# A survey of computer software for the urban design process

James A. Charlton, Bob Giddings and Margaret Horne
*Northumbria University*
*Ellison Building*
*NE1 8ST, Newcastle Upon Tyne*
*England*
*james.charlton@unn.ac.uk*

**Key words**: Urban design, Software identification, 3D modelling, Pedestrian modelling, Wind modelling, Noise mapping, Thermal comfort, VR Engine

**Abstract**: Urban design is concerned with the shape, the surface and the physical arrangement of all kinds of urban elements, the basic components that make up the built environment, at the level of buildings, spaces and human activities. It is also concerned with the non-visual aspects of the environment, such as noise, wind and temperature and humidity.

The city square is a particular urban element which can take many forms and its geometrical relationships such as maximum dimensions, ratio of width to length and building height to length have been analysed for centuries (Alberti 1475), (Vitruvius 1550), (Sitte 1889), (Corbett 2004). Within the current urban design process there are increasing examples of three dimensional computer representations which allow the user to experience a visual sense of the geometry of city squares in an urban landscape. Computer-aided design and Virtual Reality technologies have recently contributed to this visual assessment, but there have been limited attempts at 3D computer representations which allow the user to experience a *greater sense* of the urban space.

This paper will describe a survey of computer tools which could support a more holistic approach to urban design and which could be used to simulate a number of urban texture and urban quality aspects. It will provide a systematic overview of currently available software that could support the simulation of building density, height, colour and style as well as conditions relating to noise, shading, heat, natural and artificial light. It will describe a methodology for the selection and filtering of appropriate computer

applications and offer an initial evaluation of these tools for the analysis and representation of the three-dimensional geometry, urban texture and urban quality of city centre spaces.

The paper is structured to include an introduction to the design criteria relating to city centre spaces which underpins this research. Next the systematic review of computer software will be described, and selected tools will undergo initial evaluation. Finally conclusions will be drawn and areas for future research identified.

## 1. INTRODUCTION

The main objective of the urban designer is to formulate and present the problem as accurately and vividly as possible (Gosling and Maitland 1984). It is therefore a visual thinking of space that is necessary in the design process. Within the current design process and traditional methods of visualisation, Xia and Qing (2004) state that current design methods only allow for a 2D representation of a space to be created. Architectural design practices will produce computerised renderings or 3D computer massing models that allow for a more accurate representation of the space. However there have been limited attempts at three dimensional computer representations which allow the user to get a greater sense of the urban space. Ratti and Richens (1999) propose that the further application of three dimensional computer representations would be the ability to analyse and simulate visual and non-visual aspects of urban design. The ability to analyse and simulate a change in a building's urban fabric and density, the noise environment, microclimate (sunshine condition, heat and temperature environment) and the ability to control the height, the colour and the style of the buildings would aid the urban designers in improving the quality of city centre spaces

This paper will evaluate the use of several commercial and academic software applications within the urban design process. The paper will be structured around a systematic survey used to identify software capable of modelling and simulating the basic elements that make up the urban space; building height, density and style. Software capable of analysing and simulating; pedestrian movement, noise, wind, thermal comfort properties and artificial and natural lighting will also be identified. Hence, the review will concentrate on identifying and selecting software from six categories; 3D geometric modelling, pedestrian modelling, environmental noise mapping, thermal comfort software, wind analysis software and platforms (VR engines). The paper begins by giving a background to design criteria for city centre spaces which underpins this research.

## 2. BACKGROUND TO RESEARCH

Urban design is primarily and essentially three-dimensional design (Gosling and Maitland 1984), concerned with the shape, the surface and its physical arrangement of all kinds of urban elements; the basic components that make up the built environment at the level of buildings, spaces and human activities (Xia and Qing 2004). However, both Gosling and Maitland (1984) and Ratti and Richens (1999) identified that urban design is also concerned with the non-visual aspects of environment, such as noise, wind, temperature and humidity which contribute significantly to the character of an area. This view has led them and others to identify the need for a holistic approach to urban design, one not only dealing with the geometrical characteristics of urban design but also the environmental issues, the non-visual aspects. This view forms the basis for the research and is the rationale for this survey.

