PUBLIC PARTICIPATION
GEOGRAPHIC INFORMATION SYSTEMS

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ABSTRACT

Increasing societal inclination towards participatory democracy is encouraging research on the development and use of public participation geographic information systems (PPGIS). This paper summarizes three scenarios describing actual and/or potential use of a PPGIS. One scenario concerns a public-private coalition strategy for brownfield development (urban land rehabilitation) in and near Seattle, WA. A second scenario concerns neighborhood crime watch in Milwaukee, WI. A third scenario concerns forest conservation planning and action in the Southern Appalachian Mountains. Generalizations are drawn from these scenarios to synthesize a table of general requirements for a PPGIS. Concluding comments assess the current state of development and address future prospects.

1. INTRODUCTION

A societal trend toward shared decision making about public concerns is a basic motivating factor that encourages research on the development and use of public participation geographic information systems (PPGIS). Some of these public concerns include decisions about resources and environment that involve land use planning (Duffy, Roseland, Gunton 1996), strategies for planning a citizen crime watch, and plan development for forest conservation and sustainable use of limited natural resources (Diamond and Noonan 1996). The primary rationale for enhanced public participation in the decision process is based on the democratic maxim that those affected by a decision should participate directly in the decision making process (Smith 1982).

Current GIS technology has been developed mainly to support organizational use of GIS (Campbell and Masser 1995). Such developments can be labeled first generation GIS, or GIS/1. Because of the need to expand the access to geographic information for participatory kinds of activity, as well as more personal use of geographic information , many researchers are recognizing the need for a new kind of GIS which has been called GIS/2, or second generation GIS (http://ncgia.spatial.maine.edu/ppgis/criteria.html). Personal GIS and PPGIS compose GIS/2.

The goal of this paper is to articulate a set of functional requirements for PPGIS. Sandman (1993) has identified nine publics relevant to discussion about community problems. The publics are: neighbors, concerned citizens, technical experts, media, activists, elected officials, business and industry, and local, state and federal government regulators. Which of these publics is involved in any particular scenario of PPGIS use depends on several characteristics, for example, topic of concern, geographic location, meeting venue, public process, and technology used to facilitate conversation. In this paper we present three application scenarios for use of a PPGIS. From these three scenarios we synthesize a sense of the overall system requirements for a generic PPGIS.

2. APPLICATIONS OF PUBLIC PARTICIPATION GIS

Three application scenarios described below were selected so as to capture a breadth of issues about public process and how a PPGIS might be used.

2.1 Public Participation in Brownfield Development Usi ıg GIS
Brownfield projects are public-private partnerships for urban industrial land parcel rehabilitation. A general strategy for a brownfield project is to clean a land parcel(s) to a level which puts the land back into productive use. However, clean-up standards in local jurisdictions must meet federal and state across-the-board-standards that commonly are more stringent than needed for the land use activity actually practiced in those areas. Consequently, land costs are prohibitively high because clean-up costs become part of the transaction. A major challenge is therefore to have commercial/industrial, regulatory and financial organizations collaborate to achieve a "brownfield" level of clean rather than "greenfield" level of clean.

The Duwamish Coalition in Seattle, Washington is responsible for one of seventy-six brownfield pilot projects co-sponsored by the U. S. EPA headquarters or regional offices (Institute for Responsible Management 1996). Convened in April 1994, the Coalition is composed of representatives from small and large businesses; labor unions; local, state and federal governments; Native American Tribes; environmental and community organizations; and local banks, business associations and educational institutions. The Duwamish Corridor, includes a mix of industrial, commercial and residential land uses, marine terminals and transportation infrastructure, open space/parks, public

facilities, landfill sites, Superfund sites, habitat restoration areas, and tribal fishing areas along the Duwamish Waterway. The mission of the Duwamish Coalition (Duwamish Coalition 1996) is to "...preserve and reclaim industrial land for the purposes of expanding the manufacturing and industrial job base, and protecting and enhancing the natural environment of the corridor. ... Meetings of the Coalition's Steering Committee and Task Forces are open to the public", with public interpreted to mean all who want to participate.

