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Managing public discourse: towards the augmentation of GIS with multimedia

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'Urban planning' is a key process in democratic societies: it is the interface between democracy and operational management and, as such, reflects the operations of the state in microcosm. It is becoming increasingly important as local communities come to assert their interests and values against those of officialdom or big business. Central to this planning is discourse between different parties.

Management of planning is therefore a non-linear operation without line managers in any conventional business sense. This chapter describes how combinations of GIS and multimedia can facilitate the active involvement of many different groups in the discussion and management of urban change through planning. It deals with different components of public discourse, notably debate and consensus-building, and with communications between parties sometimes separated by space and time. Recent experiments have already demonstrated the practical possibilities and difficulties in use of these technologies in the planning context. Evolving technology will diminish some of the difficulties in the years to come.

1 INTRODUCTION

There are many ways in which information technology can support the various stages in a city planning process. Much of this has been documented by Armstrong and Densham (1990), Batty and Xie (1994), Couclelis (1991), Harris (1989), and Klosterman (1992) among many others. This chapter concentrates on the subset of planning that involves information exchange for the purposes of managing public discourse. In many of these contexts the information consists of plans, proposals, and alternatives which have already been generated from raw data (frequently with the help of a GIS). Here, the focus is on innovative ways in which the results of GIS-based analyses have been augmented and conveyed effectively to support public discourse. We will also explore how such results can be manipulated in a limited fashion to allow for some degree of additional analysis by a broader group of people than those who undertook the initial work (see also Cova, Chapter 60; Yeh, Chapter 62).

Public discourse in city planning contexts frequently consists of positioning, consensus-building, argument, and deal-making (among other things) in a variety of settings such as planning meetings, individual review, letter writing, and news reporting. If one were to observe, at a more basic level, what is actually communicated, it would be likely to include some degree of recollection, description, or speculation.

Furthermore, the settings for this discourse can differ by time and place. For instance, community stakeholders might communicate in the same place at the same time (through community meetings), at different places at different times (through the news media), and so on. This chapter describes how recent developments in information technologies (particularly spatial multimedia technologies) provide the capacity to augment traditional GIS to support public discourse. We begin by discussing various types of planning-related discourse in terms of recollection, description, and speculation, and go on to explore how GIS can be augmented with spatial multimedia to support these forms of discourse. The various settings in which planning-related information is accessed and how the augmentations to GIS identified above might be applied are also described. Finally, by drawing from some early experiences with these technologies, some of the issues that have arisen involving their construction, implementation, and use are identified.

2 FORMS OF DISCOURSE

The forms of discourse which occur in the context of planning tend to include:

- the recognition of problems and issues faced by a community;
- understanding of the range of alternative scenarios which can begin to address these problems and issues;
- acknowledgement of the actors and institutional mechanisms available to support action;
- some appreciation of the implications of action based on an understanding of present conditions and past trends.

Knowledge in the planning context is frequently shared through recollections of the past, descriptions of the present, and speculation about the future. This section discusses recollection, description, and speculation. It explains how key applications of spatial multimedia technologies can support these forms of discourse.

2.1 Recollection

In recollecting the past history of a given site or planning issue, conversations may include (among other things) what was said, what was done, or what a place was like. For example, members of a group may try to recall the impact of past interventions on an urban landscape. The purpose of this is to understand and anticipate what may lie ahead, given similar circumstances.

Where the recollection is about fairly structured recent activities (such as past planning meetings), the conversations can be supported with records and systematic documentation of past interactions. However, access to this information can be dependent on a specialised information recording and retrieval 'system' such as a meeting secretary or stenographer. Furthermore, such methods of recollection rarely incorporate spatial referencing with such things as historical maps. Where systematic documentation is lacking, as with recollection of the past environmental conditions of an area, the high degree of dependence on human memory can lead to problems based on the inconsistency of individual memory. For example, one person may recall traffic on a particular street to have been heavy whilst another may think of the same stretch of roadway as lightly travelled.

Where there is a lack of documentation or data to support these recollections, arguments related to inconsistent memories are likely to persist. These arguments can dominate a discussion and shift the focus of a meeting from the matters at hand. Nevertheless, it should be noted that, while various participants in a planning process have their own individual perceptions of a problem, this informal means of knowledge retrieval can be tremendously useful – especially for eliciting informal institutional knowledge that would not have been conveyed in other, more formal, ways.

GIS support of recollection, especially in the contexts of public discourse, has traditionally been somewhat limited. This has been due to a number of factors, including fairly weak historical references in much of the available spatial data. While GIS in combination with historical data can indeed be used to facilitate recollection about characteristics such as demographic trends, property values, and other generalisable information, it is less adept at conveying the past character of an area. Furthermore, using this technology to assist recollection depends on systematic archival of spatial 'snapshots'.

