hand drawings are made." [Interviewee 8]

7.14 Limitations and poor quality visualisations have a number of adverse impacts, all making the proposed use of the materials unsuccessful, and potentially the opposite impact to that intended. Lessons to learn from the feedback from respondents can be grouped as follows:

Content

7.15 The materials should not have overly complicated content, and tailoring the level of detail to the purpose of the task. Tomlinson (2007) sets out some guiding questions when discussing the planning for Geographic Information Systems. Similar questions are as applicable when considering the design and production of 3D visualisations, which can be worded as:

- How do the individuals who make the decisions currently do it?
- What do they need to know to do their tasks?
- What materials are appropriate for these tasks?
- What do they need to know to carry out their responsibilities?
- How wrong can they afford to be?

7.16 Feedback from Interviewees 10 and 11 notes

> "What is unhelpful is to have too much information, too detailed and irrelevant, too early. You can visualize anything. The trick is in showing the restraint to highlight the message you are sending in just enough and no more visualisation." [Interviewee 10]
>
> "It is critical for our work that we know enough points of reference." [Interviewee 11]

7.17 This feedback also reflects the requirements of the stages in a strategy for engagement and awareness raising (**Table 2**).

Presentation

7.18 The quality and level of detail of the visualisation materials should be commensurate to the purpose. For example, if the stage of the planning process is to elicit initial ideas from communities, or consult on options then the details in the visualisations should be consistent with the use a facilitator may make of the materials. If the materials and purpose for their use are out of synchronisation the impact can be negative to that intended. For example:

> "Highly polished 3D digital visualisations can give an impression that proposals are so advanced that decisions have already been made and are fixed. This can sometimes compromise community engagement processes." [Interviewee 8]

7.19 The tailoring of presentation materials to each stage of the planning process will facilitate good quality interactions and resultant outputs from that stage of the planning process. The significance of the opportunity is noted by Interviewee 10:

> "This raises an issue for outputs: if visualisation outputs are too detailed and spatially specific, then they narrow down the thinking of possibilities which are more strategic. This is about the difference between 'blobs on a map' to kick start discussion and detailed proposals. The order is important; at strategic level discussions, you tend to need the blob on a map approach, and an ability in the person preparing the visualisation that this is enough information for the decision-making task; it is also important to have an awareness that someone else will need to prepare work at a different level of detail to make sense of the decision." [Interviewee 10]

7.20 Examples of successful uses of 3D models and visualisations, presented in case studies, illustrate some of these points by matching the representation to the role the materials are planned to play at the relevant stage of the planning process.

Accuracy

7.21 As noted in Section 4, accuracy in 3D visualisation is recognised as of key importance for the adoption of appropriate content and technologies (Sheppard, 2005b). The use of inappropriate technology and materials (e.g. data, software functions, hardware) can undermine the intended purposes of the 3D visualisations. The accuracy and resolution of the input datasets require to be coherent, i.e. mutually consistent.

> "We often get the wrong information visualised well. … What we need is to see what matters, done well, and accurately. There is a tendency in development proposals to have too many visualisations, in different forms, which more or less tell you one story, with more or less the same information, just shown differently. On a technical side, bad sketch up models which are presented as CGI can be off-putting and inaccurate; however, they can be excellent as a basis for sketch discussions." [Interviewee 10]

7.22 For example, data which are inappropriate for the purpose may lead to the misrepresentation of a proposal (e.g. by use of a low resolution DTM overlaid with high resolution aerial imagery and detailed model features, combined in a visualisation). Similarly, from Interviewee 3:

> “The use of 3D models to demonstrate scale and massing of buildings has proven a challenge to some members of the public to understand. For example, it has been assumed that models shown are a very accurate representation of the final buildings, which is not the case, e.g. comments received about the colour of buildings of lack of entrance doors etc.” [Interviewee 3]

7.23 As new technology makes tools increasingly available so care should be exercised with respect to early releases of software, data and their uses. Current examples include the increased availability of Apps for use on mobile devices.

> “We have found that some of the Augmented Reality Apps are not yet accurate enough to be of great use.” [Interviewee 22]

7.24 If such tools are to become of operational use in the planning process, it will be essential that the outputs (e.g. views presented on screen) are reliable, trustable and their use fits an appropriate step in a process.

7.25 A different form of error is in the prospect of the user to be unable to reference a visualisation in relation to the environment being represented. Generally visualisation materials enable this to be done successfully, and moderately easily. However, this can be more problematic with some forms of visualisation, notably wireframe diagrams.

> “Wireframe diagrams can be tricky, and it would help if some of the features (e.g. hilltops) were named.” [Interviewee 18]

7.26 This is particularly so when there are limited terrain features with which to cross-reference the visualisation with the physical environment.

> “Visualisations are harder to use in flat landscapes. They work best where it is easiest to match the skyline topography to the skyline wireframe/photomontage. In flat landscapes, a match to other features is always needed, and so wireframes can be difficult to use without matching photographs and/or photomontages.” [Interviewee 22]

7.27 It is recognised that very few images can, or will, be 100% accurate, despite the best intentions of their creator. Generally they are considered to be more accurate than hand-drawn sketches and much more informative than elevation drawings. However, their authenticity can be more difficult to scrutinise than a hand-drawn sketch.

Methodology

7.28 The methodology used for generating a 3D visualisation requires to be properly documented and followed, providing metadata for the 3D model or visualisations, with tolerance levels associated with each method or component. Errors can be introduced at each stage of a process, which will vary by approach and tool used. They could include the photography, identification of location (including elevation) of viewpoint and reference points, photo-stitching, accuracy of digital elevation module, aligning photos, photo-editing and presentation of image (size, resolution and projection).

> "Visualisation guidance has come a long way in the last 10 years, however visualisations can only ever be illustrative – they do not show every aspect of the development and can only show what is known." [Interviewee 22]

7.29 Of particular importance is the appropriate use of materials to synthesise and represent the space of interest rather than the technical ability to visualise it. If survey data is used then the imagery should be an accurate representation of the environment whereas if any form of CAD is used then there will always be an element of subjectivity to the content of the scene.

> "The poorest visualisations happen when there is a greater level of skill on presentation and less on synthesis of the spatial and volumetric possibilities and realities." [Interviewee 10]

7.30 A distinction is drawn between whether the imagery is honest and truthful and whether they are realistic representations of a landscape or scene. Credibility and authenticity may be lost when trying to recreate landscapes and features which can no longer be verified. In such cases, the accompanying information should make clear that the visualisations are not intended to be accurate representations. The challenge is to provide a faithful representation so that the reader can make the same level of interpretation of the content as they would on site.

> "Similar, but also in terms of the completeness and integrity of the information that is used. There is a lot of literature about the creation of imagined past landscapes that could never actually have existed, and how that can be both convincing and misleading" [Interviewee 11]

7.31 The application of 3D modelling tools and materials was identified as aiding decision-making for "any form of built development" [Interviewee 1]. This was particularly the case in urban environments where …

> "issues such as scale and visual impact are the principal issues to assess." [Interviewee 8]

7.32 Foremost amongst the examples given for the types of uses of computer visualisations were major infrastructure projects, exploration of scenarios, Masterplanning and Strategic Development Planning.

> "Scenario mapping is useful as part of pre-project and strategic planning/design stages, particularly in terms of understanding public policy and economic synergies.
>
> Masterplanning proposals which focus on form and massing and the relationship to the wider landscape are helpful. CGI details of specific houses are less useful at this scale. Major infrastructure projects are useful again in massing and location, to inform the design process and the evaluation of impacts." [Interviewee 10]

7.33 Other uses identified included street design with different scenarios of proposals. Recently, particularly useful has been 3D visualisation images which can illustrate

> "imaginative and understandable layouts of street furniture" [Interviewee 5].

7.34 However, the level of detail in plans does not always convey sufficient information, especially from the perspective of vehicle users. Improvements would include the provision of imagery which would enable an impression to be obtained from the perspective of a driver. Uses have also included the illustration of night time lighting, but the production of good quality imagery can be problematic.

7.35 3D visualisation tools were perceived as being of particular assistance with proposals for windfarms.

> "Potentially any large planning application but, in practice, it's windfarms." [Interviewee 19]

7.36 This was partly due to the extent of the experience with such applications, and that:

> "as most guidance exists for this type of visualisation, and therefore the outputs tend to be more standardised." [Interviewee 22]

7.37 Therefore, there are clearly defined and accepted stages in the planning process for which developers and consultants have a basis for investment in tools and materials for development proposals, and statutory consultees have processes for their reviewing and interpretation for assessing environmental impacts.

7.38 Their use in relation to planning of housing developments was reported as less effective.

> “To a lesser extent they can be useful in new housing developments to relay the character of a place, although more traditional techniques such as sketches and hand drawing may be equally or more useful.” [Interviewee 8]

7.39 The issue of accuracy and reliability also arose, with concerns expressed about the accuracy of computer visualisations.

> “They can provide useful additional material to that provided in the environmental statement, but cannot replace this. This is because the user cannot verify the images provided in 3D and cannot test how they have been produced.” [Interviewee 9]

7.40 3D imagery provides one source of information alongside others at each stage in the process of planning, whether in a workshop, Committee, by an individual, or on site.

> “… actually visiting the site and creating a mixed economy of evidence which sets a context for the visualisation.” [Interviewee 10]

7.41 However, visual representation is only one element of landscapes. Information about other aspects is also important.

> “although maybe 3-4 in terms of visual representation in good cases. The problem being that visualisation is only part of the story, and other aspects of setting, association etc. can be equally or even more important.” [Interviewee 11]

7.42 The nature of many 3D visualisation materials is reported as being inflexible, being printed or as digital images in a report.

> “These are not flexible (e.g. cannot see 'round the corner' in a street design).” [Interviewee 5]

7.43 The use of visualisation tools to test alternatives, early in the process of a proposal, can take advantage of the flexibility of 3D modelling systems. As a proposal is moved through stages of the planning process so that capability becomes less relevant.

7.44 With some 3D visualisation tools, the preparation of outputs can also be a time consuming process, and materials are not always required to be updated to reflect ‘as built’ compared to ‘as planned’. The magnitude of the difference may be low, but for development proposals which have a history of being contentious this can be a cause of friction between stakeholders, or accusations of deliberately misleading. With reference to wind turbines the reason for final changes in a layout can be expected to be micro siting rather than changes in the proposal.

> "It is very difficult. Even removing a single turbine means re-doing the visuals to properly see it, rather than just imagining it was not there. Micro siting could be an issue for this - generally there are conditions allowing this to be varied by up to a certain distance, say 50m. The effects of this (if any) are not generally shown or known." [Interviewee 10]

7.45 This reflects also the differences between 3D visualisation tools, and the purposes for which they were designed, or their individual strengths and weaknesses. The use of a given tool should reflect its capability for supporting the use required for the relevant responsibilities to be discharged. So, at different stages in a process different functionality will be most relevant, such as walk-throughs, viewing different options for the development, changes through time, photo-realistic imagery, and the inclusion of non-visual information. For example, functionality at the initial stages of development, to aid understanding of the development proposed, may be walk-throughs. For assessment of proposals, viewing different options for the development may be more important, together with a capability to communicate the nature and location of specific changes (e.g. between layouts in proposals for replacing turbines on wind farms).

7.46 The inclusion of non-visual information to accompany visual representations is particularly important.

> "All of these are important and they all must be available and used, but the key thing from the cultural aspect is the last one, non-visual information, because this is the key to past and current cultural significance, and can include both tangible and intangible features and associations. . Battlefields like Culloden and Bannockburn are good examples. [Interviewee 11]

7.47 Finally, views of the proposed development within the surrounding context are also important, i.e. the details of the representation of the development in combination with other features adjacent or in the vicinity. This is likely to require geospecific models, imagery which is coherent. Evidence of their relevance to the task of decision-making will be the most significant factors affecting uptake.

> "A greater instance of visualisations being referred to or used in determination of applications will encourage greater use through improving the perceived value for the investment required." [Interviewee 8]

New visualisation tools

7.48 New visualisation tools also offer new opportunities. Recent relevant developments in technology include that associated with gaming.

