

Issues in use of computer visualisation of large-scale urban developments as planning support tools

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1 ABSTRACT

A focus on planning procedures at different stages helps to recognise some of the difficulties inherent in planning, particularly the outcome of changes to the built environment and the importance of people's involvement in the process. One of the areas that gives rise to significant public dissatisfaction and feelings of dis-empowerment is that of urban planning. The replication on the web of existing plans cartographic-based approaches tend to perpetuate the requirement for trained interpretations, thereby contributing to the exclusion of the general public from participation. Similarly, static computer generated representation of 3D models that aspire to simulate the real environment, described as "an incomparable tool"[1] for winning approval quickly or speeding the funding process, are often questioned for not providing a comprehensive understanding of the proposed developments. We argue that more effective tools are required to clearly display urban planning proposals, in particular large scale commercial developments. Planning support tools and representations were examined through two projects, an ESRC funded investigation of perceived credibility of design representations and the Interreg funded VEPs project. In this paper we examine the expectations of the agencies involved, the primary purpose of the representations and tools that is served and whether they support exchange of views and discussion by providing an effective base for consensus. The feedback and responses to date have shown that various stages and purposes within the planning process require different level of information and that appropriate visualisation techniques are needed in order to reduce the requirement for trained interpretation and encourage the participation of the general public in planning process.

2 THE PLANNING PROCESS IN NORTH WEST EUROPE

The urban planning process can be broadly defined as: seeking advice; appraising the site; consulting the public and experts; briefing; developing technically acceptable proposals; negotiating; applying for and gaining legal consent and public acceptance. They all contribute to both "efficient process and an improved product"[2]. However, the process is costly and so at any late stage difficult to deflect. One of the areas that gives rise to significant public dissatisfaction and feelings of dis-empowerment is that of urban planning. While the mechanisms differ from state to state in Europe [3], the problems as perceived by the public, are often the same, including lack of meaningful consultation resulting in lack of influence over developments and changes, particularly those affecting the home and its immediate environment. These concerns have yet to be addressed by EC harmonisation initiatives, such as: E-Europe 2005; and INSPIRE.

2.1 Planning in the UK

In the UK, for example, guidance on planning policy and process can be found in various places in the Central Government Planning Policy Statements (PPS) to planning authorities. However these are at times conflicting thereby permitting latitude to developers and professionals, to the greater confusion of the public. PPS 1 on 'Delivering Sustainable Development' [4] emphasises the importance of proper presentation of planning applications and PPS12 on Local Development Frameworks [5] draws attention to the importance of local participation and the need for local authorities to prepare detailed plans and drawings which show the proposed development in its setting. Yet according to a statistical analysis, coverage of these issues was until recently still generally sporadic; and presentation of applications, environmental impact analysis and site analysis were only referred to in a fifth of the plans in the UK. [2]

The UK Central Government has now started actively to seek ways to improve both the planning process in general and public participation in that process, through its recent e-Planning Blueprint, published in August 2004 [6]. Initiatives since launched include the national PARSOL (Planning and Regulatory Services Online) project, a range of 'Pathfinder' projects and the Implementing e-Government (IeG) initiative. The main focus of these initiatives is to develop a set of toolkits, standards and 'demonstrator' projects with the aim of assisting planning authorities to implement e-Planning in forms that citizens will both comprehend and use in

their dealings with the councils. New online planning portals are aimed at introducing partnership working, bringing together planning, building control and licensing services.

2.2 Planning in Germany

In comparison to the flexible and discretionary planning system in the UK, German Städte und Gemeinden (cities and municipalities) have a constitutional right of self-government. Local land use planning in Germany is largely about zoning and a municipal responsibility, documented in preparatory and subsequently binding land use plans. The cornerstone of local land-use planning is the power to designate land for specific uses (for example residential and commercial use, public purposes), or to impose restrictions (for example maximum dimensions of development including number of storeys and roof structure). All municipalities are required to have a Flächennutzungsplan, a zoning plan that lays out in general terms the types of land use prevailing or envisaged for the whole of the municipal territory. Preparatory land-use plans are in most cases drawn to a scale of 1:10,000, or occasionally 1:20,000, and have to take into consideration the planning objectives and principles at higher level as set out in the respective Landesentwicklungsplan and Regional plans [7]. Thus, although local authorities are solely responsible for the preparation of their local land use plans, the legal framework provides mechanisms that ensure conformity between different levels of plans ('duty of compliance'). The second type of plan at local level is the Bebauungsplan (B-Plan), a plan which contains legally binding designations, drawn up to a scale of 1:5,000 or 1:1,000, regarding the proposed development and structure. [7].