2.1.1 Current Scenario. The Coalition's brownfield development activity is incremental in nature, and part of a policy implementation strategy for urban growth management which focuses on land use densification in mixed-land use areas. To plan the development activity, four types of group meetings, hence clusters of participants, carry out the work: staff meetings, task force meetings, steering committee meetings, and annual summit meetings.

For the most part, standard communication technology has been used to support communication in face-to-face group meetings, these technologies being slide projectors, transparencies, posters, and hardcopy print. In some face-to-face meetings the Coalition made use of hardcopy maps based on geographic data from City of Seattle and King County Arc/Info data files. Poster size maps were available for review at meetings, and notebook-sized (8.5" x 11") maps were made for review at other times. In other words, standard access to paper-based documents was the only mode supported for access to geographic data.

To help expand the distribution of Coalition information, a WWW site was developed that includes their mission statement and brief description of activity (Duwamish Coalition 1996). Due to limited resource availability little of the details of the Coalition discussion appear on the WWW site, including the GIS maps reviewed in various meetings that provided information overview.

2.1.2 PPGIS Needs Revealed. We assume here that topic, place, and publics participating will likely stay the same for the brownfield collaborative effort, but venue and technology can change the nature of the participation process, and thus reveal a new set of needs for enhancing participation. The venue is affected mostly by available communication technology. With changes in communication process, the other three technologies, data management, computer map graphics, and spatial analysis, are likely to be influenced as well.

In regards to communication management, dialogue is constrained by meeting venue. Although everyone is invited, few have the time to attend all face-to-face meetings. The frequency of meetings and the extended process required to carry through on a topic hamper participation. Together, those constraints limit a group's ability to undertake information synthesis.

In regards to information management, a lack of resources to make GIS data available is a major barrier to a balanced dialogue among the publics. Wide distribution of all geographic information among participating publics should be a goal. Satisfactory public review of the data used to generate the information takes time. GIS data management techniques open to all publics at

any time/library can enhance participation, including an ability to collect their own data in support of their arguments.

In regards to map display, several members of the Coalition often discussed patterns on maps in the various meetings. Group memory of their discussions can be enhanced by providing text hot links to descriptions of the topics discussed. Other maps were used to assess the priorities of areas to be developed, each stakeholder group having their own priorities. New types of maps that depict both the individual stakeholder group as well as overall consensus priorities among the stakeholder groups could be useful.

In regards to spatial analysis, although King County staff created several maps, many groups would like to have access to GIS software and data to undertake their own GIS analysis. GIS can be used to assist with risk assessment at three levels: vulnerability analysis, screening analysis, and probability analysis. For vulnerability analysis, all potential hazards and receptors are identified in a broad-based approach to estimating potential risk. For screening, the most significant hazards and receptors are identified for which a risk estimate is provided. For probability analysis, a probability range is computed for biomarkers relevant to receptors based on a screening analysis.

2.1.3 Discussion. The four types of technologies mentioned above -- communication, database management, computer graphics display, and spatial analysis -- are fundamental for opening brownfield discussions to a wider audience. All meeting venues are important in facilitating the participation process. Unfortunately, same-time, same-place meetings are the only ones supported, whereas different-time and/or different-place meetings are not.

2.2 Public Participation in Urban Crime Surveillance

A second scenario concerns neighborhood residents discussing issues and options for a local response to urban crime issues. The Sherman Park community is an integrated community of black and white, middle and lower income residents. The community has been organized as an Association for more than 20 years to address issues in the neighborhood. The Crime Watch program has been in place for only five years, involving a volunteer pool of 60 volunteers and two staff members.

2.2.1 Current Scenario. Monthly meetings of the Crime Watch task force thrive on information. Calls to the Association, a printout of weekly police calls, and observations of the volunteer patrols through the neighborhood help in the review of problems the group must anticipate. Because GIS is not used at the current time, we speculate on how it might be used in the next subsection.

