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Application of Interactive Graphics in Citizen Participation

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FOREWORD

The potential of computer-generated pictures to communicate complex and technical information to nontechnical people has yet to be realized substantially. The papers in this RECORD represent initial probes into an area that is largely unknown and undefined. Pictures are a valuable means of communication, but humans are equipped naturally to produce words. The development of computer graphics has changed this situation dramatically. Present technology allows almost anyone to create a bewildering variety of pictures almost instantly by using only a few simple commands. Now, we must discover what this new picture-drawing capability can do for us.

We have often heard citizens say that transportation planners are speaking in a foreign tongue. And many of the conflicts that arise in citizen reviews and public hearings may be due to an inability of the citizens to understand the words used by transportation planners. Pictures are understood universally, and, although a few pictures cannot be expected to solve all problems, they can, if they are constructed properly, increase communication and understanding.

The field of computer graphics cannot yet determine what can be learned by a viewing of a graphic display of 30 years of urban growth and change that has been compressed onto a film that runs for 3 min, what can be learned about the nature of the expected land use impacts of a new transit system in the 1990-2000 time period by seeing pictorial representations of how an existing urban structure might change in response to the construction of such a facility, or what effect color has on our ability to perceive complex patterns of change in space and time. Investigations in the fields of perception, psychology, social anthropology, education, and computer graphics are being conducted that are looking at these and other questions. W. H. Huggins and Doris R. Entwisle in their book Iconic Communication: An Annotated Bibliography published by the Johns Hopkins University Press in 1974 have summarized this work. It should be read by anyone who wishes to use computer graphics as a communications technique.

The papers in this RECORD are not all optimistic about the utility of computer-generated displays to aid in communicating the results of technical studies to citizens and elected officials. Their approach is cautious and tentative, as is appropriate. It is clear that one can mislead people with pictures as easily as one can mislead people with words. But, for example, in the area of environmental impact statements, one can instruct the computer to redraw a picture to fit a different set of values or objectives and obtain a response almost instantly. This technique would enable more people to be involved than does the present system in which written comments are published several months later in a huge document that few people will ever read.

Even though we know very little at present about how to construct pictures that will communicate effectively, the ability that many people have to comprehend and assimilate large amounts of visual information suggests that exciting possibilities exist for those who wish to improve the quality of interaction and mutual understanding between transportation professionals and the people that must live with their products. The modest start represented by the papers in this RECORD hopefully will stimulate others to probe more deeply the potential utility of computer graphics in citizen participation.

—Jerry B. Schneider

CONCEPTS, APPROACHES, AND PROBLEMS OF APPLYING INTERACTIVE GRAPHICS IN COMMUNITY PARTICIPATION PROGRAMS FOR URBAN TRANSPORTATION PLANNING

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A framework for using interactive graphics to strengthen community participation in urban transportation planning is outlined. The relationship of interactive graphics to basic community participation objectives and techniques is assessed. A variety of interactive graphics needs and capabilities are reviewed, and 6 potential areas of application are described. The relevance of interactive graphics to planning and participation is examined. Illustrative, hypothetical interactive graphics applications for regional system and corridor-center planning projects from the Los Angeles area are used. A series of challenging implementation problems is given.

•TO GAIN a better understanding of how interactive computer graphics might apply within community participation programs, one should review the objectives and techniques of community participation. It is no coincidence that at least 1 broad approach to community participation emphasizes the need for stronger interaction between transportation planning professionals, such as highway location teams, and the communities through which proposed transportation facilities will pass. This interactive need of 2 groups that often misunderstand and misrepresent each other is quite similar to the interactive need of computer users, especially nontechnical users, and the data and modeling systems that are computer processed. Interactive graphics already has addressed this need, but stronger interaction also is needed here partly to reduce misunderstandings and misrepresentations and to achieve additional objectives. These include reduction in computer processing turn-around time. Real-time person-computer communication also can facilitate better comprehension of graphic-displayed information.

Among 3 sets of objectives for community interaction programs (1, 9) that establish the responsibility of the transportation agency, increase the effectiveness of the transportation facility location team, and generate alternative courses of action that are responsive to the values of the affected community, 4 objectives fall in the last category. The achievement of these could be facilitated by use of interactive graphics as a supporting tool. They consequently serve as objectives for interactive graphic applications in community participation programs. They include

1. Concept forming, which means generating new ideas about relationships between communities and major transportation facilities, particularly for potential impact problems;
2. Problem detecting and anticipating, which means identifying all important existing and potential impact problems for both users and nonusers;
3. Solution finding, which means enlarging the set of alternatives, both transportation and nontransportation, under consideration; and
4. Value exploring, which means attempting to determine the relative importance of impact conflicts and trade-offs, for different interest groups within a community.

Interactive graphics techniques may be used in association with and support of a

Table 1. Importance of interactive graphics to community interaction techniques.

Community Interaction Technique	Potential Application of Interactive Graphics
Field work method	Probably minor
Holding and attending meetings	Could be useful
Operating a field office	Could be useful
Using advisory committees	Significant
Mediation	Could be useful
Analyzing past and current community plans	Significant
Reviewing local election issues	Probably minor
Mapping sociopolitical and environmental data	Significant
Illustrating final form of an alternative in everyday language	Significant
Hiring an advocate for the community	Probably minor
Carrying out a demonstration project	Probably minor
Employing community residents on project	Could be useful
Role playing	Could be useful
Sensitivity training and laboratory method	Significant
Charette	Significant

Table 2. Classification of interactive graphics needs and potentials.

	Range of Output Formats		Potential Application	
Output Category	System Level	Corridor-Center Level	Major	Minor
Maps*	Zones Networks Grid coordinates Facility symbols	Blocks Routes Grid coordinates Facility symbols	Design and analysis of alternatives	Comparison of alternatives (significant differences)
Graphic aids	Bar charts Pie charts Line graphs Frequency distributions Tabular displays Scatter diagrams Perspective drawings 3-dimensional surfaces	Bar charts Pie charts Line graphs Frequency distributions Tabular displays Scatter diagrams Perspective drawings 3-dimensional surfaces	Comparison of alternatives (detailed and summary)	Redesign or modification of alternatives

*Static or dynamic.

wide range of different community participation or interaction techniques. Generally, their potential value will correspond to the degree to which community (and decision-maker) participants are directly involved in the work of the transportation planner-engineer, particularly work with data, impact analysis, and computerized forecasting models. If a basic interactive need is to give the citizen and decision-maker participants a better understanding of the differences and interrelationships among various trade-offs among alternative plans, then interactive graphics should be used to strengthen, extend, simplify, and generally increase interactive capabilities. In a sense, community participation can be strengthened both by more interaction with planner-engineers themselves and by more interaction with their data and modeling systems.

Table 1 gives a number of possible community participation techniques that have been implemented or proposed recently and a subjective assessment of how interactive graphics would apply (1, 9). This assessment reflects the amount of impact information likely to be processed as well as the importance of the analysis tools of the planner-engineer. Of course, the specific application of any of these participation techniques will involve many more details affecting the applicability of interactive graphics. Therefore, these generalized participation techniques are presented only as background on the types of community participation programs within which interactive graphics might be employed.

The need for improved communication devices in urban transportation planning is serious. It is probably most serious when plans are presented to citizen groups and political decision makers. Plan results, particularly the significant differences among alternative plans, must be clear, unambiguous, and understandable. Communication problems can become quite severe when the number of alternatives is large, a wide range of different impacts is to be considered, or considerable use must be made of the outputs of computerized simulation models.

Computer and interactive graphics can potentially solve these communication problems. This section will briefly review various computer graphic display techniques. Computer-based display devices fall into 2 broad categories, maps and graphic or visual aids. In mapping, there are regional-system levels and corridor-center levels of detailing, and these correspond generally to transportation planning and community participation. Table 2 gives a summary of these basic graphic or communicative needs. The data given in Table 2 also indicate that several basic types of maps can be involved.

The computer mapping technique of spatially distributed data is of general interest in urban transportation planning, because it is quicker and cheaper and produces more maps than traditional drafting techniques can. The flexibility and speed of this technique also can be of great value in community participation or interaction activities, especially when new questions are raised or a desire to examine additional, geographically oriented data arises. Coupled with the low turn-around time offered by computer mapping is an on-line capability of an interactive mapping analysis procedure to sequentially examine a number of different maps or to modify or supplementarily analyze the characteristics of some maps.

The participatory implications and potentials of these computer mapping display techniques are particularly related to the levels of planning at which they might apply. Community participation in urban transportation planning has been weak at the regional-system level, and the recent surge of interest and progress in strengthening community participation has been associated largely with the corridor level of planning and project implementation. At both levels, however, interactive mapping might serve to clarify for the participant the results of planner-engineer analyses. Particularly at the regional level, dynamic mapping of, say, changes in travel volumes or residential densities might be quite helpful. At the corridor level, reduction in geographic scale permits increased detail in interactive mapping to the individual block and street or route level. Interactive mapping potential for participation at this level is particularly high, especially if the participant is allowed to manipulate on line certain route and neighborhood characteristics to examine associated consequences.

A major use for interacting mapping tools is in the design and analysis of transportation alternatives (14). This again applies at both system and corridor or center levels of planning. The ability to quickly generate additional alternatives and quickly examine some of their direct and indirect impacts will be a key feature. Additional system alternatives could be generated, for example, by adding or deleting specific routes or by increasing the capacity or flow characteristics of other routes. At the corridor level, additional alternatives could be generated by modifying route alignments, relative mode capacities, associated land uses, and other characteristics. In both cases, the ability to immediately display the results of comparative analyses of impact is essential.

Another important potential use of interactive mapping of particular significance for community and decision-maker participation activities is the comparison of alternative plans through a mapping of differences only. This could involve identifying only those subareas, point locations, or network links where 1 alternative displays an impact or distribution significantly different from another alternative. Displaying only these differences could allow the participant to quickly focus on the significant trade-offs among alternatives. Several alternatives could be analyzed in sequence and perhaps several different kinds of impacts could be displayed on a single map. This technique could offer a way of simplifying and reducing the quantity of data.

A second general category of graphics needs involves the various nonmap visual aids and display devices that might be devised (Table 2). Such devices could probably be used equally well at either system or corridor-center levels of planning and community participation. Their primary purpose is to simplify and clarify the relationships among different impacts or data items as well as among different alternative plans.

As a general rule, particularly for community and decision-maker participants, graphic aids of this type appear to be especially useful in comparing alternative plans. Devices such as the goal-achievement profile (10) allow a summarized comparison of relative impacts among different alternatives. Achieving this kind of simplicity, of course, sacrifices considerable detail and specific impact information from which the relative scores were derived. Interactive techniques could be used to determine the relative changes in impact that would be necessary to achieve, for example, a different ranking of goal-achievement scores. Such devices also could be used selectively to examine only the major or most significant differences among alternative plans. To some extent, such devices also might apply on an interactive basis in the redesign or modification of alternatives. Here an analysis result or impact might be modified interactively, and the associated plan changes necessary to achieve that impact could be derived. In this kind of redesign, both map and other graphic aids might be used simultaneously on an iterative basis.

INTERACTIVE GRAPHIC POTENTIALS

Using 1 or more of the community participation techniques and graphic display techniques previously mentioned, one can identify a fairly wide range of instances in which interactive graphics might improve the community and decision-maker participation process in plan making. In fact, many of these areas of potential application correspond to features of the transportation planning process that are generally in need of improvement at the technical-professional level and in terms of community inputs. Each of 6 potential application areas to be discussed, therefore, is relevant for both improving community participation and strengthening the overall planning process. The distinction between system and corridor-center levels of planning continues to be an important way to classify planning-participation improvement needs. The most pressing needs appear to lie at the corridor-center level.

The same general scenario for using interactive graphics in support of community participation programs might apply for each application, but, because of the many ways in which participation techniques evolve in an actual case study, many additional details of the scenario would remain to be delineated. A carefully designed user environment for interactive graphics and other participation activities would be needed. Within this specially equipped room or area, a wide variety of wall-mounted charts, maps, tables, and graphs depicting major problems and the characteristics and differences of alternative solutions might be displayed. A remote computer terminal could be located here to facilitate not only interactive graphic applications but also the full range of conventional computer modeling applications and reports. Staff and community participants in the planning process could be encouraged to make full use of all materials in the room. Demonstrations and orientation sessions for computer applications, including interactive graphics, might be held. Appropriate technical assistance and backup particularly for interactive graphics applications could be provided.

Of the 6 applications to be described the first 3 emphasize interactive mapping and the second 3 emphasize other graphical aids.

Incremental Development of Alternatives

To improve the performance or impact characteristics of a base case, one should interactively adjust certain features of an alternative. After examining the results of these incremental changes, one might test further changes. In addition to displaying in map form each alternative transportation system or corridor configuration for interactive modification, accompanying analyses of performance and impact outputs would be conducted by the computer and printed out on the display device to guide the next iteration. Changes in route alignment, capacity, number of entry points, frequency of service, and similar characteristics might be examined. The results of each test would be saved for later comparison. The UTRANS methodology, developed at the University of Washington (11, 12, 15), can be applied at a corridor level.

Pure Development of Alternatives

One of the most attractive features of the interactive graphics is its ability to flexibly, incrementally, and almost immediately revise alternative plans to achieve different kinds of performance or impact improvements. A separate application might be the initial development of the base case. This development of a single alternative could serve as a useful learning experience. It might then proceed to various forms of incremental improvement and analysis interactively, but perhaps on a different set of terms (such as teamwork rather than individual effort). For example, the first phase of the UTRANS program involves the development of the initial base system through a consideration of design and capacity limitations. This application area might be organized around a mapping of demand and environmental constraints, perhaps by using overlays, so that alternate facility and route locations and sizes can be designed interactively by the user.

Map Comparison of Alternatives

In addition to numerical analysis of the differences among alternative plans, one may also find it useful to examine the spatial distribution of such differences. If emphasis is given only to those differences that exceed some minimum level of significance (such as 20 percent variation), interactive mapping could be used to display only those differences for any pair of alternatives. Examples could include differences in accessibility provided, relative network loading, and residential displacements. Again, in this and other potential applications, relevance to community participation lies in strengthening communication and comprehension. In all instances, the technical aspects of user interaction, for both inputs to be made and outputs to be comprehended, must achieve greater clarity and simplicity for community and decision-maker participants than for the staff and professional participants.

Graphical Comparison of Alternatives

Devices such as goal-achievement profiles, bar charts, pie charts, frequency distributions, and similar graphical devices might be used to indicate the differences among alternative plans (10). Emphasis would be placed on evaluation of alternatives rather than on their further refinement. Comparison tables or charts might be used to compare regional and community level impacts and possibly to calculate summary scores or cost-effectiveness ratios (16). A selective display of only the most significant differences among alternatives might be emphasized. Interactive and participative aspects could be strengthened by permitting a wide range of impacts and community versus regional differences to be quickly and efficiently displayed or recombined in sequence or both. Intermediate calling of maps for further examination also might be desirable.

Classification of Regional and Community Goals

Classification of regional and community goals might take the form of comparative assessment of the impacts projected for different plans at regional and community levels. Although emphasis might be given to various graphical summary devices, supplementary use of computer-generated maps might also be made. The thrust would be toward a rethinking of transportation and transportation-related goals and objectives in light of the additional insights provided by specific impact forecasts, especially at the localized level. Experience has shown that the weights assigned to goals in abstract situations are likely to differ significantly from the weights assigned in actual conflict situations, which are frequently encountered at the transportation corridor planning level. The speed and flexibility of interactive graphics might be useful here to assist in such goal-weighting exercises as the Delphi technique (17).

Sensitivity Analysis of Plan Evaluations

When the evaluation of alternative system or corridor plans is well advanced, a need may arise to acknowledge the uncertainty associated with many elements of the evaluation. Three kinds of uncertainty that exist are forecasted impacts, forecasted costs, and goal weights. An interactive sensitivity analysis technique could be applied to explore these uncertainties and to test a wide variety of user-selected changes in impact forecasts, goal weights, and cost forecasts. The purpose would be to test the degree of confidence that might be attached to the preferred alternative and to identify those conditions under which other alternatives might be preferred. Such a technique has been partially developed but has not yet been linked to computerized visual display devices where either graphical or map outputs might be used (19).