Within the last 20 years, many computer tools have been developed to assist in the environmental design of the interior of individual buildings. Heat, light, sound and in particular energy consumption can be analysed in many different packages. Ratti and Richens (1999) states that this is not true for city centre spaces. There are many computer software applications that can analyse and simulate the visual and non-visual aspects of urban design separately. Some of these software applications are relatively new and some need to be adapted for appropriate use. However there is not one software package that can be used to analyse and simulate all the aspects needed for a holistic approach to urban design. To date there has also been little attempt to synthesise several software applications to aid in a holistic approach to the design of city centre spaces; there is clearly a need for an extensive investigation into this area.

In the context of the research background outlined above, the primary aim of the research is to develop virtual simulations, demonstrating a holistic approach to the design of city centre squares. The virtual simulation will be developed using a VR engine and incorporating findings and results from other identified computer software applications. The squares will be based on design criteria established from a comprehensive literature review.

### 2.1 Design criteria: City centre squares

For as long as cities have existed, the city square has been a focus for the public life of the urban population (Corbett 2004). However in the early 20$^{th}$ century city planners somewhat overshadowed the fundamental importance of the square as a basic factor in urban design (Zucker 1959). Even towards the end of the 19$^{th}$ century the city square had become too loose, it had lost

its enclosed character and predictable effect (Sitte 1889). City squares had also become too big and no longer bared any relationship to the surrounding buildings. The opening up of the square continued throughout the 20th century, leading to a concept of the city completely at disagreement with its historic role (Heckscher 1977). No longer did the city offer space to deliver and contain the major activities of people's lives. While many city squares continues to be neglected during the 20th century, often being dominated by traffic and car parking, today the importance of the square within the city is again starting to re-emphasised.

By reviewing notable publication relating to square design, the research established both traditional methods that have been neglected, along with new ideas and criteria's for city centre urban square design. Aspects of square design were established for the; form and function, three-dimensional geometry, urban texture and environmental condition of the square. The establishments of these urban aspects led to development of coherent framework for the design of city centre squares. The coherent design framework summarised the key findings from the design criteria and detailed both the visual and non-visual aspects of city centre square design. The research then aimed to identify and evaluate software that could be used to simulate and analyse the established urban aspects of square design.

## 3. SOFTWARE IDENTIFICATION AND REQUIREMENTS

The urban aspects that were established from the review of theoretical concepts of square design would be analysed and simulated using software identified from this survey. The software applications selected for each of the six categories will be used to analyse and simulate at least one of the aspects identified to create a holistic approach to urban design, *see; Figure 1*.