2.2.2 PGIS Needs Revealed. Information and visualization are required in real time. Imagine a computer with a large screen at the conference table. An Internet connection links data from the Police Department and the Metro Drug

Unit. The local network taps reports from Crime Watch patrols and calls from the neighborhood. General neighborhood demographics are also available.

The mapping system has been customized for the work of the task force. A parcel-based map of the neighborhood is the default screen. Symbols for each of the major categories of crime may be presented by selecting from a set of check boxes to the right side of the screen. Other attributes may also be selected to define the characteristics of parcels or other areas on the map. The parcel map may be generalized to block level patterns and statistical aggregates through a variety of choices on the left. At the bottom of the screen, a history bar allows selecting time periods for display - even animation.

Have burglaries on the east side of the community been increasing recently? Is this due in part to the intense anti-crime effort in the Metcalfe Park neighborhood further east? Adjust the frame to show the area of interest. Check the burglaries box to display. Widen the history bar to show six months of data at a time. Move the history bar back three years and start a slow speed animation. The trends are apparent on the screen. Select two sets of blocks within this area and the data may also be summarized as a time series bar graph.

Is a rash of assaults in one block related to reports of a new drug house in the community? Zoom into a four block area. Select assaults and the parcel attribute identifying reported drug houses. Set the history bar for a static display of the last three months. Save or print the results and reset the history bar to the same period one year ago.

Where have calls to the agency regarding crime been coming from? Select the "Calls" database. Leave all categories active. Set the history bar for the past month. A cluster of calls is apparent in one block. Is this an increase in crime or a more active block club? The task force would need to sort that out. Select one of the symbols on the map and notes about the call can be read.

2.2.3 Discussion. In these crime watch scenarios, comprehensive sources of current information are critical. The political process this represents will be more difficult than the technical issues are. Information also needs to be treated with caution. Some data includes confidential material. Access must be managed by a sophisticated database program aware of the level of information that can be made accessible to specific users. Information may often be incomplete. For example, a suspected drug house is recorded quite differently than an established drug house - if at all. Certain crimes may be unreported. Additional factors - the involvement of youth or gangs, relationship to drugs or the extent that a crime of assault involved persons within a family - may not be apparent in the data systems.

Neither data nor software can insulate the task force from the misuse of data, especially when a correlation seems obvious. A cause and effect conclusion can be influenced by the personal opinions of lay persons on the task force. Despite these limitations, residents provide a valuable perspective on the data from their experiences. Encouraging participatory review of data will add value that the professional analyst limited by formal data sets cannot achieve.

2.3 Public Participation in Forest Conservation Planning and Action
    In this scenario, GIS is used for forest conservation planning by a
collaborative of conservation groups. Led by the Chattooga River Watershed
Coalition (CRWC), the planning team also included the Southern Appalachian
Forest Coalition (SAFC) and the SE Regional Office of the Conservation Fund
(CF). The geographic focus of plan is the Chattooga River watershed.
Highlighted by the Chattooga River Wild and Scenic Corridor, the watershed is
a globally significant hotspot for biological diversity and white-water recreation.
The watershed contains about 70% public lands, and is trisected by the borders
of three states and National Forests. Though CRWC was the key player, the
participation of SAFC and CF was vital. These organizations provided staff and
support, making the project possible. Additionally, GIS facilities were available
in the Clemson University Dept. of Planning and Landscape Architecture, and a
grant to CRWC funded a GIS-astute graduate student during Summer, 1995.

