

<b>Institution:</b>	University of Northumbria at Newcastle
<b>Unit of Assessment:</b>	16 - Architecture, Built Environment and Planning
<b>Title of case study:</b>	The co-ordinated virtual city model in urban design, planning and management
<p><b>1. Summary of the impact</b></p> <p>This case study presents research of the Virtual Reality and Visualisation (VRV) Group, particularly its lead project, the <b>Virtual NewcastleGateshead (VNG)</b> agreement and city model. This work has influenced and harmonised the <b>planning processes and assessment methodologies</b> of the two municipalities and has enhanced professional practice, enabling the proposals of <b>developers and architects of 12 major urban development projects</b> to be more accurate, efficient and profitable. The model has also informed the business decisions of Nexus, the Tyne and Wear Metro operator and impacted upon public awareness (e.g. in creating a <b>virtual e-mobility route</b> linking North Sea Region countries). Its cultural and artistic impact includes a <b>virtual reconstruction of Medieval Newcastle</b> and its role in supporting public exhibitions and artistic endeavours.</p>	
<p><b>2. Underpinning research</b></p> <p>The Virtual Reality and Visualisation (VRV) Group was set up within the Unit to develop virtual reality (VR) technologies for the built environment. This led to the Virtual NewcastleGateshead (VNG) initiative and creation of a VNG City Model, in 2009. The following examples of research relate firstly to the <b>applications of visualisation throughout the built environment</b>, then to the <b>benefits of the VNG model itself</b>, and how they were realised, and finally, to the use of VNG (and virtual city models in general) as a basis for <b>simulation and experimentation to inform design and decision-making</b>.</p> <p>The aim of the first piece of work (<b>Reference 1</b>) was to investigate the current use of VR in the building industries of four countries (China, Sweden, UK and USA). Semi-structured interviews with senior professionals from each of six leading construction companies within each country revealed the extent of usage and perceived benefits of VR. The findings included the rationale for VR adoption and the barriers to doing so.</p> <p>The next article (<b>Reference 2</b>) <i>presents</i> a detailed study of the creation of VNG, set in the context of earlier efforts at 3D city modelling. Based on investigations undertaken prior to setting up VNG, it defines the ideal requirements of a virtual city model for city authorities (urban planning and design), citizens (public participation) and practitioners (architects, developers). It critically examines available technologies, remote access issues, collaboration, and version control. By 2012, VNG was sufficiently well-established to influence the planning processes of the two authorities (<b>Sources 1 and 2</b>).</p> <p>The next piece (<b>Reference 3</b>) examined the challenges of sustaining virtual city models and how their success depends on strategic collaborations between multiple organisations to ensure the model is regularly used, continually updated, authoritative, and sustainable in the longer term. The work also discusses 'layering' models with data for visualised simulations of the performance of urban spaces (movement, noise, wind, and thermal comfort) and the consequent issues of data and software interoperability.</p> <p>This is taken up in a paper (<b>Reference 4</b>) focused on the optimum design of 'public squares' which considers the use of simulation software (for solar and wind effects, thermal comfort, noise and pedestrian and traffic movement movement). Noting the difficulties of interoperability between available simulation software, the use is proposed of the virtual city model 'layered' with information in 3-D form from databases of climatic and dynamic information.</p> <p>Virtual models can also make an important contribution to our understanding of the spatial performance from the standpoint of users (<b>Reference 5</b>). The paper presents a framework that integrates three important factors – the spatial structure itself, the cognitive maps that users construct, and their spatial strategies and abilities – that are of major importance to building</p>	

## Impact case study (REF3b)

designers. The use of virtual environments for experimental work in this area is examined.

The final paper (**Reference 6**) presents research carried out under the €6.6 million NSR e-Mobility project. The study is focused on developing (for analytical purposes) a virtual route for electric vehicle (EV) mobility in the North Sea Region by integrating the visualisation capabilities of the VNG model with algorithms of agent behaviour.

The research on which this case study focuses was carried out by Professor D Greenwood (1980 – date), Ms M Horne (retired, 2012), Dr E M Thompson (2005 – date), Professor R Giddings (1987 – date), Professor B Agnew (2009 – date), and Professor R Dalton (2010 – date): all part of the VRV group at Northumbria University during the period.