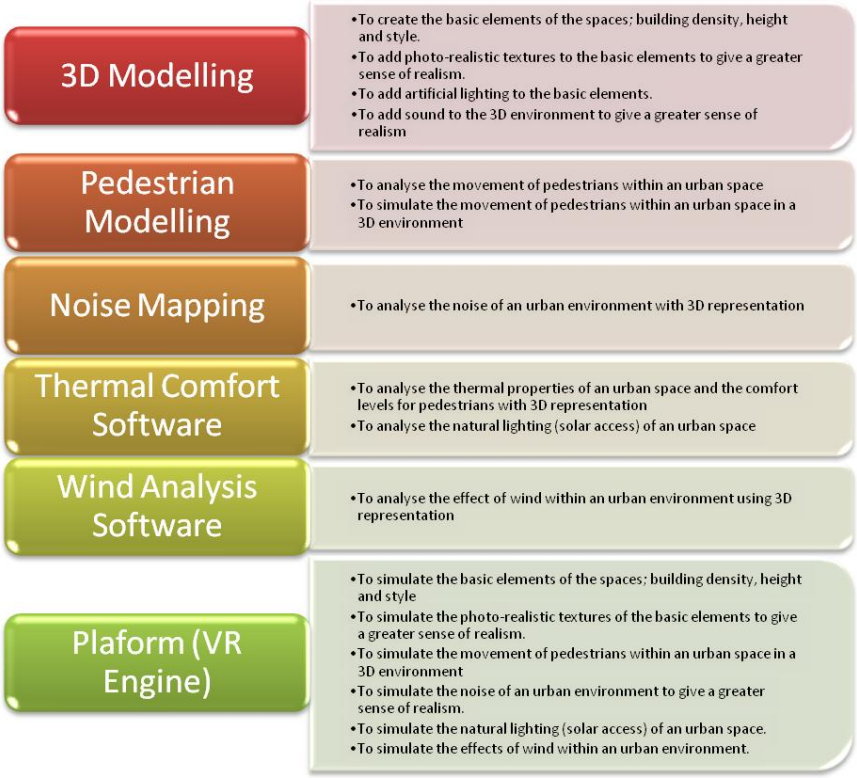


Figure 1. Objectives of each of the software packages.

## 3.1 3D Modelling

3D computer modelling is the process of developing and creating three-dimensional objects using a combination of standard or manipulated 2D and 3D shapes with the aid of specialized software. The result is a mathematical; wireframe, solid or textured geometrical representation of any three-dimensional object. Depending on the software capabilities, further applications of 3D modelling packages can be the ability to animate an object, add special effects, create photo-realistic objects and environments and add advanced lighting.

The survey identified 23 different software packages capable of 3D modelling, these were; 3Ds Max, Houdini, Maya, XSI, Carrara, Silo, Google SketchUp, Cinema 4D Architecture, Blender, Bryce, Swift 3D, Rhino, TrueSpace, Piranesi, Microstation, Autodesk VIZ, FormZ, Lightwave 3D, Modo, Blink 3D, AutoCAD, Archicad and FastCAD.

## 3.2 Pedestrian modelling

Pedestrian modelling software can either be a 2D or 3D application used to model the movement or flow of pedestrians within a given space and environment. A pedestrian model provides estimated values for the number of people walking within a given urban area or even a whole city. Pedestrian models are also often used to simulate pedestrian evacuation from a building under emergency conditions, i.e. a fire. Pedestrian modelling software is often based on a statistical model which links real observed flows with a range of factors that have been shown to influence movement patterns.

The survey identified 6 different software packages capable of pedestrian modelling, these were; PAXPORT, Depthmap, STEPS, SimWalk, Legion Studio and PERS.

## 3.3 Noise mapping

Noise mapping software is used to map noise within a set area using predefined codes, rules and algorithms. The software can be used for example to test to see if a new urban area will be greatly affected by the noise from the surrounding environment (from a busy road, railway line, industrial site, etc). Some software packages also allow for 'what if?' scenarios to be asked, for example, what if the speed of a road was reduced? Noise maps are then produced with the 'what if?' scenario in mind. Noise mapping software works by imputing various forms of data, such as geometry data; terrain, building height and density information, and environmental conditions, along with several noise sources (i.e. noise readings from a road, railway line, industrial buildings, pedestrian street, etc.). Results are produced from the generation of multicoloured noise maps representing different noise levels within a set area.

This survey has identified 4 different software packages capable of noise mapping, these were; CadnaA, MITHRA, LIMA and Predictor.

## 3.4 Thermal analysis

Thermal analysis software for the external environment is very similar to software used to analyse and simulate the environmental conditions of a building, but possibly is not so advanced. Thermal analysis software for the external environment is used to analyse and simulate the microclimate conditions of an urban space or area. Current software takes into account the geometry (terrain and building height and density) of an urban area, and microclimate conditions such as; solar access, wind strength and direction and various weather conditions. The software also takes into account meteorological parameters (humidity, clouding, etc) and vegetation masks,

to produce various graphical results. It is unclear at this stage if current software can also take into account the surrounding materials of the urban space, which would have a great effect on the microclimate conditions and thermal comfort.

