

# **Collaborative Geographic Information Systems**

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## Chapter XII

# Design Considerations for an Internet Portal to Support Public Participation in Transportation Improvement Decision Making

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### Abstract

*Recent research about "analytic-deliberative" decision processes shows that meaningful public participation is possible, and decision outcomes are improved. The analytic component provides technical information that ensures broad-based, competent perspectives are treated. The deliberative*

*component provides an opportunity to interactively give voice to a diversity of values, alternatives, and recommendations. Unfortunately, such public participation has been expensive and time consuming, and thus involved small groups. An Internet system that combines geographic information system technology, decision modeling technology, and communications technology into a geospatial portal to support analytic-deliberative processes might be one way to facilitate meaningful participation in large groups as a way for agencies to more effectively engage a public who wishes to participate. The core research question underpinning our work on system design is: What system design considerations for various analytic-deliberative capabilities will foster support of structured and flexible, analytic-deliberative, transportation improvement decision processes?*

### Introduction

Research about local governance suggests that there is little "meaningful public participation" in public-oriented decision making because it is a complex process, and communication within large groups of publics can be time consuming and rather expensive (National Research Council, 1996; Renn, Blattel-Mink, & Kastenholz, 1997; Smith, 1999; Taylor, 1998). Despite this expense and complexity, laws mandate that it occur. For example, U.S. federal (NEPA, 1970; U.S. Department of Transportation, 1998) and many state transportation laws mandate public participation in at least three pervasive decision situations—long-range planning, capital improvement programming, and major investment studies—that occur at local, regional, and state levels of government. Similar laws mandate public participation in many democracies around the world.

Consequently, it makes sense to investigate the development of advanced information technologies that may be able to foster more efficient, effective, and equitable approaches to meaningful public participation in decision processes. In our research about information technology to support complex decision processes, we focus on the transportation improvement program (TIP) decision situation because it is the intermediate spatial-temporal scale of decision process between planning and project-level decision situation. A TIP consists of a set of transportation projects proposed for development on a "roll-over" basis, that is, projects get added to a 6-year programming budget to be scoped, designed, and then constructed, with those constructed getting "rolled-off." Preparation of a TIP is a rather complex group activity. The activity can involve elected officials, policy analysts, technical specialists, and the public as diverse groups of interested and/or affected persons (Smith, 1999; Taylor, 1998). The TIP process can take months to complete, every 2 years.

Transportation decision processes, like many complex decision processes as, for example, in land-use and environmental decision making, have commonly included analytic and deliberative components performed by different groups. Planner/analysts as technical specialists commonly analyze transportation options, and then hand off information to policy specialists (policy makers and elected officials) who deliberate over what options to select. There has not been much chance for the public to participate in that process in any meaningful way other than to be the recipient of information (in "decide and defend processes"), despite the fact that they are among the principal stakeholders in such decisions.

Meaningful public participation is about *access to voice* and *competence of knowledge(s)* that foster *shared understanding* about cultural values, interests, and concerns (Renn, Webler, & Wiedemann, 1995; Smith, 1999). Research about analytic-deliberative, environmental decision processes shows that meaningful public participation is possible, and decision outcomes are improved in relation to such concerns (National Research Council, 1996; Renn et al., 1997). Although analytic-deliberative decision settings have been convened in synchronous face-to-face settings particularly in small groups, there have been no settings that support, and thus empower, large groups (e.g., 100 or more people) in asynchronous, analytic-deliberative public participation. An Internet system that combines geographic information system technology, decision-modeling technology, and communications technology into a geospatial portal to support an analytic-deliberative process might be one way to facilitate meaningful participation in large groups.

Based on the above context for complex, group decision making in which a plural and diverse public is involved, the Participatory Geographic Information Systems for Transportation (PGIST) project is developing asynchronous, Internet-based geographic information system (GIS) tools to support creation and use of analytic information structures (e.g., maps, tables, models) within the context of online deliberative discourse. The PGIST portal will be used to support public participation in a regional transportation improvement decision situation in the central Puget Sound area of Washington State, constituted as a field experiment. The PGIST project contributes to the overall advancement of digital government and electronic democracy research by articulating analytic-deliberative decision processes in terms of multilevel granularity, and expressing that process as a system design.

The system design for the PGIST portal has been conceptualized in terms of five functional clusters that work together as one integrated whole: agenda management, concerns-values organization, alternatives generation, choice modeling, and reflective document review. The agenda manager establishes decision situation and session agendas, that is, the overall sequence of work in an asynchronous setting. The concerns-values organizer supports asynchronous discussions about what is important among the public in transportation improve-

ment decision making, as well as articulating those concerns explicitly in ways that can be reconciled with the concerns of others. The alternatives generator helps groups establish scenario alternatives composed of multiple transportation project alternatives, for which various economic, social, and environmental impacts related to participant concerns are modeled and visualized. The choice modeler supports trade-off analysis of the impacts, from scenario to scenario and project to project. The reflective document review capability allows users to submit their comments on any aspect of any particular outcome within any functional cluster. Each functional cluster contains a collection of analytic-deliberative tools; each tool developed as a Web service to support participatory decision making. Consequently at this stage of the project, the core research question underpinning our work on system design is: *What system design considerations for various analytic-deliberative capabilities will foster support of structured and flexible, analytic-deliberative, transportation improvement decision processes?*

In section 2, we first lay out the theoretical framework in which this research is situated, describing how we are moving from years of developing participatory information systems and studying their use within a small group context to development and study of information technology in large, public groups. We discuss the underpinnings of our theoretical framework, particularly fundamental constructs in enhanced adaptive structuration theory that we extend with principles from deliberative democracy theory. We subsequently relate principles from deliberative democracy to more specific system design goals as a detailing of process design considerations. That framework is used to then pose and answer three subquestions in the remainder of the chapter. First, what is the nature of the analytic-deliberative participation we seek? Second, what is the nature of the public who is participating in the process? Third, what analytic-deliberative system capabilities are necessary to foster that public participation? Those subquestions are addressed in sections 3, 4, and 5, respectively. In section 3, we draw upon research and practice in structured participation to identify more concretely what system design functionality may help us to realize the normative goals expressed in section 2. In section 4, we discuss our conceptualization of the diverse and plural public for whom we are designing the PGIST portal, and describe a research strategy that enables us to iteratively improve the system design by enabling us to question our assumptions about the participant/user. In section 5, based upon our design principles for analytic-deliberative process and people participating, we introduce the functional capabilities expected to implement the system design. We do this in terms of "function screens" that depict system capabilities. In section 6, we conclude the chapter with observations about the design process.