2.2 Description

Description of present conditions generally involves familiarising participants in a collaborative situation with an area being discussed, so that everyone can work from a common base of knowledge. These descriptions frequently include some type of spatial referencing. While many of these references are verbal (i.e. 'over by the river', 'on the site of the former factory') and cognitive (see Mark, Chapter 7), such references may be increasingly inappropriate where familiarity of the participants in the meeting with a particular site is lacking. For example, the term 'on the site of the former factory' is completely meaningless to meeting participants who are unfamiliar with the area being discussed.

The lack of familiarity with a given site can be rectified through an up-to-date map that is used as a central reference point. Individuals describe present conditions verbally and augment this by gesturing at a map spread on a table or tacked to a wall. Such descriptions may be further augmented using thematic data and visual imagery. The thematic data may be provided in the form of land-use maps or demographic conditions of an area. Visual imagery may include photos or video tape of selected sites. The juxtaposition of the above media can strengthen a collective understanding of the various characteristics of a given site.

Until recently, GIS has been unable to support in an effective manner real-time descriptions of existing conditions in collaborative situations. This has been because of issues of speed, the human interface, and a lack of integration with other forms of media (see also Egenhofer and Kuhn, Chapter 28). While many of these issues are being addressed using modern GIS tools that take advantage of interoperability and component software (see Sondheim et al, Chapter 24), the techniques for the effective juxtaposition of this information for retrieval in collaborative contexts still need to be developed further.

2.3 Speculation

Speculation about the future of an area generally involves extrapolating measurable phenomena from past experience and applying the results to the future using informal mental models. For example, a participant in a planning meeting might recall the impact on property values in one area of a previously developed transit station and simply speculate about such an impact at another comparable location under similar conditions. Speculation can also involve hand calculations that can be quite sophisticated. While such speculation is likely to become less accurate as the complexity of the scenario increases, a much more formalised mechanism for speculation in more complex situations has been made available through prediction and modelling using computer-based analysis tools (see, for example, Batty and Xie 1994; Harris 1989; Harris and Batty 1993).

Augmentation of discourse using analytic tools has traditionally been handicapped both by a lack of immediate response and by the production of abstract output that tends to exclude from such conversations those who are not technologically sophisticated. For example, it has been traditionally difficult to interact with an analytic tool, such as a GIS, in the context of a meeting room and expect the immediate response necessary to support a conversation. Furthermore, technical output such as a predicted automobile traffic level of 13 000 cars a day can have little meaning for people who are not transportation specialists.

The issues of speed and responsiveness can be addressed to a limited extent with advances in processing speed of computers, as well as through the employment of direct manipulation computer interfaces that allow users to 'push buttons' and 'slide levers' on a display to elicit an immediate response from the computer. The issue of relatively abstract output can be addressed using multimedia representational aids such as images and sound which can portray the output of analytic tools more descriptively. However, more still needs to be understood about how these techniques can be applied in actual collaborative settings.

3 KEY APPLICATIONS OF MULTIMEDIA

Many of the difficulties described above can be addressed through creative application of multimedia information technologies (see, for example, Câmara et al 1991; Fonseca et al 1993; Jones et al 1994; Laurini and Milleret-Raffort 1990; Polyorides 1993; Shiffer 1992). Recently, the Department of Urban Studies and Planning at Massachusetts Institute of Technology (MIT) has been working with several government agencies and private firms to identify effective combinations of tools and techniques for the support of city planning meetings. The overall goal of this research is to improve the communication of planning-related information with a specific focus on the environmental effects of proposed urban interventions.

3.1 Augmenting recollection: annotation mechanisms

Spatial annotation mechanisms have the capacity to assist in recollection of past annotations by providing an archive that can be accessed based on geographical relevance, chronological relevance, and associative relevance. Geographical relevance allows users of an information system to search for annotations which are related to a specific region or sub-region using typical GIS operations such as buffers and overlays. Chronological relevance allows a user to add the capacity to search for annotations made before, after, or between two stipulated dates. Finally, associative relevance allows searching by keywords or related concepts that could be hyperlinked together in a World Wide Web (WWW)-like associative structure.

An annotation mechanism was implemented as part of a prototype collaborative planning system tested at the National Capital Planning Commission in Washington DC among other locations (Lang 1992; Shiffer 1993, 1995b). The annotation capabilities included the capacity to add text, sound, and video to spatial representations. Initial implementations of such an annotation mechanism in a collaborative setting were not very successful for several reasons. In the first instance, it was awkward to stop meetings for annotations, as such interruptions would tend to disturb the flow of conversation. Second, the issue of which party had the right to annotate a particular representation surfaced. The value of such annotations was not readily apparent due to the fact that there was no precedent for accessing previously annotated maps; and finally, many meeting participants were wary of 'going on the record' with informal comments pertaining to specific regions.

With the maturating of the WWW, it is now possible to incorporate spatial annotation into a distributed planning review process. This practice can help to support scenarios where stakeholders are unable to meet together at the same time. For example, in Washington DC the National Capital Planning Commission has recently experimented with the capacity to annotate a WWW-based virtual streetscape. In Lisbon, two MIT students have separately explored the use of the WWW to gather public comments surrounding various development proposals (see Ferraz de Abreu 1995; Gouveia 1996). While the technical capacity to incorporate a spatial annotation mechanism with GIS now exists, several issues such as the 'legitimacy' of comments and the 'life' of an annotation remain to be resolved.

