Virtual Cities: Management and Organisational Issues

Martin PODEVYN
PhD Researcher
School of the Built Environment
Northumbria University
Newcastle upon Tyne
NE1 8ST
United Kingdom
Tel: (+44-191) 227 4301
Fax: (+44-191) 227 3167
E-mail:
martin.podevyn@northumbria.ac.uk

Margaret HORNE
Principle Lecturer
School of the Built Environment
Northumbria University
Newcastle upon Tyne
NE1 8ST
United Kingdom
Tel: (+44-191) 227 4693
Fax: (+44-191) 227 3167
E-mail: m.horne@northumbria.ac.uk

Peter FISHER
Director of Research
School of the Built Environment
Northumbria University
Newcastle upon Tyne
NE1 8ST
United Kingdom
Tel: (+44-191) 227 4542
Fax: (+44-191) 227 3167
E-mail: peter.fisher@northumbria.ac.uk

Abstract: This paper describes an audit of current practice in VR city modelling within Europe, with focus on the management, financial and organisational issues of models used for urban planning. While computer hardware and software for city models continue to develop, the organisational aspects regarding their creation, operation and maintenance remain problematical. Little is known about available options, models of best practice (Bishop and Forster, 2007) or how VR functions as a means of communication for urban planning applications (Sunesson et al, 2007). City models that are used for planning functions are of particular value when assessing the likely visual impact of a new project in its context. As the technical process of integrating Architectural models into a city model is well practiced, this paper examines the trends in current city models around Europe.

Keywords: Virtual cities, city modelling, management, urban planning, stakeholders.

1. INTRODUCTION

This paper describes an audit of city models carried out between September 2008 and January 2009. City model stakeholders were consulted from industry, academia and government to investigate the varied roles that are involved in managing a city model. A Virtual City Exchange website has been set up to create a community for city modellers and a forum for discussion concerning the development and maintenance of virtual city models. The audit described in this paper is based upon

European city models that have been identified through an extensive literature review and interview process conducted between June and December 2008.

City models were initially identified and selected from across Europe based upon pre-defined criteria (location, size, detail, secondary application) that were then shortlisted for further investigation. The study looks at the life cycle of city models established specifically for urban planning purposes, beginning with data acquisition and licensing issues. Copyright and legal issues are addressed, as well as the running costs involved with operating and updating city model data. This paper, offering the results of an extensive audit process, highlights current trends in city modelling being practiced in projects across Europe. Common themes in city model management techniques are explored and suggested methods of good practice could be considered by urban planners about to embark on the development of a virtual city model.

The overall aim of this research programme is to design a business framework for the management of 3D virtual city models for hosts who are seeking to operate a city model for urban planning functions. The research will outline standards and protocols for its creation, copyright and legal issues for its distribution and suggest processes for both its update and improvement. This responds to research by Dokonal, Martens (2001) and Bourdakis (2004), who have recommended a 'guiding source book' for the creation and use of city models. The diverse issues and needs of various stakeholders will be also addressed (Horne et al., 2006) in order to address the organisational issues and common concepts involved with establishing, hosting and managing a city model (Voigt et al., 2004).

2. BACKGROUND AND THEORETICAL CONCEPTS

2.1. 3D Virtual City Models in Urban planning

Many technical barriers to the inclusion of various stakeholders exist in the UK's urban planning process. Moreover, current methods for communicating development proposals to the general public are not only difficult to understand but do not give appropriate opportunities for participation (Mantle et al., 2007), contrary to the Office of the Deputy Prime Minister's 2005 publication of 'The Draft Town and Country Planning' (ODPM, 2005).

Establishing links with Local Authorities is crucial for city model hosts to ensure successful public participation in projects at national and EU level, who are strengthening public participation and e-democracy by encouraging involvement of urban development by residents (Knapp et al., 2007). Historically, calls for comments, statements and general public opinion on regional development plans, environmental impact assessments or zoning changes typically attract very low turnout (Strobl, 2006).