RELEVANCE TO PLANNING AND PARTICIPATION

Among the many different issues and needs in urban transportation planning, at least 5 can be identified that have important implications for community and decision-maker participation. These 5 issues appear to be important at both regional and local levels, particularly at the local, corridor-center level of planning. Current trends in community participation seem to be emphasizing these more localized regimes for expanded community-planner interaction. Because each of these issues essentially involves an increase in the complexity, level of detail, and thoroughness of both planning and planning-related participation processes, there appears to be strong relevance for the application of an analytic tool that will streamline and intensify the process of information exchange. Interactive computer graphics appears to have this potential.

In addition to these substantive issues, however, a larger, overriding issue involves the stronger integration of community participation techniques in the ongoing urban transportation planning process. Before an interactive graphic component within community participation programs can be valuable, there must be a sustained commitment to the community participation process itself. All too often, particularly at the system planning level, community participation is sporadic, formalized, and relatively ineffectual. At least 3 steps of the planning process—goal identification, alternative development, and alternative evaluation—appear to need strengthened participation not only on a continuing system planning basis but also in terms of corridor-by-corridor and center-by-center planning. Until the system and locally oriented levels of participation are adequately strengthened, considering a role for interactive graphics will be largely academic.

Significant, participation-related transportation planning issues include

1. Number of alternatives, including incremental variations, that are considered;
2. Extent to which various staging options for implementing (and possibly mixing) alternatives are considered;
3. Range of localized impacts, both direct and indirect, that are considered;
4. Extent to which trade-offs within and between regional and localized goals are analyzed; and
5. Extent to which coordination with localized plans (especially nontransportation plans) is pursued.

Expanded community and decision-maker participation can help deal with each of these issues. They apply at both system and corridor-center levels of planning.

To help illustrate how such issues become embodied in specific plans and planning controversies, a series of examples from the Los Angeles region will be described briefly. Three examples involve system-level planning, and 3 involve corridor-center-level planning. In each case, significant opportunities appear to exist for strengthening community participation. In some examples, extensive revisions to propose plans have been made as a result of citizen reactions. However, these are not examples of the use of interactive graphics in strengthening community participation activities. Several of the transit-related examples, because of the expanded levels of community participation that are called for, will offer significant potentials in the next few years.

System-Level Examples

Rapid Transit Plan

Between August 1, 1973, and May 1, 1974, a consultant team undertook phase 3 of a major rapid transit planning effort for the Southern California Rapid Transit District (SCRTD) (18). This phase dealt with the refinement of a rapid transit plan reported in July 1973 and involved the most sustained level of community input of any of the 3 phases. During August, September, and October 1973, presentations were made at 18 formal community meetings in addition to other working sessions, presentations, and meetings that were held at each of the 78 municipalities in the district. County, state, and federal officials also were met with. The primary thrust of this participation effort was aimed at response and reaction to an already prepared plan. Many questions and suggestions regarding route, network, and station configurations were raised.

More than 900 specific responses from citizens and public officials were cataloged. They fell into 5 categories: stations, alignments, hardware, and technology; service and safety; funding, financial, and costs and benefits; environment; and political and public participation. A significant number of responses suggested additional and relocated rapid transit lines and stations. More than 100 responses asked how individual communities can be more strongly involved in plan refinement. The diversity of these responses and the clear indication of the need to define and analyze additional alternatives suggest that a major contribution might have been made by interactive graphics procedures, particularly to efficiently test proposed system modifications for performance and environmental impacts. The large number of suggested refinements was further evaluated eventually by the consultant team along 4 dimensions: capital costs and engineering issues, system usage potential, physical impact, and social impacts and planning policies. A substantial use of judgment appears to have been made in these assessments, and a considerable opportunity for more direct, immediate community participation in these plan refinement activities appears evident.

Policy Analysis of Guideway Transit Systems

The SCRTD transit plan emphasizes a single, high-capacity, conventional rail technology alternative. The Southern California Association of Governments (SCAG) has inaugurated further studies of a wider range of technology options (3). These include bus rapid transit, small-group rapid transit, and personal rapid transit. Significantly different hypothetical guideway networks were layed out for initial sketch planning by case study sector. Widely varying travel performance and environmental impact characteristics were indicated preliminarily. Major emphasis was given to the need to consider both evolutionary and geographic staging options for the various technologies and their components. Any continuing refinement of these guideway transit options also should include opportunities for significant community and decision-maker input. Because, as an extension of work on the SCRTD rapid transit plan, careful evaluation of many kinds of service and impact trade-offs will continue to be necessary, a potential for using interactive graphics to define and evaluate a fairly wide range of alternatives appears to be good.

Regional Aviation System Plan

During June 1973, a specially appointed citizen hearing board completed a 1-year comprehensive review of a Southern California regional aviation systems study previously conducted for SCAG (4). A series of 10 public hearings at various locations throughout the region were held by this citizen board. The board itself held 14 working sessions to evaluate testimony as well as to consider further details and information compiled in several different impact areas. Again this form of community participation represents essentially a reaction to, rather than an ongoing involvement in, the preparation of a system-level transportation plan. Several serious deficiencies in the initial plan, from the local community's point of view, were advanced. The citizen board consequently presented to SCAG its own recommendations regarding the regional airport system.

The citizen board determined that several aspects of the initial plan (airspace conflicts, noise levels, and air quality) were insufficiently handled. Concern for these indirect effects as well as reduced projections of air travel demand led to suggested reductions in the size and number of airports listed in the initial plan. Because of the complexity of various demand and impact characteristics and criteria applied to 17 existing and proposed regional airport sites, efficient, easily understood analysis tools and communication devices were needed during community participation. This also was an opportunity for effective employment of interactive graphics. For example, such techniques could have been used to explore the implications of various site-related criteria for noise levels (including examination of noise contours), air pollutant emissions, and land use types and densities in the vicinity of airports as well as the implications of different ground access connections, runway and terminal capacities, and overall airspace capacities.

Corridor-Center-Level Examples

Wilshire Corridor

First priority staging in the rapid transit planning activities of SCRTD has been given to the 16-mile (26-km) Wilshire corridor, which extends west from the Los Angeles central business district (CBD). Several major activity centers lie along this corridor, together with some of the higher residential and employment densities in the region. Recent local-level controversy regarding the proposed mass rapid transit, conventional-rail, subway line within the corridor suggests that considerable further analysis and planning of multimodal transportation options within the corridor will be necessary (7). A full examination of other transit options, including low-capital-intensive measures, bus rapid transit, personal rapid transit, vehicular control measures, and improved conventional bus service, appears appropriate for levels of travel service and impacts on adjacent land uses. If major corridor-level transportation studies are forthcoming for the Wilshire corridor, significant opportunities appear to exist for using interactive graphics to sharpen and strengthen the number and diversity of multimodal transportation options in association with their land use relationships in the corridor. Resolution of transportation issues in this corridor is likely to influence strongly the direction of rapid transit in other portions of the region.

Los Angeles Central Business District People-Mover Network

Detailed planning for a 1.7-mile (2.7-km) automated people-mover distributor, integrated within the downtown Bunker Hill urban renewal project that links two 4,000-space parking garages, also has been accompanied by preliminary planning for a larger transit distributor network serving the entire downtown area (8). As many as 10 different peripheral parking facilities could be linked by up to 19 miles (31 km) of elevated people-mover guideways. Community involvement in this preliminary planning has not been significant to date, but it is probable that any more detailed work on a CBD distributor transit system will require extensive input from downtown business people and landowners and downtown commuters and shoppers who would provide the bulk of system patronage. Inputs also should be sought from peripheral residents, who would also be significantly affected. Interactive graphics could again provide a potential for more carefully examining 2 broad kinds of trade-offs: local (aesthetics, integration with downtown buildings, station locations, coordination with other modes, street traffic congestion, air quality levels, noise, and station sizing) and those dealing with linkages to other parts of the region (coordination with rapid transit systems, coordination with freeway access points, peripheral parking facilities location, and relation to direction of approach to the CBD). A wide range of locational and technological alternatives already appear worthy of consideration, and community response to such alternatives is an important feature of their evaluation.

Norwalk-El Segundo Freeway Corridor

The Interstate 105 (Century Freeway) corridor straddles a 17-mile (27-km), 10-lane, east-west freeway connecting Los Angeles International Airport with 9 communities and 4 north-south freeways to the east. One of 12 alternative route alignments was adopted in November 1965 and July 1968. In 1969 and 1970, a series of public hearings were held regarding detailed design of the adopted route alignment within the traversed communities. Two cities, Downey and Hawthorne, opposed the final route location from the beginning, and they offer an example of the difficulties in achieving consensus on both alignment and design. An interdisciplinary consultant team conducted detailed design studies for the freeway. They considered such indirect impacts and opportunities as economic and fiscal structure, housing displacement and replacement, community facilities, local circulation, neighborhood environmental values, and joint use development (5).

Community participation in the design of the freeway ranged widely, varying from official refusal to accept the route itself to extensive community communication and involvement programs, and many formal and informal contacts in the Watts-Willowbrook area. For those communities where some degree of participation was achieved, it was found useful to distinguish 5 different categories of community interest groups. These categories show the orientation that application of interactive graphics might have taken. In general, the detailed level of analysis and the range of social, economic, and environmental impacts considered suggest that communication of the differences among alternative freeway designs could have been facilitated by interactive graphic means. The 5 different interest groups together with the kinds of impacts that were analyzed are as follows:

1. Owners and occupants of property displaced by freeway (impact on property values, extent of displacement, and types of families and businesses displaced);
2. Owners and occupants of properties left adjacent to freeway (impact of noise, air, and dust pollution; impact on property values; changes in neighborhood boundary; and barrier effects);
3. Neighborhood or area adjacent to freeway (barrier effects on access to schools and other community facilities, changes in local vehicular and pedestrian circulation patterns, and development of freeway-related land uses);
4. School districts (impact of noise, air, and dust pollution; change in school attendance boundaries and pupil loads; and reduction of tax revenue); and
5. City and county, including special districts and special interest groups (changes in economic tax base, local traffic reorientation and freeway access, and pressure for accelerated land use change.)

IMPLEMENTATION PROBLEMS

While the potential of interactive graphics to sharpen the participatory process in urban transportation planning appears strong, there have been few, if any, real accomplishments to date. Problems of implementation appear to be major, but these are concerned less with the technology of interactive graphics and more with the nature of the planning process itself. The most serious implementation problems relate to these broader planning process questions. Several problems relating to the technical aspects of computerized modeling and interactive graphics, though significant for any potential user, are particularly demanding for the nontechnical user associated with community and decision-maker participation. In some instances, the problems of implementation of interactive graphics in community participation appear formidable but not insurmountable.

1. Community participation process itself must be strong.
2. Interactive graphics must be built into the existing planning and participation process.
3. Interactive graphics must be "sold" to public agency staffs.
4. The suspicions of community residents and political decision makers concerning computerized analysis procedures need to be overcome.
5. Careful attention must be given to the data absorption capacity and attention span of participants.
6. Results must be understandable to nontechnical participants.
7. Maximum advantage must be taken of the limited time available to participants.
8. Related computerized forecasting procedures must be sensitive to a wide range of policies.
9. Quicker, less costly demand simulation models need to be developed.
10. Regional and local planning agencies cannot be expected to bear the software development costs associated with interactive graphics applications.

The community participation process itself must be strong. Interactive graphics can be viewed only as a supplementary tool for strengthening the broader process of interaction of community groups, decision makers, and the planner-engineer. Because community participation at the system planning level has characteristically been weak, the most promising area for using interactive graphics appears to be in those corridor planning activities built around well-organized, sustained, community participation efforts.

Interactive graphics must be built into the existing planning-participation process. Technical specialists in interactive graphics must work closely with planning agency staff members and other potential users and must fit interactive graphics to ongoing community participation activities rather than the reverse. For interactive graphics to gain real acceptance and use, a practical, incremental, small-start approach is probably necessary.

Interactive graphics must be "sold" to public agency staffs. For ongoing applications within overall community participation programs, public agency planner-engineers must provide leadership and guidance. Their own interest in these techniques and their capabilities for applying them themselves must be high. If their commitment to computerized analyses and plan evaluations is low, their interest in this form of interactive graphics will also be low.

The suspicions of community residents and political decision makers about computerized analysis procedures need to be overcome. The frequent confusion and fear associated with computer modeling in general will most likely carry over into interactive graphics procedures. The confidence of nontechnical participants in the reliability, usefulness, and workability of person-machine interaction must be firmly established. This means confidence in the use of computers in the first place. The key role of the participant's own judgment in the process must be clearly shown.

Careful attention must be given to the data absorption capacity and attention span of participants. This is an important problem area in interactive graphics when a trade-off has to be made between simplicity of operation and flexibility to perform many kinds of analysis (6). For the nontechnical person to participate, even more simplicity, including straightforward and step-by-step capabilities, is required. If the nontechnical participant is overwhelmed by maps, charts, data, and procedures, he or she will quickly lose interest.

Results must be understandable to nontechnical participants. As a general rule, maps must not be overly complex and detailed, charts and tables must not have too many different dimensions, and data and impact displays must be explicit enough to illustrate effectively the basic trade-offs. A major purpose of interactive graphics in community participation is to make the results of analysis more immediately informative and useful.

Maximum advantages must be taken of the limited time availability of participants. Effective use must be made of the short turn-around time advantages of interactive graphics. In addition, however, advance technical preparations must be carried out smoothly, so that, during actual interactive operations, the process moves quickly and smoothly for all participants. Transition from interactive graphics activities to other dimensions of the community participation program also must be smooth.

Related computerized forecasting procedures must be sensitive to a wide range of policy issues. Although they are not directly a part of interactive graphics capabilities, the supporting analysis and forecasting models that must be used to project the impacts of various alternatives must be improved. These modeling needs are now receiving considerable attention in the transportation planning community (2). Their link-up with more sensitive interactive graphics analysis procedures is significant. In general, a series of forecasting models is likely to be necessary to permit effective trade-off analyses among conflicting issues and goals.

Quicker, less costly demand simulation models are needed. For interactive graphic systems that are supported by travel demand forecasting models (particularly trip distribution, modal split, and traffic assignment models), past experience has shown that a large computer core is required. Combined with the computer storage requirements of interactive graphics systems, the processing time and cost characteristics associated with interactive graphics applications using such models can be excessive. This indicates need for more "sketch planning" models in travel demand forecasting (2).

Regional and local planning agencies cannot be expected to bear the software development costs associated with interactive graphics applications. Because the use of interactive graphics in community participation activities and in transportation planning is still in its early stages, and because, at the local level, applications are likely to be unique and nonrepetitive, the relatively high case-specific development costs of interactive graphic systems will be prohibitive at the local level (6). There appears to be considerable merit in the concept of developing a series of modular interactive packages that can be used by the transportation planning community as a whole (13). U.S. Department of Transportation sponsorship of interactive graphics demonstration projects, perhaps for transit planning applications at the corridor level, appears to be appropriate.

REFERENCES

1. H. Bleiker, J. H. Suhrbier, and M. L. Manheim. Community Interaction as an Integral Part of the Highway Decision-Making Process. Highway Research Record 356, 1971, pp. 12-25.
2. D. Brand and M. L. Manheim, eds. Urban Travel Demand Forecasting. HRB Special Rept. 143, 1973.
3. Cambridge Systematics, Inc., and Barton-Aschman Associates, Inc. Guideway Transit for Southern California: A Policy Analysis. Southern California Association of Governments, May 1974.
4. Citizens Hearing Board. Southern California Regional Airport System: Recommendations. Southern California Association of Governments, June 1973.