The survey was only been able to identify two software packages capable of carrying out thermal comfort analysis for urban areas. There are several software packages available for thermal analysis of buildings and internal environments. However, there appears to be very few software packages capable of thermal analysis for external urban environments. The identified software packages capable of thermal comfort analysis in urban areas, were; ENVI-met and TownScope.

## 3.5 Wind analysis

This survey has identified two different forms of software that can produce the results needed for wind analysis. The first software type identified, is simply software designed from the start to analyse wind within an urban environment. The second type of software identified, is software designed to model Computational Fluid Dynamics (CFD). CFD software is used to simulate the interaction of fluids and gases within an environment and is often used in engineering. Although it is complicated software it can often give accurate results and its applications stretch beyond engineering. It is proposed that CFD software could therefore be used to analyse and simulate wind within the urban environment. CFD software works by first turning imported 3D geometry into small cells to form a volume mesh. In 2D the mesh consists of triangles or pyramidal solids in 3D. Sophisticated algorithms are then applied to the model to simulate the flow of fluids or gases within the environment.

The survey identified 6 different software packages capable of wind analysis and simulation, these were; Fluent, APUS-CFD, Star-CD, MECA Wind, CFX and WinMISKAM.

## 3.6 Platform (VR Engine)

A VR engine is the core software component for interactive applications, allowing the user to experience an environment with real-time graphics. The core functionalities typically provided by a VR engine include; a rendering engine for 2D or 3D graphics, a physics engine, sound, scripting, animation, artificial intelligence and advanced lighting capabilities. The outcome of a VR engine is an immersive environment which allows the user to experience different sights and sounds and perform a selection of pre-defined actions. Within the research the VR engine will be used to simulate the aspects identified for a holistic approach to urban design. The VR engine will also

be used to represent findings and results from several of the software applications.

The survey identified 18 different platforms capable of simulating an immersive environment for interactive applications, these are; Click-VR Visualizer, Deep Creator, GameCore, Jupiter Extended, RelentEngine, Unigine, Unreal Engine, CryEngine, GAMEBRYO, Unity, GameStudio, Rtre, Quest 3D, Irrlicht, Torque Game Engine, C4 Engine, Source and VR4MAX.

## 3.7 Interconnectivity of the software

A major issue to consider when identifying and selecting the software was its accessibility and its interconnectivity between other software packages. This would be greatly dependant on the ability of each of the selected software applications for exporting and importing several file formats. The current thinking of the research is that the 3D geometric modelling software would act as the core software, exporting its three-dimensional geometry data to the various software packages for analysis or simulation, *see; Figure 2*. Results would then be exported directly into the VR engine to create and develop the virtual simulation, *see; Figure 2*.

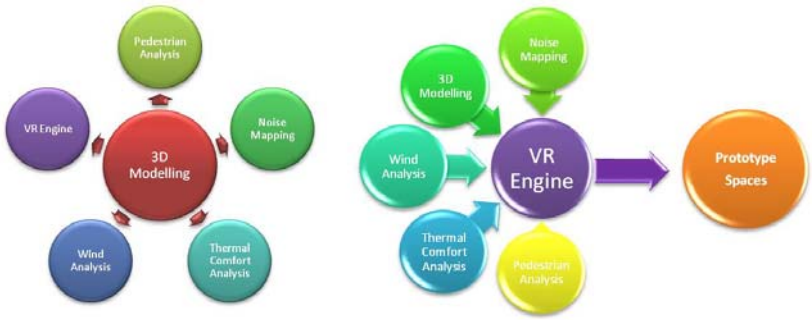


Figure 2. Connectivity of software packages.

## 4. SELECTION PROCESS

This survey aimed to establish commercial and academic computer software applications, capable of three dimensional computer representations

that could be used to analyse and simulate both visual and non-visual aspects of urban design. Upon consultation of academic literature for software identification and selection, the process that was considered most appropriate for use within the research, was the systematic approach adopted by Horne (1998). The process involves; understanding the needs and requirements of the research and identifying a set of criteria to meet these needs, identifying the functional requirements and performance characteristics required by the software, screening potential software and then selecting software.

