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Decision Support and Consensus Building

for

PLANiTS

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ABSTRACT

Decision Support and Consensus Building for PLANiTS

Developments in intelligent transportation systems simultaneously present challenges and opportunities to urban transportation planning. The challenges to planning stem from the increased range and added complexity of the choices available to transportation planners. The implementation of IVHS technologies, many of which have system-wide implications, will require change in the institutional arrangements that are currently at work in transportation planning, The opportunities for improved transportation planning are arising from the availability of information, communications, and computation technology.

These same elements, which add intelligence to the transportation system, can be "harnessed" to enrich the planning process and to address the increasing complexities. Indeed a major advantage of new transportation technologies such as IVHS is the availability of new or enhanced information sources that can be of use to improve planning. But increased access to information can also overwhelm participants. A significant opportunity exists to assist planners to understand, synthesize and optimize ever growing amounts of information and choices.

With these complexities and opportunities as specific objectives, PATH researchers have developed a framework and are designing a prototype to integrate planning and analysis in a computer supported environment that facilitates deliberation and consensus seeking. This framework is called Planning and Analysis to Integrate Intelligent Urban Transportation Systems or PLANiTS. Placing the planning process in a computer aided environment makes it more transparent and gives users the opportunity to seek consensus on the basic assumptions, criteria and models of analysis, as well as the programming decisions. The prescribed planning process, conducted with the aid of an intelligent facilitator, integrates on-line analysis capabilities.

Since decision making occurs during the entire planning process, decision support encompasses the entire conceptual framework. The intelligent facilitator will support a deliberative process in which alternative strategies are analyzed and evaluated and decision makers are assisted in reaching resolution concerning plans and programming of projects.

This paper describes the specifications and the determinants for inclusion of a deliberative process to support intelligent transportation planning. Specifications for a system suitable for transportation planning have been defined, as have the determinants of a prototype for inclusion in early versions of an intelligent transportation planning process.

I.   DECISION SUPPORT FOR PLANiTS

A.   Decision Support of Intelligent Transportation Systems

Developments in intelligent transportation systems simultaneously present challenges and opportunities to urban transportation planning. Intelligent systems are characterized by real time information feedback in their operations and management, and by increasing levels of automation of their various components. The challenges to planning stem from the increased range and added complexity of the choices available to transportation planners. The implementation of IVHS technologies, many of which have system-wide implications, will require change in the institutional arrangements that are currently at work in transportation planning. The opportunities for improved transportation planning are arising from the availability of information, communications, and computation technology.

These same elements, which add intelligence to the transportation system, can be **"harnessed"** to enrich the planning process and to address the increasing complexities. Indeed a major advantage of new transportation technologies such as IVHS is the availability of new or enhanced information sources that can be of use to improve planning. But increased access to information can also overwhelm participants. A significant opportunity exists to assist planners to understand, synthesize and optimize ever growing amounts of information and choices.

With these complexities and opportunities as specific

objectives, researchers at <u>Partners for Advanced Transit and
Highways</u> (PATH) have developed a framework and are designing a
prototype to integrate planning and analysis in a computer
supported environment that facilitates deliberation and consensus
seeking. This framework consists of bases of tools, methods and
knowledge that guide the planner through the entire planning
process.

Since decision making occurs during the entire planning
process, decision support encompasses the entire conceptual
framework. This paper describes the specifications and the
determinants for inclusion of a deliberative process to support
intelligent transportation planning. Specifications for a system
suitable for transportation planning have been defined, as have
the determinants of a prototype for inclusion in early versions
of an intelligent transportation planning process.

B.   **PLANiTS** and Decision **Support**
The prescribed planning process, conducted with the aid of an
intelligent facilitator, integrates on-line analysis
capabilities. The capabilities are

- a policy and goals base that helps define the objectives and
  criteria of the planning process;
- a strategy and action base that assists in the search for
  actions to improve transportation systems;
- a knowledge base in which data, information, and knowledge

about the transportation system reside:

ₐ a methods and tools base in which planning analysis and

operations analysis models are integrated: and

• a deliberation and consensus building base that supports

decision making throughout the process.

These bases support a deliberative process in which
alternative strategies are analyzed and evaluated and decision
makers are assisted in reaching resolution concerning plans and
programming of projects. Placing the planning process in a
computer aided environment will make it more transparent and give
users the opportunity to seek consensus on the basic assumptions,
criteria and models of analysis, as well as the programming
decisions. This framework which encompasses all of these
concepts is called the <u>Planning and Analysis to Integrate
Intelligent Urban Transportation Systems</u> or PLANiTS.

Throughout the transportation planning process, important
decisions must be made that sometimes inspire conflict amongst
the participants. Deliberation, conflict settlement, and
consensus building support techniques have the potential of
enhancing the decision process that is necessary to successfully
conclude programming decisions. The planning process that is
being employed by the PLANiTS model aims to reduce this potential
for conflict, to facilitate conflict resolution, and to improve
the quality of decisions. This remainder of this paper explores
the feasibility and usefulness of computer support for group

decision making that occurs in support of the planning and
programming of transportation actions.

The conceptual framework builds a structure which will
promote consensus building, negotiation and deliberation
techniques as part of the intelligent transportation system and
planning process. Section I, Background, discusses the expected
scope of computer support within PLANiTS and provides on-going
development elsewhere. Section II, Design Objectives, discusses
the design objectives for decision support and consensus
building. Section 111, A Logic for Selecting Techniques,
proposes the framework upon which decision support will be
provided. Major criteria are suggested to guide the a
facilitator though technique selection. Section IV outlines the
development approaches for the proposed prototype and for long
term design. First the list of techniques is presented and then
strategies for implementation is discussed.

