TRANSPORTATION RESEARCH RECORD
563

Public Transportation Planning

10 reports prepared for the 54th Annual Meeting of the Transportation Research Board

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
Washington, D. C., 1976

Transportation Research Record 563
Price $8.00
Edited for TRB by Marjorie Moore

Subject area
84 urban transportation systems

Transportation Research Board publications are available by ordering directly from the board. They may also be obtained on a regular basis through organizational or individual supporting membership in the board; members or library subscribers are eligible for substantial discounts. For further information, write to the Transportation Research Board, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competence and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The views expressed in this report are those of the authors and do not necessarily reflect the view of the committee, the Transportation Research Board, the National Academy of Sciences, or the sponsors of the project.

LIBRARY OF CONGRESS CATALOGING IN PUBLICATION DATA

National Research Council. Transportation Research Board.
Public transportation planning.

(Urban transportation systems; 84) (Transportation research record; 563)

1. Urban transportation–United States–Congresses. 2. Transportation planning–United States–Congresses. I. Title. II. Series. III. Series: Transportation research record; 563.
TE7.H5 no. 563 [HE308] 380.5'08s [388.4'0973]
ISBN 0-309-02473-0 76-16549

CONTENTS

URBAN PUBLIC TRANSPORTATION GOAL DETERMINATION: A RESEARCH APPROACH

David W. Cravens, Robert B. Woodruff, and John F. Harper,
University of Tennessee

Urban problems such as energy shortages, congestion, and increasing highway costs are prompting communities to reassess the need for public transportation. A solution can be achieved if citizens are encouraged to rely less on the automobile and more on public modes for intracommunity travel. However, achieving user shifts in mode preferences is not easy because of the automobile's popularity. Consequently, if public transportation is to realize its potential, effective planning is essential, and it must begin with the setting of appropriate goals for community transportation services. Among the complexities that add to the difficulty of setting goals are the differing needs of existing and potential user groups, the variety of transportation service alternatives, community role structure, environmental constraints, and limited resources. A promising approach to setting community transportation goals is the policy Delphi method. Through this technique information is collected independently from various individuals and groups concerning future events and policy issues. Opinions and information are gathered without the participants' having to interact. Moreover, feedback of information from other participants is provided to each Delphi panel member. The paper examines the community transportation goal-setting task in the context of a complete transportation planning process. Major attention is given to applying the policy Delphi method to generating community transportation goal information and assessing the extent of agreement among policy makers.

•DESIGN of new and improved urban public transportation systems will be a major community responsibility in the decades ahead because of gasoline shortages, traffic congestion, and rapidly increasing highway costs. These problems can be reduced if public transportation services are properly planned and implemented such that consumers are encouraged to rely less on private automobiles. Nevertheless, achieving this shift in preferences is a difficult and complex task. Some experts have speculated that, as long as gasoline is available to consumers, it is doubtful whether drivers will change to public transportation (1). Consequently, to achieve any shift in transportation mode preferences will require effective planning that must begin with the setting of and agreement on appropriate goals for a given community.

Goals are quantitative and qualitative guidelines for use in focusing and directing public transportation planning efforts. Determination of goals in urban communities presents a complex challenge because of differing needs of existing and potential user groups, transportation service alternatives, community role structure, environmental constraints, and resource limitations. Yet effective transportation planning cannot be accomplished unless operational goals and action priorities are established. Typically, when goals are specified at all, they focus on system efficiency and tend to neglect needs of various user groups and the role of public transportation in solving community problems.

Our point of view toward public transportation encompasses various service alternatives such as conventional bus and rail fixed-route, fixed-schedule systems, car and bus pooling, taxicabs, and demand-responsive systems (e.g., dial-a-bus and shopper minibuses). The goal-setting process should consider all feasible system alternatives in a particular urban community. Because of the wide variation of factors that influence public transportation from one city to another, goal determination should be community specific. Of course, to the extent that federal and state public transportation policies (e.g., funding support) influence local planning, they should be recognized in the goal-setting process.

One promising approach to the urban public transportation goal-setting process is the Delphi method of independently collecting and analyzing information from relevant groups on uncertain future events and policy issues. The unique characteristics of transportation goal setting at the community level match well with the advantages and requirements of the Delphi procedure. Accordingly, our purpose is to examine how the Delphi approach can be used to generate information for the public transportation goal-setting process. The nature and scope of public transportation goal setting are outlined, and major goal areas are identified and discussed. A methodology for determining goals is presented that uses the Delphi method as a systematic approach to identifying goals, obtaining community feedback, assessing conflicts among individuals and groups, and obtaining a consensus from those involved in the public transportation decision-making process.

GOAL-SETTING TASK

Goal Setting in the Planning Process

Goal setting is only one element in an integrated planning process. Planning, implementation, and control of urban public transportation systems involve six major phases of activity:

1. Community inventory or audit—The community characteristics that may influence (or constrain) public transportation must be identified. This includes travel origin-destination analysis, geographical patterns, land use, residential and employment distribution, and other factors.
2. Determination of community goals—Goals provide a set of guidelines (including priorities) on the role and importance of public transportation within which the overall planning process should be accomplished.
3. Identification of feasible transportation system alternatives—The purpose of this phase is to identify relevant public transportation system options for various community groups (e.g., senior citizens, school children, commuters).
4. Selection of operational objectives—At this stage, operational (measurable) objectives should be set regarding specific public transportation needs. Objectives should be set for each citizen group (market target) to be served and should be consistent with overall community goals (stage 2).
5. Design and testing of systems—Next strategies must be formulated and tested (if appropriate) to achieve objectives for each market target including new and revised transportation systems, organizational design, and other management and operational decisions.
6. Implementation, evaluation, and control systems—Here plans are executed, results are evaluated, and necessary modifications are made over time to bring actual results as close as possible to desired results.

Prior Work in Goal Determination

Various approaches to public transportation policy planning are discussed in the literature, and broad categories of goals and objectives are mentioned; nevertheless, little attention has been paid to actual methods of goal setting. Part of the difficulty in developing specific transportation goals and objectives has been due to the political nature of the planning process, lack of priorities, and the problem of developing accurate forecasts of future needs.

Engelen and Stuart acknowledge the importance of developing explicit goals and objectives while realizing the problems in establishing approaches for identifying, stratifying, measuring, and analyzing the relative importance of different goals to various interest groups (2). They recommend several specific development goals for urban transportation systems as guidelines for beginning community value research. Ellis (3) indicates several problems inherent in the transportation planning process including (a) assessment of the impact of a transportation program on various individuals and groups, (b) measurement of the change in community values over time, (c) use of abstract values in the planning process, and (d) the inflexibility of the hierarchical transportation process. Ellis recommends that the planner assist the political process in achieving a consensus rather than merely presenting alternatives. Other writers such as Hossack and Hocking (4) and Douglas (5) also recognize similar problem areas and offer a variety of planning models to develop transportation objectives. However, these models are more useful in carrying out the planning process after the general goals have been set. Hauser and Cameron discuss, within a regional transportation concept, the need to ascertain goals from various community leaders and planning agencies as a means of placing an objective, measurable bound on the problem definition (6). They suggest using an interdisciplinary team to integrate specialized disciplines into the planning process.

An excellent review of several transportation forecasting techniques is provided by McDaniel (7). He points out that transportation planning is concerned primarily with societal decisions, a fact that is not realized by most long-range forecasts. He reasons that forecasting of this nature can best be done by people outside of the transportation profession. The professional is viewed as an enabler rather than a forecaster. Thus a technique such as the Delphi might well be more revealing if panel participants were made up of generalists from a transportation point of view.

Although some attention has been given to determination of public transportation goals, few systematic approaches have been recommended for accomplishing the task. There is, nevertheless, a clear acknowledgment of the need for specification of goals to guide the public transportation planning process.

Factors Influencing Goal Determination

Three groups of factors normally influence the determination of public transportation goals in a particular community: community problems, transportation needs of various citizen groups, and system effectiveness and efficiency. These areas are shown in Figure 1 along with the specific factors in each of the three groups. In general, goals should result from needs of citizens in the community and the problems that public transportation can help solve. Desired system effectiveness and efficiency influence the extent to which contributions can be made to these needs and problems. The three areas are, of course, closely interrelated. For example, a community that desires to provide transportation to senior citizens as a public service must decide, based on both benefits and costs, the extent to which these needs should be met.

Who Should Set Goals?

The question of who should determine goals is difficult to answer because of the variations that exist in community role structure. Moreover, a variety of points of view, preferences, and motivations are present. An individual may respond differently, for example, as a commuter, taxpayer, businessman, and real estate investor. His or her preferences concerning appropriate community goals may vary depending on his or her point of view (e.g., commuter versus real estate investor). Also, some individuals and groups that are influential in the community are not members of the formal power structure. Although these problems exist, decisions concerning goals must be made. Thus, it is essential that those responsible for goal determination develop effective mechanisms for collecting and analyzing information from various individuals, groups, and organizations in the community.

In many cases, elected officials function as the goal-setting group for the community. They represent the citizens and are influenced in varying degrees by individuals and organized groups. Moreover, they typically have developed formal and informal information channels to make them aware (at least in general terms) of community needs, problems, conflicts, and opportunities. Yet, because these information systems are probably not adequate, consideration should be given to improving information flows to public officials from various individuals and groups in the community concerning public transportation goals. In this regard an interesting proposal has been made for a citizen information system using technology to extend citizen and government dialogues (8). Charnes et al. offer useful guidelines concerning information requirements for urban systems (9). Improvement in information flows represents a major challenge if information needed for planning is to be effectively generated.

Figure 2 shows the goal-setting process in public transportation planning with elected officials as the focal point. Information and influence flow from individuals and groups in the community to the elected officials. Decision makers also may be influenced by federal and state government policies and guidelines, particularly when financial support is sought from these sources. If a transportation planning unit or other group involved in public transportation planning exists in the community (e.g., transit authority, transit operator, planning commission), elected officials may receive information and recommendations from these sources. Based on these inputs, elected officials are viewed as responsible for goal formation. Their role in this process seems appropriate since they will frequently determine whether or not public transportation plans are to be implemented.

How public officials function in the goal-setting role varies from community to community. The description of the goal-setting process shown in Figure 2 is sufficiently flexible to include various approaches within this general framework. For example, the transportation planning unit might be charged with formulating goals to be approved by all or certain elected officials (e.g., mayor or city council or both). In this case, the relative position of the elected officials and transportation planning unit boxes in Figure 2 would be interchanged.

DELPHI TECHNIQUE

The Delphi technique is a systematic method for soliciting opinions individually from a group of people, combining responses, and feeding the information back to participants for use in reassessing their opinions. This process continues for two or more rounds until some degree of consensus is reached. An extensive bibliography and discussion of the methodology and applications are provided by Turoff (10). The Delphi method has been applied mainly to forecasting technological change and, to a lesser extent, to corporate planning. Specific uses include projected developments in medicine, department store personnel requirements, forecasts of information processing technology, public affairs forecasting, and industry trends.

The Delphi procedure provides an alternative to group discussion as a way of obtaining a consensus on some future estimate. Use of the Delphi removes direct interpersonal interaction and confrontation characteristic of committee and organized group activities. It encourages individual thinking and, at the same time, provides an external stimulus (via feedback) to participants. Because individuals can analyze a problem, issue, or future event and can provide estimates or answers in private, many behavioral aspects of group deliberation are avoided. Members of a Delphi panel working independently are more likely to be candid in their responses. Group pressures are not present, and subordinates are less likely to feel a need to echo responses of superiors. Using a multistage approach of two or more rounds allows panel participants to modify answers given in one round in a subsequent round. They avoid going on record as would be the case in a group meeting and thus are more likely to modify initial estimates of uncertain events or preferences. Also, the use of multiple rounds

Figure 1. Factors that influence determination of public transportation goals in the community.

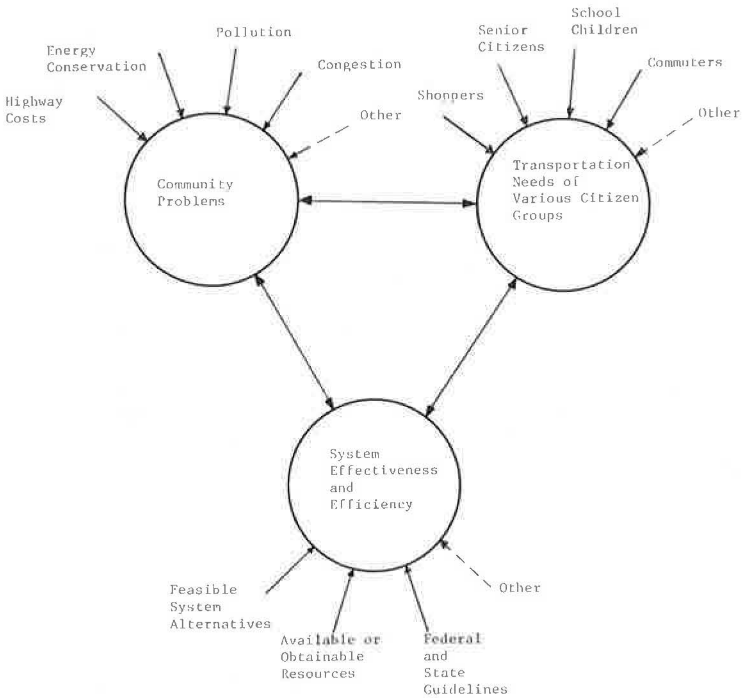
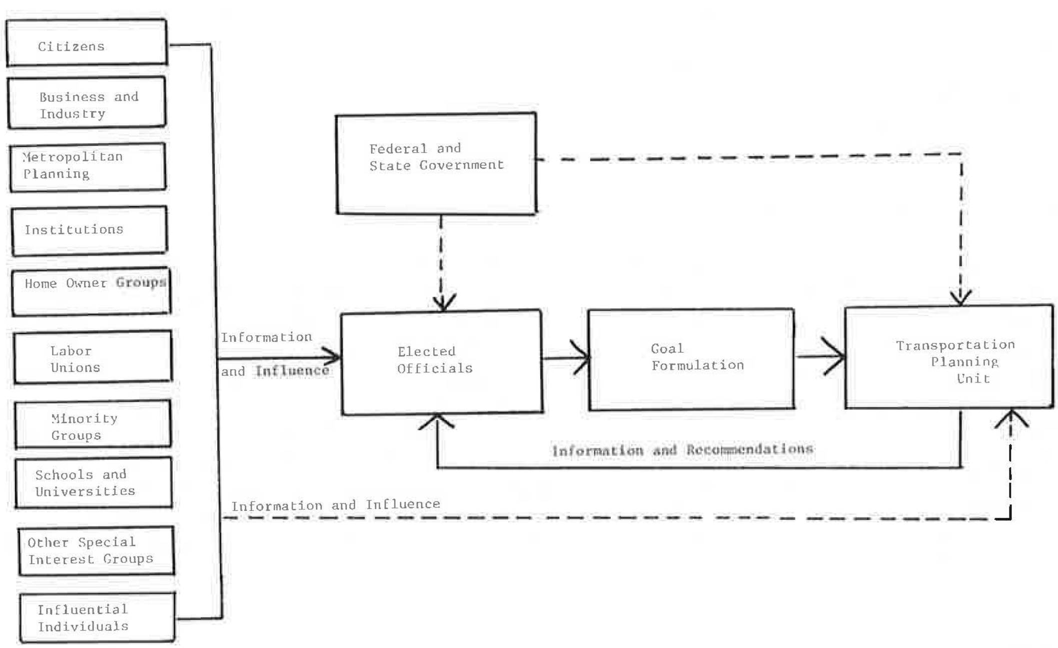


Figure 2. Public transportation goal-setting process.



provides an opportunity for more gradual development of a preference, opinion, or estimate as compared to a one-shot approach. Although the accuracy of Delphi estimates is difficult to evaluate (particularly in regard to policy issues), where testing has been possible Delphi results have been shown to to be more accurate than other forecasting methods when historical data are not available (12). These advantages are particularly relevant to overcoming some of the problems in establishing public transportation goals.

Application to Policy Areas

Use of Delphi procedures has largely been centered on forecasting future events or their probabilities of occurrence. A limited number of applications have been made in the policy area (10). Delphi procedures have been used by Oak Ridge National Laboratories to derive weights for indexes of land use with a high potential for future land use. A policy application concerning commercial land use development is discussed by Schneider (11). Inasmuch as goal determination for urban public transportation is a type of policy formulation, the Delphi methodology also appears quite promising for this use. Public transportation goal development typically involves the consolidation of different points of view.

Issues and Problem Areas

Although the Delphi procedure has significant advantages, there are also problem areas that should be recognized by those considering use of the approach. According to Turoff (10), several relevant questions that should be considered by designers, participants, and users relate to selection and briefing of the panel, type and content of information feedback after each round, assessing the accuracy of Delphi-generated information, and use and interpretation of results.

Many of these questions must be addressed in the initial design effort. Their importance varies by application. Because Delphi information is subjective, judgments must be made. For example, should responses of panel members be weighted to reflect each participant's expertise? Perhaps most important, the potential user of Delphi should recognize that the method is deceptively simple. The designer and user must consider all relevant implications if Delphi results are to be properly integrated into the decision-making process.

DELPHI GOALS STUDY APPROACH

The first task in a Delphi goals study is the selection of a design team who will be responsible for planning, implementing, and analyzing the results of the study. The major stages in a Delphi goals study are shown in Figure 3. Building on prior work in goal determination, the design team must define the scope of the study and identify appropriate goal areas for study (Figure 1). Analysis of the community's role structure as related to public transportation will be helpful in guiding selection of the Delphi panel. Concurrently, a questionnaire should be designed for use in soliciting opinions from panel members. With these tasks complete, the first round of responses can be obtained, analyzed, and fed back to participants for their use in the second round of responses. This process continues through two or more rounds until responses concerning community goals stabilize. A more detailed discussion of the major elements in the study approach follows.

Design Team

People from various professional areas can contribute knowledge and experience that are useful in urban public transportation planning. Transportation involves and influences government, business, other institutions, and citizens. The planning task requires engineering and management skills, understanding of government and legal processes, and knowledge of land use and other aspects of urban planning. Based on the importance of considering different points of view and using various professional capabilities, the following design team was used in a pilot test of the Delphi procedure for generating public transportation goal information in an urban community:

1. Professional civil engineer with extensive experience in public transportation system design and operation,
2. Business administration professor with experience as a businessman and as a management consultant,
3. Sociologist with extensive research experience in urban communities,
4. Geographer with technical expertise in urban geography and demographics,
5. Political scientist with experience in the state and community where the pilot study was conducted, and
6. Professional urban planner with extensive planning experience.

A multidisciplinary team like this can facilitate the design of a goals Delphi by providing various points of view concerning public transportation goal development. This group proved invaluable, not only in study design, but also in analysis and interpretation of the information generated. For example, the design team must have a clear understanding of the community role structure to aid in identifying the Delphi panel. Much of the detailed design work can be accomplished by two or three individuals, providing the other members of the team assess the approach and provide suggestions for improving it.

Selection of Panel Participants

The logical role of elected officials as a goal-setting body has been discussed. Although this group may appropriately accomplish the task or alternatively respond to recommendations from the transportation planning unit, a question remains on how information should be assembled for public transportation goal analysis. Different levels of role structures relevant to public transportation issues and policies are shown in Figure 4.

Consideration should be given to soliciting information from one or more of these levels. Various alternatives exist for assembling goal information (Figure 5). For example, a representative sample of citizens could be surveyed on goal preferences. Also, the sample of citizens could serve as Delphi panel members. The resulting information could be analyzed by the planning unit and used as a basis for developing recommendations for review by elected officials. Alternatively, results of a citizen survey could be reviewed by elected officials; they subsequently could serve as a Delphi panel for developing goal preference information. As shown in Figure 5, other combinations of information from different role structure levels could be used depending on the assessed need for goal preference information in a particular community. Selection of appropriate sources (role structure levels) of goal information in a given community should consider (a) extent of citizens' concern and interest in public transportation, (b) indicated desire for involvement in transportation planning by representatives of various groups and organizations, (c) public officials' experience with public transportation issues and problems, and (d) extent of perceived controversy in the community concerning the role and scope of public transportation. Because of the energy crisis, public transportation has become significantly more visible in many communities because of its possible role in helping to conserve energy and reduce travel costs. This will likely place increased importance on obtaining goal information from various sources in the community.

Figure 3. Stages in Delphi study to determine urban public transportation goals.

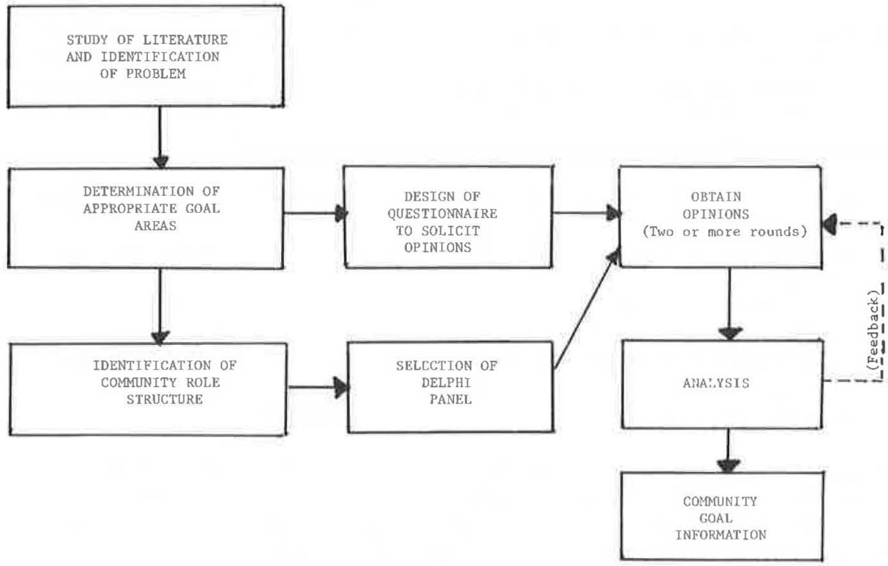


Figure 4. Community role structure for public transportation goal determination.

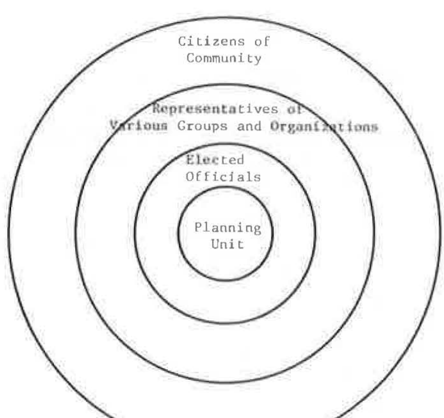
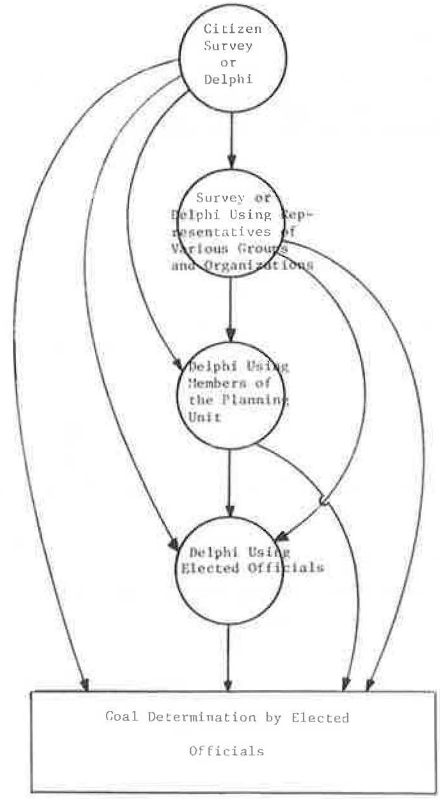


Figure 5. Alternative approaches to assembling information by elected officials for goal determination.



Questionnaire Design

The format of the questionnaire used to obtain responses from panel members can vary from highly structured (forced choice) to open-ended questions. In either, the range of questions asked should be sufficiently comprehensive to cover all relevant goal areas. With a structured format, fewer rounds are needed to reach a stable response level; for an open-ended questionnaire, typically more revisions in the original questionnaire are needed. Alternatively, the responses to nonstructured questions would probably not be gleaned through forced-choice questions. Both formats can be used in a single questionnaire. For example, where all possible responses are uncertain, open-ended questions can be used. In the pilot study using the three general goal areas discussed earlier (community problems, transportation needs of various citizen groups, and system effectiveness), a comprehensive structured questionnaire was developed and pretested by the design team. Provision was also made for respondents to ask questions and to add areas that they believed should be covered in the study. An example question from each of the three goal areas is shown in Figure 6. Also shown are open categories allowing participants to add questions.

Implementation and Analysis

It is important that panel participants be briefed on the nature and purpose of a Delphi study. This can be accomplished through written instructions in combination with a personal visit with each participant on the first round by a member of the design team. Subsequent rounds could be handled by mail. Other approaches to orientation are possible depending on the group involved, participants, geographic location, nature of the study, and related considerations. These include detailed written instructions sent by mail, telephone briefing of respondents, and group briefings (providing there is no reason to withhold the identity of participants).

So that each participant can assess group responses as an input to his or her answers in subsequent rounds, some type of summary must be provided. This can take the form of high, low, and median values for each question; a frequency count for each response category of a question; percentile breakdowns; or other appropriate summary statistics depending on the type of question. A percentile or frequency breakdown may be preferable in terms of giving participants as much information as possible about group response. In cases where open-ended questions are asked, responses can be listed for review by respondents.

The time span of a goals Delphi can be several weeks if three or four rounds are used along with feedback of summary responses on each round. Follow-up will typically be necessary when questionnaires are mailed to speed up response and to eliminate nonresponse. Even though participants in our pilot study were highly cooperative, several weeks elapsed before the completion of only two rounds.

Results

It should be emphasized that the primary role of the Delphi panel in the public transportation goal determination process should be to provide information to those responsible for setting goals rather than to establish the final goal. This is particularly true when the Delphi is used to obtain goal preferences from various levels in the community. In cases where the Delphi is used by public officials to assemble information on their own goals preferences (rather than to try to achieve the same objective through group meetings), they will ultimately need to meet as a group to resolve issues in areas where lack of a consensus is obtained. One advocate (10, p. 153) of the usefulness of the policy Delphi has observed that it

Figure 6. Examples of questions included in a transportation goals Delphi questionnaire.

CITIZEN'S TRANSPORTATION NEEDS AREA

Any family totally dependent upon public transportation in the community should have services available to travel to and from:

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Schools	1	2	3	4	5
Place of employment	1	2	3	4	5
Recreation and entertainment facilities	1	2	3	4	5
Shopping facilities	1	2	3	4	5
Health care facilities	1	2	3	4	5
Religious facilities	1	2	3	4	5
Community organizations	1	2	3	4	5
Other:					
____________	1	2	3	4	5
____________	1	2	3	4	5

EFFECTIVENESS AND EFFICIENCY AREA

How do you feel the public transportation system should be financed on a continuing basis? (Please answer all three questions below.)

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Totally by fares	1	2	3	4	5
Low nominal fares with partial subsidy	1	2	3	4	5
Free to rider--total subsidy	1	2	3	4	5

COMMUNITY PROBLEMS

Do you feel that public transportation could be used to help solve problems in the following areas?

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Reducing automobile pollution	1	2	3	4	5
Reducing traffic congestion	1	2	3	4	5
Reducing gasoline use	1	2	3	4	5
Reducing traffic accident rate	1	2	3	4	5
Reducing noise level	1	2	3	4	5
Improvement of strip development patterns	1	2	3	4	5
Improvement of parking conditions	1	2	3	4	5

Can you think of other problem areas which should be included?

____________	1	2	3	4	5
____________	1	2	3	4	5
____________	1	2	3	4	5

> ... is not in any way a substitute for studies, analyses, staff work, or the committee. It is merely an organized method for correlating views and information pertaining to a specific policy area and for allowing the respondents representing such views and information the opportunity to react to and assess differing viewpoints.