The methodology adopted by Horne (1998) uses a selection process to initially identify suitable computer programs. This is then followed by an outlined evaluation of each program by comparing a set of program criteria in the form of a comparison chart. The identification of general attributes of the various potential software packages in this manner enables a filtering process to be used to eliminate clearly unsuitable programs from further consideration. From this filtering process a more detailed evaluation of the program(s) can be carried out. As identified by Horne (1998) this methodology is only adopted for its software selection techniques. As with Horne (1998) benchmark testing will not be used for this survey, as benchmarking is usually associated with assessing performance characteristics of computer hardware, for example measuring the processing power, whereas this research is interested in modelling and visualisation capabilities of the software.

## 4.1 Identification of software capabilities

In the process of identifying potential software for use with urban design, a two stage process was applied to each of the six categories. The first step in identifying potential software was to establish a set of criteria by which identified software could be compared against. The established criteria reflected the requirements and the final outcomes that the research expected of the software. Although the criterion differed slightly depending on the software in question, it addressed the modelling capabilities, visualisation capabilities, links to other software and evidence of previous use and application within academic research.

The second step in identifying potential software was to carry out a technical evaluation of the identified software. The survey identified numerous software packages for each of the six categories. The leading features of each of the software packages were then identified and entered into a comparison chart, *see; Table 2*. The features identified for each of the software applications differed depending on the category of software in question. Those features that were consistent throughout are shown in *Table 1*.

Table1. Features of software applications

| Feature | Definition |
|---|---|
| **Origin** | |
| Title | - Title of software |
| Author | - Author of software |
| Distributor | - Distrubutor of software |
| Country of origin | - Country of orignin of software |
| Latest Version | - Latest version of software |
| Operating System(s) | - Operating system(s) of software |
| **Cost** | |
| Cost | - Cost for a single commercial licence |
| Further Costs | - Further costs. i.e. yearly licensing, maintenance, etc |
| **Basic Modelling Capabilities** | |
| 2D drafting | - Is the software capable of 2D drafting? (Yes/No) |
| 3D modelling | - Is the software capable of 3D modelling? (Yes/No) |
| Architectural focus | - Is the software more targeted towards use within the built environment? (Yes/No) |
| **Visualisation Capabilities** | |
| 3D visualisation | - Is the software capable of 3D visulisation? (Yes/No) |
| **Links to Other Software** | |
| Compatible file import | - Compatible file formats for importing |
| Compatible file export | - Compatible file formates for exporting |
| **Program Availability and Use** | |
| Number of users | - Number of registerd users (commercial/educational) |
| Readily accessible | - Is the software readily acccessible? (Yes/No) |
| Easy to learn | - Is the software considered easy to use? (Yes/No) |
| Requires Training | - Will the software require training? (Yes/No) |

Table 2. Example of a comparison chart: Wind Modelling

| | Title | Fluent | APUS-CFD | Star CD | MECA Wind | CFX | WinMISKAM |
|---|---|---|---|---|---|---|---|
| Origin | Author | ANSYS | Symban Power Systems Ltd | CD-adapco | MECA Enterprises | ANSYS | Lohmeyer |
| | Distributor | ANSYS | Symban Power Systems Ltd | CD-adapco | MECA Enterprises | ANSYS | Lohmeyer |
| | Country of Origin | USA | UK | USA | USA | USA | Germany |
| | Launch Date | 1988 | 2005 | | | | 1989 |
| | Latest Version | Fluent 6.3 | APUS-CFD | Star-CD V4 | MECA Wind 5 | CFX-5 | WinMISKAM 5.2 |
| | OS(s) | PC | PC | | PC | | |
| Cost | Software cost | £3,950.00 | | | £55.25 | | £5,844.66 |
| | Further Costs | £1,650.00 | | | | | £670.64 |
| Basic Modelling Capabilities | 2D Drafting | Y | | | | | Y |
| | 3D modelling | Y | Y | Y | | Y | Y |
| | Architectural focus | Y | Y | Y | Y | | Y |
| Visulaisation Capabilities | Data Output | Y | Y | Y | Y | Y | Y |
| | 2D output | | | | | | Y |
| | 3D Output | Y | Y | Y | | Y | Y |
| Links to Software | 3Ds / DXF Import | Y | Y | Y | | Y | |
| | CryEngine Export | | | | | | |
| Program Accessibilty and Use | Number of users | 13,000 | | | | | |
| | Readily accessible | | | | | | |
| | Easy to Learn | | Y | | Y | | |
| | Requires Training | Y | | Y | | Y | Y |