The decisions required throughout the planning process are
frequently complex, with numerous considerations for each
situation. Simply modeling human behavior behind decision making
is an uncertain process. Group decisions are prone to even
greater complexity, uncertainty and uniqueness. It is envisioned
that PLANiTS will provide computer support for both individual
and group decision making. Computer support of group
interactions is not nearly as well understood as individual
decision support. Therefore, while individual decision support
will be provided within the PLANiTS system, ideas in this chapter

focus on support of the group processes. Individual decisions and evaluations can be regarded as a component of the larger decision process.

C.   Scope of PLANiTS support

Players with opposing or entangling alliances, powerbrokers with formal or informal empowerment, and the conflict of local interest pitted against regional concerns all contribute to the intricacy of the planning process. The mandates of state and federal legislation force many of these players to cooperate. The cooperative process of decision making for these group are extremely differentiated, involving the interaction of multiple goals of different scope and nature as well as different heuristics and conceptual frameworks.

A widely-held expectation is that use of an electronic medium to facilitate group processes will lead to better decisions and higher productivity by more fully extracting the resources of group discussions and interactions. However, accurately articulating the logic of human decision making continues to challenge those engaged in modeling human behavior and cognition. The direction and magnitude of impact of a computer-based group decision support system on final solutions are not completely understood. For example several studies report higher levels of conflict and negative feedback in computer-mediated communications than in face-to-face communications [Applegate, Konsynski, Nunamaker, 1986; Siegel,

Dubrovsky, Kiesler, 1986]. Researchers have found that computer
support may raise the level of conflicts by heightening the
awareness of members' viewpoints and causing greater objectivity
in reviewing proposed ideas or solutions to a problem. It is
unclear whether increased conflict is a direct result of the
computer mediated communication itself, or whether the support
systems simply provide a mechanism that brings out existing
differences among group members [Watson, DeSanctis, Poole 1988].
It has been established, however, that group cohesion and
interpersonal attraction diminish with greater physical distance
and anonymous working conditions. The usefulness of computer-
based facilitation in conflict situations is not without dispute.

Early software development focused primarily on technology
issues, without sufficient attention to the complexities of group
dynamics. Even the successes have consistently fallen short of
expectations [Grudin, 1990]. The disparity between those who
would benefit from an application and those who were required to
do additional work to support it is a significant cause for many
system failures [Markus and Connolly, 1990]. Increased use of
keyboard input and greater volume of information flow can add to
the level of effort required in a group meeting, thus lowering
group efficiency.

The sophistication of a decision support facilitator in
PLANiTS will understandably be limited by this lack of
understanding. In line with the general philosophy of the
overall development strategy, incorporating increasingly

sophisticated tools on an incremental basis could contribute to the understanding of the influence of computer support on group processes while still producing a helpful product in the short term. Methods could eventually be designed to support a human facilitator alone, the group alone or both. A long term goal of PLANiTS would be a sophisticated facilitator that could guide participants through the process--assisting in individual decision-making, detecting possible conflict, suggesting and brokering resolution techniques. A short term goal would be to develop a small set of techniques that could aid a human facilitator and perform some of the simpler tasks itself.

D.   Product Development

When compared to computer support for individual decision making, commercial applications for group decision support systems are still relatively early in the product development cycle. Computer support for group decision-making has attracted a moderate amount of academic and commercial research; however, thus far none has been specifically tailored for public sector applications, much less for transportation planning. The following briefly describes current progress in the development of computer support for group decision making.

The general term for software support of group processes is Groupware, which is defined to be any specialized computer aid designed for the use of collaborative work groups [Johansen 1988]. Groupware encompasses three distinct concepts, group

decision support systems (GDSS), computer-based systems for cooperative work *(CSCW)* and electronic meeting systems (EMS). The distinction between GDSS and CSCW is in the primary type of group support each was designed to provide. GDSS is an integrated computer based system that facilitates the solution of an unstructured or semi-structured task by a group that has joint responsibility for performing it [Gallupe, DeSanctis, Dickson, 1988]. It typically is task oriented in that it provides a means for a group to perform and complete a task, such as reaching a decision, planning or solving problems, CSCW-based applications are more driven by communication needs. They provide a means for small groups to communicate more efficiently, enabling them, for example, to jointly create or critique a document. However, it is believed that these two classes of systems will completely overlap or converge to a single class of information technology systems to support groups, a concept coined "electronic meetings". Electronic meeting systems (EMS) enhance communication channels by adding structure to meetings and completely recording groups sessions to aid productivity in subsequent sessions. EMS may also structure problems, idea generation and organization, planning, and even elicit knowledge for the construction of knowledge systems [Dennis, George, Jessup, 1988]. Certainly most of these concepts are relevant to PLANiTS.

While the idea of computer support for groups was first introduced over forty years ago, it was only with the

proliferation of personal computers that its application was seriously considered. Software applications with simple versions of the capabilities described above are now offered on the market. Available commercial applications include Lotus Notes, CTC VisionQuest, IBM TeamFocus, Ventana Group Matrix, SmartChoice OptionFinder and NCSA Collage. Some of the techniques offered, such as support for co-authoring, shared databases, asynchronous brain storming and electronic "blackboard", are potentially useful to support processes within transportation planning. A variety of universities are conducting research in the development of these applications, as well as the impacts that they may have on the users and the ultimate decisions. The University of Arizona has a dedicated research facility called the Plex Center where electronic meeting forums are researched [Dennis, George, Jessup, Nunamaker 19881. Xerox PARC and University of Minnesota have explored the influences of computer mediated group support in addition to developing applications [Poole, Holmes, DeSanctis 1988]. A list of existing applications of both research and development and commercial, as complete as possible, is included in Appendix A. The influence and usefulness of electronic media on group processes and decision making continues to be researched.

