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# Emerging Issues, Challenges, and Opportunities in Urban E-Planning

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## Chapter 10

# Urban Planning and Climate Change Mitigation: Using Virtual Reality to Support the Design of a University Master Plan Extension

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### **ABSTRACT**

*The aim of the research described in this chapter is to explore the use of intelligent virtual transport modelling within the context of a case study involving the development of a university estate. Through the application of visualisation techniques, the study was able to explore how such techniques can lead to enlightenment of potential solutions, whilst simultaneously demonstrating the effects of design solutions on CO<sub>2</sub> emissions. Such an approach leads to a better understanding of the transport complexity from the perspective of potential clients and users. Although images and physical models of the case study were appreciated by stakeholders, these did not provide more information than their current state and could not help in making funded decision by decision making community. Animated data, including calculated predictions of the effect of design on daily vehicles, human traffic, and CO<sub>2</sub> emission, enlivened and illuminated the designed situation, and allowed decision makers to appreciate the real current and potential challenges.*

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## INTRODUCTION

The aim of the research described in this chapter was to explore the use of intelligent virtual transport modelling, within the context of a case study involving the development of a University estate. Through the application of visualisation techniques, the study was able to explore how such techniques can lead to enlightenment of potential solutions, whilst simultaneously demonstrating the effects of design solutions on CO<sub>2</sub> emissions. The study arose from a line of research concerning the utilisation of computer-based visualisation in the planning and design of urban public space. Perhaps more importantly, though, the research concerns the manner in which the planning of our towns and cities, including the planning of infrastructure, must adapt to meet the pressures of climate change. It is arguably the case that the impact of most new buildings will be considered as part of a wider planning process, with consideration of the effects on infrastructure and possibly environmental issues. Architectural visualisation, and particularly computer based visualisation, has been championed for many years. Indeed, it is possible to also trace other strands of participatory design which use non-digital approaches, and which date back to the 1960s and earlier, for example (Arnstein, 1969). However, it is certainly not the case that such research has been widely adopted as normal practice, with visualisation often used to 'sell' designs, rather than to genuinely elicit opinion or instigate debate.

The research described in this chapter drew on experiences from CARE North, an Interreg-funded initiative (IVB North Sea Region Programme) aimed at developing '*a comprehensive, strategic and practical approach to urban and regional transport accessibility in the North Sea Region*'. CARE North extended across 9 partners and 4 countries, and included input from ICLEI, an association of local governments committed to sustainable development. Partners include the cities of Bremen, Malmo and Gothenburg, all of

which have implemented ambitious programmes concerned with both sustainable transport and the urban realm, and have successfully implemented both technical and social programmes to encourage and support behavioural change among residents and decision makers alike.

The chapter takes a combined philosophical and practical approach, in that the work is placed within a consideration of participation in the planning and design of urban areas. The methods and approach described should be viewed within this context.

## CONTEXT

The research described in this chapter has implications for the study of sustainable urban transportation from a number of perspectives. Firstly, and most obviously, the work deals with the situation faced by many organisations as they attempt to relocate a workforce to a new facility.

This means that the type of research undertaken here can offer pointers, certainly, for urban design, but the work must also surely have further far-reaching implications for the travel behaviour and preferences of groups and individuals. In the case of the study site reported, the organisation has made efforts to introduce a sustainable transport strategy, yet this requires both potential benefits to the user (e.g. convenience, reduced CO<sub>2</sub>, price, cycling facilities) as well as perhaps less positive implications for others (e.g. charging for car parking, and other such disincentives).

Through actions of the EU and its constituent countries, towns and cities across Europe are beginning to address the challenges posed by climate change. The complexity of urban areas means that particular challenges are posed by the needs of residents including energy use in buildings, management of resources and transportation. Whilst it is certainly true that many of the challenges could be met through behavioural change on the part of individuals, it is also true

that an integrated approach to planning is required to ensure that individuals are suitably empowered and able to act. The EU has instigated a range of mechanisms through which change can be planned, facilitated and implemented, including the relatively recent development of the Smart Cities programme (<http://eu-smartcities.eu/>). Such programmes recognise that technology must be introduced in such a way that it helps to support change, but cannot be regarded as a solution in itself. Within a context of participatory design, the starting point for this research was that urban development will continue to have a significant effect on the carbon footprint of cities, but that a potentially significant part of that impact (i.e. mass transportation) can be mitigated through visualisation of options in a manner which encourages engagement, and refinement of designs.

The research study reported here concerns a common situation, where an organisation (in this case a University) has decided to move a significant part of its activity to a new location. Where that location is part of a city centre, one could argue that the transportation implications are directly related to mass public transport, as space pressure would normally mitigate against the introduction of new car parking space. However, the situation studied here was one where the new site was to be within the peri-urban city edge, thus posing challenges of how to facilitate the transportation of thousands of additional staff and students each day without vastly increasing the carbon footprint of the organisation. Within the city of the case study (Aberdeen, Scotland), the city faces challenges regarding air quality and travel related CO<sub>2</sub> emissions<sup>1</sup>. The problem faced is very real, and needs to be addressed by all major stakeholders in the city, including Universities. This perhaps opens a wider discussion of the changing nature of educational provision with regards to 'normal' campus delivery of classes, but the study here concentrated instead on developing a visualisation tool which could help decision makers to understand the environmental and practical implications of their design decisions.