5. Gruen Associates. Interstate 105 Freeway: Design Team Concepts. California Division of Highways, December 1970.
6. Y. Gur. INTRANS and BROWSE: An Interactive Graphics System for Planning Related Data Analysis. Highway Research Record 455, 1973, pp. 23-35.
7. R. Hebert. Beverly Hills Opposes Wilshire Transit Plan. Los Angeles Times, June 7, 1974.
8. Progress Report: Bunker Hill People Mover. Los Angeles Community Redevelopment Agency, Dec. 1973.
9. The Impact of Highways Upon Environmental Values. NCHRP Project 8-8(3).
10. C. H. Oglesby, B. Bishop, and G. E. Willeke. A Method for Decisions Among Freeway Location Alternatives Based on User and Community Consequences. Highway Research Record 305, 1970, pp. 1-15.
11. M. H. Rapp. Transit System Planning: A Man-Computer Interactive Graphic Approach. Highway Research Record 415, 1972, pp. 49-61.
12. M. H. Rapp. Man-Machine Interactive Transit System Planning: Concepts in Their Design. In Socio-Economic Planning Sciences, 1972, pp. 95-123.
13. E. R. Ruiter and J. M. Sussman. Interactive Computer Graphics in Transportation. Highway Research Record 455, 1973, pp. 11-22.
14. J. B. Schneider. Interactive Graphics in Transportation Systems Planning and Design. Univ. of Washington, Jan. 1974.
15. J. B. Schneider, C. D. Gehner, and D. Porter. Man-Computer Synergism: A Novel Approach to the Design of Multi-Objective, Multi-Modal Urban Transportation Systems. International Conference on Transportation Research, Bruges, Belgium, June 1973.
16. J. L. Schofer and D. G. Stuart. Evaluating Regional Plans and Community Impacts. Journal of Urban Planning Division, ASCE, March 1974, pp. 93-109.
17. M. Skutsch and J. L. Schofer. Goals Delphis for Urban Planning: Concepts in Their Design. Socio-Economic Planning Sciences, No. 2, 1973, pp. 305-313.
18. A Public Transportation Improvement Program: Summary Report of Consultants' Recommendations. Southern California Rapid Transit District, March 1974.
19. D. G. Stuart. Interactive Sensitivity Analysis in Transportation Plan Evaluation. Transportation, 1974.

THE RELATIONSHIP OF SIMULATION, INFORMATION, AND INTERACTIVE GRAPHICS TO PUBLIC PARTICIPATION PROGRAMS

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This paper discusses the dissemination of simulation models by urban information systems as initiated by the University of British Columbia. The model building process includes great emphasis on disseminating the generated information. Each stage of the process feeds back ultimately to the model conceptualization phase through publication of information. The role of computer graphics and public demonstrations is a key part of the process. The first public demonstration in this study met with mixed response. Most felt the demonstration was too technical and contained too much jargon. Some felt that the intricacies of the computer could not be explained in 1 or 2 h. The most successful demonstration began with a 1-h discussion of what the audience was going to see during the computer show so that the audience would know what to expect before the computer terminal was used. The actual graphics provided the catalyst required to start the group interacting with each other and the computer system. Only special interest groups and sociopolitical institutions related well to the graphics demonstrations. Most of the general public usually lack the interest to achieve a minimal level of understanding. It also was found that, unless a graphics system has a variety of users, it tends to be used as a means to achieve some end, rather than as a tool to promote discussion. The information being displayed by the graphical system was the key to the usefulness of the system.

•THE HISTORY of urban simulation models is not glorious. Valid criticisms have been made about virtually all elements of the model-building process, from the model conceptualization and calibration stages to public policy (1, 7). The criticisms generally have been well founded. The study described in this paper was begun in the winter of 1969-70 (2). It was the hope of the interinstitutional policy simulator (IIPS) project that evolving tools from a number of disciplines could be brought to bear on construction of a simulation model for the Vancouver, British Columbia, region.

Figure 1 shows the overall institutional base for the project. The model-building process as it has evolved is shown in Figure 2. It can be seen that the process is continuous; each stage feeds back ultimately to model conceptualization. It was hoped that, by this, the process of model building could be emphasized and the danger of creating a rigid model set that was unchangeable and unresponsive to new information of new policy needs could be avoided. This process orientation has been stressed elsewhere (3, 4). We mention it here because information, especially that provided from interactive graphics, keeps the process functioning. In Figure 2, the public input requirements are significant. The key to this type of input is easily understood information. Interactive graphics are a means to an end; they provide information to the public to involve them clearly and directly in model building and the political process. This paper will briefly illustrate, by use of simple flow charts and diagrams, the nature of the model set.

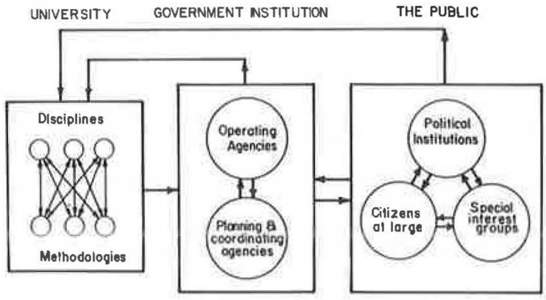


Figure 1. Framework for interinstitutional and public involvement.

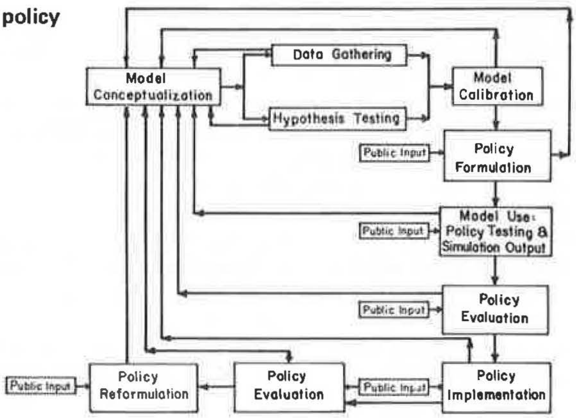


Figure 2. Framework for model refinement, policy evolution, and public involvement.

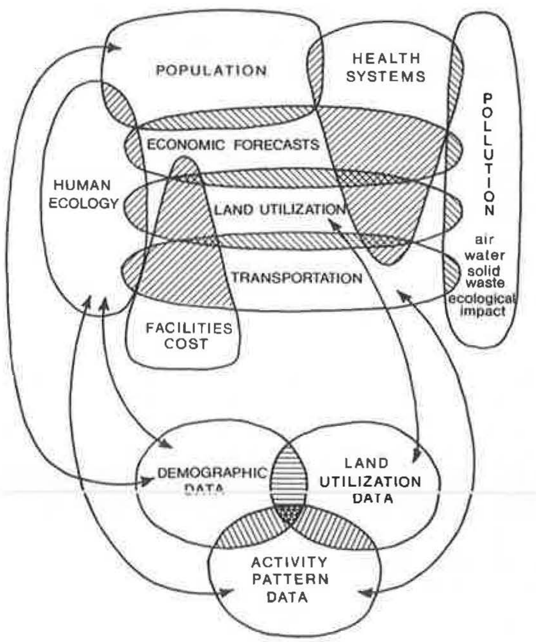


Figure 3. Relationships among the interinstitutional policy simulator (IIPS) subgroups.

MODELS AND THEIR EVOLUTION

At the outset of the project, some 70 individuals from 15 different academic departments in the university were involved. Disciplines that were represented ranged from the physical to the behavioral sciences. The major modeling groups shown in Figure 3 evolved from this broad participation. The groups at the top of the figure represent modeling efforts; those at the bottom represent service activities engaged in developing the necessary data bases on which the models could be built.

From these diverse modeling efforts a subset of 4 central models—population, land use, employment, and transportation—were identified. These are shown in Figure 4. Figure 4 shows the nature of the linkages among the models. A more detailed description of these models is available elsewhere (5).

Forecasts of employment (disaggregated into as many as 27 sectors) and population (disaggregated into as many as 100 age groups and for males and females) are derived from the economics and population models. (These aggregate forecasts are aspatial in that they treat the entire region as a single point in space.) They then are allocated to anywhere from 17 to 180 regional subareas depending on the level of spatial disaggregation desired. This spatial allocation is done by the land use models, which are shown in simplified form in Figure 5. Land use models break down into the 2 principal components of supply and demand. Both are further broken down into subclasses. In general, supply traditionally has been the area in which government policy has been focused, and the degree of disaggregation is needed for testing a range of policies.

Demand is broken down into 2 principal components: demand for land for employment and demand for land for population (housing).

The land use model then allocates demands by type of land use to subareas and compares demand to supply. If supply is sufficient, then the activity is located in that subarea. If supply is insufficient, available supply is used up and excess demand is reallocated. This process continues until all forecasted employment and population is allocated to a subarea. When this is done, then the employment and population models generate a forecast for another year, and the process continues over the time period being simulated. Policy variables include zoning; urban demolition and renewal; creation of new towns, subdivisions, and shopping centers; and rezoning for other uses.

Land use and population variables, which citizens tend to be most concerned about, will be used to illustrate the graphics capabilities of the system.

PROGRESS OF INTERINSTITUTIONAL POLICY SIMULATOR GRAPHICS

Interactive graphics displays sometimes large quantities of numbers in an interesting and easily assimilable fashion so that the user is able to modify or easily change both the type of graphics and the actual information being displayed. Computer software in 1971 was inadequate for this. It was too rigid in graphic style, and often only a preselected set of information could be graphed. This inadequacy together with a need for an automatic monitor for the set of models previously described prompted the development of a number of computer systems at the University of British Columbia in conjunction with the IIPS project (8, 9, 10, 11).

The 2 principal systems developed were SIM-SUP, a simulation supervisor with graphics for multiple simulators, and GIDS, a geographic information display system. SIM-SUP allows the user to display subsets of a large set of information on a variety of paper and cathode-ray-tube (CRT) graphical devices, change the assumptions of the model set, and easily use the simulation models. All of this is attained by using a simple command language. For example, DISPLAY TOTAL—POPULATION BY TIME would produce a graph of total population on the Y axis versus time in years on the X axis. CHANGE MIGRATION—OPTION TO 3 would cause the population model to use equation set 3 in computing the migration component of the population. A more complete discussion of the command language can be found elsewhere (6).

The graphic package started with simple line graphs, but the more complex struc-

Figure 4. Interaction between the module and the regional transportation model.

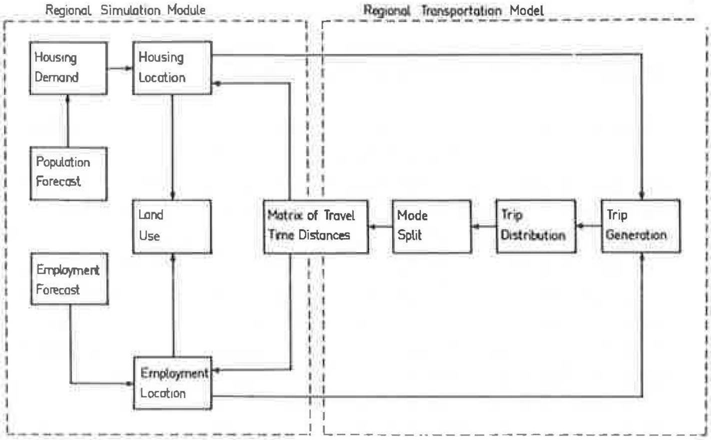


Figure 5. Land use models.

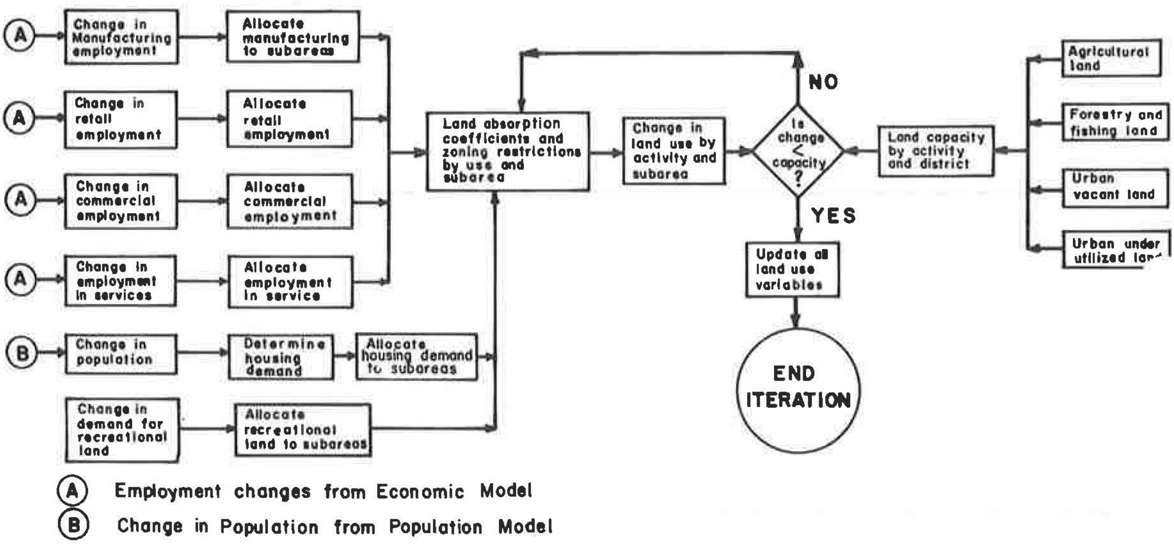


Figure 6. Low-cost housing for all municipalities.

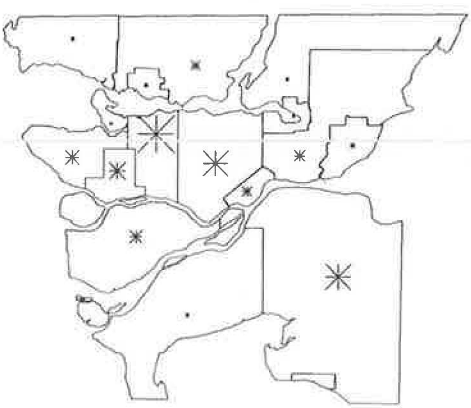
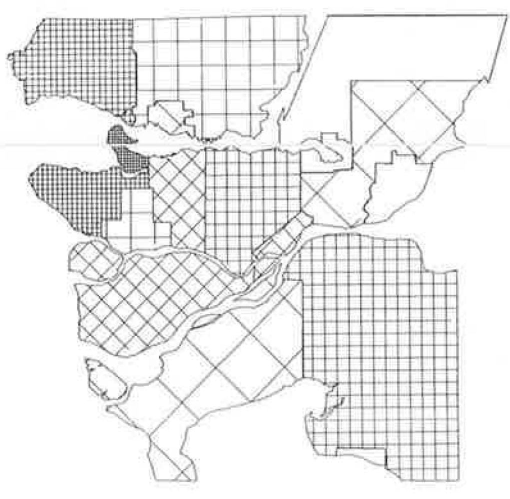


Figure 7. Advanced method of showing expected relative total employment for each municipality after 15 years of simulation.



tures of urban information forced the graphics to be more flexible. The problem of easily displaying large quantities of geographical information also had to be solved. A housing distribution for 17 subareas cannot be adequately displayed on a line or bar graph. This must be done on a series of maps that are sequenced through time. (Compare Figures 6 and 7 with Figure 8.)

It must be stressed that the present interactive graphics system is functional and deals with these complex urban information structures. It has proved useful in displaying population and demographic data and employment, housing, recreation, and transportation information. It has also been used for public finance and capital expenditure analysis for local governments.

This computer system can be used on-line or interactively from a computer terminal. The user enters a display command and observes the requested output within seconds. The user can then use the change command to modify the constraints of the models. Another display command that is superimposed on top of the previous one or is plotted beside it on a split screen will force the simulation models to be rerun and will show the effects of the modified assumptions. This entire process only takes 1 or 2 min, and the user is in complete control of the information being displayed and the assumptions being used for the simulation. The process is interactive because the user is able to respond to output from the computer almost instantaneously.

Figures 6 through 11 show some of the permanent (hard-copy) graphical output that is available.

PUBLIC REACTION TO THE GRAPHICS PACKAGE

The graphics package and the format for giving demonstrations were evolved from a series of IIPS forums or internal reviews. The forums were attended by IIPS participants, but usually some invited guests were present. These demonstrations, then, were given to a highly skilled and knowledgeable group that did not represent a fair test group. The level of the demonstration was far too technical for the general public.

The first public demonstration, which was given to a college class of political science students, was met with mixed response. Most of the group felt the demonstration was too technical and contained too much jargon. Some felt that the intricacies of the computer could not be explained in 1 or 2 h. Most, however, found the diagrams and predrawn graphs useful. The computer terminal, a portable Texas Instruments Silent 700, was used by means of a telephone line. The style of graphics on this particular machine was very primitive and was found to be inadequate for a group of more than 10 people. In other public demonstrations, a Techtronix CRT graphics device was used. This machine, although small, had excellent resolution and worked well, but it required proximity to the main computer.

Some demonstrations were given without the use of a computer terminal. All computer output was either prefilmed or preplotted on paper. Although this method is safer (the computer system cannot fail during the demonstration), the premade graphics tend to be too static and less stimulating to an audience.