Applications development has focused on group processes that are related to content--processes pertaining to the production of a particular product or service [Bannon and Schmidt, 1991]. Indeed, the major development focus historically has been for the

specific needs of business teams.   Some corporations have taken
advantage of these specialized packages.   Dell Computer Company,
Proctor and Gamble, Marriot, Metropolitan Life Insurance
Corporation, and Westinghouse are exploring the usefulness of
groupware.   Users of groupware in these instances are primarily
executives, managers, sales persons and other "knowledge
workers".   Notwithstanding these examples, widespread usage of
generalized applications of groupware systems, even in the
business community, is limited.

II. DESIGN OBJECTIVES

The fundamental purpose for developing PLANiTS is to enhance the transportation planning process. The initial systems architecture definition for PLANiTS will include three primary functions to support this objective: <u>idea aeneration. decision-makina and consensus buildinq</u>. Idea generation, or brain storming, a widespread requirement across many organizations responsible for transportation planning and programming, is most important in the problem identification, and strategy formulation phases. Computer applications supporting electronic brain storming have been developed under the auspices of cooperative work techniques. Computer support of structured decision-making and consensus building, which occurs at almost every stage in the planning process, has been explored under the auspices of GDSSs.

The decision-making and facilitation component of PLANiTS to support problem formulation and solution for groups will combine communication, computer, and decision support technologies. The diversities of these developing technologies offer exciting opportunities for facilitating group interactions. The following outlines specific goals to support these functions and, where possible, suggests the type of tools that would be useful.

A. Consensus Building
Group cooperation and negotiation is ubiquitous throughout the planning process and often pivotal to the quality of the

resultant decision. The theory underlying implementation of group decision support systems for these purposes would maintain that a GDSS should foster more even participation in situations requiring group consensus, especially from those who have slow verbal latencies [Hiltz, Turoff 1978]. This then should facilitate a systematic or structured group decision and negotiation process, and promote effective conflict management. Consequently, group consensus in GDSS situations should be higher than when compared to groups that are not computer-based [Zigurs, Poole, DeSanctis 19881.

The process of using computer-supported methods for group decision making does appear to improve the level of participation, but it does not make the process of decision conclusion any easier--indeed sometimes it makes it harder. There is also some evidence that the decision, when finally reached, may be of lower quality than if the "best" decision maker in the group has acted on his or her own [Rohrbaugh 19811--although the overall commitment to the decision could well yield better results than this would appear to indicate. Lastly, electronic support does not guarantee consensus, especially amongst players with deeply held, mutually exclusive positions.

Voting, ranking and rating schemes are some of the concepts that will be incorporated into PLANiTS. Existing research in conflict management for global peace and environmental mediation will be particularly useful [Isard, Smith 1982; Rahim 1990; Susskind, Bacow, Wheeler 19831. Primary tools for PLANiTS

support, already available in commercial packages listed in the appendix, permit yes-no, true-false, or agreement-disagreement for voting, and shuffling the order of items on a list to create a ranked ballot, or assigning a numeric weights to each item. Other voting support techniques could include fixed point allocation routines or voting matrices. Voting matrices could reveal group agreement or disagreement over a range of alternatives.

Conflict mediators have found that voting often reduces consensus and that other structured techniques should be employed first to encourage compromise and negotiation [Poole, Holmes, DeSanctis, 19881. Alternative decision support technologies include decision modeling methods (such as decision trees, risk analysis forecasting methods, and multi-attribute utility functions), structured group methods (Nominal Group and Delphi techniques), and rules for directing group discussion (agenda-setting techniques, identification of conflict style) [Thomas, Kilman 1974]. Capabilities such as tracing group thinking patterns over time for group and sub-group analysis would also be useful for consensus and negotiation purposes. [Blake, Mouton 1964]

B.   **Balance of Power**

An important opportunity for PLANiTS is to reduce the "group think" phenomenon. Groups are often susceptible to "group think" where a single or small minority of participants dominate the

direction of the logic, inhibit idea expression and distort
subsequent decisions through member control and social pressure.
Group think is considered undesirable because it may dampen the
potential creativity of a group and often leads to suboptimal
decision-making. It is believed (or hoped) that group decision
support systems may lessen this phenomenon by permitting equal
participation. A more democratic decision process should emerge
by facilitating greater participation [Gallupe, DeSanctis,
Dickson 1988; Janis 1972].

Conceptually, greater participation and promotion of an
equal voice in transportation planning appears appealing, yet
complete equality between participants is not always proper or
just. In order to be credible to users of the prescribed model
and even observers external to the process, PLANiTS must also
preserve the integrity of varying levels of power and authority
within a particular transportation planning group. Throughout
the spectrum of actions and decisions made during the planning
process, only some will be democratically decided. Politically
speaking, there are appropriate times in the planning process for
"one person, one vote". At other times, a committee may consider
the views of various interested parties and make their decisions.
Employing a neutral mediator, be it human or computer, sometimes
dilutes accountability [Burton, Dukes 1990]. Informal processes
that invite special interest groups to participate can confer
onto them a legitimacy that is not due. Certain players have
more at stake, while others may have greater authority. PLANiTS'

group support procedures must then not only promote group
communication and shared knowledge, but create a decision arena
that can accommodate players with differing levels of power,
accountability, and authority.