One of the most important aspects designers need to consider fairly early on is that of energy saving, cost, thermal comfort and the effect on the environment in terms of CO<sub>2</sub> emissions (Bennadji et al., 2004). At present, during the early design stages, different options are assessed using simple tools (tables, graphs and software) that contain a large number of assumptions, the very nature of which can bias choice or possibly lead to an inappropriate solution. It can be argued that the only way to provide a rational assessment of options is to use calculation methods that represent in detail the physical processes involved. Furthermore if this tool is also used during detailed design it would introduce a consistency that is normally absent from the analytical design process.

## **TRANSPORT STUDIES AND SOCIAL IMPLICATIONS**

In addition to the wealth of research which has been undertaken concerning the policy and economic drivers behind urban transport strategy, an angle which could be applied to the work in this paper concerns that of the behaviour of groups and individuals. Whilst the work reported here attempted to model and visualisation new infrastructure (e.g. roads, cycle ways and pedestrian bridges), these cannot in themselves lead to change without the active participation of city residents. Recent research undertaken within the field of environmental economics has tended to show that respondent behaviour can be influenced by both personal demographic background, and the perceived benefits of change. In addition, evidence of the skewed perception of low carbon transport (particularly public transport) appears to suggest that negative experiences in such environments can become magnified in the memory, which in turn has a detrimental effect on whether people may choose to use public transport in the future. For example, the likelihood of public transport being 'on time'

tended to be under-estimated by users, based most likely on limited (yet perhaps unrepresentative) negative experiences in the past (Arentze & Wielens, 2014).

## **PARTICIPATION**

The importance of engaging end-user participants in the design of spaces and buildings intended for their use has been a major area of research for many years, and certainly dates back to the 1960s (Sanoff, 2000). The belief underpinning a desire to involve users in design, generally, stems from a desire to produce designs which meet the likely needs of individuals, in addition to meeting wider pragmatic and aesthetic needs. When dealing with architecture and the arts, it is important of course to undertake participatory design in such a way that artistic and aesthetic originality is not stifled through a reversion to ‘design by committee’. However, others would argue that the output of architecture and infrastructural works is intrinsically political, and will have an impact on peoples’ lives (Blundell Jones, Petrescu & Till, 2005). Therefore, far from participation being something which can be undertaken simply to meet procedural needs and guidelines, the participation should be regarded as a central and extremely valuable process at the very centre of design. It could be argued, in fact, that participation helps to develop design briefs which are far better informed than would otherwise be possible, and thus provide designers, even at the conceptual stage, with valuable information and guidance. Thus, whilst the locus of power within design changes to one of shared input and responsibility, the expertise of trained design participants is directed towards embracing the outputs of participation within a cyclical design process aimed towards refinement of the ultimate design output.

Within Scotland, there has been a growing acceptance at all levels of government of the need for a robust method for better understanding of

public perceptions within public decision-making. Having said that, and although public consultations has been required for well over 25 years in the UK, a move towards a deeper participation has been hampered by a lack of reliable, efficient and relevant methodologies.

Related to that topic of discussion, previous research has established that there are often gaps between the perception of architectural and infrastructural developments, between design professionals and the lay public (Hershberger & Cass, 1988; Hubbard, 1997; Wilson, 1996; Wilson & Canter, 1990). Indeed, it has been widely accepted for many years that design professionals hold a different system of constructs to lay people, through which they understand and evaluate the environment (Hubbard, 1997; Wilson, 1996). Therefore, although there has been some impact within architectural design and planning practice, there is also a requirement for recognition that the ‘lens’ through which individuals, and groups, view the constructed environment will be significantly influenced by their previous experiences, education and their resulting views and opinions. There is also a corresponding need to recognise that the participation of end users in any design process will never extend beyond being an aspiration, without a deep consideration of the manner in which it might alter practice, and the design process itself (Luck, 2007).

## **LOCAL POLICY**

Recent work by the research team explored the manner in which sustainable transport best practice across the North Sea Region could be regarded as being transferable from one city to the next (Tait et al., 2014). By extension, a similar question could be asked with regards to similar institutions, or of organisations contemplating similar travel planning initiatives. What the research demonstrated very clearly was that whilst it may be possible and reasonably straightforward to enact demonstration

and trial initiatives, that adoption within planning and construction required evidence, and the support of local decision makers. Therefore, it can be argued that the visualisation work reported here, which aims to better communicate the practical and aesthetic implications of new transport strategy, can indeed have positive implications for urban change.

## **VISUALISATION WITHIN PARTICIPATORY DESIGN**

The use of visualisation within participatory design has been studied in academia and applied in practice for many years. With regards to the former, it is useful to discuss aspects of the key strands of research which have together begun to form a wider methodological approach. With regards to the latter, computer based visualisation has frequently been employed in attempts to convey the likely aesthetic appearance of architecture or infrastructure (e.g., roads), although this has often been instigated as part of the planning process (with modelling undertaken by or on behalf of beneficiaries should the work be allowed to proceed). Nevertheless, it is true that methodologies developed within academic research are now available, which can facilitate the use of visualisation within studies of realism, scale, navigation and preference, including studies concerning the impact of the ability to navigate environments freely (Conniff, 2010).