It is certainly conceivable that GIS-based archival mechanisms can be set up to aid future recollective efforts. But this requires that a substantial spatial data infrastructure be already in place. Since we are only beginning to realise the development of substantial spatial data infrastructures around the world (see Rhind, Chapter 56), we will need to continue to rely on the (frequently paper-based) libraries of local historical societies for more specific spatial descriptions which can effectively convey the character of a local area. Even in this case, the issue becomes a question of what material is worth maintaining – which has profound implications for the scalability of such a system. For instance, is it reasonable to expect a planning council to archive a spatial representation of every proposal made, along with the corresponding minutes of every planning meeting? If so, what is a reasonable time frame for keeping the record in the archive? Five years? Fifty years? Forever? If not every proposal is archived, then how is the choice of 'what is relevant' to be made?

3.2 Augmenting description: navigational aids

Navigational aids have had the capacity for several years to support descriptions of existing conditions by offering a link between oblique imagery and orthographic maps (see, for example, Batty, Chapter 21; Brand 1987; Kindleberger 1990; Rhind et al 1988; Wiggins and Shiffer 1990). While this technology has traditionally relied upon specialised hardware configurations such as randomly accessible videodisk technology, recent developments such as component GIS and the capacity of digital video clips to incorporate objects now makes it possible to link images (and objects within images) to spatial databases.

For instance, a user can now select an area of a map and see a corresponding motion video of that location playing on the same screen. Users can also 'browse' a region using a navigational video, 'stop' upon identifying an item of interest and see its location highlighted on a corresponding map. More recent developments, such as 'nodal digital video', make it possible to pan, tilt, and zoom from a specific location. Furthermore, these nodes can contain objects that allow users to connect to other video nodes, spatial objects, or other descriptive materials such as those found on the WWW. Much of this is made possible by the standardisation of software-based digital video display tools that allow the use of digital video navigational aids independent of specialised hardware configurations. Finally, the proliferation of component-based WWW browsers and GIS WWW 'plug-ins' makes it possible to access such navigational aids without specialised software (Coleman, Chapter 22).

3.3 Augmenting speculation: multimedia representational aids

The capacity to do urban and regional development forecasting has existed for some time. Yet such forecasts can go unappreciated in city planning meetings where there is a significant mix of participants with various skills (Forester 1982; Schon and Rein 1994). Such a mismatch can be characterised as a 'gap of understanding'. This gap not only exists between (and among) technical specialists (planners, geographers, engineers, architects, etc.) and the public: it also frequently exists between such specialists and key decision-makers and/or other stakeholders. 'Closing the gap' can be accomplished through the augmentation of typically abstract environmental representations using direct manipulation interfaces and multimedia representational aids (Norman 1986).

Direct manipulation interfaces translate human desires into commands that the computer can understand. Multimedia representational aids support information flow in the other direction by augmenting numeric values with graphical representation and associated imagery to transform abstract data into concepts that the human can understand. This results in the use of images and sound to portray the output of analytic tools more descriptively than traditional symbolic representation. The intended result is to make analytic tools and their outputs more manipulable, understandable, and appealing so that information which would normally be meaningless and intimidating to the lay person can be comprehended effectively.

Both direct manipulation and multimedia representational aids have been made available to planning settings through recent increases in computing power available to the masses. While it is important to apply such power to the undertaking of previously unattainable analyses, it is also important to improve the comprehension of existing analytical tools, especially in collaborative contexts with varied participants.

Virtual environments (see Neves and Câmara, Chapter 39) have the capacity to tie all of the above together. Whether future multimedia spatial analysis tools are likely to be manifest as GIS components constructed on top of a WWW architecture, or multimedia components constructed along a GIS backbone, depends to a large extent on the implementation environment.

4 IMPLEMENTATION ENVIRONMENTS

There seem to be four types of environments in which people are likely to access planning-related information. These are:

- meeting at the *same place and same time*, such as in attending a traditional meeting;
- incorporating information supplied by various participants located in *different places at the same time*, such as through the use of human proxies;
- accessing information in the *same place at different times*, such as with individual review of plans that are accessible to the public at a central location;
- bringing together information from *different places at different times*, such as through letter writing and newspaper articles.

This section will describe how recent developments in information technology have augmented discourse in each of these four areas as illustrated in Figure 1, adapted from Armstrong (1993).

4.1 Same place/same time

This is the traditional 'community meeting' environment in which planners are likely to find themselves. It allows for a substantially broad 'bandwidth' of communication because of the capacity of humans to augment verbal communication with non-verbal signals such as gestures. Depending on the institutional mechanisms in place, this environment can lead to a significant degree of participation and discourse with direct verbal interaction.