> "This is already happening thanks to hardware and software developments, but the most significant development at present is the widespread usability of gaming technology, associated with various 'reality' related outputs." [Interviewee 11]

7.49 Other supporting issues identified included:

i) training in the use of visualisations in addition to their creation, which is increasingly easy to do, but not necessarily in the most appropriate ways, or with the best input materials;
ii) more user-friendly, publicly accessible resources;
iii) financial resources;
iv) reassurance on the quality of the outputs.

7.50 In addition to training, the practicality of available time to keep abreast of new opportunities is reported.

> "Keeping-up with the technology whilst still finding the time to use it" [Interviewee 11]

Cost savings

7.51 Some cost savings are anticipated, from reducing all requirements for activities on site and an increase in the use of digital media and reductions in costs of reproductions on paper. The accrual of such savings is most likely to be to the developer or development proposer. However, if there is no compensatory reduction in requirements for existing materials and media then the use of such tools may lead to extra costs.

Benefits

7.52 Most benefits are perceived as being able to provide new forms of information for decision-making, and add to the options available for content at different stages in a planning process. Benefits could include reducing the scope for inaccurate reporting of a proposal.

> "If clear images can be shown as part of a planning application, then they might help to stop/reduce campaigns developing against proposals on the back of hearsay and rumour. Not everyone is comfortable with reading plans, but most can understand 3D images, so it would be a much more effective way of communicating a proposal to the community/stakeholders. Obviously there would be a cost to the applicant though." [Interviewee 6]

7.53 Some are new capabilities, not realistically available previously, such as analysis of a site using 3D models rather than only its visual representation.

> “3D visualisations have proven helpful for measuring daylight/shadowing impacts which are otherwise difficult/time-consuming to measure.” [Interviewee 3]

7.54 However, if there are multiple sets of requirements or standards associated with the acceptance of some forms of visualisation then there are additional costs involved. Examples given include those sought by Scottish Natural Heritage and The Highland Council.

> “Improved 3D visualisation software/technology may reduce these costs somewhat, but there would need to be consensus and agreement between stakeholders as to the minimum requirements.” [Interviewee 22]

7.55 The choice of software and associated hardware infrastructure, licencing and data, are all considerations in the assessment of financial benefits. ‘Open source’ software, i.e. developed to agreed standards, often by volunteers, with functionality to match proprietary systems, is becoming increasingly available. Tools such as QGIS have functions similar in capability to ArcGIS. The Virtual terrain Project (http://vterrain.org/) has a wider range of functionality than most 3D visualisation packages. However, many organisations have regulations which restrict the use of open source materials, which may have the unintended consequence of limiting the scope for the exploration of the potential uses of tools where cost is otherwise the principal limiting factor.

> “Open source software can enable testing of skills and methods, and enable organisations to establish capability in visualisations. This can be supported by Open data from the public sector and mixed data clusters, from google, to other forms of generally accessible information. It is possible without massive cost, and the right skill, with some patience, to develop the capability of visualising well and create economies in decision making and option testing.” [Interviewee 10]

7.56 In general, the increase in ease of creating 3D visualisations, and their use at the most appropriate stages of a planning process, should be of benefit all stakeholders.

> “If more people were able to make visualisations more easily, then it is likely that developments would be better designed - i.e. a developer could use software to more easily explore alternatives and to come up with a better site/development design/infrastructure layout – if they have a good understanding of the constraints.” [Interviewee 22]

Technical benefits

7.57 Technical benefits also enable potential benefits to users, including experts and non-experts, for example in relation to understanding what is being proposed in a development.

> "The main benefits from a Council perspective would be better understanding by officers, elected members and the public." [Interviewee 19]
> "Increased public understanding of street layouts and designs of new townscapes. Detailed drawings are limited and can be off-putting to non-experts." [Interviewee 5]

7.58 Use of the other infrastructure, such as the internet, provides means of delivering to some of the aspirations of public policy referred to in Section 3.

> "Ability to share and disseminate with large number of people." [Interviewee 21]

7.59 Challenges to the uptake of computer visualisations were identified from organisational and functional perspectives. These can be grouped into four categories:

i) Costs:
   a. training of relevant staff
   b. software
   c. support (e.g. technical advice)

ii) Computing infrastructure:
   a. choice of software appropriate to each tasks in the planning process
   b. compatibility of software tools
   c. addressing institutional IT restrictions to enable use of Open Source software
   d. secure IT systems which enable use of interactive visualisation tools
   e. up-to-date IT hardware and communications networks

iii) Data:
   a. standardised metadata for 3D models and visualisations
   b. maintenance of data (e.g. for uses in assessing cumulative visual impacts of wind turbines)
   c. good baseline data (e.g. photography)
   d. the ease of exchanging 3D models between stakeholders at different stages in the planning process (i.e. the evolution of a model from one stage to the next)

iv) Outputs:
   a. difficulties in obtaining high quality outputs of visualisation due to large file sizes and printing
   b. provision of low resolution versions of imagery (e.g. photomontages) for public audiences via ePlanning portals to enable easier downloads but at the expense of making available copies of the original quality of imagery.

7.60 Issues relating to computing infrastructure also reflect the findings in scientific and technical literature, as described in Section 4, such as the need for tools to be fit for purpose.

7.61 The functional aspects of these issues include distinctions made by respondents with different institutional roles, such as volunteers and those working with communities (e.g. noting the weaknesses of providing materials via ePlanning portals at lower resolutions than originals, thus compromising the quality of engagement).

7.62 Interviewees who described themselves as familiar or very familiar with 3D models and visualisations, identified some areas in which visualisations may become increasingly available and used in the near future. These included more seamless access between features as viewed and information associated with development proposals, which may be presented as augmented reality, animated video clips and presented on mobile devices. A closer link can be anticipated between knowledge of environmental physical processes and socio-economic factors, and the visualisation of landscapes, such as the use of quantification of land use types and values. Some specific software packages were identified where some evidence of these facilities are emerging included Ventus AR and CityCad.

Table 4. A summary of Strengths, Weaknesses, Opportunities and Threats (SWOT) (as reported in stakeholder survey responses).

Strengths	Weaknesses
• Easily interpreted by the public • Accurate and realistic opportunity to assess impact	• Time/cost implications • Not so useful for planning decision making and LVIA
• Very good for public engagement	• Not always reliable or representative (confidence issue)
• Provide better understanding of a proposal e.g. Health centre • The consideration of multiple alternatives & the potential to integrate/access meaningful non-visual elements via a visualisation • Ability to visualise scenarios which you cannot physically see (e.g. virtual reconstructions and construction animations)	• Poorly documented, difficult to use • Often limited for some types of submissions e.g. wind turbines
• Communicate visual information	
Opportunities	**Threats**
• Better understanding 3-dimensionality and engagement • Improved options through navigable 3D models rather than static images.	• Dependency and compatibility of software • Poor quality in representation can undermine a proposal or argument
• Potential for integration into e-planning	• Additional cost to developers if made mandatory. There is a risk that by using 3D visualisation, people pay less attention to other important information when considering applications, especially a ZTV map and the assessment of effects.
• Improve reliability and representativeness	• Perhaps the danger of being misled
• Addressing development of real-time interaction, and having data-rich rather than passive models • Engagement of a wider range of audiences with digital data via visualisations	• Misleading representations discredit the technique • Visualisations may be seen as a substitute for real sites - e.g. if you have a digital record and visualisation of a site, there may be a perception that you don't ever need to visit it, or that the real site can be destroyed since there is a digital record
• Potential to reach a wider audience with reduced cost both of producing them and of printing and sharing them (web-based viewers etc.) and greater flexibility	• The potential to place too much weight on visualisations in the assessment and decision making process, reducing the weight given to professional judgement and experience – and to the making of judgements by professionals in the field. Non-landscape professionals can't undertake professional landscape and visual impact assessments themselves.
• Increased uses for streetscape design, consultations and exploration of safe environments e.g. simulations of driving, cycling and walking	

8 Case Studies

8.1 A set of case studies were selected, informed by interviews of stakeholders, covering different types of development, strategic and tactical planning for development. The level of detail available for each case study varies depending up on the sources of information, content and nature of use.

8.2 The case studies illustrate the use of different types of digital imagery, visualisation tools and outputs ranging from provision of a local development plan with associated spatial data and policies, interactive 3D models to the presentation of photographic panoramas, and from large-scale strategic plans to detailed consideration of changes in the environmental conditions affecting a single property.

8.3 The usability of the information and functionality of the tools and models includes the basic capabilities identified by interviewees for uses at different stages in a planning process: walk-throughs, viewing different options for the development, visualising changes through time, the provision of photo-realistic imagery, and the inclusion of non-visual information (e.g. maps). The key functions are identified for the purposes to which the 3D model or visualisations were put.

8.4 Two categories of ‘use’ are provided in the case studies.

1. Modifiable – users, or a proxy, can interact with the 3D models such that content can be modified, exchanged between stakeholders, parameters changed, or navigation following a user specified rather than pre-set route.

2. Prepared – 2D or 3D digital imagery made available from existing data stores, or generated from 3D models and presented as single images, as printed or digital presentation materials, videos of pre-set fly-throughs, viewing of imagery from pre-set viewpoints.

8.5 The materials in several of the case studies have multiple uses, most with a role in raising public awareness or engagement, and align with the classification of De Montmollin (2006) described in Section 4.

8.6 Tools and visualisations which have ‘Modifiable’ uses tend to have functions which enable audiences to provide inputs through the identification of aspirations for inclusion in a plan (e.g. Birmingham City Centre, Loch Lomond and The Trossachs Main Issues), or to change or comment on aspects of the detail of a proposal in development (e.g. in field augmented reality of agri-renewables). In each case, the principal audience is considered in the design and selection of materials and media (as per the strategy for engagement in **Table 2**).

8.7 Generally, the capabilities of the 3D visualisations and tools support the testing of ideas, seeking advice, and working in partnership between stakeholders in the classifications of Dorcey et al. (1994) and the UNDP (1997); defining interests, actors and determining agenda of Environmental Management, as set out by Green and Hunton-Clarke (2003); and the Citizen Power class of Arnstein (1969), as summarised in **Table 1.**

8.8 The uses of such tools align with the aspirations of the Scottish Land Use Strategy of “People should have opportunities to contribute to debates and decisions about land use and management decisions which affect their lives and their future” (Principle I).

8.9 A different use of a 3D model to those of public awareness raising is that of a single cottage for the calculation of specific impacts of shadows due to a proposal for an earth embankment as part of mitigation measures. Other examples of such analytical uses of 3D models were reported in the surveys of stakeholders, such as:

> “Additionally, models have been used to assess daylight/sunlight penetration into development sites.” [Interviewee 1]

8.10 This is an example of ‘self-management’ by a community (**Table 1**), contributing to the final decisions, in this case by a Reporter at a Local Enquiry. It is consistent with the aspirations of the Aarhus Declaration of obtaining “… justice in environmental matters”, as introduced in Section 3.1.

8.11 Those 3D visualisations which are ‘Prepared’ materials are generally in formal submissions of planning proposals (e.g. Wishaw Health Centre, Whitelaw Brae), following set guidelines associated with the type of development, or informing decisions (e.g. Highland Council Panorama system), and have ground level views using augmented imagery (e.g. combining a 3D model and ground photography, or annotating ground photographs).

8.12 Tools which use a 3D model as an input can be used to produce a high level of photorealism for outputs (e.g. Wishaw Health Centre). This is supported by an observation by Interviewee 1 when discussing high quality printed visualisations of buildings:

> “These are being used more extensively within planning submissions to articulate the design of buildings providing 3D perspectives rather than relying on 2D drawings. This however works more effectively when the context is provided.” [Interviewee 1]

8.13 Generally, such tools support the levels of participation of consultation and gathering information and perspectives of Dorcey et al. (1994), and consultation and informing of Arnstein (1969). They fit the category of 3D visualisations of detailed and specific, as introduced in **Figure 5**. The examples of such prepared materials contribute to achieving the aspirations of Scottish Planning Policy of delivering high-quality places and taking a positive approach to enabling high quality development.

