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# NEW TECHNOLOGIES FOR URBAN DESIGNERS: THE VENUE PROJECT

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## Forward

VENUE stands for **V**irtual **En**vironments for **U**rban **E**nvironments, and was a project funded by the Joint Information Systems Committee from October 1996 until March 1999. This paper is the final report of the project. Some of the project deliverables are available on the VENUE web pages: namely the original and new pages which are available at

*http://www.casa.ucl.ac.uk/venue/venue.html*
*http://www.casa.ucl.ac.uk/newvenue/newvenue.htm*

We would like to thank JISC for funding this project, and in particular Tom Franklin and Tish Roberts, the JTAP Coordinators, for their constant support, and for their persistence in enabling us to get these ideas as widely disseminated as possible. Dave Unwin, Ian Bentley, Bill Erikson, Georgia Butina-Watson, Graham Smith, and Basil Dimitriou all helped us in firming up and implementing the project. We also thank Alan Day, Robin Liggett, Jack Dangermond (President, Environmental Systems Research Institute), Mike Shiffer, and David Rhind (Ex-Director-General, Ordnance Survey) for their kind and generous support. Sarah Sheppard (the CASA Administrator) digitised the web catalogue of plants and shrubs for use in the Oxford Brookes project. The UCL Space Syntax group provided backup and support for the project, as well as the provision of the basic Macintosh code for ***Axman***, ***OrangeBox*** and ***Pangea***.

## 1. Executive Summary

In this report, we first outline the basic idea of VENUE. This involves developing digital tools from a foundation of geographic information systems (GIS) software which we then apply to urban design, a subject area and profession which has little tradition in using such tools. Our project was to develop two types of tool, namely functional analysis based on embedding models of movement in local environments into GIS based on ideas from the field of space syntax; and secondly fashioning these ideas in a wider digital context in which the entire range of GIS technologies were brought to bear at the local scale. By local scale, we mean the representation of urban environments from about 1: 500 to around 1: 2500.

In the event, our project has ranged much wider than our original proposal. Here we begin by outlining five areas of activity: namely the question of digital representation of local urban environments and their spatial representation, the development of relational functionality based on space syntax as the basis of urban design tools, incorporating the ability to make sketch plans within GIS which is a major function of urban design, the ability to extrude urban designs from the 2-dimensional map to 3-dimensional morphology which we achieved using ***VRML***, and finally the development of a general digital context - a collaborative virtual design studio (CVDS) - in which a team of urban designers could use these tools in a participatory context.

These issues are dealt with first in cursory fashion and then in more detail. We then outline the project that we developed with graduate students of urban design at Oxford Brookes University, and also indicate how these tools have been used by graduate students of GIS at UCL. We then turn to ways in which we have disseminated the results of the project, primarily through web pages and regular printed publications but also through direct education and through the placing of our software in the public domain, such as on the ESRI web site (www.esri.com). We conclude with ideas for future research and list in the Appendices details of the project's publications, the team involved, its Steering Group, and the wider network of contacts we have established.

## 2. Introduction

### 2.1 What is Urban Design ?

Urban design lies at the interface between architecture and planning. It has been defined by Barnett (1982, p.12) as "… the process of giving physical design direction to urban growth, conservation and change". In practice, it is concerned with the physical arrangement of the basic components which make up the built environment at the level of buildings, streets and landscape details. Unlike architecture where the concern is primarily with the construction, appearance, and internal organization of buildings, urban design relates physical arrangements of buildings and streets to functional organization which in turn reflects the social and economic structure which makes the built environment function or dysfunction. In short, the activity lies at the interface between the social sciences, engineering, and the art and science of designing built form. As such it is an interdisciplinary activity but one which is pulled in several directions.

The academic and professional education of urban designers is rather marginal everywhere in that training in urban design is usually 'in practice' or through one year graduate courses targeted at architects and planners. Nevertheless, urban design is a significant intellectual and professional activity. In many senses, it represents the heartland of architecture and planning where social and economic policies get turned into physical plans. However unlike architecture and planning, urban design has a somewhat 'Cinderella-like' existence which is seen clearly in the fact that to date, the computer revolution has largely passed it by.

Ever since microcomputers were invented and a little before, architecture has been influenced by computer-aided design (CAD). Indeed the package ***AutoCAD*** has been applied as much to buildings as to any other area of physical design. Architecture continues to be the focus for much software development in computer graphics from CAD to virtual reality (VR) systems and through to diverse applications in multimedia. In parallel, urban planning has been the subject of considerable computer applications. In the 1950s and 1960s, large scale land use and transportation models which enabled the forecast of social and economic activities in small area of cites were widely applied and were informed by a variety of urban information systems focusing on geographical data storage. More recently since the mid-1980s, geographic information systems (GIS) have been extensively developed with urban planning as a major area of application. In short, both architecture and planning are now characterized by widespread computer use from representation to modelling, analysis, forecasting, and design. Urban design however has not really been touched by these developments. One purpose of the VENUE project and the sets of tools developed here is to fill this gap, providing the field with some additional momentum to reinvigorate itself around new computer technologies.

## 2.2 New Digital Tools for Urban Designers

There is an asymmetry between computer use in architecture and planning. In architecture, CAD is largely about automated drawing and visualization rather than about design *per se*. Computer-based designing systems are in their infancy despite considerable interest in such possibilities over the last thirty years. In planning, the emphasis however has been more upon developing analytical functions for representing and modelling city systems. The contrast is best seen in terms of typical CAD and GIS software. CAD software has little functionality which relates to what goes on inside buildings whereas GIS software is entirely based on embedding various processes and statistics into spatial representation. The focus in architectural CAD is on drawing and on visualizing and on manipulating visualization in an *ad hoc* manner whereas in GIS it is on spatial analysis. Neither software is very well developed with respect to the processes of planning and design. It is almost entirely focused on building systems and on city systems, respectively.

It is thus of little surprise that neither CAD or GIS have made much impact on urban design because the focus and functions of each diverge from the central mission of such design. What is required are digital tools that urban designers can use to link socio-economic phenomena to physical form, quantitative data and models to qualitative issues. This is a tall order in any event. As urban design ranges from architecture to planning, one might conceive of adding requisite functionality and adapting software to and from CAD or to and from GIS. We focus on these two types of software, not because there are necessarily the only types relevant to urban design, but because such software represents the most widely developed and publicly available in these areas.

In this project, we argue that the kinds of tools needed for urban designers are more likely to come from GIS than CAD. In fact, architectural CAD is bereft of functions that might inform urban design. In short, GIS software scales very well from the coarse geographical scale to the finest level of the building. CAD software, however, because of its emphasis on geometry and 3D, does not scale well. Basically GIS handles the transition from geography to geometry rather well while CAD is unable to generalize away from geometry to more thematic representations. This is clearly seen in the extension of GIS from 2D to 3D which we will focus on later in this report in contrast to the almost complete absence of any generalization in CAD from 3D back to 2D.

The kinds of tools which urban designers require involve digital representation and mapping at a fine spatial scale in the first instance. Methods for urban design involve developing spatial analysis of the kind developed at coarser, more aggregate scales and this involves some training and exposure to GIS. Developing new functions in GIS specifically for urban design is important and here we will focus upon developing movement systems which are the most frequently used to date (Hillier, 1997). Sketch planning, the use of multimedia, and 3D visualization are all functions and features that appear appropriate to urban design, and in this report we will show how these can be developed through examples. Tying all these ideas together in the context of participatory design and delivering such software technologies on the desktop and across the net are issues that will also be broached.

### 2.3 The Original Idea of the VENUE Project

In the original project proposal, we argued that our focus should be upon ***integrating*** three software technologies, - CAD, GIS and remote-sensing software - within the context of the urban design activity. The project was modified before it began, reduced in scale as the integration with remote sensing software was judged to be the most uncertain and within the resources available, the most difficult to accomplish. Hence the project was to focus on CAD and GIS as basic software technologies for urban design. At UCL, some progress had been made in the 1980s and early 1990s, in developing new functionality for urban design. Local movement on the one hand, was being modelled through techniques to handle the way local spaces were related through the street pattern, this approach being referred to as 'space syntax'. In a parallel development, techniques for developing new functionality within CAD were being tested as part of a project called 'Intelligent Architecture' . This was producing 3D sketching software suitable for urban design but embedded within functionality dealing with the performance of buildings in their environment. It was proposed to integrate these tools through the medium of CAD and GIS in a desktop environment. The proposal which was submitted to JISC in March 1996 and began in October of that year, did not consider the delivery and use of such software in a networked environment although subsequent developments have meant that our work has been much affected by these generic changes in computing.

The intention in the project was to first develop a Rapid Prototype based on GIS and space syntax, and then embed this into a virtual design environment built around simple sketch planning. It was to integrate system description, understanding, analysis, and simulation which necessarily precede good design. In terms of software, it would demonstrate how modestly priced proprietary packages based on ESRI's ***ArcView 3*** (GIS), UCL's ***Axman*** (space syntax) and ***Pangea*** (CAAD) software might be linked to enable students, researchers and practising architect-planners to generate good design. In terms of disciplines, it would integrate software across the spatial sciences from geography to architecture. Finally, it would provide workable tools for sketch planning based on better data and better analysis. These would be tested in a virtual design studio (VDS) focusing on group learning using UCL graduate students and the extensive network of practice-based research which UCL's Bartlett School was pioneering as a test bed for CAAD in world-class architectural practices. We proposed to ground the project within a network of researchers and practitioners of urban design, thus forming a unique international grouping which, we argued, would be essential for the production of top quality software for the design professions in HE and in practice. The products of the project would be purpose-written macros, scripts and C code enabling users to access such low cost software. We would disseminate the project over the web.

Our project as we will illustrate in the rest of this report, has widened considerably from this initial proposal. In broad terms, we began with the development of new functionality based on space syntax methods but we quickly embraced GIS more thoroughly than we originally foresaw. We focused the development of GIS in urban design on graduate students at Oxford Brookes rather than our own here at UCL. This was a more appropriate focus as these students in question were being trained in urban design *per se* rather than in GIS or space syntax methods. During the life of the project, we also embraced the development of multimedia more consciously than we had originally anticipated and we changed our original hardware platform from the Macintosh-Sun to Windows-based PCs. As we will explain, all these decisions were based on a rapidly changing computer environment and the evolution of new software systems in the wider world as well as within our own research group here at UCL.

The original proposal for the project as of March 1996 is located on the VENUE web pages at *http://www.casa.ucl.ac.uk/VENUE/original_proposal.html*

# 3 The Structure of VENUE

## 3.1 The Process of Urban Design

Most of the readers of this report will not be trained in architecture or planning and thus it is important that we give some idea of the process of urban design before we embark on a summary of software technologies which extend the process. In essence, the planning process follows a cycle from gathering information about the problem to an analysis of that information with respect to how the problem might be addressed. This invariably involves some form of analysis of data from several different perspectives - from the social, economic and physical but in the case of urban environment at the scale of buildings and streets in terms of their visual and more general environmental quality. Usually urban design involves identifying problems of design which may range from traffic and access issues to redevelopment or to new development, all of which must meet various perceived needs. Town centre design, housing layouts, historic conservation, the detailed design of shopping centres and such-like problems are those which are typical.

The process usually proceeds from survey, thence analysis to the identification of plans, policies, or proposals for change. These proposals are often in the form of alternative plans which then need to be elaborated and evaluated against some preset goals or objectives. A large part of the design process is fixing these goals and then measuring the extent to which such goals might be met by the different planning alternatives. The process of fixing objectives invariably involves ***analysis*** of the problems to be solved while the process of generating alternative plans or solutions is one of ***design*** in which information about the problem is brought to bear in the invention of new solutions,. Throughout the planning process, digital techniques and methods are useful but it is in analysis that GIS is of particular import and in design that CAD has its greatest use.

Although we might develop an entirely automated form of design through computation at every stage of this process, we can identify five key aspects of the process where digital tools might best be developed. These involve

- representing the geometric and geographic form of the system in question in terms of buildings, streets, land usesetc, at different geographic-geometric scales, and using different types of media

- modelling movements and relationships between the various components of the built environment

- enabling the designer to sketch different alternative designs which address the problem in question

- visualizing the 2D map geometry or geography in 3D at different scales

- tying together all this various software in a networked participatory digital environment - a virtual design studio - where various users might participate and collaborate in the process of design

We will deal with each of these stages in turn, identifying how the various software technologies we are working with aid the designer. This will illustrate the process at a preliminary level and then we will illustrate what we have done in more detail when we present the software we have used. The various tools are illustrated with respect to their position within the design process below.

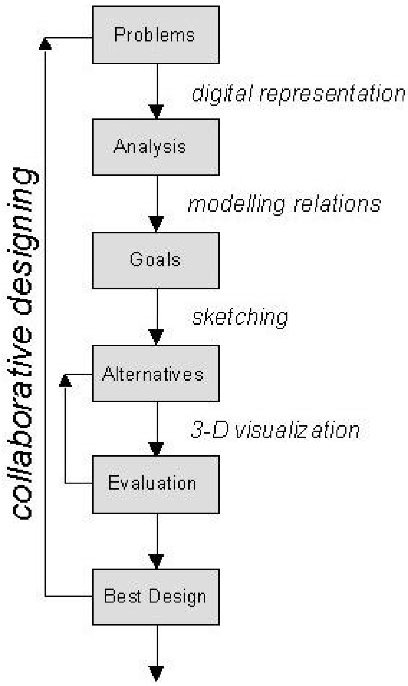



*Figure 1: Digital Tools within the Urban Design Process*

We will develop our discussion along the same lines as we did when we introduced these methods to graduate students of urban design at Oxford Brookes University. Although we will detail the Oxford project below, readers interested in this exposition will find a rudimentary introduction to these new computer tools for urban design at <http://www.casa.ucl.ac.uk/oxford/oxford.html>

### 3.2 Spatial Representation and Urban Design

The basic material with which urban designers work are maps of land use, traffic movement, floorspace, building types and forms, landscape details, topography, and other physical characteristics of the local environment. 3D block models are sometimes used to represent form while photographs and other forms of visual media complement the basic data sets which are at the foundation of such design. Many of these data can now be captured and represented digitally. As urban designers work more in the medium of the map than the 3D model, GIS represents a good starting point for computer-aided developments.