The results of a goals Delphi may not reflect a consensus in all goal areas. For example, it is unlikely that all elected officials will agree on how public transportation should be financed (e.g., fares, partial subsidy, or total subsidy). Yet, by providing each panel member with summary responses of the group, a given respondent is aware of the preferences and opinions of others. Information that indicates the lack of a consensus can be valuable to those responsible for planning public transportation.

IMPLICATIONS AND SUMMARY

The following implications for the potential user of a goals Delphi are based on observations of those who have used the Delphi method to generate policy information and on our own experience.

1. There may be a tendency on policy issues for respondents (particularly elected officials) to answer in terms of what they think is politically appropriate, although this should be less prevalent in the Delphi process than, for example, in an official's public statement. Also, in applications where information is obtained from other levels (e.g., citizens, groups, and individuals), elected officials may find this information useful in strengthening their position or may find that it causes them to shift their position.
2. The potential problem of changes over time in opinions and preferences of Delphi participants should be recognized. Unlike forecasting applications, goal preferences may change over a shorter time span because of environmental changes or inclusion of different people in the community power structure (e.g., newly elected officials). For example, the energy crisis no doubt has significantly influenced goal preferences regarding public transportation. Because of the possibility of changes over time, goal information should be collected at least every few years.
3. The question of who should set community public transportation goals at the community level is not resolved, although a rationale in support of elected officials' fulfilling this role has been offered. This issue deserves further study and analysis.
4. The effectiveness of the information systems of elected officials should be assessed. A two-stage Delphi study involving, for example, representatives from community groups and organizations in stage 1 and elected officials in stage 2 should be tested to assess the influence of such goal information on elected officials.
5. A particularly complex question related to public transportation goal development in many communities is that of geographical governmental boundaries. For example, in our pilot study, some of the goal areas in which lack of agreement existed apparently occurred because the panel was made up of city and county officials. The Delphi application discussed by Schneider (11) involved representation from two central business districts plus a third group with no possible geographical bias; participants were organized into three subpanels. A Delphi approach can be a very effective means of identifying controversial goal areas between different levels of government.

The many advantages of the Delphi method for collecting goal information outweigh the possible limitations. Nevertheless, the implications related to the nature of a policy application and the specific characteristics of the public transportation area should be recognized. Preliminary tests of the approach have been sufficiently encouraging that further applications should be undertaken. Effective mechanisms for aiding the goal determination process in public transportation are critically needed. Delphi offers a promising contribution to this methodological gap.

ACKNOWLEDGMENT

The authors acknowledge the partial support of the research discussed in this paper provided by the Bureau of Mass Transit, Tennessee State Department of Transportation, and the Transportation Research Center, University of Tennessee.

REFERENCES

1. Making Mass Transit Work. Business Week, Feb. 16, 1974, pp. 74-80.
2. R. E. Engelen and D. G. Stuart. Development Objectives for Urban Transportation Systems. Traffic Quarterly, Vol. 24, No. 2, April 1970, pp. 247-264.
3. R. H. Ellis. Reexamination of Transportation Planning. Transportation Engineering Journal, ASCE, Vol. 99, No. TE2, May 1973, pp. 371-382.
4. J. W. Hassack and R. J. Hocking. Transportation in Regional Plan for 1970's. Transportation Engineering Journal, ASCE, Vol. 96, No. TE4, Nov. 1970, pp. 633-649.
5. W. S. Douglas. Public Transportation as Part of Total Urban Transportation. Traffic Quarterly, Vol. 5, No. 4, Oct. 1971, pp. 551-561.
6. E. W. Hauser and W. J. Cameron. A Framework for Regional Transportation Planning. High Speed Ground Transportation Journal, Vol. 6, Winter 1972, pp. 27-38.
7. D. E. McDaniel. Transportation Forecasting: A Review. Technological Forecasting and Social Change, Vol. 3, 1972, pp. 367-389.
8. N. Johnson and E. Ward. Citizen Information Systems: Using Technology to Extend the Dialogue Between Citizens and Their Government. Management Science, Vol. 19, Dec. 1972, pp. 21-34.
9. A. Charnes et al. Information Requirements for Urban Systems: A View Into the Possible Future. Management Science, Vol. 19, Dec. 1972, pp. 7-20.
10. M. Turoff. The Design of a Policy Delphi. Technological Forecasting and Social Change, Vol. 2, 1970, pp. 149-171.
11. J. B. Schneider. The Policy Delphi: A Regional Planning Application. Technological Forecasting and Social Change, Vol. 3, 1972, pp. 481-497.
12. G. T. Milkovich et al. The Use of the Delphi Procedures in Manpower Forecasting. Management Science, Vol. 19, Dec. 1972, p. 386.

LEGISLATIVE PERSPECTIVES ON THE STATE TRANSPORTATION PLANNING PROCESS AND TRANSIT PLANNING IN CALIFORNIA

Robert A. Burco, Public Policy Research Associates,
Berkeley, California

The state of California has created a multimodal Department of Transportation and has embarked on a major statewide transportation planning effort. Although the legislation gives much of the responsibility for planning to regional agencies in the major metropolitan areas, both the California Department of Transportation and the California legislature have important roles in the first iteration of a plan to be developed by 1976. This paper points out several concerns that the legislature may pursue in reviewing and guiding the planning process. These concerns deal with the issues of goal setting, decision making, and conflict resolution rather than with the technical details of planning. Four concerns about multimodal planning are examined in this paper: (a) planning for operations versus planning for facilities; (b) corridor versus local travel needs; (c) planning bases in technical expertise and analytical technique versus public openness and broad participation; and (d) programming versus master planning. Because transit planning has been largely absent from past state-level transportation concerns, several conceptual transit planning issues are raised in this paper as well. Examples from the recent Los Angeles planning experience illustrate legislative interest in staged decision-making and multimode transit solutions.

•IN 1972 the California legislature passed a bill that created the California Department of Transportation (CALTRANS) with multimodal responsibilities. The bill (Assembly Bill 69) gave significant powers to a State Transportation Board appointed by the governor and mandated a statewide transportation planning process that would revise regional transportation plans by early 1975 and create a state plan by January 1, 1976. The legislature became responsible for reviewing and setting goals for the planning process and instructed CALTRANS to recommend legislative changes that would improve transportation planning, financing, construction, and operations.

The author has been responsible for advising California legislators on issues relating to multimodal transportation planning, particularly transit planning, during much of the time since CALTRANS was created. This paper stems from presentations made to legislative committees during the past 2 years of planning and debate.

CALIFORNIA'S STATEWIDE TRANSPORTATION PLANNING PROCESS

In transportation planning at the state, regional, and local levels, the legislature's role in approving or modifying statewide transportation goals, objectives, and policies involves several issues. The planning process, initiated through the legislation that created CALTRANS, could substantially reorient the state's approach to transportation matters or leave it relatively untouched despite the change of a few organizational titles and the elaboration of a few financial allocation procedures.

Much of the goal formulation work of planners in the past has been so general that it was virtually meaningless. If the purpose of transportation goal formulation is to find the lowest common denominator of agreement and thereby avoid controversy, it is not likely to be of much value. Transportation planning ought to be characterized by lively controversy among contesting perspectives, agencies, and modes. To guide the process of developing local, regional, and statewide programs for construction and operation of urban, rural, and interregional transport facilities, requires that the controversy be constructively channeled into the decision-making process. Thus, what is possible, and of significance, is a formulation of state and regional transportation goals and policies in a manner that influences the framework of contention and debate between competing interests so that it is publicly open, technically productive, flexibly responsive to changing problems and values, and decisive when decision is called for.

Failure of the present process of planning, designing, and constructing highways in California to meet these criteria in recent years has resulted in court suits, legislative deletions, public acrimony, and frequently stalemate without transportation improvement. Those who believe that major transit systems that are planned and implemented in the same way will escape controversy are mistaken. Recent occurrences in Minneapolis-St. Paul, Atlanta, and even the San Francisco Bay area are evidence that the honeymoon for major fixed-rail transit systems is already over as far as broad-scale local consensus is concerned. Simply making CALTRANS responsible for a new mode or modes of travel and providing the money to implement, plan, design, and construct such modes through the same agencies and procedures used by the highway mode will not solve the underlying conflicts troubling the transportation field in California and particularly its urban regions (1).

To overcome the increasingly divisive problems of project implementation and quality of service requires new procedures, new institutional relationships, and new perceptions of the purposes of transportation facilities. These might well become the focus of legislative interest when statewide goals, policies, and objectives are set that give direction to a revitalized transportation planning process in California. They may also attract attention from the incoming state administration as means to further alter the mission and approach of CALTRANS in dealing with broader environmental and social issues.

Rather than a static, long-term plan such as that set out by the 1959 freeway and expressway system legislation it would be better to set a framework of intergovernmental procedures, financial relationships, and service objectives and let specific facility plans evolve flexibly, mainly at the local and regional levels.

Much effort by CALTRANS has already gone into such an approach that emphasizes a decision-making process rather than a fixed plan, incremental choices rather than long-term commitments, and regional rather than state or local goals (2). Soon the legislature must determine whether this approach is desired and in keeping with the intent of AB 69 and other recent legislation in the areas of transit finance, highway deletions, and issues of regionalism. This approach has already raised conflicts with individuals and institutions accustomed to operating without either a strong regional influence or a multimodal perspective. It has also pointed up weaknesses in the capabilities of regional agencies to plan well or to allocate resources effectively under evolving directives of both state and federal agencies. These are serious concerns and need to be dealt with decisively by the legislative and executive branches of California government within the next year if a new planning process is to effectively overcome past weaknesses.

The following issues are not intended as specific recommendations but are raised for legislative consideration. They have emerged from the author's work with transportation planning issues in several California regions and reading and observation of such issues in Boston, Toronto, and London.

Operations Versus Facilities

The central issue is whether to continue to construct new facilities every time a transportation problem is perceived or to make a major shift toward a management or operating focus and effectively use existing facilities. Certainly it would be an extreme position to hold that no new, capital-intensive facilities are needed in the long run for shaping and serving travel demand, but in the short run the issue is almost that stark. More effective operation of highways and transit systems could greatly improve mobility within California and its regions and reduce air pollution and energy consumption as well. Efforts such as priority bus lanes on freeways and city streets, specialized bus transit services that approximate the service characteristics of the automobile, and access and flow density limitations for automobiles on freeways and city streets have been successful elsewhere in the country. Innovative traffic and transit operations have also been implemented in California, but they are fragmented and viewed as experimental in nature. In other parts of the country and abroad they are increasingly being considered as coordinated and routine aspects of comprehensive transportation policies for urban areas.

The question of operations versus facilities, which is a question of emphasis, is important in the state and regional transportation planning process because it suggests that institutional and funding arrangements for the coordination and stimulus of integrated transit and highway operations might be a primary emphasis of legislative policy guidance for the overall process. If this guidance is forthcoming, financial incentives could be written into law that would ensure that regions and local agencies give strong consideration to the effectiveness of operations before launching major new facility projects and that these new facilities enhance the operating capabilities of the overall transportation system.

This does not seem to be the direction that most existing highway and transit agencies would follow if left on their own. It is the direction being strongly pushed by the federal agencies, particularly in the transit field. One agency in which this operating orientation figures prominently in the planning effort is the Metropolitan Transportation Commission in the San Francisco Bay area. The regional plan calls for setting up a transit council composed of all the transit operators in the region and a traffic council composed of a variety of highway, road, and street agencies such as the Division of Highways, Division of Bay Toll Crossings, and county and city road and traffic departments. However, little has been accomplished to bring these groups into existence. Little formal incentive exists to do so under existing planning and financing formulas and institutional relationships. Each agency would rather pursue its own interests in financing and constructing facilities. Without guidance in the California Transportation Plan, words rather than deeds may prevail for a long time in the field of transportation systems operations.

Corridor Versus Local Focus

Legislative guidance for highways specified in the 1959 act for the California freeway and expressway system (3) emphasized a state highway system connecting links and corridors between relatively distant points.

Aspects of AB 69 and its interpretation by the State Transportation Board suggest that the state should be concerned with the interconnections between regions and a statewide perspective of the plan. This is certainly a valuable state role, but not necessarily its predominant one. Perhaps concern for the quality and scope of local transit and street services in the form of minimum standards or variable standards related to population density or other regional or local characteristics should be considered as part of the legislature's responsibility in approving statewide transportation goals, objectives, and policies.

The emphasis of the freeway and expressway system, in places as diverse as Los Angeles and Lake Tahoe, has often been on local movement rather than on interregional travel. The local movement system of Los Angeles has been funded largely by the state and federal governments in the guise of interregional or Interstate facilities. In the past at Lake Tahoe, proposals for major new highway investments to serve local development ambitions and local travel requirements have been aimed at state and federal funds allocated through the freeway and expressway designation of basin routes, which are specified to be of statewide importance. If state funds are to be used for local purposes, that fact ought to be clear, and the sharing formulas, facility designs, and final transportation services made appropriate to the problems being addressed locally.

Research has pointed out many of the problems created by state emphasis on large-scale corridor projects and an insensitivity to or ignorance of the local conflicts they generated (4). Similar emphasis by the state on transit corridors and large-scale systems may also put that program almost exclusively in the hands and interests of land developers and chambers of commerce, as has happened until very recently with the freeway and expressway system routes. Concern for local levels of transit service to the poor, elderly, young, or handicapped, for example, might be as important to the state legislature as regional, long-distance transit accessibility for white-collar workers in downtowns.

Technique Versus Openness

Transportation planning at the systems or regional level is perceived as a technical process involving high-speed computers, complicated mathematical models, and complex behavioral data collected from extensive surveys of people's travel habits and future desires. This process is veiwed as objective and complicated and not to be disturbed by emotional concerns of citizen groups or political intrusion. That view, particularly of the highway planning process, often carefully promoted by the technical experts themselves, is politically and professionally irresponsible.

A policy-making process that shapes future transportation of a region is complex, and much valuable information is added through technical analyses. But it is also a political process involving value conflicts of regional versus local concerns, of environmental versus mobility desires, of the social equity of bearing the costs and receiving the benefits of facility construction or service quality. As such, it ought to be exposed to a wide range of citizen and political concerns. This has been the case with major transportation systems decisions in Boston, Toronto, and London (5, 6, 7, 8, 9). The California legislature was furnished with direct information on all of these cases of citizen and political scrutiny of regional or systems level transportation planning and decision making. Also, several members of the legislature examined details of these planning reviews first hand during a transit and planning study tour of Boston, Toronto, and Montreal.

The goals, objectives, and policies stated by the legislature might well deal with the degree and quality of citizen participation and local political review of technical transportation planning carried out in the California Transportation Plan process.

Programming Versus Master Planning

Past views of regional and state highway planning, as well as a considerable amount of transit facility planning (BART in the San Francisco Bay area, current Southern California Rapid Transit District rail project plans in Los Angeles, and corridor transit concepts for San Diego), have emphasized a master planning of facilities to be constructed as part of a major program over long periods of time (often as long as a decade or two). Setting goals in the form of a master plan effects political commitment, adequate funding, and broad regional or state support by offering a package of some facilities for everyone, if the program is continued relatively inflexibly and long enough. But it has difficulties too, and these should be addressed in relation to the format of state and regional plans called for in AB 69.

Is enough known about the future to plan for 20 or 30 years hence without flexibility in accommodating changes in values, technologies, and environmental or energy constraints? Many transportation planners formerly believed it was possible, but that belief has been challenged by citizens in the courts, by energy and pollution problems couched in crisis terms, and by the failure of land use planning. These planners now doubt the technical and master planning bases of their long-term rationales (10). More incremental and flexible strategies may be needed in the future and might be provided for in the approach taken to the California Transportation Plan.

Two of the many places evolving toward incremental planning and implementation of highway and transit systems are Boston and Toronto.

Shorter term programming of increments of transit and highway systems, perhaps by 2 to 5-year horizons or other recurrent technique, might be considered in setting the goals, objectives, and policies for the transportation planning process now under review in California.

The issues mentioned will be among the important matters for legislative attention in the coming months as the planning process set out in AB 69 proceeds. They are all difficult and imply more than routine continuation of existing policies and institutional relationships. Thus, they warrant careful analysis, not only by the transportation committees of the legislature but by other committees as well.

INSTITUTIONAL AND FINANCIAL ASPECTS OF TRANSIT PLANNING

A second set of issues relating to planning for major investments in fixed-guideway transit systems in several metropolitan areas of California has been the subject of legislative scrutiny and has been raised in regard to accelerating planning programs for new transit systems in Los Angeles and San Diego and, to a lesser degree, the possible extension of BART or introduction of newer rail modes in the San Francisco Bay area.

The issue of local versus corridor planning has already been discussed in the context of statewide interests. Applied on a regional context, it is equally critical in allocating financial and planning responsibilities among state, regional, and local levels of government. Figure 1, based on work of the Southern California Association of Governments (SCAG), shows the relative proportions of trips made in a large metropolitan area by length of trip (11). It also illustrates the location and extent of local communities and special activity centers within the region.

Inasmuch as most of the trips taken in the region are short and within such centers and local areas, it is remarkable that so much debate and so many resources are being allocated to issues of regional or corridor transit systems rather than local services (12, 13). Regional level rail networks and the federal emphasis on capital grants may be distorting where the needs are and where the resources seem to be directed. Regardless of the reasoning, it poses a critical problem for legislators and local officials interested in placing the priorities where the problems are.

A major problem with transit planning in the Los Angeles and San Francisco areas has been the organizational nature of the transit districts created to plan and execute regional rail systems. Both the Bay Area Rapid Transit District (BARTD) and the Southern California Rapid Transit District (SCRTD) are creations of the state legislature. These districts were authorized more than a decade ago, at a time when building rail rapid transit seemed both easier and more worthwhile than it does today. Each has come under considerable scrutiny in recent years from citizens and legislators for failures of technical and fiscal performance and for lack of popular responsiveness.

BARTD recently got its first elected board of directors from geographically defined districts within its three-county service area, which replaced the hopelessly divisive board of political appointees. The future of SCRTD is uncertain, for numerous bills calling for organizational restructuring are awaiting action in this year's legislative session and extensive rail rapid transit proposals have already been defeated twice in 6 years.

Both districts were created as special-purpose regional, rather than local, transit districts and were designed to plan, construct, and operate rapid transit systems rather than operate buses and make other transit improvements. SCRTD has operated a large bus fleet covering much of Los Angeles County since its creation, but this was not the main intent of its enabling legislation. In the San Francisco Bay area, relatively

Figure 1. Travel in percentage of person trips.

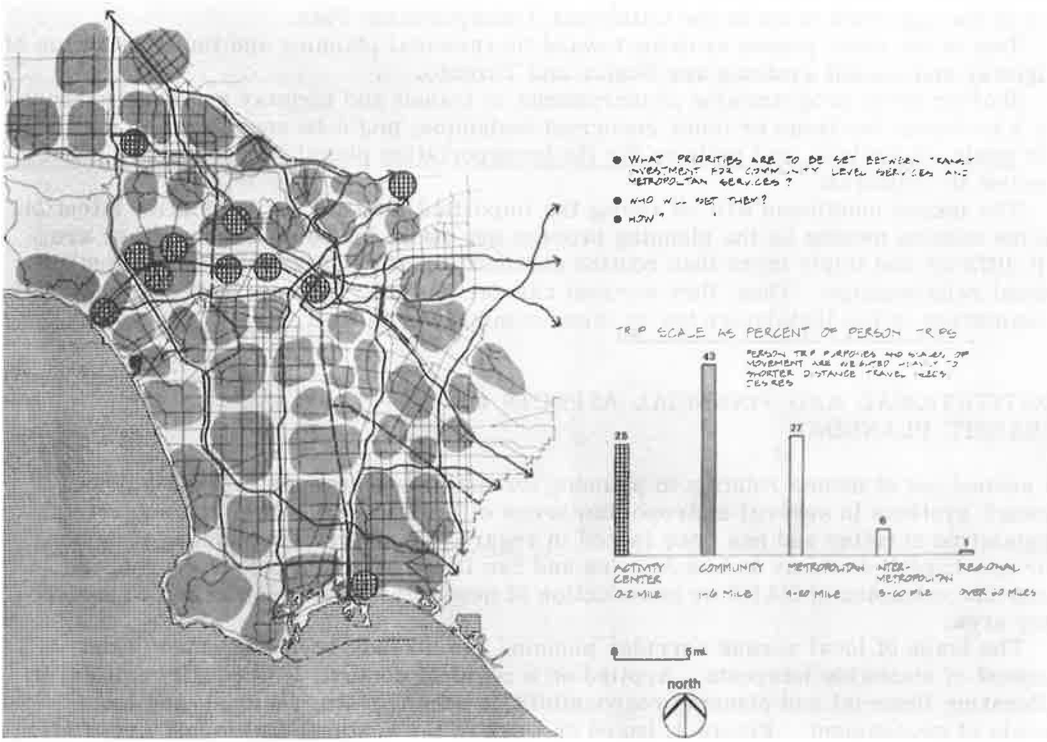
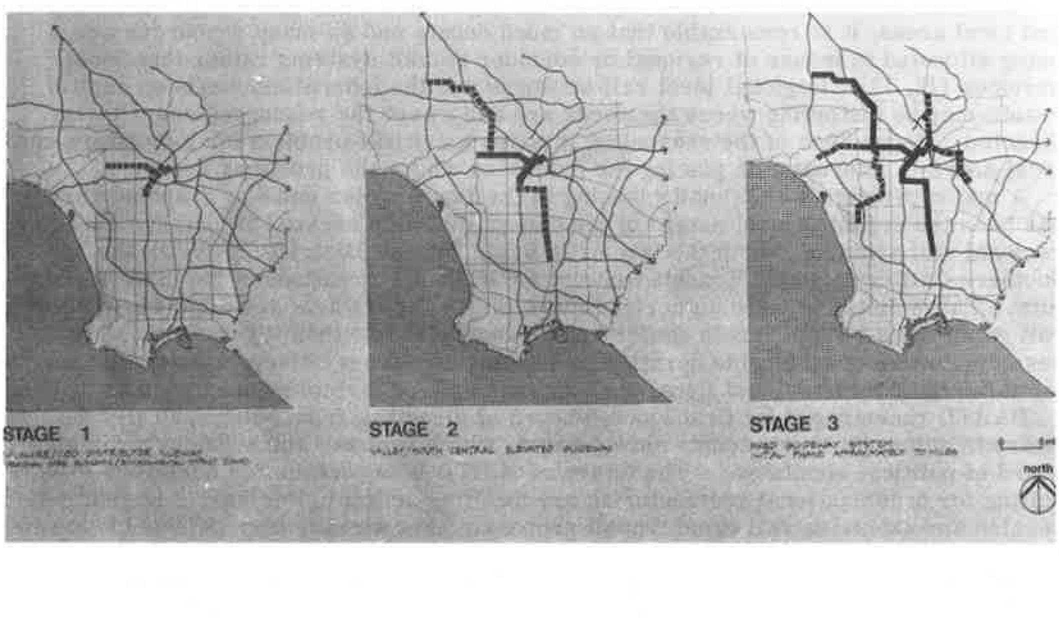


Figure 2. Staging for incremental development.



good local bus systems exist under other general and special-purpose government agencies in the same area covered by BARTD, but coordination of service has been a difficult political problem that is getting better. In the Los Angeles area, the SCRTD bus system dominates the transit scene.

In each region there is a competition for dollars and political resources between regional agencies and local needs. The special nature of BARTD and SCRTD has thus far largely biased the transit decision-making process toward regional systems and service to the detriment of the local travel needs shown in Figure 1. Since SCRTD failed in November 1974 to gain popular approval of a 1-cent increase in sales tax to finance an extensive corridor transit system spanning Los Angeles County, more incremental and more local transit systems may now be considered under a revised institutional charge from the legislature and local political leadership; and this may give more decision-making power to community rather than regional interests.

Another issue already posed in terms of programming versus master planning at the state level is also applicable in regional transit planning. Figure 2 shows the concept of incremental decision making (a form of project programming) as opposed to master planning as one comprehensive solution at a fixed and distant point in time.

This figure shows, in Los Angeles, for example, how one might begin to build a regional fixed-guideway network over time, as local planning concurrences and resources became available. This seems to be how Toronto, Montreal, and a number of European cities have proceeded, by gradually increasing the service and mileage of their transit systems rather than master planning some regional goal as seems prevalent in the San Francisco Bay area, Washington D.C., and other large American cities. In Los Angeles, the transit district has elaborated this master planning perspective to perhaps its most extreme formulation—a proposed 240-mile (390-km) rail network with a price tag well above $10 billion (14). The proposed plan is shown in Figure 3. Because the financing to Los Angeles from all existing or projected sources seems well below such an amount, it is highly questionable what such master planning would have meant in terms of implementation. It was this plan and its local financing element that local voters rejected by 54 to 46 percent in November 1974.

Given the number of metropolitan areas in California that have wish lists of their own, the amount of money that could be sought by transit districts for master-planned rail systems is staggering and meaningless. Therefore, there is an interest in state and federal government to see that such plans are scaled back to realistic levels and that systems are constructed that perform highly useful, if not totally regional, services.

Figure 4 shows how such an initial stage of rail transit in a regional core can be constructed to interface with complementary express bus and park-and-ride facilities in other corridors. In addition, several concepts of localized taxation for the areas specifically served by initial guideway links are shown as means of overcoming objections to one area benefiting most from regionwide transportation concerns. At least some extra taxes on business activity, employment, or real estate development in the regional core could supplement regionwide sales, income, or property taxes to pay for the first and often most costly miles of a regional guideway system; this allows a more equitable distribution of transit resources and services throughout the majority of the region.

Financial and institutional remedies to technical and economic problems often fall to lawmakers, and thus laws and legislators should not be overlooked in the design of transit systems and their implementation strategies. Many of the distortions, difficulties, and outright absurdities of transit system planning today follow from inadequate flexibility in the size, political makeup, and financial resources of transportation planning and management agencies (16). It is hoped that these issues can be confronted squarely in California as part of the statewide transportation planning process and that this planning can advance to an implementation process responsive to changing transportation needs and opportunities.

Figure 3. Rapid transit plan for Los Angeles County.