8.14 Tools for uses of a strategic nature, either directly or for the provision of 3D imagery, have 3D models as a core input, and are used for developing visualisations from set viewpoints, or video fly- or drive-throughs (e.g. Dundee Waterfront, Glasgow Urban Model). For TayPlan’s 2nd Main Issues Report a video was created from the

3D model and accompanying 3D visualisation images prepared for the Main Issues Report.

8.15 These enable overviews of the relevant areas, with capability for representation at different levels of detail. That is, the models can be modified to provide photorealistic impressions of buildings, or stylistic representations for interpretation by experts or, to communicate non-visual information (e.g. South Ayrshire storymaps; building sustainability – Dundee Waterfront). These equate to the Symbolic overviews in **Figure 5**. Such a role is also reflected in the comments from Interviewee 1 when discussed change in urban environments.

> "Having said that in urban contexts, where there is not such a need for accuracy regarding the scale and distance of landscape (i.e. we are accustomed to scale by the presence of familiar features such as houses, trees, cars etc.), quality fly-throughs/overs can have a place both in determining the effect of a scheme as well as being able to demonstrate this at the decision making stage." [Interviewee 1]

8.16 The set of case studies provide reference examples for different types of application of digital imagery, tools and 3D models and visualisations in the planning process. Contact details or web links are included for obtaining further information on specific aspects of each case study.

Title of case study: 1. Glasgow Urban Model

1. Topic

Glasgow Urban Model is a 3D Digital representation of the City Centre and River Clyde Corridor.

2. Role of visualisation

The primary objectives of the project are to:

- enhance the understanding of the built environment through the use of a 3D photorealistic representation of the city
- improve the communication and consultation process within the planning system
- provide a highly accurate visual tool in 3D to assist in the assessment of new development proposals to the public, elected members and planning officers alike
- promote and showcase the regeneration of Glasgow
- improve the quality of all new developments on the ground.

Uses are both strategic (e.g. exploring the concept of a learning quarter; planning to cope with emergencies) and for public engagement in relation to proposed developments (e.g. redevelopment of Queen Street)

The Urban Model data was used by Air Accidents Investigation Branch/Department for Transport team to assist the investigation of the helicopter crash that occurred at the Clutha Vaults pub in Glasgow on 29th November 2013.

The model can be viewed online in two versions: photorealistic detail and block detail.

The project responds to Scottish Government's vision to deliver services fit for the 21st century.

3. Example image(s) of visualisation(s)

Example still images of views of buildings in central Glasgow (rendered with building textures)

Oxford Street / Bridge Street

Oxford Street / Nicholson Street

Example of scene in a video tour of central Glasgow

More examples images available at 'View the Urban Model' at: www.glasgow.gov.uk/urbanmodel

4. Nature of visualisation tool(s)

Video fly-throughs of central Glasgow, and JPEGs of still images of selected views of central Glasgow, and visualisation of scenarios of environmental change (e.g. flood risk).

	
Representation of George Square under a scenario of flooding	Representation of a new city centre learning quarter in Glasgow

Photorealistic detail (+/- 20 cm accuracy)

Block detail (+/- 0.5 m accuracy)

5. Requirements of visualisation (tools)

No specific technical requirements. Connection to the Internet and relevant plug-ins to internet browsers for video-fly-throughs.

6. Benefits (and limitations)

It is not freely available for use by anyone except for examples such as those included above as examples image(s) of visualisation(s)

7. Link to Planning Review Recommendations

Recommendation	Link
10	Improve access to development plans using 3D visualisation.
28	Support access to information relevant to non-statutory, pre-application engagement.
33	Improve accessibility to information of relevance, and an interface to underlying spatial databases (e.g. development plan, constraint maps).
43	Improve ease of access and interpretation of information at strategic and site specific levels of detail enabling early engagement.

8. Sources of information and follow-up contacts

www.glasgow.gov.uk/urbanmodel

Title of case study: 2. Dundee Waterfront Development

1. Topic

Urban Change: Major redevelopment area

2. Role of visualisation

The primary objectives of the model visualisation aids are for :

- Principally promotional, awareness raising / communication of concept to public and investors
- Testing of design solutions by engineers/planners/urban designers.

3. Example image(s) of visualisation(s)

Example still image of views of buildings in central Dundee (rendered with building textures)

Visualisations from underlying 3D model of Waterfront project, for operational use by project team. These show sufficient detail for almost all day-to-day purposes.

The rendered imagery was commissioned for a promotional video. This was for promotional purposes only and is hosted on YouTube, link available on the home page of the project at www.dundeewaterfront.com

4. Nature of visualisation tool(s)

Various, depending on target audience:

- Video commissioned for public promotional use
- 3D model for internal use and for generating images
- Static images for inclusion in technical documents / planning advice / website / etc.

5. Requirements of visualisation (tools)

All development work on the 3D model was undertaken in Sketchup (www.sketchup.com/). Two computers had to be upgraded to cope with the demands of the software. No detailed computer specifications available.

6. Benefits (and Limitations)

The size of the model is such that it can demand significant computer resources (memory usage) so its full usage is limited to those staff with computers that are sufficiently powerful. Other staff can be provided with parts of the model if required which due to their smaller size are able to function on more standard PCs. This is however restricted due to lack of staff training in SketchUp and version control issues that may arise.

Observed difficulties with public interpretation of the model as it is difficult to convey the concept of a building without actually having a building mass on a model – so opens the model to excessive critique.

The benefits of the model are in terms of being able to convey the scale of the project, concepts and associated design ideas. For example: extracts from the model have also been used to test floorplans in concept buildings.

7. Link to Planning Review Recommendations

Recommendation	Link
10	Improve access to development plans using information technology, digital innovation, Geographic Information Systems and 3D visualisations.
28	Support access to information relevant to non-statutory, pre-application engagement.
43	Improve ease of access and interpretation of information

8. Sources of information and follow-up contacts

www.dundeewaterfront.com

Note: The above refers to the professional work undertaken in regard to the Dundee Waterfront Development. In addition to this, Planning Aid Scotland in conjunction with The University of Dundee has been piloting a model based on the Minecraft game for the same area, used as part of a competition for seven schools in the Dundee area, run under ‘Youth Camp 2015’. This is currently being used within schools as a medium for engaging young people to consider planning as part of the review of the Strategic Development Plan (Tayplan) for this area.

For further information see:

www.dundee.ac.uk/geddesinstitute/projects/minecraft/

www.tayplan-sdpa.gov.uk

Title of case study: 3. National Park Plan Issues Statement

1. Topic

Development of content for the Main Issues Statement of the Loch Lomond and The Trossachs National Park, Park Plan (2009)

2. Role of visualisation

The primary objectives of the model visualisation aids were to :

- Attract participation by younger and hard to reach audiences
- Elicit opinions of the key issues (e.g. aspirations, aims, concerns) associated with the local environment;
- Raise public awareness of opportunities to engage in planning, and of land use changes in the National Park.

3. Example image(s) of visualisation(s)

Example still images of views of the Virtual Landscape Theatre follow:

Gartocharn: View of 3D model across Loch Lomond from the south, with combination of map and aerial imagery used for discussions

Gartocharn: View of 3D model showing south end of Loch Lomond, at Balloch, with audience interpreting features local to their school and town.

Killin: View across Killin showing village and background imagery, and additional woodland and wind turbines included by the audience either side of the village.

Killin: Overview of the national Park, with labels highlighting each town or village.

4. Nature of visualisation tool(s)

- Interactive virtual reality model of the Loch Lomond and The Trossachs National Park enabling the addition of icons representing features of interest, and 'drag and drop' of icons of features to geographically specific locations;
- Stand-alone PC with 3D model of sub-areas of the National Park (i.e. around event venues) for navigation, addition of new features, and annotation of features of interest;
- Aerial imagery of the National Park for interpretation and annotation of features (e.g. specific buildings in villages, natural heritage features).

5. Requirements of visualisation (tools)

Data:

Model of terrain from Ordnance Survey 1:10,000 PROFILE product.

Textures of landscapes using high resolution aerial imagery (c.0.25m and 0.5 m) of the national Park, draped across the terrain model.

Representations of buildings and built structures from Ordnance Survey MasterMap, projected onto the terrain model.

Ordnance Survey 1:50,000 Landranger Map series draped on terrain model, for reference information.

All these data would now be available through the One Scotland Mapping Agreement, including aerial imagery.

Representations of forestry from a library of model trees (coniferous and deciduous).

Software:

Development work on the 3D model undertaken in ArcGIS products (ArcScene), and exported to Octaga VRML viewer. Operational use of the model was in Octaga Player, with coding which enables the additional and interactive manoeuvring of individual features (e.g. buildings, wind turbines, car parks, recreational facilities, etc.).

Hardware:

Use of the model was in the mobile Virtual Landscape Theatre (www.hutton.ac.uk/learning/exhibits/vlt) with audiences of 16 to 20 people.

A stand-alone PC hosted a copy of a subset of the model for the area around the venues (e.g. Killin, Gartocharn), with large format screen and high specification graphics card

6. Benefits (and limitations)

Benefits identified by National Park planning team:

Increased participation of younger audiences (150 participants compared to c. 10 in main consultation events).

The types of issues identified were consistent with those of adults.

The 3D imagery providing additional information on context for the geographic areas of discussion, and thus the extent of the features under discussion compared to the geography of the area.

Benefits identified by teachers:

The use of an interactive 3D model enabled direct interaction with the modelled environment, and swapping between background maps and aerial imagery enabled locations to be understood.

Benefits identified by elected members of the Park Board (at least one present on each of the four days of events):

Potential for direct involvement of younger people in the identification of issues for the Park Plan, the capability of the facility for group discussions (c. 16 to 20 people at a time), particularly when used with the associated electronic voting equipment.

Limitations

Technical limits of computing were encountered on the geographic extent of the National Park compared to the computing demands required for the processing of real time visualisations.

Use of the Virtual Reality environment requires time for setting-up and taking down.

7. Link to Planning Review Recommendations

Recommendation	Link
10	Increased accessibility to existing development plan materials represented in 3D, supported by Geographic Information System for representing spatial information and capturing participant opinions
28	Support access to information relevant to non-statutory, pre-application engagement
43	Improve ease of access and interpretation of information
44	Enabling user input of information and identification of issues with potential for communities to bring forward their own ideas for local place plans

8. Sources of information and follow-up contacts

A summary of the 3D models, their use, and the events is available at:

www.macaulay.ac.uk/kte/

A description of the use of the 3D model and findings for the Gartocharn event is available at:

www.macaulay.ac.uk/landscapes/PastEvents/Gartocharn2007.php

For the Killin event, further information is available at:

www.macaulay.ac.uk/landscapes/PastEvents/Killin2007.php

Technical details of the Virtual Landscape Theatre are available at:

www.hutton.ac.uk/learning/exhibits/vlt/technical-details

Title of case study: 4. Panoramic Viewer, The Highland Council

1. Topic

The single and cumulative visual impacts of windfarm developments.

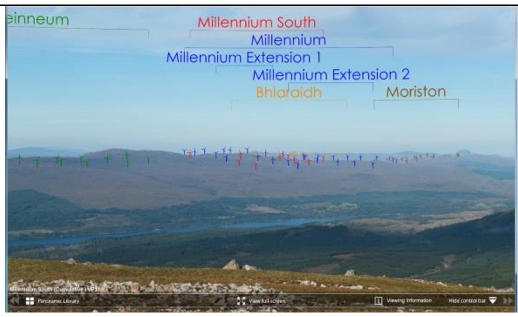
2. Role of visualisation

The primary objectives of the 3D visualisation aids are to:

- Communicate visual impacts and cumulative visual impacts of proposed wind turbines to decision-makers.

3. Example image(s) of visualisation(s)

Examples of photographic panorama images in the Panorama viewer from selected viewpoints.