Driving these possibilities is the dramatically increasing supply of digital data at the fine scale. Ordnance Survey (OS), one of our partners in this project, have essentially produced all their mapping products from a scale of 1: 500 upwards in digital format. The scale at which urban designers operate is usually 1: 1250 which is the basic OS LandLine product. Floorspace data, detailed employment and population data as well as a full range of digital photographic data from aerial survey to locally sensed imagery are becoming available at the local level. The implications for urban design are already dramatic. To give readers some sense of this data, we show various map data at different scales in Figure 2 below:

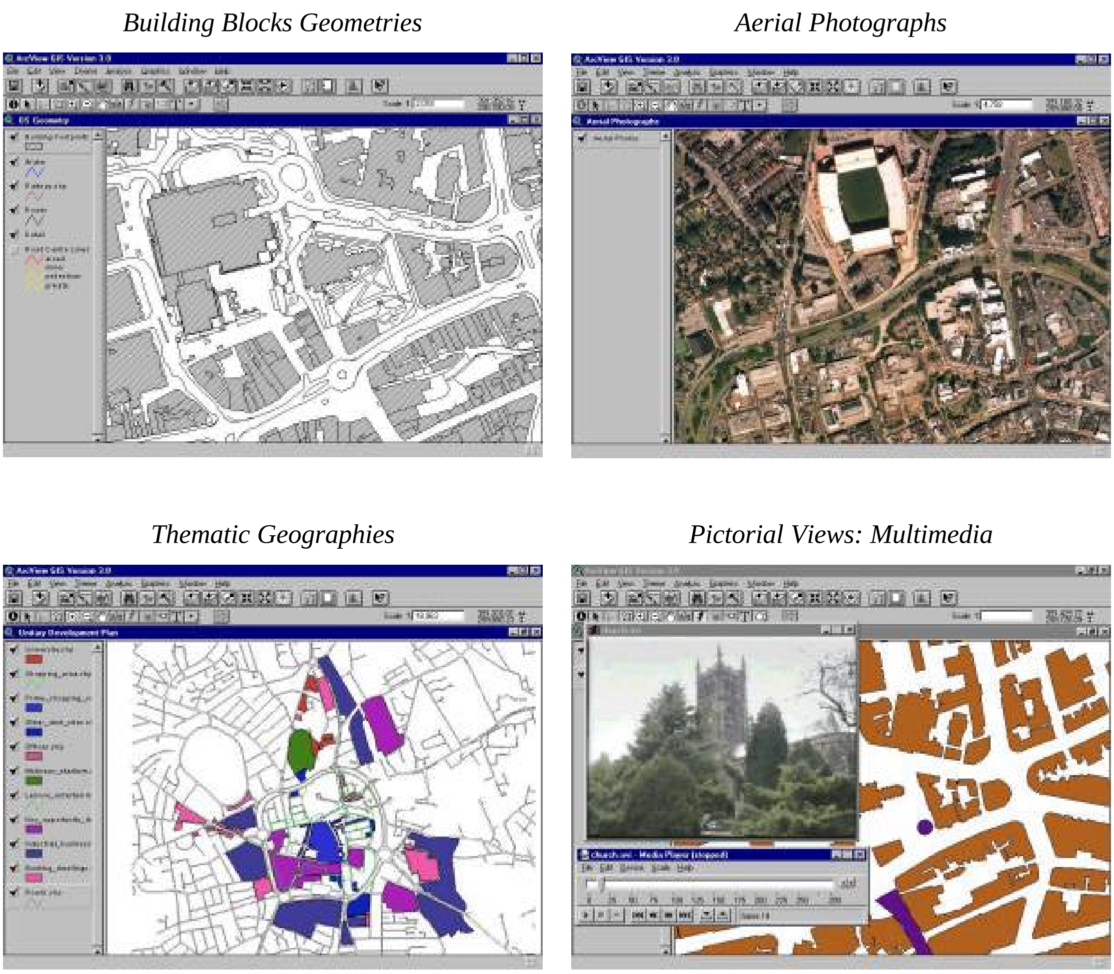



*Figure 2: Digital Representation for Urban Design*

We will detail this kind of data below but for the moment, Figure 2 suffices to show the scale and content of what urban designers are involved in.

### 3.3 Functionality for Urban Design: Modelling and Analysis

Spatial analysis tools which comprise the basic functionality of GIS - involving such operations as comparing, integrating and transforming map/data layers, computing various statistics of their spatial distributions, and providing distance-based calculations such as accessibility measures - could be widely applied within urban design. There is no tradition however in this usage and such developments require some training and exposure to the current constituency of designers. This we have tried to provide at Oxford Brookes. However there are special techniques which relate buildings to one another and which emphasize local movement. In particular measuring local accessibility between buildings and streets is accomplished using the methods of space syntax which have been widely developed at UCL and which are currently being used in much urban design. Such techniques involve measuring the relative accessibility of spaces and representing such relationship as lines of different strengths. An example is given in Figure 3 below:

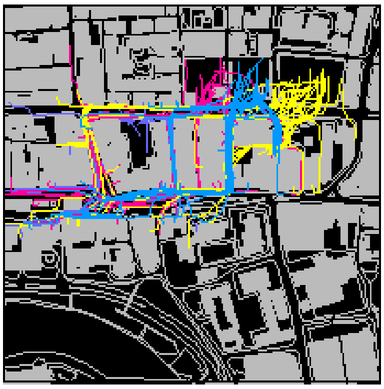


*Figure 3: Different Volumes and Flows of Pedestrian Movement in a Town Centre (http://www.bartlett.ucl.ac.uk/spacesyntax/pedestrian/pedestrian.html)*

Methods of modelling such flows can be incorporated in GIS and one of the main quests of this project is to embed such models within desktop GIS. Moreover we have also extended this kind of functionality to specific simulation models of movement which predict actual paths of walkers and the locations that they visit. An example of the kinds of flocks that can be simulated in this way is also shown in Figure 4:

*Figure 4: Individual Pedestrian Locations Observed in a Town Centre*

### 3.4 Sketch Planning and Multimedia

Representation and analysis comprise the early stages of the design process but the way designs are prepared is largely intuitive in that the various factors are brought together by the designer or design team and at some point various sketch designs must be tried before they are elaborated into fully fledged plans that might be tested. The need for sketch design is essential in any software that might inform the urban design process. Within GIS, the idea of sketching is one of being able to arrange and position new elements within different locations. To this end, we will develop various modules for such sketching but essentially this involves giving the user of the software a standard menu of items that might be organized creatively in the manner of sketching on the screen. To give an idea of such plans, Figure 5 shows the kind of interface that we might envisage with the designer being able to select from a standard set of items - buildings, trees and other more detailed built forms and landscape elements.

*a.*

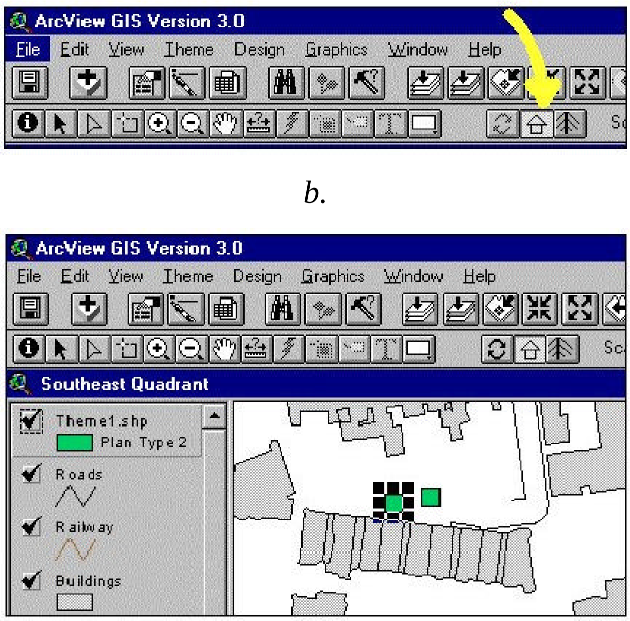



*Figure 5: a. The Upper Menu Bar: shows how the designer can point and click on a standard building icon. b. The Lower Screen: shows how the building is positioned*

This kind of sketching will be explained at length below. Just as we can add analytical functionality based on space syntax to GIS, then we can do the same with these sketching tools. In fact, these are closely linked to visualizing the environment in 3D which is the next addition we will consider.

### 3.5 Three Dimensional Representation

3D representation and hence visualization is the heartland of architectural design. One might expect the best digital representations and visualizations of buildings to be generated by CAD packages but such packages find it hard to deal with many objects whose spatial base is essential the map. CAD packages also provide great opportunities for spatial detailing and rendering but in urban design, such detail is largely redundant as the focus is on massing and on broader forms of visualization. In fact, when this project began, all GIS software lacked any capability for 3D extrusion of the 2D map, although during the project (in 1998) ***3D Analyst*** became available for ESRI's ***ArcView 3*** while vertical mapper became available for ***MapInfo***. In this project, we anticipated these needs by developing network-based CAD based on ***VRML*** software, linking the sketch planning routines to such visualization. An example of this is given below in Figure 6:

*a.* *b.*

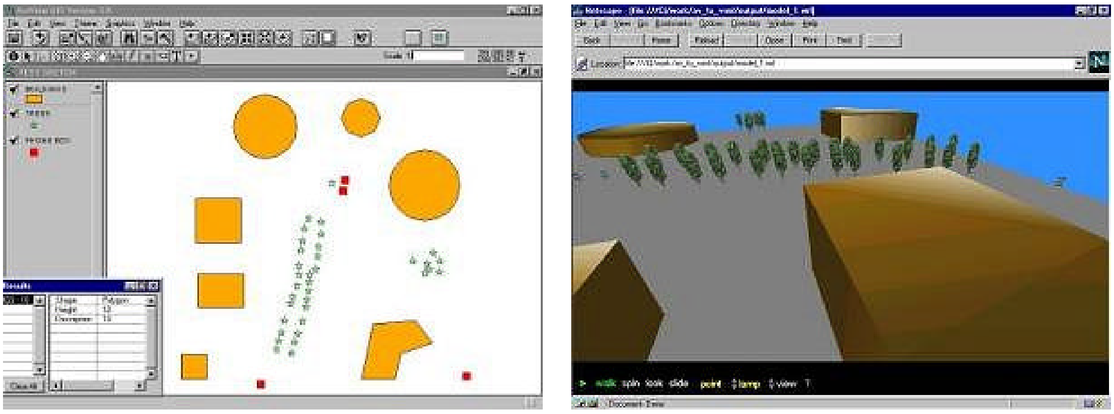


*Figure 6: Sketch Planning in* 2D *and Visualization of the Same using* ***VRML*** *in* 3D

We have also made extensive use of proprietary 3D software within GIS which is more useful for thematic mapping in 3D rather than the visualization of geometric environments. An example of this kind of visualization using ***3D Analyst*** for ***ArcView*** is given below in Figure 7, where population density in the London Borough of Hackney is visualized by enumeration districts (EDs).

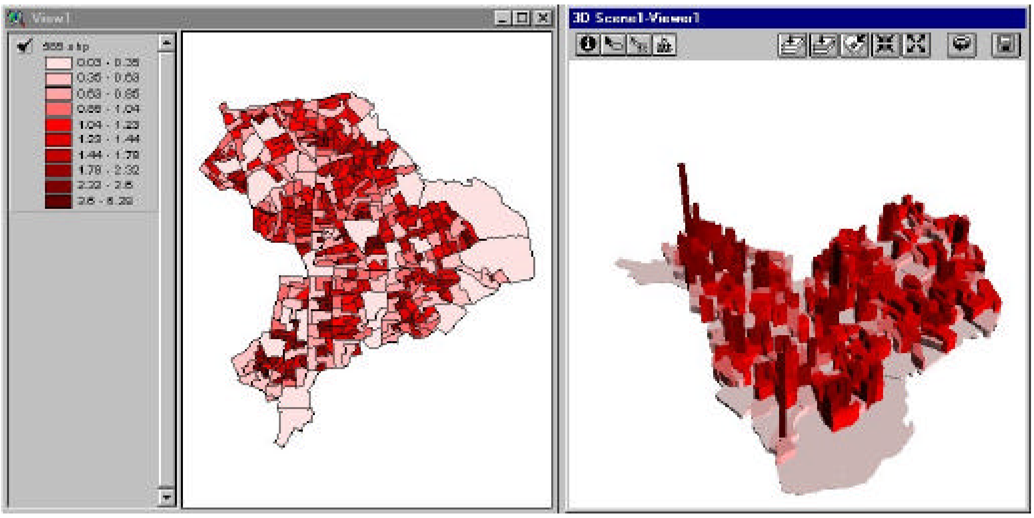



*Figure 7: Population Density by ED in Hackney in* 2D *and* 3D

### 3.6 Networked Software: The Collaborative Virtual Design Studio

The last theme but one which has been overarching within this project is the move towards integrating all this software within what is loosely referred to as the Collaborative Virtual Design Studio (CVDS). This is an environment within which this software exists on the web or at least on a local server which delivers it to users and which is configured in such a way that users engage in participatory design. This can range from the simple delivery of standard data to each user to the placing of designs on some communal bulletin board or its visual equivalent - the virtual white board - through to fully immersive design within a virtual worlds within which other users can observe and interact with respect to design decisions.

In VENUE, all we have done, and this was towards the end of our project, was to explore the idea of a virtual world, linking various 3D software to GIS but setting this in the context of already developed virtual worlds software, namely that pioneered by the ***Active Worlds*** group. To give an idea of the kinds of design that are possible, the following picture is taken from such a world in which users appear as avatars and in which they can engage in joint design/decision-making:

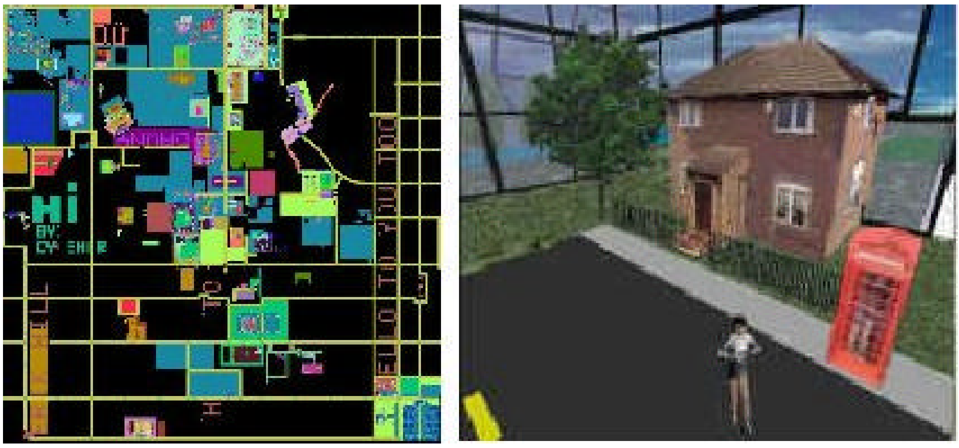


*Figure 8: Moving and Interacting in the Virtual Design Studio:* 2D *to* 3D

We will explore all these software technologies in some depth below, but suffice it to say that our collective experience of this application area is that multiple software types are necessary to encapsulate the variety. The notion of developing a fully integrated package in terms of plug-ins and extensions to some proprietary system no longer seems to be the way forward. In fact we would argue, and we will do strongly by way of conclusions, that the value in what we have been doing is to show how a range of digital technologies can be used in urban design. Thus our initial objective of a tight integration of software has been lessened as the project as progressed. More of this below.