   C.   Information Flows

New or enhanced information sources from new transportation
technologies offer the potential for improved planning. However,
increased access to information can also overwhelm participants.
Without adequate structure to integrate or synthesize various
views and data, a group can easily drift. Reducing the process
loss associated with disorganized activity, increasing the
efficiency, and decreasing processing time with fewer errors are
all goals of the PLANiTS decision support for both groups and
individuals processes.

   Electronic brainstorming, electronic information sharing,
and structured processes for idea commenting are examples of
tools that can be used to improve the synthesis of information,
make data transparent, make on-going or earlier decisions more
evident, and reveal individual beliefs. Accommodating groups
that are either geographically or temporally separated can extend
traditional scheduling constraints and increase access to
information. Particularly useful will be communication
technologies such as electronic messaging, local and wide-area
networks, teleconferencing, and store-and-forward facilities.

D.   **Summary** of Goals

From reasons described earlier, it is not entirely clear that computer support of mediation and decision making will ensure many of these desired benefits. Investigation of research results from group decision support systems indicates that there is no clear agreement on the benefits of GDSSs [Poole, Holmes, DeSanctis 19881. An important requirement in the development of PLANiTS decision and negotiation support is that it should improve the resultant decision.

Specifically, a group support system implemented in PLANiTS should facilitate the decision-making and negotiation process by

1.   Structuring decision making processes;

2.   Tempering member dominance, while accommodating differing levels of power, accountability, and authority;

3.   Increasing efficiency, communications and access to information; and

4.   Improving the quality of the resulting group decision.

III. A LOGIC FOR BELECTING TECHNIQUES

A. Structural Framework

The following proposes the logical framework to structure decision support techniques to assist or improve the group processes that take place in transportation planning, Because of the inherent complexity of transportation planning, the expertise of the facilitator must evolve organically, The design of the logical framework for this expertise should be incremental and modular: initially assisting a human mediator or facilitator with suggestions and gradually becoming more sophisticated in its support as product development improves. The structure of the decision support facilitator aims to assist in decision making and planning, yet also to accommodate increasing levels of sophistication as the design of the PLANiTS evolves.

The framework for this logic structure will have multiple criteria from which the particular characteristics for each situation can be used to define the set of appropriate decision support techniques. The logic structure is based on <u>spatial, temporal, behavioral, and contextual</u> considerations. The domain of decisions tools can be determined from these characteristics. Based on these characteristics, the most appropriate technique, or more likely set of techniques, can be identified from a taxonomy of decision-making aids that will be stored in PLANiTS.

To categorize a given scenario requiring decision support, values will be assigned based on characteristics of the

situation.   The following are the key criteria of the logic

framework with their specific evaluation parameters (Table 1).

Table 1.   Key Characteristics

TEMPORAL/SPATIAL
•accessibility/proximity
*processing mode

BEHAVIORAL
*group behavior characteristics

CONTEXTUAL
*stage of planning process
*time sensitivity
*information available
•expected outcome
•number of options

PLANNING
*planning objectives

It is unlikely that all of these criteria will be relevant

in all situations.   A component of the logic structure will then

be to recommend a set of appropriate tools from incomplete

information or the most important information.

B.   Explanation of Characteristics

The following briefly explains why these key characteristics have

been included as criteria.

1.   Temooral and Spatial

Accessibility/proximity of group.   Traditionally the

planning process required the coordination of people and face to face meetings.   However, communication and computer technologies can support planning processes across time and place.   Groups can meet at the same time yet be physically dispersed (common in *CSCW)* or groups can work together in their own agencies asynchronously.

Processing Mode.   The usefulness of decision techniques will also be driven by the capability of the processing mode.   Whether support is provided for the facilitator only, for participants only, or for both remains to be determined.   The set of support possibilities will largely depend upon the presence (or absence) of a facilitator and computer processing capabilities.

The processing arrangement is also linked to the dimensions of time and space.   A taxonomy of support techniques may be categorized based on these three variables (temporal, spatial and processing mode).   Table 2 illustrates how technical sophistication and the dimensions of time and space dictate what the appropriate technique may be for idea generation.   The methods typology will vary by whether group processing is sequential or parallel and whether the methods support single or multiple group sessions.   When multiple group sessions are permitted, the PLANiTS facilitator must integrate and use information across sessions and between groups.   If there are subgroups or if an individual works asynchronously, certain other tools may be useful.

Table 2.   Processing Support (for Idea Generation)

PLANiTS Support For:	Processing Mode	
	Sequential	Parallel
Facilitator only	Facilitator assists conventional seneration.	Facilitator assists conventional generation.
Participants only (multiple workstations)	Users take turns generating ideas, displayed on public screen.	Everyone enters comments at same time. Method decides order that comments will be displayed (Delphi).
Both (multiple workstations)	Each individual lists own ideas. Facilitator controls process by which they are presented to group (Nominal group technique).	Participants generate ideas simultaneously. Facilitator or PLANiTS may control process (Electronic Brain storming).

2.   <u>Behavioral Consideration</u>

<u>Characteristics of Group.</u>   The context (in which, for which,

by whom and for whom the decision is being made) may dictate the

appropriateness of certain decision support tools.   Features of

the group that may influence the process include group size,

individual member characteristics, coalition-related

characteristics, history, cohesiveness, experience, formality or

informality, ongoing or one-time, and organizational context

[Dennis, George, Jessup 19881.