	
Opening screen of Panorama system	Image of locations of wind turbines at Millennium windfarm and extensions
	
Photomontage of wind turbines at Bad a Cheo windfarm	Augmented photomontage of development stages wind turbines at Bad a Cheo windfarm

Examples for other windfarms are available at www.thcpanoramicviewer.org/indexpage.html

4. Nature of visualisation tool(s)

Digital presentation on screen in true colour and annotated printouts of imagery

5. Requirements of visualisation (tools)

Photographs

- Photographs of the site under consideration from selected viewpoints
- Photographs processed for use as a seamless panorama
- Photographs augmented with the overlay of wind turbines in different colours to represent

alternative layouts, dimensions, or the inclusion of different windfarms

- Photographs augmented with the annotation of different windfarms for the interpretation and communication of cumulative visual impacts

Software:

Panorama software system for presentations on suitable format displays.

6. Benefits (and Limitations)

The panorama viewer can be used to inform the decision maker, including the Planning Committee, of the visual impact when used along with single frame images required by the local authority. The use of a photograph-based system means that the views will be as if standing at the location of the original baseline photographs.

It provides a realistic impression of the depth and scale of the landscape and therefore, if the development is accurately modelled, the effect that the development would have on the view.

The panoramic viewer is used to understand scale and depth in the landscape, and therefore to communicate the potential visual effect of a vertical element introduced into that landscape. The image can be rotated through 360 degrees and wind turbine blades can be animated if required.

Limitations

The height of an image is ‘pegged’ at that of a 75mm single frame.

7. Link to Planning Review Recommendations

Recommendation	Link
28	Support access to information relevant to non-statutory, pre-application engagement
43	Improve ease of access and interpretation of information, for elected representative, stakeholders and the public

8. Sources of information and follow-up contacts

www.highland.gov.uk/panoramicviewer/

Title of case study: 5. Quarry access road

1. Topic

Representation of views and potential shadows with respect to a cottage (Belhelvie, Aberdeenshire) likely to be cast by a bund to be built to reduce noise and dust impacts of an access road to a new quarry.

2. Role of visualisation

The primary objectives of the 3D model and derived visualisations were to :

- Illustrate calculated extent of shadows cast by the bund which was proposed to be built to the east;
- Supporting documentation for use in a local enquiry.

3. Example image(s) of visualisation(s)

Still images of views of the Drumhead cottage and the bund proposed to be built to the east.

Cottage and shadows cast on 31st October:

With no bund to the east

With bund to the east

Cottage and shadows cast on 31st October from different view points:

The underlying 3D model of the cottage and estimated location and dimensions of the bund were used to generate visualisations of the potential effects of shadows cast across the property.

4. Nature of visualisation tool(s)

3D model used to:

- produce images of scenes from different viewpoints for submission to local enquiry;
- printouts of images for display;
- 3D model used for the calculation of shadows at different times of the day and year.

5. Requirements of visualisation (tools)

Data:

Elevation data derived from Ordnance Survey information.

Building dimensions measured on site.

Dimensions of proposed earth bund obtained from development plans.

3D model required to be geospecific to allow the derivation of shadows at different time of year and day.

Software:

All development work on the 3D model was undertaken in Sketchup (www.sketchup.com/).

Hardware:

No specialist computing hardware was required.

6. Benefits (and limitations)

According to the local community the benefits of the 3D model were the capability of assessing the potential impacts of an earth bund on the views and quality of environment of the inhabitants of a cottage.

Benefits for the model developer were that the software provided a simple tool for the development of a model for the calculation of shadows of the bund. The creation of a model was rapid and required no specialist model components or visually accurate representation of the building and surroundings. From this model images could be easily prepared for inclusion in submissions to a local enquiry regarding the route of an access road to a new quarry.

7. Link to Planning Review Recommendations

Recommendation	Link
28	Support access to information relevant to non-statutory, pre-application engagement
43	Improve ease of access and interpretation of information

8. Sources of information and follow-up contacts

Contact names can be provided on request.

Not available.

Title of case study: 6. Wishaw Health Centre

1. Topic

Proposal for a new Community Health Centre, Public Library, First Stop Shop and Housing Services in Wishaw.

2. Role of visualisation

The primary objectives of the model visualisation aids were to:

- illustrate the design and setting of the new health centre for public awareness and decisions about the proposal.

3. Example image(s) of visualisation(s)

Example still image of views of planned Wishaw Health Centre from North Lanarkshire Council's planning website, application No. 12/01356/FUL (https://eplanning.northlanarkshire.gov.uk/online-applications/applicationDetails.do?activeTab=documents&keyVal=MFBFYZBAJE000) from three viewpoints.

The visualisations are accompanied by a location plan (bottom right) and the location and viewing direction of the visualisation.

View of planned Health Centre, looking north-east along Kenilworth Avenue.

4. Nature of visualisation tool(s)

Various, depending on target audience:

- Static images for inclusion in technical documents / eplanning website
- Printed images for displays and public exhibitions

5. Requirements of visualisation (tools)

Creation of a 3D model of the proposed health centre, geospecific for preparing visualisations of the site form selected viewpoints. The imagery is embedded in photographs of the site to take advantage of the levels of details captured in both sources of imagery.

Data used will be to represent the architectural details of the buildings and associated landscaping.

The specific software used is not documented, but no specialist hardware is required.

6. Benefits (and Limitations)

View of the proposed new Wishaw Health Centre from selected viewpoints, The quality of the imagery enables an easily understood visual impression of the planned building and associated landscaping, its siting with respect to existing buildings, and the fit of the building with respect to its surroundings.

The imagery supported raising public awareness of the proposal as well as a context for planning officers to interpret the other characteristics of the development, including street access.

7. Link to Planning Review Recommendations

Recommendation	Link
28	Support access to information relevant to non-statutory, pre-application engagement
43	Improving the readability and understanding of concepts for development, enabling more effective early engagement.

8. Sources of information and follow-up contacts

https://eplanning.northlanarkshire.gov.uk/online-applications/applicationDetails.do?activeTab=documents&keyVal=MFBFYZBAJE000

3D Visualisations in documents: ‘key views’ and ‘car park key views’.

Title of case study: 7. Local Development Plan Storymaps, South Ayrshire Council

1. Topic

Communication of Local Development Plan and associated information

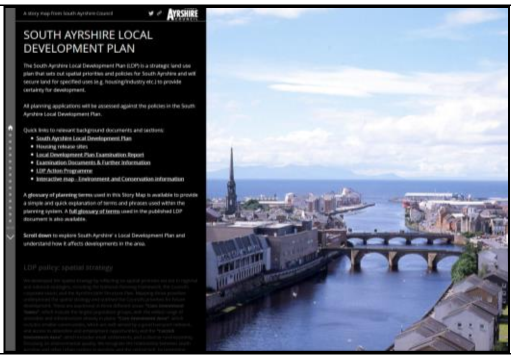
2. Role of visualisation

The primary objectives of the use of the ‘Story Maps’ tool were to:

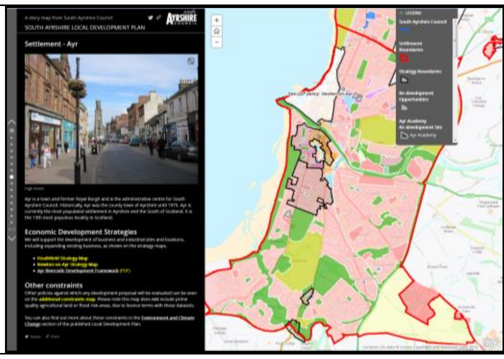
- Communicate council policies to external and internal audiences
- Identification of issues to be addressed in plans
- Promote South Ayrshire to local, national and international audiences
- Combine information (e.g. policies and supporting materials), and data within a common framework, accessed through a common online interface
- Reduce complexity of digital spatial data (Geographic Information Systems; GIS), and making spatial data more accessible and usable

3. Example image(s) of visualisation(s)

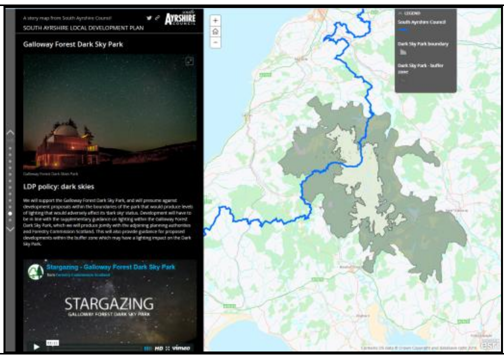
Screenshots of the South Ayrshire Local Development Plan Storymap.



Opening screen of South Ayrshire Local Development Plan Storymap.



Settlement information for Ayr, including links to other maps, the full Local Development Plan and information.



Introducing maps and information related to the Local Development Plan from other organisations, in this case the Forestry Commission Scotland Stargazing video.

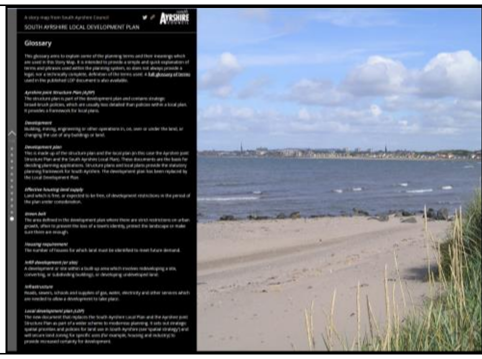


Image of the glossary provided to explain technical terms.

The Storymap site can be accessed at gis.south-ayrshire.gov.uk/ldp/

4. Nature of visualisation tool(s)

Web Mapping Server linked to panel information and associated information, imagery and videos. Printing capability to be included in forthcoming software version.

5. Requirements of visualisation (tools)

Standard specifications for PC or Mac.

Subscription to ArcOnline or ArcGIS Portal. Alternatively, as in this example, collaborate with ESRI directly to access the 'Story Map' apps. A free subscription service is available for non-commercial or public use.

Spatial data relevant to the storymap narrative, such as basemaps, local development plan, sets of policy specific data (e.g. settlements, housing release sites and additional constraints maps).

Capability to accommodate multi-media, including video and static imagery, and scope for the representation of 3D models.

6. Benefits (and Limitations)

The storymap has enabled a focus to be directed to policies of interest (e.g. housing, tourism etc.), without having to scroll through sections of the Local Development Plan which are not of principal interest to the stakeholder. The framework provided by storymaps enables a flexible implementation designed for users not familiar with mapping and associated technology, whilst it is possible for the user to interact with the spatial data by clicking on maps, zooming into and moving across areas of interest. The framework makes it easier for public or non-experts to visualise information, and more engaging than documents which are predominantly text-based and require the user to scroll through the document.

It can be used without requirements of staff skilled in GIS or information technology, enabling planners or facilitators to use the materials in workshop environments (e.g. use of the storymap by Prestwick Community Council as part of eliciting ideas and thus early engagement in planning).

The storymap framework is extendable with the inclusion of multi-media (currently maps, images, video) which could then include 3D models. It is linkable to social media to attract traffic to the storymap, and enabling the posting of information (e.g. issues, feedback on plans). Plans for the storymap are to link to new ESRI digital information tools to enable information to be captured online, templates of which can support crowd sourcing and citizen science. This can provide a basis for early engagement, and capture of issues for Main Issues Statements.

The storymap framework proved successful in encouraging people to access the LDP. This is evident from the increased traffic to the site which was over 3 times the number of hits to the site in its first two months of its launch (4,500 views), compared to a 12 month period (1,500 views) of the previous online version of the LDP.

The storymap interface resizes to the resolution of the device being used for access (e.g. desktop PC, tablet, smartphone), and thus self-aligns to the hardware and software of the user. Indeed, 65% of the traffic to the storymap site is from mobile device (as of summer 2016). (http:/www.south-ayrshire.gov.uk/opendata/).

There is also evidence of use of the site outside office hours, thus possibly illustrating benefits from broadening the nature of access to the LDP.

Limitations

Storymaps and associated tools (e.g. QuestionWhere) are rapidly developing leading to the identification and resolution of technical limitations. Examples have included the capability for users to print outputs from storymaps and annotate according to user needs, and constraints on the implementation in different internet browsers.