At a fundamental level, it has been recognised that the approach taken to the display of information can have a deep effect on the meanings taken from that data (Tufte, 2001). It has also been argued that we need to consider the notion of ‘enlightenment’ coming as product of that consideration, in that the medium employed to display information will in turn influence the types and depth of conclusions which will most likely be drawn from that data. With regards to architectural plans, for example, highly techni-

cal drawings of buildings details require that the ‘viewer’ of the drawing has sufficient prior knowledge of both construction and architectural detailing to be able to glean ‘knowledge’ from the drawing. That is, architectural details do not often resemble photographs of architecture, as their primary purpose in most cases is to convey construction information, rather than information about the intended aesthetic effects. It has also been shown that designers themselves require the use of abstract visualisation, including sketches, to develop their own ideas from conceptual stages onwards (Suwa & Tversky, 1997).

A key point when considering any method of information visualisation is the result of looking at a diagram, picture, image or data resource (Spence, 2007). Where that result has been acquired in the mind of the observer, rather than as a result of text or statistical analysis, we can say that ‘insight’ has been acquired. In this sense, we must try to remember that visualisation is essentially a cognitive activity, which is not reliant on computers. In the study reported here, by example, we see a physically complicated scenario involving the introduction of a new road layout within previously disused ‘brownfield’ land. Although this could be readily represented using architectural drawings, the likelihood is that important aspects of the design regarding heights and sizes would be difficult to glean for viewers outside the design professions.

Within participation, the use of visualisation has been the subject of much applied research. Indeed, previous work undertaken by the author (Laing et al., 2005) explored the use of internet based studies of streetscape redesign, with a particular emphasis on the end user. In those studies and others (Appleton & Lovett, 2005; Laing et al., 2009) it has been recognised that the views of disparate groups may vary and even be in conflict with each other, depending on aims, perspective and discipline. What becomes clear is that a longer term, or deeper, engagement with both decision makers and end users requires a planned strategy

(for example: Pettit, 2011). The potential value of engaging end users in the design of their own towns and cities has been argued for many years, though, with some recent notable examples of this being applied at both the micro (design) scale (for example: Nilsson, 2011) and macro (region) scale (Bugs, 2010; Wu, 2010).

Although the visualisation technique applied in the case of the research reported here utilised rendering which approximated real perspective in three dimensions, it must also be recognised that such an approach might be less appropriate when dealing with conceptual design, construction detailing or longer term management of a site. Additional issues to consider include the ability to collectively glean the opinions of a collective group, including group dynamics (Salter et al., 2009) and to understand the implications of using a range of methods to convey design options and to encourage creativity. Romice (2005), for example, demonstrates the use of a range of information to capture and design visualisation techniques in the context of community planning.

## **RESEARCH SCENARIO**

The University campus studied is located in the North East of Scotland, and stands approximately one mile long, with a relatively narrow plot stretching along the northern bank of a major river. A visual survey of traffic loading was undertaken prior to a spatial design study. That study created a new 'virtual' route solely for University staff to reduce their travelling time to and from the campus, and reduce CO<sub>2</sub> emissions along major road tributaries. The purpose of the modelling undertaken here is concentrated on campus development, rather than on wider or macro scale traffic developments.

Over the course of the last two decades, staff and student numbers at the University have grown by 50% across four campuses, with a plan to move to a single site by 2014. Amongst staff and

students, 633 parking permit were distributed in 2012. Amongst those, 23% use the 'A90' dual carriage route to reach the University. The modelling work reported in the article also drew on data concerning university population growth, shown in graphs 1-3.

It can be observed in Figure 1, that student numbers have increased dramatically when comparing to staff numbers, Figure 2, with recruitment very local at the undergraduate level, however the overall number grew by 30% in a decay, Figure 3. This then indicates a perceived need for enlarged parking capacity. The University population has also grown since 1994 which will suggest that infrastructures including parking facilities and pedestrians paths should be planned ahead and possibly the development of the south bank of the River Dee. Garthdee University campus can accommodate a limited number of students as the majority of its students' accommodations are located in the city centre beside the two other campuses, Saint Andrews and Schoolhill campuses, closed in July 2012.

Transferring these accommodation facilities will reduce the transport and its impact but at a huge investment cost where a carefully planning process is required.

## **PROBLEM IDENTIFICATION**

Staff at the University expressed their concerns about the time that it takes to travel the last five miles separating the campus and the last portion of 'dual carriageway' before the Dee Bridge, including 2 roundabouts. This is illustrated in Figures 4 and 5. It is of course true that the effects of congestion and a lack of driving efficiency can have a significant effect of carbon emissions (Zhang, Batterman & Dion, 2011; Scott, Kanaroglou & Anderson, 1997), leading the study towards solutions which could help to ameliorate these issues.

Figure 1. Student numbers in the case study organization.