A cartographic representation of the territory of the municipality forms the central part of both types of local land use plans in Germany. Public participation requirements on plans at local level and development proposals (which have to comply with the regulations set out in the Bebauungsplan) are clearly set out in the Baugesetzbuch. For development proposals, these usually only extend to third parties that would be directly affected by the development. The most recent revision of the Baugesetzbuch (2004) has made provision for public participation through the use of on the Internet, i.e. online plans and proposals. This is a major innovation for the German planning system, which until recently has had strict requirements for two-dimensional versions of local plans, and will allow local authorities to make better use of other online tools as well as three-dimensional models. [8].

3 THE ROLE OF VISUALISATION IN THE URBAN PLANNING PROCESS

Communication and visualisation are already at the heart of the planning system. The rationale for visualisation in urban planning and design, according to Langendorf [9] is based on three premises:

- To understand nearly any subject of consequence it is necessary to consider it from multiple viewpoints, using a variety of information;
- Understanding complex information about urban planning and design may be greatly extended if the information is visualised;
- Visualisation aids in communicating with others.

The importance of visualisation is being recognised as crucial for almost all design and planning professionals who need to represent, communicate and evaluate design ideas and planning proposals [10]. According to Sawczuk “the design and planning process revolves around client’s needs and therefore the client should be part of the team.” [11]. Recent research findings have revealed that while skilled participants appreciate traditional media, such as drawings, unskilled participants prefer photorealistic presentations. Similarly, it was reported that when lay-people were exposed to architects’ drawings “plans had little meaning as the people could not understand what was represented” [12].

Traditionally, there is a strong relationship between plans and cartographic representations, and the planning discipline. Maps, plans, sketches, images or other cartographic representations are (besides language) important communication media for planning. According to some researchers only these media are able to clearly demonstrate visually the complexity of different demands on space. [8] In architecture, visual representations are fundamental to the practice of architecture because they are graphical means of information visualisation about the design philosophy, appearance and the impact of the development upon the locality. [13] However, there has been little consideration given to these aspects of 'mapping' in the planning literature to date. Likewise, cartographic science has failed to connect theory and research to the

real-world tasks of spatial planning, and the question of how communication through 'planning maps' could be improved has been given little attention [8]. In architecture, as well, despite some effort, "this gap in our knowledge has persisted and it would appear that intuition, prior practice and trial-and-error approaches have guided the production of architectural representations of design proposals". [14]

Over the last thirty years, many perception and cognition studies have been undertaken and the effects of visual variables have been investigated systematically [15] [16]. However, there is growing recognition amongst cartographers worldwide that there will never be an all-embracing theory of map reading or, of cartographic communication in general. This is due to the fact that there are certain variables which are difficult to control or even to identify in the process, such as the map user's skills and capacities, and the purpose the map is used for in different circumstances. Rase for example stated that 'we are not sure what really attracts the attention of the reader, how the essence of the map is extracted, how the content is stored in memory, or what makes a specific map type superior to another one under certain conditions'[17][8]. As a result, empirical research and the theories proposed appear disjointed and unconnected. Cartography is thus often still applied as a craft discipline rather than a science, and knowledge of map acceptance and map perception is mostly based on intuition, assumptions and personal experience, and to a lesser extent on scientific evidence. There is little previous work that explicitly addresses the relationship between planning and cartography, and the role and function of cartographic representations in the planning process. [17][8] Thus, it remains difficult to see how the interpretation of plans and their cartographic symbols can be made adequately transparent to the untrained user.

In architecture, within the range of representations there is a rich repertoire of imaginative techniques such as perspective, axonometric drawings or artistic impressions, recently further enhanced through computer graphics and virtual reality representations. The theory [14] shows that it takes considerable experience and knowledge to read architectural drawings before one becomes skilled at interpreting them. For those professionals from other fields, outside architectural and urban design, involved in the process of decision-making and design review it is even more difficult to interpret information when presented visually. This can increase the danger of misinterpretation of the information and affect environmental decisions. Overall, current research shows that the major impediment in the design assessment area is the lack of systematic research to establish comprehensive patterns or to tease apart the differences between professionals' and non-professionals' perception through architectural representations.