## Theoretical Framing of System Design Considerations

Design considerations for information technology development are framed by our understanding of complex decision situations. In the mid-1990s, Nyerges and Jankowski (1997) developed enhanced adaptive structuration theory (EAST) to frame technology development efforts, as well as to undertake studies of information technology use. An updated version of EAST was published, along with several empirical studies, a few years later (Jankowski & Nyerges, 2001b). Over the years, EAST was used to frame the development of several GIS groupware systems, Spatial Group Choice for habitat redevelopment site selection (Jankowski, Nyerges, Smith, Moore, & Horvath, 1997), GeoChoicePerspectives as a generalized software for many types of site selection including transportation improvement (Jankowski & Nyerges, 2001a), and more recently, WaterGroup for conjunctive water administration planning (Robischon, Jankowski, Nyerges, & Tuthill, 2003). Furthermore, EAST has been used as the basis of empirical studies of information technology use by decision groups for transportation improvement (Nyerges, Montejano, Oshiro, & Dadswell, 1997), water resource management (Nyerges, Jankowski, Ramsey, & Tuthill, 2003; Ramsey, 2004), habitat redevelopment (Jankowski & Nyerges, 2001c), and health resource allocation applications (Jankowski & Nyerges, 2001b). The current version, EAST2, includes eight constructs that characterize complex decision situations. Three of the constructs describe convening influences of complex decision situations: 1) institutional influences such as what laws or regulations motivate the decision situation and the nature of the task to be accomplished, as in this case transportation improvement program decision making; 2) group participant influences such as who scopes the task, how many people are to be involved in the process, and the group and/or individual motivations, responsibilities, authority for participating in the task; and 3) what information technology is available for generating information relevant to the process. Three other constructs characterize the social-technical decision processes: 4) what is appropriated, that is, which of the three convening construct influences are actually part of the decision process; 5) what is the nature of the analytic-deliberative group process characterized in terms of flow and management; and 6) what are the emergent influences not anticipated within the appropriation of convening influences (i.e., constructs 1-3). The process results in the last two constructs that are 7) what decision task outcomes are relevant to the original mandates motivating the decision situation, and 8) what social outcomes characterize the changed dynamics of the (inter)organizational decision situation that feed future decision situations. The variety of EAST2

constructs encourages us to understand that information technology use (and hence by reason, its specification, design, and implementation) is influenced by a rather broad-based set of issues. When dealing with a system designed to improve democratic decision making, chief among the constructs described above is the analytic-deliberative decision process (construct 5), and the way in which analytic subprocesses combine with deliberative subprocesses. While the PGIST project as a whole is motivated by attention to all eight constructs, this chapter specifically focuses on enhancing the nature of construct 5 by presenting design principles synthesized from deliberative democracy theory. Understanding the principles of deliberative democratic theory provides a basis for articulating design considerations for such analytic-deliberative processes, as we will show (Wilson, Ramsey, & Nyerges, 2005).

Deliberative democracy is an ideal form of governance in which institutions are arranged in such a way that decisions result from "processes of collective deliberation conducted rationally and fairly among free and equal individuals" (Benhabib, 1996, p. 69). This notion of democratic decision making draws from Habermas's notion that rationality is constructed socially through intersubjective communication (Healey, 1992). In other words, reason can be thought of as "intersubjective mutual understanding arrived at by particular people in particular times and places, i.e., historically situated" (Benhabib, 1996, p. 150). As proponents of communicative planning (e.g., Healey, 1992; Innes, 1998) argue, thinking about rationality and reason in this way has profound implications for planning practice. For example, rather than appealing to "rigorous" scientific analysis to identify the optimal solution to a planning problem, planners should instead create and facilitate arenas where deliberation about the problem can occur, and shared understandings can be collectively sought. Additionally, communicative planners emphasize the importance of procedures that help to ensure that deliberative forums are fair and that power differentials do not dictate decision outcomes. For example, Dryzek (2002) argues that forms of communication that involve coercion or that cannot connect an individual's particular interest to the general common good should always be excluded from deliberation. In its ideal form, deliberative democracy involves all participants striving towards shared understandings and consensus: however, many theorists recognize this ideal of consensus as unattainable, and argue that deliberation will often need to be followed by a vote to make final decisions (e.g. Cunningham, 2002; Gutmann & Thompson, 2004). In such cases, the open deliberative process provides for a more informed vote and a more legitimate decision outcome.

Young (1996) offers an important critique of the ideal notion of deliberative democracy. She argues that the assumption that participants in a deliberation can be free and equal is simply false. This is because the kind of communication called for by most deliberative theorists — argumentation — privileges aggressive and confrontational forms of speech over speech that is exploratory or

conciliatory. As an alternative, Young calls for a variation of deliberative democracy (one she calls “communicative democracy”) that explicitly attends to social and cultural difference. Essentially, she argues that deliberative forums should be open to other forms of communication that are often shunned by deliberative theorists, such as greetings, storytelling, and rhetoric. This motivates us to add “analytic communication” to that set as well: that is, deliberation through the use of analytics (maps, models, etc.). Furthermore, rather than focusing on the suppression of conflict and expressions of individual interest in favor of focusing on commonalities, Young (1997) argues that we should view difference as a resource for democratic decision making, and encourages the expression of individual perspectives and interests. This, she argues, can lead to “transformations” in which listeners recognize that their own perspectives are partial, that they are engaged in collective decision making, and learn that some people have unique needs that may not be considered when deliberations only focus on the common good.