## 4. Spatial Representation and Geographic Information

We have already spent a little time on ways of representing spatial images. Our original work with VENUE was based on a detailed case study of Wolverhampton town centre. Another project in CASA for the Department of the Environment, Transport and the Regions was concerned with developing the detailed urban geography of town centres. Wolverhampton was the first pilot example from one of 12 which were used to test the feasibility of a method for defining town centre boundaries using fine scale spatial data and desktop GIS.

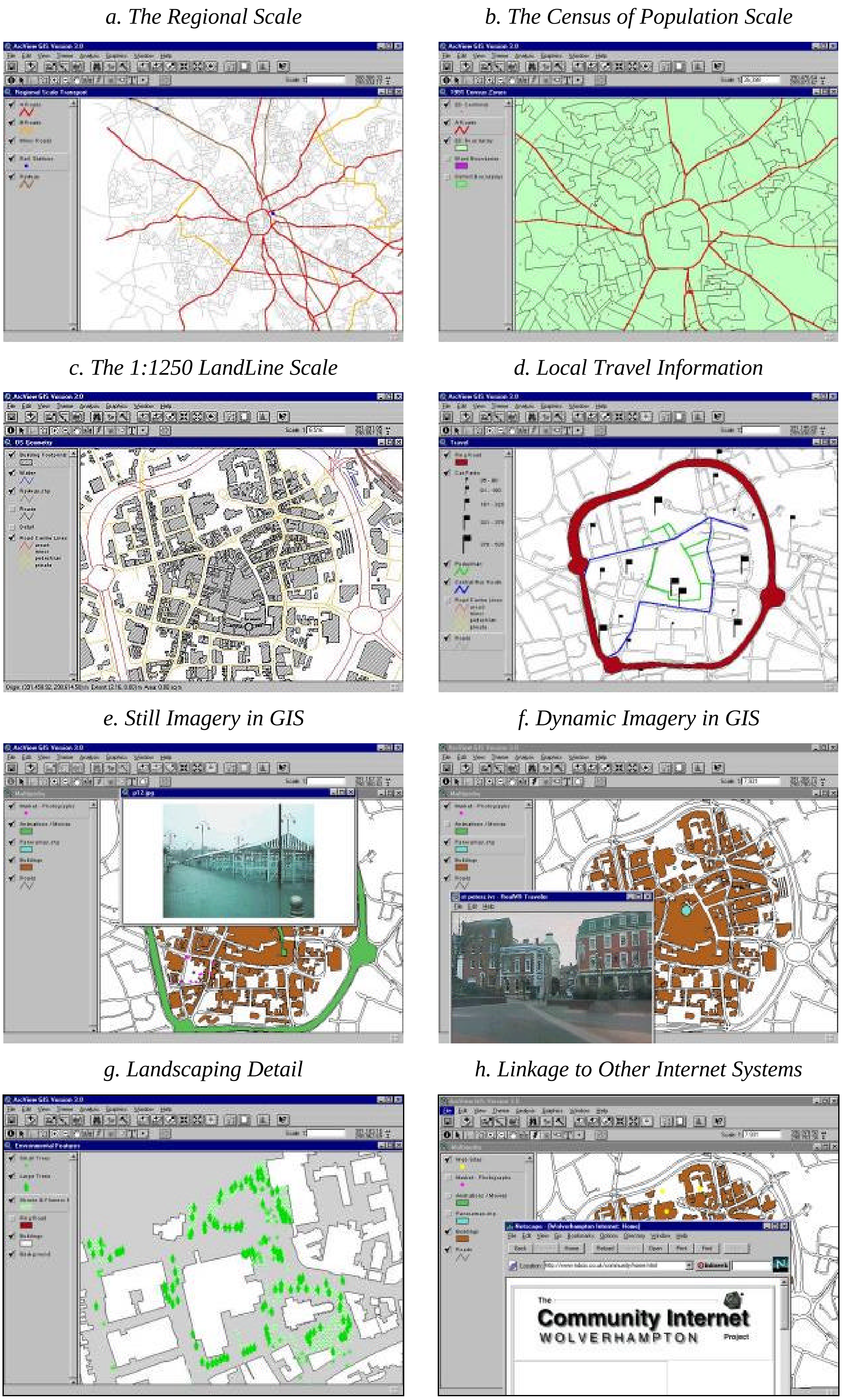



*Figure 9: Types of Spatial Representation for Wolverhampton Town Centre*

In the examples that follow, we will use Wolverhampton quite extensively although some of our examples will relate to South East Oxford which was the project which we used to develop the methods with students at Oxford Brookes University.

The best way to develop this content is to list the kinds of data and comment on each briefly. We have already made distinctions between geographic and geometric data sets and between quantitative and qualitative pictorial/image data. There are further distinctions within GIS between vector data and raster data which relate to the way these data are handled and stored. We cannot develop a tutorial on GIS but what we need to illustrate here is how versatile such software is in enabling detailed design issues to be visualized in software which was originally developed for problems of greater magnitude in scale.

In Figure 9 above, we illustrate the kind of data that drives urban design. GIS is a wonderful technology for setting the problem in a geographical context and in Figures 9a and b we show how large scale network data provides a regional picture and the census geography a local picture. It is worth noting here that now academic users in the UK can download much of this data through JISC related initiatives which have placed this data at MIMAS and at EDINA. It was not really possible to do this when our project began and we had our own link with Ordnance Survey for VENUE. But when the project ended, such data retrieval for any area of the UK down to a scale of 1: 1250 was possible for digital as well as population census data. The 1:1250 Landline data for the town centre which is bounded by a complete ring road is shown in Figure 9c and local point data based on travel information in 9d. Embedding multimedia into GIS is something that urban design requires and in 9e and 9f we show still and animated pictures of the market and central square respectively. Qualitative data based on landscape detail - shrubs and trees is shown in 9g while links to other software such as the Wolverhampton Community Information System can be hotlinked in from the desktop GIS as we show in 9h.

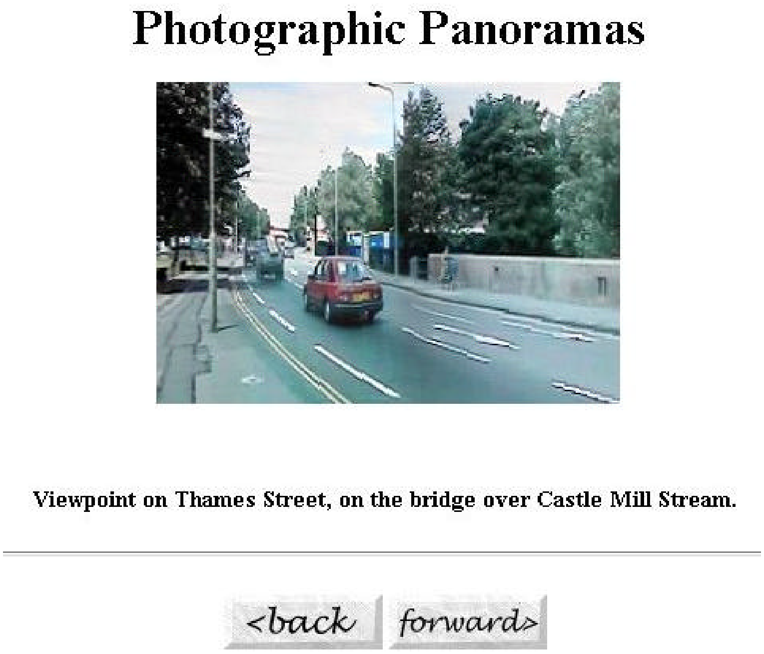



*Figure 10: The Web-Based Animated Image Around which Users can Pan and Zoom*

The multimedia interface is important for environmental quality is a central issue in urban design. During this project, we have perfected methods for visualizing panoramic images in web context and these can be called up within GIS. We can illustrate this for our Oxford Project which we detail below. In Figure 10, we show a typical image which we can pan around for a road in South East Oxford and in Figure 11, the digital panorama which is captured a series of still images and then stitched together using standard software:

*Figure 11: The Digital Panorama Composed of Still Overlapping Images*

## 5. Movement Modelling and Space Syntax

### 5.1 Relational Systems in Urban Design

A general rule of systems theory is based on the notion that systems with many components or elements which may indeed be diverse, only function if there is interaction between those components. Cities at any scale are examples of this interaction *par excellence*. The very function of buildings is to contain people and activities which interact with one another for purposes of economy or social well-being. Relational systems particularly based ideas from networks have been widely developed using graph theory. For example, transportation modelling assumes that transport flows of various kinds take place on such networks and transport design is invariably about changing the network rather than interfering with the mode or method of transport *per se*. The same exists in terms of socio-economic transactions which involves markets and these have to be taken account of in considering ways in which location, building volumes, and accessibility is changed when new designs are proposed.

It is not surprising that where there have been formal methods developed in urban design, and there have not been many, these have been based on charting, explaining and using qualitative relations particularly those that take place between building and their activities through various types of route network particularly streets. There is a long tradition of such work dealing with such network morphologies, and an obvious step forward in developing digital technologies specifically for urban design is to embed such technologies into the relevant software packages.

**5.2 Space Syntax Methods**

The methods that we will illustrate here and which are quite widely used in urban design, at least in the UK, are based on space syntax. Space syntax is a set of techniques that compute the accessibility of different locations at a fine urban scale by considering the connectivity of the street system. In essence, a planar graph is defined for a set of streets which are not necessarily the simplest line segments between street junctions but streets defined in some integral way. These are called axial lines and one criterion for their definition is based on lines of sight. From the basic set of streets defined as axial lines - which are very much defined intuitively by the designer who knows the area, relationships between each pair of streets are defined if those streets intersect. The bipartite graph which is formed by arraying the streets against their intersections is then composed into a regular graph of links between streets and this is then used in the computation of various indices of connectivity, based on the in-degrees, out-degrees, shortest paths, cliques and such like within the graph. From these measures, various statistics of accessibility are computed for entire streets - for axial lines - and these provide measures of attraction which can be displayed in the usual fashion as lines of differential accessibility. There is some suggestion that these levels of accessibility are correlated with traffic movement, which is an obvious enough consequence of their location and density.

We have developed this kind of functionality within desktop GIS. One of our tasks which was central to the original proposal was to add such routines to ***ArcView 3*** as an Extension. This was accomplished during the first year of the project and is now available as a downloadable Extension (called ***Axwoman*** in analogy to the basic UCL software ***Axman***) to ***ArcView*** on the ESRI homepage. We will come back to this later but readers who wish to test the method directly are encouraged to download it from

*http://gis.esri.com/arcscripts/details.cfm?CFGRIDKEY=-2057687617*

The Extension which enables designers to develop space syntax is configured as a simple addition to the standard ***ArcView*** interface. The user loads an image of the street and building plan and then draws the axial lines directly on the screen. These are stored in a simple data structure, their intersections calculated and the relevant graph computed. Various measures of access can then be computed and displayed on a standard color scale. An example of the map for the entire area of Wolverhampton is shown in Figure 12

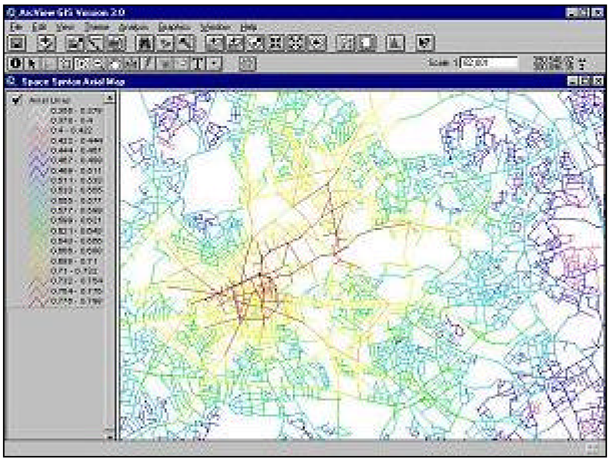


*Figure 12: Axial Lines and their Connectivity for the Wolverhampton*

The interface is shown in Figure 13 for the example of central Wolverhampton. Three key windows show the relational data, the map window which is coloured to show the axial lines and the relative accessibility, the table of accessibility values and their transforms, and a graph of one set of access measures against another. The user can cycle around this interface, performing the same sorts of analysis on different subsets of the axial lines which can be defined manually on screen. Different measures can be computed and the user can interactively delete lines and add them, thus using the tools in a sketch-planning-like mode.

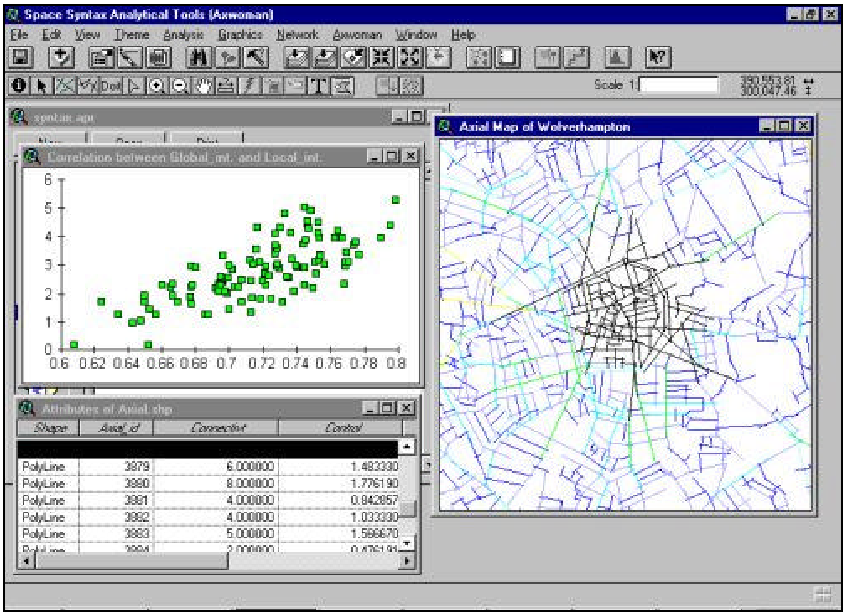



*Figure 14: The **Axwoman** Extension to the **ArcView** Interface*

A detailed summary of these techniques are available in the papers cited in Appendix A. A recently published paper which gives the details is by Jiang, Claremont and Batty (1999).