4 COMPUTER VISUALISATION AS URBAN PLANNING SUPPORT TOOL

According to research literature recent moves towards computer generated visualisation models reflect the acknowledgement that traditional, hand made representation techniques fail to communicate design and planning information effectively and clearly [18]. In regard to computer-generated visualisation, architecture, for example, has been greatly influenced by computer technologies such as computer-aided design (CAD) software packages. In parallel, GIS have been extensively developed with urban planning as a major area of application in most European countries. The sheer diversity of computer technologies and the versatility of their application has encouraged an interest in their use for visualisation in planning. A UCLA (USA) group of researchers Ligget, Jepson and Friedman have pioneered exemplary information rich 3D modelling environments, while other researchers such as Day at Bath University have tested CAD generated computer visualisation of urban environments [19]. Findings by a research group at the Queensland University of Technology, Australia, led by Buccolo, tested computer visualisation on the design for the new town centre of Capalaba and the Brisbane Airport [20]. This research group identified certain advantages in the use of computer visualisation when compared to the traditional static tool, such as a better comprehension of the depicted scene, way-finding and evaluating physical change but they suggested that more systematic research would need to be carried out to prove the reliability and validity of new technologies and tools. Similarly, Mahmoud confirmed this conclusion and extended it by proposing more experimental research to be conducted to investigate the benefits of these methods for the potential users [21]. As Kalay [22] points out, while computer programs "made communication easier and more efficient, they have not, in and of themselves, improved shared understanding, which is fundamental for making joint decisions and for negotiating tradeoffs among competitive worldviews".

The use of the web for planning purposes is one area that is receiving a great deal of attention lately, in particular, the visualisation of urban forms and landscapes. As the Internet has become accessible and faster,

an increasing number of applications are being tested and developed in encouraging public participation in planning process. Research shows that these new tools have improved the communication process [18] and that 3D forms of representation “made the plan understandable”. [23] Daniel and Meitner cite several experimental studies that have demonstrated the power of visualisations “to affect attention, to alter interpretations of complex concepts and differentially to arouse positive and/or negative emotions”. [24] Although researchers' views vary on the appropriate use and place of visualisation in the planning process, all agree that communicating design can be more effective and improved if computer generated visualisation is used as the means. Pietch states that with “increasing participation of non-design professionals such as elected council members and members of the public, the demand is there for a better communication medium than conventional 2D drawings”. [25] However, Kalay [22] points out, while computer programs “made communication easier and more efficient, they have not, in and of themselves, improved shared understanding, which is fundamental for making joint decisions and for negotiating tradeoffs among competitive worldviews”.

Some research suggests that three-dimensional and interactive computer visualisation (based on using 3D VRML in research into community based 'planning for real') is one of the “most important developments in visual communication for urban planning and urban design since the development plan”. [26] This is an area that needs more research to establish when it is appropriate to simplify, by how much to simplify while retaining verisimilitude, and how reliable are the consequent judgements. Kaplan and Kaplan argue that “a simplified model is more likely to parallel people’s cognitive structure. Hence the very simplicity of the model may encourage its use. A simplified model also encourages generality; details make things particular, thus narrowing their range of appropriateness. Finally, simplification reduces the total load to one’s processing” [27]. Other researchers as Santella state that “the basic goal of realistic rendering is to create images perceptually indistinguishable from real scenes. Since the human observer judges the fidelity and quality of the resulting images, the perceivable differences between the appearance of a computer graphics image and its real world counterpart should be minimised. Thus, visual perception issues are clearly involved.” [28]

5 THE ESRC PROJECT

The focus of this research study is on people’s perceptual responses to static visual representations that provide an understanding of the three-dimensionality of design schemes. In these cases one is unable to interrogate for information other than that which is shown in the view. By comparing traditional and computer generated architectural representations the study aims to establish whether some methods of architectural representation are regarded as more credible in communicating design than others and in what way and why.