A significant aspect of many public decision-making processes that is not explicitly addressed in these theorizations of deliberative democracy is the use of analytic information, such as maps, computational models, scientific research findings, or other information that is created with the intension of informing decision makers. In order to better understand the relationship between analysis and deliberation, we turn to the work of scholars in the fields of planning and environmental decision making. This issue is explicitly addressed in the book *Understanding Risk*, published by the National Research Council (1996). The authors propose an “analytic-deliberative process” as a normative approach to involving citizens and stakeholders in environmental risk assessment. This is a process of iterative analysis and deliberation designed to help participants work to create a broad understanding of the situation (National Research Council, 1996). In the analytic-deliberative process, deliberation is used at each stage of a structured process to elicit concerns, ideas, and questions from participants, which in turn guides and motivates analysis, while analysis provides reliable (detailed) information in order to inform deliberation. In their examples, technical experts perform the analysis while stakeholders do the deliberation. This division of labor is consistent with many participatory consensus building models, such as the one proposed by Renn et al. (1997). Assuming that the stakeholder participants represent the spectrum of interested and affected parties, the analytic-deliberative process, the authors argue, can help to avoid the problem by which analysts fail to address the questions of central concern to those affected by the decision (National Research Council, 1996).

Along those same lines of reasoning, Rinner (2001) and Kirschner et al. (Kirschner, Shum, & Carr, 2003) suggest the use of “argumentation maps” for providing both analytic and deliberative perspectives to conversations. Argumentation maps provide discussion contributions embedded at the feature

locations where those contributions are relevant “on the ground.” Using such maps, one should be able to follow a discussion via maps, or follow map-to-map sequences through a conversation. This is the notion that Couclelis and Monmonier (1995) were after in their spatial understanding support system suggestions. Combining analysis and deliberation through maps can open conversations about place and space.

Despite all of those developments above, details about analytic-deliberative processes are still in need of research investigation. In a review of the analytic-deliberative process, Fischer (2000) acknowledges its benefits for supporting meaningful stakeholder participation in complex decision processes, but also argues that the strict boundary between analysis and deliberation reinforce a false binary. According to Fischer, all acts of analysis involve deliberation and likewise, deliberative practices involve analysis. Therefore, he advocates for opening up analytical processes, and the information produced by these processes, to critical (deliberative) scrutiny. Furthermore, he argues, the goal of deliberation should not only be “to improve understanding but rather to create it through exploring the social meaning of the research and its findings” (Fischer, 2000, p. 250). These recommendations are consistent with the research findings of Judith Innes. Reflecting on her studies of consensus-building processes in planning and policy making, Innes (1998) argues that in order for information to be influential in the decision-making process, it needs to “represent a socially constructed and shared understanding created in the community of policy actors” (Innes, 1998, p. 56). One way that this can happen, she says, is through deliberation between participants regarding the meaning of the information.

From the research contributions to analytic-deliberative processing described previously, we take our initial motivation about analytic-deliberative processes from the National Research Council (1996) report. We add to that Fischer’s (2000) and Innes’ (1998) conceptualizations of a more intertwined analytic-deliberative process. We then articulate multiple levels of granularity in the relationship between analytic and deliberative processes. In working out our contribution in the design presented below, we do not expect that the analytic information available in our system, such as maps and scenario impact visualizations, will simply *inform* the deliberative process. Rather, we will encourage participants to discuss the relevance of information, contest or defend its validity, and otherwise deliberate *about* the information. Through this deliberation, we hope that participants will generate shared understandings about the meaning and significance of different kinds of information to the decision problem, and that the information is *actively* considered (or dismissed) as participants generate opinions about their preferred decision outcomes.

Based upon these various normative conceptualizations of deliberative democracy and their relationship to analytic-deliberative process, we have synthesized

Table 1. Deliberative democratic principles as design spirit motivate system design goals

Principles as Design Spirit	System Design Goals
Participation is open, fair, and equitable.	<ol style="list-style-type: none"> <li>1. The system should be easy to use, particularly by those with less experience with information technology.</li> <li>2. Accommodate and encourage as many kinds of participant contributions as possible rather than limit to arguments or statements about the common good.</li> <li>3. Avoid privileging any particular kind of contribution or communication.</li> <li>4. Downplay the domination of deliberation by the vocal few, as well as help to empower those who are less vocal (e.g., "lurkers") by providing ample opportunities to contribute in anonymous and/or non-verbal ways.</li> <li>5. Provide equitable access to information about the decision problem (i.e., file formats all can read, simple and understandable language, etc.).</li> </ol>
Participants are free to deliberate about (and therefore influence) the decision making process.	<ol style="list-style-type: none"> <li>6. The system design should be flexible enough to allow for the timely alteration of the procedural agenda at any stage during the decision process.</li> </ol>
Deliberation is augmented by votes or other procedures to bring about resolution when consensus is not possible.	<ol style="list-style-type: none"> <li>7. Include functionality that allows for a quick tally of votes on an issue when the need arises.</li> <li>8. Provide functionality for polls, prioritization, ranking, and other aggregative procedures to provide snapshots of the level of overall consensus.</li> </ol>
Deliberation leads to transformations, in which participants begin to think beyond their individual interests and perspectives.	<ol style="list-style-type: none"> <li>9. Recruit participants with diverse backgrounds, interests, and perspectives.</li> <li>10. Encourage and accommodate expressions of differences in perspective (including conflict).</li> <li>11. Encourage participants to make contributions to the deliberation that are compelling to other participants.</li> </ol>
Deliberation supports and encourages the consideration of analytic information (i.e., the analytic-deliberative process).	<ol style="list-style-type: none"> <li>12. Provide analytic information that participants are likely to find relevant to the decision problem.</li> <li>13. Have technical and/or policy experts available to quickly respond to questions as they arise.</li> <li>14. Support and encourage deliberation about the meaning and relevance of this information.</li> </ol>