Among many others, Lange (2005) explains that computer-based visual simulations can potentially function as the link between the classic top-down approach in urban planning, i.e. experts providing information to the general public, and the bottom-up approach, i.e. the general public being consulted and participating in decision making. Brown et al (2005) states that a major problem that faces the a city model host is the issue of merging those involved in the participation, urban planning and the development processes together within a common framework of understanding(Brown et al., 2005)(Brown et al., 2005)(Brown et al., 2005)(Brown et al., 2005)(Brown et al., 2005)(Brown et al., 2005)(Brown et al., 2005). Bishop and Forster (2007) explain that the many technological and organisational barriers that affect the use of VR in collaborative planning may be overcome by a thoroughly designed model implementation and use. Much research has been carried out to explore the barriers and perceived barriers to adopting VR in various stages of the urban planning process (Hudson-Smith, 2005, Fu et al., 2005, Bourdakis, 2004, Firmino et al., 2006, Appleton and Lovett, 2005), which reveal that cost and time for training are major factors restricting its use (Mantle et al., 2007). The purpose of this research is to tackle some of the organisational barriers that face implementing a 3D city model.

2.2. Users and Stakeholders

Wang et al (2007) suggest that the insufficient integration and interoperability between software applications have caused considerable barriers to communication between the stakeholders. According to Hall (1996), there are four relevant parties in the urban planning process whom are seen as legitimate ‘stakeholders’: city planners, architects working for clients, the clients and the general public.

The planning participation environment can also determine the success of the process, as research shows that many VR environments or ‘Decision Theatres’ do not boast many returning visitors, once an initial project has been completed (Kobayashi, 2006). Cases such as Berlin’s Business Location Centre and Glasgow’s Digital Design Centre are examples of city models which have an increasing frequency of users and returning users for urban planning, architectural visualisation and real estate applications, demonstrating a robust framework for attracting and communicating to their users. Originally, it was architects and academia who have been the driving factor for the creation of city models for spatial analysis, there is a shift towards users from surveying, programming and GIS driving the development of city models around the world for a variety of applications (Dokonal, 2008).

2.3. Modelling Procedures and Standards

Much progress has occurred over the last 5 years in the standardisation of city model data, such as the recognition of the CityGML (City Geography Mark-up Language) data standard, which is a multi-purpose representation for the storage and interoperable access to 3D city models (Kolbe et al., 2005). In 2008, the KML (Keyhole Mark-up Language) language was officially recognised as an ISO standard, emphasizing Google's foothold in the Geographic Information (GI) industry. This is also in line with the development of Industry Foundation Classes (IFC)[1] and Building Information Models (BIM), which have a great deal to offer to data-rich city models. Beside the technical issues of these large complex models (Wang et al., 2007), it is the lack of high level commitment by key players in both the construction and software industries that hinder the standardization efforts in the Architecture, Engineering and Construction (AEC) industry (Behrman, 2002). The uptake of BIM in practice will present information rich, accurate geometric models for larger 3D virtual city models (Kohlhaas and Mitchell, 2007).

Although CityGML does outline some thematic methods of representing digital building models ('Level-of-detail 0-3'), established recommendations are necessary for quality levels and methods of depicting the content of a building proposal (Bourdakis, 2004). This is essential for better understanding of a planning scheme and a democratic aspect of city planning decision-making (Sunesson et al., 2007). Furthermore, different stakeholders involved in the development process require to see the model from different perspectives and qualities (Brown et al., 2005).

2.4. Ownership and legal issues

Although virtual cities have been established by a range of users, from educational establishments to private urban modellers, Le Heron (1999) highlights the importance of the careful hosting of a city model for specialist applications. This is necessary to ensure that information is secure, its distribution is controlled and to protect Intellectual Property rights. Virtual Cities that are used for urban planning and Government functions require careful control of its data so that it does not become a commercial or marketing tool and lose its integrity and reliability. In this situation, the legal rights to the data can also become complex and fragmented, which can restrict the use and increase the costs of operating the city model. The risk of a host losing some commercial or contractual control raises obvious concerns to stakeholders in the urban planning decision-making process (Bishop and Forster, 2007).

Legal issues concerning 3D city models can be associated with the data acquisition and management of the data's use. This model data is often sourced from 3rd party aerial imagery or specialist city modellers. This approach can be restrictive for the distribution and intended use as the necessary Intellectual Property Rights (IPR), security or privacy laws may be applicable. Historically, it has been noted that the lack of proper copyright protection or digital signature stamping in 3D geometry,

[1] An IFC is a 3D file format enabling interoperability between other IFC compliant software.

coupled with the relative ease at which file can be transferred across the internet was hindering the development and availability of urban models (Bourdakis, 2001).