The most successful demonstration was given to a group of about 10 urban professionals. The session started with a 1-h talk about the simulation models and the simulation supervisor. At the end of this discussion a brief premade computer demonstration was given. All of the commands had been previewed by the demonstrator, and all of the results were known. Following this, a discussion period was used to debate various options available to planners in the region. Suggestions on land banking, satellite cities, light rapid transit, and subsidized housing were put forth. At this point we chose the option on satellite cities to be worked through to a conclusion, and discussion was channeled toward this topic. The various interventions available were debated and decided on. Most of the options were listed on a blackboard and were erased or rewritten as the discussion progressed. After the final set of policy options were decided on, a set of corresponding computer commands were written on an adjacent blackboard. It must be noted that the discussion was always focused toward the options that were handled easily by the simulation model.

Figure 8. Housing units by time by region (too much information).

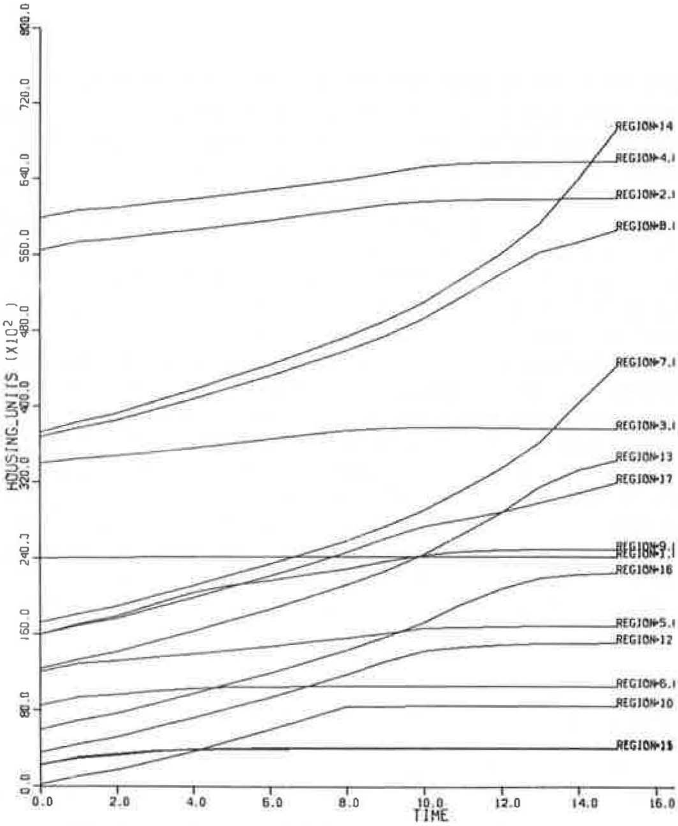


Figure 9. Total people by time for 2 migration options.

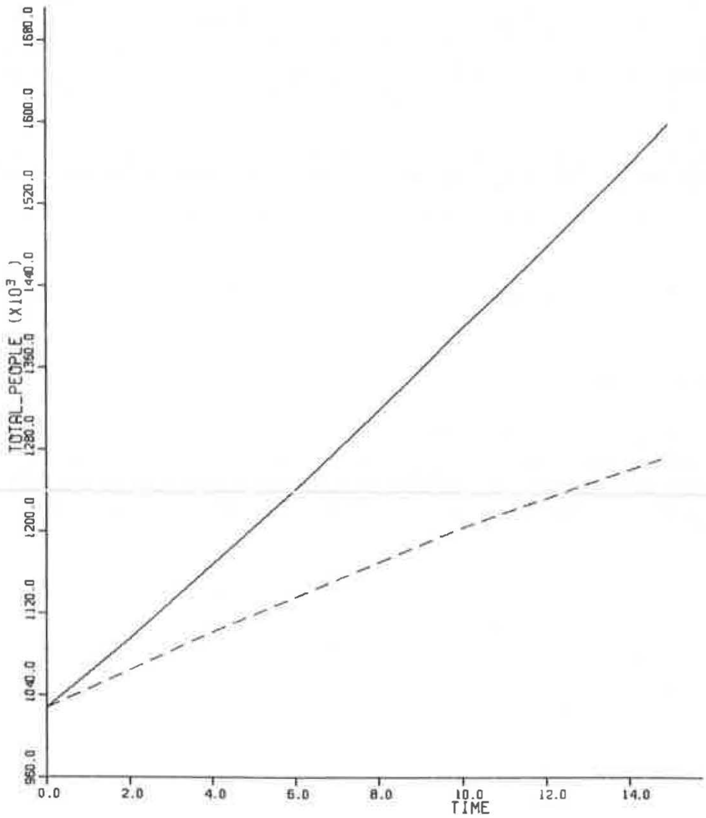


Figure 10. Male population by time by age.

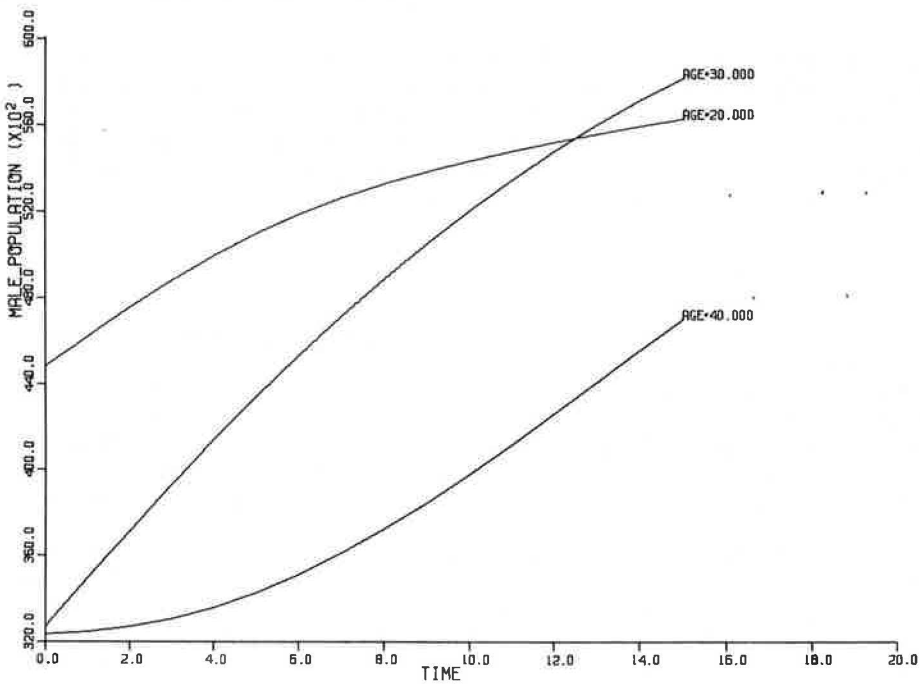
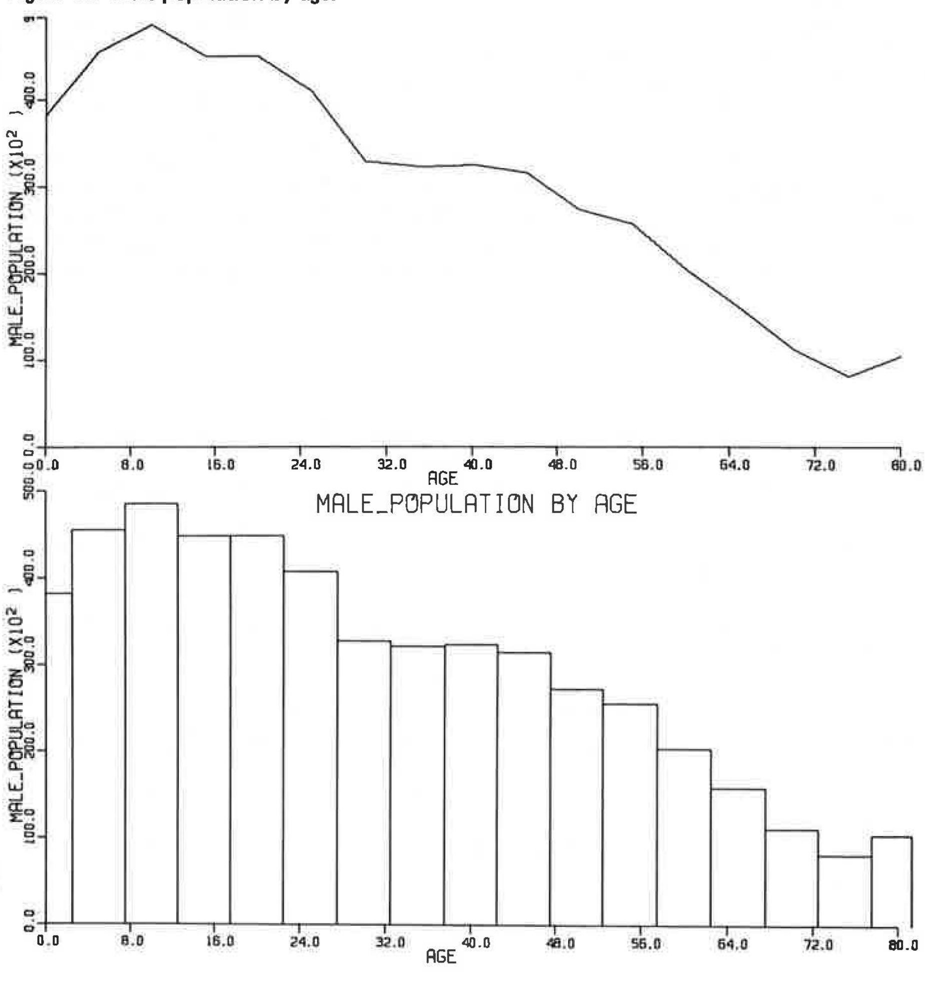


Figure 11. Male population by age.



After the discussion was complete and the computer commands had been constructed, one of the audience entered the commands into the computer. The results were overwhelming. The audience crowded around the display screen and everyone wanted to try other planning options. In this case the audience knew what to expect before the computer terminal was used. The actual graphics provided the catalyst to start the group interacting with each other and the computer system.

RECOMMENDATIONS AND CONCLUSIONS

Of the 3 public groups shown in Figure 1, only the special interest groups and political institutions were catered to with any success. These graphics systems were designed originally so that the untrained person could use them, but the system required at least a fundamental understanding of the information being displayed for the user to effectively interact with the urban simulation models. Most of the general public (those who are not affiliated with some special interest group) usually lack the interest to achieve this minimal level of understanding. Those who do future work in this area should be aware of this.

In theory, interactive graphics can be used to promote discussion of urban system dynamics. The primary danger is that these usually stimulating graphical tools can be used as a means to promote a particular scheme. Many people can be overwhelmed by the computer graphics if sufficient background discussion and explanation are not provided. This is a typical problem encountered when there is only 1 major user of the system (a city planning department may try to push for a pet project). We have found that a strong user-oriented program based in a multi-institutional framework is best for circumventing the problems associated when there is a single user.

The major concern of any interactive graphics system is the quality of the information being displayed. Even if the graphical system is very stimulating and interactive, the audience will not respond properly if its information is questionable. A sound data base (including a reliable set of models) is an essential prerequisite for a meaningful interactive graphics and public information program.

There are many pros and cons regarding interactive graphics as a public involvement tool. Against the promise of interactive graphics one must weigh the dangers of narrow in-house use. Against the promise of graphics as a discussion stimulator, one must acknowledge the dangers of graphics as a justifier of decisions. We hope that shedding light on these problems and prospects can advance the public decision-making process.

REFERENCES

1. D. E. Boyce, N. Day, and C. McDonald. Metropolitan Plan Making. Regional Science Research Institute, Philadelphia, 1972.
2. M. A. Goldberg and C. S. Holling. The Vancouver Regional Inter-Institutional Policy Simulator. Resource Science Centre, Univ. of British Columbia, 1970.
3. M. A. Goldberg. Development of a Metropolitan Environmental Quality Simulator. In Land Management in the '70's (W. L. Bathke and W. A. Haney, eds.), San Francisco Press, 1972, pp. 137-147.
4. M. A. Goldberg and H. C. Davis. An Approach to Modeling Urban Growth and Spatial Structure. Highway Research Record 435, 1973, pp. 42-55.
5. M. A. Goldberg. Simulation, Synthesis and Urban Public Decision Making. Management Science, Vol. 20, No. 4, Part II, 1973, pp. 629-643.
6. L. D. Hueftlein and D. A. Ash. The User's Manual for the Simulation Supervisor. Resource Science Centre, Univ. of British Columbia, 1974.
7. D. B. Lee. Requiem for Large-Scale Models. Journal of American Institute of Planners, Vol. 39, No. 3, 1973, pp. 163-178.
8. R. N. McRae. A Supervisor to Monitor Multiple Simulators. Department of Computer Science, Univ. of British Columbia, 1973.

9. J. L. Parker. Information Retrieval With Large-Scale Geographic Data Bases. Department of Computer Science, Univ. of British Columbia, 1971.
10. J. L. Parker. A Graphics and Information Retrieval Supervisor for Simulators. Department of Computer Science, Univ. of British Columbia, 1971.
11. J. L. Parker. Graphics and Information Retrieval for Large-Scale Simulators—A Virtual Data System. Department of Computer Science, Univ. of British Columbia, 1973.

COMPUTER GRAPHICS AND PUBLIC HEARINGS

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Computer-generated graphic displays can be used by transportation agencies to inform the public about certain aspects of a project before, during, and after a public hearing. These displays may be passive, or they may be generated interactively at a computer graphics display. In addition, some information may be presented as computer-generated animation. The application areas of passive computer graphics include mapping, land use plots, perspective views of facilities, origin and destination study plots, and environmental study plots. Interactive computer graphics may be used in these same areas, but the parameters used to create a plot may be changed to quickly create a new display. Animation has been used to simulate driving along or flying over a project. Current technology allows computer graphics to be used in the public hearing process. Future developments in computer graphics hardware and software should allow displays to be created that are more aesthetically pleasing and cost effective.

•SINCE the adoption of the 1968 Federal-Aid Highway Act, transportation agencies have placed more importance on public interaction at public hearings. In the past, public hearings were used only to inform the public of impending projects. However, the current emphasis in public hearings is not only to inform the public but also to allow for interaction between the community and the transportation agency. Information must be presented clearly and understandably to facilitate interaction.

A 1970 study of the public hearing procedure in Virginia identified 5 problem areas in public hearings (1).

1. Plans for the proposed project are not easily accessible to the community before a public hearing.
2. Highway hearings are too formal and technical.
3. The procedure for receiving testimony tends to intimidate some citizens.
4. Visual aids should be upgraded.
5. Publicity for future public hearings needs to be improved.

Observations of public hearings in other states indicate that these problems are not unique to Virginia.

Based on an analysis of these problem areas, a new public hearing strategy was proposed. The following are among the recommendations included in this new strategy (1):

1. Project plans and someone to explain them should be available at a convenient location;
2. Engineers should be provided to informally answer questions before the hearing;
3. More imaginative visual aids should be used; and
4. Appropriate action should be taken on important feedback from citizens.

Because pictures are at least as effective as words in explaining many things, some form of computer-generated graphics may be used to help the transportation agency fulfill these 4 recommendations. This paper will review the possible uses of passive, interactive, and animated graphics in public hearings. Some new technological improvements that may help make computer graphics presentations more aesthetically pleasing and cost effective will be discussed.

PASSIVE GRAPHICS

Passive computer graphic displays do not allow user interaction and may be produced before a public hearing. Many software packages currently exist that can provide graphical output suitable for use at a public hearing. Included in these packages are mapping, perspective plotting, and transportation-engineering-related programs.

Several programs exist that perform mapping functions and that may be useful before, during, and after a public hearing to show the public the orientation, layout, and some specific details of a proposed project. Contour maps may be produced that show the terrain features with the roadway superimposed. Three-dimensional perspectives of a region and drainage maps may also be produced by computer graphics for use in public hearings (2). It should be noted that many of the new plotters can use more than 1 ink color; this ability could be taken advantage of to produce more pleasing maps.

Land parcel plots giving some form of the legal descriptions of parcels in the vicinity of a project may also be of interest to citizens in the project area. These plots may be produced by special programs or may be produced by general coordinate geometry programs (3). Producing land parcel plots by computer can simplify other public hearing processes. For example, if a land parcel data base is created, it is possible to maintain the owner of a parcel, his or her address, and any other pertinent information on the data base. This data base may then be searched to categorize the parcels or to gather statistics on the land in the vicinity of the project. The data base may also be used to create a mailing list so that the landowners may be informed of a future public hearing.