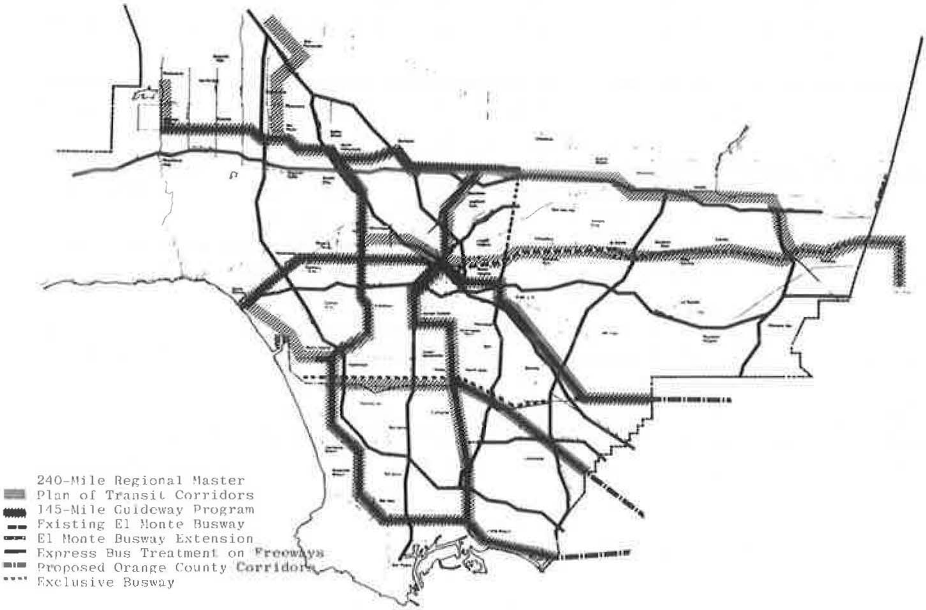
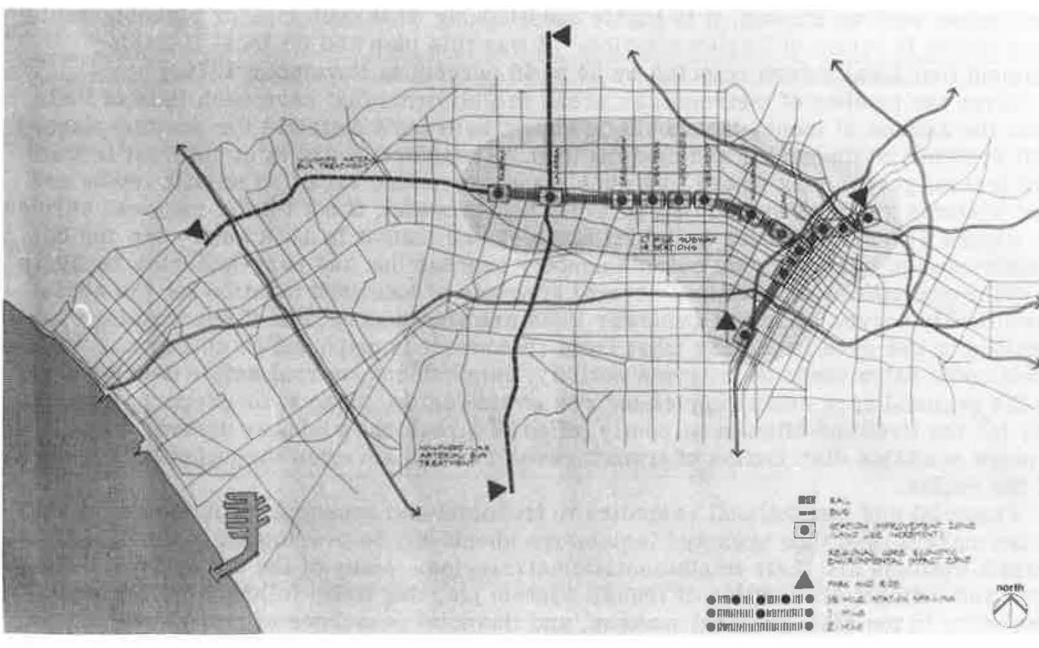


Figure 4. Wilshire-CBD distributor subway.



REFERENCES

1. S. McCausland. Along for the Ride—People, Politics and Transportation: California-Style. Assembly Committee on Transportation, California Legislature, Oct. 1974.
2. California Transportation Plan. Business and Transportation Agency, California Department of Transportation, initial draft, Dec. 1973; progress rept., April 1974; supplement, June 1974.
3. Statutes Relating to the California Department of Transportation. In California Streets and Highways Code, California Department of Transportation, Jan. 21, 1974, pp. 119-124.
4. R. A. Burco. Policy Planning in the Lake Tahoe Basin: The Case of Transportation. Transportation Research Record 508, 1974.
5. R. Gakenheimer. Technics and Conflict: The Open Study in Urban Transportation. M.I.T., 1974.
6. S. C. Lockwood. The Boston Transportation Planning Review: A Case Study in Community/Technical Interaction. Planners Notebook, Vol. 2, No. 4, Aug. 1972.
7. Study Prospectus. Metropolitan Toronto Transportation Plan Review, Toronto Transit Commission, June 1971.
8. Transportation Information for the Bathurst-St. Clair Area. Metropolitan Toronto Transportation Plan Review, Toronto Transit Commission, 1973.
9. Comments by the London Transport Executive. Greater London Development Plan, Greater London Council, Nov. 1970.
10. Interrelation of Transportation System and Project Decisions. Federal Highway Administration, U.S. Department of Transportation, Nov. 1, 1973.
11. Towards a Balanced Transportation System. Southern California Association of Governments, Los Angeles, Nov. 1974.
12. Study of Alternative Transit Corridors and Systems. Southern California Rapid Transit District, Los Angeles, March 1973.
13. Rapid Transit for Los Angeles. Southern California Rapid Transit District, Los Angeles, July 1973.
14. A Public Transportation Improvement Program. Southern California Rapid Transit District, Los Angeles, March 1974.
15. Transit for Los Angeles County—A Subregional Transit Element of the Transportation (SCAG) Plan. Southern California Rapid Transit District, Los Angeles, July 1974.
16. W. Boyarsky and N. Boyarsky. Waiting for the Transit Revolution. In Backroom Politics, J. P. Tarcher, Inc., Los Angeles, 1974, pp. 204-227.

CONSUMER ATTITUDES TOWARD PUBLIC TRANSIT

Gordon J. Fielding, Douglas P. Blankenship, and Timothy Tardiff,
Orange County Transit District, Santa Ana, California

Transit planning requires a high level of input from the public. Market survey research has been found to be a very useful and simple tool for collecting and analyzing data on key user groups and public opinion segments. Therefore, the objectives of this study were to identify and weight the factors that jointly influence the use of public transportation and, with this information, to formulate guidelines for both marketing and policies of transit operations. In summary, a transit system must, if it is to solve urban transportation problems, be designed to provide service that is attractive and competitive in a consumer-oriented market and socially concerned society. This paper reports preliminary results from a 1972 study conducted in Orange County, California. Changes have been made in the questionnaire, and a more detailed market segmentation study was conducted in 1974.

•BEHAVIORAL RESPONSE is one method of validating public attitude. The Orange County Transit District had considerable success between 1972 and 1974 in effecting a large increase in transit use. In part, this success is attributed to the development of transit service that was responsive to consumer desires. Operations began in August 1972, with only five buses. As of July 1974, ridership had increased from 25,000 to more than 520,000 a month, and the bus fleet had been expanded to 103 vehicles. Another 111 buses were added during 1975. Of those, 67 were for expansion of demand-responsive transportation (DRT) service and 44 for improved service on the fixed routes.

Such expansion of transit use in Orange County is encouraging; the most recent survey indicates that 97 percent of all households have at least one private vehicle, and 62 percent have more than one. To maximize potential service and to make transit responsive to the perceived needs of the 1.7 million population of Orange County require that studies of consumer attitudes and preference be conducted.

STUDY OBJECTIVES

The broad objectives of this research were to identify and assess the relative importance of the attributes of the transit system as conceived by the consumer and to determine the extent to which consumers think existing modes of transportation satisfy their needs.

In the first phase of the research, answers to questions on transit attributes and service level were sought. Although the questionnaire used was preliminary, it did supply information in five areas.

1. What attributes do transit users regard as important on a typical trip?
2. What attributes of transit are important for all transit trips in an ideal system?
3. What are the most important trip purposes for which consumers prefer transit?
4. What are the expectations of the public in terms of financial support for public transit?
5. Why do people desire public transit?

The objectives of this study were to weight the factors that influence the use of public transportation and to use techniques of analysis and prediction that would assist the evaluation of future needs and development of transit in Orange County.

STUDY METHODS

Two questionnaires were used in the study; one was a general questionnaire relating to standard fixed-route, fixed-schedule bus service. The second was modified to measure the anticipated reaction to the demand-responsive transportation system. Both questionnaires had similar format, and most questions were duplicated. The conventional bus survey was distributed among a stratified sample of 267 respondents in each of three cities: Santa Ana, Costa Mesa, and Cypress. The DRT questionnaire was used in La Habra where the Orange County Transit District (OCTD) was introducing such a system. The sample size for the DRT survey was also 267.

The questionnaires were revised after the first phase of the research, and a second, countywide survey was conducted in 1974. This paper does not include the results of the 1974 survey. These will be presented in a subsequent paper, in which the results will be segmented to reflect the opinions of groups by sex, socioeconomic status, attitudes to public transit, and places of residence and work.

Nor are detailed cross-tabulated results included. The figures summarize some of the results. Time constraints do not permit in-depth analysis. The purpose here is to outline the methods used and to indicate through figures some of the conclusions that have influenced route planning, marketing, and policy decisions.

RESEARCH DEVELOPMENT

The OCTD study was preceded by research aimed at understanding of transit use and development. Previous research concentrated on trip purpose, trip frequency, and the demographic characteristics of the existing modal split. Much of this research is oriented toward the construction of aggregate behavioral models. The following is only meant to be a brief summary of the status of knowledge about transit consumer behavior. The development of the OCTD research effort was assisted by the methodology and results of six seminal studies (2, 3, 5, 6, 7, 8, 9).

The conclusions drawn from these six studies are presented below.

1. The automobile is universally held as being more satisfactory than public transit, which is rated unfavorable.
2. The major determinants of modal choice include reliability, time, cost, mode of payment, and physical and psychological comfort.
3. A mode shift from automobile to transit would result from better transit accessibility, more frequent scheduling, routing that was responsive to demand, and low cost.
4. Present transit users think that the attractiveness of transit would improve by maintaining schedules, decreasing origin to route and route to destination distances, and reducing trip-time expenditure.
5. Speed and punctuality are less important for nonwork trips than for work trips. Other costs and conveniences are, however, equally important for both purposes.
6. The relative importance of transit attributes varies according to the survey instrument used, the geographic location of the sample, and the existing use made of public transportation.

These conclusions are from studies that investigated the nature of an ideal system as perceived by the respondent and measured the performance of the existing or proposed systems against the ideal. The major problem with using attitude studies is the assumption that the respondent has sufficient information to make a valid judgment between the alternatives offered. In Orange County, 40 percent of the respondents were unaware of the presence of the nearest bus line, and 79 percent replied that members of their households never used the bus. The interpretation of the results must incorporate these limitations.

ORANGE COUNTY RESULTS

Both Likert and semantic differential scaling procedures were included in the questionnaire used in Orange County. The Likert scale asked respondents whether they agreed with 40 statements about public transit. These responses were used to group respondents into attitude groups. Semantic scaling proved more useful in assessing different attributes of bus transportation because respondents were asked to scale statements from not important to very important. A summary of the responses for level of service, bus design, and convenience is shown in Figure 1.

From the point of view of users, the public transportation system is a part of a decision-making framework and, as such, is measured against other modes of transportation by satisfaction criteria (Figure 1). These criteria are often speed, safety, comfort, and economy, but for the most part overall level of service (arrival on schedule, closeness to bus line, driver attitude, and arrival frequency) is extremely important. This conclusion is consistent with the six aforementioned studies. Figure 1 shows a measure of the intensity of preference.

All four attributes were more important than attributes reflecting price, travel time, and the inconvenience of transfers. These latter attributes were perceived as being about equal in importance to smoothness of ride, availability of a seat, and provision of bus stop benches and shelters. The perceived importance of design attributes that would reduce smog was expected in southern California. The real surprise was the importance that the public places on the attitude of the driver. A friendly and helpful coach operator appears to be far more important than most attributes of the bus itself. And yet, most transit properties devote more attention to bus design features than they do to either employee relations or the training of coach operators in customer relations.

It is extremely costly to add more buses to improve the schedule of service. Each additional bus costs approximately $60,000 per year to place in service. By comparison, a program of customer relations for coach operators could substantially increase use of existing services. The coach operator is the best salesperson that a transit property possesses. Too often this attribute has been overlooked as a means of attracting and retaining riders who have a choice between automobile and transit.

The overall findings of this section have definite marketing implications that will be considered later in the paper.

POTENTIAL TRANSIT RIDERS

The real challenge for public transit in suburban metropolitan areas is to expand ridership in areas in which almost everyone has access to an automobile. Only 3 percent of the households interviewed did not have access to an automobile, and even this minority had friends and relatives who provide essential transportation. Yet this statistic is deceiving: Of the 1.7 million people residing in Orange County, it is estimated that 500,000 do not drive. They are dependent on others for transportation.

For what trips can public transit be substituted for the automobile? Further, for what trips can public transit offer a viable alternative to those who normally drive? Also, how can the needs of those without access to automobiles be met? Answers to these questions provide direction for transit managers.

To answer these questions we collected data on work, school, shopping, and social trip purposes. This information was cross-tabulated with the respondent's intention to use the bus if the fare was 25 cents, the bus route was within three blocks of the origin of the trip, and the bus arrived at 30-minute intervals. Of the respondents who made a daily work trip, 35 percent stated that they would use the bus for work trips. Similarly, 32 percent would use it for school trips, 30 percent for shopping, 32 percent for entertainment, 21 percent for visiting, and 37 percent for church on a regular basis (Figure 2). These categories are not mutually exclusive and are percentages of those already making these trips who would use transit at least once a week.

Conversely, 70 percent of all respondents were unwilling to discontinue car use even if the public transit service were as described. After examination of total trips, it was found that, with the bus service stated above, 38 percent of person trips would be made by bus. Inasmuch as this is far greater than the recorded split of 2 percent, it is probable that lack of experience with the public transportation system and the increasing scarcity of gasoline in the fall of 1972 when the interviews were conducted resulted in overstatement by respondents of their potential transit use.

Some respondents perceived bus transportation as a substitute for the automobile for certain trip purposes. Use of bus transportation for shopping was greater than anticipated. Preliminary analysis of responses indicates that heavier than anticipated use by persons 12 to 17 and above 65 years old can be anticipated for shopping trips. This is important for operations because selective marketing could increase patronage during the off-peak hours and on Saturdays.

MARKETING ASPECTS

One of the primary aspects of this study was to gather data that would be useful in developing a marketing strategy. The respondents ranked the importance of public transit attributes on a scale from 1 to 5—not important to very important. These attributes were then grouped into more general categories. Figure 1 shows the results of three categories: level of service, bus design, and convenience.

Under levels of service, the most important attribute was that the bus arrive on schedule. This was followed by driver attitude, closeness to the bus line, and arrival frequency. These ranked more highly than bus design items, which in turn ranked more highly than convenience items.

A smog-reducing characteristic was considered the most important in bus design, which is emphasized by general concern about air quality at the time of the survey. Smoothness of ride, air conditioning, quietness of ride, and seat comfort and bus appearance were considered more important than bus size and storage space. Seat availability was the convenience factor rated the highest, followed by the need for shelters at the stops.

The survey showed that route design and scheduling were important. Respondents required punctuality and closeness of the route to their trip origin. The latter demand fell markedly after a three-block distance from the respondent's home. If the bus ran within one block, more than 50 percent of respondents stated that they would use the bus to some extent. The cost of the ride was less important than distance to the route.

The groups with the highest potential use were those with no cars, those who earn less than $7,900, and those 12 to 17 and 35 to 65 years old. It was also found that three groups are unlikely to use the bus, regardless of its proximity, and these were those 18 to 24 years old, households with two or more cars, and households with an income greater than $25,000.

The importance of accessibility to the bus lines caused the OCTD to feature a sectional rather than areawide marketing strategy. The actual placement and selection of advertising were aimed at the individual who resides or works within three blocks of the bus route. Hence, corridors of marketing activity may be defined. The media selected, such as posters, direct mailing, and bench advertising, reflect this local effect.

Previous to the results of the survey, radio and newspaper advertising was emphasized. This established an image for the OCTD but has had limited effect on ridership. An intensive direct mail advertising program was initiated in 1973, and it will be interesting to determine the effect of this program on the decision to use the bus for different trips. This information will be available in a subsequent publication.

A strategy has been developed to involve the coach operators in marketing and public relations. The objective was to improve their knowledge of the total transit

Figure 1. Total sample mean attitude scale for conventional bus transportation.

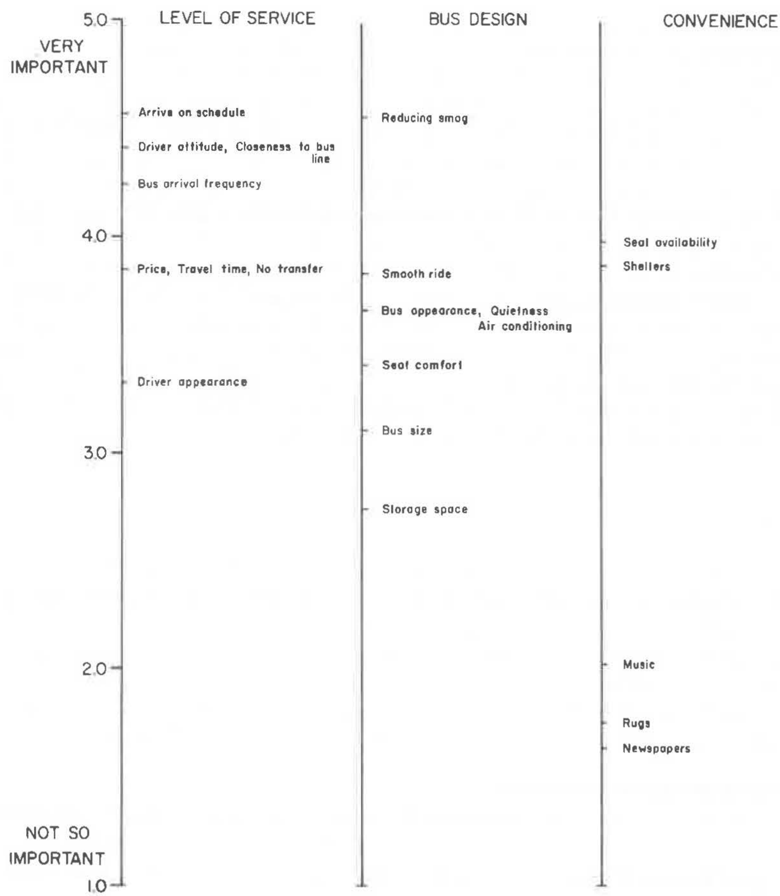
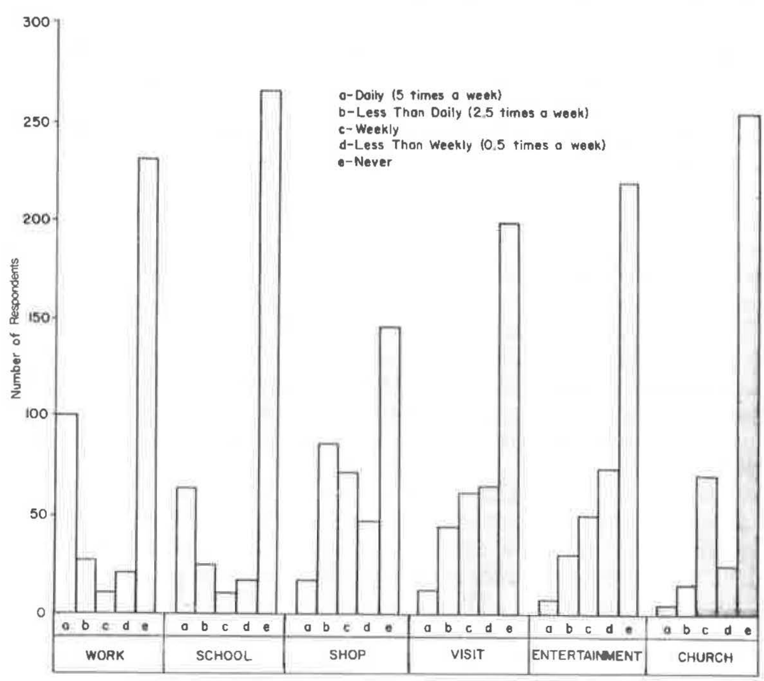


Figure 2. Number of respondents traveling by purpose and frequency—conventional bus transportation.



system and to encourage them to be more helpful to the customer. The emphasis has focused on an advanced training educational program rather than individual awards.

POLICY FINDINGS

Several opinions related to policy issues of the transit district were tested in the study. The aspects considered were financing, formulation of goals, and general public support.

Respondents generally expected the bus company to be a profit-making organization and to earn its revenue from the fare box. Only 19 percent favored financing from gas taxes and only 9 percent from sales tax. Attitude scaling confirms the prevailing unwillingness to use public funds to subsidize transit. Respondents agreed (65 percent for, 29 percent against, and 6 percent no opinion) that public transit should be a public service. However, transit managers will have to educate the public on the economics of the industry if they desire continued public support for operating subsidies.

Only two groups disagreed with the flat fare concept, but these form a significant proportion of the total sample. These were those with incomes of $15,000 or more and those with a college education. The preferred method of fare payment was a monthly pass or multitrip ticket. Credit cards or exact change arrangements were disliked; the 25-cent fare was most preferred.

Support for public transit was overwhelming; 84 percent responded that the benefits of public transit are well worth the cost, and 90 percent thought that bus transport would make their city a better place in which to live. Coupled with this support was the desire to participate in bus routing and to be involved in the planning process. It should be pointed out that a feeling of impotence is not limited to public transit; it is a feature of governmental planning in general.

An apparent paradox is that the strongest support for transit comes from the demographic groups least likely to use it but most likely to face indirect costs of the system. These were groups with annual incomes exceeding $25,000 and households with two or more automobiles.

Continuing concern with the smog problem was evident on questions dealing with bus design characteristics. Reducing smog was the highest rated feature. It may be pointed out that, although reducing smog is a number one concern today, this is the type of issue that can change quickly. Reduction of bus noise and fumes might improve the perception of the bus as an alternative mode of travel.

CONCLUSIONS

This transit study was undertaken to evaluate the attributes of the bus within the travel decision process. The aim was to investigate means of improving the competitive position of public transit against the private automobile. The attitude survey was designed to locate potential users and identify those features of route location, scheduling, cost, comfort, and convenience that would encourage these people to use the service provided. It should be stressed that the results are preliminary and that the survey was a pilot study for an expanded attitude study covering the whole of Orange County. Distinct attitude and user groups can be identified from the attitude survey, and the expanded study will give special attention to market segmentation and the characteristics of people in each segment.

Use of cross tabulation and mean scaling produced the following results, which are a step toward preparation of future studies and on which interim management decisions and policy guidlines can be based.

1. Consumers overestimate their proposed use of transit. This may be related to lack of information or experience.
2. Use of transit is directly related to the proximity of the trip origin to a bus route.
3. The attitude of the coach operator is more important to the public than many of the costly amenities of bus design.

4. The public is actively interested in the provision of bus service but must be educated in both its use and its financing. The public is, however, interested in becoming actively involved in the planning processes.

5. Promotion of "take a bus shopping" will appeal to youthful and senior citizens who can travel during off-peak hours.

6. Concern for the quality of life seems to be a major determinant of the popularity of public transit. This is indicated by the concern about smog reduction in making the city a better place to live.

In summary, a transit system must be designed to provide service that is attractive and competitive in a consumer-oriented market and socially concerned society. Surveys of consumer attitudes can assist management in designing competitive service and monitoring its acceptance over time. Future reports will provide information about the attributes of population groups whose attitudes toward public transit differ. The aim will be to segment the population for marketing and policy purposes.

REFERENCES

1. Technical Report 1. Orange County Transit District, Santa Ana, 1974.
2. G. J. Fielding. Structuring Citizen Involvement in Freeway Planning. Highway Research Record 380, 1970, pp. 23-36.
3. G. J. Fielding, D. E. Benson, and T. J. Tardiff. Designing and Marketing Transit Systems With the Aid of Attitude Studies. Proc., URISA Conference, San Francisco, 1973, pp. 82-95.
4. R. L. Gustafson et al. User Preferences for Dial-a-Bus: A Comparison of Two Cities. General Motors Research Laboratories, Warren, Mich., 1971.
5. T. F. Golob et al. An Analysis of Consumer Preferences for a Public Transportation System. General Motors Research Laboratories, Warren, Mich., 1970.
6. C. H. Lovelock. Consumer Oriented Approaches to Marketing Urban Transit. Stanford Univ., dissertation, 1973.
7. R. K. McMillan and H. Assael. National Survey of Transportation Attitudes and Behavior—Phase I: Summary Report. NCHRP Rept. 49, 1968.
8. R. K. McMillan and H. Assael. National Survey of Transportation Attitudes and Behavior—Phase II: Analysis Report. NCHRP Rept. 82, 1969.
9. F. T. Paine et al. Consumer Conceived Attitudes of Transportation: An Attitude Study. Univ. of Maryland, 1967.

CHARACTERISTICS, ATTITUDES, AND PERCEPTIONS OF TRANSIT NONUSERS IN THE ATLANTA REGION

Joseph P. Byrd IV, Metropolitan Atlanta Rapid Transit Authority

Immediately after transit fares in Atlanta were reduced, transit ridership increased dramatically, exceeding the previous estimates by 50 percent. Total ridership for the 6-month period following the March 1, 1972, fare reduction was almost 15 percent greater than that for the equivalent period in 1971. The fare reduction program of the Metropolitan Atlanta Rapid Transit Authority (MARTA) generated considerable local and national interest, and research was designed to measure the effect of the fare reduction and subsequent transit service improvements on ridership. The study effort consisted of two surveys: (a) an on-board interview of transit riders and (b) an in-home survey of households in the two-county transit service district. This paper deals exclusively with the in-home survey. The MARTA in-home survey dealt with two principal areas of inquiry to complement the on-board survey findings. The first area consisted of the characteristics of transit nonusers as well as their attitudes toward and perceptions of transit. In addition, the in-home survey was designed to determine whether the characteristics, attitudes, and perceptions of nonusers were significantly different from those of transit users. The second area dealt with why the increase in ridership was not even higher and what actions would be necessary to attract additional riders.

•THE MARTA in-home survey focused primarily on the characteristics, attitudes, and perceptions of transit nonusers but also sought responses from transit users. For additional comparison, several questions were identical to those that appeared on the on-board survey questionnaire.

The in-home survey form was designed to require a minimum of conditional responses and was worded to maximize objectivity. The survey form was divided into three parts. Part one included questions addressed to all persons interviewed. Items such as perceived convenience of transit, perceived quality of service, and priority of service improvements were contained in this section. The second and third sections were directed toward nonusers and users respectively.

Determination of sample size and actual sample selection for the MARTA in-home survey were made in conjunction with the Atlanta Regional Transportation Planning Program (ARTPP) update. All interviews were conducted in Fulton and Dekalb Counties and spanned a 6-month period from October 1972 through March 1973. A sample size of 0.5 percent of the total number of dwelling units was set as the standard for the survey.

Before the in-home survey was initiated, an official letter was sent to each household selected explaining the purpose of the study and requesting cooperation. Interviews were conducted between 9:00 a.m. and 9:00 p.m., Tuesday through Saturday. Interviewers were provided with identification cards, which they showed to each person interviewed. Only responsible persons 15 years of age or older were interviewed. If no members of the household were present when the interviewer arrived, arrangements were made to contact the most qualified adult to provide the information.

After completion of field work, approximately 1,400 coded interview forms were returned for editing and processing. All survey data were sorted by geographical zone: a central zone, which basically conformed to the city of Atlanta and four suburban zones. All zones were designed to conform to 1970 census tract boundaries.

Of the 1,239 usable interviews, about half (618) were conducted in the Atlanta zone and the remainder in the four suburban zones. Location of geographical zones within the two-county study area is shown in Figure 1. Figure 2 shows the transit service area as of March 1, 1973, in relation to the five geographical zones.

After final editing of survey data, survey records were sorted by 1970 census tracts and checked to ensure both a random and proportional distribution throughout the study area. In addition, the number of survey records in each tract was divided by the number of dwelling units to determine the sample proportion. Of the 190 census tracts in Fulton and Dekalb Counties, only six did not contain any usable interviews.

The data were tabulated by applying a general-purpose system similar to that used to tabulate the on-board survey data. The system allowed the user to specify up to three parameters for tabulation and had the additional capability of separating transit user-nonuser responses. Because of the small numbers in some sample cells, three-level stratification was rarely used.

Based on the sampling techniques used, it is felt that the information derived from the survey is reliable and that the percentage distributions found are within ±3 percent of true at a confidence level of at least 90 percent and within ±4 percent at a 95 percent confidence level. These indications of statistical reliability are based on a standard assumption that a random sample of dwelling units was made throughout the study area. Stated confidence levels apply to observations made by persons classified as nonusers of transit.