2.3.1 Current Scenario. A primary use of the project plan is as a citizens'
alternative in the planning processes of the three National Forests. The
collaborative evolved project requirements that included: (1) perform the GIS
analysis on the CRWC-owned PC; (2) document all analyses, so that the process
is repeatable by other conservation groups, and so that all aspects are open to
scrutiny. (The latter involved a peer review process); (3) produce a *poster* and a
slick document suitable for distribution as *public relations* pieces.
    Since data limitations precluded calculating and overlaying various habitats
as a suitability model would require, the collaborative adopted a strategy to
further expand and protect (buffer) existing protected areas on a sub-watershed
basis. The procedures applied in GIS demonstrate concepts developed by
landscape ecologists (Forman and Godron 1986).
    The group evaluated versions of the plan by comparing plan boundaries to
known locations of resources. The final draft of August 1995 encompassed
significantly more areas of importance within sensible boundaries. The final
methodology was clear, defensible, and supported the vision of the participants.
    Ten to fourteen persons attended meetings at critical points in the project.
Other meetings were convened for reviewers and Board members. The venue
for these meetings was *face-to-face (same time/same-place)*, although analyses
planned at these meetings were performed *same-place/different-time*. The
purpose of the meetings was to review or set direction and criteria for the GIS-
based plan development. They depended on hard copy draft maps of data
elements and analyses, usually produced with Arcview version 2.1. Attempts to
use Arcview in real-time were not particularly successful due to lack of a
projection system, and slow redraw times. Thus, letter sized maps, along with
printing these same maps onto transparencies and projecting them, became the
major geographic mode of communication. We documented the meetings and
analysis design manually, on paper and white-boards.
    The final phase of the project centered on peer reviews, and on producing
the poster and document. These tasks took place in the geographically removed

offices of CRWC, SAFC, CF and the university. The graphic design firm was near SAFC, but distant from all others. Data, documents, products and revisions of necessity moved amongst all these locales -- the venue had shifted to *different-place/different-time*, and lacked effective supporting technology.

2.3.2 PPGIS Needs Revealed. A difficult task in this analysis was coping with the reality of the available data within the short time frame. Although a USFS project developed a GIS database, it was incomplete. Additionally, coalition-performed field work products needed digitizing and documentation. Data transfer amongst the venues and computers consumed scarce resources. Similarly, limitations of the PC and PC Arc/Info created additional work.

 Lack of adequate (GIS) personnel and technological resources caused some problems. Without special support, this project would not have been possible using a GIS/1. It relied upon GIS expertise available *outside* the conservation groups. In particular, it depended upon work by knowledgeable graduate students. Losing a graduate student to another opportunity stymied GIS work late in the stages at the CRWC office. Tools that check for processing errors and which thoroughly document the processing undertaken would be helpful. Access to *smarter* GIS tools could make it possible to do without outside support, and make needed analyses more compatible with available resources. Finally, improved *what-if* tools flexible amongst venues would allow more robust and time-efficient collaboration in plan development.

 A poster publication eventually took on a life of its own. Because the collaborative wanted the poster to have appeal beyond that of a *mere* map, it hired a graphic design firm. Identifying the firm, design, editing, communication, and data transfer difficulties added nearly one year to the process. A substitute for this process would facilitate local creation of *slick* output in any desired media.

 The limitations encountered in the Chattooga process are summarized below. For communication management these include the need for tools which aid geographic communication across all meeting venues. In addition, there is a need for tools which interface seamlessly across output options and media (e.g., web, printing, CD-ROM).

 For information management the tools include the need: to develop feasible ways to share data and results in a timely and inexpensive manner, including assurance of adequate access to the Internet or viable alternatives; to support field development of local data; to support critique of data and results; and the need to provide metadata tools which track and know the *meaning* of data bases, so that information is not lost due to staff and constituency changes within organizations. In addition there is a need for tools which record analyses processes such that the record of the analysis becomes part of the product, and at the same time a *model* usable by others.

 For spatial analysis there is a need for tools with capabilities to substitute for human GIS expertise. There is a need for accessible tools to model population viability, and out-of-region externalities (e.g. air quality, continental

rarity). Given that groups successfully develop multiple sub-regional plans, we need tools to aid in their combination into a bio-regional plan.

2.3.3 Discussion. It is apparent that the needs of conservation groups encompass many venues, ranging from in-house personal analysis and in-house group collaboration, to interfaces with the planning and analysis processes of other agencies and groups in more public venues. The ideal PPGIS should support the full continuum of venues and modes of interaction if participation is to be fully encouraged.