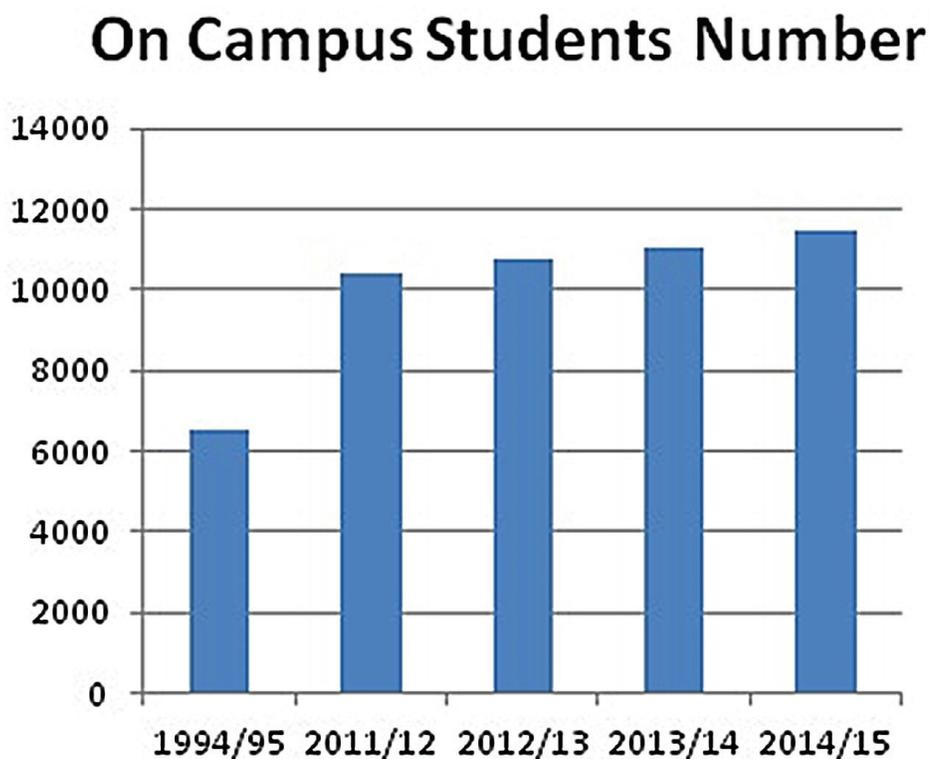


Figure 2. Staff numbers in the case study organization.

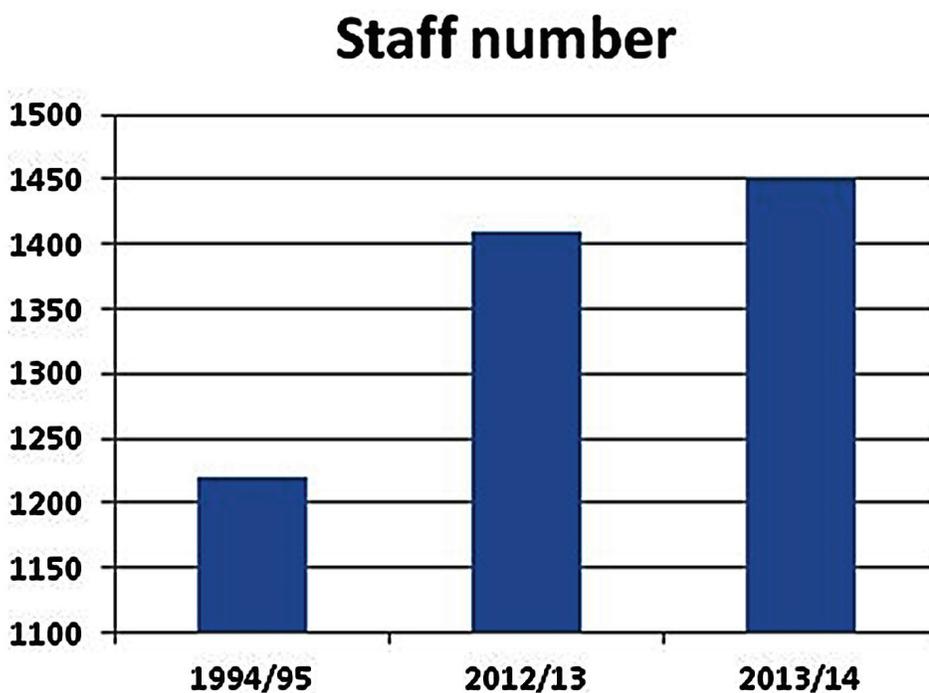


Figure 3. University population in the case study organization.

