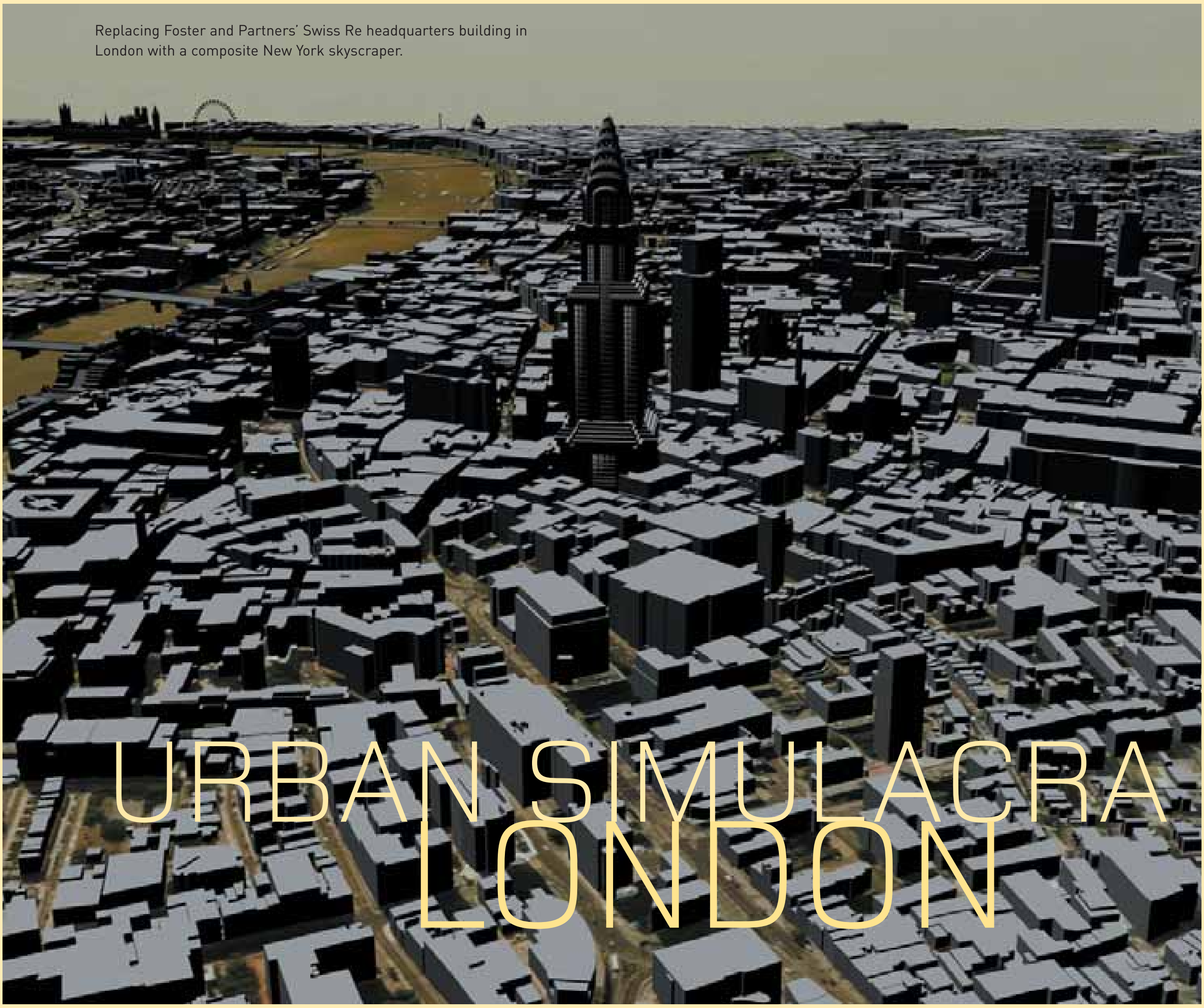
From Architectural Design, Volume 75 (6), 42-47, 2005

As the digital revolution deepens and pervades every aspect of daily life, virtual realities begin to penetrate one another in a multiplicity of ways. The amount of sensing data being compiled on the city grows, enabling the construction of virtual realities that can, in turn, be transformed for diverse purposes. Here, Michael Batty and Andrew Hudson-Smith from the

URBAN SIMULACRA LONDON

URBAN SIMULACRA LONDON

Centre for Advanced Spatial Analysis, University College London, outline how they went about the construction of a virtual city in central London. A conventional 3-D-GIS/CAD model was used as the basis on which to build a digital realm in which designers are cast as avatars and populations as agents, so as to define new ways in which to understand and plan the city.