GENERAL SUMMARY

1. More than 25 percent of the nonusers interviewed stated that they would be either very likely or somewhat likely to ride MARTA if service were sufficiently improved. This represents a potential increase in ridership from a substantial portion of the nonuser market. Slightly more suburban nonusers than Atlanta nonusers indicated likelihood of becoming bus patrons.

2. Nine of every 10 nonusers and virtually all (99 percent) users felt that MARTA was necessary or valuable to Atlanta.

3. The nonusers interviewed generally expressed a favorable opinion of MARTA's service quality. About half of those responding rated bus service as good, and only one out of 10 judged service as poor. These percentages compare favorably with those of transit users interviewed in both the in-home and on-board surveys.

4. About one-third of the in-home survey respondents stated that they ride MARTA either regularly or occassionally. More than three-fourths (78 percent) of these bus riders reside within the Atlanta city limits.

5. In general, transit was perceived as less convenient by nonusers than by MARTA users. Only 30 to 35 percent (depending on trip purpose) of the nonusers judged transit to be either very convenient or somewhat convenient. This is roughly one-half the proportion of favorable responses (60 to 65 percent) from MARTA users.

6. In Atlanta, a higher proportion of both transit users and nonusers felt transit was more convenient for shopping or personal business trips than for work trips. Almost two-thirds (63 percent) of the interviewees rated MARTA as convenient for shopping trips, closely followed by personal business trips (59 percent). Only 51 percent rated transit as convenient for work trips.

7. Suburban respondents perceived very little difference in the convenience of transit for various trip purposes. In addition, as expected, both transit users and nonusers in the four suburban zones generally perceived transit as less convenient than did their counterparts in Atlanta. For shopping trips 12 percent of the suburbanites judged transit as very convenient, and another 18 percent felt transit was somewhat convenient—roughly one-half the proportion of Atlanta respondents.

8. Public awareness of the regular 15-cent MARTA fare was quite low. Only 55 percent of the nonusers interviewed correctly stated the fare. The remaining 45 percent either declined to respond to the question or incorrectly stated the fare. This happened in spite of the fact that the fare reduction had been widely publicized for some

time prior to the in-home survey.

9. In response to the survey question on most needed service improvements, both transit users and nonusers ranked greater frequency of bus service first and bus shelters second. However, there were some notable differences in the perception of other transit service priorities. Getting a seat on the bus was more important to transit users, who ranked it third, than to nonusers, who ranked it seventh. Nonusers ranked schedule reliability third in importance, and users ranked it fifth. The greatest difference in the perception of service improvement priorities was in the ranking of increased weekend service. Transit users ranked it fourth whereas nonusers considered it least important.

10. Transit service priorities were perceived differently by Atlanta and suburban nonusers. As expected, park-and-ride service was more important to nonusers residing in the suburban areas, who ranked it fifth, than to Atlanta nonusers, who ranked it tenth. Improved transfer efficiency was also significantly more important to suburban nonusers than to their counterparts from Atlanta (fifth versus ninth). On the other hand, Atlanta nonusers placed more emphasis on seat availability (fifth) and weekend service (sixth) than did suburban respondents (eighth and tenth respectively).

SUMMARY OF FINDINGS

What are the characteristics of nonusers, and what are their attitudes toward and perceptions of transit? Are the characteristics, attitudes, and perceptions of nonusers significantly different from those of transit users?

As expected, the majority (78 percent) of survey respondents who indicated either regular or occasional use of transit resided in Atlanta. About two-thirds (66 percent) of all nonusers resided in the suburban areas. Respondents from Atlanta reported more frequent use of transit for work trips than did respondents from the suburban zones. About 17 percent of the Atlanta respondents stated that they regularly rode the bus for work trips compared to only 4 percent of the suburban respondents. Overall, 447 of the 1,239 survey respondents were classified as transit users. Table 1 gives the numbers and percentages of users and nonusers.

From the survey tabulations, mean household automobile ownership rates were calculated for comparison. The average for transit users was 1.2 automobiles per household; the average for nonusers was 1.9 automobiles per household. Only 4 percent of the nonuser households did not own an automobile compared to more than a third (34 percent) of transit user households. As expected, the average ownership was higher for suburban respondents (1.93) than for Atlanta respondents (1.29).

A larger percentage of transit users than nonusers live in multifamily structures. This is related to the fact that better transit service is more compatible with areas of high density. It should also be noted that the majority of transit users reside in the city of Atlanta where population and housing densities are the highest in the two counties. More than one-third (37 percent) of the transit users surveyed resided in apartments compared to 26 percent of the nonusers. The difference was even greater for single-family residences. Almost two-thirds (64 percent) of nonusers resided in single-family dwellings compared to less than half (47 percent) of transit users.

Distribution of interviewees by age group was similar to the two-county distribution of that portion of the population. Comparisons were not made for those age groups under 17 since less than 1 percent of the in-home survey respondents were under 18.

Overall, almost 35 percent of the persons interviewed in the survey were black. This proportion is slightly higher than the actual percentage for the two counties combined. Two-thirds (67 percent) of the Atlanta transit users were blacks and a little more than one-third (35 percent) of the suburban transit users. On the other hand, whites made up a disproportionate percentage of nonusers: 61 percent of the Atlanta respondents and 89 percent of the suburbanites.

Distribution of household income for the sampled dwelling units reveals significant differences between transit users and nonusers. Only one-fourth (25.1 percent) of the users reported annual incomes in excess of $10,000 compared to almost two-thirds

(62 percent) of the nonusers. The relative difference between Atlanta respondents and suburban respondents was almost as great (32 percent versus 67 percent respectively).

The proportion of respondents who did not drive a car at the time of the survey was significantly greater for transit users than for nonusers. More than 38 percent of the transit users interviewed did not drive an automobile compared to only 6 percent of the nonusers. This relative difference was greatest in Atlanta and somewhat less in the four suburban zones where larger percentages of both transit users and nonusers stated they were automobile drivers.

Nonusers were questioned on the necessity of having a personal automobile available during the day for making business trips. Of those responding, about 26 percent (or 30 percent of those respondents who were employed at the time of the survey) stated that they needed their car on the job.

All transit users were asked whether they rode the bus before the fare reduction. For all trip purposes, the proportion of prior users from Atlanta exceeded that from the suburban areas. The proportion of prior users from Atlanta ranged from about one-fourth (23 percent) for school trips to nearly three-fourths (74 percent) for shopping trips; the percentages were somewhat lower for suburban respondents. The distribution of prior bus use by trip purpose is given in Table 2.

Nonusers of transit were asked whether they had ever attempted to ride the bus for any reason. Of the 792 nonusers, 48 stated that they had ridden the bus at least once. These respondents were questioned on why they no longer used transit. The most common response was that they rode the bus out of necessity when their personal automobiles were inoperative. Most of the other responses had to do with particular circumstances rather than some unpleasant aspect of riding a bus. Three other common responses were

1. Purchased a private automobile and subsequently decided to use it for trips previously made by bus,
2. Changed personal travel characteristics (e.g., the person no longer shopped downtown), and
3. Found that bus service was not close enough to place of residence (or destination) to warrant continued use.

Based on survey results, only 55 percent of the nonusers interviewed correctly stated the regular MARTA bus fare. The remaining 45 percent either gave the wrong answer or declined to respond to the question. It is difficult to know exactly what percentage of the no-response category actually knew the correct fare. For purposes of tabulation, it was assumed that no response indicated the person had no knowledge of the reduced fare. Regardless of the exact percentage, it is evident that a significant portion of nonusers were unaware of the 15-cent bus fare at the time of the survey. This occurred despite ample publication of the fare and radio and newspaper advertising and public service announcements.

Transit nonusers perceived a lower overall quality of bus service than users did. Table 3 gives a breakdown of responses to the question, In your opinion, is the bus service good, fair, or poor? In both Atlanta and the suburban areas, the majority of transit users gave a favorable opinion of transit service. Overall, about 60 percent of the users interviewed rated bus service as good—about twice the proportion of nonusers. According to survey results, geographical location was not an important factor in comparing the responses of nonusers. The ratings for service quality by percentage of nonusers responding are as follows:

Quality	Atlanta	Suburbs
Good	48	47
Fair	42	42
Poor	10	11

Figure 1. Survey study area.

Figure 2. Regular bus service area as of March 1, 1973.

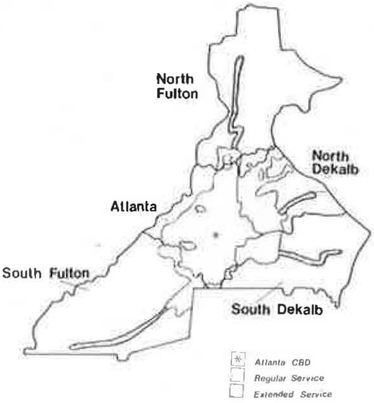


Table 1. Distribution of transit users and nonusers by geographical zone.

Area	Population		Interviews		Transit Users		Nonusers	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Atlanta	501,500	48	618	49.9	349	78.1	269	33.9
North Fulton	91,600	9	80	6.5	6	1.3	74	9.3
North Dekalb	241,300	23	256	20.7	50	11.2	206	26.0
South Dekalb	129,100	12	170	13.7	25	5.6	145	18.3
South Fulton	88,700	8	115	9.2	17	3.8	115	14.5
Two-county total	1,052,200	100	1,239	100	447	100	792	100

Table 2. Percentage of prior use of transit by trip purpose.

Prior Use of Transit	Shop		Personal Business		Social-Recreation		Work		School	
	Atlanta	Suburbs	Atlanta	Suburbs	Atlanta	Suburbs	Atlanta	Suburbs	Atlanta	Suburbs
Regular	39	25	36	25	20	18	33	27	16	14
Occasional	35	28	29	29	28	26	12	11	7	5
Never	26	47	35	46	52	56	55	62	77	81

Table 3. Perception of service quality.

Quality of Service	Atlanta		Suburbs		Total	
	Number	Percent	Number	Percent	Number	Percent
Users						
Good	216	62	52	53	268	60
Fair	110	32	31	32	141	32
Poor	15	4	7	7	22	5
No response	8	2	8	8	16	3
Total	349	100	98	100	447	100
Nonusers						
Good	92	34	153	29	245	31
Fair	81	30	138	26	219	28
Poor	19	7	35	7	54	7
No response	77	29	197	38	274	34
Total	269	100	523	100	792	100

In general, nonusers perceived transit as less convenient than users did. More than half (51 percent) of the users felt transit was either very convenient or somewhat convenient for work trips compared to less than one-third (32 percent) of the nonusers. There was an even greater difference in the perception of convenience for making shopping trips by transit; about 71 percent of the transit users indicated some level of convenience compared to 33 percent of the nonusers. Survey responses of nonusers were about the same for all trip purposes (Table 4). This indicates a tendency on the part of the nonuser to view transit as equally convenient (or inconvenient) for any type of trip. Manual editing of the survey forms confirmed this observation.

Geographical location was also an important factor in the perception of transit convenience. Transit was perceived as more convenient by Atlanta respondents than by their suburban counterparts for all trip purposes. More than half of the Atlanta respondents (51 percent) felt that transit was either very convenient or somewhat convenient for making work trips compared to 27 percent of the respondents in suburban areas. Details are given in Table 5.

The vast majority of persons surveyed felt MARTA was either valuable or necessary to Atlanta (Table 6). Favorable responses were obtained from most residents regardless of whether they used MARTA.

All persons interviewed were asked to select the most needed service improvement from a list provided by the interviewer. The 11 possible choices indicated a wide variety of improvements ranging from greater frequency of bus service to improved attitudes of bus operators. The largest segment of both users and nonusers (27 and 19 percent) felt that greater frequency of transit service was most important. Surveys of a similar nature conducted in other cities have revealed that schedule reliability is the most important service improvement. Respondents to the MARTA on-board survey ranked schedule reliability second in importance. In-home survey respondents ranked schedule reliability as less important; nonusers ranked it third and transit users ranked it fifth. Table 7 gives the ranked responses.

Perhaps the most important question directed solely to nonusers was, If bus service were improved, would you be very likely, somewhat likely, not very likely, or not at all likely to use a bus? The responses to this question are given in Table 8. The more favorable responses (very likely or somewhat likely) were chosen by 49 percent of the respondents in North Fulton and 20 percent in South Fulton. This difference is interesting in view of the fact that North and South Fulton both had the lowest perceived level of transit service convenience and the least amount of actual service at the time the survey was conducted.

Additional tabulation was generated by stratifying nonuser responses by income level. Table 9 gives a breakdown of responses by level of income, from which the following observations can be made.

1. Potentially, the greatest relative increase in ridership is from the upper middle-income ($20,000 and more) households. In this income group, 37 percent indicated some likelihood of future transit patronage if adequate improvements in service were made.

2. Higher income respondents were more likely to have a fixed, definite idea of how they would react if transit service was improved. More than one-third of the highest income group (37 percent) stated that they were either very likely or not at all likely to ride transit.

3. Lower income groups generally exhibited more indecision in their responses. Only 15 percent of the respondents whose annual household incomes were less than $5,000 stated definitely that they would or would not ride transit if service was sufficiently improved. It is interesting to note that the $5,000 and under income group accounted for 13 percent of the nonusers.

Why was the increase in ridership not even larger? What actions would be necessary to attract additional riders to transit?

Although there is no single answer to the question of why ridership was not higher, several indications can be derived from the survey results. There was the lack of le 4. Perception of sit convenience by :entage of users and users.

Degree of Convenience	Work	Shop	Personal Business	Social-Recreation	School
Users					
Very	34.0	45.6	38.9	33.3	25.5
Somewhat	17.2	25.5	23.5	19.5	11.6
Not very	9.2	8.3	8.5	7.8	8.1
Not at all	30.2	13.9	18.6	25.7	41.1
No response	9.4	6.7	10.5	13.7	13.4
Nonusers					
Very	12.9	14.0	13.5	13.5	13.1
Somewhat	18.9	19.3	19.2	18.4	17.8
Not very	18.4	18.1	17.8	18.2	17.8
Not at all	40.7	39.1	40.0	40.2	41.5
No response	9.1	9.5	9.5	9.7	9.7

le 5. Perception of ısit convenience by ȝraphical location.

Degree of Convenience	Work	Shop	Personal Business	Social-Recreation	School
Atlanta					
Very	30.6	38.5	35.1	31.4	26.9
Somewhat	20.2	24.9	23.8	21.4	14.9
Not very	13.1	12.1	12.1	12.3	12.5
Not at all	21.2	20.0	24.0	28.3	39.1
No response	4.9	4.5	5.0	6.6	6.6
Suburbs					
Very	10.5	12.4	10.3	10.0	8.4
Somewhat	16.4	18.2	17.7	16.3	16.3
Not very	17.1	16.9	16.7	16.6	16.1
Not at all	42.5	40.1	40.6	41.5	43.8
No response	13.5	12.4	14.7	15.6	15.4

ole 6. Perception of ie-necessity of transit by anta users and nonusers.

	Transit Users		Nonusers		Total	
Perception	Number	Percent	Number	Percent	Number	Percent
Valuable, necessary	442	98.8	708	89.4	1,150	92.8
Not valuable, necessary	1	0.2	45	5.7	46	3.7
No opinion	4	0.9	39	4.9	43	3.5

ole 7. Service rovement priorities.

	Users		Nonusers		Total	
Service Improvement	Rank	Percent	Rank	Percent	Rank	Percent
Seat availability	3	12	7	4	5	7
Greater frequency	1	27	1	19	1	22
Air conditioning	9	3	8	4	8	4
Bus shelters	2	16	1	13	2	14
Weekend service	4	8	10	2	7	5
Later service	8	4	9	4	9	4
Schedule reliability	5	8	3	13	3	11
Transfer efficiency	5	8	5	5	6	6
Schedule information	7	5	4	10	4	8
Park and ride	10	2	6	4	10	3
Good driver attitude	10	2	11	2	11	2
No opinion		6		21		15

ole 8. Percentage of lihood of transit ronage by geographical e.

Likelihood	Atlanta	North Fulton	North Dekalb	South Fulton	South Dekalb	Suburbs	Nonusers
Very	9.3	28.5	8.7	7.7	11.7	12.0	11.1
Somewhat	14.5	20.3	15.5	13.3	12.4	14.9	14.8
Not very	54.6	35.1	36.4	53.1	45.2	41.9	46.2
Not at all	8.6	13.5	31.1	20.4	29.7	26.2	20.2
No response	13.0	2.7	8.3	6.1	1.0	5.0	7.7

ole 9. Percentage of lihood of transit ronage by income level.

Likelihood	To $5,000	$5,000 to $10,000	$10,000 to $20,000	More Than $20,000	Total
Very	8	12	7	14	10
Somewhat	15	17	12	23	16
Not very	69	61	58	40	57
Not at all	8	10	23	23	17

knowledge of the reduced fare as demonstrated by the high percentage of respondents who did not state the regular fare when asked. This occurred in spite of the fact that the fare reduction was widely publicized before and after implementation on March 1, 1972. It is possible that, if all nonusers had been aware of the fare reduction, a portion would have used transit to take advantage of the savings.

It is possible that additional riders could be attracted to transit if there was an improvement in the perception of convenience by nonusers. As shown in Table 4, not all transit users perceived transit as very convenient or even somewhat convenient for various trip purposes. However, the general perception of transit convenience of users is significantly higher than that of nonusers, regardless of geographical location. For example, even though transit was perceived as more convenient by Atlanta respondents than by suburban respondents, transit was perceived as significantly more convenient by both Atlanta and suburban users than by their nonuser counterparts. Several comparisons of users and nonusers residing approximately the same distance from regular transit service confirmed the survey findings. Perception of transit convenience, therefore, is not solely related to proximity to regular transit service. Further analysis of individual and travel characteristics will be required to determine all the factors influencing one's perception of transit convenience. In the meantime, the MARTA in-home survey findings do point to the importance of the perception of transit convenience and the need to communicate this concept to the general public.

A significant increase in the perception of transit convenience may certainly help increase ridership, but there are limitations to this approach since about 30 percent of all nonusers stated that transit was either very convenient or somewhat convenient for various types of trips. Obviously, additional measures must be taken to encourage people to use transit, but taking steps to improve nonusers' perception of transit convenience is very important.

Several types of service improvements were ranked higher by nonusers than by transit users, and those should be carefully evaluated even though four of the top six choices were selected by both users and nonusers. Further ranking of service improvement priorities by geographical zone reveals significant differences in the perceived needs of both transit users and nonusers.

Improved park-and-ride service ranked sixth in importance for Atlanta nonusers and fifth for suburban nonusers. Users ranked park and ride least important along with driver attitude. It is interesting to note that more importance was placed on schedule reliability by nonusers than by transit users. More than 13 percent of the nonusers ranked it most important compared to 8 percent of transit users, collectively ranking third in importance after greater frequency and bus shelters. Nonusers also placed more emphasis on better schedule information than transit users did (fourth versus seventh). Responses of Atlanta nonusers were similar to those of suburban nonusers with two exceptions. More emphasis was placed on increased weekend service by nonusers in Atlanta (sixth) than by suburban nonusers (tenth). On the other hand, suburban nonusers ranked park and ride fifth, and Atlanta nonusers ranked it tenth.

Based on the ranking of service improvement priorities, there appears to be a great deal of interest in park and ride by suburbanites and nonusers. However, only 6 percent of the suburban interviewees and 4 percent of all nonusers ranked park and ride as most important.

It is evident from the survey results that geographical location, income, and other factors have a direct bearing on the perceived priority of service improvements. Implementation of service improvements should have the greatest positive impact on increased transit ridership if they are carefully tailored to the needs of the transit market.

From the survey findings, it appears that a large segment of nonusers already perceive service quality as good, although one of every three failed to state their opinion. It is interesting to note that two (somewhat different) potential transit markets were identified as a result of the transit fare reduction study. The first consists of new riders identified and described in the on-board survey who responded to the significant decrease in transit fare. About one-half of all new riders (on-board survey) stated that the sole reason they had started riding transit was the reduction in fare.

On the other hand, only a small portion (less than 5 percent) stated that they were riding transit entirely because of improvements in service. The in-home survey questions were directed more toward the service responsive market. Of the 792 nonusers who were interviewed, 205 (26 percent) stated that they were either very likely or somewhat likely to use transit if services were improved. Because much of the in-home interviewing took place after the completion of the on-board survey, it may be likely that the percentage of new riders responding solely to the fare reduction had reached its peak and future diversion of persons would relate directly to service improvements.

This service-responsive market holds the key to further gains in transit ridership in the MARTA service area. Evidence points to the fact that the significant reduction in transit fare had a short-range effect on ridership. The point has passed where the majority of new riders are attracted to transit in Atlanta on the basis of a reduced fare. Large numbers of survey respondents in both counties have indicated some likelihood of riding transit in the future if service is sufficiently improved. It is a difficult task to predict what level of service will be required to divert additional automobile drivers to transit, but any program of improvements in service should continue with the individual needs of the market in mind, particularly those of the nonusers. In addition, steps should be taken to improve communications with the residents of metropolitan Atlanta so that they may better understand the benefits associated with MARTA's transit service.

TRAVEL PATTERNS ON A NEW REGIONAL RAPID TRANSIT SYSTEM: CLUES FROM THE EARLY STAGES OF OPERATIONS ON BART

Wolfgang S. Homburger, Institute of Transportation and Traffic Engineering, University of California, Berkeley

This paper reports on some of the traffic patterns that developed on the Bay Area Rapid Transit (BART) System from November 1973 to August 1974, when only portions of the BART network were open to traffic. Data from fare gates at stations, counts on trains, transfer tickets, and highway traffic counts were compared to BART estimates made in 1971. Indications are that BART will attract far fewer short trips (less than 6 miles or 10 km) in San Francisco and Oakland than had been anticipated. Short trips in some outer areas with less surface transit and trips greater than 10 miles (16 km) long may have been underestimated. This suggests that the forecast inaccurately evaluated submodal split between rail and bus transit over short distances and may have weighted cost differentials too highly for long trips. On peak shopping days, BART attracts shoppers to downtown areas and to regional shopping centers near BART stations. BART is quite successful in attracting those who commute to industrial and commercial areas and to universities outside downtown areas who use feeder buses at their trip ends. In one corridor BART appears to have caused an increase in total transit use, partly by diverting travelers from the automobile and partly by generating new trips. When a surface transit system in BART territory ceases to operate, some additional short trips are made on BART, but there is a loss of longer trips that used feeder buses.

•THE Bay Area Rapid Transit (BART) System is the most extensive rapid transit system developed in the United States since before World War II. Twenty years in the planning and construction stages and $1.5 billion went into this first rail transit system west of Chicago. BART is the largest system to attempt a technological leap forward in automation, construction methods, fare collection, and integration with the automobile.

Although BART is still not fully operational, it is being watched with great interest in many parts of the world. Although many are interested in evaluating the technological innovations, others are asking how the public is responding to this new transportation network. Final judgments must be postponed until the complete system is operating at frequent and reliable headways, but some indications are apparent from the partial operation in 1974.

This paper briefly describes the extent of BART service as of mid-1974, some of the available data, and some of the patterns emerging in these data. It must be emphasized most strongly that during the period covered in this report operations were far below the ultimate standards of service. Therefore, relative numbers in the data and how they follow or deviate from the patterns predicted during the planning of the system, rather than absolute numbers, are of significance here.

BART IN MID-1974

Figure 1 shows the BART routes open for service before September 16, 1974, as well as those yet to be inaugurated. Opening dates were as follows:

Route	Date Opened
Fremont to Richmond	
South of MacArthur	September 11, 1972
North of MacArthur	January 29, 1973
Concord to MacArthur	May 21, 1973
Montgomery to Daly City	November 5, 1973

Each of these lines operated independently, but there was a direct transfer between the first two lines at MacArthur station. Service was scheduled at 10-min headways from before 6 a.m. to after 8 p.m. (10 p.m. between Thanksgiving and Christmas) Mondays through Fridays. There was no weekend service. Because of mechanical difficulties in some of the cars, the number of train failures per day was rather high, resulting in some irregularity in the headways. The public was aware of this and, presumably, took this factor into account.

The ultimate network, for which traffic estimates were made, involves joining the Concord-MacArthur and the Montgomery-Daly City routes into a single trans-Bay route between Concord and Daly City. This and the Fremont-Richmond routes will operate 20 hours per day, 7 days per week. Direct trains will also operate between Richmond and Daly City and between Fremont and Daly City except nights and Sundays. Typical headways at that time will be on the order of 2 minutes in the peak periods between Daly City and West Oakland and between downtown Oakland and MacArthur and 4 to 6 min elsewhere. Oakland West station was added to the network when partial trans-Bay service began on September 16, 1974. Embarcadero station, still under construction, was not in the original plans or in the original traffic estimates.

Fares charged on BART are 30 cents for the first 6 miles (9.6 km), 35 cents plus 3 cents/mile (1.6 km) for the next 19 miles (30.6 km), and 1 cent/mile beyond that distance to a maximum fare of $1.25. There are some variations to this formula. All fares are rounded to the nearest nickel. (A 10-cent surcharge is added for trans-Bay trips.)

TRAFFIC ESTIMATES

Four sets of estimates for BART patronage were made during the planning and construction stages of the system. The first figures, on the basis of which the plan was presented to the voters for approval, were developed by Parsons, Brinckerhoff, Tudor, Bechtel (1). This work, done before the days of modern modal-split techniques, used a set of diversion curves stratified to consider the difference between regional and intracity trips, between trips involving one of the major central business districts and those not originating or terminating there, and between peak and off-peak trips. In 1967 a new projection was made as a part of the federally financed Northern California Transit Demonstration Project, which actually was a planning exercise looking at the problems of coordinating BART with the two major existing local transit systems (2). Simpson and Curtin, the consultants in this project, developed a transit trip generation model based on social data and on factors describing the accessibility of analysis zones to the two CBDs by BART and by automobile. It "produced very conservative estimates of BART trips in areas not now served by an extensive transit system. For example, the estimate of daily transit trips from Central Contra Costa to San Francisco in 1975 has already been exceeded by the existing transit service" (3). (Central Contra Costa County is the area served by the Concord line from Orinda eastward.) In 1970 BART requested Wilbur Smith and Associates to prepare another projection of patronage based on previous work in estimating total Bay area travel for the California Division of Bay Toll Crossings. As described (3), this was done by a modal-split technique in which total trips were split among BART, surface transit, and automobiles on the basis of comparative out-of-pocket costs and travel times. Finally, that estimate was revised by BART staff based on the previous three efforts and the collective judgment of the staff (3). In the comparisons made in this paper, the revised estimate is used.

DATA SOURCES

Data on BART patronage and related traffic behavior are becoming available in various forms.

Passenger Trip Ends

BART passenger trip ends are recorded by the fare collection system. Each entry and exit gate has counters that record the number of passengers processed and the number of dollars "extracted" from tickets of passengers. These counters are read by station personnel at the start and end of each day's service and also at the end of the morning peak and the start and end of the evening peak. Generally these data are reliable, although some readings may be recorded incorrectly or may be postponed or skipped when station personnel have more important duties to attend to. Occasionally, a fare gate gives erroneous information because of faulty operation.

BART is in the process of installing a data acquisition system (DAS). Each exit gate now reads the station of origin on a passenger's ticket in order to extract the correct fare. The DAS will save this information so that the central computer can poll all gates at regular intervals (up to 10 or 12 times per hour) and obtain a complete origin-destination matrix of passengers who have left the system since the previous poll. The system will furnish data of much higher quality.

Passenger Surveys

BART passenger surveys were conducted in early May 1973 and in May 1974. In the latter survey, passengers entering the system between 6:30 a.m. and 1 p.m. received questionnaires, and about 25 percent of the total riders responded. However, there were substantial differences in the response rates for different times of the day and for different areas, and at the time this paper was written the necessary statistical expansion factors had only been approximated. The survey contains origin-destination, access mode, trip purpose, previous travel mode, and trip maker characteristics data.