Land use plots are typically produced with programs like SYMAP (4), and they may be printer plots or inked drawings. More imaginative plots can be created by using different color inks and by producing some plots on a clear plastic so that an overlay technique can be used when presenting the material.

Perspective plots may be produced to show a view of a highway based on terrain and roadway data. Programs have been developed that allow for the automatic generation of perspective views based on the coordinates of the viewer's position and the point at which he or she is looking (5, 6). Figure 1 shows a sample plot from 1 of these programs (5). This technique has been used for several projects. One application included the visual analysis of the environmental impact of a project (7).

An extension of this technique allows a computer-generated perspective view to be superimposed on a photograph of the roadway terrain (8). These montages may be more aesthetically pleasing and realistic than views produced entirely by a computer. Figure 2 shows a computer-generated roadway perspective superimposed on a photograph; for purposes of comparison, a photograph of the actual roadway after construction is included. The computer-generated picture can be made to look even more realistic by deleting cross-sectional lines and adding colors and striping.

The perspective view technique has been extended to include the structures on a project. A perspective plotting program has been converted to plot perspective views of highway structures as shown in Figure 3 (9). This program can be used to generate views of other structures such as pedestrian overpasses, buildings, and elevated guideways for transportation facilities. These plots also can be made more realistic with coloring and shading. It should be noted that, as development continues on this process, it will be possible to superimpose perspective views of structures on photographs of the terrain.

In urban areas it may be desirable to develop a perspective view of the urban area before and after a project. Although it would be tedious to put in digit form the x, y, and z coordinates of all the structures in an urban area, a program is being developed that will allow the user to construct a display by combining objects from a predefined library of objects (10). For example, to define a simple building tower, one needs to specify only the 3 dimensions of the building and its position with reference to some

Figure 1. Computer-generated perspective view of highway.

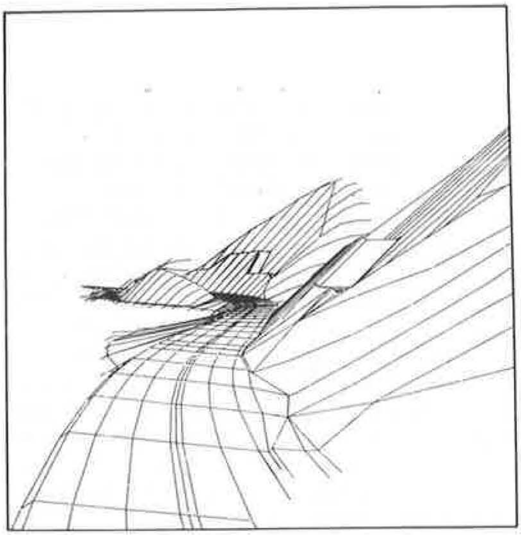


Figure 2. Montage view of highway.

Figure 3. Computer-generated perspective view of bridge.

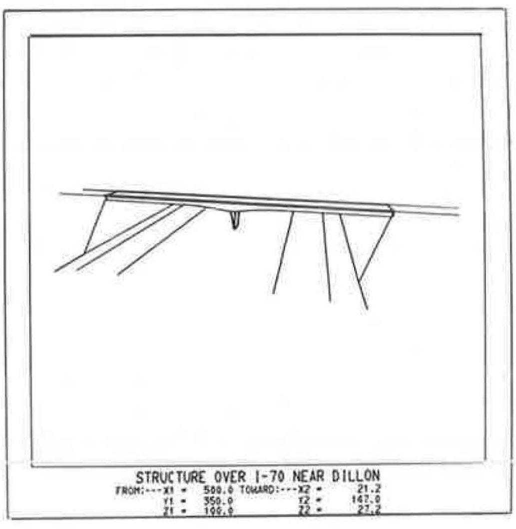


Figure 4. Highway perspective view on interactive graphics terminal.

global coordinate. By combining the appropriate objects, houses, trees, bridges, roadways, and buildings can be created to simulate the urban area. By using this technique, a perspective view of some part of an urban area could be created and then modified to show the area before and after a project.

Although the graphical output from many highway design programs may not be useful during a public hearing, it may be useful in discussions with the public before and after a hearing. For example, cross-sectional plots and slope stake plots may be of great interest to landowners whose properties are adjacent to the project right-of-way. The output of some transportation planning programs may be of interest to the public. Origin and destination study plots may be of general interest to the citizens in both urban and rural areas.

INTERACTIVE GRAPHICS

Interactive graphics programs exist that produce output quite similar to the programs identified in the previous section. Interactive programs allow parameters to be changed to rapidly generate a new view. Uses additional to those of passive graphics are suggested by rapid response to user inputs. All of the facilities of interactive graphics may not be necessary during a public hearing, but they may be useful before and after a hearing.

Generally, the same sort of mapping functions as those described in the passive graphics section may be performed with interactive graphics programs. The display screens of most interactive graphics devices are too small for displaying complex images. However, if a particular area of a map is of interest, it could be enlarged on the graphics terminal for further study.

Land use plotting programs could be used quite effectively from an interactive graphics terminal. For example, simple land use plots could be generated to acquaint participants with the plotting technique. Then more complex plots could be produced as the citizens learned the technique. Finally, plots based on user queries could be produced. A system is being developed in which interactive graphics is used to draw maps based on geographical references (11).

Perspective plots of roadways also can be produced in an interactive fashion as shown in Figure 4. The user of the graphics terminal may select the station and the height above and distance left or right from the centerline for both the viewing position and the point being viewed. The observer's viewing position may be moved to any station along the project, and the perspective view is displayed on the graphics terminal. In this fashion an engineer could show those at a public hearing what a proposed roadway would look like from many points along the project.

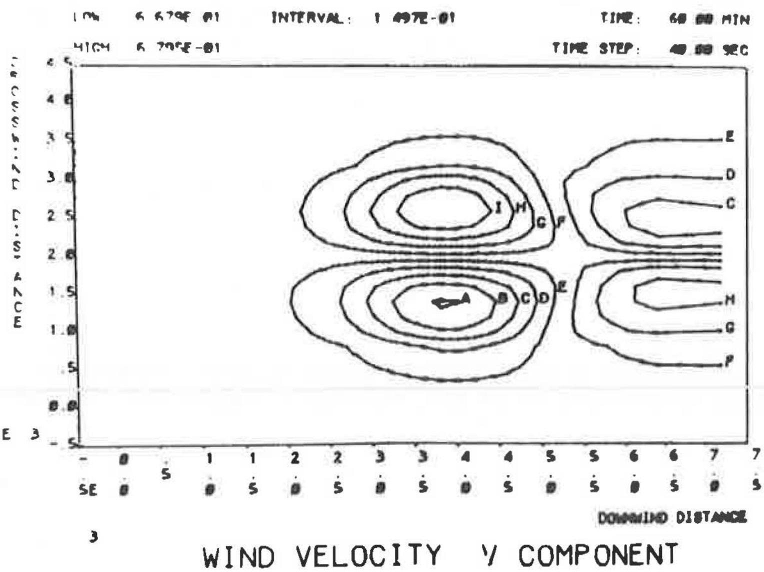
The bridge plotting program may be used in much the same manner as the roadway viewing program. The program operates interactively. The user specifies the viewing position and the point to be viewed. A perspective view of the bridge then is generated and displayed at the terminal. The user may then reposition the viewing positions to generate different views of the structure. The user also may display views of other structures on the project. Figure 5 shows a perspective plot of a bridge on an interactive graphic terminal.

Some of the existing design and analysis programs have some interactive graphic capabilities that may be of use either before or after a public hearing. These programs cover transportation planning (12, 13, 14, 15), structural analysis (16, 17), and soil mechanics (18, 19).

The transportation agency that is using interactive graphics in any part of the public hearing process should take steps to ensure that the public will be learning about some feature of a project rather than learning about some feature of a computer graphics system. The use of interactive computer graphics also should be planned carefully to minimize adverse reaction to small display screens, computer failures, and green displays.

Figure 5. Bridge perspective view on interactive graphics terminal.

Figure 6. Air pollution contours.



ANIMATION

Computer-generated animations of certain aspects of a transportation facility may be quite helpful in a public hearing. For example, driving down a proposed highway has been animated by using the roadway perspective view programs. By the appropriate use of these programs, a movie can be produced that simulates driving down or flying over the length of a proposed project.

Animation techniques could also be used in some environmental impact areas. For example, it may be desirable to show the pollution levels generated by a highway in a particular area as a function of time. Figure 6 shows an air pollution contour display. An animation could be produced by using an air pollution modeling program to generate pollution level contours for discrete time steps. A few film frames taken of the contours at each time step allow a movie to be made that will show the change of the contours as a function of time (20).

OTHER EFFORTS

Several other activities have defined or are attempting to define the role of computer graphics in planning. Some of the developments suggested by these groups may be of general interest to those participating in public hearings.

A Harvard University report (21) examines the function and use of aesthetic criteria in highway development. In the report a methodology is developed that integrates visual and behavioral criteria for more complete planning.

Another report (22), by the National Science Foundation, is of interest. This report surveys several research and development activities that are using some form of computer graphics in regional policy making or planning.

FUTURE DEVELOPMENTS

Current research in computer graphics hardware and software indicates that better graphical output will be achieved at a lower cost. The PLATO plasma display currently allows color slides to be overlaid and mixed with computer-generated graphic images on the screen of the display (23).

Raster-scan graphics devices are being developed that will allow color pictures to be generated at a relatively low cost (24). Extensive software development needs to be undertaken to make these newer devices usable by transportation agencies.

In the future, direct video mixing of videotapes of the terrain of a proposed highway alignment and a computer-generated view of the proposed roadway may be possible.

All of these developments will allow more realistic computer graphics images to be generated more efficiently. Existing software packages will have to be modified and new packages will have to be developed to enable transportation engineers to use these devices.

CONCLUSIONS

This paper has indicated how existing computer graphics packages can be used in the public hearing process. The applications are classified according to passive, interactive, and animated techniques. Not all of the programs listed are of use in a formal public hearing; some programs may be used better before or after hearings.

Computer-generated graphic displays should be used in public hearings if they show a feature of a project better than other techniques do. However, care should be taken to ensure that the public is not overwhelmed by the complexity of graphics devices or graphical techniques. The important point is that the transportation facility rather than the graphics system should be emphasized.

ACKNOWLEDGMENT

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REFERENCES

1. L. E. Walton and J. B. Saroff. Proposed Strategy for Public Hearings. Highway Research Record 356, 1971, pp. 26-31.
2. A. H. Voelker and C. R. Meyers. Computer Display in Spatial Modeling. Oak Ridge National Laboratory, Oak Ridge, Tenn., ORNL-NSF-EP-25, Aug. 1972.
3. R. A. Jones. COGO Reference Guide. Computing Center, Univ. of Colorado, Sept. 1973.
4. Users Reference Manual for Synagraphic Computer Mapping. Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard Univ., March 1971.
5. L. J. Feeser. Computer-Generated Perspective Plots for Highway Design Evaluation. Office of Development, Federal Highway Administration, Rept. FHWA-RD-72-3, Sept. 1971.
6. B. J. Blanning. Interactive Graphics for Highway Design. Transportation Focus, Business and Transportation Agency, California Department of Public Works, Vol. 1, No. 1, Jan. 1973, pp. 11-35.
7. E. R. Kunit and K. S. Calhoon. Smith River Highway Visual Analysis Study. Royston, Hanamoto, Beck, and Abey, Inc., San Francisco, Feb. 1973.
8. J. B. Berrill and L. J. Feeser. Photo-Computer Plot Montages for Highway Design. Highway Research Record 437, 1973, pp. 1-8.
9. R. H. Ewald. DRAW3D—A Three Dimensional Plotting Program. Computing Center, Univ. of Colorado, Nov. 1974.
10. J. R. Warner. BRIDGE-PLOT—A Three Dimensional Object Plotting Program. Computing Center, Univ. of Colorado, Dec. 1974.
11. E. J. Christiani, R. J. Evey, R. E. Goldman, and P. E. Mantey. An Interactive System for Aiding Evaluation of Local Government Policies. IEEE Trans., Man and Cybernetics, Vol. SMC-3, No. 2, March 1973, pp. 151-156.
12. C. D. Gehner and J. W. Clark. Documentation. In The Urban-Region Transit Analysis System (UTRANS), Urban Transportation Program, Univ. of Washington, Research Rept. 72-2, Vol. 1, 1973.
13. C. D. Gehner and J. W. Clark. User's Manual. In The Urban-Region Transit Analysis System (UTRANS), Urban Transportation Program, Univ. of Washington, Research Rept. 72-2, Vol. 2, 1973.
14. Y. Gur. INTRANS and BROWSE: An Interactive Graphics System for Planning Related Data Analysis. Highway Research Record 455, 1973, pp. 23-35.
15. M. H. Rapp. Man-Machine Interactive Transit System Planning. Socio-Economic Planning Sciences, Vol. 6, 1972, pp. 95-123.
16. R. H. Ewald. STRAIN—An Interactive Computer Graphics System for the Analysis of Skeletal Structures. Computing Center, Univ. of Colorado, Rept. 70-15, Aug. 1970.
17. R. Anderson. CDFRAME—An Interactive Computer Graphics System for the Design and Analysis of Skeletal Structures. Computing Center, Univ. of Colorado, Dec. 1974.
18. R. L. Schiffman. Interactive Computer Graphics in Soil Engineering. U.S.-Japan Joint Symposium on Computer Aided Design, Association for Civil Engineering Design System of Japan and Japan Industrial Planning Association, 1972.
19. R. L. Schiffman and J. R. Stein. Interactive Graphics: Settlement and Slope Stability. Journal of Structural Division, ASCE, Vol. 97, No. ST1, 1971, pp. 253-272.
20. P. T. Baldwin. WINDIF—An Experimental Interactive Computer Graphics Model

to predict the Distribution of Highway Associated Air Pollution. Computing Center, Univ. of Colorado, Rept. 73-18, 1973.

21. Highway Esthetics. Landscape Architecture Research Office, Graduate School of Design, Harvard Univ., June 1968.
22. W. R. Ewald. Graphics for Regional Policy Making: A Preliminary Study. Research Applications Directorate, Office of Exploratory Research and Problem Assessment, National Science Foundation, Aug. 1973.
23. D. L. Bitzer, R. L. Johnson, and D. Skaperdas. A Digitally Addressable Random-Access Image Selector and Random-Access Audio System. Computer-Based Education Research Laboratory, Univ. of Illinois, CERL Rept. X-13, Aug. 1970.
24. J. Staudhammer and D. J. Ogden. Computer Graphics for Half-Tone Three-Dimensional Object Images. Computers and Graphics.

TECHNOLOGY FOR CITIZEN PARTICIPATION IN PLANNING

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Experiments involving a certain technique on citizen participation in community planning were conducted in 200 group meetings in a great variety of settings. By means of special voting technology and meeting procedures, the experimental technique allows every participant to make an anonymous coded response to questions posed by the moderator or another participant and to observe instantaneously a tally of how many people voted in each category. The technique permits a rapid appraisal of consensus and controversy; it allows participants to reveal their ignorance, deal with controversial questions without intimidation, and generally make the discussion more responsive to the real interests and needs of the group. In some cases, quantitative procedures are used to rate alternatives against criteria and find group utilities, but mostly these procedures are regarded as an augmentation of normal free discussion and idea formulation rather than a means for commitment to final decision. These techniques are evaluated as a function of the type of topic and questions used, the personality and experience of participants, the style of the moderator, and other factors including rapidly increasing capabilities for large-scale community communication, such as those provided by 2-way cable television.

•MUCH concern has been voiced recently about citizen participation in community planning (1, 2, 3, 4, 5, 6). Various programs have been proposed to improve such participation, and politicians have given their enthusiastic endorsements to the general idea. In a few cases, such as highway planning, legislation has been passed requiring a certain amount of citizen input. Unfortunately, much of the enthusiasm has been naive. It has been based on an expectation that effective citizen feedback comes freely, but not everyone feels that being a good citizen is a moral obligation. There is also the expectation that a representative spectrum of the community will get involved, but usually those who do are self-selected and usually are not statistically representative. Most of the difficulty, however, results because the channels for ordinary citizens to communicate with those in power simply are insufficient.