3.   Contextual Consideration

Stage of the Plnnnins Process. Appropriate decision support
techniques depend upon the stage of the planning process. To
identify relevant decision techniques, each step in the planning
process can be roughly illustrated by describing its primary
feature as judgmental, rational, political, complex, etc. We
recognize that all of these steps will contain some of these
characteristics, to a greater or lesser degree. Table 3 shows
preliminary estimates of the primary descriptors for each of the
steps. At a later point, other features may be deemed
appropriate to add.

Table 3.   Stages in Planning Process

Stages	Judge-mental	Rational	Political	Complex
Problem identification	X	X	X	
Problem definition	X		X	
Selection of actions	X	X	X	
Analysis of actions		X		X
Discussion of analysis		X	X	
Selection of action		X	X	X

Time Sensitivitv. The process time required can dictate the
appropriate or possible tools. If a group needs to make a
decision immediately, certain tools will no longer be applicable

because of the intricacy involved.

Information Available. The level of information available to each participant may vary. Incomplete data sets or uncertain forecasts will influence the possible tools to use. Information about other participants' utility or weights, or actions for certain options may also drive decisions, potentially setting up a Prisoner's Dilemma scenario.

Expected Outcome. "Outcome" refers, in this case, to the result of any particular decision scenario. As such, expected outcomes sometimes drive the entire planning process; they frequently drive negotiation processes. While the desirability of this practice is debatable, it is, at the very least, necessary to recognize this as the reality of politics.

Objective criteria for outcome expectation include quality of decision or outcome, participant satisfaction with the outcome and process, participant confidence in the outcomes, level of group consensus, and number of alternatives considered during the process. Commitment to outcome is also important. Some participants are committed to solving the problem, while others are committed to their particular solution. When participants hold steadfast to certain ideas, resolution to conflicts becomes increasingly difficult. Understanding this commitment assists the mediator in selecting the tools.

Conflict over which resolution technique to use also may arise. A sophisticated user may be able to predict which technique would be most beneficial to his or her favored option

and consequently bias the process. Techniques which yield
<u>preindeterminate</u> outcomes would be preferable to use to reduce
this advantage and to avoid conflict over which procedure to use.

<u>Policy Options</u>. The number of options that is being
considered may influence the quality of the resulting decision.
A large number of complex options may limit the quality of the
evaluation because of time and money constraints. One standard
would be, of course, to limit as much as possible the number of
options.

4.   <u>Planning</u>

<u>Planning Objectives</u>. The guiding principles of different
players may certainly lead them to value differing objectives.
Identifying the motivations and attitudes behind certain
judgments is often helpful to conflict resolution.

C.   **Example of Logic Structure**

Consensus building techniques such as tracing group decision
patterns and displaying clusters can be used throughout the
process. However, there will be certain points where significant,
non-incremental decisions must be made, requiring formal
negotiation, compromise or agreement between parties.   To
illustrate how the proposed logic structure in PLANiTS would
support this more formal step, an example is shown. This example
supporting formal negotiation is based on one described by Isard
[Isard, Smith 1982].

Suppose PLANiTS had diagnosed that the most relevant considerations were:

1.   number of options being considered:

2.   type of utility functions that the participants could use (i.e., ability of participants to judge various options):

3.   concern of participants with improvement over the current state of affairs or with concession from stated positions that differ, the position of each being that which he considers best: and

4.   ability of participants to focus on outcome or actions. If the outcome is too divisive, it may be necessary to focus only on prior actions and indirectly on the final outcome.

A matrix of these characteristics and all possible values is shown in Table 4.

Table 4. (Partial) Matrix of Characteristics

No. of Options	Utility Function	Planning objective	Expected Outcome
Few	Rank Outcomes	Inprovement	Only Actions Outcomes
		Concession	Only Actions Outcanes
Few	Assign Relative Values	Improvement	Only Actions Outcomes
		Concession	Only Actions Outcomes
Few	Assign Precise Values	Improvement	Only Actions Outcomes
		Concession	Only Actions Outcomes
Many	Rank Outcomes	Improvement	Only Actions Outcomes
		Concession	Only Actions Outcomes .
Many	Assign Relative Values	Improvement	Outcomes Only Actions
		Concession	Outcomes Only Actions
Many	Assign Precise Values	Improvement	Outcanes Only Actions
		Concession	Outcomes **Only Actions**

Using Isard's illustration, if there were **a few** number of options, if participants were able to **rank** outcomes in order **of** preference and to focus on **improvements,** and **outcomes,** a finite domain of techniques could be identified. PLANiTS could recommend the set of appropriate decision support techniques based upon the values in this matrix (finite, ordinal, focus on improvement, outcome-oriented). Table **5** contains those tools that would be most practical for the scenario described.

Table 5. Recommended Tools for Example

```
1.   Minimum total of ranks (highest
     rank = 1) (weighted or
     unweighted)
2.   Minimum difference in ranks
     weighted or unweighted
3.   Maximum total of rank
     improvements
4.   Maximize the minimum in rank
     improvements
5.   Minimize the difference in rank
     improvements
6.   Maximize equal rank improvement
7.   Changing actions to
     "if..,then.. ." policies
8.   Maximize good-cause payment
9.   Apportionment principles
10.  Achievement of minimum
     requirements (satisficing)
11.  Last-offer arbitration (with
     incentive to think of others)
12.  Method of determining group
     priol ^U^S^T^U^^^Saaty Analytic
     Hierarchy Process principles)
```

Source: Isard, Smith 1982. p 11.