BART Train Occupancy Counts

Train occupancy counts are costly and therefore are not made regularly. When DAS becomes operational, an algorithm will be able to compute traffic volumes on any link of the network.

Transfer Data

Transfer data reveal the use of free transfers available to BART passengers continuing their trips via a bus of the Alameda-Contra Costa Transit District (AC Transit). Transfers issued by ticket "spitters" show the station, date, and time of issue. The tickets are collected by the bus driver and then turned in to the accounting section of AC Transit still sorted by the route on which received. Inasmuch as analysis showed little, if any, misuse of transfers, the transfer data are probably quite accurate. Passengers transferring from AC Transit to BART pay the regular fare on each system. Because the transfer arrangement results in unsymmetrical use of buses toward and away from BART, the available data cannot be expanded to show the pattern for the reverse direction. (During the period covered by this report, no transfer arrangement had been inaugurated between BART and the Municipal Railway of San Francisco.)

Highway Traffic Data

The highway traffic data used in this paper were obtained by standard traffic counters that are connected to detectors embedded in the highway pavement and that record subtotals at 6-min intervals. Passenger car occupancy rates were obtained by manually recording a sample of about 30 percent of these vehicles.

The data described are the only ones used in this paper. However, large quantities of other data are being collected as part of a major BART impact project financed jointly by the California and the U.S. Departments of Transportation and administered by the regional comprehensive transportation planning agency, the Metropolitan Transportation Commission. These will include (a) extensive highway traffic data on routes paralleling BART and on some routes feeding BART stations perpendicularly, (b) travel time data on major highway routes, and (c) intensive, though limited, home-interview data as well as information on retail sales, real estate values, and noise and air pollution.

BART PATRONAGE ON A TYPICAL DAY

The average patronage observed during 4 weeks of April-May 1974 was taken to represent normal usage of the system at that time. Table 1 gives a comparison of these numbers to the predictions in the revised estimate. Because the revised estimate (3) is based on the full operating conditions described earlier, all trans-Bay trips and all trips with one end at Oakland West station were subtracted so that the data would be comparable with the 1974 counts. The revised trips in Table 1 were based on a rider survey conducted December 20, 1973. The following trans-Bay trips transferring at MacArthur station to or from AC Transit were deducted:

Station	Number
South Hayward	10
Union City	40
Fremont	105
Orinda	335
Lafayette	315
Walnut Creek	380
Pleasant Hill	515
Concord	400
Total	2,100

An energy crisis was also unanticipated. Therefore, comparisons of absolute quantities of patronage are not meaningful, but comparative patterns may be.

The numbers at individual stations are sums of passengers moving in and out of the system, and the subtotals and totals are trips; i.e., the subtotals and totals are half the sums of the sets of figures to which they refer. Because some trips in the East Bay are actually trans-Bay trips (described below), they have been subtracted from the field data. (Actual average East Bay trips were 42,118, and the actual system total was 68,566.) Comparison of the predicted and actual figures suggests several usage trends.

Figure 1. BART network.

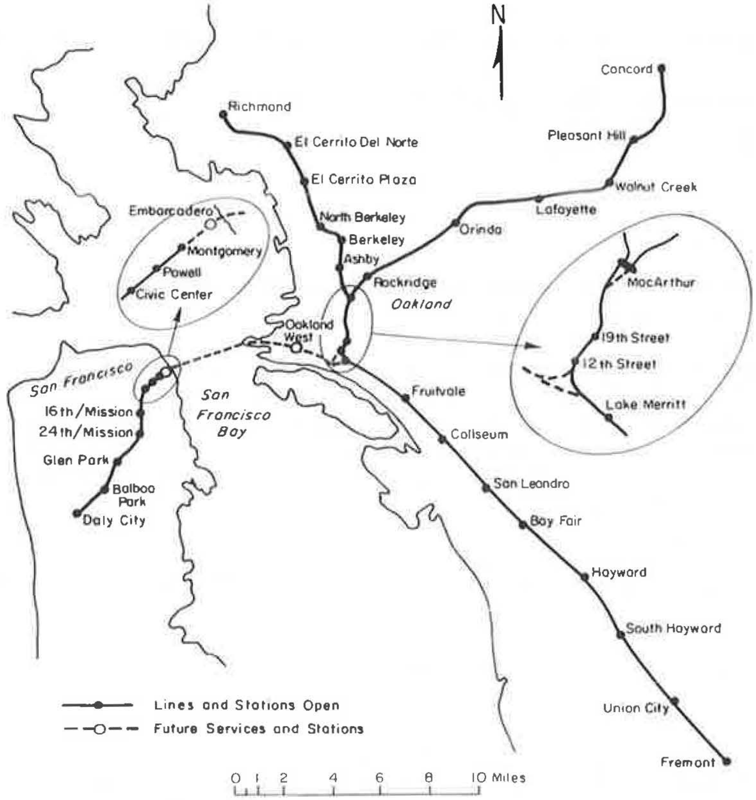


Table 1. Comparison of BART station usage in January 1974 and 1975 revised estimate.

	Daily Patronage[a]			Average Fare Paid[b]		
Station	Predicted	Actual	Actual-Predicted	Predicted	Actual	Actual-Predicted
Montgomery	26,665	15,581	0.60	0.311	0.334	1.07
Powell	11,705	8,640	0.74	0.308	0.339	1.18
Civic Center	10,726	4,553	0.42	0.308	0.320	1.04
16th/Mission	13,162	2,287	0.17	0.300	0.306	1.02
24th/Mission	11,093	3,848	0.35	0.300	0.304	1.01
Glen Park	10,127	4,758	0.47	0.300	0.302	1.01
Balboa Park	12,597	4,786	0.38	0.300	0.302	1.01
Daly City	11,465	11,753	1.03	0.342	0.349	1.02
San Francisco total	53,770	28,103	0.52	0.309	0.328	1.06
MacArthur	3,880	2,601[c]	0.67	0.385	0.546	1.42
19th Street	12,754	8,823	0.69	0.483	0.539	1.12
12th Street	13,838	6,417	0.46	0.474	0.536	1.13
Lake Merritt	8,075	2,664	0.33	0.433	0.518	1.20
Fruitvale	9,243	2,724	0.29	0.374	0.456	1.22
Coliseum	3,395	2,195	0.65	0.357	0.469	1.31
San Leandro	5,967	2,982	0.50	0.413	0.524	1.27
Bay Fair	2,451	2,681	1.09	0.476	0.521	1.09
Hayward	4,417	4,365	0.99	0.531	0.602	1.13
South Hayward	971	1,946[c]	2.00	0.640	0.630	0.98
Union City	1,737	1,813[c]	1.04	0.717	0.765	1.07
Fremont	3,840	3,422[c]	0.89	0.849	0.858	1.01
Ashby	3,796	1,473	0.39	0.369	0.445	1.21
Berkeley	7,971	8,144	1.02	0.380	0.475	1.25
North Berkeley	2,389	1,742	0.73	0.340	0.420	1.24
El Cerrito Plaza	1,812	2,508	1.38	0.345	0.400	1.16
El Cerrito Del Norte	2,282	2,964	1.30	0.380	0.417	1.10
Richmond	5,131	1,793	0.35	0.469	0.532	1.13
Rockridge	2,213	1,342	0.61	0.359	0.517	1.44
Orinda	867	1,396[c]	1.61	0.421	0.443	1.05
Lafayette	608	1,827[c]	3.00	0.571	0.547	0.96
Walnut Creek	1,049	2,675[c]	2.55	0.674	0.635	0.94
Pleasant Hill	853	2,144[c]	2.51	0.723	0.690	0.95
Concord	3,400	2,489[c]	0.73	0.898	0.817	0.91
East Bay total	51,470	36,565	0.71	0.471	0.550	1.17
System total	105,240	64,668	0.61	0.388	0.455	1.17

[a]On and off. [b]Arriving passengers. [c]Revised.

1. The average trip on BART is longer than predicted. This can be seen by analyzing East Bay data; in San Francisco, data are less conclusive because of the short route operated. The average East Bay fare was 55 cents or 8 cents above the estimate. The estimated average fare of 47 cents corresponds to a 10-mile (16-km) trip, but the actual average trip length was 12.5 miles (20 km). This is confirmed by preliminary analysis of the passenger survey data, shown in Figures 2 and 3. Because of the skew in the trip length distributions, the difference in the median trip length values is even greater, 3.5 miles (5.6 km).

2. The missing trips are mostly those that were to take place within the cities of San Francisco and Oakland. As Table 1 shows, the ratio of actual to predicted trips at all stations within 6 miles (10 km) of the two CBDs—16th/Mission, 24th/Mission, Glen Park, and Balboa Park in San Francisco and Fruitvale, Coliseum, MacArthur, Ashby, and Rockridge in the East Bay—is below the average for their side of the Bay. Conversely, those stations that exceed average system performance and, in 13 cases, the 1975 predictions, are 7 miles (11 km) from the nearest CBD. Figure 2 also shows that the actual number of trips longer than 13 miles (21 km) generally exceeded estimates for 1975. The patronage record of Daly City indicates that on the west side of the Bay, too, the longer trips are attracted to BART, but the shorter ones are not. Evidently, the automobile or surface transit or both are more competitive than the estimating procedures supposed when the access effort to BART becomes disproportionately large in relation to total door-to-door trip length. Also, for short trips the waiting time for trains operating at 10-minute headways is a deterrent. When BART reduces headways to 2 or 4 minutes, perhaps an increase in shorter trips will result.

3. In certain situations in outlying areas, the record of short trips exceeds estimates. Data from passenger surveys indicate that the patronage between Berkeley and the two El Cerrito stations exceeds the 1975 estimate by a factor of two or more. This partly accounts for the high usage of these stations and may be explained by the fact that between Berkeley and El Cerrito the BART alignment is roughly diagonal to the grid pattern of streets and bus routes, thus offering more time advantages than elsewhere.

4. The activity record at stations from Orinda to Pleasant Hill is so much above the 1975 estimate that the explanation must lie in the shortcomings of the estimate and, specifically, in the effect that the Simpson and Curtin model had on the revised estimate. On the other hand, the predicted average fares (and, hence, trip lengths) were slightly on the high side. In this area the potential for short trips was also somewhat underestimated. Activity at the Concord station is near the system average but below that of the next four stations to the west. Perhaps the tributary area for this terminal was assumed to be somewhat greater than is the case.

5. The low activity at Richmond was partly because, as of early 1974, redevelopment plans in downtown Richmond had not been implemented. It also appears possible that the estimate included patronage from the north, which, because of the location of the freeway in the area, has much easier access to El Cerrito Del Norte than to Richmond.

6. Daly City patronage exceeded both 1975 predictions and activity at adjacent stations. This is because (a) the area surrounding and beyond it is densely settled, (b) commuting by transit to San Francisco had been well established previously, and (c) it is the only station west of the Bay with parking facilities. Activity here was second only to Montgomery station in the entire system and would probably have been even higher were it not for capacity constraints in the parking facilities and approaches and inadequacy in feeder bus service.

7. Downtown stations include 19th and 12th Street stations in Oakland and Montgomery, Powell, and Civic Center stations in San Francisco. There has been relatively poor use of the Civic Center and 12th Street stations. The proximity of Civic Center to adjacent stations probably explains the low actual-predicted ratio. The revised estimate calculated that almost 5,000 trip ends per day at Civic Center station would be 2 miles (3.2 km) or less in length. These may be entirely missing because of the long BART headways and the high frequency of service on alternate surface bus and streetcar routes. The low patronage at 12th Street is attributable to the Oakland City Center Redevelopment Project, which has cleared much of the adjacent land but which

Figure 2. Comparison of estimated and actual trips.

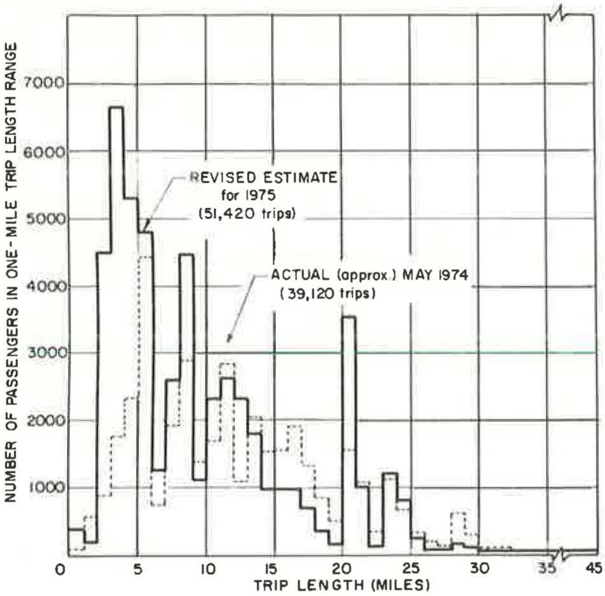
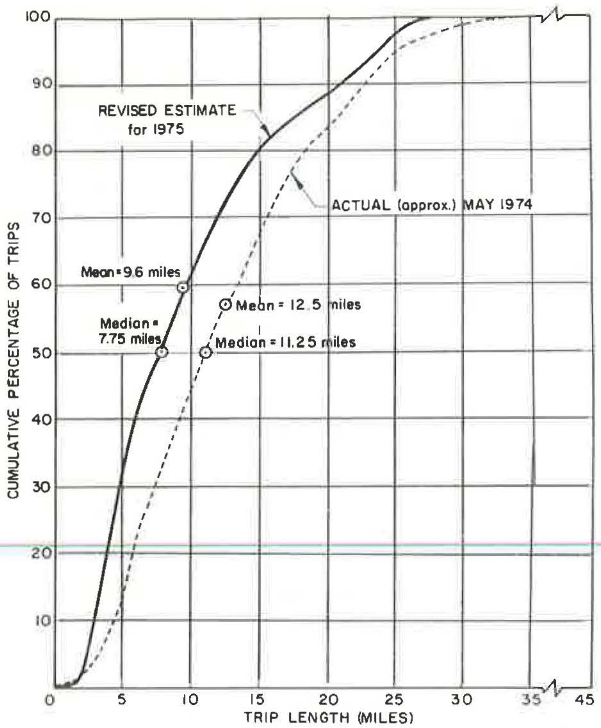


Figure 3. Comparison of estimated and actual trip length distribution.



has so far completed only one of the many buildings planned.

8. Lake Merritt station represents a borderline case, on the edge of the Oakland CBD, that was designed (with parking lots) to attract trips from residential areas in parts of the city of Alameda and around Lake Merritt in Oakland. The revised estimate matrix showed large quantities of off-peak trips between this station and points as southward as Hayward (2,815 trips versus only 1,465 trips during peak periods), suggesting the possibility of a computational error or an aberration in one or more of the estimating models.

BART PATRONAGE ON A PEAK SHOPPING DAY

Traffic on BART set a record to date on Friday, November 23, 1973. This day after Thanksgiving is the traditional start of the Christmas shopping season and a school holiday. Subtotals of morning peak-period patronage indicate that many employees were given the day off. However, these subtotals are not available for some of the major stations. Also, BART personnel were kept so busy assisting passengers that they had no time to read the fare gate counters, so it is not possible to provide exact data. Indications are that commuting was at about half the normal rate and represented only 20 percent of the day's traffic instead of a normal 55 to 60 percent; off-peak travel for shopping, sightseeing, and other purposes was about three times the normal rate.

Data for November 23 are given in Table 2, which also compares them to the normal average observed in December 1973 and to predicted patronage. Again, the revised figures refer to trans-Bay peak-hour trips transferring at MacArthur station to or from AC Transit. The deductions are as follows:

Station	Number
Fremont	50
Orinda	150
Lafayette	150
Walnut Creek	200
Pleasant Hill	250
Concord	200
	1,000

There were probably some trans-Bay trips for shopping during the off peak, but the quantity is unknown and was therefore not subtracted.

It is important to note that, except for Thanksgiving Day itself, this was the first school holiday and partial work holiday on which the Montgomery-Daly City line was open to the public. Traffic on the west side of the Bay therefore included a large number of sightseers.

The data in the table and the partial data on trips in the morning peak and the middle of the day point some interesting trends.

1. The stations closest to major shopping areas in the East Bay are 19th Street and 12th Street in downtown Oakland and Bay Fair and El Cerrito Plaza adjacent to regional shopping centers. The two downtown Oakland stations attracted about 5,000 midday passengers on this day, double the normal amount. Bay Fair had 1,550 arrivals between the morning and afternoon peaks, compared to 350 on a normal day, and El Cerrito Plaza had 1,150 compared to a normal 450.

2. In San Francisco, only a very rough guess is possible because of missing data. It may be that 16,500 persons arrived at the Montgomery and Powell stations during the off-peak period compared to 4,000 on a normal day.

3. Fremont and Concord showed the largest passenger increases in the East Bay.

Probably this represents a large group of shopping trips from residential areas beyond the BART terminals. Even though the lines involved had been open for 14 and 6 months respectively, including all summer, there may also still be a substantial sightseeing element.

4. All stations on the Concord line from Orinda outward already perform well in excess of 1975 predictions and were among those showing the highest surge on the day after Thanksgiving.

The patronage records for the remainder of the Christmas shopping season showed no such sharp increases in BART traffic. Perhaps the public was particularly concerned about parking problems in downtown and at regional shopping centers on the day after Thanksgiving. In past years newspapers have highlighted traffic congestion and parking problems on this peak shopping day.

TRANSFERS FROM BART TO AC TRANSIT

The concept of a regional rapid transit system, such as BART, assumes that many passengers will use other modes of transportation for access to and from the system. The long distance between stations decreases the probability of large proportions of the population living within walking distance of BART and, if they do not work in a CBD, working within walking distance.

One of the two major access modes is the surface transit system. Considerable study has been made of the need for feeder bus routes on both sides of the Bay (2). In the East Bay, the AC Transit system has served the area between Richmond and South Hayward since 1960 and was therefore available for coordination with BART. However, other areas of the East Bay in southern Alameda County (Union City and Fremont) and in central Contra Costa County had virtually no feeder bus service as of mid-1974.

As mentioned earlier, free transfers are issued from BART to AC Transit but not in the opposite direction. It is apparent that travel patterns are not symmetrical because of this cost difference. Some passengers who use the free transfer outbound from BART walk inbound or find automobile rides to BART stations. This lack of symmetry should be kept in mind when the data are reviewed.

A summary of all transfers from BART to AC Transit on a day in May 1974 is given in Table 3. The striking characteristic is the extensive use of transfers at the job end of home-to-work trips. If passengers changing at MacArthur station to trans-Bay buses (for which they cannot transfer) were included, the total number of transfers would be about 1,600, and the percentage of arriving passengers would be 70. Total transfers for all stations would be 8,400 and 30 percent. Systemwide, there is more use of transfers in the morning peak than in the afternoon peak. This leads to several tentative conclusions.

1. Although BART was designed primarily to transport workers to the San Francisco, Oakland, and Berkeley CBDs, it is also performing this service to major industrial and military areas west of the Fremont-Richmond route, including the Port of Oakland, and to universities.

2. The high use of transfers in the morning at MacArthur, Coliseum, San Leandro, Ashby, and Rockridge stations confirms, as noted earlier, that these stations generate relatively few trips into and out of downtown Oakland. For example, of a total of 746 arriving passengers at Rockridge, 30 percent did so between 6:30 and 9:30 a.m. and transferred to buses. Thus, trip production by residents of the Rockridge area was even less than the station activity totals suggest.

3. Characteristics mentioned in 1 and 2 above are confirmed by the percentage of all arriving passengers at each station who use transfers (Table 3). These percentages are lowest where the bus network feeding the station serves residential areas (Bay Fair, South Hayward, the two El Cerrito stations) and highest in the vicinity of industries and universities. The bus feeder system, as it operates at present, provides good links to these types of clustered employment centers but can cover only portions

Table 2. Comparison of BART station usage on the day after Thanksgiving to normal average use and predictions.

Station	Patronage on Nov. 23, 1973	Ratio: To Normal Day's Patronage	Ratio: To Predicted Patronage	Remarks
Montgomery	22,346	1.41	0.84	Morning peak arrivals off more than 25 percent
Powell	34,146	2.68	2.92	Nearest to downtown stores
Civic Center	7,592	1.52	0.71	
16th/Mission	4,225	1.41	0.32	
24th/Mission	7,633	1.58	0.69	
Glen Park	8,799	1.74	0.87	
Balboa Park	9,925	1.77	0.79	Holiday at City College
Daly City	24,038	1.83	2.10	
San Francisco totals	59,354	1.82	1.11	
MacArthur	3,333[a]	1.44	0.86	
19th Street	10,042	1.06	0.79	Morning peak arrivals off 52 percent
12th Street	6,312	0.96	0.46	Morning peak arrivals off 57 percent
Lake Merritt	4,054	1.34	0.50	
Fruitvale	3,350	1.22	0.36	Morning peak arrivals off 67 percent
Coliseum	2,679	1.24	0.79	Morning peak arrivals off 72 percent
San Leandro	2,870	0.97	0.48	Morning peak arrivals off 85 percent
Bay Fair	4,800	1.72	1.96	Adjacent to shopping center
Hayward	4,115	1.02	0.93	Holiday at Hayward State University
South Hayward	2,145	1.12	2.21	
Union City	2,379	1.30	1.37	
Fremont	8,741[a]	2.61	2.28	
Ashby	1,508	0.96	0.40	
Berkeley	6,595	0.86	0.83	Holiday at University of California
North Berkeley	2,358	1.31	0.99	
El Cerrito Plaza	4,313	1.58	2.38	Adjacent to shopping center
El Cerrito Del Norte	3,715	1.25	1.63	
Richmond	2,347	1.32	0.46	
Rockridge	1,855	1.51	0.84	
Orinda	2,463[a]	1.90	2.84	
Lafayette	2,893[a]	1.64	4.76	
Walnut Creek	5,826[a]	2.20	5.55	
Pleasant Hill	4,054[a]	2.06	4.75	
Concord	6,467[a]	2.72	1.90	
East Bay total	49,815	1.36	0.97	
System total	109,169	1.58	1.04	

[a] Revised.

Table 3. Use of transfers from BART to AC Transit.

Station	Morning Peak 6:30 to 7:30	Morning Peak 7:30 to 8:30	Morning Peak 8:30 to 9:30	Afternoon Peak 3:30 to 4:30	Afternoon Peak 4:30 to 5:30	Afternoon Peak 5:30 to 6:30	Transfers Used	Arriving Passengers	Percentage Using Transfers	Predominant Land Use Served by Feeder Buses
MacArthur	85	101	28	46	42	38	514	2,291	22.4	Industrial, medical
19th Street	47	75	28	45	73	32	468	4,153	11.3	Commercial
12th Street	180	154	59	64	58	69	970	3,108	31.2	Industrial, military, commercial
Lake Merritt	13	7	8	5	6	5	72	1,183	6.1	Mixed
Fruitvale	31	91	39	61	83	83	620	1,298	47.8	Industrial, residential
Coliseum	53	170	24	47	48	47	607	1,029	59.0	Industrial, airport
San Leandro	58	93	17	51	51	40	423	1,461	29.0	Industrial, commercial
Bay Fair	13	28	11	31	41	29	213	1,245	17.1	Residential
Hayward	89	256	160	44	45	52	992	2,075	47.8	Industrial, university
South Hayward	1	7	0	19	16	25	96	888	10.8	Residential
Ashby	30	25	13	20	17	8	158	617	25.6	Industrial, residential
Berkeley	28	56	82	89	100	116	912	3,173	28.7	Residential, university
North Berkeley	12	47	14	21	38	18	203	749	27.1	Residential, commercial
El Cerrito Plaza	9	19	7	19	42	36	202	1,168	17.3	Residential
El Cerrito Del Norte	21	17	17	30	50	27	239	1,388	17.2	Residential
Richmond	41	30	19	34	23	34	269	828	32.5	Industrial, residential
Rockridge	65	109	86	12	18	16	404	748	54.0	University, residential
Total	776	1,285	612	638	748	675	7,362	27,402	26.9	

Table 4. Change in morning peak travel from central Contra Costa County.

Time	Bus Riding Before BART: To San Francisco	Bus Riding Before BART: To East Bay	Bus Riding Before BART: Total	Transit Riding After BART: To San Francisco Via Bus	Transit Riding After BART: To San Francisco Via BART	Transit Riding After BART: To San Francisco Total	Transit Riding After BART: To East Bay via BART	Transit Riding After BART: Total
6:30 to 7:00	1,025	45	1,070	695	25	720	405	1,125
7:00 to 7:30	2,000	100	2,100	1,945	225	2,130	730	2,900
7:30 to 8:00	1,535	200	1,735	1,245	300	1,495	685	2,230
8:00 to 8:30	560	75	635	460	250	685	360	1,070
8:30 to 9:00	110	30	140	185	100	275	210	495
Total	5,230	450	5,680	4,530	900	5,305	2,390	7,820

of widespread residential areas. The automobile seems to be the preferred access mode at the home end of BART trips.

One would expect use of feeder buses to be low in downtown Oakland, since many trip ends are within walking distance of a BART station. The fairly high figure at the 12th Street station is explained by the fact that the previously mentioned land clearing there has eliminated many nearby trip generators and that bus routes to much of the Port of Oakland and to military bases in Oakland and Alameda go past this station.

CENTRAL CONTRA COSTA COUNTY CORRIDOR

Traffic on the Concord line is surprising the estimators. The line's popularity entitles it to a closer look. This route connects the center of the metropolitan area with a series of cities and unincorporated communities with more than 200,000 population. Some of the area is strictly residential and is the bedroom community for the region. In Concord and north thereof are some industrial areas. Orinda, Lafayette, and the area south of Walnut Creek are wealthy; the median family income in 1970 was $17,000 to $20,000. Families in Concord, Pleasant Hill, and Walnut Creek have incomes 10 to 30 percent above the median for BART counties as a whole, which is $11,000.

Topography confines traffic between this area and the center of the region to one freeway, which penetrates the Berkeley Hills via the Caldecott tunnels. The roads across the top of the ridge are few and inadequate. It is therefore easy to get a complete picture of traffic in this corridor. Studies made over the years have shown not only the usual increase in automobile flow but also a remarkable rise in bus riding on the Greyhound buses. This growth has been continual since 1959, when the California Public Utilities Commission required Greyhound to improve service drastically as a condition for permission to increase fares. Total patronage doubled in the 5-year period from 1959 to 1964 and doubled again by 1972. This growth has been entirely in peak-period commuting to and from San Francisco, but commuting to and from points in the Oakland-Berkeley area and during off peak has been virtually static.

The data given in Tables 4 and 5 show that BART has had a large effect on commuting from central Contra Costa to the East Bay. The before BART data were collected on a typical weekday in April 1973. The after BART data for automobile and bus traffic were collected on a typical weekday in October 1973. The total BART count was made on November 13, 1973. The breakdown for destination (to San Francisco and to East Bay) was estimated based on transfer activity at MacArthur station. Greyhound was permitted to drop all peak-hour service to and from Oakland and Berkeley. So BART presumably is transporting the 450 commuters who previously used these buses. But it has also attracted about 2,300 additional peak-period riders. If this portion of the transit market had grown since 1959 at the same rate as the demand to and from San Francisco, current bus patronage might have been just about what BART's patronage has turned out to be.

The failure of East Bay commuters to avail themselves of Greyhound service, while those working in San Francisco did so, may be due to two reasons.

1. The Bay Bridge presents an unpleasant driving experience in rush hours, which East Bay workers from the central Contra Costa County do not have to face. Parking charges in San Francisco have risen more rapidly than elsewhere.
2. East Bay work locations are more scattered than those in San Francisco, and Greyhound routes did not serve many of them. BART provides closer and much faster access to employment in industrial areas, especially in East Oakland, San Leandro, and Hayward, than did the previously available transit services.