### 5.3 Simulating Pedestrian Flows

In our original proposal, we did not consider extending the set of tools we were proposing for urban design to specific simulation models. However for diverse reasons, as much to do with the logic of this development and the momentum generated through relational modelling, we have developed several such simulations which are relevant to urban designers. None of these models has been developed within GIS software for we have used a widely available agent-based package called ***StarLogo*** from the Media Lab at MIT (Resnick, 1994) to demonstrate what is possible. ***StarLogo*** is particularly appropriate for simulation modelling in a design context in that it contains a design function - a sketching package within - which can be used to clean data or to change data in ways that might resemble new designs. We have applied this model to our basic case study of Wolverhampton as well as to a variety of other small scale urban and building systems such as the Tate Gallery. We are not able to explain the mechanics of such modelling here but in essence, agents who are walkers or movers in the urban space react to various spatial detail such as that associated with different locations. A typical example might be walkers engaged on a shopping trip reacting to the types of shops in the local environment and constrained by limits on their time and energies in making the trip. This is the kind of detail encoded into the simulations. A typical example of the simulation is given in Figure 15 where we show the movement of shoppers in Wolverhampton from car parks at different stages of the simulation. The VENUE web pages contain more examples and also enable animations.

*a. Sources (Car Parks)* *b. First Movements* *c. Last Movements*

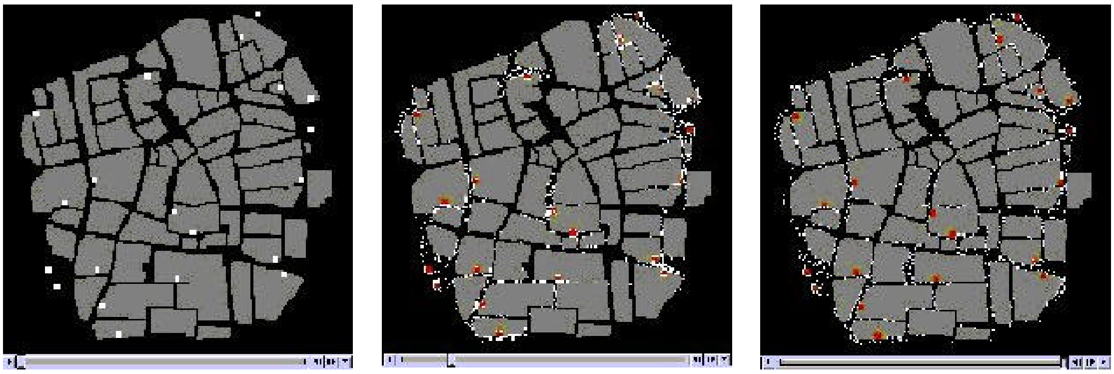


*Figure 15:Animated Movements of Shoppers from Car Parks in Central Wolverhampton*

## 6. Sketch Planning and the Design Process

### 6.1 The Need for Sketch Planning

Urban design is largely accomplished in the same manner as architecture - by single individuals developing a sketch design which meets the intuitively perceived needs posed by the problems and context in hand, and then detailed in various ways by a design team. This process is under considerable scrutiny as indeed is the process of architectural design in that its top-down elitist nature invariably ignores the needs of those who are the ultimate users of the buildings and environments created. At the same time as automating these design procedures using computers, there is a move to broaden the process involving a wider group of users as well as professionals. This too is being aided by computation particularly across networks. In this part of the project, all we will do is introduce design tools into GIS which enable any user to sketch. Sketching - that is adding and changing the basic data in creative ways - is not a feature of most GIS software in that GIS largely is focused on some grounded reality. Changing and improving data might be a function but in general, radical change to data in ways that need to maintain the design coherence of the data is not a feature. It is this kind of functionality that we have been adding to desktop GIS. In the same way that we added analytical capabilities to ***ArcView*** through scripts written in the associated ***Avenue*** language, we have added scripts which enable sketching. However we have done more than this in that we have also provided a detailed repertoire of building and landscape features which users can call up as standard geometric pieces to be assembled within the urban scene.

In fact there are 66 building types reflected in five geometric types - house, flat, maisonette, shops and stair elements - which can be generated and then assembled. Landscape features are also important and there are some 6 types which consist of different species which can be 'planted' virtually by the user. The interface is one based on icons and drop down menus which enable these operations to be added to the ***ArcView*** interface and then simply leaving the user to employ these if and when necessary. One of the features of this entire project is the assumption that as urban designers become more skilled in GIS, then they will develop a variety of creative links with other standard GIS functions.

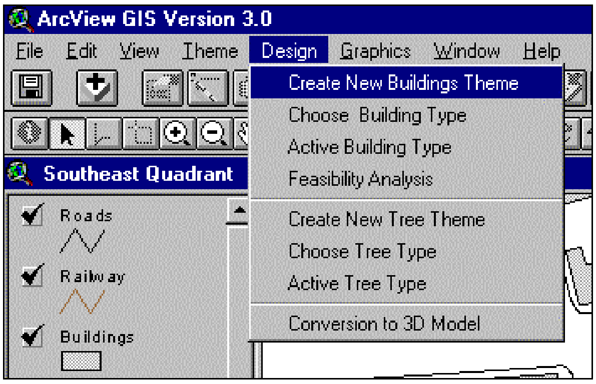
### 6.2 An Illustration of the Routine

We will simply illustrate the stages through which a user might progress when producing such sketch design. These are taken from the VENUE web pages.

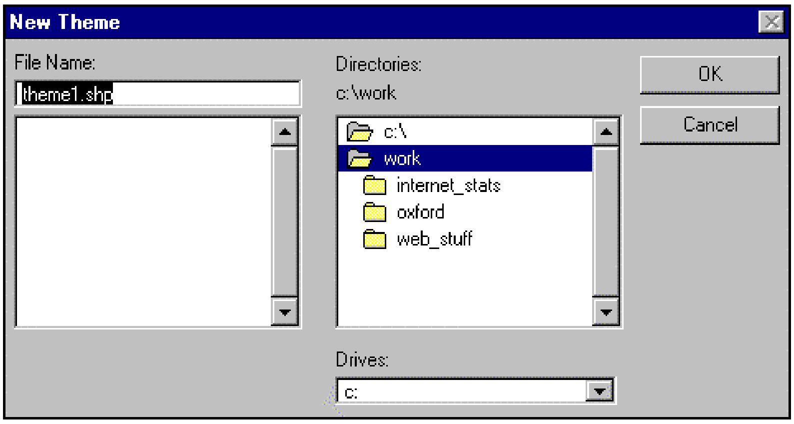
The sketch design tools allow you to quickly layout pre-defined buildings and trees & shrubs.

To begin you need to create a new theme (a map layer in ***ArcView***) which will contain your buildings or vegetation. Themes should contain data about same kind of map features. For example you have been provided with five themes of Ordnance Survey map data, one contains road features, another has buildings and so on.

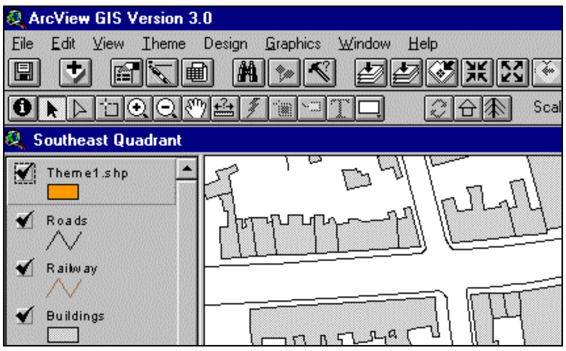
To create a new theme for your buildings go the **Design** menu and chose the **Create New Buildings** Theme option.




You will be asked for the file name of this new theme and where to save it on the computer disk. You should save the theme in your own account.

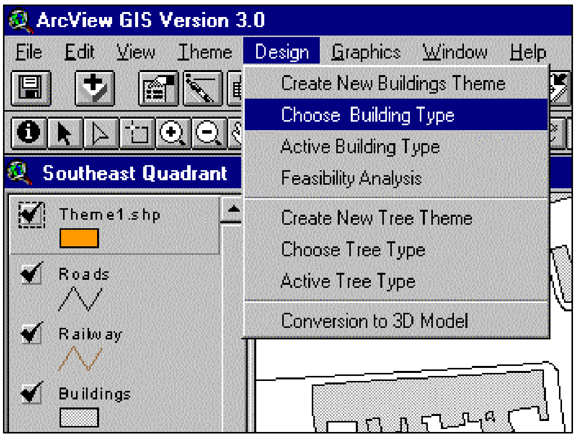



A new theme will then be added to the table of contents of the view, as shown below. In this case the new theme is called Theme1.shp.

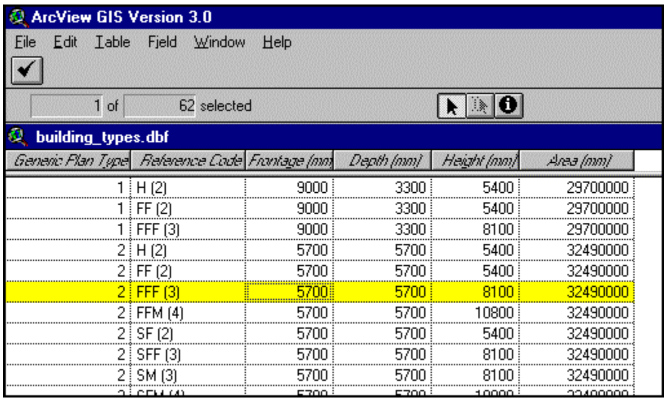



Theme1.shp is currently empty as it contains no map features. The dotted line around the tick means that this theme is editable so you can add new buildings to it.

Now, you must select a pre-defined building types to work with. To do this, go to the **Design** menu and select the **Choose Building Type** option.



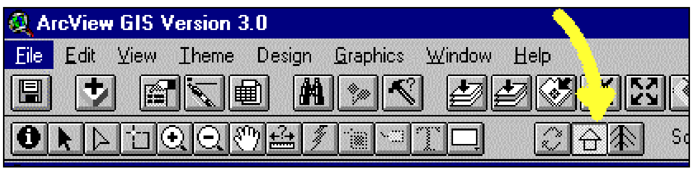

You will then be presented with a long list of pre-defined building types to choose from, as shown below.



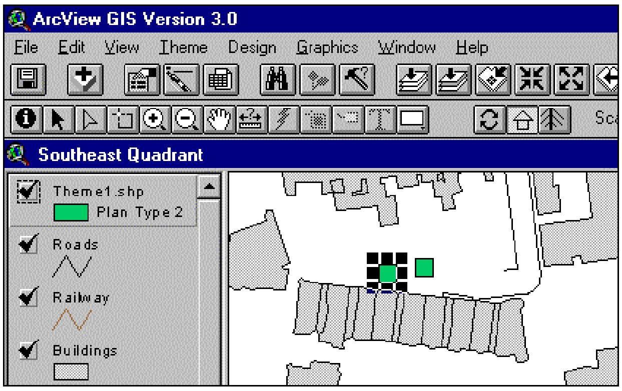

| Generic Plan Type | Reference Code | Frontage (mm) | Depth (mm) | Height (mm) | Area (mm) |
|---|---|---|---|---|---|
| 1 | H (2) | 9000 | 3300 | 5400 | 29700000 |
| 1 | FF (2) | 9000 | 3300 | 5400 | 29700000 |
| 1 | FFF (3) | 9000 | 3300 | 8100 | 29700000 |
| 2 | H (2) | 5700 | 5700 | 5400 | 32490000 |
| 2 | FF (2) | 5700 | 5700 | 5400 | 32490000 |
| 2 | FFF (3) | 5700 | 5700 | 8100 | 32490000 |
| 2 | FFM (4) | 5700 | 5700 | 10800 | 32490000 |
| 2 | SF (2) | 5700 | 5700 | 5400 | 32490000 |
| 2 | SFF (3) | 5700 | 5700 | 8100 | 32490000 |
| 2 | SM (3) | 5700 | 5700 | 8100 | 32490000 |

To select a building type simply click on a line. The currently selected building type is highlighted in yellow. When you have chosen a building type, click on the tick button at the top of the screen to confirm your selection. The list of building types will disappear and you will return back to the map view.

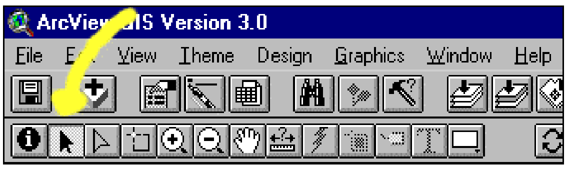
You are now ready to add new buildings to your theme. To do this choose the **building tool** button.



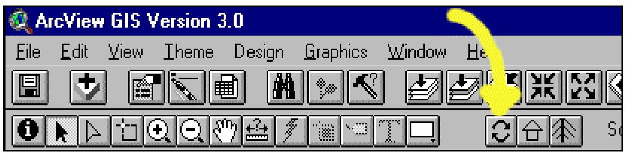
Now, click on the map at the point where you want a new building and one will be added. The point at which you click is the location of the bottom left hand corning of the building. In the example below, two buildings have been added to the theme.



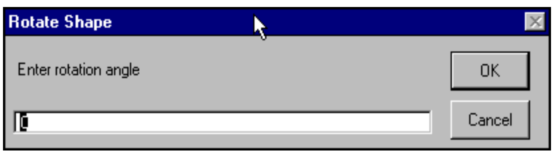

The building features can be easily moved, arranged or deleted to meet your requirements. Use the Pointer tool to selected individual buildings and move them around.