While this form of communication can be highly efficient, it may be constrained by a lack of access to information or (more recently) a lack of filtering of relevant media. Furthermore, such meeting environments may suffer from a lack of access to analytical tools such as GIS, because of the individual design of many of these tools and a lack of representational aids that would otherwise allow a group of people with diverse backgrounds to participate in a meaningful conversation.

Recent advances have made it possible to augment this kind of environment with a collaborative planning system (CPS). Such tools have been implemented on an experimental basis as described in Shiffer (1993, 1995a, 1995c). Similar approaches have been implemented in several

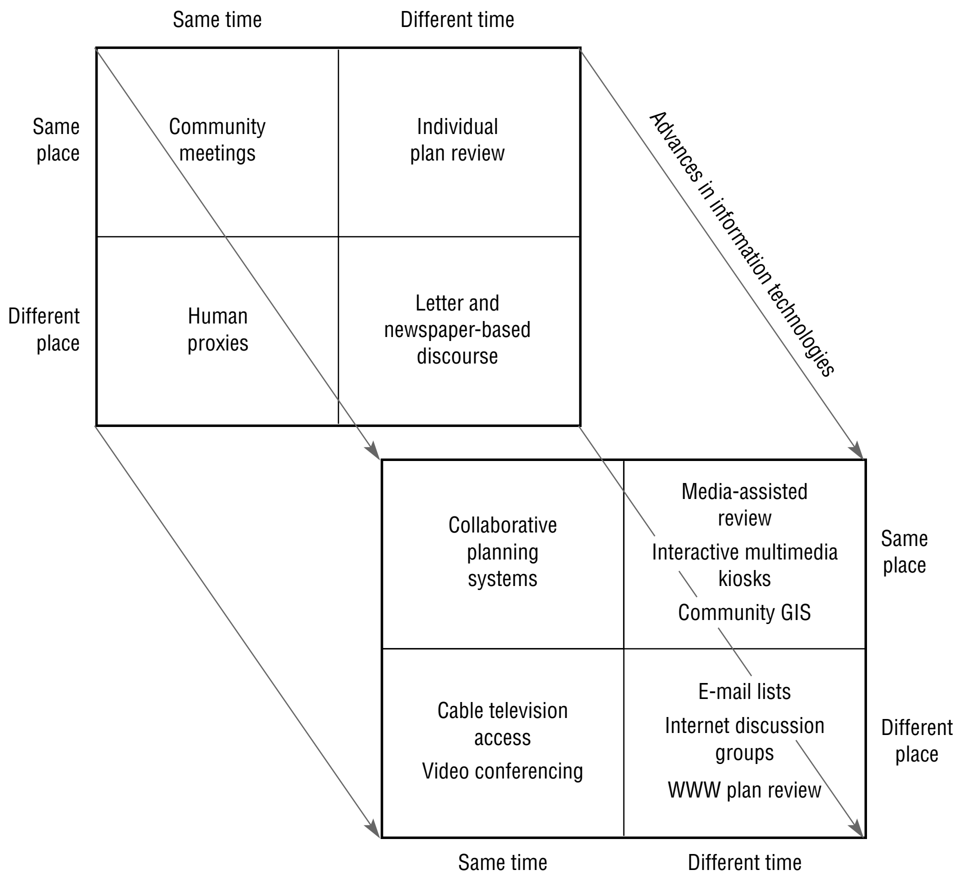

Fig 1. A diagram that outlines how advances in relevant information technologies have augmented public discourse in various settings.

contexts including those described in Dubbink (1989) and Faber et al (1995). A CPS makes significant use of the 'annotation mechanisms', 'navigational aids', and 'multimedia representational aids' described above and projected onto the wall of a meeting room. Participants interact with the system using cordless pointing devices or a technical facilitator to elicit information about selected geographical areas through a direct manipulation graphical interface. The intended result of many of these implementations is to make analytic tools and their outputs more manipulable, understandable, and appealing, so that information that would normally be meaningless and intimidating to the lay person can be more effectively comprehended.

In one case, a CPS was tested in an exploration of alternative uses for a former Air Force base, as described in Shiffer (1995a). In this situation, individuals followed the agenda of the meeting and used the system to access information about the various locations within the Air Force base for display to the group, using a portable computer and projector as illustrated in Plate 42. Such information included descriptive text and panoramic views of the base from key locations identified on a digital map. The environmental noise implications of proposed aircraft operations at selected locations around the former Air Force base could also be heard.