There was a net increase of 1,600 peak-period trips. Transit riding increased by roughly 3,400 trips, and automobile person-trips dropped only about 1,800. There was a 15 percent reduction in total trips before 7:00 a.m., suggesting that the relief of congestion at the height of the peak permitted some commuters to leave home later than before BART operations started.

The growth pattern on Greyhound had pointed to a strong tendency by downtown San Francisco workers who live in this part of Contra Costa County to use transit rather than drive. On the day that the Concord line opened, about 250 commuters used BART to MacArthur station and transferred there to an existing trans-Bay AC Transit line. By the end of the third week, the number of riders had risen to 500, after 7 months there were almost 1,000, and on the first anniversary there were about 1,400. AC Transit responded to this unexpected demand by instituting shuttle service between MacArthur and San Francisco and conducted several surveys of the riders on these buses. The results of the last survey taken are given in Table 6. Cost and time data are given in Table 7. It was determined that 70 percent of the riders had switched from Greyhound, representing 13 percent of the before BART bus riders. Another 24 percent previously used automobiles, and the remaining 6 percent, who did not check either answer, may have been new riders who did not previously make this commute trip.

The survey also found some riders from southern Alameda County, a scattering of riders from other BART stations, and 50 shuttle bus riders whose origins were in the neighborhood of the MacArthur station.

Based on the number of riders originating at each of the five BART stations, the attractiveness of this trans-Bay route alternative tends to increase as total trip length and travel time savings increase (while varying inversely with savings in fare!). However, no data are available on the total number of commuters from each of these five areas, and it can therefore not be said whether proportions of riders attracted to the BART-AC Transit alternative varied in the same manner as the absolute numbers.

EFFECT OF A BUS STRIKE ON BART PATRONAGE

The AC Transit System was closed by a strike from July 1 to August 31, 1974. The effects of this on BART patronage are given in Table 8. (Differences in station activity shown as before strike in this table and in Table 1 are primarily caused by school and college vacations.)

As might be expected, BART gained passengers. However, it also lost some. The chief gain was in that part of the AC Transit service area that is most densely developed from Richmond to the southern city limits of Oakland. The percentage gain was greatest at stations near downtown Oakland and Berkeley and tapered off as distance from these centers increased. The substantial drop in average fare paid at these stations shows that the gain was in short trips and again underlines the competitive advantage of surface buses (when they are running) over BART for trips shorter than about 6 miles (10 km).

The major loss was in the trans-Bay traffic described earlier (excluded from Table 8). Other losses occurred within the AC territory south of Oakland, where development densities are low, and in areas not served by AC Transit. This patronage loss probably comprises commuters who had been using feeder buses at the work end of their trips before the strike. MacArthur, Coliseum, San Leandro, Ashby, and Rockridge presumably lost most of this traffic (although some informal car pooling between BART and work places doubtlessly took place) and gained even more patronage generated within walking distance than the figures in Table 8 indicate.

The final result of the strike was an increase of about 3,500 trips per day—6,700 added East Bay trips minus 3,200 trans-Bay trips. Total revenue per day, however, dropped; the large number of East Bay trips at an average fare of only 50 cents versus the 55 cents average in June produced only about $1,440 per day in additional revenue. The disappearance of the trans-Bay traffic caused a loss of about $2,090 per day, or a net reduction of $650 for the entire East Bay operations. The trip length distribution during these months was doubtlessly closer to the revised estimate curve in Figure 3 than the May 1974 pattern, but the average fare collected suggests that the average trip was still about 1 mile (1.6 km) longer than estimated. Hence, even the absence of the competing surface transit service did not produce the anticipated number of short trips.

Table 5. Change in person-trips from central Contra Costa County during morning peak.

Time	Person Trips Before BART: By Automobile	By Bus	Total	Person Trips After BART: By Automobile	By Bus	On BART	Total
6:30 to 7:00	5,030	1,070	6,100	4,670	695	430	5,795
7:00 to 7:30	5,480	2,100	7,580	5,270	1,945	955	8,170
7:30 to 8:00	5,110	1,735	6,845	5,220	1,245	985	7,450
8:00 to 8:30	4,550	635	5,185	4,270	460	610	5,340
8:30 to 9:00	3,060	140	3,200	3,380	185	310	3,875
Total	23,230	5,680	28,910	22,810	4,530	3,290	30,630

Table 6. Trans-Bay passengers from central Contra Costa County using BART and AC Transit via MacArthur station.

Origin	Total Passengers	Previous Mode (percent): Greyhound	Automobile	No Response
Orinda	165	68	21	11
Lafayette	160	72	21	7
Walnut Creek	190	65	28	7
Pleasant Hill	255	72	22	6
Concord	200	72	27	1
Total	970	70	24	6

Table 7. Cost and time comparisons for BART-AC Transit and Greyhound.

Origin	Cost per Ride (dollars): BART-AC	Greyhound	Estimated Travel Time (min): BART-AC	Greyhound	Headways (min): BART-AC	Greyhound
Orinda	0.80	0.83	27 to 37	29 to 32	10	1
Lafayette	1.05	0.975	32 to 42	42 to 44	10	4
Walnut Creek	1.15	1.043	36 to 46	46 to 48	10	2
Pleasant Hill	1.20	1.115	39 to 49	50 to 52	10	2
Concord	1.35	1.18	44 to 54	58 to 60	10	2

Table 8. Effect of bus strike on BART daily patronage.

Station	Before Strike: Actual	Before Strike: Revised[a]	During Strike	Changes: Actual Number	Changes: Actual Percent	Changes: Revised[a] Number	Changes: Revised[a] Percent
AC Transit territory							
Richmond	1,933		2,113	+180	+9.3		
El Cerrito Del Norte	2,897		3,110	+203	+7.0		
El Cerrito Plaza	2,625		3,297	+672	+25.6		
North Berkeley	1,616		2,625	+1,009	+62.4		
Berkeley	7,068		9,310	+2,242	+31.7		
Ashby	1,379		2,831	+1,452	+105.2		
MacArthur	5,482	2,282	3,654	-1,828	-33.4	+1,372	+60.1
19th Street	9,186		11,471	+2,285	+24.9		
12th Street	6,854		7,495	+641	+9.4		
Lake Merritt	2,430		4,094	+1,664	+68.5		
Fruitvale	2,829		4,274	+1,445	+51.1		
Coliseum	2,695		3,309	+614	+22.8		
San Leandro	3,462		3,210	-252	-7.3		
Bay Fair	3,157		3,041	-116	-3.7		
Hayward	3,745		3,148	-397	-10.6		
South Hayward	2,294	2,279	1,802	-492	-21.4	-477	-20.9
Rockridge	1,204		1,670	+466	+38.7		
Subtotal	30,339	27,124	35,322	+4,983	+16.4	+6,590	+24.3
Other East Bay areas							
Union City	2,090	2,030	1,766	-324	-15.5	-264	-13.0
Fremont	4,107	3,947	3,532	-575	-14.0	-415	-10.5
Orinda	1,913	1,403	1,437	-475	-24.8	+35	+2.5
Lafayette	2,380	1,900	1,744	-636	-26.7	-156	-8.2
Walnut Creek	3,506	2,931	2,793	-713	-20.3	-138	-4.7
Pleasant Hill	2,942	2,142	2,054	-888	-30.2	-88	-4.1
Concord	3,472	2,872	2,598	-874	-25.2	-274	-9.5
Subtotal	10,205	8,612	7,962	-2,243	-22.0	-650	-8.2
East Bay total	40,534	37,334	43,284	+2,750	+6.8	+5,950	+15.9
East Bay revenue, dollars	22,588	20,554	21,587	-1,001	-4.4	+1,033	+5.0
Average fare, cents	55.72	55.05	49.87	-5.85	-10.5	-5.18	-9.4

[a]Revised by deducting from the June counts 3,200 trans Bay trips transferring at MacArthur to or from AC Transit, based on the proportions used in Tables 1 and 2.

CONCLUSIONS

The pattern of BART trips made in mid-1974 suggests that the system will attract relatively few riders for trips shorter than 6 miles (10 km) long, but projections for the longer distance market may be exceeded. This is due to the long station spacing in the system generally and in the inner cities of Oakland and San Francisco specifically and to the competitiveness of the automobile and surface transit lines in these areas. Cost and time savings on rapid transit are minimal or negative when access to and from the nearest station becomes a major proportion of the trip. As total trip length increases, the time savings become obvious and cost savings reach substantial levels in comparison to single-occupant cars.

The public is showing a willingness to use BART for shopping trips, at least on peak shopping days when they face the possibility of parking problems in downtown areas and at shopping centers. Much of this shopping traffic seems to be generated beyond the ends of the BART lines.

BART users are also willing to use feeder buses on their way to non-CBD workplaces, such as industrial areas and universities. By comparison, patronage of feeder buses at the residential end of trips has been below expectations.

In one corridor that has a history of steady growth in bus riding well above regional patterns, BART immediately attracted riders from automobiles and from the parallel bus service and generated new trips.

When competing surface transit is removed, as happened during a bus strike, some of the shorter trips are made on the rapid transit system, but some of the long trips that depend on feeder bus lines at the work end of the trip are lost.

These trends have interesting implications for designers of future regional rapid transit systems. If the decision is made to use the same design criteria as in BART—average speed of 45 mph (70 km/h) and, hence, average station spacing of more than 2 miles (3.2 km)—the number and location of stations within 6 miles (10 km) of the CBD need careful review. They may have to be located primarily in relation to workplaces along the route or accessibility to feeder buses, provided that a sufficient market of travelers from outlying areas served by the system exists. The relationship of these stations to the homes of downtown employees would be of less importance.

Conversely, if one criterion is to connect downtown with residential areas located less than 6 miles (10 km) away and to compete with or replace surface transit, area coverage will have to be increased by providing closer station spacing and, perhaps, more routes. Within a few years, a streetcar subway will open in San Francisco and will serve the southwest part of the city with five surface routes that converge on a new tunnel immediately above the BART downtown route. This network will succeed in attracting short trips much more than will the BART line.

BART is likely to fulfill the main purpose for which it was designed—to link the San Francisco and Oakland CBDs with outlying suburbs where many downtown workers live. It, however, may not attract travelers within the inner cities. It may exceed expectations in serving industry, universities, and other dispersed employment centers. When the three patterns are added, the total performance will not be far below estimates and, with the energy crisis as an added stimulus, may actually exceed them.

ACKNOWLEDGMENTS

The author gratefully acknowledges the help of the personnel of the Bay Area Rapid Transit District, the AC Transit District, and District 4, California Department of Transportation, in furnishing data on which this report is based. The author also acknowledges the Metropolitan Transportation Commission, which provided funds for some of the data collection by the Institute of Transportation and Traffic Engineering and for computer analysis as a part of the BART impact project.

REFERENCES

1. H. D. Quinby. Traffic Distribution Forecasts—Highway and Transit. Proc., Thirteenth Annual Meeting of Institute of Traffic Engineers, Western Section, San Francisco, 1960, pp. 85-96.
2. Coordinated Transit for the San Francisco Bay Area—Now to 1975. Simpson and Curtin, 1967, Chapters 8 and 10.
3. BART Interstation Fare Schedule Report: Draft. San Francisco Bay Area Rapid Transit District, Oakland, May 18, 1971, Chapter 4.

FORECASTING DIAL-A-BUS RIDERSHIP IN SMALL URBAN AREAS

David T. Hartgen and Carol A. Keck, Planning and Research Bureau,
New York State Department of Transportation

A method is developed for estimating potential demand for innovative transit services such as dial-a-bus and park-and-ride in small urban areas and suburban communities currently lacking such services. The method assumes that the rate of usage of a particular type of service is similar for particular population groupings, regardless of their geographical location. The rate of usage is presumed to depend on factors such as age, sex, and service attributes rather than characteristics of the community under consideration. The procedure is applied in the analysis of demand for dial-a-bus service in Oneonta, New York, by using the existing system in Batavia, New York, as the base for determining actual rates of response to such a service. Results indicate that the method gives reasonable estimates of demand and demand sensitivity to policy variables such as fare and gasoline price.

•THE BASIC PROBLEM addressed in this research is as follows: Forecast the probable usage of innovative transportation services such as dial-a-bus and park-and-ride in a variety of urban and rural environments. Dial-a-bus has been used successfully in Batavia, New York, and it is important to know whether such service is applicable to other communities throughout the state. Similarly, the success of park-and-ride in suburban Rochester suggests that its application be extended to other communities. A third type of service that may be feasible is conventional transit service operating in suburban communities or isolated towns.

Three considerations from these situations bind them together.

1. Generally speaking, none of these services has been previously provided to the communities being studied. In other words, demand is being forecast in situations where extrapolation from existing service is not possible.
2. In addition, the community attitudes toward the use of such services in study locations may be significantly different from those in the locations in which such services exist. Therefore, it would be unwise to estimate demand for these services in the study communities based solely on demand experiences in existing systems.
3. Further, upward or downward revisions of the estimates of demand for these services based on the energy crisis (particularly the price of gasoline) or the cost of the service are desirable. Therefore, knowledge of the sensitivity of demand to such variables is needed.

The procedure for estimating remote park-and-ride demand has already been documented and developed (1, 2). Criteria for implementing park-and-ride service have been documented (3), and the procedures for conducting small urban area surveys to estimate demand for park-and-ride have also been detailed (4). Procedures for forecasting peripheral park-and-ride demand have also been documented recently (5).

The method described extends the previously devised method of forecasting demand for remote park-and-ride, with emphasis placed on dial-a-bus and conventional service, in communities where no such service now exists. The procedure is based on the following key assumption: Although individual preferences for modes in the test community may be different from those in communities where the service currently operates, the rate of response (by user groups) to these new modes will be the same in the test community as in the control community. In other words, if we can determine the rate of usage of the innovative service where the service exists, then this rate (adjusted for differences in service level) will be the same in other communities in which we use the methods.

Schematically, the procedure is shown in Figure 1. In the control area, the observed rate of usage (point A) for the service being operated in that community is estimated from an on-board survey. These rates are then translated to a resident base so that the rate of usage per urban resident of a given type may be estimated.

In the test area, no such rate can be determined inasmuch as the service does not exist there. However, through a survey of community residents we may obtain noncommitment rates of usage (curve B, Figure 1) at different levels of a given policy variable. This is the rate at which residents indicate they would use the service if it were implemented; actual usage, of course, is likely to be considerably less.

The true demand for the innovative service in the test area is estimated by applying the noncommitment bias ratio from the control area to the test area, based on this ratio at point A. In other words, the survey of residents in the test area provides information on the shape of the demand curve, and the survey of riders in the control area determines the height of the curve.

DETAILS OF THE METHOD

The following outlines in detail the procedure for conducting this method.

Determine Observed Response for the Innovative Service

As mentioned, this information is obtained through an on-board survey in the area with innovative service. From the on-board survey, the observed rate of ridership for the service in this control area can be estimated. Let

f = frequency of use (trips/week),
n_{ijf} = number of interviewed riders of type i who indicate they use the service f times/week for purpose j (existing policy level k),
t_{ij} = total trips made by all system riders of type i for purpose j (policy level k),
factor = expansion factor, to raise on-board sample to total on-board ridership,
N_i = number of urban area residents of type i, and
R_{ij} = rate of usage (trips/week/resident) by residents of type i, for purpose j (policy level k).

Clearly, the total number of trips per week by all system riders of type i for purpose j is

$$t_{ij} = (\text{factor}) \left[\sum_f (f)\,(n_{ijf}) \right]$$

The rate of usage for this person-purpose-policy combination is

$$R_{ij} = \frac{t_{ij}}{N_i}$$

It may be useful at this point to discuss the kinds of stratifiers (i and j) to be used. If the major stratifier (i) is a person-related attribute rather than a household-related attribute, the usage rates for the control and the test area can be calculated directly. Further, the variables chosen should efficiently partition the market by different usage rates, for trip purposes. Parallel data (i.e., N_i) should, of course, be available from the 1970 census for these urban areas by person types. Therefore, variables such as sex and age are recommended as the primary stratifiers for riders, and work-school and other are adequate for trip purpose stratification. This procedure has an additional advantage in that it permits differential factoring of the data to account for different response rates by individuals within households. One survey, for instance, turned up a very large proportion of women and elderly individuals answering the questionnaire.

Determine Noncommitment Usage of the Innovative System in the Test Area

In Figure 1, the noncommitment curve (B) is estimated for the test area. Bear in mind that this is done in reference to a specific new technology (e.g., dial-a-bus) and must be repeated for each combination of person and trip purpose. Noncommitment demand is determined by computing the noncommitment rates anticipated for this service, based on the above summary tabulations. The method is as follows. Let

n_{ijfk} = number of interviewed respondents of type i who indicated they would use the service f times/week, for purpose j (at an assumed policy level k),
t_{ijk} = total number of noncommitment trips/week, from respondents of type i for purpose j (at an assumed policy level k),
n_i = number of interviewed respondents of type i, and
R_{ijk} = noncommitment rate of use (trips/week/resident) of type i for purpose j, in response to policy level k.

The total number of noncommitment trips from the sample for combination ijk is

$$t_{ijk} = \sum_f (f)\,(n_{ijfk})$$

From the entire area, for combination ijk, one expects $(t_{ijk})(N_i/n_i)$ trips. The anticipated rate of usage per urban resident for combination ijk is

$$R_{ijk} = (t_{ijk})\left(\frac{N_i}{n_i}\right)\left(\frac{1}{N_i}\right) = \frac{t_{ijk}}{n_i}$$

Note that the computation of the noncommitment rates for the community survey is different from that for the on-board survey. This is because the on-board survey must be reduced to a resident base, but the community survey noncommitment rates are themselves a community resident base (because the community survey is a random sample of residents rather than riders).

Estimate True Demand for the Innovative Service in the Test Area

As Figure 1 shows, the procedure for estimating the true demand curve is as follows.

First the position of the observed rate of usage for the control area (A) is estimated at the present policy level. The noncommitment rate of use in the test area is expressed by B. The true demand curve for the test area (C) is then estimated by stepping

Figure 1. Demand forecasting procedure.

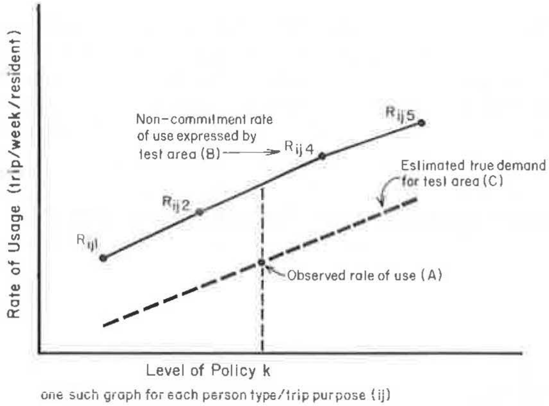


Table 1. Stratification of data from Oneonta home-interview survey.

Respondent	1970 Census Number	1970 Census Percent	1974 Sample Number	1974 Sample Percent
Male				
16 to 24	2,677	20.1	10	3.3
25 to 54	1,717	12.9	34	11.3
55 and over	1,183	8.8	42	13.9
Female				
16 to 24	4,083	30.6	15	5.0
25 to 54	1,862	14.0	105	35.7
55 and over	1,816	13.6	95	31.5
Total	13,338		301	

Table 2. Noncommitment response rates for dial-a-bus in trips per week per respondent.

Population Group	Trip Purpose	Fare Free	$0.50	$0.75	$1
Males					
16 to 24	Work	7.0	3.0	1.9	1.6
	Shop	2.0	0.6	0.2	0.1
Total		9.0	3.6	2.1	1.7
25 to 54	Work	0.8	0.5	0.3	0.2
	Shop	2.2	1.4	0.6	0.4
Total		3.0	1.9	0.9	0.6
55 and over	Work	0.6	0.4	0.2	0.2
	Shop	2.1	1.3	1.0	0.6
Total		2.7	1.7	1.2	0.8
Females					
16 to 24	Work	1.8	0.7	0.5	0.1
	Shop	3.5	1.8	1.5	1.0
Total		5.3	2.5	2.0	1.1
25 to 54	Work	1.5	1.0	0.7	0.6
	Shop	2.0	1.5	1.1	0.9
Total		3.5	2.5	1.8	1.5
55 and over	Work	0.5	0.4	0.4	0.2
	Shop	2.6	1.9	1.4	1.2
Total		3.1	2.3	1.8	1.4

Table 3. Estimated noncommitment ridership in trips per week.

Population Group	Fare $0.50	$0.75	$1
Males			
16 to 24	9,600	5,600	4,600
25 to 54	3,200	1,500	1,000
55 and over	2,000	1,400	900
Females			
16 to 24	10,100	8,100	4,500
25 to 54	4,700	3,300	2,800
55 and over	4,100	3,200	2,600
Total	33,700	23,100	16,400

Table 4. Comparison of reported and factored trips per week from Batavia on-board study.

Population Group	Reported Work	Reported Shop	Factored Work	Factored Shop
Males				
16 to 24	34	8	41.70	26.58
25 to 54	51	10	62.55	33.23
55 and over	17	3	20.85	9.97
Females				
16 to 24	207	9	253.86	29.91
25 to 54	277	38	339.71	126.28
55 and over	240	79	294.34	262.52
Total	826	147	1,013.01	488.49

down the noncommitment curve obtained in B proportional to the difference between the noncommitment and observed rates in the control area (A versus comparable point on curve B). Curves such as C are the demand curves that are used for forecasting demand in the test area. They are constructed to be sensitive to different levels of the policy variable k and therefore may be used to estimate the differential demand for service as a function of this policy.

PLANNING APPLICATION

To illustrate the procedure with a fairly detailed example, a recent study in Oneonta, New York, is discussed. Oneonta has a population of approximately 16,000 and is located in the east central portion of New York State. It is the central urban place in a predominantly rural area. The city is the home of two colleges with a combined enrollment of approximately 7,000 students. There are no large industrial employers in the area; the colleges are the city's major employers. The city currently has one bus that provides service along the main street, once per hour, between 9 a.m. and 5 p.m. The bus does not serve the college campuses. In December 1973, the city considered the possibility of instituting an improved, municipally owned and operated transit service if a significant need and demand for such service could be demonstrated. The New York State Department of Transportation was asked for assistance in determining the nature and magnitude of this demand.

Oneonta Home-Interview Survey

To assess this need, we selected a small sample (301 households) of urban residences from telephone directories. Individual responses (one per household) showed an overrepresentation of older women in the sample (primarily because of the time of day of the interviews). For analysis purposes the sample was therefore stratified into six categories (Table 1).

From the survey results, tabulations were made of total noncommitment trips (one-way) per week on a resident base. Two trip purposes (work-school and shop-other), six person categories, and four fare levels were used. This analysis was completed for dial-a-bus service. Table 2 gives the results. As expected, noncommitment rates of usage decrease as fare level increases. These rates are shown plotted versus fare for each person-purpose combination for dial-a-bus (DAB) service in Figures 2 and 3 and are represented by the Oneonta noncommitment curves.

Multiplication of these noncommitment rates by the total population in each category of user is given in Table 3. Clearly, these border on the absurd: The ridership estimated for DAB in a Batavia type of situation (50-cent fare) is 33,700 one-way trips/week, compared to 1,500 trips/week actually observed in Batavia! (Both communities are the same size!) Therefore, using noncommitment response data directly requires great care.

Batavia On-Board Survey

To estimate the probable usage of dial-a-bus in Oneonta, we used data collected from an on-board survey in Batavia. As in Figure 1, the first step in the procedure was to calculate the observed rate of use (A) for each category of rider and trip purpose in Batavia. Under the existing fare structure in Batavia, trips can be made at various fare levels; therefore, an average fare (in cents) for each rider category was calculated as follows:

Figure 2. Noncommitment and estimated actual ridership on proposed Oneonta dial-a-bus system for males (a) 16 to 24, (b) 25 to 54, and (c) 55 and over.

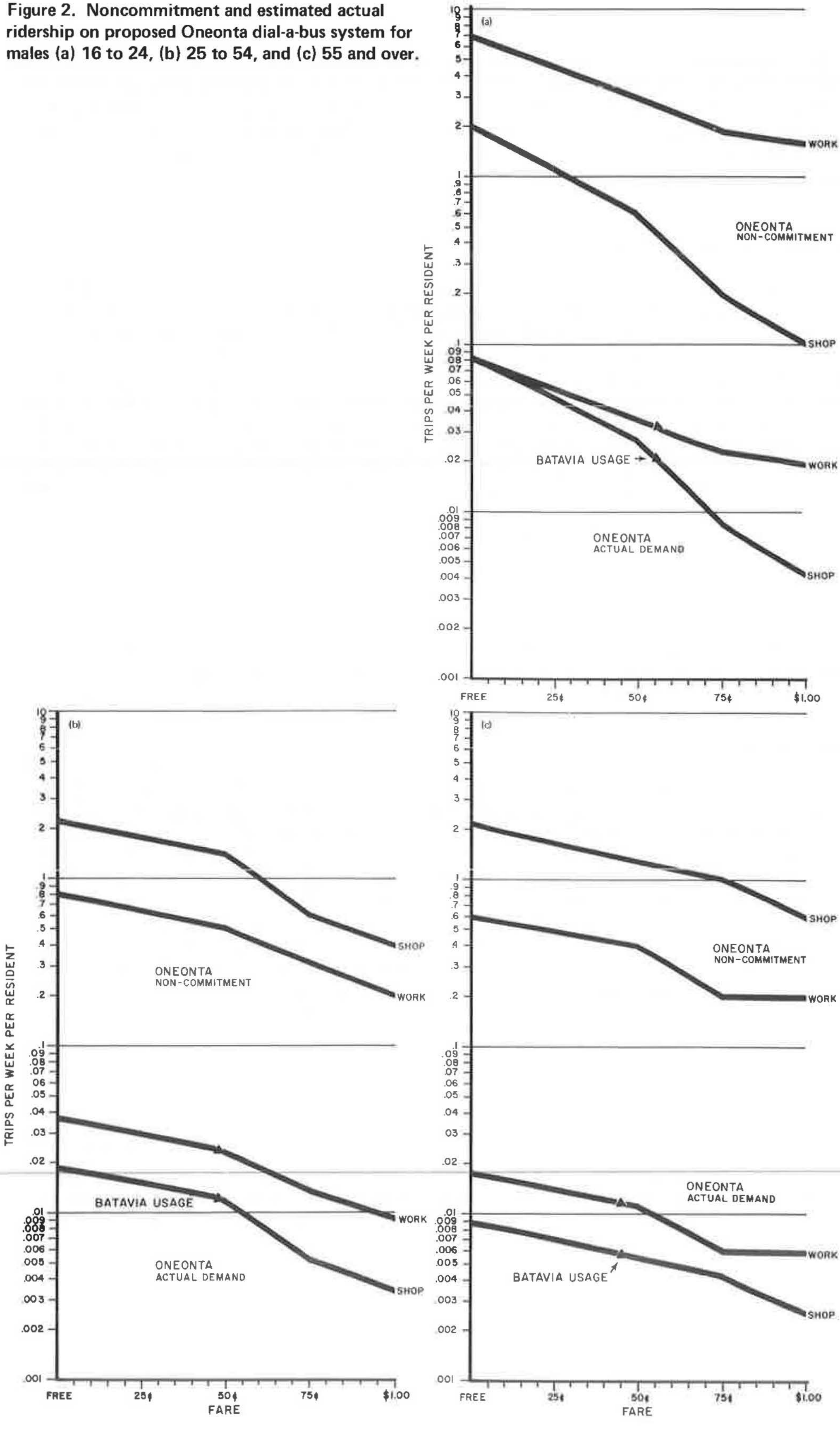
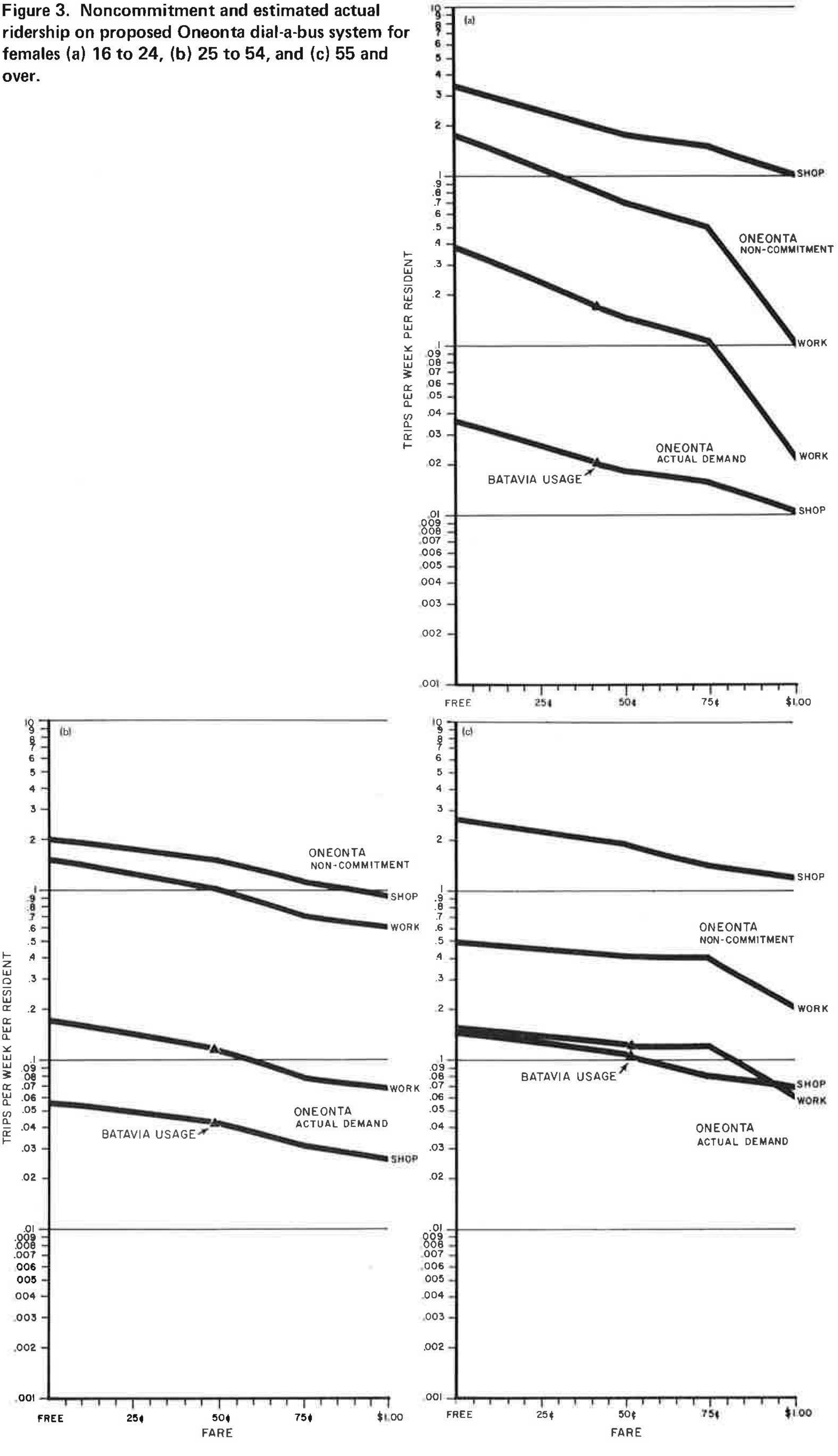


Figure 3. Noncommitment and estimated actual ridership on proposed Oneonta dial-a-bus system for females (a) 16 to 24, (b) 25 to 54, and (c) 55 and over.