Replacing Foster and Partners' Swiss Re headquarters building in London with a composite New York skyscraper.

1. Virtual Cities

Jean Baudrillard (1994) defines a simulacrum as a 'simulation of a simulation', a model of a model if you like.[1] In terms of cities in the digital realm, it is easy to translate such a conception into multiple layers of abstraction that we build up from the raw data we sense, perceive and explain in simulating urban form and structure. A generation or more ago, when computers were first used to represent cities, typical simulations were immediate and direct. Either the geometry of the city was used to construct digital 'iconic' models through which one could navigate, and sometimes use for CAD (computer-aided design), or geographic and economic functions were represented using 'symbolic' mathematical models that could be analysed and manipulated for the same ends: better design, better planning. As the digital revolution has matured, these conceptions have blurred, and now there are mathematical models that sit within iconic models, and vice versa, whose symbology exists on many levels. More importantly, perhaps, as computers have come to be used in everything from extracting data remotely, to mining it to find new patterns, visualising it in diverse ways, modelling it for the same diversity, and embedding users virtually into the process of use, models have come to be represented within models, worlds within worlds, as the power of recursive digital construction has gathered pace. This is simulacra: virtual cities within virtual cities where such embedding twists the process in curious but illuminating ways.

We will begin by describing the construction of a digital iconic model of central London that we somewhat euphemistically refer to as 'Virtual London'. Virtual London is in fact a 3-D geographic information system (3-D-GIS), which is in essence a large spatial database that can be analysed and queried. We can view it in 3-D because we can hold and file the data via digital representation of streets and building blocks. However, this is just one way of viewing the data – one perspective on the virtual city – and there are many others that need not stress the spatial dimension nor its built form. We construct this model as a series of data layers that we can overlay in 3-D. We can then embellish the model, adding a variety of digital media that we can deliver and display in everything from web browsers to holographic-like displays.

Such models can also be imported into other digital media. We illustrate the conception of a simulacrum by embedding it within a virtual world – a virtual design studio or exhibition space – which users can enter as avatars and then view and manipulate the model in the presence of other users, who are also avatars. This embedding can be recursive in that we can enter such worlds, view the model and then fly through it, adding new digital media at points where we need to render the environment with different images. Like many of our simulacra, Virtual London is designed so that users can learn about and redesign their environment in a

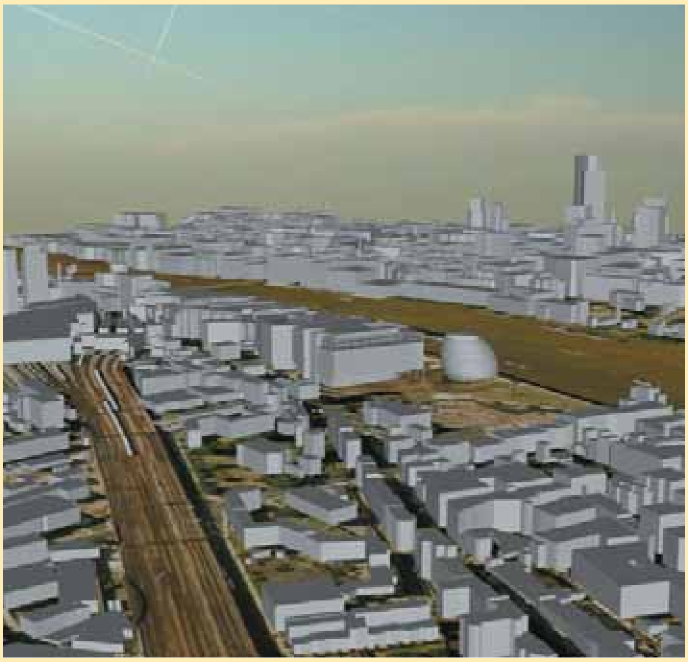


Figure 1: View west from Tower Bridge across Virtual London, showing the raw geometry of the virtual city before it is populated with data.