7. Link to Planning Review Recommendations

Recommendation	Link
10	Increased accessibility to existing development plan materials represented in 3D, supported by Geographic Information Systems for representing spatial information and capturing participant opinions
28	Support access to information relevant to non-statutory, pre-application engagement.
33	Improve accessibility to information of relevance, and an interface to underlying spatial databases (e.g. development plan, constraint maps).
43	Improve ease of access and interpretation of information, linking multi-media including 3D visualisations and social media.
44	Enabling user input of information and identification of issues with potential for communities to bring forward their own ideas for local place plans

8. Sources of information and follow-up contacts:

South Ayrshire Storymap, http://gis.south-ayrshire.gov.uk/ldp/

ESRI Storymap information, https://storymaps.arcgis.com/en/

QuestionWhere information, https://marketplace.arcgis.com/listing.html?id=ef411f82398b483a9ee2a421bb45bada –

Contact: Stewart McCall, South Ayrshire Council

Title of case study: 8. linknode - VentusAR

1. Topic (e.g. wind farm, urban change, strategic planning, infrastructure)

In field augmented reality of agri-renewables

2. Role of visualisation (i.e. link to report headings; e.g. inception, raising awareness, consultation, decision-aid)

The primary objectives of the use of the mobile augmented reality tool were to:

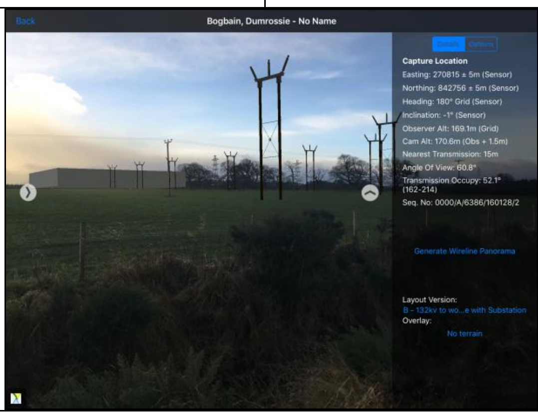
- Enable viewing of a proposed development in the field, on site
- Support discussion of the proposal in the pre-application phase of development
- Provide supporting information on potential visual impacts of developments as part of planning submissions

3. Example image(s) of visualisation(s)

Examples of photographic panorama images in the Panorama viewer from selected viewpoints.

In the field capture of imagery with mobile device (Source: linknode)

Augmented reality imagery and 3d (Source: GreenCat)



View of iPad screen running VentusAR, showing new proposed electricity grid project, with wood poles, substation and pylons (Source: linknode)

4. Nature of visualisation tool(s) (e.g. paper printout, video, interactive model,)

Digital presentation on-screen with real-world backdrops, producing still imagery or animations (both background and model features), and associated site information.

5. Requirements of visualisation (tools)

Hardware and operating systems

- Standard mobile devices (tablet and smart phone)
- The tools are available on systems supporting use with Microsoft, IOS and Android platforms. VenturAS is available on IOS and Android platforms, not Windows; and, the UrbanPlanAR is on IOS and Windows, and not Android.

Data

- Use of the HDMI output enables the recording of what is seen on-screen to provide an animated background to subsequent representation in augmented reality
- Snapshot of field location for use as background to superimposed images of 3D models
- 3D models of individual features (e.g. Photovoltaic panels, wind turbines, electricity grid related overhead structures)

Software

- Proprietary software, VentusAR

6. Benefits (and limitations)

The use of real world imagery (still or animated) provides high levels of realism for use at early stages of a project, with a low cost and level of risk associated with the investment in the visual representations. The incorporation of real-world video enables the representation of movement in the landscape (e.g. swaying trees, plants, vehicles), which are consistent with the scale of PV structures and thus important in coherent representation of a scene of proposed change. Coherence supports the impression of credibility of visualisations.

The use of augmented reality enables supporting information to be superimposed, or alternative designs of features incorporated for rapid assessment of potential impacts on landscape and visual and cultural and heritage impacts, in the field.

Future development is being undertaken in urban areas under a grant from the Technology Strategy Board in collaboration with Heriot Watt University (UrbanPlanAR). This is enabling use and reuse of digital information such as 3D data from Building Information Modelling (BIM).

Limitations

GPS location in retail tablets and mobile devices are generally sufficiently accurate for applications in rural environments. However, in urban environments the accuracy is not always to an appropriate standard.

7. Link to Planning Review Recommendations

Recommendation	Link
10	Increased accessibility to existing development plan materials represented in 3D, supported by Geographic Information System for representing spatial information and capturing participant opinions
28	Support access to information relevant to non-statutory, pre-application engagement.

33	Improve accessibility to real-time data through underpinning information of relevance, and an interface to underlying spatial databases (e.g. existing renewable energy developments, thus assessing cumulative visual impacts).
43f	Improve ease of access and interpretation of information, with real-world 3D visualisations aiding the association of representation of change with features identifiable by local communities.

8. Sources of information and follow-up contacts (assuming permission granted), reference to report, website if available

More information about the context of the use of the augmented reality tool is at:

http://ventusar.com/wp-content/uploads/2015/07/GreenCat_VAR_CaseStudy.pdf

and more generally at:

http://ventusar.com/market/solar/

Contact: Crispin Hoult, linknode Ltd.

Title of case study: 9. Kirkcaldy – Town Centre Design and Development Framework

1. Topic

Representation of Town Centre plans

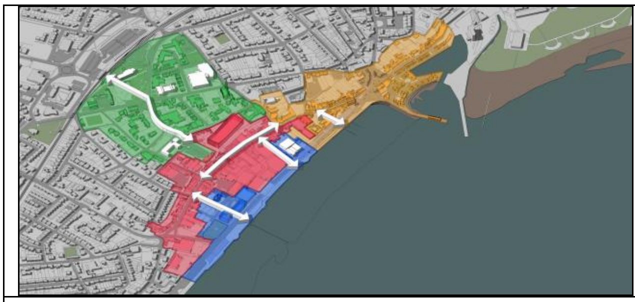
2. Role of visualisation

The principal aim of the 3D visualisation imagery was:

- To provide representations of conceptual visions for four quarters of the town centre to be easily understood by a range of stakeholders (e.g. businesses, public) for use in stimulating discussion and debate.

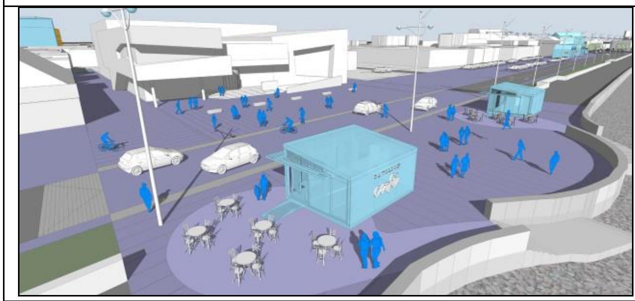
3. Example image(s) of visualisation(s)

Examples of schematic representations of visions for the town centre for use in public engagement.



Strategic overview of Kirkcaldy town centre

Social Quarter: The Postings



Waterfront Quarter: shared space

Merchants quarter: entrance

4. Nature of visualisation tool(s)

Perspective views of 3D models of town centre sites as digital images for use in report and public engagement.

5. Requirements of visualisation (tools)

Hardware:

- High specification PC or Mac

Software:

- Sketch-up and 3DsMAX

Data:

- Initial materials were imagery (e.g. photos and 2D imagery), and an existing 3D block plan model of the town centre of Kirkcaldy and Ordnance Survey data, to which detailed models were developed and added

6. Benefits (and limitations)

The Town Centre Toolkit approach was used to prepare concepts for proposals and a catalyst for future planning of the town centre, as part of delivering placemaking in Fife. The outputs were stylistic, designed to be easily understood representations of ideas and visions of the town centre. These provided core visual materials for the Kirkcaldy Town concept-based Centre Design and Development Framework, which sets out ideas for actions, presented in ways to stimulate discussion and debate, and used in public consultations.

There was a positive response to such an image rich document from stakeholders. This included elected representatives, businesses in the Business Improvement District Company, and the Kirkcaldy Ambitions Group (includes the Fife College, Cultural Trust, press, other interest groups). The use of such stylistic imagery was considered a significant improvement on the alternative types of documents in which the key messages about ideas of future uses are of low prominence.

Limitations

No specific limitations were identified for the uses intended. If taken out of context, the schematic nature of the imagery may be misinterpreted, with scope for more photorealistic representation used to address questions of what individual developments may look like.

7. Link to Planning Review Recommendations

Recommendation	Link
41	Local authorities should pursue the establishment of shared services.
43	Improving the readability and understanding of concepts for development, enabling more effective early engagement.

8. Sources of information and follow-up contacts

Ewan Campbell, Fife Council

Access to the report on the Town Centre plan, and component imagery is at: www.gov.scot/Resource/0048/00489261.pdf

3D visualisations used in Kirkcaldy Masterplan, Angus Cummings and Janet Pope, Ironside Farrar www.ironsidefarrar.com/3d-visualisation.htm

Title of case study: 10. Birmingham City Council

1. Topic

Development of City Centre Masterplan

2. Role of visualisation

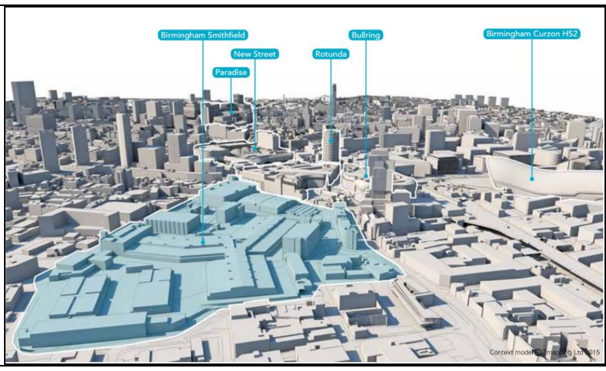
The primary objectives of the use of the 3D models were to:

- Support development of city centre Masterplans
- A tool for planning specific developments
- Support implementation of a strategy for tall buildings
- Promote Birmingham City

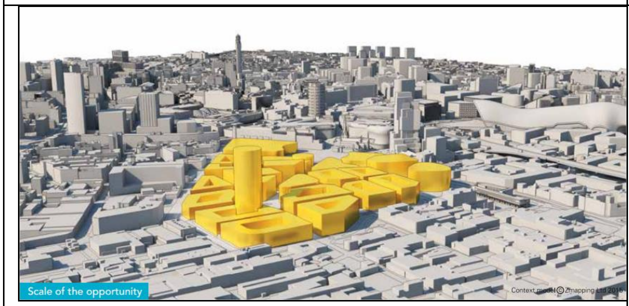
3. Example image(s) of visualisation(s)

Examples of 3D models and their use in developing a Masterplan for Birmingham City Centre and the Smithfield Market

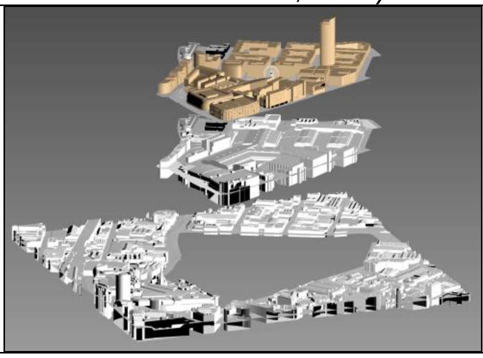
Overview of 3D model of Birmingham city centre (Source: Birmingham City Council and Zmapping Ltd.; © Crown Copyright. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings. Zmapping Ltd, 2016)



Annotated, schematic overview of context of Smithfield market, inset to 3D model of city (Source: Birmingham City Council; © Crown Copyright. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings. Birmingham City Council. Licence number 100021326, 2016)



Visualisation of the context Smithfield market, inset to 3D model of city centre (Source: Birmingham City Council; © Crown Copyright. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings. Birmingham City Council. Licence number 100021326, 2016)



Exploded view of 3D city model and height models of existing site and proposed site (Source: Birmingham City Council; © Crown Copyright. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings. Birmingham City Council. Licence number 100021326, 2016)

4. Nature of visualisation tool(s)

Visualisation on-screen of 3D model of Birmingham city centre, schematic views of development sites, images of visualisations for reports, 3D printed models of development sites

5. Requirements of visualisation (tools)

Hardware:

- High performance PC hardware (96 Gb RAM, 32 processors, graphics card), network rendering for high resolution imagery and animations

Software:

- Sketch-up, 3DsMAX

Data:

- For city planning, 3D model of Birmingham City Centre (www.zmapping.co.uk/)

6. Benefits (and limitations)

The existing 3D model of Birmingham City Centre provides a 3-dimensional, spatially explicit, core element of the data infrastructure informed consideration of new proposals for change in the city. The Council offers a facility for developers to submit 3D models of proposals at an early stage, exploiting the 3D models prepared for discussion with investors, designers and prospective clients.