## 4.2 Selection of potential software

Following the identification of the software applications within each of the six categories, the next stage was to carry out the process of selecting the software that would be used within the research. The process of selecting software was done by applying a filtering process to identify those software that were unsuitable for further consideration and those that required further and a more detailed study. The filters used in the survey differed depending on the category in question and the requirements for the software. Generically the filters aimed identify software that was capable of modelling and visualising in 3D, were developed for or showed evidence of use within the built environment, were capable of linking to other identified software packages and were considered appropriate for use within the research. The filtering process consisted simply of asking closed yes and no questions. Software that answered yes to the question passed through to the next filtering process. Software applications that answered no to the question were eliminated from the survey. The application of the filters aimed to indentify between two to four software applications that were considered suitable for use within the research and required further and a more detailed study. An example of the filtering process is shown in *Table 3*.

Table 3. Example of filtering process: Wind modelling

| Software | Filter 1 | Filter 2 | Filter 3 | Filter 4 | Filter 5 | Select |
|---|---|---|---|---|---|---|
| **Fluent** | YES | YES | YES | YES | YES | YES |
| **APUS-CFD** | YES | YES | YES | YES | YES | YES |
| **Star CD** | YES | YES | YES | YES | YES | YES |
| **MECA Wind** | NO | | | | | NO |
| **CFX** | YES | NO | | | | NO |
| **WinMISKAM** | YES | YES | YES | NO | | NO |

# 5. SELECTED SOFTWARE

The final stage in the survey was to compare the remaining software applications against the initial criteria. This allowed for a more detailed study of the remaining software applications against the requirements of the research. The software applications that were selected for each of the six identified categories; 3D modelling, pedestrian modelling, noise mapping, thermal comfort, wind modelling and VR engine, are summarised below. The selected software applications were considered to meet the requirements

of the research. The selected software applications were also considered appropriate for use within the urban design process.

## 5.1 3D modelling

3D modelling software packages are difficult to compare because of the many different features that each of the software packages offer. Each one may be targeting its own audience and will therefore accelerate the evolution of features within that area. Therefore, to choose one software over the rest depends highly on the requirements of the user and the intended project. The systematic review of the 3D modelling software established that the software considered appropriate for modelling the 3D geometry of the urban environment was 3D Studio Max 2008.

### 5.1.1 3D studio max 2008

3D Studio Max 2008 is a highly customisable and scalable 3D modelling, animation, and rendering, solution for design visualisation, games, film and television. 3Ds Max 2008 is able to cope with large files with ease and can produce stunning photo-real imagery. Other features include advanced polygon and spline based 3D modelling tools, fast rendering with network support, animation capabilities, cloth and particle simulation and advanced lightening techniques.

## 5.2 Pedestrian Modelling

There are several pedestrian modelling software packages that are available on the market today. Most of them are very powerful and can successfully simulate pedestrian movement and flow in various environments and situations. However, very few of them are able to simulate there results in a 3D environment, a key requirement of the research. From applying the filtering process to the identified pedestrian software packages, the survey identified that Legion Studio with Legion 3D is considered most appropriate for use within the research. This was due to the advanced features offered by Legion 3D for producing 3D environments and the wide use of Legion Studio within industry for modelling pedestrian movement.