a set of principles that become the spirit for our system design (Table 1). A "spirit" for system design is a concept articulated in the group support-systems literature as a foundational guide for system development (DeSanctis & Poole, 1994). Commonly, principles are rather abstract, but they do help designers to articulate a corresponding set of goals for system design (Table 1). While these principles are useful for guiding our design process in the broad sense, three major questions remain unanswered. First, what is the nature of the analytic-deliberative participation we seek? Second, what is the nature of the public who is participating in the process? Third, what analytic-deliberative system capabilities are necessary to foster that public participation? In section 3, we address the first subquestion by turning to the facilitated-participation literature to seek insight about the practice of deliberation. Fortunately, a number of structured

participatory methods are available that have been proven to help realize many of these principles of deliberative democracy and motivated system design goals in face-to-face settings involving small- to medium-sized groups. However, how can such methods be used as the basis of structuring analytic-deliberative participation that we seek for large groups? We turn to this question in the following section.

## A System Design Strategy for Supporting Analytic-Deliberative Process

We recognized early on that one of our system design goals would require significant attention in the system design process: the need for a design that is flexible enough to allow for the timely alteration of the procedural agenda at any stage during the decision process (system design goal 6). Therefore, rather than focusing our system design strategy on a single, linear set of analytic-deliberative procedures that the portal needs to support, we focused on identifying individual tasks and procedures that could occur at any point in a decision process. To do this, we first present a comparison of four structured participation methods commonly used in face-to-face decision processes. After unpacking each method into a series of procedures, we describe how the procedures can be realized in an online asynchronous setting in the form of "participatory-games" (or p-games). Finally, we present a participatory actions framework as a finer-grained approach to translate p-games into actual system implementation. It is through this unpacking of methods that we make the design considerations for asynchronous, online analytic-deliberation a manageable software development activity.

### Comparison of Methods of Structured Participation

Commonly across the strategic planning and facilitation literature, structured participation methods organize activities for participants for generating and refining ideas, especially those designed to problem solve and provide for "meaningful participation." Four methods have thus been identified from planning and management literature as potential alternatives to conventional, unstructured group processes. These include nominal group technique, Delphi process, Technology of Participation, and citizen panel/jury (Andersen & Jaeger, 1999; Brahm & Kleiner, 1996; Delbecq, Van de Ven, & Gustafson, 1975;

Table 2. Procedures of four methods of structured participation

Nominal Group Technique (NGT)	Delphi Process (DP)	Citizen Panel / Citizen Jury (CPJ)	Technology of Participation (ToP)
1. Goal statement 2. Brainstorm ideas 3. Clarify/negotiate ideas 4. Vote on idea priority	1. Goal statement 2. Generate ideas 3. Collect ideas 4. Synthesize ideas 5. Playback ideas 6. Request for further change	1. Listen to evidence 2. Discuss evidence 3. Negotiate positions 4. Vote 5. Repeat until reach consensus	1. Goal statement 2. Generate ideas 3. Collect ideas 4. Cluster ideas 5. Synthesize ideas 6. Label ideas 7. Negotiate idea priority

Dowling & St. Louis, 2000; Roth, Schleifer, & Switzer, 1995; Spencer, 1989; Turoff & Hiltz, 1996). Each method was chosen for this comparison study as each offers a set of quite different procedures to address similar consensus-driven outcomes. Nominal group technique is a structured form of brainstorming or brainwriting, followed by a vote or prioritization in a synchronous setting with up to 10 participants and an experienced facilitator (or 3 to 4 groups of up to 10 participants, with a spokesperson for each group and a single facilitator overall) (Mycoted, 2003). Delphi process, developed in 1950 by the Rand Corporation, is a series of questionnaires, each building on the responses of previous questionnaires, that require a panel of participants to synthesize and determine the nature of follow-up questionnaires (Delbecq et al., 1975). Technology of participation (ToP) is a participatory process of defining a context for discussion as a goal and then following through to address that goal using brainstorming, ordering, labeling, and prioritizing ideas through facilitated, group discussion (Spencer, 1989). Citizen panel/jury, also known as a consensus conference, is a situation where citizens are informed of an issue and encouraged to deliberate (through formal presentation of evidence, argument, and rebuttal) to offer a solution to a governing body (Jefferson Center, 2004; Sclove, 2000). The comparison of these four structured participation methods illustrate that, while differing in procedure, each is steeped in the principles of deliberative democracy (that of a privileging of procedure, a notion of shared understanding, and support of consensus-building) (Wilson, 2005). As can be seen in Table 2, each method offers a particular ordering of a specific set of procedures.

### “Participatory-Games” as an Organizing Framework for System Design

A primary goal of the PGIST project is to develop a system capable of implementing these face-to-face structured participation (deliberation) methods,

Table 3. Participatory-games that comprise the normative concerns and values organization process in the PGIST system design

NGT	DP	CPJ	ToP	Participatory-game	Description
X	X		X	Goal statement (context setting)	Participants deliberate over the goal for the decision making situation.
X	X		X	Brainstorm items (uncloaked or cloaked to group)	Participants are encouraged to submit multiple items in contributing to the decision making situation.
X		X	X	Negotiate (clarify) items	Participants discuss generated items, and in the process clarifying the item for the entire group.
	X		X	Synthesis cluster and label items	Participants cluster and merge items with other items in a synthesis process.
			X	Refine clusters	Participants refine the sets of items, taking the new labels and evaluating if each item still fits the clusters.
X		X	X	Vote/poll	Participants vote/prioritize/rank items according to criteria.
	X			Survey	Participants are allowed a more open-ended response to directed questions.
	X	X		Review/evaluation	Participants review and evaluate.
These p-games were specifically designed to facilitate certain activities within PGIST.				Threaded discussion	Discussion is facilitated as needed, somewhat informally.
				Develop concerns hierarchy	Participants convert concern clusters into concern hierarchies.
				Convert concerns hierarchy into value hierarchy	Participants type each concern in concern hierarchy as a value, goal, objective, or criteria.

but in an online and asynchronous setting. The procedure would be moderated, combining facilitation and technology chauffeuring into one role called a moderator. In order to implement those four methods as well as perhaps to discover a new one, we unpacked and synthesized the procedures listed in Table 2 into a set of distinct activities that we call “participatory-games” (or p-games), forming perhaps the most important level of conceptualizing an analytic-deliberative process design. In Table 3, we present a core set of p-games that may be used in any functional clusters mentioned in the introduction to this chapter, but particularly in a concerns and values elicitation and organization process. On the



left side of Table 3 are four columns listing those methods, and in the cells of the table an "X" indicates which games are a part of which methods.