Whether more participatory democracy is good for large-scale planning in transportation or similar areas is sometimes questioned. Experts and visionaries cannot be replaced. Democratic rule by an ignorant majority may result in mediocrity and tastelessness. Such arguments challenge the idea that more communication is desirable. One must agree that, when any new communication tools can be manipulated by a few powerful persons, there is real peril. Alternatively, even if these tools are not subject to manipulation by a few people, a community of well-meaning persons may unwittingly adopt technocratic procedures that will allow the majority to oppress the minority. Therefore, in any attempts to improve citizen feedback, one is obliged to assess these dangers along with any benefits that might accrue and to examine the desired balance of democracy, authority, and laissez-faire (7).

Various means exist to bring more citizen participation into transportation planning operations. Individual letters and verbal petitions have impact, but they provide little satisfaction for the sender and the recipient usually treats them as statistics. Citizens are most effective when organized in groups in which they can share concerns, educate each other, and, in the process, become more clear and persuasive in arguing for a particular policy alternative. Whether the citizens are meeting to clarify for themselves a particular issue or whether they are participating in a public hearing or other meeting with public officials or other experts, a central problem is to make that meeting more effective.

We saw a need to develop and evaluate techniques for improving community dialogue in group meetings and make use of the best technology available in order to aggregate and display responses from all participants.

At the outset, we considered the greatest current need to be that of groups that meet in a single room rather than in meetings in which participants are geographically separated and communicate over telephone or video. Aspects of the latter are discussed in a more complete report of this research (8). It was also taken as an axiom that whatever technology would be employed in the meeting should not constrain the participants from normal and free discussion in natural language.

The subject matter of transportation system and policy planning is typical of a larger class of subjects that community groups deal with. There are always some experts present, but the community at large is not altogether trusting of their expertise. Most of the participants know how transportation affects them, and they consider their own expertise to be valid. Couching problems in technical terms is annoying and alienating to them.

Typically, many of the citizens in a community meeting on transportation hesitate to speak out because they are not accustomed to the give and take of large groups that the experts or politicians appear to thrive upon. They have come to listen, observe, determine the important issues, and share their own perceptions and feelings, provided they can do so without looking foolish.

TECHNOLOGY AND PROCEDURES USED IN THE EXPERIMENTS

The technique we evaluated, the electronic voting and discussion technique (EVDT), employs an electronic polling system as shown in Figures 1 and 2 (9). Figure 1 shows a 10-position participant response switch. Figure 2 shows central display and control equipment. The small display at left indicates in sequence each category number and corresponding votes. The tall display indicates votes for all categories simultaneously. The tall display is the one normally used, but its height [6 ft (1.8 m)] is a disadvantage. A smaller column display [19 in. (48 cm) high] has been used recently. The hardware itself is similar to that of student response systems (10, 11) that have been wired into classrooms in what I consider to be mostly mechanical and unimaginative testing applications. The study discussed in this paper emphasizes the software and participants' reactions.

Five steps outline the procedure.

1. The meeting moderator or some participant poses a question or makes a statement by means of an overhead projector, blackboard, or chart. Accompanying the question or statement, 2 to 10 alternative responses coded with numbers from 0 to 9 are listed. From those each of the participants is asked to select the most appropriate. Both the question and the responses can consist of words, numbers, or pictures or a combination of these. Sometimes the responses are direct substantive answers to the question; sometimes they are reactions such as "I don't care," "I want to object," or "Other."
2. Each participant (up to 90 in a group) holds a small 10-position thumb-wheel switch. These are wired to a common line that runs to the front of the room. After observing the question and possible responses, the participant sets the number on the switch corresponding to his or her choice from the response alternatives. Voting is secret. The switch dial setting is recessed in a plastic case and can be guarded from view simply by covering it with the thumb.
3. After all participants have been given sufficient time to make their selections (usually no more than a few seconds) the moderator pushes a button and instantaneously a totalizer display in the front of the room indicates the number (00 to 99) of people voting in each category.
4. The first 3 steps, which normally take 1 to 2 min, serve as a basis for a longer period of group reaction and discussion, which is the most important step in the series.

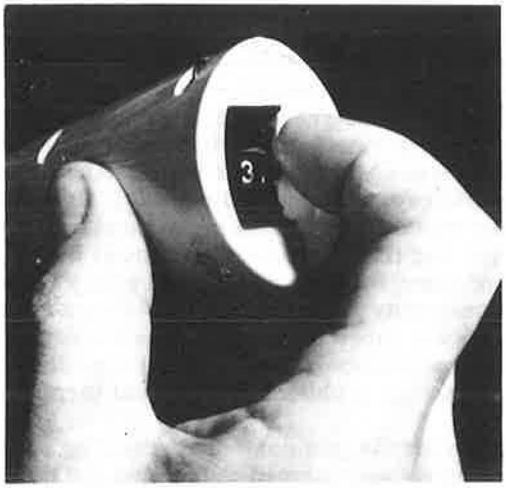


Figure 1. Response switch.

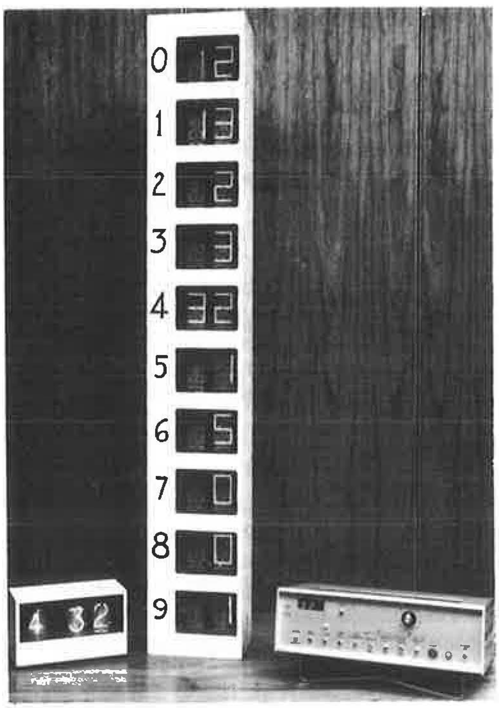


Figure 2. Central display and control equipment.

The moderator's task during this period is to point out salient features of the polling results—where consensus is indicated and where there is controversy—and to induce representative participants from various response categories to indicate why they voted as they did. Equally important is drawing out the reasons why people did not understand or objected to the question.

5. When certain words in the question or response categories are criticized, the moderator sometimes solicits a rephrasing and a revote. A change in the vote profile invariably motivates a discussion on the cause of the change. If certain assumptions are questioned, the moderator can ask for several revotes under different assumptions, limit the next vote to particular subgroups, or go on to the next question.

PLAN OF EXPERIMENTS

EVDT technology and the polling-discussion procedure were applied in approximately 200 group meetings. The groups ranged in size from 10 to 90. The meetings lasted from 1 to 3 h each. Some of the types of the experimental meetings will be discussed.

In designing the experimental evaluation, we decided that the conventional type of meeting with discussion and rules of order should be the basis from which to measure changes in objective behavior and subjective evaluation. We also believed that the meeting to be studied must be real. It would consist of people who come together to communicate on an issue or make a group decision. Participants would be told that they would use a novel procedure for their meeting, but their purpose for the meeting would be emphasized and not the experimental nature of the dialogue technique. (When groups feel they are guinea pigs serving an experimenter, social interactions are abnormal and experimental findings become biased.)

General

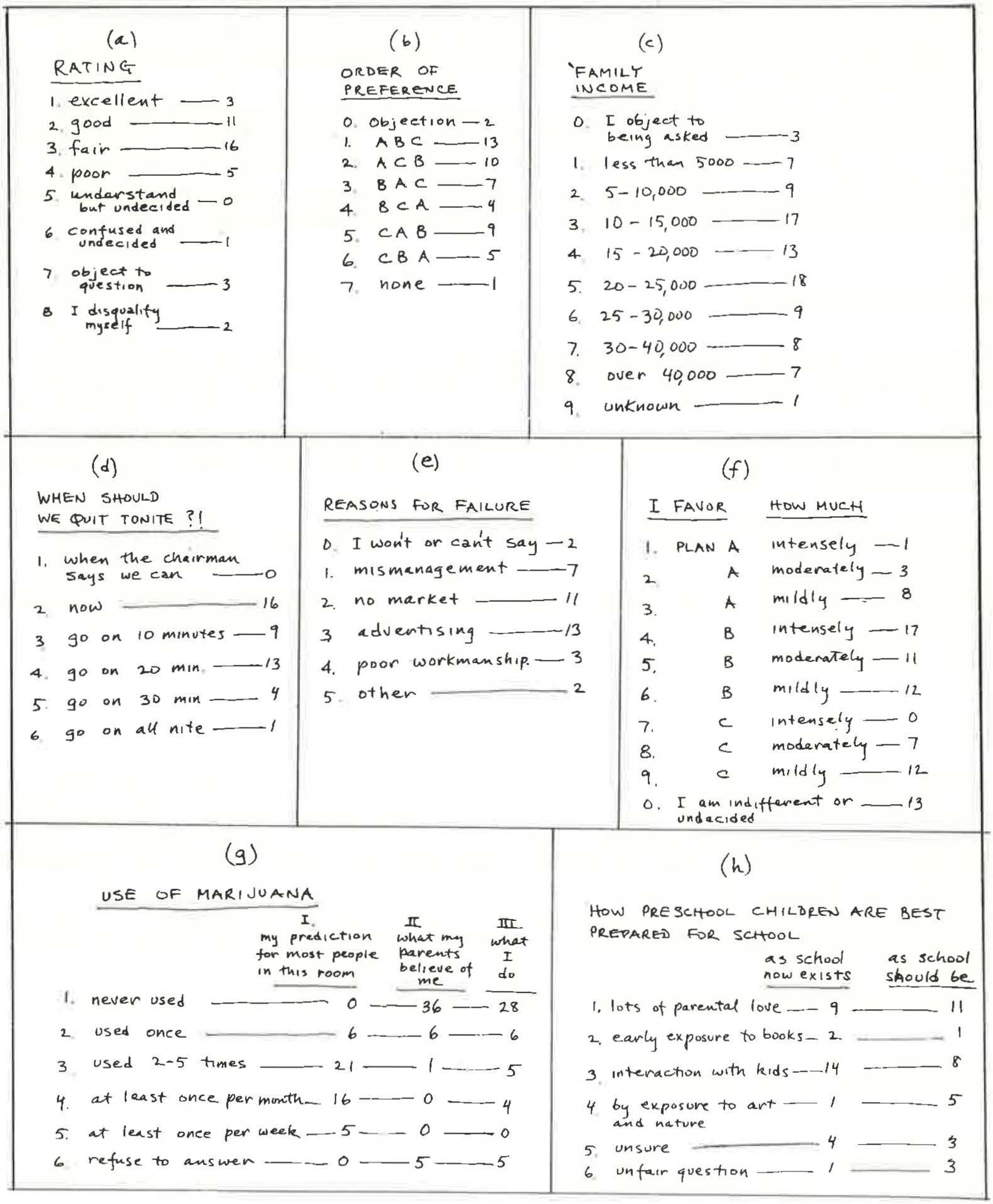
The general type of meeting, the one in which EVDT uses were solicited by the client, was the largest category and the least amenable to experimental control. The operative criterion was that some group requested the services of the project presumably to see whether the novel technology and procedures might help the group achieve its purposes.

Typically, one of the project staff who was to serve as moderator would meet with a few of the leaders of the requesting group and explain what the procedure is. For example, it is a means to focus quickly on how members of the group feel about an issue and on where there is consensus or conflict; it is a means to involve everyone in the room, but it allows them to do so anonymously to be able to deal with controversy or admit what they do not know without embarrassment; it is a means to let the agenda be guided by what the group wants to deal with; and, most important, it is a means to augment natural discussion.

The project staff person also would explain to the client group leaders what the procedure is not. For example, it is not a replacement to a paper and pencil questionnaire in which individual answers are sought and in which reaction to responses is not relevant; it is not a foolproof means for casting final votes on important decisions. The traditional paper ballot, because of its built-in time delays, has real advantages.

Questions or propositions and alternative responses to them put in the briefest possible wording were usually drawn up in the preliminary meeting. Almost always a few of the 10 switch categories were left to be filled in by suggestions from the participants during the meeting. Sometimes all of the response categories were left open. Some examples of questions and response categories are shown in Figure 3. Figure 3a shows rating of alternatives including some process feedback; Figure 3b shows the complete preference ordering of 3 alternatives; Figure 3c shows a quantitative scale; and Figure 3d shows a typical procedural question. Figure 3e shows an ad hoc list of categories drawn from a group discussion; Figure 3f shows a 2-dimensional response, that is, alternatives versus degree of favor; Figure 3g shows a sequence of 3 votes on the same question and compares perceptions to facts; and Figure 3h shows a sequence of 2 votes

Figure 3. Questions and responses.



on the same question under different assumptions. It can be seen that a fairly rich communication can be accomodated this way with words, numbers, photographs, and multiple votes.

The EVDT has several modes. The mode just described is the question mode. There also is the branching mode, which is a procedure that does not depend on prepared questions. In this mode the meeting begins with a blank blackboard or one on which only a general indication of the problem to be discussed is found. The moderator then begins by asking for suggestions on what should be discussed, what the problems are, and what some relevant criteria are to generate a list of 5 to 10 items. Then the group, by using the polling devices, votes on first choice, and perhaps second or third choice. The most popular item or items then are selected for further discussion, and, based on these, a new list of items is elicited from the audience, a new vote is taken, and so on. In this way, a branching list that provides an idea map of the discussion is produced.

Of the 70 meetings conducted in this general category, most were moderated by project staff; some, however, were moderated by people not connected with the Massachusetts Institute of Technology. Subject matter and size and constitution of the groups ranged widely. The questions mode was used in most of the meetings.

Use of Electronic Voting and Discussion Technique in Transportation Planning

A transportation consulting firm proposed to the county planning commission of a major eastern city a transit study that would include several citizen seminars. This firm was dissatisfied with the results of previous seminars. They had been frustrated with both the level of participation they had been able to elicit and the judgments and rankings of alternatives. They were not sure that the individuals filling out rating sheets had understood the ranking concept. This firm decided that EVDT would be used at a citizen seminar. I served as the interactive moderator, a company representative served as the principal resource person, and an official of the planning commission acted as chairman of the proceedings. This ensured that responsibility for use of EVDT did not fall on someone unfamiliar with it. It also did not require that I pose as an expert on the transportation problems of the community.

Overhead projector slides were prepared containing questions similar to those employed in previous citizen seminars. Items included relative importance of different routes and frequency of buses, different fare structures, transit goal priorities, and new alternatives such as demand-responsive transportation.

The consulting firm tended to plan too many questions. I suggested that if free reaction and discussion were desired then 15 to 20 questions would be the most that could be handled. Because unanticipated questions from the moderator or audience should be allowed for, I prepared 12 questions. The consulting firm prepared 25 questions in case free time occurred. But, even though the participants voted (using the EVDT) to go on 30 min longer than the original schedule specified, only 12 questions were used.

The sponsors did not get all the quantitative data they had wanted, but they gleaned qualitative expressions and arguments that they had not anticipated.

In a vote taken at the end on how useful the EVDT was for the meeting, the majority felt that it was useful. Their comments revealed an increased sense of participation for many who normally would have been completely passive during the session.

Other Uses of Electronic Voting and Discussion Technique

A new state secretary of educational affairs posed 8 questions to a gathering of 90 regional superintendents and principals to learn what they thought his policies should be.

A national professional society convention arranged that speakers in 2 sessions ask the audience after each speech 2 or 3 questions about the presentation.

Two classes of high school students were asked 10 questions about drug use. Questions covered their own experiences, their judgments of what their parents knew, and their estimates of drug use by their peers.

One hundred businessmen met in Washington and went through a list of questions pertaining to federal policies affecting their companies while a group of 30 government officials observed.

A regional medical organization invited experts to estimate 1975 personnel needs in various nursing, laboratory technician, and other paramedical specialties to plan state college programs in these areas.

A citizen committee planning a town's participation in the 1976 bicentennial celebration started with a matrix with alternative proposals as columns and criteria as rows. After they accepted 1 or 2 additional proposals and criteria from visitors, they rated the relevance of each criterion to each proposal.