Each *of* these tools represents an established negotiation technique that the mediator may elect to use to achieve consensus amongst participants. Comprehensive descriptions [Isard, Smith 1982; Rahim 1990; Susskind, Cruikshank 1987; Fraser, Hipel 1984; Burton, Dukes 19901 and detailed descriptions of these specific techniques [Saaty, Vargas; Hill 1973; Rappoport 19741 are available.

To further assist the mediator in reducing the set *of* possible techniques, PLANiTS could prioritize the domain of techniques based on cost, outcome transparency and other selected criteria. PLANiTS could indicate the techniques that have a high cost (in this

example, procedures 7 and 12 are expensive to operationalize); the techniques that have preindeterminate outcomes (techniques *8*, 10 and 11); and the techniques (7 and 12) that do not require information about preferences of other participants, a situation that may occur when a workshop or meeting is not feasible.

Early in the development cycle, PLANiTS' role in negotiation and conflict resolution may be to simply pro^T3% *^T (^U(such as the one shown in Table 5 and provide text describing each technique, their advantages, and their disadvantages. As PLANiTS evolves, the electronic facilitator can assume a greater role in the consensus building process and actually begin to guide the mediator. The following section explores more fully the role that PLANiTS may assume during its development.

IV.   RECOMMENDATIONS FOR DEVELOPMENT

A.   General Approach

This section proposes the development approach for implementing'the negotiation and conflict resolution techniques. First a taxonomy of possible techniques is described, and then the general strategy for implementing the logic to support their use is presented. The taxonomy is presented by major decision support functions, while the logic strategy is separated by short and long term objectives. The short term objective is to achieve an operational prototype for demonstration purposes within a calendar year. The long term objective is to construct a fully operational PLANiTS planning support model. The level of sophistication of the logic and of the techniques are expected to improve during the entire development of PLANiTS: this two-tiered strategy reflects this expectation. Accordingly, the theme of modularity and incrementalism promoted in earlier chapters continues to be essential in the development of decision support. Since a significant milestone for the PLANiTS development is a prototype of the system, the suggestions are centered on this objective. Obviously the more detailed and complex issues, while discussed here, must be examined further and addressed more fully in later design stages.

B.   Taxonomy of Techniques

The following describes the taxonomy of techniques, separated

by major categories. Listed under each of these categories are some techniques that would be useful. The lists are not all encompassing--a wide assortment of **consensus-building/decision-making** techniques are available. The four categories of the techniques are idea generation, decision support, consensus building, and facilitation. The first three categories are based on the design objectives of PLANiTS decision support listed in Section II. The PLANiTS function discussed in Section 111, describing the logic of the mediator or facilitator, is included as the final category. This facilitator will act as the overseer of all techniques.

1.   <u>IDEA GENERATION</u>

     <u>Electronic brain storminu:</u> should encourage idea generation and promote creativity. It can be supported by sequential or parallel processing. Member dominance can be tempered easily with computer supported brain storming, since it can permit anonymous participation and can structure contributions. This is a proven concept that is already implemented in many existing groupware applications. It is an obvious tool to include early in the development of PLANiTS.

     <u>Issue analvzer:</u> should consolidate key items produced from idea generator. This could useful for many purposes. It could serve as a feedback mechanism: it could provide a forum for discussion; and it could supply a summary of the idea generation process. Eventually, the Issue analyzer could integrate external, yet relevant, information from the literature and knowledge bases. The logic required for this category of techniques is likely to be sophisticated, requiring capabilities such as word pattern

recognition and a dictionary of common terms.

Topic commentor: should provide a forum for participants to freely interact. Participants may enter, exchange and review information on self-selectedtopics. It could support solicitation of ideas and provision of additional detail in conjunction with a list of topics.

2.   DECISION MAKING

Voting tool: should provide a variety of prioritizing methods. Examples include rank ordering and weighting, (e.g., minimizing total of weighted or unweighted ranks; minimizing difference in weighted or unweighted ranks; maximizing total of weighted or unweighted rank improvements; maximizing the minimum in rank improvements; minimizing the difference in weighted or unweighted rank improvements; and maximizing equal rank improvement), multiple choice, and Likert scales.

Alternative evaluator: should provide multi-criteria decision making support. Alternatives can be examined under flexibly weighted criteria to evaluate decision scenarios and tradeoffs. Examples include concordance-disconcordance procedures, stochastic methods, reduction methods, fuzzy set analysis etc.

Non-quantitative procedures: should include among others, Burton's workshop theory (interaction process for zero-sum to positive sum games), Kelmans workshop theory, Fisher's Yesable Propositions.

3.   <u>CONSENSUS BUILDING</u>

<u>Idea oraanizers</u>: should include stakeholder identification or assumption surfacing, Saaty's method of determining group priorities, questionnaire assistance, and group dictionary.

<u>Structured resolution techniaues:</u> should include conventional delphi, goals delphi or policy delphi and nominal group techniques. Other established techniques include achievement of minimum requirements (satisficing), apportionment principles; changing actionsto "if...,then..," policies; maximizing good-cause payment; last offer arbitration (with incentive to think of others),

<u>Policv formulation:</u> should support group in developing a policy objective.

4.   <u>FACILITATION</u>

<u>Session director:</u> should guide the facilitator or eventually replace human facilitator responsibilities in selection of tools to be used in a session. An example of this capability would be to generate an agenda of useful tools for a given meeting. The Director could diagnose key characteristics of a situation to assist the facilitator in selecting the appropriate tool. As PLANiTS evolves, the Director will become more reliant upon an expert system and a knowledge base; it is not apparent at this point if the expert system and knowledge base will be part of the larger PLANiTS "knowledgebase", or if it will be a separate component dedicated to decision support applications.