We use the term "game" to describe a basic set of rules (as steps in a procedure to organize peoples' behavior) for conducting an information exchange. It is at this level that structured participation occurs as an articulation of analytic-deliberative process. In order to better understand the interplay between analytic and deliberative activities, we articulate participatory-games as being comprised of a combination of analytic and deliberative activities. For the purpose of system design, we define analytic activities as periods in which individual participants interact with an information structure (e.g., map, model, table, etc.). Deliberative activities, on the other hand, involve the interaction among participants based principally on communication as conversation or discussion, including some aspect of reasoning.

What was somewhat surprising about this analysis, but not terribly unexpected, was that the total enumeration of these games in this manner showed us that the procedures in the four participatory methods are insufficient to support analytic activities. For example, the analytic-deliberative process we are designing to support the ability of participants to express and organize their concerns about transportation improvement includes developing hierarchies of concerns, and then converting these to value structure hierarchies consisting of values, goals, objectives, and criteria (following Wachs & Schofer, 1969). These tasks involve specific analytic activities that are not supported by the other participatory games. Therefore, we added two additional participatory games, which are listed at the bottom of Table 3, that include these analytic activities.

### A Participatory Actions Framework

In order to detail a system design framework, we must drill down to articulate the steps within "games" and further to articulate the various user-system level activities that support the analytic or deliberative acts that comprise the games. This method of drilling down enables us to develop a "participatory actions framework" articulated through the prototyping of analytic and deliberative acts. These acts relate to each other through an abstraction hierarchy, whereby methods are composed of organized games that are composed of sets of acts (each act being a procedural step in a process). This framework enables a more comprehensive design, supporting analytic-deliberative process. As described above, a participatory game is one in which we mix analytic operations together with deliberative procedures, or in other words, we mix *competence* building in the analytic act with *voice* building in the deliberative act. By detailing this in a participatory actions framework, we are able to design a more nuanced approach, whereby analytic and deliberative acts coalesce into a comprehensive

and integrated system design of software objects. It is necessary to establish multiple levels of process granularity in order to design software objects that operate at different levels of analytic and deliberative functionality. Process granularity refers to navigation among an abstraction hierarchy, where objects located in the upper levels of the hierarchy are potentially composed of objects located in lower levels of the hierarchy. The different levels of process granularity provide the basis for an aggregation (embedded building block) description of analytic-deliberative human-computer-human interaction, but they also provide a basis for a generalization hierarchy, that is, more general and more detailed descriptions of actions. The participatory (analytic-deliberative) actions design framework is presented in Table 4.

The elements in the framework provide a rough sense of the granularity of analytic and deliberative acts (and software objects) that embed and interact. The embedding occurs from row-to-row, down the table within each column. Hence in an analytic context, control-validity rules constrain geospatial data elements in the database. Validity rules with data elements are used within operations types, and so forth, down the left column. On the deliberative (right column) side of the table, speech intents can only exist in an asynchronous context using speech signals, and speech intents must be recognized as meaningful transmissions, and so forth. The purpose of the framework is to provide a general design approach about how analytic and deliberative acts can be described at different levels of granularity, and is not intended to unpack all levels of analytic and deliberative acts. The analytic and deliberative cells at each row level are required to design software for enabling analytic-deliberative (partici-

Table 4. Participatory (analytic-deliberative) actions design framework

Participatory Actions	
Composed of Analytic-Deliberative Actions	
Analytic Actions	Deliberative Actions
Data element measurement	Speech Signals
Control validity rule type on data element	Speech Intents
Operation type links data elements into a relationship	Recognized transmissions of intent as content
Analytic expression as an information structure	Speech act makes use of widgets
Analytic-act (a-act) makes functional use of information structures	Deliberative-act (d-act) makes use of communication functions
Analytic and deliberative acts can be combined in a sequence to form p-games	
Participatory methods make use of one or more p-games	
Decision making sessions make use of one or more participatory methods	

patory) acts. The most important rows to provide insight into the design of core functionality in the portal are the *acts*, *games*, and *methods* levels.

The “act” level of granularity makes use of information structures. An information structure is defined as a somewhat common visual communication convention by which people understand the exchange of information. The information is “structured” in such a way that many people can recognize what they see when they are looking at it. For example, a-acts make use of information structures such as maps, decision models, tables, and so forth. In the case of d-acts, for example, people make use of asynchronous conversational exchanges as phrases, sentences, and paragraphs that are basic information structures showing up in online chat, threaded discussions, and even e-mail, and so forth. Together, the a-acts and d-acts create an idea exchange about some topic that, in our case, deals with transportation improvement decision making. In an analytic-deliberative context, when we combine the use of a-acts and d-acts, by design we compose p-games where information exchange can take place.

This normative framework describes human-computer-human interaction using a notion of analytic and deliberative processes, and builds a language for system development whereby each session of asynchronous decision making can be supported using system objects designed from this abstraction hierarchy. However, one way to evaluate this framework in parallel with system development is through empirical evidence. In the next section, we discuss our research strategy about participant users, which will help us conduct this evaluation during iterations of design and implementation.