A few of the meetings used the branched discussion. For example, in an environment-conscious West Coast region, 8 meetings were conducted to raise the consciousness level of citizens regarding the effects of growth on the region. They started with the idea of growth of the region and elicited various meanings and implications. Then they assigned importance and desirability ratings. The branched discussion that followed inevitably led to questions concerning quality of life and other broad issues.

Systematic questionnaire data were collected from only a few of these meetings. Anecdotal evidence was recorded by the moderator or another meeting attendee in all of the meetings; it also was collected from debriefings, letters, and comments received after the meetings.

Results

The meetings generally were successful, and the reactions were positive. A few meetings were disasters, and most could have been better in some respects. Some of the factors that seem to have had the most effect will be reviewed.

1. It was important that the organizers of a meeting be briefed on the EVDT, plan not more than 12 questions/h, decide on the mode to be used, and dispel the notion that an electronic voting machine is necessarily a balloting device to be used only after all in the group are clear on the question and response alternatives. It was also important to ensure that the moderator (at least during the EVDT part of the meeting) be experienced in EVDT techniques; otherwise the regular chairperson might try to run the meeting in the conventional manner. Awkward pauses to vote would result. Worse, the moderator, not knowing what to do with the devices, might simply save the votes until the end of the meeting.

2. Meetings went better when the physical arrangements were informal and gave those present a sense that they had something to contribute. This meant that the meeting had to be moderated from the same level as the audience and that the chairs had to be arranged in semicircles (if possible) rather than straight rows. It also meant that a large blackboard or pieces of newsprint pad were needed so that the moderator, in addition to showing the question and response categories, could record the votes and the comments made in the discussion that followed. (In the branched discussion mode, it was essential that none of the discussion map be erased.) The moderator was assisted on occasion by a person who sat facing the audience and took notes on the discussion.

3. The success of the meeting was highly dependent on the skill of the moderator. At the beginning of the meeting the audience generally appreciated a chance to try out the devices and learn that the votes would not be traced to their origins. Humor was especially helpful at the beginning and served to relax the group. It was found helpful at the beginning of the meeting to use EVDT in having the participants identify themselves anonymously according to their organizational affiliations and politics. As meetings progressed to their main agendas, the moderator had to pay attention to the

apparatus and the audience simultaneously. The danger was that he or she might pay too much attention to the apparatus and too little to the audience. Thus, following each vote, the moderator had to make sure that expressions representative of the different vote categories were heard especially from those who voted "other" or "object to question." If, in the course of this discussion, other questions or suggestions came up, including those on procedural matters, the moderator needed the presence of mind to use the EVDT to get spontaneous opinion from the group. The moderator had to learn to use the EVDT to encourage shy people and discourage those disposed to making lengthy speeches or haggling about procedure. Sometimes the moderator would have to impose his or her will to force a vote.

4. Reactions of the participants and meeting organizers generally were enthusiastic. To a great extent, the reactions were dependent on the backgrounds and expectations of the participants. Some groups loved the intellectual game-playing aspect, and some regarded the whole EVDT as not serious or even irrelevant. Many individual reactions from participants and moderators are available elsewhere (11, 12, 13, 29).

Acceptability Studies

Another set of experiments, administered in a semicontrolled fashion and based on repeated uses of the technology by the same groups, assessed the acceptability of the technology and EVDT meeting procedures as a function of certain individual characteristics of the participants and certain procedural differences. These experiments were carried out by Lemelshtrich (12).

Most of the meetings were conducted among social studies students in a Springfield, Vermont, high school and a Boston, Massachusetts, high school. Some were conducted among the parents of these students. There were 9 groups that had an average of 22 participants. All but 2 of the groups met repeatedly; 3 met at more than 12 sessions. All of the groups kept the same moderator, and several moderators served 2 groups. The moderators predominantly used the open, branched-discussion procedure. There were very few prepared questions.

The primary measuring instrument was the written questionnaire, parts of which were multiple choice and parts of which were constructed response or open comment. Questionnaires were administered to both meeting participants and moderators at the beginning of the experiment to obtain data on age, sex, social and religious preferences, and experience, ease, and effectiveness in group participation. After each meeting, questionnaires were administered to obtain subjective reactions to the technology, procedures, other participants, and the moderator. Questions focused on interest in continuing use of the technology at subsequent meetings, effects of the technology on participation, effects of the technology on discussion quality, participant attitudes toward the anonymity that the technology allowed, and effects of the technology on the participants' attitudes toward each other.

A nonparticipating observer categorized group votes according to whether they were taken to provide opinions or information on the discussion theme or whether they were taken to make decisions about the group's process, to evaluate the quality of discussion, or to change the theme entirely.

Certain of the constructed subjective statements on the questionnaires were independently analyzed and categorized by 3 coders. Extensive chi-square significance tests were performed on the coded results as well as on the multiple choice and observational data by means of the statistical program for social scientists software package. If the requisite data involved insufficient intercoder agreement, the test was not used. Some of the noteworthy results will be discussed.

1. From as early as the conclusion of the first session, large majorities of the groups expressed interest in continuing with EVDT. After subsequent meetings the groups that were allowed to control their agendas sustained high interest in continuing; the groups whose agendas were set by the moderator showed less interest.

2. The EVDT has significantly more effect on nonvocal participation than on vocal

participation. About half the participants claimed they became more involved after experience with EVDT. Only 5 percent claimed they became less involved. Twenty percent claimed they were more encouraged to speak out; about 5 percent were less encouraged.

3. About half the participants stated that they liked the anonymity that EVDT provided; negative reaction was insignificant. The number of positive references increased over time. Participants claimed the use of the feedback technology made them know more about each other but not like each other more. Anecdotal evidence suggested that strong social pressures previously had inhibited students from speaking out on certain issues that EVDT had helped them confront.

4. The most vocally aggressive and, to a lesser extent, the most vocally inhibited participants by their own rating were significantly less favorable toward the EVDT than the larger group at neither extreme.

5. Female participants, with significantly greater frequency than males, expressed positive reactions to EVDT, indicated that it made them more involved nonvocally, and concluded that EVDT improved the quality of their group's discussions.

6. The majority of moderators claimed that EVDT increased their awareness of the participants' opinions and helped them focus the discussions to satisfy the group. On the other hand, most moderators said that it was harder for them to predict the direction of the discussion, and therefore they had to work harder to keep up with all that was going on. The most important features of EVDT cited by the moderators were its anonymity guarantee and its potential to increase participation. All the moderators felt that their own and the students' abilities to benefit from EVDT would increase with continued use.

Use of EVDT Aided by On-Line Computation for Quantitative Social Choice

The problem considered in this study was that of aiding large, technically unsophisticated groups to make quantitative policy decisions in 1 session by using real-time online computation and utility theory. These experiments are reported by W. B. Rouse and T. B. Sheridan (13).

Theoretical Considerations

Conventional procedure provides a means by which to scale on a single continuum different kinds of things or events in terms of their worth to a single person (14). Various procedures have been devised for scaling the utility of events as functions of multiple attributes (15, 16, 17). Although many questions remain about the validity of the assumptions (18), the theory is being developed actively.

Yntema and Kelm (19) have shown experimentally that, if a computer is given only the extreme values of a person's multiattribute utility space and a small set of marginal values, the computer can predict that person's utility values within the space rather well. It can predict these values better, on the average, than another person familiar with the situation can.

Although developments in assessing multiattribute utility for single persons is encouraging, the same cannot be said for more than 1 person. The reason is because of a landmark contribution by Arrow (20). Arrow questioned whether, given knowledge of how each of a number of persons orders his or her preferences among alternatives, there is a fair way to order preferences for the whole group. Arrow's paradox or "impossibility theorem" has created lively debate in theoretical economics and political science, and various writers have tried to show why Arrow's result is irrelevant to practical matters. The difficulties here are significant and are not likely to be resolved by any theoretical brushstroke in the near future.

The EVDT has been employed mostly to allow each person only 1 vote from a set of alternatives; frequency of first choices determines the social order. This procedure obviates the Arrow problem because it never asks a person to order other-than-first-choice alternatives. Curiously, this is the principle by which the consumer market functions and on which most empirical economics is based. Faced with any set of decision alternatives, a person decides on only 1 alternative; anything else considered has no effect on the market.

Group Interaction With a Computer-Based Model

It is common that the general form of a policy is given and the community or institution assumes the task of setting its parameters. Can this be done democratically? And can group interaction make the final decision more than a simple average or majority vote (21, 22)? The model TAXPKG was devised to explore this problem for income taxation. It fits the present Internal Revenue Service policy except that the following parameters were left free:

1. Maximum taxation percentage,
2. Gross income below which there is no tax, and
3. Gross income tax above which the maximum percentage is applied.

A computer was programmed with the model, the distribution of gross incomes in the United States, and the national budget figure that would have to be met by a satisfactory policy. Various on-line input and display schemes were devised that permitted parameters to be set 1 at a time by democratic vote. The result would be displayed in tabular or graphical form.

Trials with a few groups revealed interest and some surprise at the effects of their decisions. These trials also showed that nonsophisticated persons were unable to grasp the quantitative trade-off problems. They became impatient with the need to format data for entry and the need to wait and interpret the results. Many participants enjoyed espousing their goals and moral theories, but some did not want to be involved in the quantitative detail.

Group utility functions can be derived from such models after the group is finished setting parameters if one assumes that with a fair taxation policy everyone experiences the same utility loss by taxes relative to gross income.

Group Searching of a Utility Space

One software package in this category, SOLVER, was designed to help a group deal with any arbitrary multiattribute choice problem (24). The group was asked to name the relevant dimensions (attributes) with respect to which alternative policies might differ. Then they were asked to specify several levels of each including the level that represented the status quo. The combinations of these levels for the various dimensions served as points in a utility space. The computer tried to maximize group acceptance of an allocation policy by considering points in the neighborhood of a given reference point starting with the status quo and asking for a popular vote on whether each neighboring point was better than the reference. The program let percentage of better votes be a positive gradient and percentage of worse votes be a negative gradient. The steepest ascent procedure would, theoretically, lead the group to a more acceptable position.

Trials were not completely successful with this procedure because groups had difficulties estimating costs, and many comparison trials seemed to the subjects to be unnecessary. From the efforts to help groups make decisions by interacting with a computer it became evident that most participants need more understanding or a mental model of what the computer is doing. Further, the group should not have to deal with special entry or display formats; the programmer-moderator should do that job and serve as an intermediary between computer and group. Finally, time-sharing pauses should be eliminated whenever possible because they are socially awkward and distracting.

Other Experiments

Several other experiments are described more fully elsewhere (8, 25, 26, 27, 28, 29, 30). They will be discussed only briefly in this paper.

Interactive Slide-Tape Shows

Four slide shows formulated to be used interactively with EVDT were produced on controversial value-laden themes. The subjects were patriotism, racism, sexism, and nutrition (25, 26, 27, 28). Each consisted of a showing of several slides sometimes accompanied by a sound track to introduce an issue, visually awaken feelings, and associations and a posing of a question and response alternatives to be voted on and discussed by the group. Such a sequence might take 2 min to show, 1 min to vote, and 10 min to discuss. There were 8 to 10 such sequences in a complete show. Reactions to these interactive slide shows were enthusiastic and revealed even distribution of participation in discussion (29).

Experiments on Continuous Feedback

In continuous feedback, EVDT is used to provide the speaker or panel continuous audience reaction on whether they are understood, whether the audience agrees with them, and whether the audience feels the pace is too fast or too slow. The few experiments performed in this mode indicate that continuous multiattribute feedback is difficult for the listener to provide and for the speaker to absorb (8).

Interpersonal Behavior and Attitude Change Under EVDT and Videotape

These experiments were designed to compare several means by which a group can deal with a threatening situation: (a) direct face-to-face discussion, (b) videotaping comments and showing them to the group, (c) EVDT in branched face-to-face discussion, and (d) EVDT and videotape combined. Preliminary results from this experiment suggest that the most significant effect is that of the EVDT on increasing verbal participation (30).

Use of EVDT on Television

A series of three 90-min TV shows used an in-studio audience to respond to questions by means of EVDT and to elaborate their answers in discussion. The experiments are discussed further elsewhere (8, 31).

CONCLUSIONS

According to the variety of applications discussed, EVDT can be very useful largely independent of group size and subject matter for delving into issues with greater speed and penetration. It can help to uncover the profile of participants' opinions and clarify an initially poorly stated or vaguely defined issue. The instantaneous anonymous feedback promotes participation and involvement not only in the opinion-voting phase but also in the discussion that follows. The meeting no longer can be dominated by a few people. EVDT also permits the group to deal with subject matter that normally would be intimidating either because it is too controversial or too personal or because people might have to reveal their ignorance.

Although some positive results may have been caused by the novelty effect, there were numerous situations in which the same group employed EVDT repeatedly. Evidence suggests that as moderators and participants gained experience they became more favorably inclined toward the system.

Individual reactions depended on certain background and personality factors. Those who were accustomed to dominating group discussion and those normally alienated tended to be negative; EVDT could be considered threatening to both groups. Most people in between these 2 groups tended to be positive.

EVDT works best when meeting organizers have been briefed properly and when the physical arrangements of the room are conducive to informality.

The most significant factor in the success or failure of EVDT meetings was the style of the moderator. The success of a meeting depended on the moderator's ensuring that voting results were discussed and different viewpoints heard, that the EVDT was used spontaneously to resolve questions that arose, and that the group was allowed to guide the agenda. Participants were most satisfied when the moderator kept the meeting moving at a brisk pace with humor, wide participation, and a minimum of procedural haggling.

To some extent, EVDT altered the conventional face-to-face group communication process. Because the group became involved in coding ideas in words and phrases for voting, they seemed to become committed to such words and phrases. The EVDT also separated people's opinions from their personalities; a statement could become significant not because a particular person presented it or another spoke favorably of it but because the group voted anonymously to support it. At the same time, the voting introduced new pressures into the group; the votes revealed decisions of surprising and compelling agreement that had to be dealt with immediately.

RECOMMENDATIONS FOR FUTURE DEVELOPMENTS

Training

Because the success of EVDT depends heavily on the moderator's skill, there is a need for better means to train moderators. This can include instructional documents, films and videotapes, training seminars, and short courses. Use of EVDT also should be subjected to further critique and refinement by organizational development experts and similar professionals in group process.

Production and Use of EVDT-Media Interactive Packages

The process of producing interactive EVDT slide shows provides a promising mechanism by which a group of concerned people can come together, focus on a problem, and share ideas to determine what they, as a group, want to say and ask of other groups. Because it is a flexible mode of communication, EVDT can render ideas in verbal, graphical, and pictorial form. It is a welcome change from the conventional committee report. Most important, it has a built-in guarantee of producing feedback and reaction from the group at which it is directed. EVDT should be exploited for schoolroom or community education and consciousness raising or to have opposing groups respond to each other.

EVDT Equipment

Most electronic voting systems are not portable and are otherwise inflexible. Some are outrageously expensive for what they provide. Wireless systems can be accommodated in the technology, but the requirement that the totalizing computer receive independent messages from each participant's transmitter makes them more complex and costly.

Rugged, flexible, and, especially, lower cost systems for EVDT use should be developed.

Cable Television

Two-way cable television systems are in their infancy, and no serious experiments involving cable television for town meetings, citizen polls, and the like have been completed (32). Because participants would be further isolated from each other on a cable network, industry probably will strive to make cable EVDT closely resemble single-room EVDT. By artificially keeping participants from speaking or talking to each other, the EVDT meeting in a single room can simulate the meeting over cable at a much lower cost and with far more flexibility in experimental control than by using actual cable systems at this stage.

Democracy and Other Perils

EVDT developments raise questions about how extensively decisions should be made on a democratic basis, or how far the vote of the unsophisticated, apathetic, self-interested, or imaginative citizen should be counted. Making important decisions on a large scale by electronic voting has dangers, such as the bandwagon effect, which have been discussed, and surely other perils that have not been anticipated. There is the ever present danger of electronic manipulation or of deceiving participants about anonymity and then identifying individual votes electonically. Dangers and safeguards related to small- and large-scale EVDT need further exploration.

