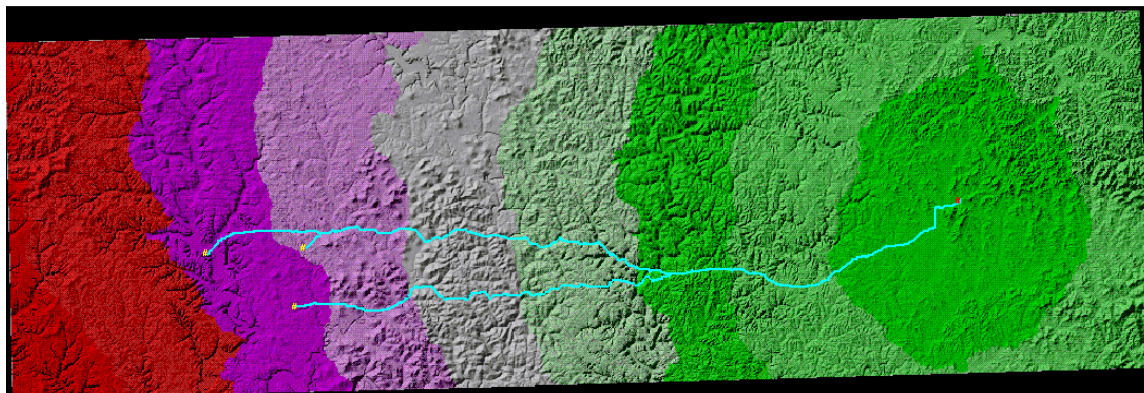


Highway Corridor Routing using the Enhanced Participatory Analytic Minimum Impedance Surface (EP-AMIS) methodology

This paper describes the adaptation and development of the Analytic Minimum Impedance Surface (AMIS) methodology for participatory highway corridor evaluation. The AMIS methodology was introduced by Grossardt, Bailey and Brumm (2001). It features the combination of hybrid Analytic Hierarchy Process (AHP) and a Geographic Information System (GIS) that is used to identify and evaluate input criteria, to compute trade-offs and from these factors to generate a decision landscape. The AMIS decision landscape consists of a GIS-generated surface representing a decision criterion, such as cost or desirability. It is generated by means of a two-stage process: first, the specification and quantification of a decision criterion for a wide variety of physical, environmental and socioeconomic attributes and second, assigning them a geographical location. Physical attributes include features of the built environment, such as airports, cemeteries and archaeological sites. Environmental attributes include not only the location of endangered species, but also their range and habitat. These also include air and water quality indices and ecosystem evaluations. Socioeconomic attributes are modeled in the form of social and community impacts. The decision landscape is computed and displayed by means of a raster-based GIS (ArcInfo / ArcView®). The input from these phases is then processed into a Spatial Decision Support System or SDSS (Densham 1991).

The decision landscape paradigm is an extremely powerful and flexible means of assessing environmental factors in a dynamic social context. First, it provides a graphical summary of all development features that facilitates comment and feedback at public meetings and other forums. Second, it offers an exceptionally powerful analytic tool that can be used in a number of ways to examine any type of development and its impact on this landscape. Various operations can be performed on this decision landscape: such as point-to-point route cost minimization, buffer zone impact minimization, net areal pollution mitigation and so on. Because the methodology is quantitative, the benefits of specific strategies may be analyzed closely and compared with a strong degree of confidence. The technical details of the AMIS methodology and its mathematical specification have been detailed previously (see Grossardt et. al. 2001).

Figure 1 AMIS Isocost Surface showing least cost paths from origin to three destinations.