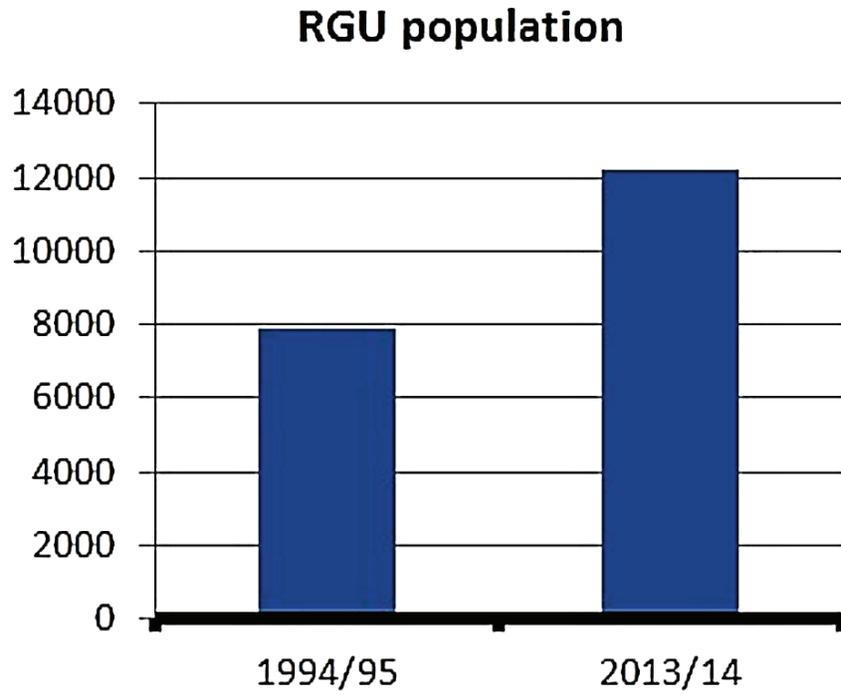
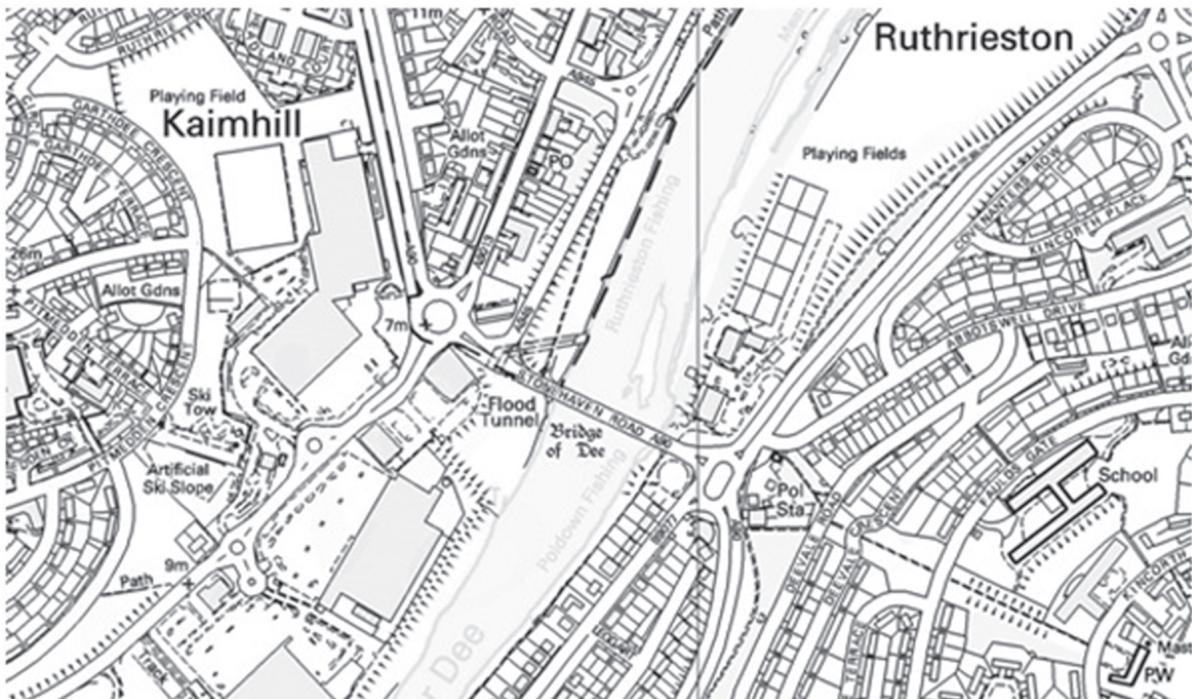


Figure 4. Map showing the Bridge of Dee, Aberdeen (extracted using Digimap)



*Figure 5. View of University Campus, located on the north bank of the River Dee.*



## **SITE INVESTIGATION**

The researchers investigated the case and it was evident that incoming staff and students from the A90 to RGU spent an average of 20 minutes driving the last 5 miles (Figure 6). This is due, at least in part, to a lack of alternative routes leading to ‘bottlenecking’ at peak travel times.

## **ANALYSIS**

Analysis of the situation, including a future projected (increased) master plan, suggested a suitable case study site to facilitate exploration of the use of an intelligent visualisation system. With traffic projected to increase, there was an arguable case to explore a reconfiguration of traffic at the campus. As is discussed in the following section, the software package used to undertake model-

ling work for this research enabled some degree of intelligence to be built into the system. For example, one could imagine applications were it was essential to model the likely effects of design decisions upon known flow rates of traffic. Within the context of a university campus development, for example, this would allow for the theoretical modelling of changes to the campus, such as the location of student residences, or as is the case in the work described here, the location of significant areas of car parking. Nevertheless, as the main aim of the modelling work described here was to provide a visually recognisable representation of the effects of master planning decisions at the human scale, the decision was taken to concentrate on the translation of static drawn information of the traffic proposals into a dynamic visualisation, allowing users to appreciate and understand the implications of design decisions from the driver’s perspective.