Another example involved the employment of a CPS to support a planning review process by the National Capital Planning Commission in Washington DC (as described by Shiffer 1993, 1995b). Several of the techniques that were originally proposed as part of the prototype CPS

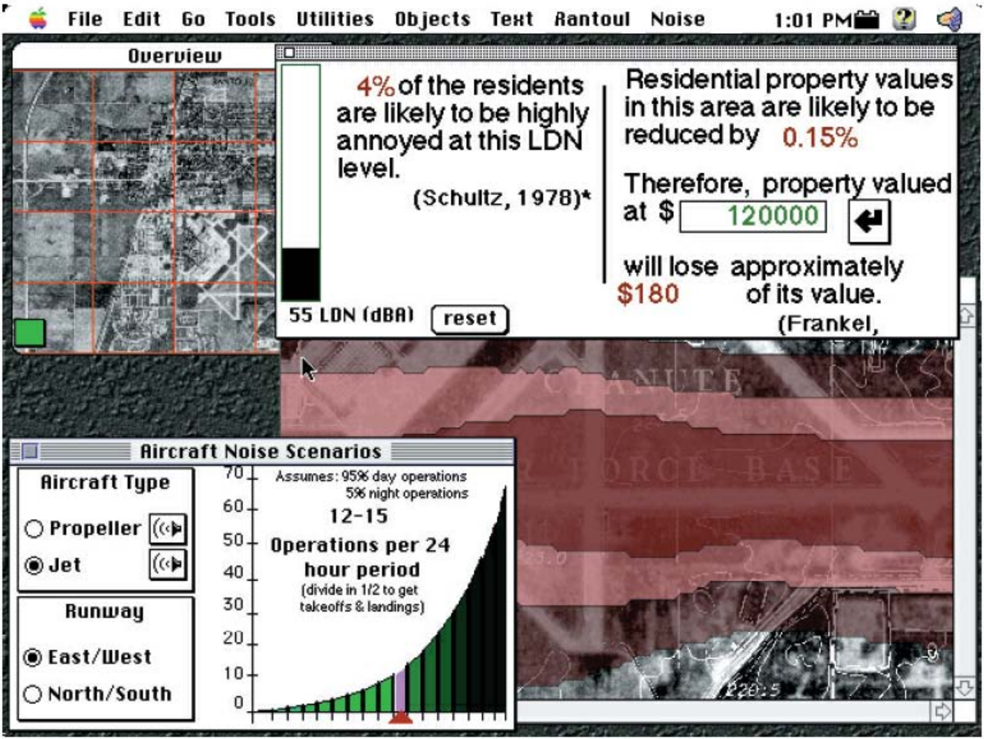

Plate 42 A collaborative planning system being tested in a 'same place/same time' environment to study the effects of aircraft noise on a community.

have been incorporated into the Commission's monthly review activities. These include the access and use of digitally stored aerial images, site plans, and video clips of physical models.

Several implementation and use issues arose out of early experiences with the CPS. For instance, early tests illustrated a reluctance on the part of users to pick up a pointing device and interact directly with the system during a meeting. Most preferred to interact with the CPS through an 'information expert' – a person who is very familiar with the system's content. Such an individual could anticipate group needs and display relevant information when called upon. Thus, while it would be necessary for the information expert to be familiar with a meeting's agenda, this individual could also track a random conversation and display maps and images as they were discussed.

The development of the prototype CPS has led to the identification of a broad set of issues ranging from institutionalisation to technical infrastructure (some of which are discussed in Shiffer 1995b). The benefits of this approach are that it is fast and self-contained. However, key participants may not be able to attend meetings because of place and time constraints. Other scenarios are therefore described below.

4.2 Different place/same time

While it is difficult to imagine how a geographically dispersed set of individuals could participate in a planning meeting at the same time, such interaction has been traditionally made possible through the use of human proxies (such as spouses, friends, or more formal representatives). If a stakeholder is unable to attend a meeting that is of particular interest, a proxy might attend in his or her absence. This type of situation can allow for limited interaction through conveniently accessible telephones which allow the proxy to report specific events to the stakeholder and give the stakeholder a chance to respond.

This model of communication has recently been augmented by local-access television in many communities. These 'televised meetings' frequently take the form of a fixed camera in a room where a planning-related meeting takes place in an otherwise normal manner. The television broadcast allows individuals not present to see and hear what is going on (at least in front of the camera). While television does indeed add a visual and audible characteristic to the interaction, frequently this kind of interaction is one-way (flowing from the meeting to the stakeholder). In some advanced cases of local access television, a mechanism might exist for 'phone-in' interaction, where remote participants have the capacity to pose questions. Nevertheless, the remote participant in these situations is frequently at a disadvantage because of a lack of access to (and interactivity with) the media. Even worse, the remote participant or 'caller' feels (and quite often is) completely at the mercy of the meeting's facilitator (or the person accepting the call).

A technical augmentation of this is the capacity to employ teleconferencing mechanisms. While this approach has been instituted successfully in the past to support design interactions that involve a limited number of participants (see, for example, Mitchell 1995), teleconferencing has not taken root in the planning arena in a substantial way. This is largely because of the need for relevant parties to have an adequate infrastructure in place to support such discourse. While Internet video conferencing has recently been popularised with programs such as 'CU-See Me' (as illustrated in Plate 43); a truly high quality connection often still requires a specialised connection and compatible hardware at both ends – something we are likely to see in the not-too-distant future.