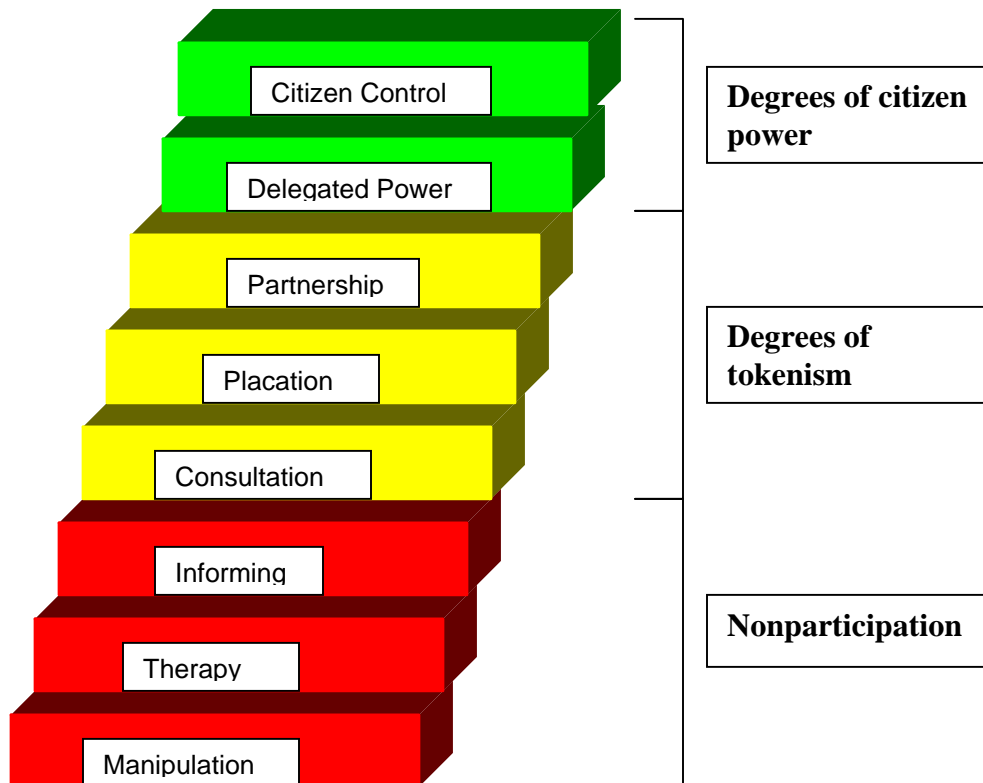


This paper discusses the operationalization of AMIS in a context of Structured Public Involvement or SPI. The cultural and regulatory context of highway development in the U.S. is outlined and placed in a framework of broader civil infrastructure development and public involvement. The public involvement protocols that are used to solicit and evaluate the input factors are described. These protocols include the use of the *SharpeDecisions*® electronic polling system and the use of Distributed Outreach to ensure that minority and non-elite stakeholder views are taken into account when generating the decision landscape. This process allows communities and other local groups more input into public processes that are often perceived as opaque and inaccessible. This structured public involvement protocol assists the State Highway Agency in determining which environmental factors are important, and it allows public participants to add and weight other factors. The conjunction of the enhanced participation protocols and the AMIS method leads to the nomenclature Enhanced Participatory-AMIS, or EP-AMIS.

Context for Participation

Although it is increasingly regarded as essential, public involvement in infrastructure decision making in the United States has a highly problematic history. Public skepticism about the activities and motivations of transportation planning, design and engineering professionals remains high. Arnstein's (1969) famous "Ladder of Citizen Participation" is still a useful way of characterizing levels of public involvement, ranging from the ideal of citizen control to creeping manipulation by officials and powerful interest groups (Figure 2).

Figure 2: Ladder of Citizen Participation



Surely everyone can agree that the objectives are to move up the Ladder, that is, to improve stakeholder satisfaction with both process and product. Yet not all parties agree on ways that these laudable goals can be accomplished. After all, transportation planning and design processes are complex and demanding. They involve many stakeholders, often with competing ideas and goals. Transportation authorities find themselves in the middle of these currents. Public involvement is both mandated and, most agree, desirable (ISTEA 1991, FHWA 1996, also see [TRB White Paper on Public Involvement](#), O'Connor et. al. 2000). Yet, under these circumstances, rooted in a history of mistrust and skepticism, public involvement can easily become something to be avoided or minimized instead of a genuine opportunity to improve the design product (Maier 2001).

Structured Public Involvement: What is it? Who does it?

To address these concerns, the Structured Public Involvement (SPI) framework has been devised ([Bailey et al. 2002](#)). SPI is aimed at increasing stakeholder satisfaction with planning and design processes for public infrastructure. It uses a carefully selected combination of advanced methods including an electronic polling system, 3D visualization and Geographic Information Systems to increase public participation in decisions that affect their neighborhoods and communities.