The **Rotate** tool can be used to orientate the buildings to the required angle.



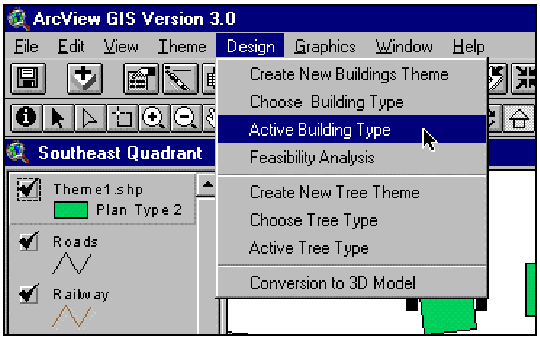

Click in the centre of the selected building you want to rotate. A box like this



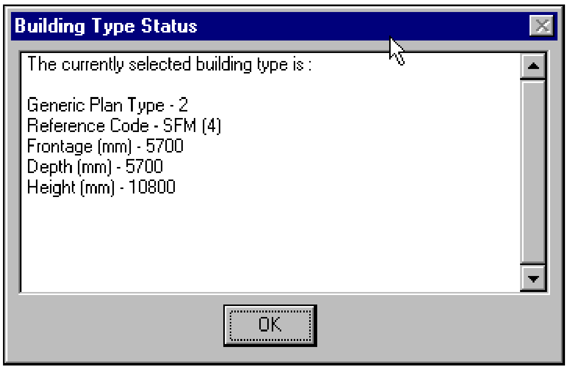
will pop up, asking you for the rotation angle in degrees. Enter your angle and press OK. (Note, a positive angle rotates the building in a clockwise direction, while a negative angle is anti-clockwise.)

To change to a different building type, follow step 3 again.

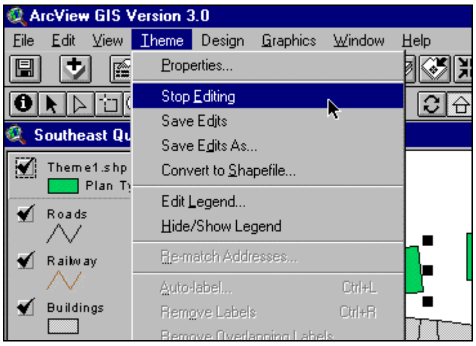
To find out the characteristics and dimensions of the currently selected building type your are working with, go to the **Design** menu and select the **Active Building Type** option.




This will present you with a pop-up box, like the one below, showing the building characteristics.

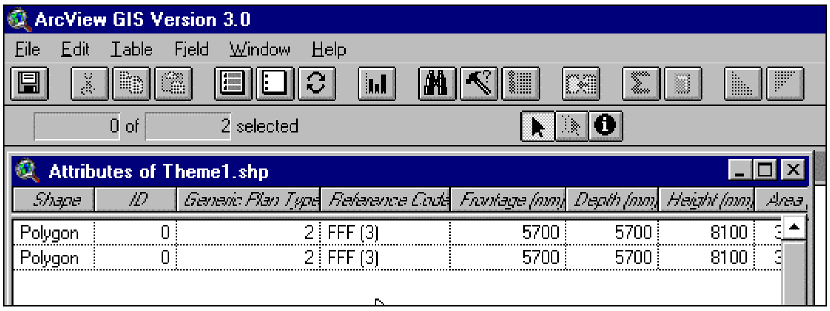



Once you are happy with the number, type and layout of buildings in your theme, you need stop editing and save the updated theme. To do this go to the Theme menu and select the **Stop Editing** option.

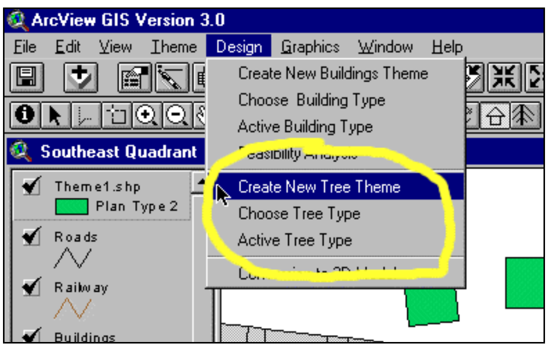



Your buildings theme is linked to a table and each individual building feature has one record (a row) in this table. To show the table, simply click on the **Show Theme Table** button.


It will open a table like this one.




Note, you can use steps 2 - 9 to create a vegetation theme using the pre-defined tree & shrub types. Except, of course, you use the relevant tree options on the Design menu.



This complete the procedure for producing the sketch, which can then be elaborated by adding attributes in the same manner as any other data set which is handled within GIS.

# 7 Three-Dimensional Representation

## 7.1 Different Types of 3D within Urban Design

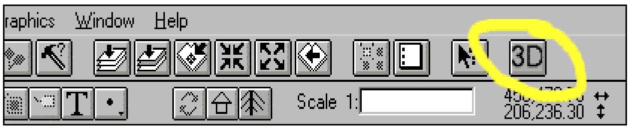
Within GIS, the third dimension is usually handled using surfaces and consequently standard software is restricted to continuous surfaces such as those based on topography or surfaces interpolated from discrete point data such those based on thematic socio-economic data. In urban design however what is required are methods which visualize the third dimension in the same manner as in computer-aided architectural design but which also retain the functional content of a GIS. Strictly speaking, 3D GIS is required for urban design, rather than CAAD but when we began this project, such visualization capabilities did not exist. ESRI were planning ***3D Analyst*** but we saw this for the first time in March 1997 while visiting ESRI HQ in Redlands, CA and it was not released until later that year. By this time we had evolved our own version of £D GIS which was based on using ***VRML*** code which was widely available as part of internet browser software.

Since we have concluded this project, during the first months of 2000, we have been reviewing 3D GIS and CAD for cities on world wide basis (for the City of London). We are able to state fairly definitively that 3D GIS is hardly developed anywhere for urban design and that where 3D models do exist with the focus on buildings in cities, these are largely designed for presentational terms and for assessing the visual impact of new buildings. They are rarely linked to the kind of data that urban designers use. We feel that this situation may soon change but even with the extensions now available for desktop GIS such as ERSI ***3D Analyst***, these lack functionality within the third dimension, and are still only useful for large scale visualization. Here we will concentrate on the ***VRML*** Extension that we produced, walking through the process of constructing such models from the basic 2D map data.

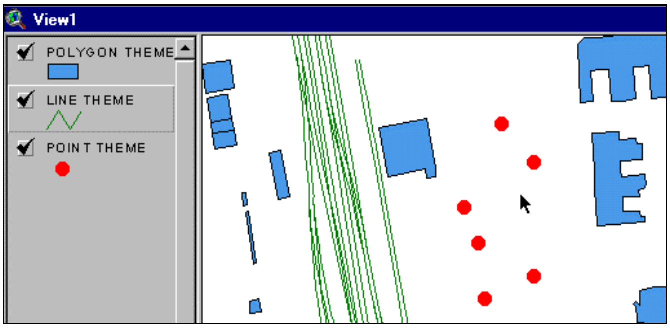
## 7.2 The Process of Adding 3D Content: Links between GIS and *VRML*

We have written a series of custom scripts using the macro language ***A***VENUE, that convert 2D plan sketches into 3D format, using ***VRML*** 1.0. Attributes from the 2D GIS database are used to determine the characteristics of the 3D model, for example, height and colour. ***VRML*** was chosen as a means of visualizing in 3D because it offers a platform and software independent file format. The user can easily interact with the 3D model, walking or flying around and through it. It was also the chosen 3D format for the Web when first used. There are many ***VRML*** browsers that can be used to view and interact with the model, although there is considerable variation in how well they render the models. We have chosen to use the ***Live***3D ***VRML Netscape*** plug-in. We will now illustrate the various stages involved in this process, which are again taken from the VENUE web pages.

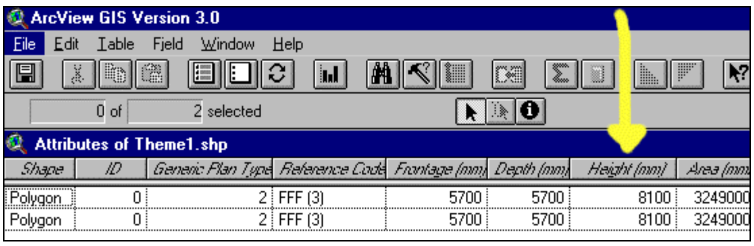
You can use the 3D tool to quickly create block model visualizations of your design.




The 3D tool will only work with polygon themes. In ***ArcView***, themes can be point, line or polygon themes. The Ordnance Survey buildings themes is an example of a polygon theme.

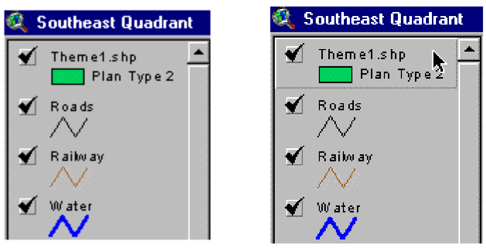



Also, any polygon theme you want to view in 3D must contain a column in its table called Height, which has the height of each feature in millimeters.

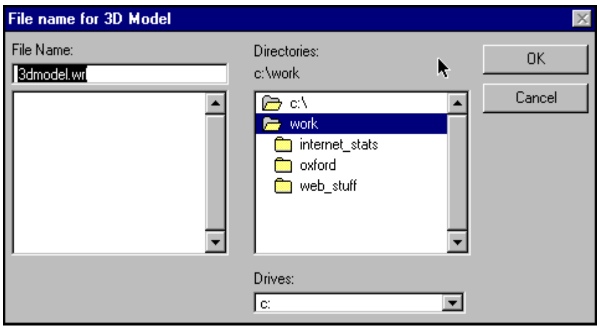


If you use the pre-defined building and tree & shrub types from the Design menu, a Height column is automatically added to the table.

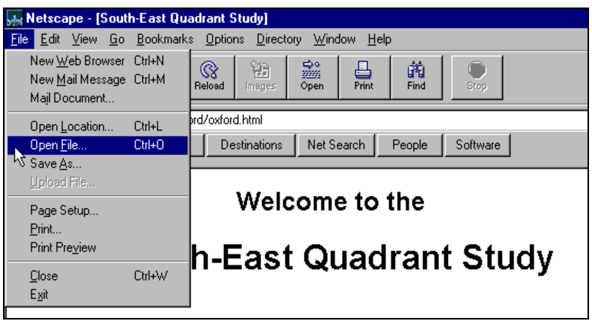
Select the themes you want to view in 3D. More than one theme can be selected. To select a theme you click on the theme description in the table of contents and it stands out with a bevelled edge. To select more than one theme, hand down the shift key on the keyboard while clicking with the mouse.



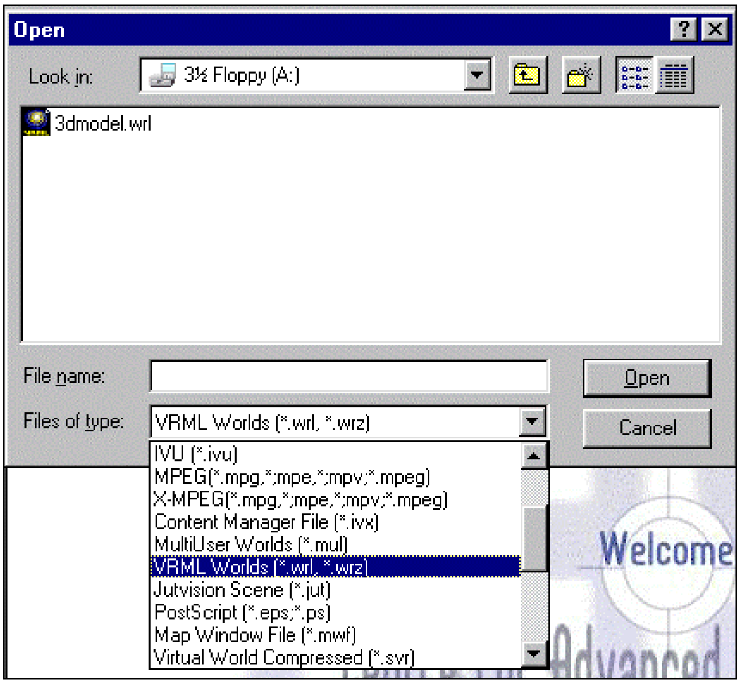

Click on the 3D button . This will produce a 3D model file. You will be asked for a file name and location to save the 3D model. If you want to keep the 3D model you must save this file to your own account.



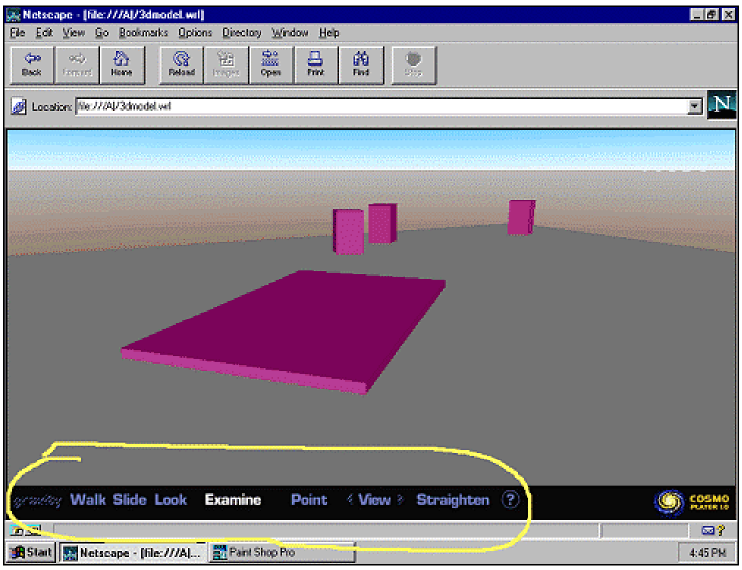

To view your 3D block model, you use the Netscape Web Browser. Start Netscape and go to the File menu and select the File Open.... option.




At the bottom of this dialog box set the Files of type :to ***VRML*** Worlds (*.wrl, *.wrz) file type.




The 3D model should load into the browser, looking something like the image below.




Try walking around your model. You can use the buttons at the bottom of the browser window to change the mode of navigation.