To reduce extraneous influences, the selected cases for analysis were limited to some proposals for significant commercial developments with similar contextual attributes. The units of analysis were 'collections' i.e. sets of images, with a descriptive role. They were put together to allow concepts and ideas to become visible [29] and to be both representative and statistically significant and thus unit and choice of representation is regarded as “a reliable source of factual evidence”. [30]

The preliminary results of the various group perceptions show that an important requirement from three-dimensional representations of the architectural design schemes is the apparent realism of the visual representation. This factor affects people’s perceptions of credibility in the way that it makes the images believable and possessing “no sense of fudge” according to an architect with over 20 years of experience. Computer generate photomontage was regarded by the majority of participants as representation that possesses the highest level of realism and thus, the one where the information presented leave the viewers with the impression that it is the most studied design which is both, technically and accurately presented. Architects and some other professionals still regard traditional forms of visual representation as both a useful and credible form of representation. Yet, these forms appear to be better as a means of communication that they use internally, among themselves for the discussion and analysis during the design development stage, than for the stage where the conceptual design is communicated to other parties involved in the process. Another form of representation that has not been investigated in the study was frequently mentioned during the group discussions: that of interactive three-dimensional visualisation. According to theory interactive computer visualisation is the form of visual representation, which is one of “the most

important developments in visual communication for urban planning and urban design since the development plan".[31] Indeed, several participants from various groups mentioned the examples of three-dimensional interactive computer generated walkthroughs as the most credible form of visual representation.

6 THE VEPS PROJECT

VEPs, the Virtual Environmental Planning system is an Interreg IIIB funded European project focused on the North West Europe region. [32] The project brings together partners from the UK, Germany and France, with skills in geographic visualisation and spatial planning, led by the Environment Agency for England and Wales. VEPS has received additional support from the UK government as a potential contribution to its e-Planning programme.

The VEPs project is focused on what can be described as a 'person-centric' approach to evaluation of planning issues, based on a credible sense of presence in the scene to support effective judgement. This is perhaps a bottom up approach, contrasted with the usual top down approach to planning. Workshops have indicated that users are most likely to become engaged in the participative planning process when they are conscious of a particular impact on their own lives. One of the areas that gives rise to significant public dissatisfaction and feelings of dis-empowerment is that of local planning. "Not in my backyard" or 'NIMBYism' is now often quoted in the UK as the almost automatically cynical response to local planning proposals. It is then necessary to find mechanisms that create consensus beyond the person centred view, and to allow the cumulative impact of individual decisions to be appraised. The workshops held in the partner countries within the VEPs project have identified that the issues most likely to engage citizens in this way are for example changes to the neighbourhood of their home, or changes they wish to make to their home in the context of their neighbourhood.

The VEPs prototype tools created are aimed at bottom up use by Citizens, able to model their own explorations as well as viewing street level impacts in their immediate neighbourhoods. Other investigation during the VEPs project is examining how to facilitate the planning process and planners. In Stuttgart the Stuttgart University of Applied Sciences is working with the City Planners on a case study of the Rosensteinviertel area proposed for major air-rights extension to the city centre over undergrounded railway tracks and for urban regeneration. For regional appraisal "there are several planning support systems (PPS) available on the market today to ESRI users. PSS use indicators and alternative development scenarios ... can measure and compare performances of different ... indicators for land use, transportation, natural resources and employment...." There are a range of what are now termed Planning Support Systems under development such as Metroquest , and it is not intended to replicate these, but rather to identify what data needs to be passed from local and neighbourhood impact proposals in order for such systems to be pump-primed so that matching sites can be identified and the cumulative effects of similar development modelled forward over decades. Equally further constraints may be formulated using such simulations that will better inform decision making at the local level, so a two-way exchange needs to be established.

The VEPs project focuses on the master planning stage where visualisation can assist in avoiding delays in the planning process - here, the judgments required can be made before a specific proposal has been formulated and / or before an application for planning approval. The project is also developing means of enabling the public to 'what-if', to modify proposals and to examine the impact of their modifications, or to upload alternative proposals. An underpinning spatial database assists analysis of the potential impact. Such spatial databases are in effect a form of GIS when associated with spatial analytical tools. The benefits of GIS in this context is borne out by recent research in this field which states that "the potential for extensive and alternative use will be directly reflected where GIS will prove to be powerful" [26]. In the resulting VEP system an underpinning spatial database will be crucial throughout, from data acquisition to modelling process, to enable on-demand responses and for maintenance of the system.