SPI improves decision making by:

- Integrating advanced methods more effectively
- Gathering more input from a wider range of stakeholder groups
- Providing clearer guidance for engineers, designers, planners and architects
- Building “civic capacity,” or willingness to participate, for future decisions

To avoid misconceptions about SPI and what it can and cannot do, it is useful to consider how it works. SPI is not a checklist of options or practices to be followed in a strictly predetermined sequence that guarantees these desirable outcomes in every case. Nor is SPI a marketing tool designed to convince the public that one preferred or predesigned alternative is better than other possibilities. Designers, planners and engineers must be ready to cede part of the design domain to the other stakeholders. This does not mean their expertise is not necessary or valued, but that it cannot be imposed by main force, or sleight of thought, on the public if genuine alternatives exist.

SPI is a structured method for integrating appropriate and useful technologies into an advanced decision support system. To design an SPI protocol, it is necessary to work with interested parties to consider the decision system as a whole. This entails legal and practical questions that require the input of a variety of officials and other groups. It entails iterative and broad-based public hearings and focus group meetings. And finally, it entails consideration of the appropriate technologies and their uses and properties.

Here are the key questions that can be used to shape a specific SPI application:

- What is the decision envelope? i.e what construction regulations, zoning or other legal factors control the decision? Related to this concern, how much input do stakeholders have? While there are clear legal requirements, for example in highway improvement the design must conform to standards listed in the [AASHTO Green Book](#) (1995) for highway engineers, these standards often allow for considerable design latitude. SPI takes advantage of this latitude by encouraging stakeholder input to determine what is preferred subject to these constraints.
- What groups can participate? How can their expertise be recognized? It is very important to avoid imposing a planner’s vocabulary, or engineer’s terms, on publics that do not understand these words, and are not willing to be talked down to. The highway safety engineer’s “level of service” terminology, for example, is poorly if at all understood in public forums. Rather than attempting to educate the public, who have little time and less patience for what they see as professional pedantry, highway visualizations can overcome this language barrier by showing graphically the potential “level of service” in an easily comprehensible way.
- How should input be gathered? Which technologies are most suitable? If GIS is to be used, is it cost effective in this case? Moreover can it be used to solicit input rather than showing people what has already been decided? This requires working to develop an analytic framework that gives designers maximum information from the stakeholder input.

Given these considerations, and others, appropriate technologies must be selected and a way of using them to solicit stakeholder input must be defined. [TRB](#), [EPA](#) and [FHWA](#), among other agencies, have identified a wide range of methods for public involvement and outreach. However these resources do not specify how the methods can be integrated effectively into a multistakeholder decision system. This is a job for the involved parties who in collaboration can develop an SPI application.