<u>Coordinator:</u> encompasses generic collaborative task support. Tools such as group writer, group outliner, and appointment calendar could be useful to meetings. These capabilities already exist in commercial packages.

C. Prototype Design Approach

The most preferred techniques could be implemented in the prototype. If possible, surveying potential users of the tools they would be most interested in having implemented in the prototype would ensure that participants would be provided with assistance in which they were interested or eager to receive. Opinions could be solicited at planning workshops or from surveys.

If this method is not possible then the following approach is recommended. To maintain simplicity while ensuring usefulness, the prototype should include a single technique from each of the major functional categories. The first technique listed in each major category is suggested as the one to include in the prototype development: each are the most straightforward application in their respective functional categories. In every category, except perhaps the facilitator, each of these techniques already have been incorporated in groupware applications. More specific descriptions of suggestions are described below.

1. <u>IDEA GENERATION</u>

It is recommended that brain storming be the first application to develop. Electronic brain storming is an appealing and proven concept that can promote creativity of participants. It is likely that participants will find this a practical and productive tool. By providing an instrument whose usefulness is readily transparent, participants can become familiar with the potential of PLANiTS, begin adapting their work habits to using it, and may become

influential in shaping the direction of succeeding versions of
PLANiTS.

2.   <u>DECISION MAKING</u>

PLANiTS will eventually be custodian to both qualitative and
quantitative decision support. Qualitative decisions that can be
converted to quantitative measures are more straightforward, have
been more fully explored as software applications, and can be more
easily included than more pure qualitative decision support.
Initially providing voting, ranking, and rating tools would be a
modest and feasible goal.

3.   <u>CONSENSUS BUILDING</u>

Major objectives underlying consensus building are conflict
avoidance, resolution or settlement. While it certainly relates to
the magnitude of the conflict, mediation frequently requires
sophisticated diagnosis and prescription of problem and procedure.
Methods based on human interactions have been used extensively in
the past to manage conflict and, of course, are difficult to
translate into computer applications. Including a consensus
building technique in the prototype that is simultaneously simple
to implement, yet effective as a technique, may indeed be a
formidable task.

However, a fundamental principle of consensus building is to
facilitate communication between parties. Practically speaking,
any technique that improves communications may accomplish consensus

building. A well constructed electronic brain storming application
may be a sufficient tool to assist a human facilitator in consensus
building.   If a more elaborate technique is desired for
demonstration purposes, visual feedback techniques may be the most
serviceable structure to include. Direct tracking and plotting of
on-going qualitative and quantitative decisions may help the
mediator recognize patterns of decision-making and be useful in
facilitating groups to reach agreement.   Similarly, **"assumption
surfacing"** techniques that assist'the facilitator in drawing out
beliefs and levels of commitments, such as Method of Determining
Group Priorities, could be useful.

4.   <u>FACILITATOR</u>

At the prototype stage, the facilitator should probably
function simply as a warehouse for the available techniques,
providing descriptions rather than prescriptions for a human
facilitator.   The PLANiTS facilitator can provide detailed
descriptions of procedures that would assist the human facilitator
in performing them.   The logic for diagnosis of conflict
situations, while a fundamental responsibility of the facilitator,
is sophisticated and is probably too complex for any meaningful
development under a rapid prototype situation.   It is therefore
recommended that the criteria for the logic parameters, as
described in Section III, be included to permit consideration by
the human facilitator, but not to have PLANiTS actually execute or
support it.   Perhaps later, as PLANiTS matures, the logic can

become automated.

D.   Long Term Implementation Strategy

The following lays out an incremental development strategy for long term implementation of the decision and consensus support module, The key benefit from incremental, modular implementation is that portions of consensus building support can become functional relatively early in the development of PLANiTS. Accordingly, the logic to build an increasingly sophisticated support system should incorporate any development from the prototype. The basic design approach is to begin to incorporate the logic framework described in Section III. The ultimate design objective will be to include all the of the criteria (Temporal/Spatial, Behavioral, Contextual, and Planning) in the logical structure. However, it is recommended that each of the criteria be incorporated as separate modules, with a smart facilitator that coordinates them coming on-line at a later point. The following suggests how to begin implementing the logic criteria.

A straight-forward criterion to begin incorporating is the Stage of the Planning Process described under Contextual Considerations. In Table 3 (in Section 111), stages of the planning process were identified and characterized by salient features (judgmental, rational, etc.) . The next step beyond the prototype design is to use these features to catalogue the major functions of decision support (consensus building, decision making, idea generation) by likelihood of use for each of these stages.

The second column in Table 6 associates these categories to the stages of the planning process and includes the most relevant functions of the category that will likely be used in that planning stage. This matrix of functions linked to stages should include work accomplished in prototype development, but will probably require additional development. The next refinement would be to more precisely define the techniques and their usefulness in particular situations. The salient features of each stage can be used to help identify which techniques appropriate for that particular stage.

As PLANiTS becomes more sophisticated, both the repertoire of techniques within each category and the decision support functions associated with each stage of the planning process will increase. It is likely, however, that the techniques for some of the stages can be more standardized than for others. In particular, the Analysis of Actions stage should eventually have access to a wide-ranging and diverse set of decision support techniques, while techniques for Problem Identification and Problem Definition may remain fairly routine. Examples of specific techniques that would be useful in each stage of the planning process are shown in the last column of Table 6. Sometimes, the type of specific techniques recommended for the planning stage is identical to the function (i.e., the functions of idea generation are identical to the techniques recommended).