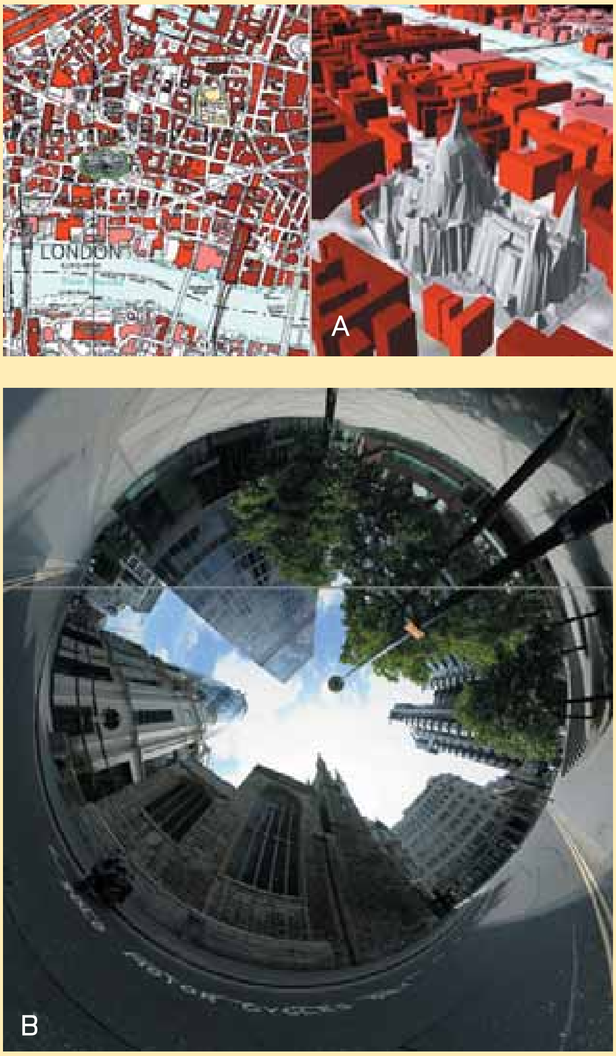


Figure 2: Building the virtual city in layers from the ground up. (a) Extruding parcel data to average height and inserting a LIDAR image of St Paul's Cathedral into the scene. (b) Adding a digital panorama of the area around the Swiss Re headquarters building.

participatory sense. However, this also requires more formal analytical techniques – symbolic or mathematical models. To this end we will also illustrate how people as agents can be represented within the model, and how users can view these agents in using such models for solving real-world problems that, in turn, can be visualised within the wider Virtual London model. Our vision of the virtual city is thus one of many penetrating virtual worlds, from the world of data to the world of agents moving within the world, to the world of end-users manipulating the environment with other users in a participatory context.

2. Virtual London: Navigating and Analysing in 3-D using GIS, CAD and Multimedia

The most obvious of virtual cities is based on the geometry of the city that we represent as streets and buildings and compose in layers. An image of our model, which includes 45,000 buildings or blocks over 20 square