## Personas as an Approach to Designing for a Plural Public

Thus far, we have described a rather linear and deductive strategy for arriving at a system design — one that does not explicitly take into account the needs, goals, and perspectives of the users. In actuality, the process is far more iterative. One of the main forms of iteration that we perform is reflecting upon, and calling into question, the assumptions about the participant/user that are implicit in the normative theories and participatory methods that motivate our system design. This process of iterative reflection is assisted through the use of personas and decision scenarios, a process we will now describe.

Personas are fictional, but realistic, users developed based on qualitative research about intended users of a software application (Grudin & Pruitt, 2002). The strategy of developing user personas for use in software design settings is

a response to a tendency of software developers to make false assumptions about the goals and motivations of their imagined users. Researchers and practitioners suggest that the development of user personas can help system designers to understand and contextualize the perspectives, goals, motivations, and anticipated behaviors of potential system users, which hopefully leads to design outcomes that help users meet their goals. The intent of generating personas is not to paint a picture of a generic or essentialized user type or representative of specific user groups (such as the “average citizen” or the “environmental activist”). Rather, the point is to generate a set of unique and richly described fictional users based on detailed user research. Personas often focus on the differences, rather than only the commonalities between users of an application. Finally, a persona includes the multiplicity of subject positions that influence how somebody will act in a given situation, rather than one or two essential characteristics that are assumed to dominate.

There are two main groups for whom we are explicitly designing the system. The first is transportation activists: people who are already somehow active in transportation decision making through their attendance at public meetings, active participation in interest groups, and so forth. The second group is potentially active individuals with an interest in transportation issues (e.g., they occasionally read about issues in the paper, are concerned about the impacts of specific transportation projects, etc.), but seldom voice their concerns to decision-makers (other than voting in elections). Both groups could be classified as interested/affected parties based on the three-way decomposition of the public in analytic-deliberative decision situations introduced by the National Research Council (1996). In this classification, the other groups are elected officials/policy makers and technical information specialists/scientists. The three-way grouping takes into account the fact that different people have different official responsibilities/powers in public decision processes. We imagine that all three groups could make use of the PGIST portal: however, we are explicitly designing for interested and affected parties because of our goal of supporting public participation.

We are in the process of conducting in-depth interviews with a diverse sample of individuals who fall within each of these groups. The interviews are focused on gathering information about a variety of individual characteristics, from basic demographic information and daily transportation patterns to in-depth questions about their history of interactions with local government agencies and feelings towards public participation and democratic process. Based on these interviews, we are synthesizing a small set of personas that adequately represent the spectrum of diversity in backgrounds and perspectives among those we interview. In other words, the personas will be fictional composites, inspired by different characteristics of different people we interview. Table 5 provides a

Table 5. Example persona, "Cindy Kramer"

*The following text is excerpted from a more detailed persona loosely drawn from some of our preliminary interviews.*

Cindy is a 33-year-old grade school teacher. She lives and works in the city of Seattle, commuting daily by car. Her primary concern regarding the transportation system is safety. Two years ago she was mugged and assaulted when walking home from the bus after dark, an experience that has had a lasting affect on her. While she recognizes the problems of traffic, sprawl, and pollution, and appreciates efforts to encourage transit use and concentrated urban living, she believes individual safety should always trump these concerns.

More generally, Cindy cares deeply about making the world a better place. However, she does not see political engagement as the best way to do this. In fact, she avoids keeping up with politics at all because she finds political rhetoric to be cynical and manipulative, and feels politics, while necessary, tend to get in the way of making positive changes in the world. Part of the problem with politics, she believes, is that people are under-informed and do not have the time or resources to change that. Along these lines, Cindy feels that social change is a bottom-up process, not top-down, and that education is a key part of creating change.

Finally, she wants people to be more civically-minded and involved in their communities. However, she regrets that she herself has trouble finding time for community involvement due to her busy life.

short excerpt from a sample persona named "Cindy Kramer," which we developed based on preliminary interviews.

One way in which the personas will be used is by imagining how they would respond to different scenarios of system use. We have developed a number of scenarios based on how we currently anticipate the p-games will be used in context. For example, participants may be encouraged to engage in a threaded discussion regarding the benefits and drawbacks of different proposed taxes for generating revenue to pay for transportation improvement projects. In this example, we can imagine how one of our personas may respond or behave by asking questions such as: "What kind of information structures would seem most relevant to her (the persona) in this context?" or "What would be her motivation for making a contribution to this discussion in the first place?" In other words,

we imagine walking through the scenario in the persona's shoes in order to evaluate the accuracy of our original assumptions about how participants would respond. Note that this kind of system evaluation can be done before any code has been written. Therefore, this strategy is extremely useful for iteratively working through information system design problems as very early stages in the system design process. Of course, once a working system is available, we will enlist real human subjects for usability testing and the evaluation of the participatory methods in a transportation improvement decision-making context.

The use of personas as a design strategy changes the notion of the stable and fixed user (a notion that deliberative democratic theory reinforces through implicit and explicit preconditions for unity). The persona then becomes a way to conceptually juxtapose a diverse and plural public with consensual decision making, a process we hope will result in a further nuanced system design that is continually informed by the (re)negotiation of particular subject positions captured by the persona.

## PGIST Portal Functionality

In this section, we outline our preliminary efforts to identify specific system functionality based on the general design strategy outlined in section 3. In other words, we begin to articulate what the user interface will look like and by extension, what the user experience will be like. Focusing on user experience helps us to leverage to explore the needs of users through the development of personas as discussed in section 4. As mentioned earlier, the PGIST portal was originally conceptualized in terms of five functional clusters: agenda management, concerns-values organization, scenarios-alternatives generation, choice modeling, and reflective document review. While this has helped us to articulate the kinds of functionality that the system will be able to support, it does not help to put the use of such functionality in context (i.e., to understand what the user experience will be like). To do that, we have articulated a sample 10-step agenda as the basis of a use-case model that describes how such functionality might be used in a hypothetical decision transportation improvement decision process. In practice, we intend for the participants to use the agenda manager functionality to collaboratively develop the agenda of their choosing with the help of a facilitator. Therefore, the actual agenda in a decision process could vary significantly from this sample. Our actual sample agenda also includes detailed substeps that we eliminated for the purpose of brevity.