In a collaborative city model situation, architects and designers who share their 3D models frequently request to retain rights to their data. This is usually to avoid misrepresentation, particularly during the course of planning proposals, not exclusively for IPR purposes as would be expected. For these reasons, more recent examples of city models have acquired data using laser scanning technologies to avoid legal restrictions and produce 'as-built' 3D geometry, rather than relying on architects' drawings (e.g. Glasgow, Westport) (Pritchard, 2007).

2.5. Management and update of virtual city models

Based on research carried out on virtual city models, it is evident that although much research has been carried out on the process and application of virtual city models, little work has been carried out on the theoretical organisational and management issues that these technologies encounter. Hamilton et al (2005) verifies the notion that the ability to manage urban planning data leaves much to be desired and that practical aspects, such as the management of 3D city models and how they can be sustained, must be addressed (Dokonal and Martens, 2001). It has also been recognised that the majority of GI (Geographical Information) users do not yet know what they require from 3D building data (Sargent et al., 2007), which adds to a vast knowledge gap , further confused by the thwarting question: 'what to model'.

Concepts for 3D change detection and automatic updates of city models have been developing for some years now and are evident in some of the city models in this study. These concepts however, generally focus on the comparison of temporal information (e.g. remote sensing imagery) to identify discrepancy so that areas for re-modelling can be detected and carried out (Song and Deren, 2003). Holland et al (2003) describes this process as the comparison of two sets of imagery that require the manual intervention from a user who must interpret and prioritise all change illustrated in the graphical display that is adopted. For city models as with most forms of Geospatial data, update can be carried out by either re-audit or revision, depending on the extent of work to be done (Song and Deren, 2003). One area of research on updating city models is rapidly converging on complete automation (Holland and Tompkinson, 2003, Song and Deren, 2003) although the cost and prolonged time-scale of this approach is still extremely high and data must be periodically acquired by remote sensing (aerial photography in most cases) for data comparison.

3. METHODOLOGY

The audit aimed to gather qualitative research data from a cross sectional sample of current city models in Europe, designed to be an informative critical appraisal of city model management methods.

In order to establish boundaries for this data collection, only European city models have been shortlisted for the audit. Information gathered from the literature review indicated that there are many common issues pertaining to hosting and managing city models within this group, such as software, applications and legal issues. The latter point also includes recently implemented EU legislation that has been the key driving factor for the establishment of many city models by its members. Finally, the accessibility of the audit participants was an important factor for consideration for the purposes of the research, as interviews will be necessary and issues such as language and time differences were taken into account.

A second reason for auditing city models that had been used for urban planning functions was done to target data of a particularly high quality and whose accuracy was an essential aspect of the data- from data collection/ acquisition, to the modelling process and application. Furthermore, this attention to accuracy and quality has been proven in practice, particularly for well established city models. The subsequent interview stages would then aim to consult city model hosts who had succeeded in managing self-sustaining and updated city models that would paint a picture on the best practice of managing city models.

The initial aim of the audit was to gather qualitative research data from a cross sectional, representative sample of current European city models. This extensive list of models will be categorised so that a representative sample can be selected to create a shortlist of interviewee participants. A series of interviews will follow to explore key issues and greater understanding of the management, financial and organisational issues of virtual city models. Having completed the second stage of the audit, the gathered data will be analysed in order to critically appraise the management methods that have been adopted from the interview sample.

The selection criteria were eventually chosen to highlight city models that demonstrated an emphasis on accuracy, quality and high level-of-detail (LOD). Furthermore, for the purposes of the research, only city models that were established primarily for urban planning functions were chosen for the audit.

Following an extensive, ongoing literature review it became apparent that city models that had been developed solely for GIS purposes had little emphasis on data accuracy and displayed a broad range of detail, precision and organisational value. Many of these had been developed for simple visual enhancement of 3D Digital Terrain Models (DTM) and have used fairly basic techniques to create a model, such as extruding 2D building footprints to varying heights. These tools that are used for creating simple, low-polygon, low detail city models are becoming increasingly economical and viable for many users, using simpler, low-cost or even free software and more competitive rates for GI and building data.