### 5.2.1 Legion studio with Legion 3D

Legion Studio is a powerful and accurate pedestrian simulation software application and is the flagship product for Legion. It allows users to simulate pedestrian movement within a variety of defined spaces. Legion Studio enables the user to perform virtual experiments on the design or operation of

a space and assess the impact of different physical designs or levels of pedestrian demand.

One drawback of Legion Studio is that as a single software application in its self, it can only simulate results in 2D. However Legion does provide an extension to Legion Studio to allow the user to simulate the results produced in Legion Studio in 3D. Legion 3D is a companion to Legion Studio and can visualise any simulated model as a three-dimensional environment, featuring realistically-rendered pedestrians and other animations. Legion 3D combines simulation data recorded from Legion Studio projects with scenes developed in 3D modelling software. This allows for 3D pedestrians to move exactly as they did in the original Legion Studio simulation.

## 5.3 Noise Mapping

The survey identified several software applications capable of mapping noise within an urban environment. From the identified software, three certainly appeared more advanced and appropriate for use within the research and urban design. CadnaA, Lima and Predictor are all very powerful noise mapping software applications that have been adopted by many users to map noise within the urban environment. From the application of the systematic review of noise mapping software, the survey identified that CadnaA would be the most appropriate for use and application within the urban design process. CadnaA was selected as it appeared to have some extra features over Lima and Predictor that would aid in modelling, adapting and editing the created model with greater ease.

### 5.3.1 CadnaA

CadnaA (Computer Aided Noise Abatement) is a leading software application for the calculation, presentation, assessment and prediction of environmental noise. Developed by DataKustik in Germany, CadnaA has many features including more than 30 implemented standards and guidelines, powerful calculation algorithms, extensive tools for object handling, the ability to import and export information from Google earth, outstanding 3D visualization and a very user-friendly interface. CadnaA is also able to communicate with other Windows applications like word processors, spreadsheet calculators, CAD software and GIS-databases. Another facility in CadnaA is the Dynamic 3D environment which allows the user to drive through or even fly over a project model in real-time.

## 5.4 Thermal analysis

This survey has only been able to establish two software packages capable of analysing thermal comfort in external urban environments. The software packages identified were; ENVI-met and TownScope. Both software packages are quite capable of analysing and simulating thermal comfort levels, however only TownScope is capable of visualising the results in 3D, a key requirement of the research. For this reason Townscope has be selected for use within the research and identified for use within the urban design process.

### 5.4.1 Townscope

TownScope software is the main in-house software developed by TownScope in Belgium. The TownScope software contains analysis tools available to analyses and simulate; solar access, including assessment of direct, diffused and reflected solar radiation, thermal comfort in an urban open space and sky opening, view lengths and visibility analyses providing perceptive qualities of urban open spaces. Other features of the software include the ability to; import both 3Ds and DXF file formats, add Meteorological parameters (humidity, clouding, etc.) and vegetation masks specified as monthly data, create terrain from 3D points and the ability to render opacity and daylight shadings.

## 5.5 Wind analysis

This survey has identified several software packages capable of analysing and simulating the effect of wind in the urban environment. Software packages built from the start to examine wind, and software packages designed to deal with CFD were identified as possible solutions for the requirement of the research. From the systematic review of wind analysis software, the survey identified that Star-CD would be the most appropriate for use within the research. This was due to its prior use within academic research by I.P Castro, Z Xie et al. at Southampton University, who used Star-CD to research the effects of wind in the urban environment using CFD software in 2006.

### 5.5.1 Star-CD

STAR-CD has a long established a reputation for being a versatile platform for industrial CFD simulation. Developed by CD-adapco, STAR-CD V4, introduces the capability to perform structural analysis calculations using a methodology based upon its industry-leading CFD solver

technology. Used within the built environment Star-CD has helped in the analysis and simulation of external aerodynamics of the built environment, and has been applied to aid in predicting wind loading on buildings and bridges, optimizing comfort and safety in stadia and in urban spaces in general.