*Figure 6. Traffic at Bridge of Dee roundabout*



## **PROPOSED DESIGN SOLUTION**

The wider site investigation and site analysis revealed a potential route between the A90 and a brownfield site located on the south side of the river Dee. The route would require a negotiated passage through existing private agricultural and forest lands. For the purposes of this study, the solution suggested the creation of new parking provision and student's accommodation as well as indoor and outdoor sport facilities. Pedestrian bridges along the river Dee would link the two sides of the campus.

## **TECHNICAL MODELLING**

The models undertaken for the research reported here were constructed using UC-Win/Road, which was selected due to its VR capabilities, and the ability to visually simulate the aesthetic effects (in particular) of changes to the transport

arrangements present in a given urban situation. As noted elsewhere in the paper, there would be great value in exploring the possible implications of increasing numbers of pedestrians and cyclists on the campus under study, and perhaps the implications for entry and exit of the site and buildings. In such a case, which would be a useful source of further research, the likes of Viswalk2 would be more appropriate.

The research used UC-win/Road software that supports the integration of road planning within urban settings and enables the creation of walkthrough visualisations, useful in communication with non-specialist end users. UC-win/Road requires a terrain as a platform on which the traffic will be simulated; therefore an editable terrain of 10km<sup>2</sup>, with RGU campus at centre of the terrain, was utilised as available through Google Earth. UC-win/Road is a 3D urban visualisation and transport modelling software. Users can manipulate dynamic 3D space, import and edit CAD data, build and texture simple block models,

automatically build roads, tunnels; bridges, view multiple design alternatives in real-time, both of-line and online<sup>3</sup>. The use of this tool is beneficial in that it allows one to use geographical data drawn from various sources, including Google Earth, and implement the existing roads network using other software such as Digimap and AutoCAD. It allows the user to generate traffic visualisations, exportable as video files<sup>4</sup>.

The protocol of implementation takes various stages and requires input from different platforms. There are many problems associated with developing VR city models of various countries. We classify the problems into 4 categories; 1) difficulty with the collection of data, 2) sharing of knowledge and application of various design tools, 3) difficulty of communication with people from different countries, and 4) Collaboration with a software development company (Kobayashi et al., 2010). The existing road map was then implemented on the model with accurate levels taken into account the model contours. Vegetation was added to the model as an existing function in UC-win/Road. Considering the existing land around the campus, a route from the southbound A90 to the North river bank was negotiated through farmlands to create a new access to the University. That new road was designed and linked to the level of the new car park.

Modelling cities does involve heavy data to be brought together from various sources and thereafter manipulated from different locations worldwide. Many software were not capable of such heavy data and remote manipulations including UC-win/Road, however more recently; the developing team of UC-win/Road made it possible through the Cloud version. Users can work in collaboration from various locations and manipulate heavy data.

The use complex equipment such as 3D laser scanner is becoming very popular in the preparation of digital urban animation, such capability was made in addition to allowing the user to import point cloud data directly into UC-win/Road, the Forum8 Point Cloud Data Plug-in option allows point cloud data obtained from surveying equip-

ments, to be imported into the 3D VR software. Such option was unfortunately not used during the case study and buildings' 3d modelling option was the only alternative we had. Although accuracy could have made the animation more realistic for the observer point of view, but the data analysis was the focus of the study and therefore the research aims were met.

To visualise the traffic, many scenarios were created showing the number of vehicles moving from different directions and moving across the existing roads around the case study site. The vehicle numbers reflect the number of cars using these roads during the rush hour, to better illustrate the problem we were aiming to solve in this visualisation exercise. UC-win/Road has the ability to generate vehicle movement including speed, number and type of car. The first animation was a fly over showing existing access from the A90 dual carriageway to Robert Gordon University through the Bridge of Dee, passing two roundabouts at both sides of the river. UC-win/Road has the capability to visualise the vehicle movement either from a driver level or as a fly over to show a wider image of the traffic and the result was enough close to reality. Once the traffic as modelled here is determined, the 'virtual' congestion will build up progressively and the camera location and movement require to be defined logically to gain a clear idea of the congestion problem. For this study, the model was used to generate a series of flythroughs, to help determine the likely impact of design and road layout on congestion.

The second animation began with a fly over showing the point of derivation from A90 then a vision of what a driver will see during his driving experience from A90 derivation to the car park. A further step of the visualisation showed a pedestrian crossing the bridge linking the North Campus to the south; this bridge was designed using 3Dmax and imported to UC-win/Road. A water movement of the river added clarity to the reality of the animation with few university buildings in the background.

On top of the Google Earth a grid of existing road was created under UC-win/Road, a condition that allowed the system to show traffic flow, with the terrain will be just a background and a contour guidance. This implementation was followed by the implementation of the proposed roads connecting A90 road to the south river bank. This is illustrated in Figures 7 and 8.