The information required for the audit was gathered primarily from literature and web-based information in order to formulate the initial list and categorise them based on their characteristics. Further information was collected by contacting the hosts directly.

4. CITY MODELS IN EUROPE

The audit identified the following city models in Europe that are currently being used for urban planning functions (2008):

Salzburg	Paris (3)	Potsdam	The Hague
Vienna	Paris (Bezons)	Rostock	Utrecht
Birmingham	Toulouse	Schwerin	Lisbon
Edinburgh	Vierzon	Stuttgart (2)	Bratislava
Glasgow (2)	Berlin	Weimar	Maribor
Manchester	Bochum	Wiesbaden	Barcelona
Newcastle	Bonn	Westport	Madrid
London (4)	Bremen	Florence	Seville
Bruges	Chemnitz	Lucca	Valencia
Brussels	Coburg	Milan (2)	Gothenburg
Ghent	Cologne	Naples	Stockholm
Liege	Dortmund (2)	Parma	Geneva
Brno	Dusseldorf	Rome	
Copenhagen	Essen	Turin	
Helsinki (2)	Frankfurt (2)	Venice	
Dijon	Hamburg (2)	Amsterdam	
Lyon	Hannover	Antwerp	
Marseille	Heidelberg	Delft	
Nantes	Munich (2)	Diestadt	
Nice	Neubrandenburg	Rotterdam	

Clusters of detailed city models are evident in some countries for two main reasons. Firstly, established GI data providers that boast 3D modelling services can offer city model data for large parts of their resident country (e.g. GTA Geoinformatik GmbH in Germany, ZMapping in the UK and Vectuel in France). Secondly, recent EU legislation has encouraged their use, such as the Environmental Noise Directive (2002). Many cities in Germany have been modelled, partly for this reason, but also due to Germany's approach to the city modelling technology and an established GIS underpinning that have been driven by research and academia in the country.

From the sample list, no current city models were found that existed before 2001. This is surprising as 3D city models have been used in urban planning for almost 20 years, explaining a life span of less than a decade for many city model data. This could be linked to a distinct lack of regular update procedures by the hosts. The period between data acquisition and final city model using photogrammetry are, on average, 2 years apart. Although the modelling time is far greater to reflect the higher level-of-detail, terrestrial laser scanning has a far smaller development time for creating the models (typically 2-6 months) for the audit sample. This also reflects the in-house process of 3D data collection and modelling compared to an outsourcing approach that is favoured by many current hosts. This lengthy stage between data capture and final model for many of the city models can be extremely problematical, as a model can effectively be a number of years out of date 'straight out of the box' and their reliability for urban planning is immediately questionable.

The sample data collected ranged from 4 to 2,500 km^2 in representative model size, boasting anywhere between 185 and 300,000 buildings. Generally speaking, the greater the coverage, the lower the level-of-detail. Many models created in the last 3 years, however, that have used automatic or semi-automatic modelling processes from oblique imagery, display facade textures. However, this does not affect their Level-of-detail according to CityGML standards, as their positional accuracy and architectural detail remain fairly simplistic. This follows an holistic approach in the GI industry to 'capture once use many' in terms of airborne data collection so that a range of imagery and LIDAR data are captured at the same time (Ordnance Survey, 2006). Generally speaking, the audit sample displays an increased level of detail than a decade ago, where simple urban block models (LOD 1) were used to visualise the landscape. Roofscapes and facade details are evident in most cases, as well as photorealistic textures and building details (LOD 3, providing suitable positional and height accuracy), mostly due to technological advances in data storage and capture techniques.

Furthermore, some European countries are carrying out strategies that are forcing the entire country's cities to be modelled in 3D. Denmark-based Blom asa recently announced an initiative to model every building in the country (2.2 million buildings approximately), which can be achieved using recent advances in automated city modelling technologies, provided that suitable data is collected and used for the process. Sweden's national cadastral and mapping agency, Lantmäteriet, collects and publish 3D data that is freely available for its citizens (Hallebro, 2006). This means that there are many examples of small 3D models of its cities, which make it difficult to identify any official, unified or exemplar work from this region.