This is then used in direct engagement with architects, enabling discussion, direct modification of model features, and exchange of feedback on the proposal, leading to modifications of plans and associated models and an iterative process of engagement. Feedback from applicants was of positive experience of early engagement and thus saving on costs.

This enables the use of 3D models and infrastructure as a planning tool in development management, aid judgements of proposals in relation to surrounding buildings, heights of developments, and to inform refreshes of the Supplementary Planning Document on Tall Buildings.

Applications at a site level have included the development of a masterplan for Smithfield Market, with the 3D information converted into a virtual reality model, viewed using VR headsets. These provided a new means of engaging with local stakeholders, particularly market traders, to obtain their feedback on the plans for redevelopment. The digital model also enabled the printing of a physical model, which stakeholders (e.g. Smithfield market traders) reported as providing a very valuable, and tangible, insight to what was planned.

Current plans are to test the use of the virtual reality tools with elected representatives, and add other non-visual information in an augmented reality format, and provide information on an app for use on mobile devices, and exploring their use in a 3D theatre.

Limitations

Technical factors limited the use of the 3D model, which includes trees, buildings and other street furniture, prior to the availability of hardware and software which could accommodate the numbers of polygons in the model. To enable full sharing of information with developers, licencing issues require to be addressed, which will constrain the potential for expanding the engagement to public audiences.

7. Link to Planning Review Recommendations

Recommendation	Link
28	Support access to information relevant to non-statutory, pre-application engagement
33	Improve accessibility to real-time data through underpinning information of relevance
43	Improving the readability and understanding of concepts for development, enabling more effective early engagement.

8. Sources of information and follow-up contacts (assuming permission granted), reference to report, website if available

www.zmapping.co.uk/#/Gallery/Cities/

Contact: Simon Delahuntly-Forrest and Henry Cross, Birmingham City Council

9 Discussion and Conclusions

9.1 The description of definitions in Section 6 recognise that there are distinctions between a 3D model and 3D visualisation, and the outputs from them; and those models and outputs which are geospecific and those which are not. The examples in Table 3 cover a broad range of tools, software and visualisation materials, most of which are in use in existing planning processes in Scotland.

9.2 The following discussion summarises the findings of the study with respect to the aims as set out in Section 1.

1. Identify what digital imagery and visualisation technology is currently available and in use in planning

9.3 Spatially referenced digital imagery is available for all of Scotland of a variety of types, content, quality and spatial and temporal resolution. It is becoming mainstream in its use, enabled by extensive access through retail products (e.g. mobile devices), and common reference to vendors (e.g. Google). Datasets which have been tested, of verifiable standards, suitable for purposes at different stages in the planning process are increasingly available, supported by public and private sector providers. Most have specific update policies or obligations, but this is not universal, and the temporal consistency of such data can be poor where change is rapid (e.g. urban areas), as well as slow (e.g. remoter rural areas).

9.4 A priority is to review and consider if there are opportunities to coordinate updates to digital data observations and supply.

9.5 A wide range of visualisation technologies are currently available, and used in Scotland. They are diverse in their level of sophistication and associated requirements for hardware, software, data, and developer and user training. These technologies are generally compatible with PC or Apple hardware, but may have additional requirements for the display or use of 3D models and generation of 3D visualisations.

9.6 The uptake of some form of 3D models, tools and visualisations is by all types of stakeholder, but there is diversity in the terminology used in their descriptions. Therefore, there is inconsistency in the understanding of what comprises ‘3D visualisation’. Use of training and standardised terminology in relation to 3D visualisation and models would remove potential misunderstandings and barriers to discussion and implementation of recommendations, notably No. **10 (IT Task Force)**, and **43 (improving early engagement in planning).**

9.7 Stakeholders understand the key objective of the use of such tools. The tools aid decision-making within the planning process. However, there is also evidence that some tools and visualisation materials are not used at the most appropriate stages of the planning process. This could be improved by better awareness of the effectiveness of digital information and 3D visualisations at different stages of the planning process, facilitated by sharing of experiences through a suitably designed event series events (e.g. similar to Scottish Natural Heritage Sharing Good Practice series). This would contribute to proposed **Outcome 5** of Beveridge et al. (2016) of a sharing of skills.

2. Identify how it is used with respect to planning by local and central government, using case studies of different types of development and stage in the planning process

9.8 Digital information and 3D visualisation tools are used at different stages throughout the process of planning, from eliciting initial ideas from stakeholders, including the public, through to final decision-making. The subjects of such tools in Scotland include large infrastructure projects of national importance, such as the Queensferry Crossing, to smaller areas of urban development or regeneration, such as street design, and small-scale wind energy and housing.

9.9 The availability of new tools which support sharing of information in an easily understood and effective manner can be expected to be taken up as their benefits become apparent. The reported effectiveness of the promotion of the Local Development Plan of South Ayrshire using storymaps (Case Study 7) is an example of such technology which could transform the access and usability of LDPs, particularly if extended to include capabilities for public reporting of issues or input to plans **(Recommendations 28 and 44**). Improving cross-referencing of relevant information, by topic and spatially, and enabling ease of access to such information, such as the use of storymaps, could contribute to supporting greater prominence of the production of local development plans, and ease of their interpretation.

9.10 Such tools can be targeted for specific uses, perhaps emphasising agreed issues such as housing or transport, and links established across local authority boundaries to circumvent artificial barriers, not materials to the practicalities faced by residents or employees (e.g. linking **Outcome 5** on smarter resourcing, **6** on collaboration, and **2** on delivery of high quality homes).

9.11 The preparation of 3D visualisation is generally by, or on behalf, of the proposer of a development. The recipient or user of imagery produced from 3D tools is guided by the purpose and stage in the process of a proposal; that is, to match with the stages in the strategy for engagement (Table 2). For example, the users of materials in a submitted planning proposal will be the statutory consultees, planning departments, and public. However, the actual use of each piece of information provided may differ.

9.12 3D models are very rarely exchanged between stakeholders (e.g. elected representative, planning team, developer, consultant, NGO, civil society and public). Rather, they are used in the preparation of 3D visualisations and subsequently used by different stakeholders, which are then made available using various types of digital media (e.g. videos, simulations of sites post-development). However, the Case study of Birmingham City (Case Study 10) demonstrates how the process can be iterative with 3D data of proposals being exchanged and then discussed between developer and planner, thus saving time and associated costs, so also delivering to

Outcome 6. It also contributes to the maintenance of data infrastructure and thus relevance and usability of digital information (**Recommendation 10)**.

3. Assess likely financial and technological benefits and challenges to developers, decision-makers and community engagement

9.13 Little information was available regarding costs for the different stages of development of the 3D models in the case studies. Some information may be commercially sensitive or not recorded. However, from the details available, the costs are predominantly for the development of 3D models rather than their use or the production of visualisation materials from them.

9.14 Costs for relevant geographic data in Scotland for local authorities and public agencies are predominantly covered by the One Scotland Mapping Agreement. This provides access to data provided by Ordnance Survey, including terrain (1:10,000 and 1:50,000), and the new 5m x 5m DEM; building footprints, and new product data for building heights and the locations of individual wind turbines. The OSMA also includes aerial imagery for all of Scotland, aiming to be no older than 5 years at any location. So, most key contextual data for 3D modelling systems identified in the surveys and case studies are available to planning teams, and public sector uses. Generally, private developers have to pay for access to such data. Site specific data, such as imagery for building textures, high resolution terrain data (e.g. 0.5 m), ground photographs for photomontages all require to be collected for specific proposals. This agreement significantly facilitates the sharing of information across areas of responsibility and could underpin the transformation of the use of digital data, delivering to several of the recommendations notably **41** ('Local authorities should pursue the establishment of shared services'). This is one means of addressing the issue of licencing which is reported as inhibiting sharing or exchanging of 3D data.

9.15 Consideration of digital data as part of essential infrastructure would aid the achievement of **Outcome 3 (an infrastructure first approach)**, and enable progress towards other related recommendations such as 33 (the use of information technology to improve accessibility and allow for more real-time data to inform decisions), and **28** (the quality and effectiveness of pre-application discussions with planning authorities and consultation by developers should be significantly improved). Such a data infrastructure could be supported by a cloud-type environment.

4. Identify the potential technology likely to be available in the near future and how it might best be used to positively improve stakeholder interaction and engagement with the planning system in Scotland to inform good practice

9.16 A better understanding of the principal users of materials developed for planning proposals might aid in the design and choices of tools and types of outputs, including 3D visualisations. In particular, that understanding would be for any changes in the audiences for materials submitted at different stages in planning as more emphasis in public policy and best practice is placed on public participation (as per the Aarhus Convention), and information is made more widely available digital imagery and information. Such digital imagery could form part of the wider process of democratisation of planning such as supporting live televising of decision-making forums, such as planning committees, and increased use of social media **(Recommendation 43)**. It could be one of the challenges to be addressed by the IT Task Force (**Recommendation 10**).

9.17 Other types of developments which have characteristics that map onto similar stages of a process of planning can use similar forms of 3D visualisation tools, media and imagery. Stakeholder engagement for testing ideas and seeking advice from a wide range of sources for most aspects of strategic visioning (not necessarily always at the level of the Strategic Development Plans) could use the types of tools described in the case studies (e.g. interactive 3D models, Case Study 3, online identification of issues, Case Study 7). However, the case studies did not include examples of uses of 3D models for all forms of strategic development, notably linear features, such as the introduction or modification of major transport routes, or utility networks. Other software solutions may be more appropriate which enable the representation of the completeness of a network or connectivity of new sections into an existing network.

9.18 Increased interest in development in the marine environment suggests that new uses of spatial digital information and 3D tools may be sought. Although not explicit regarding land and sea, most of the outcomes sought by Beveridge et al. (2016) (e.g. Planning Review **Outcomes 3, 5 and 6**) appear to be transferrable to coastal and marine environments, for which digital spatial information is becoming a core part of spatial planning (e.g. Scotland's Marine Atlas). This interest reflects the attention of policy teams to Marine Spatial Planning, marine renewables, and natural heritage designations. In particular, the coastal zone and seascapes are areas where processes for development should link with the Principles of the Scottish Land Use Strategy as well as those of the Marine Spatial Plan, in each case encouraging stakeholder participation in discussions about natural resource management and sustainable development.

9.19 Increased use of digital imagery and 3D visualisations can be anticipated in street design and 'creating places', and greater uptake in the more detailed planning of large housing developments. For example, the new Scottish Detailed Rivers Network, and Flood Risk mapping, both created with Scottish Government funding, are examples of new types of data which can be inputs to planning proposals which take greater account of risk and resilience to environmental change. This would be consistent with treating digital data as part of an infrastructure first approach (Planning Review **Outcome 3**).

9.20 A programme of awareness raising of stakeholders of elected members, developers and consultants of the availability of new types of data, which are relevant to the aims of progressing a development through the planning process, and compatible with 3D visualisations, may increase the use of such tools. This was recognised in **Outcome 5** (Leadership, resourcing and skills), for which there is considerable scope to draw upon the expertise in academia and industry in Scotland, and the models of best practice and CPD, such as the Sharing Best Practice model of SNH, referred to above.