Refinement of this matrix should continue in a similar fashion, with more techniques being added as the logic for

selecting the techniques becomes more sophisticated. Once this
matrix is completed and the techniques have been successfully
incorporated into PLANiTS, a useful guide will be available to a
human mediator. Groups could possibly interact somewhat
autonomously, without constant assistance of a human facilitator.

Table 6.   Categories for Each Planning Stage

Stage of Planning Process	Category of Techniques	Specific Techniques
Problem Identification	Idea generation (Electronic Brain storming; Issue Analyzer).	Electronic Brain Storming; Issue Analyzer.
Problem Definition	Consensus building (Idea Organizer; Policy Formulation).	Assumption Surfacing; Questionnaire Assistance; Group Dictionary; Policy Formulation.
Selection of Actions	Decision making (Voting Tool).	Minim Total of Ranks; Minim Difference in Ranks; Satisficing.
Analysis of Actions	Decision making (Alternative Evaluator).	Concordance-discordance Procedures; Stochastic Methods; Reduction Methods; Fuzzy Set Analysis.
Discussion of Analysis	Consensus building (Structured Resolution Techniques).	Method of Determining Group Priorities.
Selection of Action	Decision Making (Voting tools).	Maximum Total of Rank Inprovements; Maximize the Minimum in Rank Improvements; Minimize the Difference in Rank Improvements; Maximize Equal Rank Improvement.

In a similar fashion, the other characteristics for Contextual
Considerations, as well as **Temporal/Spatial**, Behavioral, and
Planning criteria, can be introduced into the PLANiTS system. As
described above, PLANiTS can begin to accommodate more and more
specialized criteria to further refine technique selection.

However, this is merely a preliminary set of criteria. Prior to implementation, it is recommended that all of the criteria and techniques that have been suggested here or deemed appropriate elsewhere be reviewed by experts. A panel of experts could be polled on the suitability of this set before it is finalized. It could be a delphi style inquiry of experts in decision support, conflict management, public policy, and of course transportation planning. This assembly of experts could not only consider and approve the set of consensus techniques that will be stored in PLANiTS, but also the logic which is associated with each Of these techniques.

E.   Issues and Recommendations

Lastly, building from points made throughout this chapter, this final portion focuses on critical issues that may define the pace, direction and extent of the development path.

Evolving Processina Support.   The support for processing in PLANiTS across time and space will most likely occur in a some kind of technology continuum. It is expected that earlier in development (i.e., the prototype stage), configuration options will be considerably more limited than later. Earlier versions of PLANiTS will support relatively simple face-to-face, real-time interactions. Issues concerning group dynamics related to the level of sophistication of the processing mode will not be as important--the assorted possibilities described in Table 2 (Section

111) will not yet be relevant.

However, PLANiTS will eventually be enhancedto permit remote, asynchronous processing. Understanding or anticipating the impact or influence of these disconnected interactions will be difficult: however it is likely that this new type of processing will alter the behavior and dynamics of group situations. The degree of sophistication of communication and computer technologies, (the available processing mode) will largely determine how influential accessibility and proximity factors will be on the set of recommended tools. Exploring the impact should be essential.

<u>Technical sophistication of mediation support.</u> As part of the long term development strategy, it is expected that a human facilitator will be a necessary component in mediation during a significant period of the development path. However, many functions of the electronic facilitator should emerge slowly and naturally during development. For example, the role of the facilitator in the Stages of the Planning Process was not even mentioned in the earlier text on the matter. It almost transcends the stages.

In a theoretical sense, the role of the electronic facilitator remains rather ambiguous. The logic for constructing a consensus building system will ultimately be a major part for the facilitator. But the role of the facilitator could be greater than just the logic. Recording or learning from on-going experiences certainly could be a valuable ability of the electronic

facilitator. The functions of (1) characterizingthe situation and
(2) diagnosing the proper mediation techniques would certainly lend
itself well to an expert system to assist the human mediator and to
learn from the on-going process. Developing rules for mediation
support should occur simultaneously with other development.

    Limitations of consensus building. Realistically, consensus
building can never eliminate some of the obstacles to decision
making. While community participation and public awareness are all
strengths that can be useful to the successful implementation of
transportation planning projects, consensus building almost always
incorporates satisficing.   Furthermore, while the concepts of
consensus building and decision support may be universally
endorsed, when these techniques should be put into action is not as
widely agreed upon. One reason is that it is not always obvious
that consensus or compromise serves the public interest the best.
While this may be difficult to operationalize, it should be
recognized that consensus or cooperative planning efforts is not
always in the best interest of the public.

    Value of computer support for decision making. Aside from a
brief discussion of the (sometimes) inappropriateness of a
completely democratic process and of the uncertainty of computer
supported mediation, this paper has almostcompletely subscribedto
the concept that computer supported consensus building is essential
to quality decision making.   And for the most part research

indicates that it is a positive objective to pursue. The value of computer support for public policy decision making, and in particular forthe field oftransportation planning, is anticipated to be significant.

However, improved information and communication flows do not always guarantee improved decisions. The expansive assortment of issues, such as huge costs, protracted planning timeframe, extensive community participation, multiple objectives (mobility, economic development, job creation, etc.), set transportation planning apart from many of the traditional applications for conflict mediation, settlement or resolution. Conclusive judgement of the impacts and influences of computer-supported mediation is yet to occur. Even in the isolated cases where computer-supported mediation in other fields has been successful, the applicability to transportation is not entirely evident.

Subsequent research for this project may contribute to and further the understanding of this body of knowledge. It is recommended that any new capability be assessed as fully as possible as to how it may impact the decision process. The promise of a computer supported decision facilitation is great, yet remains uncertain.

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