Technology Assessment

It is clear to everyone that technological development is no longer an unmitigated blessing; there is a need to forecast and assess the impact of technology. There is no objective formula for accomplishing this assessment. Such assessment must be in social values. And, because democracy is at work, a large number of people should be involved in making the judgments. EVDT and related techniques offer a means by which to focus the interest of groups of people on future technology, assess its possible effect on their values, and then share with each other their reasons for doing so. Thus, just as EVDT technology is an aid in fostering democracy, the creative democratic process is a means to assess technology.

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REFERENCES

1. J. Saloma and F. H. Sontag. Parties, the Real Opportunity for Effective Citizen Participation. Alfred A. Knopf, Inc., New York, 1972, p. 6.
2. C. H. Stevens. Citizen Feedback, the Need and the Response. Technology Review, M.I.T., Jan. 1971, pp. 39-45.
3. G. H. Ball. Research Needs in Citizen Improvement, Stanford Research Institute. Stanford Research Institute Project 1996, Final Rept., March 1973.
4. S. A. Umpleby. Is Greater Citizen Participation in Planning Possible and Desireable? Technological Forecasting and Social Change, Vol. 4, No. 1, 1972, pp. 61-76.

5. Report of Governors Commission on Citizen Participation. Commonwealth of Massachusetts, Oct. 1973.
6. A. Scoville and C. E. A. Noad. Citizen Participation in State Government. Environmental Planning Information Center, Montpelier, Vermont, Dec. 1973.
7. I. de Sola Pool. Citizen Feedback in Political Philosophy. In Talking Back: Citizen Feedback and Cable Technology, (I. de Sola Pool, ed.), M.I.T. Press, Cambridge, Mass., 1973, pp. 237-246.
8. T. B. Sheridan. Community Dialog Technology. IEEE Spectrum, Special Issue on Social Systems, March 1975.
9. T. B. Sheridan. Technology for Group Dialog and Social Choice: Proc., AFIPS Conference, Vol. 39, AFIPS Press, Montvale, N.J., 1971, pp. 327-335.
10. R. Littauer. A Student Response System. Department of Physics, Cornell Univ., Internal Memorandum Rept., July 1971.
11. W. R. Page. Report on Use of Community Dialog Apparatus Within Polaroid and in Lexington, Mass., November 1972 through April 1974. M.I.T. Community Dialog Project Rept. 14, July 1974.
12. N. Lemelshtrich. Feedback Technology and Small Group Interaction. M.I.T., PhD dissertation, Oct. 1973.
13. W. R. Rouse and T. B. Sheridan. Computer Aided Group Decison Making: Theory and Practice. Proc., IEEE Systems Man and Cybernetics Conference, Dallas, Oct. 1974.
14. J. von Neumann and O. Morgenstern. Theory of Games and Economic Behavior. John Wiley and Sons, Inc., New York, 1973.
15. H. Raiffa. Decision Analysis. Addison-Wesley, Reading, Mass., 1968.
16. R. L. Keeney. Utility Functions for Multi-Dimensional Consequences. Management Science, Vol. 18, No. 5, Jan. 1972, pp. 276-287.
17. C. W. Kirkwood. Decision Analysis Incorporating Preference of Groups. Department of Electrical Engineering, M.I.T., PhD dissertation, June 1972.
18. W. Edwards and A. Tversky, eds. Decision Making. Penguin Books, Inc., New York, 1967.
19. D. B. Yntema and L. Kelm. Telling a Computer How to Evaluate Multi-Dimensional Situations. In Human Factors in Electronics, IEEE Trans., Sept. 1965, pp. 3-13.
20. K. J. Arrow. Social Choice and Individual Values. John Wiley and Sons, Inc., New York, 2nd Ed., 1963.
21. N. Dalkey and O. Helmer. An Experimental Application of the Delphi Method to the Use of Experts. Management Science, Vol. 9, No. 3, April 1963, pp. 458-467.
22. M. Turoff. The Design of a Policy Delphi. Technological Forecasting and Social Change, Vol. 2, 1970, pp. 149-171.
23. W. B. Rouse. TAXPKG: A Group Computer Interactive Package for Decision Making on Income Taxation Policy. M.I.T. Community Dialog Project Rept. 3, May 1973.
24. W. B. Rouse. SOLVER: A Group-Computer Interactive Package for General Problem Solving. M.I.T. Community Dialog Project Rept. 4, July 1973.
25. I. Laskaris, T. B. Sheridan, L. B. Kasdon, and J. M. Guite. Patriotism: Who is the True Patriot? M.I.T. Community Dialog Project Rept. 6, April 1974.
26. H. Seldon, T. B. Sheridan, and L. B. Kasdon. Racism: Are You a Racist? M.I.T. Community Dialog Project Rept. 7, April 1974.
27. T. B. Sheridan, L. B. Kasdon, J. Moody, D. Leeman, and C. Dees. Sexism: What Kind of Sexist Are You? M.I.T. Community Dialog Project Rept. 8, April 1974.
28. A. Palgi, T. B. Sheridan, L. B. Kasdon, and J. M. Guite. Nutrition: You Mean You Put That In Your Mouth? M.I.T. Community Dialog Project Rept. 9, April 1974.
29. C. Pizano. Feedback Technology, the Key to Homogeneous Participation in Group Discussion. Mechanical Engineering Department, M.I.T., BS thesis, May 1974.
30. J. M. Guite. Electronic Feedback and Half Inch Videotape as Aids to Community Dialog. M.I.T. Community Dialog Project Rept. 15.
31. C. H. Stevens, F. E. Barwick, and D. S. Haviland. Feedback: An Involvement Primer. Renssalaer Polytechnic Institute, Jan. 1974.
32. I. de Sola Pool, ed. Talking Back: Citizen Feedback and Cable Technology. M.I.T. Press, Cambridge, Mass., 1973.

DISCUSSION OF POTENTIAL USES OF INTERACTIVE COMPUTER GRAPHICS IN CITIZEN PARTICIPATION

At the end of the session on potential uses of interactive computer graphics for citizen participation, a panel discussion on the session was held. This is an edited version of the panelists' presentations.

Sherry R. Arnstein, Arthur D. Little, Inc.

I assumed that the 4 papers presented would advocate immediate, widespread proliferation of interactive computer graphics as a panacea to the many problems in citizen participation. But, fortunately, none of the papers perceives computer-based participation as a cure-all, and each of them has noted that use of this developing technology should be approached with caution because of its razzle-dazzle, its potential for technological tyranny, and its ability to cover forecasting uncertainty with implied certainty. I agree with the general thrust of the papers, and I thought it might be useful to underscore various points that have been offered.

Citizen participation is deeply embedded in the fabric of democracy. Recently, demand has increased vastly for more interactive involvement by citizens in almost all public programs. These demands for increased involvement are emerging from both individual citizens and representatives of public interest organizations who increasingly distrust government, are dissatisfied with society, and are discontented with present institutions and industry practices. And these participatory demands now are coming not only from predominantly poor and powerless people who started the movement for participatory rights in the social opportunity programs of the 1960s but also from environmentalists, consumerists, feminists, and other citizen activists. In response to these demands, more public programs have begun to include requirements for citizen participation. Unfortunately, these requirements and the staff to implement them have largely grown randomly and have not reflected what has been learned from earlier experiences with citizen participation. Because there is neither a discipline known as citizen participation nor a professional association to help practitioners build a cogent body of literature and a coherent body of experience, there has been no central place through which lessons learned in one program could be passed on to another. That the Transportation Research Board did not have a permanent committee on citizen participation until 1973 emphasizes the problem.

Thus in the transportation field today we are struggling with an enormous number of questions about citizen participation on which there are many opinions but to which there are no agreed-upon answers. In my opinion, there are 12 problem areas.

1. Which citizens and citizen groups should be involved in a public participatory process?
2. What is the central purpose of citizen participation (manipulate, inform, consult, negotiate, respond)?
3. How can transportation officials be held more accountable for their actions?
4. How can the benefits and disbenefits of alternative transportation plans be decided equitably?
5. What are the most productive methods and tools for participation?
6. How can citizen distrust be alleviated?
7. How can complex technical information and data be translated into lay terms?
8. What role should value judgments play in technical decisions?

9. What commitments from public agencies are essential to effective participation?
10. What group-dynamics staff skills are essential to the participatory process?
11. How can vast geographic distances be coped with so that continuous participatory interaction can take place in systems and corridor level planning?
12. What technical assistance is needed for effective participation?

The data given in Table 1 show the areas in which interactive graphics will be useful in my opinion.

The papers in this Record alert us to be careful in considering the usefulness of interactive graphics in the areas of determining which citizens should participate, issues of equity, citizen distrust, and agency commitment. Table 1 notes that interactive graphics may have an uncertain effect on problem areas 1, 4, 6, and 9.

On problem area 9, Darwin Stuart observes in his paper:

> Before an interactive graphic component within community participation programs can be valuable, there must be sustained commitment to the community participation process itself....until the system and locally oriented levels of participation are adequately strengthened, considering a role for interactive graphics will be largely academic.

On problem areas 1 and 4, Thomas Sheridan cautions:

> One must agree that when any new communication tools can be manipulated by a few powerful persons, there is real peril. Alternatively, even if these tools are not subject to manipulation by a few people, a community of well-meaning persons may unwittingly adopt technocratic procedures that will allow the majority to oppress the minority.

On problem area 6, several of the papers noted that some citizens are distrustful or suspicious of the technology. I suspect that there is a high correlation between those who distrust the computers and those citizen activists who are highly distrustful of public officials, consultants, and academics. Much citizen distrust is legitimate. Unless we are mindful of potential misuses, there is considerable risk that interactive graphics will be used by some public agencies not to improve citizen participation but to improve citizen manipulation.

The data given in Table 1 indicate my belief that interactive computer graphics offer limited usefulness for problem areas of central purpose, accountability of transportation officials, and staff skills. Although the resolution of these issues may well determine how useful interactive graphics might be in a participatory process, the technology per se cannot help to resolve the issues.

Table 1.

	Potential Usefulness		
Problem Areas	Uncertain	Limited	Positive
1. Which citizens participate	x		
2. Central purpose		x	
3. Accountability of transportation officials		x	
4. Equity of benefits and disbenefits	x		
5. Methods and tools			x
6. Citizen distrust	x		
7. Complexity			x
8. Value judgments			x
9. Agency commitment	x		
10. Staff skills		x	
11. Geographic distances			x
12. Technical assistance			x

The data in Table 1 indicate that interactive computer graphics will be useful in the problem areas of methods and tools, complexity, value judgments, geographic distances, and technical assistance.

Although interactive computer graphics have been used to date only on an experimental basis, the early findings suggest that their chief value is in "translating" complex data into more easily understood terms. Each of the papers in this Record notes the significant potential of interactive graphics for restructuring complex problems and for helping lay people understand the interrelationships of innumerable variables in a complex plan. This ability to deal with complex data could be a breakthrough to effective citizen participation. Participation now often takes place without adequate understanding of the issues, constraints, and options. I was pleased that Feeser and Ewald urged that we not fall into the trap of using the technology to demonstrate a feature of the graphics system rather than a feature of a transportation facility. I asked Feeser how many lay citizens would find that the examples used in the presentation illuminated the controversial policy-related issues that normally concern citizen groups. Feeser noted that he sees the technology useful for informing citizens in public hearings and is skeptical about its use for continuous interaction on policy-related issues.

Several of the papers note that one of the important contributions of interactive computers is to enable exploration of values to examine the relative importance of conflicts and trade-offs. Citizen groups frequently are unaware of why they encounter conflicts among themselves. I view interactive graphics as a tool that could help them clarify the issues and the value judgments that lie within them. All too frequently professionals insist that they are making technical decisions and that they should seek greater objectivity rather than the additional biases that emerge from participatory processes. I believe that almost all transportation planning is based on values and, regardless of how objective planners try to be, personal values enter into both the questions asked or not asked. All too frequently planners fail to ask significant questions about who benefits and who does not benefit from an alternative and about what can be done to avoid or minimize disbenefits to some population sectors. By exposing data to public view in meaningful formats, planners will become more sensitive to the role of value-laden decisions.

Because so many of the important long-term decisions in transportation planning are made at the systems level where participatory processes are more difficult to maintain because of the distance and time frame involved, interactive computers might be useful in helping to narrow the distance and time gaps. I do not believe that this will occur soon because connecting distant points would depend on joining computer-based teleconferencing with interactive graphics.

One of the problems many agencies face is whether to assign their regular technical staff to interact with citizens or to hire special behaviorally trained staff for that function. Problems are associated with either choice because engineers usually are not accustomed to interacting with citizens about issues that they consider to be technical. Newly hired group dynamics staff frequently do not know enough about the critical variables of transportation planning, and this is a disservice to citizens. Computer graphics would play an important role in bridging this gap because the computer could help the group dynamics staff learn more about technical issues. They would become more useful in providing technical assistance to citizens; all too frequently technical assistance to citizens has been based on what some people have aptly termed technical ignorance.

Concerning the problem area of which methods and tools are most productive, Goldberg and Ash point out that members of the general public who are not affiliated with a special interest group usually lack the interest to achieve a minimal level of understanding. Their paper also indicated, however, that the most successful demonstration was the one in which the audience was permitted to actually try various options on their own. I wonder whether the audience interactive process by which the graphics system was introduced or audience motivation was the deciding factor in developing interest in the process. Sheridan suggests that individual reactions on various background and personality factors. He points out that the style of the moderator significantly affected how the technology worked. This brings us back to the point mentioned by several of the speakers that this technological tool is likely to be highly dependent on the skill, commitment, and objectives of the staff and agency employing the tool.

As a result of an examination of various alternative participatory tools with which I was involved (1), I recommend further exploration of the potential of interactive computers.

REFERENCE

1. Interim Report to Federal Highway Administration on Contract No. DOT-FH-11-8514. Arthur D. Little, Inc., 1975.

John S. Winder, Jr., Environmental Impact Assessment Project, The Institute of Ecology

The entry of interactive computer graphics into citizen participation in transportation planning could be dangerous because not enough is known about the technology. Feeser and Ewald show this when they suggest that a major purpose of computer graphics is to show project features better. Computer graphics should be used to facilitate public participation. On a broader scale, Feeser and Ewald suggest that public hearings are to inform the public about new projects. Public hearings should be conducted to involve citizens in the decision-making process.

That channels of communication are insufficient is a current problem that was noted by Sheridan. Interactive computer graphics can be focused on this. Sheridan points out that, although interactive computer graphics can assist citizen participation in the decision-making process, it cannot serve as a foolproof means to cast final votes on important decisions.

Stuart very clearly and optmistically describes potential uses of interactive graphics for citizen participation in transportation planning. As he suggests, interactive graphics may help define concepts, problems, solutions, and values. He supports a maximum interactive graphics potential in this context to improve community and decision-maker participation in plan making. Stuart identifies the relationship of interactive graphics to planning and participation issues. Community participation needs strengthening in identifying goals, developing alternatives, and evaluating alternatives. Stuart concluded that strong community participation, agency support, faith in the technology, simplicity, time consumption, policy issues, and cost are most crifical for the use of interactive graphics and represent potential implementation problems.

Goldberg and Ash describe some planning and participation models that can be used with interactive graphics. They focus on the principal, and easily overlooked, potential use of interactive graphics, which is to provide information to the public to involve them clearly and directly in model building and the political process.

Feeser and Ewald describe interactive computer graphics in a way that suggests that computer graphics may be another visual aid by which transportation planners can better describe their proposals to the public. They apparently disdain, however, the potential uses of computer graphics in an interactive context. They apparently view interactive computer graphics in the context of their definition of the purpose of a public hearing, which is to inform the public about new projects.

Feeser and Ewald apparently endorse study recommendations for improving the public hearing process in Virginia, which are

1. To show project plans at convenient locations,
2. To have engineers on hand to answer questions before the hearing,
3. To have better visual aids, and
4. To take appropriate action on any important citizen feedback.

This approach clearly avoids the interactive potential of interactive computer graphics and, thereby, eliminates its potential for improving citizen participation and the decision-making process.

Sheridan clearly describes the previous applications of interactive computer graphics in a planning and participation process. He describes different types of question-response modes that can be used in a group forum. He describes how interactive computer graphics can be used to rapidly identify consensus and conflict. He recognizes that this system may rapidly increase participation by, in part, permitting anonymity; he cautions at the same time that this process reduces verbal participation. Sheridan suggests that interactive computer graphics may have significant potential for improving citizen participation and the decision-making process, but he also recognizes that the technology must be used carefully and in concert with other, traditional methods of communication and participation.

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