## 7.3 Examples of 3D Visualization

There are several useful examples that we can show of 3D visualization using this method. In a first example, some simple block buildings, with trees and phone boxes have been sketched in 2D in ***ArcView***. The building block outlines are stored and represented as 2D polygons in the GIS. Each polygon also has attributes that determine its colour and height in the 3D ***VRML*** model output. In the sketch are also trees (green stars) and phone boxes (red squares). These are part of a library of useful points features that is being implemented.

Once the user has finished sketching 2D features and has entered required attribute parameters (such as heights), they convert the layers into a 3D model by clicking a button on ***ArcView's*** buttonbar. This prompts the user for a filename and then writes out a ***VRML*** description of the scene to a text file. The user can then view the 3D model in the ***VRML*** viewer of choice. We use ***Live***3D and the pictures below show the 3D model from different positions. The trees and phone boxes are rendered with small graphic textures on the geometric faces. ***Live***3D provides different shading and detail levels. As an example the last picture shows the scene rendered in wire-frame mode. These pictures are shown in Figures 16a to 16d.

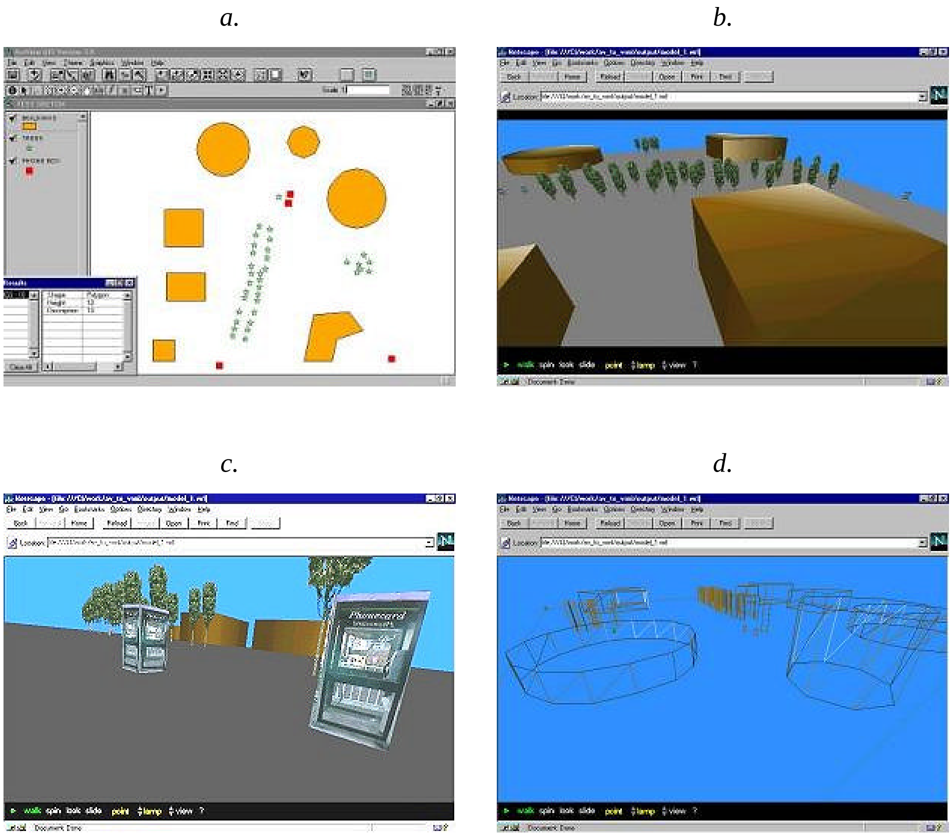



*Figure 16: Sketch Planning in* 3D ***VRML*** *from* ***ArcView***

In the next example, a rather more realistic set of urban features are visualized in 3D. The building block outlines for the central area of Wolverhampton are shown in 2D in ***ArcView***. These were derived from Ordnance Survey base data by removing building subdivisions and line vertex generalization. This was necessary to produce a 3D ***VRML*** model small enough to be usable in PC-based ***VRML*** viewers. Each block was assigned a height attribute in ***ArcView***. The red polygon around the outside is Wolverhampton's ring road. The two other pictures below show views of the 3D model in ***Live***3D. These are all shown in Figures 17a to 17d.

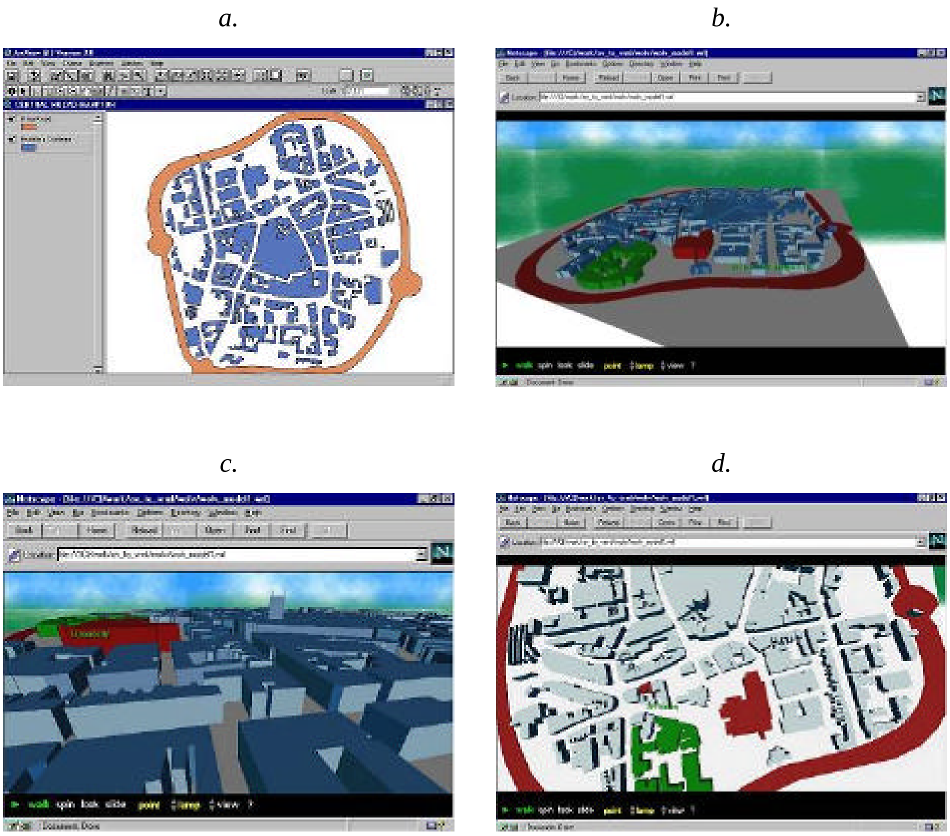



*Figure 17: Central Wolverhampton Generated in* 3D ***VRML*** *from* ***ArcView***

In our last example, the 3D visualization functions were tested on a small area of contours. The contours were stored and represented as polygons in ***ArcView***. The model output of the contours, viewed from a couple of different angles, in shown in Figure 18.

a. b. c.

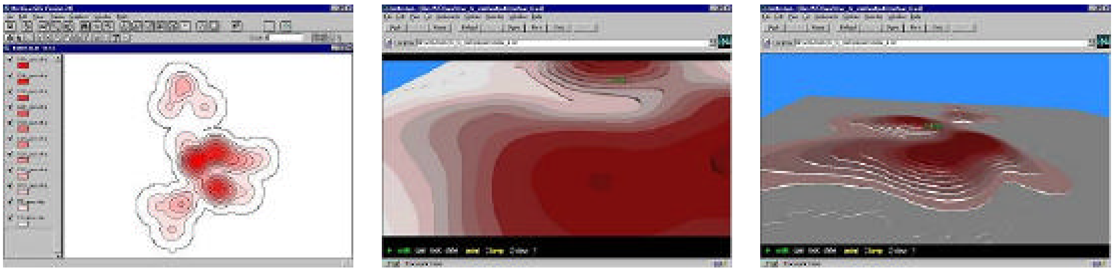


*Figure 18: Visualizing Contour Surfaces generated by* ***Spatial Analyst*** *within* ***ArcView*** *with* 3D ***VRML***

The ***ArcView*** scripts to output ***VRML*** models are being further developed and ***VRML*** version 2 was tested to provide more dynamic models with the possibilities for editing in three dimensions. However these were supplanted by the use of ***3D Analyst*** although we did explore 3D ***Studio Viz*** from Autodesk and also ***Pangea***, the home-grown product from the Intelligent Architecture Project in UCL's Bartlett School.

## 8. Internet Applications and the Collaborative Virtual Design Studio

### 8.1 The Idea of Participatory Design

The Collaborative Virtual Design Studio is the last area of research that we explored. Urban design tends to be more like team work than individual architectural design in its first stages. Such design is based on developing a common resources of data about the local environment, generating analytical as well as aesthetic insights into urban problems and their solution or at least alleviation. The design process still tends to be individualistic in that arranging buildings and landscape details need to be done by one person although this is usually embedded in a wider context of criticism and redesign in which a larger team is always involved. The need to demonstrate how these new digital tools might be fashioned in such an environment is thus important and to this end, the idea of the virtual studio in which designers can access common resources and engage in virtual design that others might be involved in, is an obvious extension of the traditional design process.

### 8.2 Rapid Visualization of 3D Form for Online Design Environments

Two critical issues need to be solved in developing such studios: first there is the placement of data in a common server context, and second there is the capacity to visualize such environments over the net. We have explored these issues in some depth and although all our solutions are somewhat *ad hoc* at present we have succeeded in demonstrating how we can build the kinds of virtual worlds referred to earlier and use real environments to fashion the backcloth in which participatory design in such virtual worlds can take place. Placing data online can be done quite easily as we demonstrated in our Oxford project although there are now internet GIS solutions which enable the interfaces to be somewhat friendlier and more powerful. We will not explore these developments here but will concentrate on showing how building forms can be rapidly modelled and placed online to create such virtual environments.

Problems of placing models of built form online are two fold, firstly one of file size and available bandwidth. The majority of users logging into the Internet from home or the office have a maximum connection rate of 56K per second and this varies according to the load on the network. As such the file size of models placed on a server for online distribution need to be kept to a minimum, the recommended maximum file size is 500K. Secondly, is the need for an acceptable frame rate when exploring or digitally manipulating the model. While advances in graphic card technologies over recent years have overcome a lot of earlier problems, frame rate can still vary considerably between users machines. For real time interaction a rate of 8 frames per second or above is preferable, although acceptable levels of interaction can still take place at 4 frames per second.

In our work on 3D visualization, we developed ***VRML*** models as the solution to online CAD. The ***VRML*** format was widely viewed as being the answer to the distribution of three-dimensional models online, indeed a number of high profile CAD and three-dimensional modelling packages export to the ***VRML*** format. However, the formats future is doubtful, problems arise with ***VRML*** in relation to both file size and frame rate with models representing even basic urban form becoming un-viewable on standard machines. While impressive models in ***VRML*** have been created - the example of Bath in the United Kingdom is the most commonly sited ***VRML*** model of urban form - they were often limited to high end workstations and thus could not compete with traditional CAD output. However, even with ever increasing processor power and frame rates, ***VRML*** is no longer widely supported or indeed viewed as the standard platform to distribute three-dimensional models online. The original promise of three-dimensional models communicated via the Internet has failed to materialize, at least in any useable form. Models of urban form currently available online, for example Virtual Helsinki, New York and Ottawa, to name but a few, are limited to basic block form models with limited texturing. With this in mind, the ‘Shared Architecture’ project was set up as part of VENUE project to explore how the built environment can be conceivably communicated online. Shared Architecture has focused on two concepts, firstly, on how to construct rapidly, urban models to convey a sense of location and place on standard home or office computers and secondly, the placement of these models in a multi-user real time environment.

Figure 19 illustrates the modelling package ***Canoma***, from Metacreations, used for rapid modelling from multiple photographs

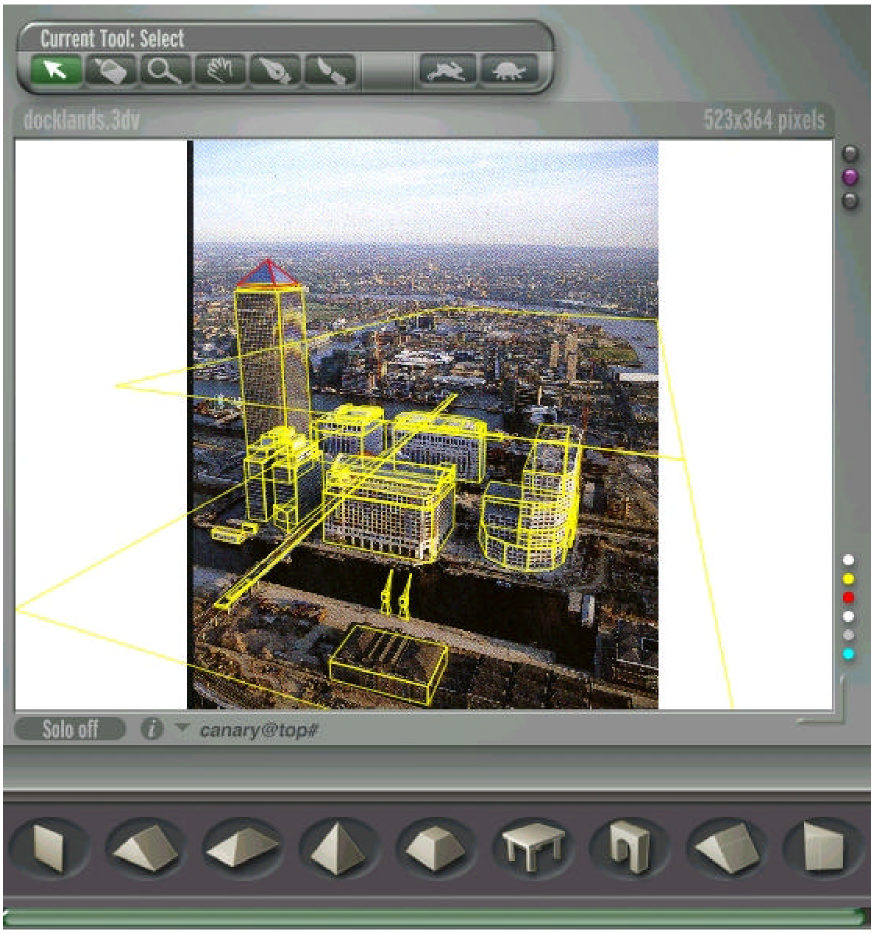



*Figure 19: Visualizing Urban Form for Placement in the Virtual Design Studio*

***Canoma*** was chosen for its ability to quickly construct the existing environment using a range of pre-defined polygons. As Figure 19 illustrates, images are imported into the software and 'pinned' with a range of polygons to overlay the architectural features. The utilization of photographs ensure that details traditionally difficult to model rapidly, often due to lack of data, such as roofing structure can be included. The use of photographs also allows a high level of detail to be obtained using texture mapped surfaces. These textures can be subsequently modified in a standard image processing package to represent changes in lighting, shadowing etc. The ability to quickly model urban form using photographic software is an emerging field. In this project, ***Canoma*** was utilized although a number of new software packages have since emerged. Notable of the emerging packages is Geometra from AEA Technology which offers a free functional version to be downloaded from the Internet. Such packages are allowing the non-expert to construct realistic architectural models of existing buildings and distribute them online.