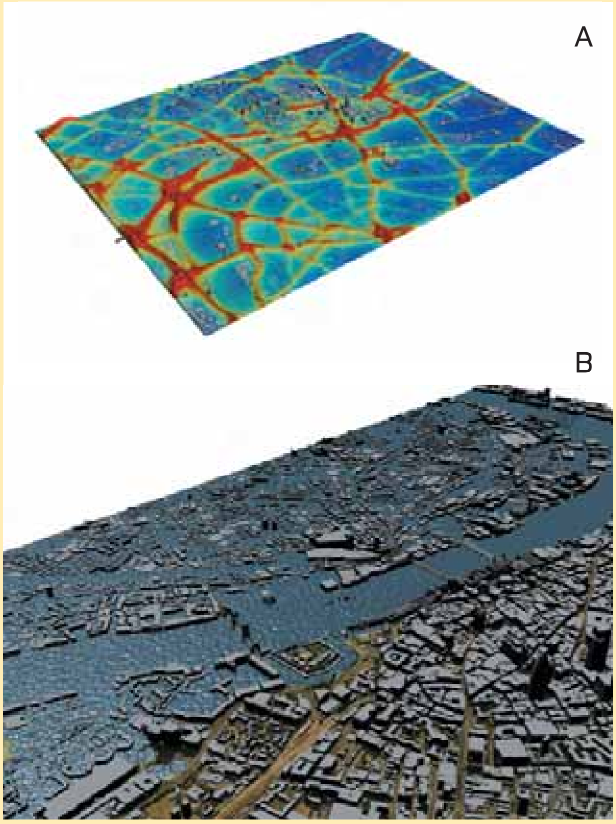


Figure 3: Populating the virtual city. (a) Adding a layer of pollution based on nitrogen oxide. (b) Flooding the model to a 10-metre rise in sea level.

kilometres, is shown in Figure 1. Building starts with a digital terrain model – the bare earth. Onto this is draped an aerial photograph. We then lay out the digital street and parcel map, then extrude the parcels to their average heights using LiDAR[2] data – clouds of x-y-z points defining the third dimension generated from low-flying aircraft using lasers that scan the geometry of the city as they fly across it. Figure 2(a) shows an example of this for St Paul's Cathedral. We can then populate this basic-skeleton model (the building blocks) with data, ranging from building populations, air pollution along the streets, financial data such as rents and property taxes, social conditions such as crime rates, analyses of the impact of tall buildings in terms of locations from where they can be seen, the energy associated with building masses, employment, diversity of building use, and so on. We can also embed within the model other multimedia – for example, digital panoramas that record the 'real' detail of the city more superficially, yet also more directly – at any point where such detail might enhance the experience. And of course we can render each building in as much detail as we like, as demonstrated by the fish-eye view in Figure 2(b).

Examples of the applications described above are illustrated in Figure 3, in which we have 'flooded' the model with new layers of data. The figure shows how a visualisation of pollution, based on the particulate nitrogen oxide (mainly associated with vehicle emissions), can be layered as a surface onto the geometry. It also shows what would happen if the sea level rose 10 metres, which is equivalent to a rise in sea level in the North Atlantic if the

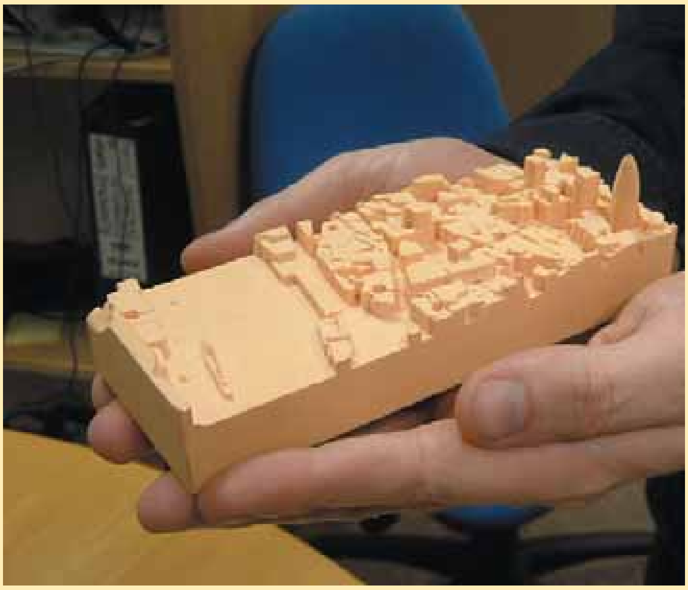


Figure 5: Back to 'the material world': printing a little bit of Virtual London.