Another less technically sophisticated approach is to broadcast the visual display of a spatial multimedia system or GIS during the course of a televised meeting. This method precludes direct interaction with the system on the part of the person who is viewing from 'home'. But if such persons 'had the floor' through a telephone connection, they could interact with the system using an information expert on the other end. Furthermore, skilful switching between images of meeting participants and televised maps (augmented by video) can convey spatial relationships more effectively than a simple broadcast of a meeting.

4.3 Same place/different time

Where it is not possible for a stakeholder to participate in a planning meeting (either in person or remotely), it is still possible to use a centralised location as a base of information sharing and communication. This model of communication represents a situation where physical media (such as paper-based reports, plans, drawings, physical

Plate 43

Video conferencing software being tested in a 'different place/same time' environment to present student projects (in Cambridge, Massachusetts) to professional planning staff in Washington DC.

models, etc.) are left in a specific location for the review of a broad group of individuals over a period of time. Interaction in this case is usually limited and has traditionally taken the form of written comments that could be entered into a notebook or posted on a (non-electronic) bulletin board.

In some cases, this means of discourse has been augmented through the provision of video tapes made available for individual review. Like the more traditional media, the tapes might contain proposals, plans, and drawings. These are usually put forth in the context of persuasive arguments for or against a particular development.

More recent implementations of this model of communication have included some limited access to GIS or other types of public service system through the employment of electronic information kiosks (as illustrated in Plate 44). The more sophisticated of these actually have the capacity to collect comments electronically through digitised video or audio facilities. Kiosks make it somewhat easier to control access to the information because they are frequently strategically placed in the communities that they are designed to serve, typically located in libraries and municipal buildings. They also have the capacity to deliver large amounts of information (such as video) much more rapidly than the WWW. Furthermore, software licensing and data costs can be more easily controlled with this model. Some of the more sophisticated kiosks have actually been designed to allow public interaction with GIS through the employment of graphical user interface modifications that are made possible using some of the more recent GIS tool kits (see Egenhofer and Kuhn, Chapter 28).

Individuals with a broad variety of skill levels are likely to interact with public access kiosks. Therefore, specific attention needs to be paid to ergonomics issues related to the design of the software interface (see Batty, Chapter 21; Coleman, Chapter 22; and Elshaw Thrall and Thrall, Chapter 23). The drawbacks are that they cannot be everywhere and a deployment infrastructure is needed; this can be costly.

4.4 Different place / different time

This model of communication involves people who are separate both temporally and geographically. For instance, a person may be unable to attend the meeting of the planning review board in their home community because they may be at work in another community during relevant meetings. In this case, their capacity to participate is typically limited to traditional forms of correspondence, such as letter writing and reading relevant newspaper articles. A significant difficulty of this is that local newspaper editors often become biased filters through which the information must flow. Furthermore, managing (archiving, categorising, etc.) public comments in such situations can prove to be challenging due to the limitations of print media.

This type of discourse has rarely been augmented with GIS because of the complexities of delivering the same information base to different parties while retaining the capacity for meaningful augmentation. The complexities of delivery tend to be concentrated more in the capacity of the different parties to interact meaningfully with the information base rather than with the technological limitations of delivering the same information base to multiple parties.

Voice mail, e-mail, and now the WWW make it possible to broaden the audience and these permit a more deliberative review. For example, Plate 45 illustrates a WWW-based application of a 'virtual streetscape' for Washington DC that allows the user to explore an area using either an orthographic photo and map overlay, or by using a nodal digital video. A text annotation capability allows the user to attach comments to specific nodes identified on the map. Limited Internet bandwidth and the problems of ensuring access to relevant parties continue to be drawbacks of this approach to planning-related discourse at present.

5 PROSPECTS FOR THE FUTURE

Several years ago we envisaged the capacity to link maps to highly descriptive representations of the past, present, and future by integrating GIS and multimedia with predictive and descriptive models. In many areas, this has become reality. While the exploration of *what* is delivered will continue to advance, the most profound changes in the near future are likely to concentrate on *how* it is delivered to different groups.

The WWW is just beginning to support direct manipulation of decision-aiding algorithms in a manner similar to GIS and stand-alone hypermedia collaborative planning tools. Thus software developers are faced with the challenge of creating directly manipulable components which can be