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

1. Greenwood D., Horne M., Thompson E.M., Allwood C.M., Wernemyr C., Westerdahl B. (2008) 'Strategic Perspectives of the Use of Virtual Reality within the Building Industries of Four Countries', *International Journal of Architectural Engineering and Design Management*, **4**, 85-98. DOI: 10.3763/aedm.2008.0076
2. Thompson E.M., and Horne M., (2009) 'Sharing 3D City Models' in *In: Computation: The New Realm of Architectural Design* (27th eCAADe Conference Proceedings). Education and Research in Computer Aided Architectural Design in Europe (eCAADe), pp. 261-267. Available from HEI on request.
3. Horne M., Thompson, E.M., and Charlton J., (2012) 'Towards a Multifunctional Virtual City Model', in N.N.Pinto, J.A. Tenedorio, A.P. Antunes, J. Roca (Eds.). *Urban and Spatial Planning: Virtual Cities and Territories*, IGI Global. DOI: 10.4018/978-1-4666-4349-9
4. Giddings, B., Charlton, J. and Horne, M. (2011) 'Public Squares in European City Centres'. *Urban Design International*, **16** (3), 202-212. DOI: 10.1057/udi.2011.6
5. Pflitsch, A., Bruene M., Steiling, B., Killing-Heinze M., Agnew, B., Irving, M., and Lockhart, J. (2012) 'Air flow measurements in the underground section of a UK light rail system'. *Applied Thermal Engineering*, **32**, 22-30. DOI: 10.1016/j.applthermaleng.2011.07.030
6. ElBanhawy, E.Y., Dalton, R., Thompson, E.M., and Kotter, R. (2012) 'Real-Time Electric Mobility Simulation in Metropolitan Areas: A case study: Newcastle-Gateshead' in Achten, H., Pavlicek, J., Hulin, J.; and Matejdan, D. (eds.), *Digital Physicality - Proceedings of the 30th eCAADe Conference - Volume 1*: pp. 533-546. Available from HEI on request.

### 4. Details of the impact

**Contributing to commercial successes:** Since its formation the group has been consulted by over 50 external organisations in the UK and overseas. Following the evaluation of VR potential and its uptake internationally in construction (**Reference 1**) the group began to engage with developers to maximise the potential of projects. An example is *The Stephenson Quarter*, a 'key regeneration project in the heart of Newcastle'. The developer Silverlink Holdings Ltd. engaged the unit's Virtual Reality and Visualisation Group to create a virtual model of the scheme, since: "*it has strategic links with Central Station, the historic core and the stylish Quayside - it was absolutely vital that we were able to demonstrate connectivity to these key areas and to communicate that message to different audiences.*" Following the work, the Director of Silverlink Properties reported that: "*The project through Northumbria University not only delivered that objective, it provided a platform for many other uses from design development and improvement through to promotion and marketing.*" (**Source 1**).

**Aiding council's planning processes:** Our most significant route to impact came from the formation of Virtual NewcastleGateshead (VNG) Partnership and the creation of the VNG City Model (both in 2009). In doing so, a great deal of research was conducted into the optimum organisational structure of VNG (**Reference 2**) and attention paid to ensure its sustainability (**Reference 3**). The model now covers over 100km<sup>2</sup> and compared with established practices, represents an effective stakeholder communication tool and an efficient way of examining the wider implications of planning applications. As a result, it has shaped and improved the planning processes of both

## Impact case study (REF3b)

councils. For example, the methodology of **view impact assessment** available with the VNG model has been adopted by the two municipalities, and has played a critical role in harmonising the planning processes of both. As a result, explicit recommendations for use of VNG have been included in Gateshead and Newcastle Councils' *Urban Design Supplementary Planning Documents*. To quote from the NewcastleGateshead Urban Core Area Action Plan (2011): "(VNG) ...has been established to provide developers with the opportunity for an accurate and effective view impact analysis to be undertaken of new development set within the context of the Urban Core and its views. Both Councils recognise this methodology of view impact assessment as being of sufficient accuracy for planning application purposes". (**Source 2**).

Improved decision-making for the built environment: The ideal requirements of a virtual city model for enhancing the delivery the public service of planning and regulating the built environment were established at the outset (**Reference 2**). In a report produced by Gateshead Council (2011) its Urban Design Officer stated that VNG has provided: "developers and architects with services which enabled their proposals to be more accurately and efficiently developed and assessed within their urban context". The report continues that benefits include much greater accuracy and efficiency for all those involved in planning decision-making, by way of greater certainty, quicker decisions, and resultant significant time and cost savings. Benefits exist for: "all stakeholders, including developers, architects, planning authorities and their elected members, statutory consultees, marketing agents, potential occupiers, and the wider general public" (all citations from **Source 3**).

Supporting professional practice through 3-Dimensional modelling and Visualisation: VNG has supported 12 major urban development projects (and many smaller schemes) by: "assisting architects and visualizers to produce accurate imagery to help their clients, stakeholders and other interested parties progress a project through the design development and planning process." (**Source 4**) The model has been systematically introduced to over 30 client organisations and over 50 architectural practices via strategic partnerships with RIBA and Northern Architecture, and has informed the design of Gateshead's most significant recent projects, including *Trinity Square* and Gateshead's quayside developments.

Ideally, city models should permit integration with applications that assist decision-makers in understanding the performance characteristics, as well as visual aspects of urban spaces. Our work is concerned with understanding how best to increase user engagement and develop VNG to support multi-system modelling, with applications such as transport, energy, pedestrian and heritage visualisations (**Reference 3**). An example is the Gateshead Boulevard project, where the Principal Engineer (Transportation) of AECOM cites: "three major benefits" that the VNG model brought to the project, namely (i) interoperability with: "multiple software packages (which) allowed us to visualise and fit our proposals in three dimensions"; (ii) its use with tools simulating: "the movement of vehicles ...(and)... the impact of vehicle queuing on the street scene"; and (iii) as "an essential part of our consultation exercises with Gateshead Council members... such that funding could be secured for further design" (**Source 5**). The developers of the £150 million Trinity Square project recognised that the VNG model: "provided the architects with the benefits of an established and recognised tool"...and..."allowed us to address the Local Authority's requirements of the impact of the development ... and how the development would appear ties into the existing urban fabric as part of a regenerated town centre" (**Source 6**).