Greenland ice cap were to melt. However, more traditionally the model can be used to assess the visual impact of tall buildings on the surrounding area. In Figure 4 (see pp 42–3) we replace Norman Foster's new Swiss Re building (the 'Gherkin') in the City of London with a composite New York skyscraper, illustrating the impact of such a change in scale. Using a 3-D-GIS, we can compute the viewsheds from every place to any other, thus assessing the impact of relaxing the low-buildings policy that has dominated central London for the last 50 years.

This traditional virtual city model, conceived now as a 3-D view of a large spatial database, can be connected back to the sensing of data in real time – for example, to the air-pollution monitors used to generate Figure 3(a) – using new forms of distributed computing such as the 'grid'. But we can also connect the digital model back to more traditional icons. Just as we can print a paper copy from a GIS, or a static 3-D image from a CAD model, we can print a hard copy of the digital city in material terms.

In Figure 5, we have printed a little bit of Virtual London (an area around the Gherkin) using a CAD/CAM printer. This took two days to print or, rather, 'mill-out', but in the future this type of operation will become routine. Connecting peripherals such as sensing and printing devices (the most obvious being web cams) to the digital model is thus becoming more routine. Once we have such a structure, we can then port it to other worlds and it is to these that we now turn.

3. The Recursive Virtual World: Avatars in Panoramic Space

Any digital media can be embedded within any other digital environment – different from the one in which it is created, displayed or accessed – the simplest of such embeddings being those into web pages or portals. Slightly more elaborate and distributed environments might comprise a virtual world – a virtual exhibition space or room – into which one might enter perhaps as an avatar. Being able to control one's digital presence allows one to navigate the room and, if the model is displayed therein, also navigate the model. In a sense, this is the same kind of navigation that might be played out in the more direct form of virtual city described above, but in the virtual world it is much easier to associate with other users whose digital presence can also be displayed as avatars in the same scene. Avatars are, of course, coordinated, and can interact via the model, initiating dialogues about the environment or regarding issues such as design or problem-solving.

Such a picture of our virtual world is shown in Figure 6. It is based on porting the model into a virtual exhibition space, with users logging on from different places on the Net entering the scene, and then engaging in dialogue – interacting in ways that are close to the traditional uses of real iconic city models. We can also manipulate the scale and add other kinds of media. Figure 7 shows an avatar astride the digital model at a much greater scale, moving within a digital panorama overlooking the 'square mile' in the City of London, and walking within a 'cathedral'. After first first choosing a persona (see Figure 8), avatars begin to explore the world. Figure 9 shows how all this can be stitched together in a virtual world within which a virtual city is positioned, embedded with more realistic shots from panoramas, and incorporating various ways in which users can engage in dialogue, as well as ways in which data can be imported from the real 'real' world, through various sensors and web cams. This represents a future where all these channels, and more, will come to be fashioned and linked through virtual environments.

Figure 6: Entering the virtual world. Avatars engage with each other and with the virtual city in diverse ways.

Figure 7: Scaling the virtual world and adding digital panoramas as a backdrop.

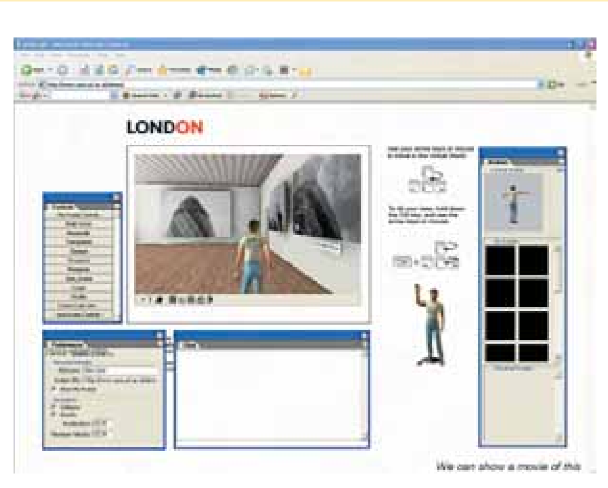


Figure 8: Manipulating a persona and entering a virtual world populated as an exhibition of the virtual city.