3. CAPABILITIES IN A PUBLIC PARTICIPATION GIS

Generalizing across the scenarios we find that a GIS-enabled public participation process involves three phases: explore data to clarify issues (availability of data), establish a set objectives from what is known, and evaluate options about what is known. The three phases can each, more or less, make use of capabilities at two levels of sophistication (See Table 1). The two levels of sophistication are essentially "building block" levels, i.e., level 2 would not work effectively without level 1, but level 1 could stand alone.

Table 1. Functional Capabilities in a Public Participation GIS (adapted from Nyerges 1995)

Level 1: Basic information handling support
(a) Group Communication: idea generation and collection includes anonymous input of ideas, pooling and display of textual ideas, and search facilities to identify common ideas, (e.g., data/voice transmission, electronic voting, electronic white boards, computer conferencing, and large-screen displays)
(b) Information Management: storage, retrieval and organization of data and information (e.g., spatial and attribute database management systems)
(c) Graphic Display: visualization techniques for a specific part of a geographical problem (e.g., shared displays of charts, tables, maps, diagrams, matrix and/or other representational formats)
(d) Spatial Analysis: basic analysis functions (e.g. overlay and buffering)

Level 2: Enhanced analysis/discussion support
(e) Process Models: computational models that describe/predict the character of real-world processes (e.g., simulation models for describing changes in crime events or surface water flow across time);
(f) Decision Models: integration of individual criteria across aspects or alternatives, (e.g., multi-criteria decision models using multi-attribute and multi-alternatives for weighting rankings or preferences).
(g) Structured Group Process: methods for facilitating/structuring group interaction, (e.g., automated Delphi, nominal group techniques, electronic brainstorming, and technology of participation).

4. CONCLUSIONS AND FUTURE PROSPECTS

Given the interest in participatory decision making, there is a clear interest in PPGIS. The above needs and system requirements identified from these needs are coincident with many of the issues discussed and outlined in recent initiatives of the National Center for Geographic Information and Analysis. Particularly relevant is work performed under Initiative 17, Collaborative GIS (Densham, Armstrong and Kemp 1995) and Initiative 19, GIS and Society (Harris and Weiner 1996). In addition, a meeting on PPGIS held in summer, 1996, at the University of Maine refined these discussions (see http://ncgia.spatial.maine.edu/ppgis/ppgishom.html).

Some implementation progress is evident in these areas. Currently two flavors of developing PPGIS seem to exist. These reflect the degree of dependence upon skilled human operators, and the venues to with which they best fit. One flavor uses the expertise of a GIS analyst in the same-time/same-place venue to aid in group-based information exploration as described by Shiffer (1992) and Couclelis and Monmonier (1995), and group decision making as described by Nyerges (1995) and Jankowski et al. (1997). We term this flavor *soft-PPGIS*. In *soft-PPGIS*, the human chauffeur encapsulates needed system knowledge. The GIS support from a technically knowledgeable person in a same-time/same-place meeting is a defining characteristic of this type of use of a PPGIS. Clearly, all three scenarios could benefit from this type of assistance for interaction.

The second flavor of work focuses on software for *same-place/different-time*, and *different-place/different-time* meetings, e.g., as reported in Jankowski and Stasik (1996). Clearly, communication management needs to evolve to address this type of interaction. System capabilities would be needed to substitute for available human expertise. Tools that allow non-sophisticateu users to perform analyses *equal* to those performed by agencies can play an important role in leveling the playing field amongst alternatives.

As discussed in NCGIA Initiative 19 (Harris and Weiner 1996), an additional important capability is to portray local or differential cultural knowledge and concepts. This knowledge, and alternatives generated, regardless of venue, must eventually interface with other schemes in the PPGIS.

The needs for and developments of PPGIS described above indicate that considerable opportunity exists for "socializing GIS". The technical developments, although important, are likely to take a back seat to the social developments of information use. Of equal importance to research on the technical capabilities of PPGIS will be the research on system use. If we do not know how information is being used in various social contexts, then our system developments might be mislead. A balanced approach to conceptual, empirical and system oriented research will likely encourage beneficial outcomes.

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