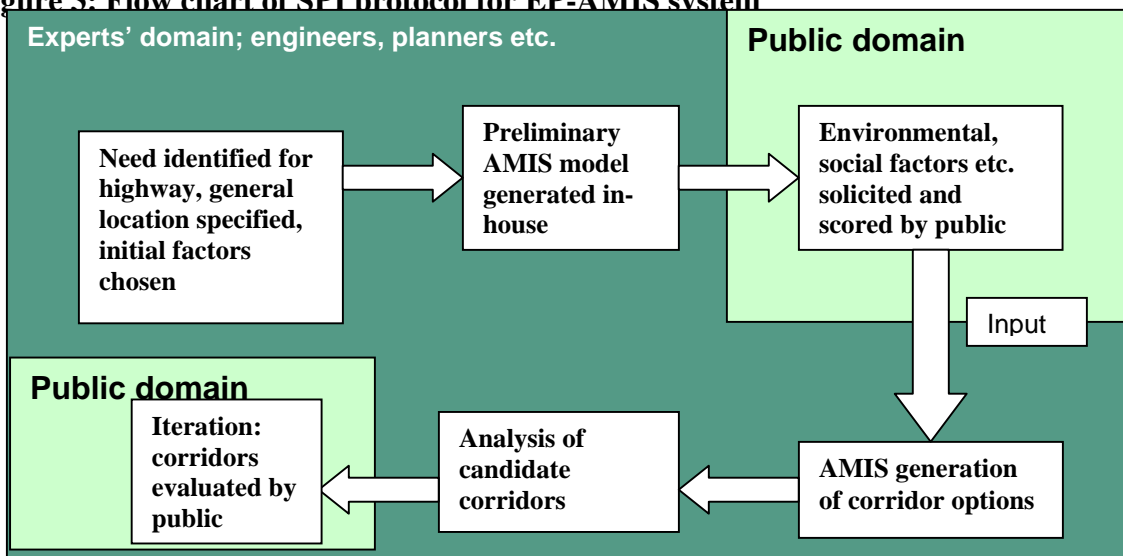
EP-AMIS

To gather stakeholder data about highway valuations it is necessary for the research team to work with the appropriate authority – in this case, the State Highway Agency that is legally charged with responsibility for the construction of new public roads (ISTEA 1991). Involved parties should be chosen with respect to the candidate corridor. In the test case these included a range of involved public officials at local governmental level; private organizations such as neighborhood groups; recreational and sports enthusiasts who used areas of the National Forest. In accord with the principle of Distributed Outreach (Bailey et. al. 2003), group meetings should be arranged at local community facilities, for example at local SHA offices, or District Offices, or schools and other

public locations, and at times that suit the schedule of the population involved. For example in a project involving a low-income minority neighborhood in Louisville, KY, these meetings were scheduled in the early evenings in collaboration with a local residents' organization so that shift workers and commuters could participate (Grossardt and Bailey 2003).

The meeting should be structured such that it does not waste participants' time. For EP-AMIS value solicitation, at the test meeting held at District Headquarters for the SHA, two hours was budgeted. Two computers with large LCD projectors were set up allowing all participants a clear view of the proceedings. One computer was used to display a Powerpoint presentation. The AMIS methodology was explained by a trained facilitator and samples of the in-house test output were shown to familiarize participants with the system. The second projector was used to display the output of the *SharpeDecisions*® electronic polling system. This was used to gather input rapidly, anonymously and fairly. This system consists of a radio-frequency base station, a set of radio-frequency keypads and the *SharpeDecisions*® software. A Likert 1 through 10 point integer scale was used for each factor. A factor was presented and each participant recorded one vote. If the input key was pressed again before the vote ended, the second vote overwrote the first. After all votes were tallied on the projector screen, the summary was shown to participants including the mean and standard deviation for the group's scores. A brief discussion was held and then the next factor was presented and the process was repeated. In this way over 50 elements were scored in less than an hour.

Figure 3: Flow chart of SPI protocol for EP-AMIS system



The team has developed scripts that allowed the *SharpeDecisions*® output to be fed directly into ArcView GIS. Another script was used to perform a real-time RECLASSIFY operation in ArcView using these weightings. This generated the final weighting for each of the more than 50 input layers. Given a user-specified origin and endpoint the AMIS corridors were then computed using a LEASTCOST-based path algorithm and displayed to meeting participants. The output showed the optimal path, and it displayed the corridor composed of the aggregated lowest-impedance paths across the landscape. This occurred at the same meeting where the input factors were specified and weighted, allowing participants a uniquely rapid, efficient and powerful means of highway corridor evaluation. The standard AMIS operations were available for those who wished to analyze the corridor, including meters of coverage along the specified path for each input element or factor and total impedance weighting along the specified path.

Conclusion

EP-AMIS seeks to advance applied geospatial decision theory by integrating distributed outreach and electronic polling into the logical framework of the AMIS methodology. By delivering a structured sequence of environmental, social and physical geographical valuations, using participatory technologies such as electronic polling, EP-AMIS assists professionals in several key areas.

- Solicits input and specific valuations from populations that would otherwise have no voice in these decisions
- Allows professionals to incorporate these views into the decision-making process in a fair and transparent manner
- Brings together diverse professionals and practitioners through the medium of the GIS.
- Allows professionals and other stakeholders to convert these abstract valuations into a graphical display of preferred routings for display and iterative evaluation

Moreover the EP-AMIS approach is modular and transferable. The case study deals with highway corridor routing, but the core EP-AMIS logic is equally suited to a wide range of spatial decision making applications, including waste facility location; electric transmission line placement; and participatory management of public and semi-public lands such as parks and national cultural resources.

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