In VEPS, the purpose of visualisation is to assist users to make decisions together about proposals for change, using a digital environment that represents the proposals. It is regarded as critical that they then endorse those early decisions when they are confronted by the final built outcome. Hence to start with, for this research, visualisations have been created and published using existing commercial and / or open standard file formats, such as VRML; to swiftly create a prototype web based virtual reality that users can freely explore. This is intended to lead to user engagement in the research process and to user driven optimisation of the final system. The final system would be expected to fall into the category of those

systems with 'full analytical features' [33]. It is hoped that this will indicate improvements in the way in which users participate in the planning process and decision-making.

6.1 The Web based visualisation tool

The VEPs project is focused on easing the task of creating and comparing 3D modelling of what does not exist, within an existing context. Because of this distinction tools are needed that allow modelling to be created in the context of the varying height of the DTM. While it is useful to be able to trace round existing aerial imagery and even to elevate modelling with bitmaps, this is not enough to meet the need. It is important to be able to freely if simply model in context using as referents the shape of the terrain and the form of adjacent buildings structure and landscape to be retained. These modelling tools should ideally be open source and deploy VRML, X3D and similar emerging open standards.

These standards require plug-ins or extensions to current web browsers to operate at present. In examining the available plug-ins those for VRML have been available the longest and are the most developed. Digitisation of new modelling in context requires a particular scripting behaviour of VRML, the touch sensor. This is now described in X3D as the "PointingDeviceSensor" component, of which the touch sensor is a particular 'node'. "Pointing-device sensors detect user pointing events such as the user clicking on a piece of geometry (i.e., TouchSensor).

This current 3D e-Planner prototype toolset is undergoing user evaluation following the EAR [34] methodology. At present it consists of a DTM with draped aerial imagery and vector mapping. It has the capacity to provide two zones, an inner neighbourhood where users can interact and model, and an outer contextual zone that is interactively navigable but 'locked'. Modelling created by one user can be shared with another across the web and viewed in context. The recipient can save the modelling of another and modify and then upload it. Within the interactive modelling zone (which can be an entire neighbourhood or scene) users can both digitise around the aerial imagery or digitise new buildings in context (see Image 2). Tools have been created to enable users to elect to share their modelling with others. Users, whether the originator or other members of the public with whom the originator has shared the modelling, can interactively modify the elevational height of a selected building and adjust the slope or form of its roof. They can also save the digitised building as a VRML (CAD) model then re-insert, move, scale, or rotate it (Image 3).

7 ISSUES IN USE OF COMPUTER VISUALISATION

In the ESRC study, the purpose of static representations was to communicate the final versions of design schemes. At this stage these representations are intended to deliver relevant information including a high level of detail and requisite specific information such as for example the use of materials. The participants therefore received highly complex information intended to support precise judgments.

In the VEPs project, the purpose of visualisation is to assist users to make decisions together about proposals for change, using a digital environment that represents the proposal. It is regarded as critical that they then endorse those early decisions when they are confronted by the final built outcome.

Both investigations consider how these tools for planning support deliver the relevant information and whether the information is delivered in an easily comprehensive form. The issue was also, how best to represent the proposed changes in the built environment so that they are perceived and understood as credible and the judgments that may be made are reliable.

The results to date show that an important requirement from the three-dimensional representations whether they are static or interactive is the apparent realism of visualisation. This factor affects people's perceptions and judgments in the way that it makes the visualisation believable and possessing 'no sense of fudge' according to an architect with over 20 years of experience. These representations appear to leave the viewers with the impression that it is the most studied design that is both technically and accurately represented. This is reinforced by the level of detail that these visualisations provide. However, architects and some professionals still regard traditional forms of visual representations as both a useful and credible form of representation. Yet, these forms appear to be better as a means of communication they use internally, among themselves for the discussion and analysis during the design development stage than for the stage where the conceptual design is communicated to other parties involved in the process. For the final stage of design they

all agreed that computer generated representations of design “sell better” design and are likely to have more persuasive power than traditional means of representation.