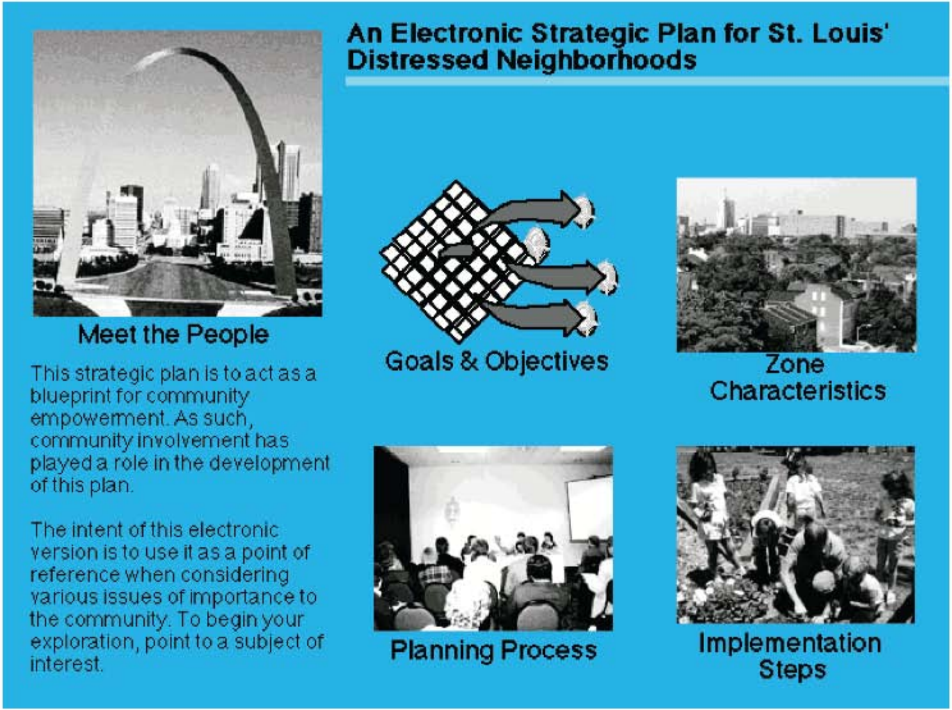

Plate 44
A public kiosk design for accessing information in a 'same time/different time' environment that describes a strategic plan St Louis' distressed neighbourhood.

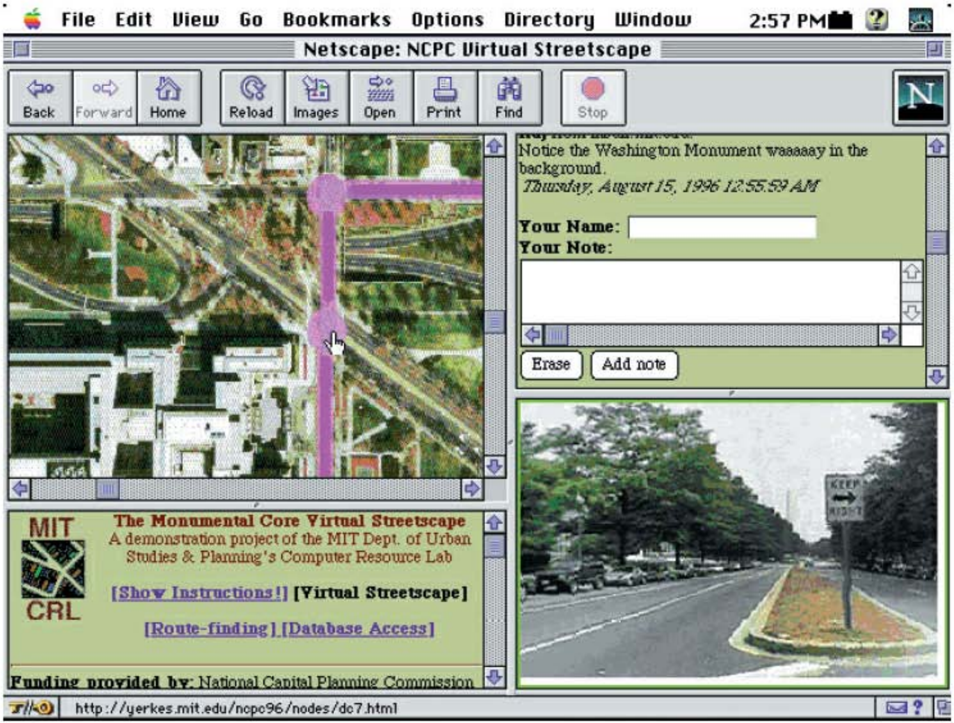

Plate 45
A test of a planning annotation and digital video navigational aid being tested in a 'different place/different time' environment using the WWW to study the characteristics of various locations in Washington DC.

accessed in a distributed manner through a networked infrastructure such as the WWW. The creation of such components is highly dependent on modular approaches to application development that involve the incorporation of relevant objects which are spatially aware. Once such components are created, it is likely that we will see an increasing number of distributed GIS with multimedia components which are organised around a spatial data infrastructure and delivered through wide-area networks such as the WWW.

Object-based development tools will make it possible to move away from the traditional GIS towards specialised applications that can be constructed through combining modular components. As advances are made in compression and network communication, future GIS components will continue to be delivered using this technology without regard to the client architecture. Open architectures will make it possible to deliver these applications to groups using a broad range of devices ranging from conventional televisions in the home to intelligent 'conference tables' (with horizontal displays) in the office and hand-held personal digital assistants in the field. The key to the success of these new architectures will be their capacity to facilitate communication across machines, among users and between the two. Though the WWW already offers unprecedented access to geographically-oriented multimedia information resources on the Internet, the capabilities of forthcoming systems seem likely to dwarf those of the present.