## 5.6 VR Engine

The survey has identified several platforms (VR engines) capable of simulating; the basic elements of the spaces; building density, height and style. The survey has also identified several platforms (VR engines) capable of simulating; the photo-realistic textures of the basic elements to give a greater sense of realism, the movement of pedestrians within an urban space in a 3D environment, the noise of an urban environment, natural lighting (solar access) of an urban space and the effects of wind within an urban environment. From the systematic review of VR engines, CryEngine was chosen for use within the research and indentified for application within the urban design process. CryEngine adoption by IMAGTP for creating immersive virtual models presents evidence that it can used to meet many of the research requirements of the platform, at a very standard.

### 5.6.1 CryEngine

CryEngine is an extremely powerful and advanced game engine. Although primarily used within the games industry, the advanced features of the engine have been recognised and applied for architectural visualisation. Used by IMAGTP to produced sophisticated, immersive environments, for architectural and urban visualisation. CryEngine has become the core product in IMAGTP full multi-functions platform, the Interactive Virtual Model (I.V.M). Some of the state of-the-art CryEngine offers, include; Real time editing, bump mapping, dynamic lights, network system, integrated physics system, shaders, shadows and a dynamic music system.

# 6. CONCLUSION

This paper identified that there was a need for a holistic approach to urban design. The paper proposed that with ability to analyse and simulate different aspects of urban design using three dimensional representations, would aid urban designers to improve the quality of city centre squares. The paper proposed to identify and select software capable of analysing and simulating a number of urban texture and urban quality aspects. Software was identified and selected by carrying out a systematic review. The

systematic review certainly appears to be an efficient process for identifying and selecting software applications. The survey effectively established software applications considered appropriate for use within the research and in the urban design process. The application of a filtering process successfully eliminated software that did not meet the requirements of the research and identified software for further detailed evaluation. The survey then effectively selected one software application for each of the established six categories; 3D modelling, Pedestrian modelling, Environmental Noise Prediction Software, Thermal Comfort Software, Wind Analysis Software and Platforms (VR engines).

Each of the six software packages selected are able to analyse and simulate at least one of the aspects identified to create a holistic approach to city centre spaces (Figure 1.). All of the selected software packages for use within the research are capable of simulating the results using three dimensional representations, a key requirement of the research. Another major requirement of the software was the interconnectivity between the software packages (Figure 2.). This survey identified that all of the selected software packages are able to import data from 3Ds Max, the chosen modelling package. However, although some of the selected software packages are able to export data, results and simulations back into CryEngine, the VR engine, it is still unclear at present if they are all able to do this. Further research will be needed to be carried out in this area.

The paper concludes by proposing that by incorporating the selected software applications into the urban design process would allow urban designers to effectively test and develop their designs. It is proposed that this would aid in the improvement of the design of city centre spaces and the comfort of users within the spaces.

## 7. REFERENCES

Alberti, L. B.,1475. *Ten Books on Architecture,* Tiranti. London.

Corbett, N.,2004. *Transforming Cities: Revival in the Square,* RIBA Enterprises Ltd. London.

Gosling, D. and B. Maitland,1984. *Concepts of Urban Design,* St. Martin's Press. New York.

Heckscher, A.,1977. *Open Spaces. The Life of American Cities,* Harper & Row. New York.

Horne, M.,1998. The visualisation of photovoltaic clad buildings, University of Northumbria.

Ratti, C. and P. Richens, 1999, *Urban Texture Analysis with Image Processing Techniques,* University of Cambridge

Sitte, C.,1889. *City Planning According to Artistic Principles, reprint 1986,* Rizzoli. New York.

Vitruvius,1550. *The ten books of architecture,* Dover publications. New York.

Xia, Z. and Z. Qing, 2004, *Applications of 3D city models based spatial analysis to urban design,* Wuhan University

Zucker, P.,1959. *Town and Square,* Columbia University Press. New York.