- Step 1: Getting started
- Step 2: Create an agenda
- Step 3: Identify objectives and criteria for project evaluation
- Step 4: Review proposed projects and generate scenarios
- Step 5: Compare and evaluate projects and scenarios
- Step 6: Select and prioritize projects and scenarios
- Step 7: Review available funding sources
- Step 8: Select funding sources
- Step 9: Compile a draft report of recommendations for a Regional Transportation Organization
- Step 10: Submit the report of recommendations to a Regional Transportation Organization

Those 10 steps provide a basis for designing a *user experience storyboard* expressed in terms of *function screens*. Function screens are structurally composed of a combination of *slates* and *bars*, which are defined as follows:

- **Slate:** The main window where different information structures (maps, charts, threaded conversations, etc.) are presented. We imagine that the slate will include a number of tabs, enabling the user to quickly switch between information structures.
- **Bar:** A collection of tools available to enable analytic and deliberative acts involving information structures on the slate.

For example, when the user chooses to view a map of the regional transportation system, that map appears in the slate area, and beside that slate a bar appears with tools that will enable the user to perform operations on the map such as zooming or identifying features. Many different types of function screens can be created depending on combinations of slates and bars. The following bar types help to differentiate the types of function screens used in the system design.

- Getting Started Bar (GS Bar) helps the user select a small online discussion group
- Agenda Management Bar (AM Bar) provides tools involved in agenda management
- Conversation Bar (Con Bar) supports conversation dialog

- Valued-Concerns Bar (VC Bar) allows user to express concerns about scenarios and projects, then organize and synthesize those concerns, transforming them into a values hierarchy composed of values, goals, objectives, and criteria
- Map Bar (Map Bar) provides tools for performing operations on a map (e.g., zoom, select, identify, etc.)
- Scenario Generator Bar (SG Bar) supports the exploration of scenario/project impacts
- Choice Modeling Bar (CM Bar) supports trade-off analysis

We have designed function screens composed of slates and bar types for multiple substeps across the entire 10-step process. There are too many function screens to present in the space provided in this chapter, so we provide only a sample. There are function screens for a splash page and registration pages in Step 1 that are not shown below.

An example function screen for completing Step 1: Getting Started is shown in Figure 1. In Figure 1, two bar types appear for each function screen in either a right vertical position or a bottom-horizontal position, as a matter of run-time choice selected by the user. Two bars active on a screen at any time allow a participant to “cross-walk information.” A participant can use one or both of the bars at any given time to communicate with other participants. This functionality implements an underlying design principle of the PGIST portal to provide participants with active voice in various visual communication modes to support a communicative rationality.

Figure 2 provides a simple example of how we imagine our system can support the integration of analytic and deliberative activities. With this function screen, the user can examine the current suggested agenda (a simple analytic activity based on the definition we provide in section 3) and discuss her thoughts about the agenda with others using the conversation bar.

Figures 3a and 3b offer another example. In Figure 3a, we depict a slate and 2 bars for individuals to compose a list of their own concerns about transportation improvement. In Figure 3b, the function screen shows that this can be accomplished in a group setting as well. The combination of both is more likely. The analytic aspect stems from creating a “list.” Sorted (ranked) lists, for example, as in priority of concerns, require people to differentiate along some dimension, even if the rank sort is based on some “gut feeling” dimension. Once again, we imagine a parallel discussion being an essential part of this process.

As mentioned earlier, we imagine the slate will include tabs enabling the user to quickly switch between information structures as necessary. We imagine this capability will be particularly useful during Step 4 of the sample agenda: Review

Figure 1. Joining a discussion group (step 1.3)

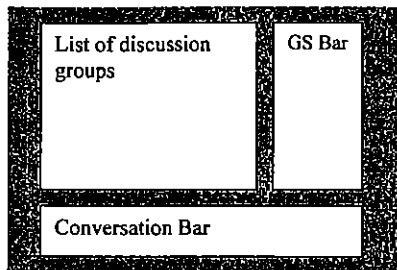
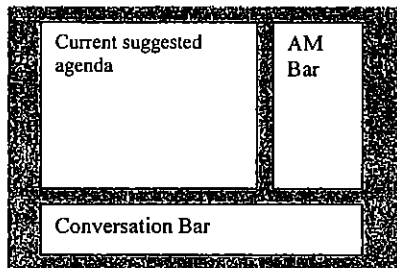


Figure 2. Agenda setting (Step 2.1)



proposed projects and generate scenarios. In Figure 4, the user can explore and learn about individual proposed projects using the map. In Figure 5, the user can generate a new scenario (or collection of projects proposed for funding) using a scenario generation guide that helps her to select projects based on her expressed concerns. During the process of scenario generation, it is likely the user will want to refer back to the map to see where individual projects in the scenario are located. The tab functionality will allow the user to iterate between the two screens as necessary while maintaining a parallel conversation in the conversation bar.