5. DATA ANALYSIS: TRENDS

The latest set of city models around Europe highlight a shift in trends towards more unified, interoperable data. Older examples of city models for urban planning functions were often setup using experimental techniques of data capture and modelling processes, with often very piecemeal results. Although some of these early models generally showed high levels of accuracy, they were usually of such a low level of detail to create any lasting practical application for urban planning.

The more modern examples of city models analysed for this study display a more unified set of data. CityGML standards are evident in a large amount of model data and previous interoperability issues have been addressed in many cases.

The results also highlight an increasing list of established city modellers and data providers who specialise in city modelling. Early attempts at modelling cities were expensive and time consuming tasks carried by a handful of academics with limited results (Dokonal, 2008).

There is also evidence that modern city modelling has reacted to the rapid development of global visualisation engines to some extent. Microsoft virtual earth and Google earth are two market rivals for web-based GIS platforms that boast 3D City model features. Although both have taken different approaches to their modelling processes, they are both developing 3D representations of major cities and countries at an impressive rate. However, it is arguable whether these platforms pose a commercial threat to city models that have been produced for the purposes of urban planning because of issues with data accuracy, copyright and quality. In other words, it would not be possible to guarantee a planning task, such as an architectural visualisation, that had been carried out using global visualisation engine.

Evidence from the audit suggests that the update and enhancement has still yet to be tackled. As mentioned above, technological approaches are still an expensive option and not feasible for most applications. However, an organisational approach, such as a close relationship with LA’s and relevant information sharing, could be the solution to a cost effective collaboration. Although the city models audited were established at different times, a resolution for periodic update of the data has yet to be solved. The cost of data acquisition and large scale modelling is gradually decreasing so that it is often the simpler and cheaper option to re-commission and purchase a more up-to-date model.

Figure 1 (below) describes the relationship between the various stakeholders who are potentially involved in current city model projects in Europe.