The study covered a wide geographical area, containing numerous secondary roads around University campus. However, the modelling concentrated on simulation of the main traffic routes, and those buildings and areas affected directly by the scenario under consideration. Finally, and to give the future visualisation some realistic features, selected existing buildings located at the campus were modelled (these including university teaching buildings). This is illustrated in Figure 9.

## **CURRENT AND NEW TRAFFIC GENERATION IN THE MODEL**

Based on the existing traffic monitored at the early stage of the study, traffic was generated in the model itself, showing vehicle routes. It should be emphasised that this traffic mapping is open to future changes since the demographic distribution might change as staff members and students would like to move to areas that suit their daily commuting (since it is likely that staff and students would move closer to the new campus, in the event of new building). Beside the existing traffic implementation we implemented the proposed new route with its derivation from A90 to the new car park.

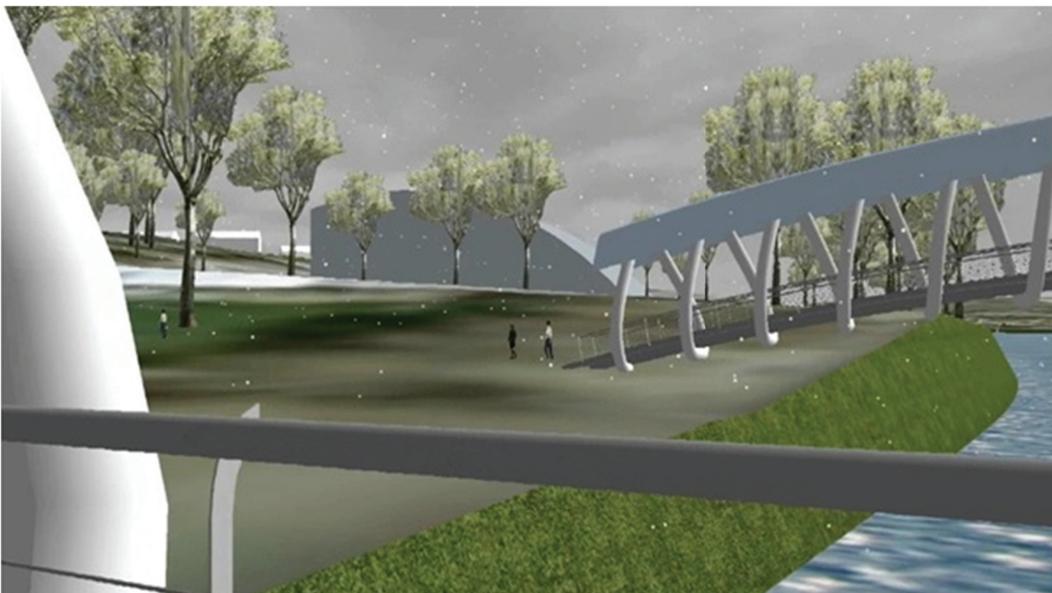
*Figure 7. Implementation of the street grid: here the Bridge of Dee roundabout*



Figure 8. Simulated A90 road during rush hour



Figure 9. 3D representation of selected University buildings around the fly through route



*Figure 10. New parking provision at the south river bank*



### **NEW BUILDINGS IMPLEMENTATION (PARKING DECKING) AT SOUTH RIVER BANK**

New projected buildings including car park decking, pedestrian bridges were also designed and implemented in 3D to provide human scale reference points within the potential presentation. This also aimed to inspire from new master plan vision in term architectural language as this is important for the global vision the University has for its campus named as the most modern university in the UK. This is illustrated in Figures 10-13.

The model and animation process requires a scenario, so as to ensure that the application relates to a real environment, and to genuinely important issues. The study undertaken here concentrated on how new infrastructure could be utilised in such a way that it resulted in reduced congestion, and this in reduced carbon emissions. Nevertheless, a number of key issues for the modelling process itself should be drawn out.

For a realistic visualisation, the study used natural features that exist in UC-win/road and which were selected to reflect usual weather conditions for the site itself. Other backgrounds were added to reflect the future campus life such as the cycling traffic between the two parts of the campus.

### **DISCUSSION**

The research utilised UC-win/Road software to support the visualisation component. The software supports the integration of road planning within urban settings and enables the creation of walkthrough visualisations, useful in communication with non-specialist end users. Outcomes of the research included an animation to assist University planners in the consideration of travel time, distance and staff experience. The evaluation reported here is a technical one. Given the nature of the case study and the reality that the University master plan is continuing to develop,

Figure 11. Route to the proposed University parking  
(extracted from UC-win/Road animation video).



Figure 12. View of the parking and pedestrian bridge



*Figure 13. Pedestrian Bridge linking the two river banks*



fuller user evaluation will become available as design and construction reaches a conclusion in the coming years.