9.21 Key benefits and challenges will differ in detail for different types of stakeholder, but will be linked. The principal benefits sought by developers and consultants are in improving the efficiency of planning processes, consistency in the basis for decision-making, and scope for imaginative approaches to design. Benefits to decision-makers (planning officers and elected representatives) are likely to be similar, with recognition of tools which help deliver public policies. For communities, greater input to discussions about proposals is already evident, but with a concomitant expectation of acceptance and impacts of the 3D materials they provide.

9.22 All types of stakeholder face some similar challenges. A shared requirement is for confidence in the reliability of information used throughout the process of planning a proposal and its determination. Specific challenges to decision-makers are the provision of materials to a known standard, which can be trusted, and applied consistently to agreed principles. The challenge to developers is to be able to provide materials to the required standard, whilst also able to take advantage of tools (software, hardware and data) for better communication of key aspects of a proposal and more imaginative and effective engagement with communities and other stakeholders, as they evolve and mature, in a cost effective way.

9.23 For communities, the challenges in 9.22 can be both more onerous and less constrained. Difficulties will arise regarding access to relevant technology, including adequate internet bandwidth to be able to use submissions of ancillary materials of a proposal. This may not be the case for more remote rural areas where digital connectivity is often poorer than more urban areas. Of equivalent importance is recognition of inequalities of access to such digital infrastructure amongst people of different socio-economic circumstances, education or training in information technologies, and factors such as age and physical abilities.

9.24 Ongoing access to contemporary versions of software and data may be problematic depending upon personal or community resources. Such resources include training or professional expertise in the development or use of planning documentation in general, and digital imagery, and 3D visualisation materials in particular. The use of storymaps by South Ayrshire Council in Case Study 7 is a good example of how access to content can be improved, both in terms of content and ease of readability. Exploitation of these types of approaches should provide good reference examples, as well as technical leadership, for delivering to **Recommendations 5, 28 and 43**.

5. **Access to expertise is also important to ensure the appropriate creation and interpretation of digital imagery and 3D models and visualisations, and understanding the limitations and weaknesses of some tools or data and thus where their use may be inappropriate or counterproductive.**

9.25 Communities have freedom to explore the use of new tools and data to advocate or object to proposals. So, 3D models and visualisations can form part of a wider empowerment of communities using increased capabilities of tools, at prices which an increasing proportion of the population will find affordable. This is consistent with the objectives of leadership in the Planning Review (**Objective 5**) and increasing empowerment (**Objective 6**), and **Recommendation 44**. In turn, achieving the outcomes of the Planning Review would contribute to delivery of Proposal 12 of the Scottish Land Use Strategy of "Identify and publicise effective ways for communities to contribute to land-use debates and decision-making", and the co-construction in design and planning environments, as articulated in Creating Places.

6. Identify the potential technology likely to be available in the near future and how it might best be used to positively improve stakeholder interaction and engagement with the planning system in Scotland to inform good practice

9.26 The availability of relevant types of spatial data, with associated metadata on accuracy and provenance, continues to increase from public bodies (e.g. Ordnance Survey, SNH, Forestry commission, local authorities) and supported data portals (e.g. Scotland's Environment Web), and the private sector (e.g. aerial imagery, high resolution terrain and building height data). These enable the increased use of data of appropriate quality and types at all stages in the development of proposals, and by all types of stakeholder, including the public, in responses to specific proposals (either in opposition or support).

9.27 As noted above, access to digital data merits treatment as an essential part of public infrastructure alongside that of broadband connectivity. This would be an appropriate reflection of its importance in underpinning the planning process, consistent with the obligations under the Aarhus Convention, and thus aid achievement of **Objective 3** of the planning review.

9.28 The development of software for use with mobile devices (e.g. phones, laptop computers and tablets) appears likely to continue, exploiting increased computational capabilities of hardware and communications networks. Whilst there are concerns about the quality of some early stage Apps which enable the visualisation of proposed developments *in situ*, they are likely to have an increasing role in stakeholder engagement, with public and consultees, prior to submission of a proposal (e.g. Case Study 8).

9.29 An extension of Apps on mobile devices is the use of low cost Virtual Reality headsets. These are likely to be used increasingly for early engagement with stakeholders for discussion about plans for proposals, or eliciting ideas for potential development. Increases in the use of 3D visualisation materials can be expected to take the form of 3D modelling tools (enabling modifications of 3D models) by all types of stakeholder rather than use of prepared imagery. This form of technical development is envisaged by Birmingham City Council (Case Study 10) as a means of improving means of communication with proposal specific stakeholders and elected representatives.

9.30 A trend which is likely to continue is the uptake of products for which there is almost universal access, with decreasing cost restrictions and increased levels of detail and shared content (e.g. online platforms of Google, Bing), and their utilization for citizen science (i.e. wider public participation at different stages in the planning process, e.g. ESRI QuestionWhere). The nature of use could be in public engagement in planning at preparatory stages of a proposal, thus contributing to aims of the review of planning (**Objective 6**) of greater empowerment.

9.31 Regulations and guidelines for best practice will take longer to evolve, but it is reasonable to expect an increase in the number of submissions of materials developed from 3D tools in responses to consultations. So, the systems of processing such submissions need to be contemporary and able to accommodate such evolutions. This is a topic which the IT Task Force may wish to consider (**Recommendation 10**).

7. **Recommend how digital imagery and 3D visualisation technology can become used or common practice within the planning system with respect to the recommendations of the review of planning (Beveridge et al., 2016), and inform discussions of the IT Task Force set up by Scottish Government.**

9.32 The review by Beveridge et al. (2016) provides a potentially game changing moment for improvements in planning in Scotland, and the wide ranging and positive impacts which that can be expected to stimulate. In a rapidly changing technical and social environment the emergence of new tools provides both opportunities and challenges for the planning process. Of these tools geospatial data and 3D visualisations are two which could have particularly significant impacts, as each is highly effective in engaging with all beneficiaries throughout the process of planning from the preparation and dissemination of Local Development Plans to the implementation of proposals.

9.33 Feedback from stakeholders identified some key issues to be addressed before digital information and 3D visualisation can become common practice throughout the planning system. These include: the time and resources for staff to use tools, scepticism over the idealised content of some materials, general concerns about accuracy, computing facilities and network access, and agreement over data standards and protocols for visualisation. The topic of standards and protocols may be the most significant in terms of adoption and acceptance of materials as formal documents in stages of a planning process (e.g. Environmental Statement, generally using wireframe and photomontage imagery) and documentation for public enquiries (e.g. Case Study 5). The principles underpinning data standards, ethical use of digital data and 3D imagery, data and reliability would be an appropriate topic for consideration by the IT Task Force (**Recommendation 10**), rather than the detail of actual specifications.

9.34 The evolution of software, hardware and data availability can be expected to progressively erode the technical barriers for the deployment of digital imagery and 3D visualisation tools at stages in the planning system where they are currently not used, or in evolving aspects of the planning system itself. For example, as greater emphasis is placed on public engagement and inputs to the processes of decision making, and new pressures for change in the landscape emerge, so one might expect the governance or procedural steps in planning processes to evolve. As with the subject of data standards, principles for the use of digital imagery and 3D visualisation tools in relation to governance and the planning process should be a significant consideration of the IT Task Force (**Recommendation 10**).

9.35 Such an evolution of processes could include any responsibilities devolved to more local forms of government (as envisaged in **Outcome 5**, integrating spatial planning with community planning) to accommodate rapid increases in rural areas of small scale renewable energy, currently most often this relates to wind turbines, but increasingly will be above ground photovoltaic, and the continuing uptake of polytunnels.

9.36 Accompanying the opportunities for the uptake of improved use of 3D visualisation tools is the potential implications of weaknesses of current tools. Such weaknesses include the representation of some development proposals (e.g. wind farms) by ground photographs taken at different times of the day, or year. It is not feasible for photographic imagery to represent exactly the same time and environmental conditions from all viewpoints. However, Case study 8 (application of mobile augmented reality to above-ground PV) illustrates how new tools and the use of real-world imagery can be very effective, with the potential for the same scenes to be captured at different times of the year or day, and thus accommodate ephemeral issues.

9.37 In the evolution of the use of tools to support different stages in the planning process, the key opportunities identified by interviewees should be balanced against the key weaknesses or threats. Most significant of those threats is minimising the risk of materials being used to deliberately mislead an audience, and the adherence to good practice and ethics to reduce risks of unintended misrepresentations. This reflects the recognition in Beveridge et al. (2016) of gaps in skills and resources (**Outcome 5**).

9.38 Skills in public engagement, knowledge exchange and communications were identified by stakeholders and in the literature as being important for the effective exploitation of digital imagery and 3D visualisation materials throughout the planning processes. The nature of the skills of relevance differ for different stages in the process, with greater requirements for translation at stages of eliciting initial ideas and public consultations, and again with final determinations and more technical interpretation at points in between. However, from the stakeholder interviews, relatively little reference was made to specific requirements for training, except in relation to investment to gain certain technical skills for better use of the tools available. The topics of training and identification of skills of relevance could be identified as a challenge for the IT Task Force (**Recommendation 10)**.

9.39 Approaches worth considering for increasing the uptake and practice of digital imagery and 3D tools in the planning system are:

- Provision of examples of the effective use of digital imagery and 3D tools in different stages in the planning process (e.g. illustrate how 3D visualisations can aid the quality and efficiency of decision-making);

- Demonstrations of where the use of such tools, or their outputs, contribute to good practice in principles of public policy and planning;

- Presentations to CPD events for planners through the RTPI, and articles to journals of professional bodies. Case Study 10, Birmingham City, has already been presented in that type of forum (July, 2016), and Case Study 7, South Ayrshire Council has been presented at a relevant GIS forum (AGI Scotland, 2016).

9.40 Collate a gallery of best practice of the use of digital imagery and 3D visualisations in relation to planning in Scotland. This can be exploited as part of awareness raising, sharing best practice, and the promotion of the towns, cities and other areas which contribute, thus also delivering to an objective of Beveridge et al. (2016). Indeed, three local authorities identified an objective of the use of digital imagery and 3D visualisations as aiding the promotion of their local authority areas (Glasgow, Birmingham and South Ayrshire).

9.41 Whilst considering the real and potential benefits of digital imagery and 3D visualisations it is worth noting a comment by Interviewee 10:

> "At the end of the day, the actual exercise is not about the visualisation. It is about the decision-making." [Interviewee 10]

10 Recommendations

10.1 An IT Task Force is taking forward Recommendation 10 of the Review of Planning of Beveridge et al. (2016), and being referred to as the Digital Transformation Task Force. This study identified how digital imagery and 3D visualisation and models are used in planning process in Scotland, or could be used in future.

10.2 Based upon the desk-to study, stakeholder interviews and case studies, a set of recommendations emerge for consideration in the work programme of the Task Force. These recommendations are:

1. To identify an approach to the development of standards for the use of digital imagery, 3D visualisations and models within the planning process. This approach should recognise the requirement to match the types of imagery, data and tools to the different steps in the planning process, and the differences between types of stakeholder relevant to each step. It should include the nature of the metadata required for 3D data and visual imagery, requirements for enabling the transfer of 3D data between stakeholders (e.g. Developer, local authority planning team, local community) to maintain consistency in representation of a development, and avoid duplication of effort. The process would then lead to the publication of agreed requirements and standards for each step.

2. To identify means of enabling access to data and tools for generating 3D visualisations by all relevant types of stakeholder. This would cover identification of the types of training in relevant principles of the use of 3D imagery, and tools for its creation, inequalities of access to relevant data and tools (e.g. socio-economic and geographic), sources of relevant 3D tools currently used in the planning process and how they could be publicised and exploited more effectively.

3. To consider how to improve and broaden access to digital spatial data of relevance to different stages in the planning process, its maintenance and update cycles. This could include: I) how to evolve the One Scotland Mapping Agreement to widen the types of data included, and membership; Ii) how to evolve Scotland's Environment Web to widen the types of data included; Iii) the benefits and disbenefits of treating certain types of digital data of relevance to planning as part of national infrastructure,

4. To identify the limitations to the effective use of mobile tools which can generate or use digital imagery and 3D visualisations. Such limitations may be infrastructural (e.g. gaps in coverage of mobile data communications of appropriate high speeds), or social (e.g. lack of access to contemporary mobile technologies across all groups in society).