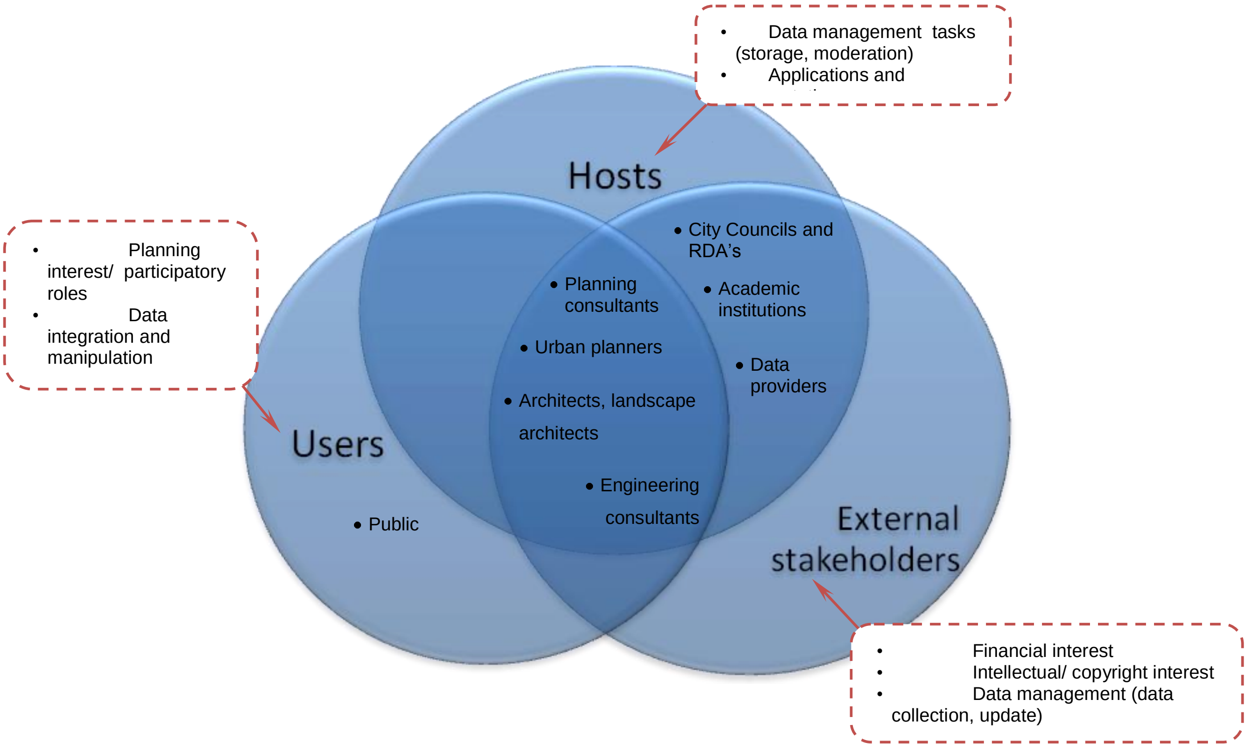

Figure 1 City model participants: roles and definitions.

The audit showed that there is still much experimentation between these roles, which are rarely clearly defined for virtual city projects. It has been proposed that this is due to the stakeholders' perceptions and expectations of city models, which is a familiar consequence in technology based projects (Laurini, 2001).

6. CONCLUSION

The latest set of city models around Europe highlight a more unified, interoperable 3D model data. The results also highlight an increasing list of established city modellers and data providers who specialise in city modelling with partnerships alongside cutting edge data capture experts. This illustrates a developing industry for the process of capturing and modelling 3D cities, which has progressed closely with academia and key research projects. Automatic and semi-automatic modelling techniques have become widespread across Europe and will play an increasing role for city models in planning.

Methods of update for 3D data are a key component to the success and sustainability of a city model. Many projects exist beyond their original planning function by their extension into other applications, typically virtual tourism, as very little consideration is given to the ongoing operating costs of a city model beyond the original data acquisition. Projects with established data licensing not only ensure a projects longevity, but also protect the legal rights of the stakeholders. Establishing the stakeholders' roles and project aims for city models in urban planning is also a key factor for their success and sustainability.

REFERENCES

APPLETON, K. & LOVETT, A. (2005) GIS-based visualisation of development proposals: reactions from planning and related professionals. *Computers, Environment and Urban Systems,* 29**,** 321-339.

BEHRMAN, W. (2002) Best Practices for the Development and Use of XML Data Interchange Standards. Center for Integrated Facility Engineering, Stanford University.

BISHOP, I. D. & FORSTER, R. D. (2007) Where is the vision? Developing systems to enhance adoption of technology for public decision-making. *CUPUM '07.* Iguassu Falls, Brazil.

BOURDAKIS, V. (2001) On Developing Standards for the Creation of VR City Models. IN PENTILLA, H. (Ed.) *eCAADe.*

BOURDAKIS, V. (2004) Developing VR Tools for an Urban Planning Public Participation ICT Curriculum; The PICT Approach. IN RUDIGER, B., TOURNAY, B. & ORBAEK, H. (Eds.) *eCAADe 2004.*

BROWN, A., KNIGHT, M. & WINCHESTER, M. (2005) Representation and Delivery of City Models. *10th International Conference on Computer Aided Architectural Design Research in Asia (CAADRIA).* New Dehli.

DOKONAL, W. (2008) Creating and Using 3D City Models. *26th eCAADe Conference Proceedings.* Antwerp.

DOKONAL, W. & MARTENS, B. (2001) A Working Session on 3D City Modeling. *19th eCAADe Conference Proceedings.* Helsinki, Finland.

FIRMINO, R. J., AURIGI, A. & CAMARGO, A. R. (2006) Urban and technological developments: Why is it so hard to integrate ICTs into the planning agenda? *11th Internation Conference on Urban Planning and Regional Development in the Information Society.* Congress Centre Vienna.

FU, C., RUFFLE, S., RICHENS, P. & AOUAD, G. (2005) USING VIRTUAL REALITY TECHNOLOGY TO FACILITATE WEB-BASED PUBLIC PARTICIPATION. *CUPUM '05.* UCL, Centre for Advanced Spatial Analysis.

HALL, A. C. (1996) *Design Control: Towards a New Approach,* Oxford, Butterworth Architecture.

HALLEBRO, J. (2006) Stakeholder Co-operation in Swedish Land Administration and Land Information. *XXIII International FIG Congress.* Munich.

HAMILTON, A., WANG, H., TANYER, A. M., ARAYICI, Y., ZHANG, X. & SONG, Y. (2005) URBAN INFORMATION MODEL FOR CITY PLANNING. *Journal of Information Technology in Construction,* 10**,** 55-67.