Population Group	Average Fare
Males	
16 to 24	54
25 to 54	49
55 and over	45
Females	
16 to 24	42
25 to 54	49
55 and over	51

The observed trip rates of the riders of the Batavia system, then, represent trip rates at those fare levels.

The observed trip rates were calculated by using the responses obtained from the on-board survey and factoring to represent the total number of trips on the system. (Data on average weekly ridership obtained from the system operator were used for this purpose.) A comparison of the trips actually reported and the factored results is given in Table 4.

The results obtained by using the factored trips per week (TPWs) and applying them to the entire Batavia population to obtain TPW/resident are given in Table 5.

Probable Demand for Dial-a-Bus in Oneonta

These trip rates, at the average fare level for each particular population group, were then plotted (Figures 2 and 3, indicated by Batavia actual usage) and correspond to point A in Figure 1 for each population group and trip purpose. The shape of the curve is then assumed to be similar to the noncommitment response rate curve obtained from the Oneonta survey (curve B, Figure 1) with point A being one point on that curve. This resulted in the development of the Oneonta actual demand curves in Figures 2 and 3. The graphical results are given in Table 6 for the three fare levels that appeared feasible for the proposed Oneonta service.

The application of these rates to the Oneonta population resulted in the ridership estimates given in Table 7. Although these estimates appear to be reasonable when compared with the experience of Batavia, the test of their accuracy would of course be the initiation of dial-a-bus service in Oneonta.

Discussion of Results

Policy level variables are expressed in the survey design in two ways: (a) by assuming a constant fare and an increase in the price of gas and (b) by assuming a constant gasoline price and an increase in fare. In the previous example for Oneonta, the fare variable has been chosen as the policy, but the analysis may be redone with the gasoline price variable as the policy.

The questionnaire design also permits evaluation of noncommitment demand for the improved local service as well as dial-a-bus. However, an on-board survey for estimating the background demand for local service has not yet been conducted but is planned.

To date experience with the method shows that an estimate of the noncommitment demand curve can be easily obtained with a sample of 300 households in an urban area, regardless of the size of the region. Estimates of the demand for the service are made by multiplying the estimated true response rate for dial-a-bus by the number of persons in the urban area of a given type. From this data estimates could be made of the amount of revenue accruing to the system, and thereby the probable deficit the system would incur with a level of service similar to that suggested in the description as presented in the questionnaire. Significant differences in service levels proposed or implemented

Table 5. Trips per week per resident from Batavia on-board study.

Population Group	Trip Purpose Work	Shop	Population Group	Trip Purpose Work	Shop
Males			Females		
16 to 24	0.0331	0.0211	16 to 24	0.1872	0.0220
25 to 54	0.0229	0.0121	25 to 54	0.1140	0.0423
55 and over	0.0121	0.0057	55 and over	0.1224	0.1091

Table 6. Oneonta actual demand rate in trips per week per resident.

Population Group	$0.50 Fare		$0.75 Fare		$1 Fare	
	Work	Shop	Work	Shop	Work	Shop
Males						
16 to 24	0.0360	0.0253	0.0228	0.0084	0.0192	0.0042
25 to 54	0.0229	0.0120	0.0137	0.0052	0.0092	0.0034
55 and over	0.0115	0.0055	0.0058	0.0042	0.0058	0.0025
Females						
16 to 24	0.1472	0.0185	0.1052	0.0155	0.0210	0.0103
25 to 54	0.1140	0.0423	0.0798	0.0310	0.0684	0.0254
55 and over	0.1224	0.1091	0.1224	0.0804	0.0612	0.0689

Table 7. Estimated actual ridership per week.

Population Group	$0.50 Fare			$0.75 Fare			$1 Fare		
	Work	Shop	Total	Work	Shop	Total	Work	Shop	Total
Males									
16 to 24	96	68	164	61	22	83	51	11	62
25 to 54	39	21	60	24	9	33	16	6	22
55 and over	14	6	20	7	5	12	7	3	10
Females									
16 to 24	601	76	677	430	63	493	86	42	128
25 to 54	212	79	291	148	58	206	127	47	174
55 and over	222	198	420	222	146	368	111	125	236
Total	1,184	448	1,632	892	303	1,195	398	234	632

would, of course, yield different results.

SUMMARY AND CONCLUSIONS

This paper has presented a method of estimating demand for innovative transit services in small urban areas or suburban communities. The method is based on a small home-interview survey in the area of interest, and the results of a survey of users of an existing service of that type in another community. Small-sample surveys have been found sufficient for these estimates and allow the planning agency to apply this procedure with minimal cost and time expenditures.

This methodology, however, should not be considered final or not requiring further tests before its acceptance. It appears to result in reasonable estimates of patronage on an innovative system, but it is necessary to implement such a system to test the validity of these estimates.

In the meantime, transit needs of several other small urban areas are being evaluated in New York State by using this same procedure. It is hoped that the results of these analyses will present at least one opportunity to test the validity of this procedure.

The authors would appreciate comments on this methodology and information on any applications of it in areas outside of New York State.

REFERENCES

1. D. T. Hartgen. Forecasting Remote Park-and-Ride Transit Usage. New York State Department of Transportation, Preliminary Research Rept. 39, 1972.
2. D. T. Hartgen. Forecasting Demand for Improved-Quality Transit Service With Small-Sample Surveys. New York State Department of Transportation, Preliminary Research Rept. 51, 1973.
3. G. H. Tanner and R. Barba. Park-and-Ride Service: Some Guidelines and Considerations for Service Implementation. New York State Department of Transportation, Preliminary Research Rept. 44, 1973.
4. R. J. Schaefer, G. H. Tanner, and D. T. Hartgen. Surveys of Park-and-Ride Transit Demand. New York State Department of Transportation, Preliminary Research Rept. 43, 1973.
5. C. A. Keck and P. S. Liou. Forecasting Demand for Peripheral Park-and-Ride Service. Printed in this Record.

FORECASTING DEMAND FOR PERIPHERAL PARK-AND-RIDE SERVICE

Carol A. Keck and Peter S. Liou, Planning and Research Bureau, New York State Department of Transportation

A method of estimating the usage of peripheral park-and-ride services is demonstrated in this study. The purpose of such a method is to evaluate the demand potential of alternative park-and-ride service operations. The data used in this study are based on a license plate survey conducted in the two peripheral park-and-ride lots in the Albany area. Results of graphical and regression analyses in this study indicate that differences in travel time, cost, and distance for the park-and-ride mode and the alternative mode (e.g., automobiles) as well as the geographic location of the parking lot have a bearing on whether a park-and-ride service is able to attract patronage from its potential service area. An example application of the regression model is demonstrated in which the expected number of park-and-ride users from one of the service subareas of a peripheral parking lot is estimated when the Albany service is expanded from state employees only (as is now the case) to the general public.

•PARK-AND-RIDE operations, both remote and peripheral, have received increased attention in recent months because of the energy crisis, the resultant shortage of gasoline, and interest in means of decreasing the consumption of gasoline by private automobiles. Park-and-ride services offer drivers an opportunity to decrease gasoline consumption as well as many of the costs associated with regular commuting.

In suggesting a method of determining the demand for peripheral park-and-ride systems, this report provides the transportation planner and transit operator with a relatively simple means of identifying locations where these systems would have a high probability of successful operation. This report expands earlier research concerning methods of park-and-ride planning. Other papers address appropriate ridership-estimating models and procedures for remote park-and-ride facilities (1), summarize park-and-ride surveys taken to date (2), and provide guidelines for park-and-ride lot (PPL) implementation (3). Together, these documents are intended to assist transit managers, transportation planners, and public administrators in instituting successful park-and-ride operations.

PERIPHERAL VERSUS REMOTE PARK-AND-RIDE

Although the differences between remote and peripheral park-and-ride services have been detailed elsewhere (3), some of the factors that distinguish the two services are pointed out here. Both remote and peripheral park-and-ride operations provide for commuting to major activity centers via an interim parking facility and express transit service to the destinations. In remote operations, the parking areas and the point of transit origination are located relatively far (more than 3 miles or 4.8 km) from the activity center, close to a residential concentration to which the service is directed. Peripheral operations, on the other hand, are located relatively close to the activity center. Thus, remote operations are characterized by express transit service for a major portion of the commutation trip and private automobile or walking as the principal means of access. Peripheral operations rely on express transit service only for a minor portion of the commutation trip, that part closest to the activity center. The peripheral parking lot acts as a collector for commuters from a wide area, permitting them to board the transit system for a short portion of their trip, usually the most congested.

DEMAND FORECASTING METHOD FOR PERIPHERAL PARK-AND-RIDE SERVICES

The development of a patronage-estimating procedure for the remote situation (1) assumes that time difference is a significant factor in a person's decision to use the park-and-ride facility, and, in fact, the likelihood that a person will patronize the system can be predicted from the amount of time that a person will save (or lose) by using the park-and-ride service.

Peripheral park-and-ride services, however, are viewed as offering other incentives, including decreased commuting costs (lower or no parking fees). Thus the following assumptions are made for this study:

1. Some combination of time and cost factors is the basis for the decision to use peripheral park-and-ride services rather than other modes, and
2. The service area for a peripheral park-and-ride system is in the shape of a cone whose point is located at the parking lot site and whose boundaries are determined by the existing highway arterial system.

The following analysis reports on these two facets of peripheral park-and-ride services by using observations made in the Albany area. Although the data appear to support the above assumptions, preliminary attempts to define a mathematical model to describe the precise relationships between the measured variables have proved to be successful only in providing general guidelines for the planner or transit operator interested in instituting such services. Although the analysis presented is useful in determining whether a particular peripheral park-and-ride site should be considered, it is not sufficiently accurate to estimate precise usage. It may be used to evaluate several proposed park-and-ride sites in a given area, from a relative standpoint. It is hoped that further research will expand on this base to provide those methodologies.

DATA SOURCE AND DESCRIPTION

Peripheral Park-and-Ride System in Albany

The peripheral park-and-ride system operated for state employees in the Albany-Schenectady-Troy area by the New York State Office of General Services was chosen for analysis. The study was begun and data were collected in July 1973.

Peripheral park-and-ride service to the downtown-South Mall area of Albany is provided in two areas: the Washington Avenue site, located to the north and west of the South Mall near New York State Thruway Exit 24 and the McCarty Avenue site near Exit 23. Persons using the service may enter these lots, park their automobiles (or disembark from a vehicle that then leaves the parking area, i.e., kiss-and-ride), and board a transit vehicle or suburban type of bus, which then travels nonstop to the destination area (downtown Albany). The charge for this service is $5 per month per vehicle. No additional charge is levied for vehicles carrying more than one person. There is no additional fare charged for using the bus service. During the peak hours buses leave the parking areas, or downtown-South Mall boarding areas, every 5 to 7 min; during off-peak hours the headways are a minimum of 40 min. The lots offer a combined capacity of 1,900 vehicles—1,200 at the Washington Avenue facility and 700 at McCarty Avenue.

The local transit system, operated by the Capital District Transportation Authority, provides no regular service to either parking lot area, although the park-and-ride buses from the McCarty Avenue location are owned and operated by the authority under contract with the state. A one-way fare on the authority's regular route system at the time of this study was 35 cents; to use the system daily for a month from these same general areas to the downtown-South Mall area averages $14. Persons traveling on routes from the Schenectady or Troy areas to downtown Albany paid twice this amount under the then-current fare structure.

Parking facilities in the destination area served (downtown-South Mall) are severely limited. Twenty-two parking areas controlled or operated by the Office of General Services (OGS) provide parking for approximately 1,900 vehicles of state employees at $5 or $10 per month. Private parking facilities charge from $15 to $40 per month.

Alternatives to this system are metered parking on both major and minor streets in the area and parking in restricted areas with its consequent hazards. All of these alternatives are not open to the average driver, however, since the OGS-controlled lots have limited capacities and long waiting lists for those spaces that do become available. The situation at the private facilities is similar although not so severe. In summary, it has been estimated that, in 1972, there was a shortage of some 6,600 legal parking spaces in the downtown-South Mall area. This deficiency was apparently being made up by illegal parking, parking outside the downtown area (4), and the park-and-ride system analyzed.

This park-and-ride system is unique in at least two important respects.

1. It is provided by the state as a convenience for state employees. (Compare the $5 monthly charge for park-and-ride service with a minimum $14 monthly fare on the regular route system.)
2. It is available only to state employees who work in those areas where parking facilities are severely restricted, in large part because of state actions (construction of the South Mall complex).

Both of these points should be kept in mind throughout this study and in any application of the principles developed here to other situations.

Zip Code Areas

The Capital District area was divided by zip code for the purpose of analysis. The area considered was within approximately a 30-mile (48-km) radius of Albany and consisted of 41 zip code areas. A comprehensive map of the zip code area boundaries was found to be lacking, so an approximation was constructed from a series of locally published maps containing this information (5).

Zip code areas were selected for analysis because the information about both the user and eligible populations already contained zip code data and required no further coding or distribution on other geographical bases. Although using zip code areas simplified data collection, in this case, there is nothing in the analysis to suggest that zip areas are better or worse than any other geographical base that could be used, if comparable data could be obtained.

Eligible User Population

The population of persons eligible to use the peripheral park-and-ride system studied consists of state employees whose principal work location is the downtown-South Mall area of Albany. A listing of all persons employed by the state in this area was obtained from payroll records of the State Department of Audit and Control. Approximately 50 percent of these state employees had listed a home zip code. The residential distribution of these persons is assumed to be random; consequently, a factor of 2 was applied uniformly to give an estimate of the total population of eligible users.

Actual Peripheral Park-and-Ride Users

The zip codes of actual users of the peripheral park-and-ride system were obtained from the State Department of Motor Vehicles on the basis of a license plate survey conducted on July 10, 1973, at both the Washington and McCarty Avenue lots. Of the 830 user plates recorded on that day, 117 could not be matched to a local zip code from Department of Motor Vehicles records. This can be accounted for by various reasons:

1. New registrations between time of license plate survey and the actual computer match,
2. Recent local residence by out-of-state persons and by persons from other parts of the state who had not yet changed their vehicle registrations,
3. Incorrect listing of numbers by surveyors, or
4. Inaccurate keypunching.

Table 1 gives the number of eligible and actual users of each lot, by zip code.

METHOD OF ANALYSIS

It is assumed that all the park-and-ride users residing in the same zip code zone originate their daily work trips from a single point. This point is chosen on the basis of the population distribution within the zone and is usually the center of the population density.

A person residing in any zone can either drive her or his car directly to the downtown-South Mall area or drive to one of the peripheral parking lots, park her or his car, and then use the shuttle bus to her or his destination. It is felt, however, that the extent of the park-and-ride system usage of each zone is largely determined by the convenience and savings in travel time or travel cost or both by using the park-and-ride service instead of driving directly to the destination area from that zone. It is therefore of interest to determine how the changes or differences in travel time and cost, along with the location of the lot with respect to the trip origin and destination, affect travelers' decisions on whether to use the peripheral parking services.

The extent of the park-and-ride system usage is represented in this study by the percentage of the eligible population in each zip code zone that uses the peripheral park-and-ride system. Travel time and cost figures associated with traveling between any of the origin zones and the jobsite by the two available modes are computed on the basis of the distances of the various trip segments. (Traveling by bus is also a possible mode. However, because bus-user trips constitute only 2 percent of the total work trips in the Albany-Schenectady-Troy area, they are not considered in this study.) The proportion of park-and-ride usage from each zone is plotted against the savings (or loss) in total travel time (ΔTT), total travel cost (ΔTC), or total air distance (ΔAD) resulting from using the park-and-ride instead of driving an automobile. In addition, simple linear regression models are estimated based on these variables.

Travel Time and Cost Elements

For an automobile trip, the entire trip consists of walking to the car at trip origin, driving the car from trip origin to CBD, finding a parking space and parking the car, and finally walking to the trip destination (jobsite). A park-and-ride trip, on the other hand, is composed of walking to the car at trip origin, driving from trip origin to the PPL, parking the car, waiting for the bus, and riding the bus to the destination. The cost elements associated with each method of travel are as follows:

Mode	Cost
Park-and-ride	Automobile operation to PPL Service fee
Automobile	Automobile operation to activity center Parking fee

Level-of-Service Variables

The definitions and specifications of the various time, cost, and distance variables are discussed below.

Automobile Air Distance

The straight-line distance between a given zonal trip origin and the automobile trip destination (e.g., PPL for park-and-ride user and downtown-South Mall area for automobile driver). The actual driving distances are obtained by factoring the automobile air distance by an index of 1.2 to account for over-the-road distance.

Walk Time to Car

A uniform 1 min is assigned as the time it takes a traveler to walk from her or his home to where her or his car is parked.

Automobile In-Vehicle Time

The time spent in an automobile is estimated on the basis of the average automobile speeds. Three speed rings are assigned in this study according to the extent to which expressway driving and local street driving are mixed. Those travelers who do not have to drive more than 4.8 miles (7.7 km) whether or not they use park-and-ride service are assigned an average automobile speed of 18 mph (29 km/h). This is because an automobile trip of 4.8 miles or less generally involves a high degree of local street driving.

The choice of the 4-mile (6.4-km) ring is based on the geographic size of the Capital District urbanized area. In the second case, where the travelers' driving distance is between 4.8 and 21 miles (7.7 and 34 km), the travel routes usually consist of equal portions of expressway and local street driving. Therefore, an average automobile speed of 25 mph (40 km/h) is assigned. In the third case, in which the travelers have to drive more than 21 miles (34 km), the travel routes are predominantly expressway, and an average speed of 35 mph (56 km/h) is assigned.

Automobile Operating Cost

The automobile operating cost is assumed to be 6 cents/mile (1.6 km). This figure approximates what travelers actually perceive as the cost to run the car and does not include insurance, depreciation, or the cost of purchasing the car.

Automobile Out-of-Vehicle Time at CBD

A total of 15 min is assigned as the time required of the automobile driver at the terminal end of the trip. This includes the time the traveler spends looking for the parking space and parking the car, plus the time spent walking from parking space to the jobsite.

Automobile Parking Cost at Activity Center

The average daily parking cost is assumed to be 60 cents, and therefore the parking cost for the morning trip is 30 cents. The cost figure considers the fact that some people park their cars on the street at little or no cost (risking the chance of receiving a traffic ticket) and some others pay as much as $40 per month to park in a garage.

Park-and-Ride Service Time

This element includes the time the park-and-ride user spends at the PPL parking the car and waiting for the shuttle bus, plus the bus in-vehicle time to the jobsite. A park-and-ride service time of 16 min is assigned to those travelers who use the Washington Avenue PPL and 20 min to those who use the McCarty Avenue PPL. These figures are based on the shuttle bus schedules and bus running times.

Park-and-Ride Service Cost

Based on a $5/month fee, park-and-ride users are charged a fee of 12.5 cents per trip.

Graphical Results

Figure 1 shows the percentage of park-and-ride users plotted against the level-of-service differences between the automobile and park-and-ride modes. The difference in total travel time is ΔTT. The figure indicates, as expected, that, the longer it takes to use the park-and-ride mode as compared to using the automobile mode, the lower the proportion of park-and-ride users will be. Also, for eight out of the 10 zones that show more than 20 percent park-and-ride usage, there is a slight time saving by using the park-and-ride mode. Another interesting observation is that the Washington Avenue PPL service provides travelers from more than half of its service zones a time saving of as much as 10 min; the McCarty Avenue PPL service generally does not provide its users any travel time saving. This is probably one of the reasons that the average zonal share of park-and-ride users is 15.0 percent for the former and only 5.0 percent for the latter.

A graph of the percentage of park-and-ride users versus the difference in total travel cost (ΔTC) is shown in Figure 2. This figure also indicates that as ΔTC increases the proportion of park-and-ride users decreases. However, it should be noted that, with the exception of one zone (Rensselaer) that has only 2 percent park-and-ride usage, none of the other zones shows any park-and-ride usage when the cost of the park-and-ride mode equals that of the automobile mode. Furthermore, zonal park-and-ride usage of more than 20 percent occurs only when the cost saving is relatively large, on the order of 35 cents per trip. Comparison of Figures 1 and 2 shows that travelers are relatively sensitive to the savings of time but relatively insensitive to that of cost. In Figure 1, park-and-ride usage increases when this mode offers a time saving of around 5 min. On the other hand, Figure 2 shows that park-and-ride usage increases when a cost saving of approximately 35 cents is offered by that mode. This appears to imply a travel time value of 7 cents/min (or $4.20/hour). This is of course a rough estimate. Again, however, the Washington Avenue lot appears to be more attractive than the McCarty Avenue lot in that the former offers users a larger cost saving than the latter.

The percentage of park-and-ride users versus the difference in the total air distance (ΔAD) is shown in Figure 3. In general, the straight-line distance is longer for a driver who goes to the downtown-South Mall area via the park-and-ride route than for one who drives there directly. However, an interesting point is that, for seven of the 10 zones that have greater than 20 percent park-and-ride usage, there is virtually no

Figure 1. Proportion of park-and-ride mode usage versus travel time difference.

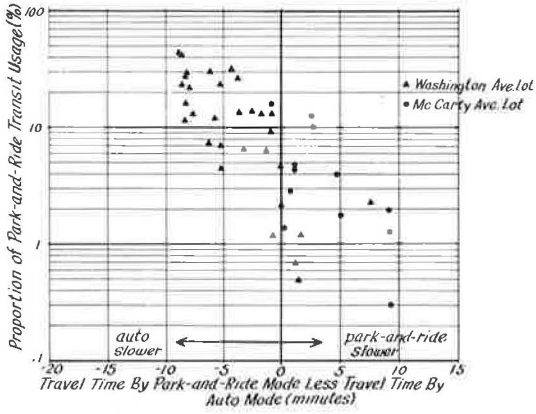


Table 1. PPL users and those eligible for PPL usage.

Zip Code	Number of Users	Number of Eligibles	Users as Percentage of Eligibles
Washington Avenue area			
12009	11	82	13.4
12010	16	52	30.8
12019	5	36	13.9
12020	9	28	32.1
12047	14	316	6.5
12054	6	506	1.2
12065	17	222	7.6
12084	8	36	22.2
12110	23	350	6.6
12118	19	72	26.4
12144	5	218	2.3
12159	7	50	14.0
12180	7	1,274	0.5
12182	5	226	2.2
12186	7	30	23.3
12188	5	54	9.2
12189	7	148	4.7
12203	56	1,248	4.5
12205	68	944	7.2
12206	9	716	1.2
12208	9	1,236	0.7
12211	16	120	13.3
12302	19	142	13.4
12303	36	128	28.1
12304	27	116	23.3
12305	7	16	43.8
12306	44	104	42.3
12307	7	42	16.7
12308	8	68	11.8
12309	27	92	29.3
12866	12	98	12.2
Total	526	8,770	
McCarty Avenue area			
12051	3	24	12.5
12054	20	506	4.0
12077	9	56	16.1
12143	6	128	4.7
12144	4	218	1.8
12158	4	88	4.5
12161	3	4	75.0
12180	4	1,274	0.3
12182	3	226	1.3
12186	3	30	10.0
12189	3	148	2.0
12202	8	576	1.4
12209	17	590	2.9
12414	4	0	—
Total	91	3,868	

Figure 2. Proportion of park-and-ride mode usage versus travel cost difference.