### 8.3 Putting Urban Form in Virtual World

A range of models were constructed and placed online using buildings selected locally. These models included a range of London tourist attractions, including Buckingham Palace to illustrate how simple new build constructions as well as buildings of rich architectural heritage can be distributed online. Each model was initially placed online in Metastream format, available for viewing as singular structures. Metastream was selected due to its ability to both compress the overall file size and stream texture data to the end user. Streaming results in a wire frame version of the model displaying on the user computer within approximately 5K followed by the texture mapping. File size varied accordingly to a number of factors such as texture resolution and the number of photographs used for modelling. On average models on the Shared Architecture site are 180k, a considerable decrease in the equivalent ***VRML*** file size.

In order to construct a street scene, and gain a sense of location and place online, each building was imported in an ***ActiveWorlds*** World Server. Figure 20 illustrates an avatar in the constructed street scene.

*Figure 20: Fashioning the Collaborative Design Studio in which Users appear as Avatars and are able to Manipulate the Elements of their Environment*

***ActiveWorlds*** is a multi-user ‘chat and build’ system for Windows 95. The ability to load each building into a multi-user environment allows various levels of collaboration in the design process. For example, each section of the scene can be manipulated and interchanged in real time, i.e. if a house is taken out of the scene and replaced with a modeled retail unit all users logged in as avatars observe the changes at the same time regardless of physical location. The models are imported into ***ActiveWorlds*** as Renderware format (.rwx), a number of modelling packages export file formats that can be easily converted into Renderware. The ability to convert into Renderware format allows traditional CAD output in .DXF to be imported to ActiveWorlds. The import of traditional CAD models combined with rapid scene construction using ***Canoma*** allows developments to be viewed and manipulated in context. The ability to interact with CAD output and small scale urban form models online presents the opportunity to aid the design and decision making process. From allowing clients to walk through a range of design options online, regardless of location, to the ability to place options online for public consultation, the Internet represents an opportunity to enhance the communication of design information.

Models, both singular and multi-user, maybe viewed at CASA's Shared Architecture Site:

*http://www.casa.ucl.ac.uk/public/meta.htm*

## 9. The Oxford Project and Related Educational Initiatives

In the Autumn and Spring terms of the University Session 1997-1998, we began to test and develop the basic tools in an educational context with the one year Masters Students of Urban Design at Oxford Brookes University. We agreed to switch the focus from UCL to Oxford Brookes because the computer infrastructure at UCL was inadequate to handle the software and because the student groups which we had access to at UCL were not focussed upon urban design *per se*. The software which was ***ArcView*** was donated by ESRI for this project although it is available under CHEST. It requires Windows 95 which was not (and is still not) available at UCL (April 2000) on the publicly financed computer systems. At Oxford, two members of the team visited for one day each week during these two terms to develop the appropriate instruction. The project in question set around these tools was an Urban Design study for the South East Quadrant of the City of Oxford in which students were to proceed through the usual process of urban design - indicated earlier - and develop specific site plans for residential and landscape developments within the wider urban context. A web page was set up to control to project and this is illustrated in Figure 21.

The exercise also introduced students to computer systems in general for remember that these students had no tradition of using computers, and thus the instruction was from first principles in the use of the ***Windows 95*** Operating System, the client-server architecture of the local area network, as well as the proprietary software itself.

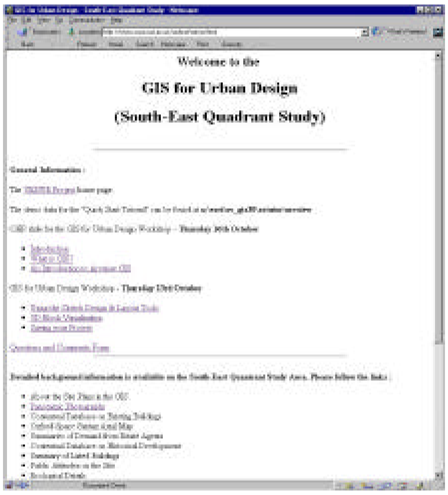



*Figure 21: The Oxford Brookes Educational Project Web Page*

Once the basic instruction was completed, then students were left under minimal supervision to use the various tools provided. In many senses, the whole experience was particularly valuable for developing the appropriate sketch planning extension. Our team had least experience of this kind of activity and the urban design faculty and students had the greatest interest in using the software in this way. We will provide a brief summary of how this module was developed. The idea that a designer must be able to flexibly locate and move standard components or building blocks is at the heart of the site planning process. This is usually accomplished by experimenting with pen and paper on the relevant site plan but what we provided was a way of using the screen as the site plan - with the plan itself as the backcloth - and the user then pulling up these standard building blocks, moving them through point and click but supplementing these operations with those of pan and zoom, and then anchoring the elements in the best positions. The value of this type of sketching is only apparent when there is a large repertoire of building blocks. In this case there were some 5 plan types giving rise to 66 building types. A sample of the catalogue which is given in terms of

Plan Type, Reference Code, Frontage, Depth, and Height is shown in Figure 22 and these plan types can be called up when the user identifies the building icon shown earlier in the sequence of sketch plan operations.

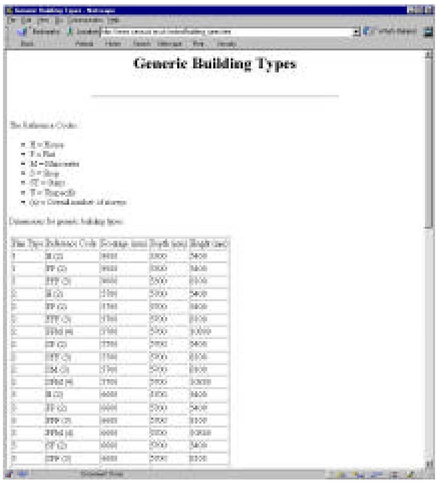



*Figure 22: A Sample of the Generic Building Types Catalogue*

The same kinds of operation relate to the planting types. In this case, the catalogue contains 6 types and 41 different species. The web page catalogue contains pictures of all these species, an example of which for the Norway Maple (*Acer Platanoides*) is given in Figure 23 which is the relevant section of the appropriate web page. Our 3D visualization of these designs is not able to take account of their specific morphologies although in principle, this is possible. Our focus was more on the kind of massing that such species give and to this end the height and spread information is relevant. Note also that in the catalogue, cost information is important in that costing the designs produced at this scale is always an important part of the evaluation process.

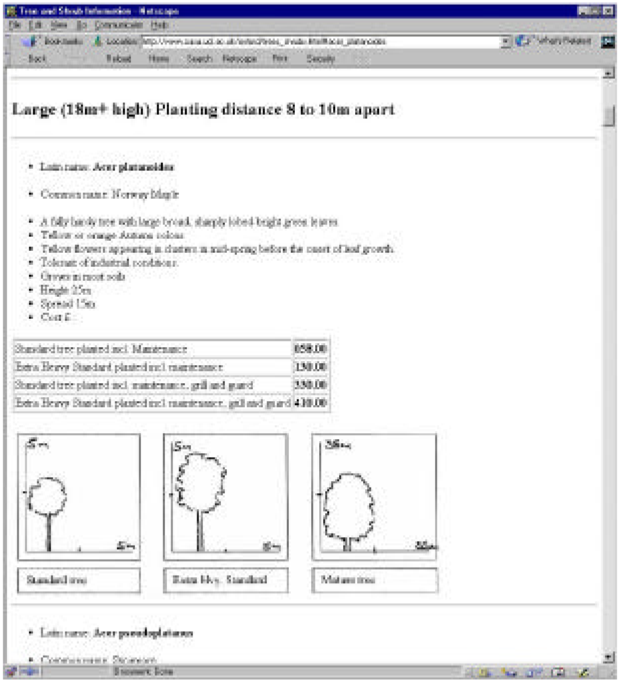



*Figure 23: A Sample of the Tree and Shrub Information*

The design process was monitored in some detail and the students were given the opportunity at each stage to feedback information and comment concerning the quality of the instruction, the value of the tools, and their role within the urban design process. This process was quite satisfactory although the nature of the responses was patchy and it was hard to generalize from this the student feedback. A web form for such comment was available and this is shown in Figure 24 as:


*Figure 24: Evaluating the Success of the Urban Design Tools*

From this project, we consider that there are some salutary experiences worthy of note: and these are perhaps of more general import for all software projects intent on introducing new technologies to professional user where there have been no such technologies hitherto.

The users were quite receptive to the idea of these technologies, and within limits found them useful, but their exposure to them was somewhat artificial. For their continued interest, a threshold has to be reached which could not be achieved in this project and probably requires a design studio to be equipped with such technologies so that they become part and parcel of the everyday working project. Moreover the faculty too have to be more deeply steeped in these tools or at least there has to be an advocate or champion amongst the faculty to keep these techniques under continuous development and use. We decided not to repeat the experience in the second year of this project because we considered that this would become a routine teaching experience and we were sufficiently impressed by how relatively successful such ideas were in practice to consider that the next stage would not be just further instruction on our part but that it was equipping the studio with the technologies. This is matter for the institution and this was beyond our remit. Had this been in UCL and had we been closely involved in this teaching, then this may have been feasible.

There also needed to be a stronger interaction between faculty in the teaching area and ourselves to ensure continuity of the kind we have alluded too. The fact that we pioneered these developments in a distant institution was problematic although we are conscious that web-based teaching in this area is a real possibility. We will conclude our report with some suggestions in this area. Finally it is worth noting that other design studios are progressing faster and farther along this road than we have been able to do because of the provision of technologies in this area. For example, in the Architecture and Planning Schools at ETH (Zurich), MIT (Boston), and UCLA (Los Angeles) and in Landscape programs at Harvard and Berkeley, there are major developments. However we consider that the kinds of tools that we have developed are unique and that it is rare to find new tools of the kind that we have developed. We will argue in conclusion that this is as much due to the orientation of our project as it is to the simple recognition that such tools are needed.

We have also noted that our tools are being used by other student groups at UCL. In fact, the Masters students in Space Syntax and the Space Syntax Laboratory have not really availed themselves of what we have done. This is as much due to the fact that this entire area is wedded to the Macintosh platform on which stands their basic software - ***Axman***. At the start of this project, we considered that we would develop the basic ideas on the Macintosh platform but the basic GIS software that we were working with is PC-based. The Space Syntax group did not use GIS at the onset of this project but since then they have begun to use GIS on the Mac, in particular ***MapInfo***, thus diverging further from the mission of this project. At some point, they will clearly have to change if they are to embrace state of the art software with major GIS functionality. In contrast, the UCL GIS Masters students have made use of our relational movement software ***Axwoman***. In a recent project (1999-2000), they have developed various approaches to detailed site planning and have reworked the ***Axwoman*** software extension for ***ArcView*** as well as writing their own extension to add line of sight and viewshed analysis to such software capabilities using the ***ArcView*** scripting language ***A***VENUE

## 10. Disseminating the Project

### 10.1 Publications

We have produced a number of publications from this project, many of which are available from the VENUE web pages, and in the working papers section of the CASA pages

*http://www.casa.ucl.ac.uk/newVENUE/publications.htm*

*http://www.casa.ucl.ac.uk/working_papers.htm*

Of the 25 paper produced, 2 were published in books, 10 in journals or magazines and 13 in conference proceedings. As in all research efforts where there are cognate projects being developed alongside that in question, there is an inevitable overlap. We have benefited particularly from the EPSRC/OST Virtual Reality Centre for the Built Environment project (PI: Michael Batty, June 1997-May 2000) and from the DETR Town centres Project (Phase 1: October 1996 to June 1997, and Phase 2: September 1998 to December 1999: PI: Michael Batty)

### 10.2 Software

We have produced a variety of software from this project. The most widely available are in the form of ***A***VENUE Scripts which form the basis of extensions to the ***ArcView*** GIS, and these are available from two sources: either our own web pages or from the main ESRI web pages. The three extensions are referred to as ***Axwoman*** - the software used to effect space syntax analysis within ***ArcView***, ***Sketching*** - the software used to enable sketch planning to take place within ***ArcView***, and 3D - the module which converts a 2D vector based map in ***ArcView*** into 3D ***VRML*** code which can then be used in a standard browser such as those associated with the ***Netscape*** products.

***Axwoman***: is available from the ESRI web site which has a variety of other scripts which extend ***ArcView***. The interface is straightforward and once the script has been downloaded all that is queried is that it be loaded into ***ArcView*** from the Extensions menu. The interface is shown as Figure 25:

***Sketching*** is available from the new VENUE Webpages as a similar download. 3D however is only available from Martin Dodge (m.dodge@ucl.ac.uk). This interface has changed the most since it was developed. ESRI have released ***3D Analyst*** for ***ArcView*** which essentially does the same but within the basic interface and although our script 3D does enable users to produce 3D without purchasing the ESRI Extension, we consider that it is now preferable for urban designers to use the ESRI products as these involve the use of lesser numbers of software producers. Moreover ***VRML*** can be tricky to use as it has several variants and it is no longer the preferred software plug-in for 3D on the web.

The other two areas of software design that we have been involved in relate to the adaptation of proprietary and free software. Andy Smith who was responsible in the project for developing many of these tools in a visual design studio has been using a variety of software products with a recent emphasis on the ***ActiveWorlds*** software, on ***Canoma*** for 3D rendering and model construction, and on web based products such as ***Flash***. Many of these products are peculiar to the applications which are simple enough to provide good solid demonstrations to non-expert potential users such as urban designers. Some of this software and its adaptations are available from the CASA web site under the Shared Architecture and related pages.