Even now, when interactive control of WWW-based information is still too unpredictable to support the dynamic discourse of a planning meeting, the World Wide Web can effectively support individual browsing or 'hunting and gathering' of multimedia information and planning-related data. In turn, this can be used to feed a locally stored planning support system. Planners and related groups will also benefit in future from the increased use of customisable intelligent agents that will aid problem-solving by identifying and gathering relevant information such as approaches used by others to address problems in comparable situations. In short, discourse in traditional planning settings will be augmented (rather than replaced) by these emerging information technologies as a broader range of individuals acquire the capacity to become active participants in planning problems and cases.

References

Armstrong M P 1993 Perspectives on the development of group decision support systems for locational problem-solving. *Geographical Systems* 1: 69–81

Armstrong M P, Densham P 1990 Database organisation strategies for spatial decision support systems. *International Journal of Geographical Information Systems* 4: 3–20

Batty M, Xie Y 1994 Modelling inside GIS: Part 2. selecting and calibrating urban models using ARC/INFO. *International Journal of Geographical Information Systems* 8: 451–70

Brand S 1987 *The media lab*. New York, Viking

Câmara A, Gomes A L, Fonseca A, Lucena e Vale M J 1991 Hypersnige – a navigation system for geographic information. *Proceedings, European GIS Conference, Brussels* April 1991: 175–9

Couclelis H 1991 Requirements for a planning-relevant GIS: a spatial perspective. *Papers in Regional Science* 70: 9–19

Dubbink D 1989 Use of acoustic examples in airport noise planning and decision-making. *Airport Landside Planning Techniques*: *Transportation Research Record 1199*. Washington DC, National Research Council

Faber B G, Wallace W, Cuthbertson J 1995 Advances in collaborative GIS for land-resource negotiation. *Proceedings, GIS 95 Ninth Annual Symposium on Geographic Information Systems, Vancouver*. GIS World Inc. 1: 183–9

Ferraz de Abreu P 1995 'Intelligent multimedia in public participation'. Unpublished PhD thesis proposal. Cambridge (USA), MIT

Fonseca A, Gouveia C, Ferreira F C, Raper J, Câmara A 1993 Adding video and sound into GIS. *Proceedings, EGIS 93 Conference Proceedings Genoa*, *Italy*, April: 176–87

Forester J 1982 Planning in the face of power. *Journal of the American Planning Association* 48: 67–80

Gouveia M C 1996 'Augmenting public participation with information technology in a Portuguese environmental assessment context'. Unpublished master's thesis. Cambridge (USA), Department of Urban Studies and Planning

Harris B 1989 Beyond geographic information systems: computers and the planning professional. *Journal of the American Planning Association* 55: 85–92

Harris B, Batty M 1993 Locational models, geographic information systems and planning support systems. *Journal of Planning Education and Research* 12: 184–98

Jones R M, Edmonds E A, Branki N E 1994 An analysis of media integration for spatial planning environments. *Environment and Planning B: Planning and Design* 21: 121–33

Kindleberger C 1990 Hypermedia for state and local government. *Journal of the Urban and Regional Information Systems Association* 2: 52–5

Klosterman R E 1992 Evolving views of computer-aided planning. *Journal of Planning Literature* 6: 249–60

Lang L 1992 GIS comes to life. *Computer Graphics World* October: 27–36

Laurini R, Milleret-Raffort F 1990 Principles of geomatic hypermaps *Proceedings, Fourth International Symposium on Spatial Data Handling Zurich*: 642–651

Mitchell W 1995 *City of bits: space, place and the Infobahn.* Cambridge (USA), MIT Press

Norman D A 1986 Cognitive engineering. In Norman D A, Draper S W (eds) *User centered system design: new perspectives on human-computer interaction*. Hillsdale, Lawrence Erlbaum: 31–61

Polyorides N 1993 An experiment in multimedia GIS. *Proceedings, European GIS Conference, Genoa, Italy* April: 203–12

Rhind D W, Armstrong P, Openshaw S 1988 The Domesday machine: a nation-wide geographical information system. *The Geographical Journal* 154: 56–8

Schon D A, Rein M 1994 *Frame Reflection*. New York, Basic Books

Shiffer M J 1992 Towards a collaborative planning system. *Environment and Planning B: Planning and Design* 19: 709–22

Shiffer M J 1993 Augmenting geographic information with collaborative multimedia technologies. In McMaster R B, Armstrong M P (eds) *Proceedings AutoCarto 11.* American Society for Photogrammetry and Remote Sensing/American Congress on Surveying and Mapping: 367–76

Shiffer M J 1995a Environmental review with hypermedia systems. *Environment and Planning B: Planning and Design* 22: 359–72

Shiffer M J 1995c Interactive multimedia planning support: moving from stand-alone systems to the World Wide Web. *Environment and Planning B: Planning and Design* 22: 649–64

Wiggins L L, Shiffer M J 1990 Planning with hypermedia: combining text, graphics, sound, and video. *Journal of the American Planning Association* Spring: 226–35