HOLLAND, D. A. & TOMPKINSON, W. (2003) Improving the update of geospatial information databases from imagery using semi-automated change-detection and user-guidance techniques. *GeoComputation 2003: 7th International Conference on GeoComputation.* University of Southampton.

HORNE, M., THOMPSON, E. M. & FLEMING, D. (2006) Virtual reality urban modelling- an overview. *CONVR: 6th International Conference on Construction Applications of Virtual reality.*

HUDSON-SMITH, A. (2005) Digitally Distributed Urban Environments: The Prospects for Online Planning. University of Central London.

KNAPP, S., BOGDAHN, J. & COORS, V. (2007) Improve public participation in planning processes by using web-based 3D models for communication platforms. *12th International Conference on Urban Planning, Regional Development and Information Society Geomultimedia 2007, Real CORP '07.*

KOBAYASHI, Y. (2006) 3D City Model Visualization in Decision Theater- a framework for multi-dimensional journey through time. *25th eCAADe* Greece.

KOHLHAAS, A. & MITCHELL, J. (2007) Modelling cities. IN AOUAD, G., LEE, A. & WU, S. (Eds.) *Constructing the future: nD modelling.* London, Taylor and Francis.

KOLBE, T. H., GROGER, G. & PLUMER, L. (2005) CityGML- Interoperable Access to 3D City Models. *International Symposium on Geo-information for disaster management.* Delft, Springer Verlag.

LANGE, E. (2005) Issues and Questions for Research in Communicating with Public through Visualisation: Trends in Real Time Landscape Visualisation and Participation. IN BUHMANN, E., PAAR, P., BISHOP, I. D. & LANGE, E. (Eds.) Anhalt University of Applied Sciences.

LAURINI, R. (2001) *Information systems for urban planning: a hypermedia co-operative approach,* London, Taylor and Francis.

LE HERON, R. (1999) *Explorations in human geography: encountering place,* Oxford, Oxford University Press.

MANTLE, E., JENKINS, D. H. & JIANG, L. (2007) THE USE OF VISUALIZATION TO ENHANCE PUBLIC PARTICIPATION WITHIN THE PLANNING PROCESS. *CUPUM '07.* Iguassu Falls, Brazil.

ODPM (2005) The draft town and country planning (environmental impact assessment) (England) (amendments) regulations. IN PLANNING, B. A. T. E. (Ed.).

ORDNANCE SURVEY (2006) Geographic Information Strategy 2006-2008.

PRITCHARD, D. (2007) CAPTURING THE CITY: THE DEVELOPMENT OF THE 3D URBAN MODEL OF GLASGOW. *CUPUM '07.* Iguassu Falls, Brazil.

SARGENT, I., HARDING, J. & FREEMAN, M. (2007) DATA QUALITY IN 3D: GAUGING QUALITY MEASURES FROM USERS' REQUIREMENTS. *Spatial Data Quality 2007: 5th International Symposium.* ITC, Enschede, The Netherlands.

SONG, X. & DEREN, L. (2003) Research on Key Points of 3D Change Detection of Geospatial Database. *MultiTemp 2003: 2nd International Workshop on the Analysis of Multitemporal Remote Sensing Images.*

STROBL, J. (2006) Visual Interaction:Enhancing Public Participation? *7th International Conference on Information Technologies in Landscape Architecture: Trends in Knowledge-Based Landscape Modelling.* Anhalt University of Applied Sciences, Dessau.

SUNESSON, K., ALLWOOD, C. M., PAULIN, D., HELDAL, I., ROUPE, M., JOHANSSON, M. & WESTERDAHL, B. (2007) Virtual Reality as a New Practice in the City Planning Process. *13th International Conference on Virtual Systems and Multimedia (VSMM '07).*

VOIGT, A., LINZER, H. & SCHMIDINGER, E. (2004) "What people really want"- user validation of "digital city" concepts. *8th Iberoamerican Congress of Digital Graphics.* Porte Alegre, Brasil.
WANG, H., HAMILTON, A., SONG, Y. & TAH, J. (2007) Implementation of a Data Integration Service for Building and Urban Planning. *Architectural Engineering and Design Management,* 3**,** 195-208.