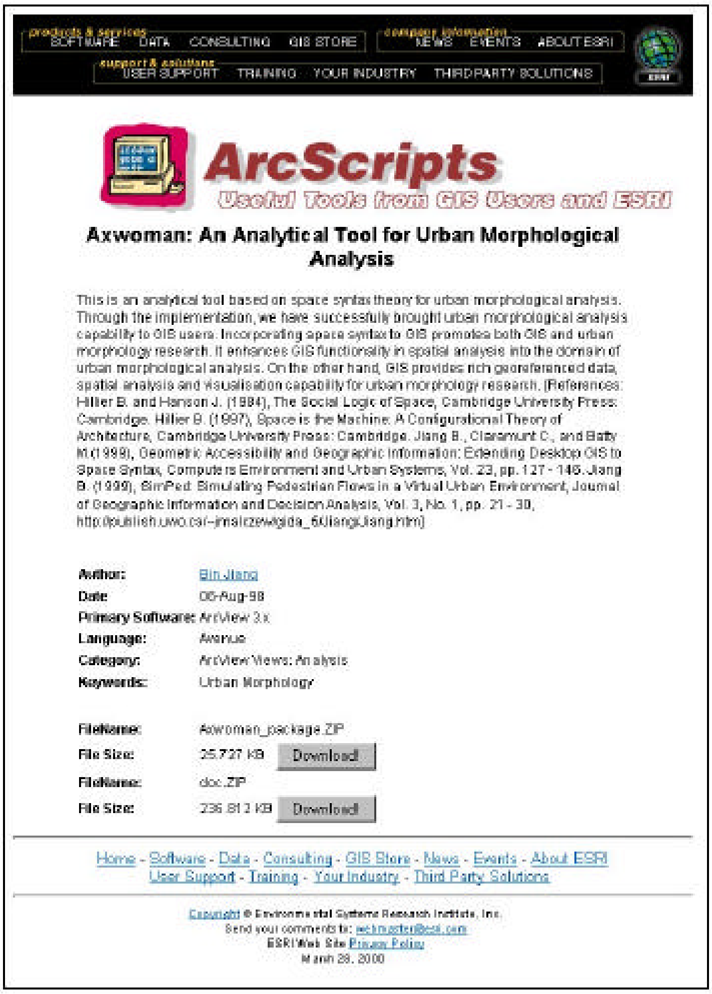


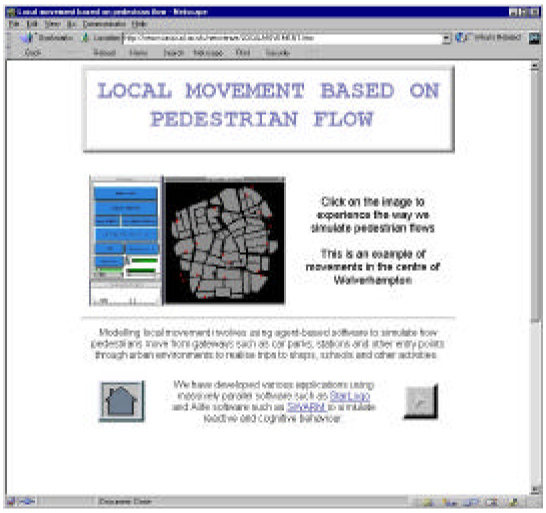

*Figure 25: The **Axwoman** Script Download Procedure*

## 10.3 Web Pages

In one sense, our web pages have and continue to provide the most focused means of dissemination. There are two sets: the initial pages which were built during 1997-1998 and the new pages which summarise and extend the old, built during the summer of 1999 and currently being brought up-to-date to coincide with the release of this report. We have already displayed some of their content at various stages of this report but it is worth concluding with a short demonstration of the new pages, which basically follow the structure of this report.


*Figure 26: The Top Level New VENUE Web Pages*


SKETCH PLANNING WITHIN GIS
Click on the image to experience the way we sketch new building blocks and add other features from a standard menu within the desktop GIS ArcView.
The animation shows frames from this sequence of sketches, edits and pastes.


LOCAL MOVEMENT BASED ON PEDESTRIAN FLOW
Click on the image to experience the way we simulate pedestrian flows
This is an example of movements in the centre of Wolverhampton


VIRTUAL REALITY: Urban Design through Public Participation
Click on the image to explore the virtual town created in 30 days on the CASA web site
It has been set in a dome around which you can pan and zoom in the Virtual Design Studio set up by this software


PUBLICATIONS FROM THE VENUE PROJECT


PROJECTS ASSOCIATED WITH VENUE
CRL
CGISM
CLRNET
The Centre for Landscape Research Inter-Network
VIRTUAL FIELD COURSE

*Figure 26: The Top Level New VENUE Web Pages continued*

The new pages essentially indicated how each software tool can be made operational. There is a top level of 11 pages from entry page 1 to final page showing links to our international network (page 11). The nine pages between consist of a home page (page 2) with links to none other pages including the last one - the links page 11. Pages 3-10 cover sponsors and collaborators, digital data, 3D visualization, local accessibility, sketch planning, local movement models, VR and the collaborative virtual design studio, and publications. Our two main sponsors - ESRI and OS - are flagged while our network of links consists of the last page.  Below these top level pages when the main graphic is clicked in 6 of the pages, animations of the process of using these tools is begun. For example, clicking on the space syntax map of Regent Street shows how the axial lines are drawn and how they are then coloured according to accessibility values while clicking on the 3D map of population density in Westminster provides a demonstration of how ***3D Analyst*** is used to rotate the 3D block diagram. Figure 26 shows these pages. The original web pages show more content and there are some web pages which we will not give the URL too which have been used in the Oxford project.

### 10.4 The International Network

When we proposed the VENUE project to JISC in March 1996, we had a agreement from two sources to provide us software and data. ESRI (President Jack Dangermond) agreed to make their various products available to us free as they have done ever since for a variety of other projects too, while the Ordnance Survey (Director-General David Rhind) also agreed to donate us LandLine data at scale 1: 1250 for the case studies that we attempted. We also secured the support of various other groups developing urban design projects world-wide: namely Robin Liggett at UCLA, Bill Mitchell, Mike Shiffer, and Joe Ferreira (Computer Resources Lab) at MIT, Tom Maver at ABACUS, the University of Strathclyde (Glasgow), Alan Day at the University of Bath, and Bill Erikson at the University of Westminster. Since then we have extended our informal network to take in Ian Bishop at the Centre for Geographic Information at the University of Melbourne, Varki George and Lew Hopkins at the School of Urban and Regional Planning in the University of Illinois at Urban Champaign, and Richard Brail and Lyna Wiggins at the School of Planning at Rutgers University. Our links with the CTI Centre for the Built Environment at Cardiff have been good while the link with Oxford Brookes has flourished through the Project.

In terms of visits, over the course of the last 3 years, we have formally visited many of these groups.

In particular, we visited the University of Bath and ESRI (Redlands, CA) in 1997. At ESRI, there was a three day meeting to explore ways in which GIS might extend to urban design which brought together many experts in a small group. Jack Dangermond used this meeting and his support of the VENUE project to focus his own development effort with ***ArcView*** on the kinds of tools that we were suggesting. ***3D Analyst*** emerged partly from this meeting of minds. Several visits were made to the Computer Resources lab at MIT (1996, 1999, 2000), and visits to ABACUS and to the Martin Centre at Cambridge University have all aided the project.

Although this is not a definitive pointer, specific links to the VENUE web pages using the ***Copernic*** Meta Search Engine resulted in 17 references from other pages to our own site, all of these being developed without any prompting on our own part and all being outside UCL.

## 11. The Next Generation of Digital Tools for Urban Design

During this project, we like everyone else developing and applying what is largely proprietary software to new application areas, have had to contend with a rapid and turbulent computing environment. We have been fortunate in that only in the area of 3D modelling have there been developments that have changed our own research direction. The heart of VENUE was and still remains the need to develop new functionality for urban design within GIS. We have shown what is possible through demonstrating how traditional designers and the traditional process of design education can be changed by these new technologies. But we have also shown how important it is to have subject and discipline experts become proficient in these new technologies if they are to have the impact that they should have.

The project has widened considerably from its inception, largely due to the fact that new software products have emerged and new research groups have formed to explore cognate issues which we have been influenced by. Although we feel that we have achieved a great deal, we are also conscious that the tools that we have produced are rather a rag-bag but we are satisfied that these are having an impact on urban design education and perhaps on the profession. The pace of change in this field is still very rapid. In 3D modelling for example, what was regarded as almost impossible 10 years ago because of the labour involved, can now be effected very quickly using all kinds of new automatic sensing software. For example producing the background content in 2D and 3D for a virtual design studio is now quite straightforward using internet GIS, rapid visualization techniques based on software like ***Canoma***, and on various web products that have appeared.

In conclusion, we consider that there are six main issues to be addressed in the near future. JISC may play a part in these especially as they all depend on broad band networking of the kind that universities have. We will list our suggestions as follows:

- The need to develop a suite of integrated analytical tools and models embedded within GIS that allow the user to interface inputs and outputs to a range of different drawing and data base software

- The need to develop analytical functionality for the analysis of 3D form based on extending GIS rather than CAD

- The need to develop catalogues of building elements and landscape details which can be routinely pulled up in terms of desktop and online use of design based software

- The need to develop new techniques of sketching which go well beyond the primitive demonstrations that we have developed here

- The need to develop integrated applications of these software elements within virtual studio like environments that are interfaced effectively with conventional design studios

- The need to ensure that an open software environment in which new packages can be imported with ease without destroying the clear integration that is needed within the virtual design studio

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## Appendix A: Publications of the Project

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## Appendix B: The Project Steering Group

*The Project Steering Group comprised :*

Ian Bentley (Joint Centre for Urban Design, Oxford Brookes University)
Basil Dimitriou (School of Planning, Oxford Brookes University),
Bill Erickson (Department of Planning and Urban Design, University of Westminster),
David Unwin (Department of Geography, Birkbeck College),
Paul Densham (Geography, University College London),
Tom Franklin, the JISC JTAP Coordinator.

## Appendix C: The Project Team

*The Project Team comprised:*

Michael Batty, Grantholder
Martin Dodge, Research Assistant, October 1996 to July 1998
Bin Jiang, Research Fellow, January 1997 to April 1999
Andy Smith, Research Assistant, August 1998 to December 1999

*Detailed Vitae:*

**Michael Batty** *m.batty@ucl.ac.uk*

is Professor of Spatial Analysis and Planning, and Director of the Centre for Advanced Spatial Analysis (CASA) at University College London (UCL). He holds a joint appointment between the Bartlett School of Architecture and Planning and the Department of Geography.

From 1990 to 1995, he was Director of the National Center for Geographic Information and Analysis (NCGIA) in the State University of New York at Buffalo, where he was also Professor of Geography. From 1979 until 1990, he was Professor of City and Regional Planning in the

University of Wales at Cardiff where he acted as the Dean of the School of Environmental Design (1983-1986) and Head of the Department (1985-1989). He acted as a member of the Computer Board for British Universities and Research Councils (1988-1990), as Chairman (1980-1982) and Vice-Chairman (1982-1984) of the ESRC (Economic and Social Research Council) Environment and Planning Committee, and as a member of the SERC (Science and Engineering Research Council) Transport Committee (1982-1985).

In the United States (1990-1995), Professor Batty directed the Buffalo site of the National Centre for Geographic Information and Analysis. This was a National Science Foundation Centre (NSF) with a budget of some $3 million per year, devoted to developing leading edge technologies for applications in the built and natural environments. CASA, the Centre that Professor Batty setup and directs at UCL, is new research focus within the University of London devoted to the development of computer based models for spatial problems with a focus on urban environments. CASA has attracted funding in the order of £1.8 million since its inception, and it was successful in the Technology Foresight Challenge Competition in 1996 where it was awarded a grant to develop a Virtual Reality Centre for the Built Environment. CASA is also heavily involved with the Department of Environment, Transport and the Regions in developing new technologies for the monitoring and planning of town centres. CASA won the Association of Geographic Information's (AGI) Award for Technological Progress in 1998, and is a key node in ESRC's Priority Network on Complex And Dynamic Processes. In 1999, he was awarded the Back Award for 'contributions to national policy and practice in planning and city design' by the Royal Geographical Society.

**Martin Dodge** *m.dodge@ucl.ac.uk*

is Systems Administrator in the Centre for Advanced Spatial Analysis, UCL. He worked on the VENUE project for two years at UCL from 1996 to 1998 and prior to that he was a research Assistant in the department of City Planning at the University College of Wales at Cardiff. He has written extensively on mapping cyberspace and on measuring web traffic. He has published many articles in this area and is the co-author of ***Mapping Cyberspace*** (Routledge, forthcoming September 2000)

**Bin Jiang** *bin.jiang@hig.se*

has been a Lecturer in the Division of Geomatics, Institutionen för Teknik, University of Gävle, Gävle, Sweden, since January 2000. From January 1997 until April 1999 he was Senior Research Fellow working on the VENUE project at UCL, and until December 1999, he had a similar position in the VR Centre for the Built Environment at CASA. He has worked on different models of movement at the local scale, particularly models of pedestrian movement. He has published widely with some 12 journal articles, and 29 conferences and working papers. His current interests involve visualization within GIS which build on his doctoral studies in the use of uncertainty analysis and fuzzy logic within cartography.

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Andrew Smith is a Research Assistant and Doctoral Student at the Centre for Advanced Spatial Analysis, University College London studying Urban Visualization for the Communication and Design of the Built Environment. His work has received wide coverage within both the academic and media worlds. He has worked on a number of projects dealing with CAD and virtual cities beginning with Wired Whitehall, a tourist web based information system and including the design for an Internet Based Virtual London as part of the Designing Better Cities Project, funded by the Engineering and Physical Sciences Research Council. His work is displayed in the Hackney Building Exploratory where he has designed a hands on interactive system to promote awareness of the built environment. He is editor of the ***Online Planning Journal***, a journal dedicated to the exploration of Internet based built form and virtual cities, currently in its 5$^{th}$ issue. He has undertaken various consultancy projects in relation to three-dimensional modelling including 'advisor for 3D modelling' in a bid to the Dublin High Buildings study. His work on three-dimensional visualization has ranged from use in a London Planning Enquiry, to visualize development, to promotional applications for housing Visualization.