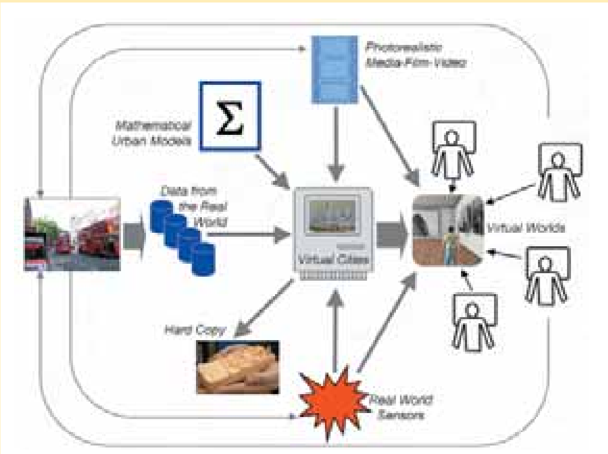


Figure 9: Deriving raw data from the real world and stitching it into virtual cities and virtual worlds.

Figure 10: Embedding mathematical models into the virtual city. (a) and (b) Crowds and the parade at the Notting Hill Carnival. (c) The street system. (d) Agents moving around the carnival. (e) The density of flow. (f) Crowding hot spots.

4. Agents as Well as Avatars Enter the Scene

The last twist in our tale is when we begin to import more mathematically inspired models into our virtual cities and virtual worlds. The cutting edge of urban modelling now represents populations as individual agents whose movement within the city is the focus. In a sense, when we embed ourselves in virtual environments, we move as we navigate, generating real behaviour in a virtual space. Building mathematical models of what we see and how we move involves a reverse symmetry based on simulated behaviour in a virtual space, and such possibilities are only just beginning to be realised. Figure 10 shows how we embed such models into digital space and visualise their form, not only in 2-D, but also in 3-D.

In London, we are hard at work building models of local movement, of the way pedestrians move through the city, and the decisions that motivate their movement. We have built agent-based models of the Notting Hill Carnival – a highly stage-managed event that is heavily controlled yet subject to a variety of public-safety problems. We have also begun work on models of flows in dense entertainment areas of the city such as Covent Garden, focusing on modelling how visitors negotiate this space. These are not avatars, but agents, in that our aim is to replicate real behaviours and then embed these within the virtual scene, visualising agents in 3-D and getting them to move through the virtual city. Our progress is shown in Figure 10, which contrasts real crowds with a simulated variety.

The environments we can create thus contain 3-D digital cities of the conventional kind, like Virtual London, populated with abstract numerical data, interspersed with multimedia such as photorealistic panoramas. These can be accessible to other web sites from within the scene, into which real-time 'live' data might be fed. These digital, yet nevertheless conventional, environments might then be imported into virtual worlds in which we, as avatars, enter the scene, moving among the digital forms, experiencing each other 'remotely', and thus being subjected to the real-time data feeds from the real city. Mathematical models of such real-time data can be instantaneously created and agents generated to interweave and intersperse with ourselves – the avatars.

Such environments are almost there, revealing enormous possibilities for innovative and exciting ways in which we might think about design and planning and the management of change. More importantly, these parallel worlds open up the design of our cities to a much wider public, as well as transforming the way we might deliver services, seek information and engage in new kinds of dialogue. The positive side of such virtualities implies a richness that intimately reflects the real world and should, with care, enhance it. ⌂

Notes

1 Jean Baudrillard, *Simulacra and Simulation*, University of Michigan Press (Ann Arbor, MI), 1994.

2 LIDAR: light imaging detection and radar.

Acknowledgements

The authors wish to thank the Greater London Authority, Ordnance Survey, Infoterra and ESRI for their support in the projects quoted herein. Steve Evans was central to the development of the Virtual London 3-D-GIS and CAD models reported here.