5. To coordinate a short series of information events on existing digital imagery, tools and approaches to 3D visualisation used in planning in Scotland, and emerging tools (e.g. Virtual reality, citizen science). Such events would target

civic society and communities; local authorities, Scottish Government and public agencies; and, developers and consultants. Content consistent to each could include digital imagery, tools and communication media, but tailored to suit each type of audience (e.g. CPD for RTPI where appropriate) and could follow models such as that of SNH Sharing Good Practice.

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12 Annexes

Annex 1. Software for 3D visualisation and supporting processing

Table A1. Tools with 3D visualisation capabilities suitable for representing landscape and developments (This table was compiled in January 2015. This list is not comprehensive and no recommendations of software are implied by their inclusion in this table. Any costs quoted in this table were correct as at January 2015 and are liable to change.)

Name	Description	Application	Operating System	Cost	Web Link
ArcGIS	Desktop GIS	Create, organise, analyse geographic information	Windows	Contact Vendor	www.esri.com/software/arcgis
ArcGIS	Mobile GIS	Data collection	IPAD, Android and Windows phone	Contact Vendor	www.esri.com/software/arcgis/platform
Autodesk Maya	Modeller	3D modelling and animation	Windows, OS X, Linux	Contact Vendor	www.autodesk.co.uk/products/autodesk-maya/overview
Autodesk 3DS Max	Modeller	3D modelling and animation	Windows	Contact Vendor	www.autodesk.co.uk/products/autodesk-3ds-max/overview
Autodesk AutoCAD Civil 3D	3D CAD and modelling	3D terrain modelling	Windows	Contact Vendor	www.autodesk.co.uk/products/autodesk-autocad-civil-3d/overview
Autodesk Infrastructure Design Suite Ultimate	3D CAD and modelling	3D terrain modelling & animation	Windows	Contact Vendor	www.autodesk.com/suites/infrastructure-design-suite/overview
BC Hydro Theatre (Decision Theatre)	Virtual reality environment (fixed)	Public participation, landscape preference surveys, awareness raising	Windows, using Community Viz add on to ArcGIS	Contact CALP at UBC	http://elementslab.ca/tools/hydro-theatre/

Blender	Modeller	3D modelling and animation	Windows	Free	www.blender.org/
Cinema 4D	3D Modeller	3D Modelling and animation	Windows	Contact Vendor	www.maxonshop.com/uk/
Community Viz	Extension to ArcGIS, with 3D tools	Community planning	Windows	Contact Vendor	http://placeways.com/gisapps/index.html
ESRI 'Story Maps'	Compilation and presentation of map and image-based narratives	Presentation of Local Development Plan (e.g. South Ayrshire)	Windows, OSX	Contact vendor	https://storymaps.arcgis.com/en/
Estonian University of Life Sciences Virtual Landscape Theatre	Virtual reality environment (fixed and mobile)	Public participation, landscape awareness raising	Windows, using Octaga	Contact Estonian University of Life Sciences	http://pk.emu.ee/en/structure/landscapemanagement/landscapetheatre/
Eyesee visualisation software	Real-time 3D Visualisation software	3D Landscape modelling & visualisation, public participation	Windows, iOS	Contact Vendor	www.pinnaclevl.com
Gear VR	Smartphone-based Virtual Reality Headset	Low-cost, portable Immersive visualisation	Mobile: Android	£79.99	www3.oculus.com/en-us/gear-vr/
Genesis IV	Landscape Modeller	3D Landscape modelling & visualisation	Windows	Free	http://geomantics.software.informer.com/
Global Mapper	Desktop GIS	GIS data processing	Windows	$399	www.bluemarblegeo.com/products/global-mapper.php
Google Earth and Street View	Visualisation software	Visualise / explore worlds	Windows, OS X, Linux, Android, iOS	Free	www.google.co.uk/intl/en_uk/earth/index.html
Google Map Maker	Map editor for Google Maps	Edit / add own map data	Uses internet browser	Free	www.google.com/mapmaker

Grass GIS	Desktop GIS	Create, organise, analyse geographic information	Window, OS X, Linux, BSD	Free	http://grass.osgeo.org/
Landformer Pro	Heightfield editor	3D Landscape modelling & visualisation	Windows	Free	http://geomantics.software.informer.com/
Lenne 3D	3D modelling software	Vegetation and natural/ semi-natural environments	Windows	Contact vendor (provided as consultancy service)	http://lenne3D.com/ Please note: website in German.
Lightwave	Modeller	3D modelling and animation	Windows, OS X	Contact Vendor	www.lightwave3d.com/
Lumion 3D	3D animation software for architecture and planning, importing models (e.g. from Sketch-up; 3DS)	Applications in architecture for planning proposals	64-bit Windows 10	1,500 Euros to 3,000 Euros	https://lumion3D.com/urban-planning-visualization.html
Nemetschek / Vectorworks	3D CAD and modelling	Architecture / Landscape Design	Windows / OS X	Contact Vendor	www.vectorworks.net/
Oculus Rift	Virtual Reality Headset	Immersive visualisation	Windows, OS X	£549.00	www.oculus.com/
Octaga Player / Panorama	3D X3D viewer	X3D presentation viewer	Windows	Contact Vendor	www.octagavs.com/
Rhino 3D	3D CAD and modelling	3D modelling	Windows	Contact Vendor	https://www.rhino3d.com/
Social Science for the Environment, Virtual Reality and Experimental	Mobile virtual reality environment, and fixed	Public participation, landscape preference	Windows, using Terragen, Visual Nature Studio (for model	Contact University of East Anglia	www.uea.ac.uk/environmental-sciences/research/virtual-reality-theatre

laboratories (SSEVREL)	version (20 people)	surveys, awareness raising	development)		
Spatial Information Exploration and Visualisation Environment' (SIEVE, Univ. Melbourne)	Visualisation and 3d environments linked	Stakeholder	Windows, using ArcObjects and gaming engine	Contact University of Univ. Melbourne	
SketchUp Make	2D/ 3D Computer Aided Drafting	3D Modelling	Windows	Free	www.sketchup.com/
SketchUp Pro	2D/ 3D Computer Aided Drafting	3D Modelling	Windows	£384.00	www.sketchup.com/
SolidWorks	3D Computer Aided Design	3D Modelling	Windows	Contact Vendor	www.solidworks.co.uk
Terragen	Landscape Modeller	3D Landscape modelling & visualisation	Windows	Contact Vendor	www.planetside.co.uk/
Unity 3D	3D Game Engine	Game engine which can display 3D models	Windows, IOS, Android	Free / $1500.00	http://unity3d.com/
UrbanPlanAR and VentusAR	In-field data visualisation	Present 3D models in situ on mobile device	Mobile: iOS on tablet, phone	Contact vendor (being checked)	http://urbanplanar.com/ http://ventusar.com/
Vega Prime	3D Openflight viewer	Training, and situation appraisal using 3D models	Windows, Linux	Contact Vendor	www.presagis.com/products_services/products/modeling-simulation/visualization/vega_prime/
Virtual Landscape Theatre (James Hutton Institute)	Mobile virtual reality environment, and fixed	Public participation, landscape preference	Windows, using Octaga, Vega Prime, Visual Nature Studio (for	Contact James Hutton Institute	www.hutton.ac.uk/learning/exhibits/vlt

	version (20 people)	surveys, awareness raising	model development)		
Virtual Terrain Project	Landscape Modeller	3D Landscape modelling & visualisation	Windows, Linux	Free	http://vterrain.org/
Visual Nature Studio / World Construction Set	Landscape Modeller	3D Landscape modelling & visualisation	Windows	Contact Vendor	http://3dnature.com/
Vue	Modeller	3D Landscape modelling & visualisation	Windows, OS X	Contact Vendor	www.e-onsoftware.com/products/solutions/?page=landscape
Vue 11 Personal Learning Edition	Modeller	Landscape Visualisation	Windows, OS X	Free	www.e-onsoftware.com/try/vue_11_ple/
Wikitude	Augmented Reality SDK and Application	Exploring environments (for mobile devices)	Windows phone, Android, iOS, Blackberry	Contact Vendor	www.wikitude.com/
WorldViz	Virtual reality Software Toolkit		Head mounted displays, hand motion tracking, curved screens, domes	$4,490 + $490 annual support	http://www.worldviz.com/

A2. Software required, or providing support for use of 3D visualisations

Name	Description	Application	Operating System	Cost	Web Link
Aris	Game authoring	Geo-tagged game authoring	iOS	Free	http://arisgames.org/
Digital video and stills	Smartphone / digital camera digital pictures	Presentation	Windows, OS X, Linux, Android, iOS	Free on most smartphones	
Google Maps and Street View	Web based Maps of the world	Exploring / navigating the world	Uses internet browser	Free	https://maps.google.co.uk/
Google Map Maker	Map editor for Google Maps	Edit / add own map data	Uses internet browser	Free	www.google.com/mapmaker
Pinterest	Social networking	Share images and notes	Uses internet browser	Free	https://pinterest.com/
Gimp	Image Editor	Photo / image retouching	Windows, OS X, Linux	Free	www.gimp.org/downloads/ http://getgimp.com/lp/index.php?pk=4769
Photoshop	Image Editor	Photo / image retouching	Windows, OS X	Contact Vendor	www.photoshop.com/products/photoshop

Annex 2. Draft questions for telephone interviews with stakeholders

3D visualisation Study: Telephone interviews

Interviewee:

Interviewer:

Date:

Time:

3D Visualisation Study: Questions

Please record the name and organisation of person completing the questionnaire:

Name: Organisation:

1. On a scale of 1 to 5 (where 1 is no experience, and 5 is very experienced) how much experience have you had of seeing computer visualisations?

Asked if score to Question 1 = 3, 4 or 5

Answer:

2. Types of visualisation technology:

(i) With which types of visualisation technology are you most familiar

Answer:

(ii) Does your organisation use any visualisation technology? If Yes, please expand on your answer.

Answer:

3. How does your organisation use computer visualisation to consider development proposals?

Answer:

4. Do you have an example in your organisation of where computer visualisations were particularly successful?

Answer:

If yes, in what way

Answer:

5. Do you have an example in your organisation of where computer visualisations were particularly unsuccessful?

Answer:

If yes, in what way?

Answer:

6. On a scale of 1 to 5 (where 1 is no recognition, and 5 is excellent recognition), how well did you recognise the landscape, points of reference, and features from the visualisations?

Answer:

7. For which types of development proposals are computer visualisations currently most useful?

   Why?

Answer:

8. On a scale of 1 to 5 (where 1 is not at all, and 5 is completely confident), how confident are you that the visualisations are an honest and truthful representation of what they claim to be representing?

Answer:

9. On a scale of 1 to 5 (where 1 is not at all, and 5 is excellent), how user-friendly is the visualisation system in helping you understand the impact of the development?

10. On a scale of 1 to 5 (where 1 is not at all, and 5 is excellent), how flexible or versatile is the visualisation system in enabling you to test options for the development apart from those presented?

Answer:

11. From the following capabilities of computer visualisations which would you say was the most important if you are asked to comment on a development proposal?

    A. Walk-through; B. Viewing different options for the development; C. Changes through time; D. Photo-realistic imagery; E. Inclusion of non-visual information.

Answer:

12. What do you think would be required for 3D visualisation technology to become more widely used or common practice for your purposes?

Answer:

13. Are there potential financial and technological benefits of computer visualisations?

Answer:

If yes, please expand on your answer

Answer:

14. What are the principal challenges to your organisation for the use of computer visualisations?

Answer:

15. What are the principal challenges to other organisations for the use of computer visualisations?

Answer:

16. Can you suggest a case study using computer visualisations in which you have been involved about which we could conduct a follow-up interview?

Answer:

If you answered Question 1 with a score of 4 or 5 then please answer the following two questions.

17. What are the characteristics of computer visualisations which are most likely to be available in the near future and how it might best be used?

Answer:

18. What are the principal Strength, Weakness, Opportunity and Threat offered by computer visualisations with which you are familiar?

Answer:

Strength –

Weakness –

Opportunity –

Threat -