The preliminary analysis of these research projects suggests that there are three viable approaches to public consultation and engagement in the planning process.

- Firstly, the complex information in a planning consultation may be “dumbed down” to a level that can be understood by the average member of the public without a qualification in planning;
- Secondly, full information can be presented but the citizen might need to receive training in order to understand it, particularly because plans and maps require training to read and interpret correctly because for an 'untrained' user they often contain ambiguities;
- Thirdly, (the proposed VEPs project approach) an interactive three-dimensional (3D) virtual reality (VR) visualisation would allow the viewer to experience the highly complex information without the need for training, because they can see and experience what the visual impacts of the planned development will be in the associated model.

This approach is also supported by the existing literature which claims that the use of 3D visualisation is particularly powerful in visualising urban and built environments as it gives the option to deliver the relevant information in an intuitively comprehensible form [19]. In this respect newly available highly accurate three-dimensional LIDAR data is becoming more widely available. LIDAR stands for Light Detection and Ranging and is a (usually) airborne mapping technique, which uses a laser to measure the distance between the aircraft and the ground. LIDAR is a range imaging data acquiring method, which is used, in conjunction with the Global Positioning System (GPS), to deliver high-resolution digital elevation models. A flash movie on the Environment Agency Website demonstrates these principles. This data can be sufficiently accurate for the precise judgments demanded in planning to be made, and, as image 1 shows, provides a digital context in which new proposals can be viewed. The issue that is then posed is how best to represent proposed changes in this environment, so that they are credible and the judgments that may be made by non-technical people are reliable - without making the proposals so photo-realistic that they are 'read' as certain.

Research studies have identified the demographic and professional bias of decision-makers to be the most significant factors in the process of communication of architectural ideas through visual representations [35]. Several studies also report differences in the evaluation of decision-tasks between experts and lay-people. For example Barker [36] states “Differences between lay and expert appraisals can be anticipated because of variations in the decision context, experience, perceived role, and ability to cope with a highly complex and uncertain situation”. These differences have been confirmed by the initial analysis of groups’ perceptual responses in the ESRC study.

The issue of acceptable and useful levels of abstraction of visual representations was particularly difficult to acquire for the perceptions and understanding by the members of the public. Their responses relied very much on the colour schemes used, impressions of the atmosphere that the images created and ‘activity indicators’ such as people and car added to the representations. These findings underscore the need to fit the form of visual representations to the audience and type of decisions to be made. The results of some current research confirm [37] these findings, which revealed that skilled participants appreciate traditional representations while unskilled participants prefer photorealistic presentations.

8 CONCLUSIONS

The point of having interactive visualisation of urban planning and design developments is that it allows some useful tasks to be accomplished, and the meaning of the visualisation is determined by what exactly the task is. During the research studies described above we have addressed two hierarchical sequences of responses to computer-based visualisation. The first element that has been studied through the VEPs project is ‘low-level’ detail. The interactive VRML environment offers low resolution images applied to objects as they are neared. In contrast, the ESRC study examined ‘high-level’ representations showing highly detailed objects in a scene, their spatial disposition and other elements of design.

We consider that there are possibly other hierarchical levels of detail. There is an ‘intermediate level’ of representation, which this research did not examine, that would be probably the equivalent of a black and white architectural drawing or the result of CAD software such as Sketch-up. There is also the perhaps

highest level of detail that would be achieved when the built environment visualisation includes the movement of traffic, plants (in the wind), and people, that would then offer a much higher resemblance to the real world. One may suggest that this has already been offered by some immersive VR technology, only currently accessible using expensive stand-alone technology. However given the pace of computer technological development, it is possible that this level of detail for planning support visualisation may be successfully introduced into future web based media.

While most of the research in this area is focused on metrics for comparing 'realism' against reality we are more concerned with the reliability of the planning appraisal judgments formed. If the non-experts are surprised when they see the built results of the planned proposals that they earlier evaluated, then there is a problem with the visualisation that provided the information. We argue that computer visualisation for planning and design decision making process should be a 'person-centric' visualisation that is based on a credible sense of presence in the scene and supports effective decisions. Considerably more work is needed to establish clear guidance for when a particular form of representation is reliable in this respect. Web based technologies currently introduce further limitations in their support of interactive representation that may disappear in future.

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