A central aim of this research was to consider how design decisions, which ostensibly deal with the aesthetic impact of architectural intervention, could in fact also have a significant effect on CO<sub>2</sub> emissions. This, though, invites consideration of how theories and approaches drawn from information visualisation could be brought to bear on the development of transport master planning. The manner in which the effects of various scales of development will be represented in practice is often heavily dependent upon the disciplines involved. For example, a major role of the landscape architect will be to provide the drawn information which facilitates both the construction process and an appreciation of the likely aesthetic impact of design. In contrast, the outcomes of an environmental assessment (including the estimation of CO<sub>2</sub> reductions) could certainly be presented in a format which was far more heavily dependent on text and numerical data. If one considers how

the management and presentation of information- and discipline-dependent data has been transformed in recent years within architecture through the development of building information modelling systems, one begins to appreciate how significant issues of communication, understanding and enlightenment can be addressed through the intelligent layering of data. Therefore, one is drawn towards a recommendation that future work should consider how slightly less tangible and less visual issues including CO<sub>2</sub> reduction and reduction in energy use can be fed back to the user of such systems in a highly visual manner.

The issue of scale, which was touched upon in an earlier section, also takes on a greater significance when we come to consider transport planning at a macro scale. The work considered in this article was very much concerned with the effects of planning decisions on both environmental performance and participant behaviour at the human scale. Therefore, it was possible to spend significant amounts of time ensuring that the model, viewed at the height of a pedestrian

or a driver, bore sufficient similarity to a recognisable 'real' environment to be considered as a reasonable surrogate for the 'real'. As we virtually 'zoom out', however, the manner in which we can effectively use visualisation to represent such an environment (whether this is even important) becomes an interesting and important issue. As we have seen in the development of virtual cities, which have been developed to facilitate decision-making at the planning and design stage, it is certainly possible to utilise such models and a number of different ways. When it is necessary to consider designs at a smaller or neighbourhood scale, it will usually be possible to populate isolated sections of the model with necessary levels of detail (for example texturing, lighting, objects, foliage and so on). However, this in no way precludes the use of such models for planning at the macroscale, where one may wish to consider the development of new suburban areas or the reconfiguration of traffic and pedestrian routes through an urban area. Therefore, it can be argued that the protocols and procedures studied in this article could be readily translated to a wider scale.

It is vital that we understand the complexity of the relationships between urban development, and issues of transport, user choice and human contact. This article has demonstrated how emerging intelligent visualisation software can be utilised to study the implications of infrastructural development in such a way that the implications for emissions, efficiency of design and aesthetic acceptability can be inter-related.

## **CONCLUSION AND SUGGESTIONS FOR FURTHER STUDY**

The work reported in this chapter offers a number of directions as to how the research could develop further. These are both technical in terms of the modelling process, and social in terms of the issues worthy of further study.

Certainly, there would seem to be scope to explore issues surrounding the intelligent and information rich modelling of urban traffic, and in particular how this can integrate with architectural and urban design. Given that an increasing proportion of new-build architecture is now designed and constructed using intelligent information models (BIM), the opportunity exists to integrate this with geographical information systems (GIS) to provide the basis for better informed design decisions. The practical reality of realising this in practice is perhaps quite challenging (as reported in Rafiee et al., 2014, for example), yet offers the possibility of ensuring that the kind of modelling and visualisation undertaken here (using UC Win/Road) can become a central part of the design process, rather than a separate activity.

With regards to the further study of social issues connected with transport behaviour, there would appear to be some value in further exploring the socio-economic drivers, which may lead to behavioural change or inertia. It is suggested that the incentives and barriers to change together form the basis for solid and informative work using methods drawn from environmental economics, and that the use of environmental valuation or conjoint analysis (choice experiments) could be a fruitful path to follow (see, for example, Laing et al., 2009).

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## KEY TERMS AND DEFINITIONS

**Climate Change:** Long term change to the Earth's climate, caused partly by the burning of fossil fuels causing the emission of CO<sub>2</sub>.

**Data:** Information pertaining to the use of an area, and in particular data concerning transport use and method.

**Design:** To form a practical and aesthetically positive solution to an architectural problem.

**Planning:** The practice of town planning, including spatial and strategic planning of urban developments.

**Transport:** Transportation methods within an urban context, including car, bicycle and travelling on foot.

**University:** Refers in the context of this paper to a University campus.

## ***Urban Planning and Climate Change Mitigation***

**Urban:** The setting of study is within a built up constructed environment, as opposed to a rural area.

**Visualisation:** The visual communication of complex data, including 3-dimensional architectural renderings and real-time animation.

### **ENDNOTES**

<sup>1</sup> [http://www.aberdeencity.gov.uk/planning\\_environment/environmental/air\\_quality/air\\_airquality.asp](http://www.aberdeencity.gov.uk/planning_environment/environmental/air_quality/air_airquality.asp)

<sup>2</sup> <http://vision-traffic.ptvgroup.com/en-us/products/ptv-viswalk/>

<sup>3</sup> [http://www.fileguru.com/apps/tube\\_mate\\_win/p4](http://www.fileguru.com/apps/tube_mate_win/p4)

<sup>4</sup> Work to extend the technical capabilities to embrace environmental characteristics has been recognised externally. <http://www.rgu.ac.uk/news/masterplan-idea-wins-award-for-scott-sutherland-lecturer>