Some function screens are more analytic than deliberative because considerable data analysis is involved, for example as in Figure 6. Because both bars in both function screens are analytic in nature, these functions would be more heavily oriented to analytic interaction. That is not to say that deliberation would not occur in this human-computer-human interaction. In fact quite the contrary, as trade-off analysis and equity mapping are likely to foster considerable delibera-

Figure 3. Individual and group concerns elicitation and sorting

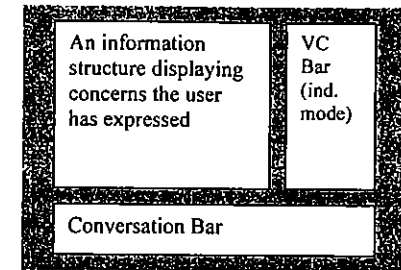


Figure 3a. Individual (Step 3.3.3)

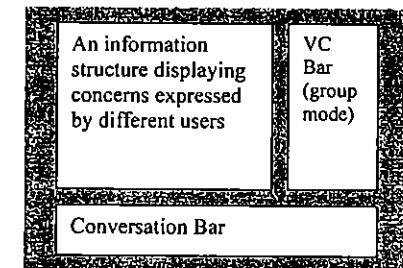


Figure 3b. Group (Step 3.3.4)

Figure 4. Explore projects in a neighborhood (Step 4.1)

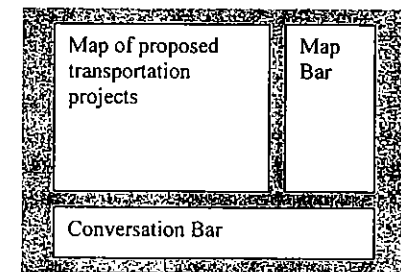


Figure 5. Explore possible scenarios impacting a neighborhood (Step 4.2)

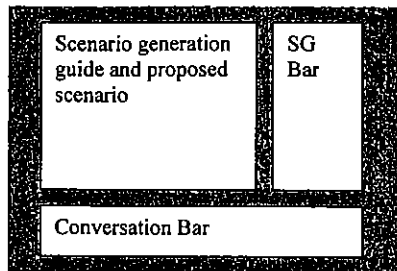


Figure 6. Trade-off analysis to support spatial equity balancing

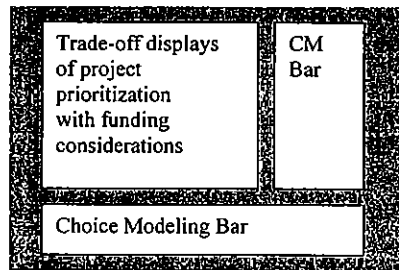


Figure 6a. Trade-off Analysis (Step 6.3)

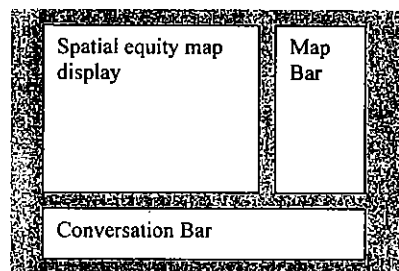


Figure 6b. Spatial equity balance (Step 9.1)

tion about who (what neighborhoods) might win, who (what neighborhoods) might lose, and what criteria are being used to determine this.

## Conclusion

In this chapter, our discussion about normative theories of deliberative democracy has shown how analytic-deliberative process can be reconceptualized as a process whereby participants discuss the relevance of information, contest or defend its validity, and otherwise deliberate *about* the information. Through deliberative processes, we hope that participants will generate shared understandings about the meaning and significance of different kinds of information to the decision problem, and that the information is *actively* considered (or dismissed) as participants generate opinions about their preferred decision outcomes.

We have synthesized principles from deliberative democracy theory and used these as design principles to formulate system design goals for the PGIST portal. From there we recognized that structured participation methods are inherently based on deliberative design principles. A detailed comparison of structured participation methods provides us a way to unpack those methods into procedures of participation. We call those procedures "participatory-games" (p-games), whereby each game (as a procedure) can be further unpacked into steps we call the "participatory acts" (analytic-deliberative acts). The transportation improvement decision situations require a multitude of analytic and deliberative acts.

These different levels of granularity for participatory act(ion)s were formed into a participatory (analytic-deliberative) actions framework, the core of which are participatory (analytic-deliberative) acts that underpin participatory-games. We have argued that the normative ideal of participant activity can be supported through asynchronous structured deliberation in the form of those "participatory-games."

One such p-game focuses on the elicitation of participant concerns and the structuring of these concerns into hierarchies of values, goals, objectives, and criteria, a central concern within public participation transportation improvement program decision making. In most system design situations, developers seek a comprehensive framework as a guide for system design. We have articulated a participatory actions framework to assist in the systematic unpacking of the various user-system level objects to support p-games.

Additionally, we employ a research strategy for design evaluation based upon personas. Personas enable us to challenge assumptions in our normative

theoretical framework, and iteratively refine our system design to reflect the needs and perspectives of actual users.

In order to understand how the p-games and actions might be situated in context, we developed a sample 10-step decision process, and used that process to develop a storyboard of functionality screens. This helped us to understand how different interface features (and therefore different web services) would need to be juxtaposed, and to understand how to facilitate the easy flow from one task to another. This design approach, using functions screens composed of slates and bars, has proved to be extremely useful for a number of reasons. First, it allows us to evaluate how well the functionality would meet the needs of our various user personas faced with particular situations in a broader decision context. Second, the storyboards can be created and changed rapidly, unlike detailed interface mock-ups, allowing us to quickly evaluate different hypothetical juxtapositions of functionality and information structures in the form of bars and slates. Once we identify a storyboard of functionality screens that we feel is strong, we can move on to the process of mocking up the interface for more detailed usability studies. Clearly we still have a long way to go before a working system is ready for use. However, we hope that this discussion of our design process may be of use to other researchers faced with a daunting system design project such as this one.

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## Chapter XIII

# Internet-Based Spatial Decision Support Using Open Source Tools

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## Abstract

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*In the last half decade, there has been growing interest in the concept of collaborative geographic information systems (GIS) in support of decision making, especially in the context of various domains of planning. This interest has spawned an already substantial literature in what is now becoming popularly known as public participation GIS (PPGIS) or community GIS. A central and general objective of PPGIS is to encourage the use of GIS technology by broadly based and geographically dispersed nonexpert users. In the context of planning decision support, this involves creating software with map-based functionality that is responsive to the needs of user groups that have limited experience with computers and only a rudimentary knowledge of even simple spatial analysis concepts. This functionality should be designed to enable these individuals to communicate and interact with higher level users and agencies on an equal footing so*