Generating cost efficiencies: Using the VNG model as an experimental and developmental tool, Giddings *et al.* have produced a methodology for the dynamic three-dimensional design of public spaces and city centre squares (**Reference 4**) that was adopted by five practices (including Jane Darbyshire and David Kendall; and Napper Architects) in a RIBA North competition to design a new major square for Newcastle upon Tyne. Professors Agnew and Dalton have adopted VNG for their research fields of (respectively) *Subway and City Climatology* and *Agent-based Modelling*. Subway climatology research (**Reference 5**) has informed our work with Nexus (operators of the Tyne and Wear Metro system) which combines airflow measurement with laser scanning to visualise air flows and produce a predictive and diagnostic design tool for underground transport systems. To quote the Plant Engineering Technical Manager of Nexus, the work: "is very important in assisting Nexus to make some critical business decisions... it is planned to spend approximately £1.6 million on replacing 6-off ventilation fans...(and)...preliminary work (by Agnew) has shown

## Impact case study (REF3b)

*that ...(they)...are likely not needed. In addition to the capital investment...(this)...will save an estimated £110,000 per year in energy costs and reduce Nexus' carbon footprint by 630 tonnes of CO2 per year"* (Source 7). Dalton's work has explored virtual environments as a method for researching human factors in human understanding of, and interaction with the built environment including the creation of a virtual e-mobility route linking UK with other North Sea Region countries (Reference 6).

**Contributing to art and culture:** The artistic and cultural contributions of the VRV Group include laser scanning of historic structures (including the Lateran 'Scavi' international collaboration, Rome; Durham Castle; the 'Black Middens' project for Tasset Archive Group, and the Durham World Heritage Site Visitor Centre physical model of Durham peninsula). Exhibitions based on the work of the Group, and the VNG model have taken place at Gateshead Hilton CBI event (2010) and the model has supported an exhibition by landscape artist Colin Booth at the Laing Art Gallery, Newcastle (July to October, 2011). The model has been showcased at a RIBA Public Programmes – A Place to Call Home Exhibition, RIBA Portland Place, 2012, as well as forming the framework for the multimedia animation in Peter Dillon's play 'GUTS', performed as part of the Festival of the North East, 2013. The work undertaken on the VNG project has been presented at, and formed the foundation for debate at the Fish Quay Neighbourhood Plan - Evidence and Issues Workshops (2011-13) on issues of Localism in Planning.

The model is also an important basis for a virtual reconstruction of Medieval Newcastle, supported by Newcastle City's Historic Environment Group, which also uses the model's spatial information in a heritage context and its data in archaeological explorations. According to the Tyne and Wear County Archaeologist, this work: "is helping with the wider understanding and management of the City's surviving timber-framed buildings and is demonstrating a methodology which will be used to create a VR model of Hadrian's Wall which will be disseminated via an augmented reality app...that will have a widespread public and educational impact, and involve community groups, who will assist in the research of the historical data". (Source 8).

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

1. **Impact on professional practice (developers):** Testimonial from the Director of Silverlink Holdings Ltd. (also available at: <http://virtualng.northumbria.ac.uk/about/comments/> )
2. **Incorporation of VNG into planning processes of Newcastle and Gateshead:** NewcastleGateshead Urban Core Area Action Plan, Sept 2011, 5.52 at pp. 33. See [http://www.newcastle.gov.uk/sites/drupalncc.newcastle.gov.uk/files/wwwfileroot/planning-and-buildings/planning/nov11\\_draft\\_aap\\_main.pdf](http://www.newcastle.gov.uk/sites/drupalncc.newcastle.gov.uk/files/wwwfileroot/planning-and-buildings/planning/nov11_draft_aap_main.pdf)).
3. **Use of VNG by local authority planners:** Extracts from email correspondence with the Urban Design Officer, Gateshead Council Urban Design Office.
4. **Value to architects and visualizers:** Testimonial from the Director of EYELEVEL Architects. (available at: <http://virtualng.northumbria.ac.uk/about/comments/> )
5. **Improvement in design solution through use of VNG:** Extracts from email correspondence from the Principal Engineer (Transportation) AECOM.
6. **Use of model by developer to meet Local Authority's requirements and demonstrate visual impact of a major regeneration project:** Testimonial from Associate Director, Holmes Miller
7. **Subway climatology research to assist Nexus.** Extracts from letter (4 May 2011) from Plant Engineering Technical Manager, Nexus Rail HQ, Newcastle-upon-Tyne.
8. **Artistic and cultural contributions of the VNG model:** Extracts from email correspondence from Tyne and Wear County Archaeologist, Environment and Regeneration, Development Manager, Newcastle City Council and representative of the Association of Local Government Archaeological Officers, UK.