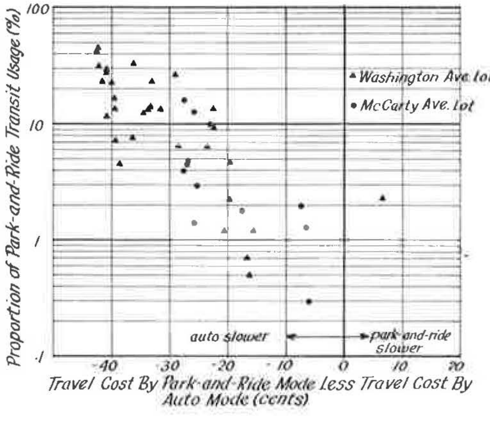
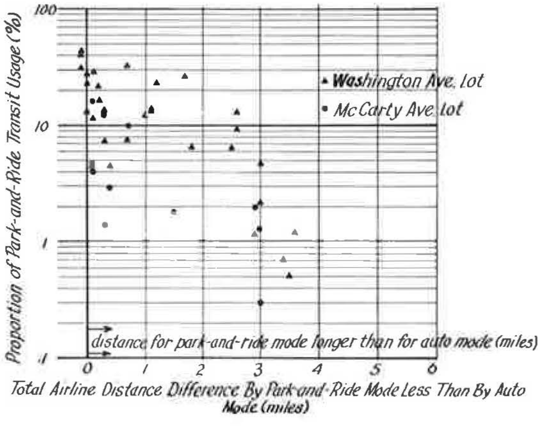


Figure 3. Proportion of park-and-ride mode usage versus total air distance difference.



difference (i.e., no greater than 0.2 mile or 0.3 km) in air distance between the two modes. For the remaining three zones, although there is some difference in total air distance, the best (or most likely) travel routes for those travelers who reside in these zones actually go past the Washington Avenue PPL. In fact, the Washington Avenue lot is located in the vicinity of the Northway Expressway as well as the several major arterials in the area. Consequently, the observation can be made that a peripheral parking lot is likely to attract more patronage if it is geographically located such that (a) the trip origin, the peripheral parking lot, and the trip destination, in that order, remain on a relatively straight line; or (b) the peripheral parking lot is situated along the most likely travel routes linking the trip origin and the trip destination. Furthermore, the average air distance between trip origin and destination for the 10 zones with the highest park-and-ride usage is 15.6 miles (25 km). This suggests that PPLs attract people who live far from their trip destinations.

A comparison of the means (averages) of the various transportation attributes for the two lots and the zones indicating the highest percentage of users, as well as their corresponding park-and-ride modal share, is given in Table 2. Although this is a highly simplistic presentation of how the various transportation attributes affect park-and-ride usage, it does demonstrate the necessary ingredients required for successful peripheral park-and-ride service. That is, the service must provide possible savings in time and considerable saving in cost, and most importantly the parking lot must be ideally located.

Regression Analysis

An attempt was made to develop a linear model so that the share of the park-and-ride usage is represented as a function of the difference or ratio of travel time-cost for the park-and-ride mode and the automobile mode. The method of estimation employed is the stepwise regression. The models are calculated based on the set of data associated with the Washington Avenue PPL because, based on the findings of the graphical analysis in this study, that PPL is clearly superior to the McCarty Avenue PPL. The service subareas of the Washington Avenue PPL are shown in Figure 4. The proportions of park-and-ride usage for these service subareas are given in Table 3. It is felt that development of a good model must be based on a successful peripheral park-and-ride service.

As discussed previously, the values of the travel cost and travel time variables in this study are derived from the same basic information, the air distance. The high correlation that this introduces between the two explanatory variables makes it implausible to include both of them in the same model. In fact, the resulting models either have incorrect model parameters or are statistically unacceptable.

On the other hand, it is evident that the traveler's decision on whether to use the park-and-ride mode is influenced by the savings (or loss) in both travel time and travel cost. Therefore, a combined cost figure that is the sum of the travel cost and the monetary value of the travel time is used as the independent variable. Travel time information is converted to its equivalent cost figure by assuming a value of time of \$4.20/hour (or 7 cents/min). This particular value of time is based on the value of time implied by the time and cost graphs in Figures 1 and 2. The model is shown below.

$$\text{Percentage of park-and-ride usage} = 3.082 - 0.209(\Delta CC)$$

where CC = combined cost of park-and-ride mode minus combined cost by automobile mode (for most cases ΔCC is negative).

This model indicates that only 3 percent of park-and-ride usage can be expected when the combined costs of traveling by the two modes are the same. In other words, to attract peripheral park-and-ride service patronage, the service must offer a considerable savings in the combined travel cost. Statistically, both the combined cost

Table 2. Comparison of attribute means.

Market Segment	Number of Zones	$\overline{\Delta TT}$	$\overline{\Delta TC}$	$\overline{\Delta AD}$	$\overline{P\text{-}R}$ (percent)
Top 10[a]	10	-7.0	-38.8	0.4	30.2
Washington Avenue PPL	31	-3.8	-30.1	-1.9	15.0
McCarty Avenue PPL	12	3.8	-20.6	1.0	5.1
Total	43	-1.7	-27.4	-1.5	12.2

[a]Zones that register more than 20 percent park-and-ride usage.

Figure 4. Washington Avenue parking lot service subareas.

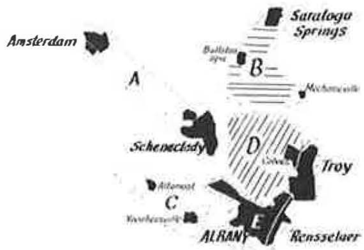


Table 3. Usage of Washington Avenue PPL by service subarea.

Subarea	Eligible Users	Observed Users	Proportion of Usage (percent)
A	708	175	24.7
B	234	45	19.2
C	198	33	16.7
D	2,006	143	7.1
E	5,572	104	1.9
Total	8,718	500	5.7

Table 4. Comparison of patronage from Washington Avenue PPL service subarea A.

Patrons	Actual Expected Users	Eligible Users	Proportion of Usage (percent)
State employees only	175	708	24.7
Public			
$5/month	400	1,814	22.1
$10/month	353	1,814	19.5
$15/month	306	1,814	16.9

variable coefficient and the model as a whole are significant at greater than the 99 percent confidence level. The standard error is 0.43. However, the estimated residue measurement (R^2) is only 0.45, which is quite low. This means that the combined cost, although a necessary factor, is not fully sufficient to explain park-and-ride usage. (Income, for example, is not included in the analysis.) Nevertheless, this model does provide some general indications of the patronage that a certain peripheral park-and-ride facility may expect from its potential service market. This type of knowledge is especially helpful for transportation planners and transit service operators during the preliminary stages of a proposed park-and-ride service study.

PLANNING APPLICATION

The regression model obtained in this study may be applied to a variety of PPL planning situations. In particular, it enables transportation planners to address issues such as the number of people who are expected to use the park-and-ride service if a PPL is placed at a certain location or the changes in the park-and-ride usage corresponding to changes in certain operating policies, e.g., service fee, service market segment, and shuttle bus operating frequencies.

As discussed previously, the two peripheral parking lots in Albany only serve state employees who work in the downtown-South Mall offices. One of the questions a transit operator may want to ask is, How many people will use the park-and-ride service if the service is available to the public? As a simplified example, the park-and-ride patronage from one of the major service subareas of the Washington Avenue PPL (area A in Figure 4) will be estimated for the situation in which the park-and-ride service is available to the public.

Two items of information are needed to estimate park-and-ride usage in this case by applying the regression model. The first item is the difference of the combined cost between the two modes. This information may be obtained, as discussed earlier, by converting the air distances of the various trip segments into the differences in travel cost-travel time and combining these variables into a single combined cost variable by assuming a travel time value of $4.20/hour.

The second item of information is the total number of eligible users in the area under consideration. It may be recalled that state employees who work in downtown-South Mall offices are the only eligible users for the existing park-and-ride facilities. However, if the facility is open to the public, then all persons who work in downtown Albany become potential customers of the service. The number of persons from each census tract who work in the Albany CBD is generally available from 1970 census data.

The proportion of park-and-ride usage from each census tract is calculated at park-and-ride service rates of $5, $10, and $15 per month. The attributes of the various rates are reflected in the regression model in values of the combined cost variable. For instance, at the rate of $5 per month the park-and-ride service cost is 12.5 cents per trip. On the other hand, at the rate of $10 per month the service cost per trip is 25 cents per trip, 12.5 cents per trip more than the previous rate; therefore, the total combined cost is also increased by 12.5 cents per trip. This, of course, results in a decrease in the proportion of park-and-ride usage.

Although many of the tracts have up to 24 percent of park-and-ride usage, the expected number of persons who will use the park-and-ride service is limited because of the low number of persons from those tracts who work in the Albany CBD. On the other hand, some other tracts that have a usage share of only 18 percent produce considerably more park-and-ride users. This is because there are a large number of potential (or eligible) users from these tracts.

A comparison of the number of park-and-ride service users from subarea A, when the service is limited to state employees and when it is available to the public at service rates, is given in Table 4 (the Amsterdam figures are not included).

A total of 670 persons from the town and city of Amsterdam, which has a proportion of 20.81 percent usage, work in the city of Albany. However, it is not known how many of these persons work in the Albany CBD. If we assume that those who work in Albany city actually work in the CBD area, a maximum of 139 persons from Amsterdam would be expected to use the Washington Avenue PPL. Clearly, this is not a proper assumption. One method of estimation is to use the proportion of CBD workers to the total city workers obtained from other subareas. For instance, the proportions for other subareas range from 15 percent in Rotterdam to 40 percent in Scotia. Evidently, there is no clear-cut value that can confidently be assumed. However, the number of park-and-ride users expected from Amsterdam can be approximated most probably between 21 to 56 as follows:

Item	Value
Park-and-ride usage, percent	20.81
Number working in Albany	670
Proportion of CBD workers	
100 percent	139
15 percent	21
40 percent	56

It should be noted that the characteristics of labor force and employment distributions are different in different localities. Therefore, planners must take great care in choosing proper estimates of these proportion values so that they are consistent with local situations.

CONCLUSIONS

Results of the graphic and regression analyses of the two peripheral park-and-ride services operated in the Albany area lead to the following conclusions.

1. Peripheral park-and-ride service tends to have a greater rate of patronage from travelers who live fairly far from their jobsites.
2. Users of these lots appear relatively sensitive to savings in time but relatively insensitive to cost differentials between park-and-ride and automobile modes.
3. More patronage can be attracted to a particular park-and-ride lot if the trip origin, the parking lot, and the trip destination, in that order, lie on a relatively straight line. This supports the intuitive view that the service area of a peripheral parking lot is a cone-shaped area with its tip located at the parking lot.
4. For areas that fall outside of the cone-shaped area, more patronage can be attracted if the parking lot is situated along the most likely travel route linking trip origin and destination.
5. Park-and-ride service must offer travelers time or cost savings if it is to receive sufficient patronage.

The purpose of this study was to obtain some quantitative knowledge on the most relevant attributes that influence usage of a peripheral park-and-ride service. It was not intended, however, that a universal formula be developed that could be directly applied to any situation. It should be stressed that the emphasis of this study was to provide overall guidelines for preliminary selection of alternative park-and-ride service lots. In particular, attempts to forecast the number of persons who might use a peripheral system solely on the basis of the above regression analysis are discouraged. A study specifically dealing with the demand estimations of this type of transit service has recently become available (5). As mentioned earlier, the combined cost variable is an important attribute but not the only one that influences the traveler's mode choice decision. Information on the traveler's income or automobile ownership and information on other members of the family working at other locations but sharing the same car would have been desirable.

Still, the regression model, along with the guidelines mentioned previously, can provide adequate indications of the potential attractiveness of proposed peripheral park-and-ride services or facilities. This is especially useful during the preliminary stages of a planning study when usually a number of alternative parking lot sites and alternative operating policies are involved.

Future research should try to determine what other factors, beside time and cost, affect the traveler's decision to use or not use a peripheral service. Interviews or surveys of persons using peripheral park-and-ride services can provide insight into their common characteristics, behavioral patterns, or attitudinal configurations. Information of this type may then provide the basis for a model capable of accurately predicting peripheral park-and-ride usage for given areas. It is hoped that this research will provide the basis for such a study.

ACKNOWLEDGMENTS

The authors are indebted to the New York State Departments of Motor Vehicles and Audit and Control and the Office of General Services for their cooperation in the data collection phase of this work; to the staff of the Basic Research Unit whose comments and time are greatly appreciated; and to Lisa Cannistraci for the typing of this report. The authors are solely responsible for errors of fact or opinion.

REFERENCES

1. D. T. Hartgen. Forecasting Remote Park-and-Ride Transit Usage. New York State Department of Transportation, Preliminary Research Rept. 39, 1972.
2. G. H. Tanner and R. Barba. Park-and-Ride Transit Service: Some Guidelines and Considerations for Service Implementation. New York State Department of Transportation, Preliminary Research Rept. 44, 1973.

3. R. J. Schaefer, G. H. Tanner, and D. T. Hartgen. Surveys of Park-and-Ride Transit Demand. New York State Department of Transportation, Preliminary Research Rept. 43, 1973.
4. A Study of the Proposed Albany Peripheral Parking System. New York State Department of Transportation, 1973.
5. P. S. Liou. Comparative Demand Estimation Models for Peripheral Park-and-Ride Service. New York State Department of Transportation, Preliminary Research Rept. 71, 1974.

PUBLIC POLICY AND TRANSIT SERVICES FOR HANDICAPPED PERSONS

John B. Schnell and Philip H. Braum, American Public Transit Association

Because of increased awareness of the need for transportation for that segment of society whose mobility is limited, there have been increased efforts to establish the funding mechanisms, the management structures, and the operational equipment for such transportation service. However, these attempts, well intended as they are, sometimes have produced less than optimal results because of a lack of (a) knowledge of appropriate solutions to the problems involved, (b) cooperative effort among agencies in some areas, and (c) overall policy direction. This paper discusses efforts being made to overcome these deficiencies. To determine levels of activity in the transit industry, the American Public Transit Association (formerly the American Transit Association) surveyed its transit-operating members for details of all types of specialized services they are providing, not only the demand-responsive services that actually provide mobility but also educational programs teaching handicapped persons how to use transit, research into needs of handicapped persons on a local or statewide basis, and cooperative arrangements with other organizations to serve the needs of the handicapped. The information resulting from the study is viewed partly as a means to assist operators in establishing or expanding their specialized services by providing examples of successful efforts already under way. Perhaps more important, this information should be valuable as an input to the formulation of a comprehensive national policy to better define the appropriate programs for transit operators. Results of this survey are discussed. Also included are details of nontransit and paratransit activities in providing mobility and how the different forms of transportation have been successfully used in different areas. The relationship of these activities to the establishment of policy and regulations by various levels of government is viewed as a crucial factor.

•MOBILITY allows those with physical disabilities to participate more fully in life. Because our patterns of land use and activity location spatially separate residences from places of employment, shopping, schools, and medical facilities, it is necessary that there be a means of movement among those locations for handicapped persons. The dispersion of activities is of course the product of automobile use, but many of those with physical disabilities are unable to drive. To enable this group to participate in normal activities, some form of public transportation service specifically designed to accommodate those whose mobility is limited is a necessity.

To provide useful transportation services for elderly and handicapped persons requires that a number of interrelated specific issues be resolved.

1. What is the appropriate organizational structure? Should service be provided by a transit operator, one or more mission-oriented social service agencies, a separate organization, or a combination of these?
2. How should the specialized service be integrated with existing transportation services? Should handicapped persons be carried on existing vehicles and routes, should a separate service be provided, or should a combination of both types of service be implemented?
3. What effect will new services have on existing transportation systems? If sepa-

rate specialized operations are implemented, will existing transit lose any of its ridership through shifts of elderly and minimally handicapped persons to the new mode?

4. For whom should service be provided? Should every person, regardless of the nature and permanence of the handicap, be accommodated?

5. How great is the need? How many people with what types of handicaps want to travel, where do they wish to go, and when?

6. What is the value of these services? Although the goal of providing specialized service is worthwhile, how much of our resources are we as a society willing and able to invest in the equipment and manpower necessary to achieve the goal?

7. How and by whom should specialized services be funded? How much public funding should be used, and what levels of government should provide it? How much of the financial burden should elderly and handicapped individuals be forced to bear?

Studies have been carried out on these topics. Some knowledge does exist, but the research has not yet provided comprehensive answers to these questions. In response to the need for specialized services, in many areas it has been necessary to establish some specific type of service when no guidance existed on what was the best overall approach.

ATMOSPHERE AND BACKGROUND IN PUBLIC TRANSIT

Traditionally, few services for the handicapped have been offered by transit operators. In most localities, existing service was established by social service organizations for each organization's constituencies or clients. Although some of these organizations have done well with the limited resources available to them, this situation has produced limited service with little or no coordination with other means of transportation.

There are a number of reasons for the lack of activity on the part of the transit industry. Perhaps the most direct constraint has been various economic factors.

Providing specialized services for elderly and handicapped persons is an expensive undertaking. Incorporating nonstandard equipment such as wheelchair lifts or redesigned systems of passenger restraints and assists into new or existing vehicles increases both the capital cost and the maintenance cost for the more complicated equipment. In some instances, personnel who drive the vehicles must be specially trained to assist the handicapped. And, because in most areas the residences of the handicapped are as widely dispersed as those of any other population subgroup, not many individuals can be served by a particular trip, which means that a small number of persons must share the cost of making that vehicle trip.

Development of the public transit industry has been strongly rooted in the tradition of free enterprise. Currently, only 18 percent of the transit operations in this country are publicly owned, even though 85 percent of transit users are carried on publicly owned systems. However, the private operators can only operate services that allow their total package of services to be financially successful. Any services offered by these companies for the elderly and handicapped must therefore either be subsidized by state or local funds, be under contract with a social service organization, or pass on the cost of the service to riders, which may not be feasible or desirable.

Publicly owned transit operations are, of course, also subject to stringent fiscal limitations. Although these operations have access to public money, including local, state, and federal funds, the amounts of money available are less than adequate for the services that these operators are called on to provide. Establishing specialized services to assist those with mobility limitations adds a further financial burden to those already existing.

Another constraint is the degree to which specialized operating equipment can be integrated into normal transit operations. Attempts to accommodate persons with any disability other than minor ones on the same vehicles as nonhandicapped transit riders create conflicts. Vehicles carrying those with more severe handicaps must stop longer to allow adequate time for safe access and egress and provide adequate time for the handicapped to move to and from seats before the vehicle moves. These vehicles must also have special seating or wheelchair positions for those who require them. This reduces the quality of service to nonhandicapped riders by reducing the average speed of the service and reducing seating capacity. At the same time, this service might not be optimal for handicapped riders. To prevent serious reduction in operating speed, handicapped persons must board and find seats as expeditiously as possible, which presents a safety hazard to those who are not able to move rapidly. And, unless entire fleets of vehicles were equipped with the necessary specialized equipment—a monumental task considering that currently more than 60,000 transit vehicles are owned in the United States—a handicapped person would have no assurance that the particular vehicle for a given trip would have the capability of accommodating her or him.

The most subtle of the constraints, and therefore the most difficult to deal with, are the attitudes and values of those whose decisions affect transit operations. This group includes not only transit management but also public officials at all levels of government and even the voters who must approve bond issues to support major programs. Although these attitudes are changing as more people realize the need for special transport and nontransport services for those with physical disabilities, this change in attitude has been gradual.

Finally, there has been a lack of direction in the field. Because of the historic lack of awareness of the need for special services for the handicapped, little has been done to systematically define the extent of that need, determine its character and distribution across specific subgroups of the handicapped, ascertain what types of services can be most helpful to handicapped persons, and design the most successful means of implementing those services, in terms of both institutional arrangements and operational equipment.

TRANSIT QUESTIONNAIRE

In spite of the many difficulties that transit operators face in attempting to institute such services, many operators are taking concrete actions to aid handicapped persons. To determine the extent and types of services being offered, a questionnaire was sent to the transit operators of the American Public Transit Association (APTA) on September 3, 1974. The purposes of the questionnaire were to

1. Determine the present level of activity by transit operators in providing transportation services and assistance to elderly and handicapped persons.
2. Provide suggestions for the transit industry on "how to do it" and other basic reference data on types of transportation services being supplied to elderly and handicapped persons.

This questionnaire (Figure 1) asked the operators whether they participate in providing various types of assistance to elderly and handicapped persons and, if so, to supply details on the characteristics and success (or lack thereof) of their efforts.

A summary of the responses to questions 5 through 12 is given in Table 1, and a list of the responding transit systems is given in Table 2.

The response to the questionnaire was quite good. A total of 89 transit systems responded, and many detailed useful and innovative programs. Many of the systems that do not have such programs indicated an awareness of the need for some type of service and requested a summary of the responses to the questionnaire as a guide to the types of efforts that have been successful in other areas.

No attempt has been made to determine statistical data from the survey results. Rather, the responses to the questionnaire were viewed individually to determine which contained information that would be useful to other transit operators in designing their own programs.

Figure 1. APTA questionnaire regarding transit accessibility for the elderly and the handicapped.

1. Name of transit system____________________________________

2. Name of person completing this questionnaire____________________

3. Date____________________________________

4. Population within transit service area________________________

5. Do you know of any studies made within your service area or state to identify the agencies and groups who are presently supplying some forms of transportation assistance to elderly and handicapped persons?

   Yes______ No______ Please name the study and its source__________

6. Have you ever loaned your transit vehicles to agencies of the blind to enable their instructors and blind pupils to learn how to board transit vehicles, find seats and to exit safetly, - in the privacy of the training school for the blind? Yes _____ No ______ Please name the blind agency ______________________________ and enclose a brief description of the training program, how often it is conducted and how many blind persons are aided.____________________

7. Have you ever loaned your transit vehicles to agencies for crippled children, cerebral palsy, Easter Seal Rehabilitation Clinic or others to enable their instructors and pupils to learn how to overcome their handicaps and to board transit vehicles, find seats and to exit safely, - in the privacy of their training school or hospital? Yes______ No_______ Please name the agency______________________________

   and enclose a brief description of the training program, how often it is conducted, how many handicapped persons are aided and any other relevant data and measures of acceptance and success of the program__________

8. Do you offer a reduced fare program for senior citizens? Yes_____ No______. Please describe the amount of reduction in fare, the hours of the day, and days of the week when the reduction is in effect, and the number of riders who have taken advantage of the program__________

9. If there is a Model Cities program in your operating area, does that program sponsor any specialized transit services provided by your organization for elderly and/or handicapped persons? Yes______ No______ If so, please describe that service__________________________

10. If there is a council of organizations in your metropolitan area which is concerned with the needs of elderly and handicapped persons, does your organization participate in that council, and if so, to what extent?

11. Do you provide any other transit services which are specifically designed for the use of elderly and/or handicapped persons, such as a demand responsive service with specially equipped vehicles? Yes _______ No________ Please provide details as to the types of vehicles used, geographic extent of service, cost to users, limitations as to who may use the system, etc.

12. Do you operate a demand responsive system which, although not specifically designed for elderly and handicapped persons, can provide them with some mobility due to the individualized nature of the service? Yes______ No_______ Describe the operation and any features which make it especially useful for elderly and handicapped persons.__________________________

Table 1. Positive responses to APTA questionnaire.

Code	Question 4	5	6	7	9	10	11	12
1	265,000					X		
2	1,300,000					X	X	
3	200,000					X		
5	3,200,000	X			X	X		X
6	3,866,000					X		
7	80,000	X				X		
11	500,000	X						
12	428,000	X				X	X	
14	750,000			X		X		
15	1,046,000	X		X	X			
16	1,051,000					X		
18	363,000	X		X		X		
19	360,000					X		X
20	100,000	X						
21	2,500,000	X						
22	150,000	X			X	X		
23	140,000					X		
24	120,000						X	
27	400,000	X			X	X		
29	1,400,000	X				X	X	
30	225,000				X			
32	47,000			X			X	
33	165,000	X		X		X	X	
35	120,000	X						
36	322,000				X	X		
37	500,000	X	X	X				
40	160,000	X				X		
41		X				X	X	
42	975,000			X				
43		X				X		
44	132,000	X				X		
46	250,000			X		X	X	
47	384,000	X				X		
48	2,713,000	X						
49	900,000					X		X
50	3,963,000		X	X		X		
51	1,200,000	X						
52	1,500,000	X				X		
53	35,000				X			
54	1,023,000	X			X	X		
55	393,000		X			X		
56	8,000,000	X	X			X		
57	538,000					X		
58	350,000		X			X		X
59	7,000,000		X		X			X
60	435,000					X		
61	275,000		X			X		
62	540,000	X		X			X	
63	1,574,000					X	X	
65	162,000							X
66	31,000	X				X	X	
67	216,000			X				
68	73,000					X		
69	658,000	X			X	X		
70	1,700,000		X	X		X		X
71	200,000		X	X				
72	1,115,000		X	X	X	X	X	
73	751,000	X			X	X		
74	1,044,000		X	X				
75	916,000	X		X		X		
78	500,000	X	X	X	X	X	X	
79	100,000	X				X		
80	140,000	X				X	X	X
82	721,000	X		X	X			
83	2,157,000	X	X			X		X
85	80,000						X	
88	–				X	X	X	X

Table 2. Responding transit systems.

Code Number	Transit System
1	Wichita Metropolitan Transit Authority
2	Kansas City Area Transportation Authority, Kansas
3	Madison Metro, Wisconsin
5	Southeastern Michigan Transportation Authority, Detroit
6	Southeastern Pennsylvania Transportation Authority, Philadelphia
7	Santa Rosa County, California
11	Lehigh and Northampton Transportation Authority, Allentown, Pennsylvania
12	Palm Beach County Transportation Authority, West Palm Beach
14	San Antonio Transit System
15	New Orleans Public Service, Inc.
16	Central Ohio Transit Authority, Columbus
18	METRO Regional Transit Authority, Akron, Ohio
19	South Coast Area Transit, Santa Ana, California
20	Tri-State Transit Authority, Huntington, West Virginia
21	San Francisco Bay Area Rapid Transit
22	Duke Power Co., Greensboro
23	Amarillo Transit System
24	City Utilities, Springfield, Missouri
27	City of Tucson Transit System
29	Metropolitan Dade County Transit Authority, Miami
30	Luzerne County Transportation Authority, Wilkes-Barre, Pennsylvania
32	Iowa City Transit
33	Lane Transit District, Eugene, Oregon
35	Regional Transit System, Gainesville, Florida
36	Mass Transportation Authority, Flint, Michigan
37	Phoenix Transit
40	Kanawha Valley Regional Transportation Authority, Charleston, West Virginia
41	Tennessee Department of Transportation
42	Milwaukee and Suburban Transport Corporation
43	Port Authority Trans-Hudson Corporation, New York
44	Topeka Metropolitan Transit Authority
46	Fort Wayne Public Transportation Corporation
47	Central Pinellas Transit Authority, Clearwater, Florida
48	Washington Metropolitan Area Transit Authority
49	Dallas Transit System
50	Chicago Transit Authority
51	Regional Transportation District, Denver
52	Mass Transit Administration of Maryland, Baltimore
53	Bremerton Municipal Transit, Washington
54	Metropolitan Atlanta Rapid Transit Authority
55	City Transit Service of Fort Worth
56	Southern California Rapid Transit District, Los Angeles
57	Jacksonville Transportation Authority
58	Metropolitan Tulsa Transit Authority
59	Transport of New Jersey, Maplewood
60	Calgary Transit, Alberta, Canada
61	Greater Richmond Transit Co., Virginia
62	Metro Area Transit, Omaha
63	City of Detroit Department of Transportation
65	Augusta Coach Co., Georgia
66	Rome Transit Department, Georgia
67	Columbus Transit System, Georgia
68	Cities Transit Co., Albany, Georgia
69	City and County of Honolulu
70	Orange County Transit District, Santa Ana, California
71	Savannah Transit Authority
72	Municipality of Metropolitan Seattle Metro Transit
73	Southwest Ohio Regional Transit Authority, Cincinnati
74	Niagara Frontier Transit Metro System, Inc., Buffalo
75	Tri-Met, Portland, Oregon
78	CNY CENTRO, Syracuse
79	Brevard Transportation Authority, Melbourne, Florida
80	Ann Arbor Transit Authority
82	Capitol District Transportation Authority, Albany
83	Toronto Transit Commission, Canada
85	Fitchburg and Leominster Railway Co., Fitchburg, Massachusetts
88	St. Petersburg Transit

Studies on Transportation for the Elderly and the Handicapped

The questionnaire asked whether the management of the transit operator knew of any studies of the existing transportation situation of elderly and handicapped persons in its own area. Thirty-three responded that they did have such studies; three more stated that a study was being prepared. Several agencies enclosed copies of their studies. The most extensive of these was a thorough study carried out by the Lane Transit District in Eugene, Oregon. Other reports received included a study of the transit strategy teams established by the Florida Department of Transportation to assist transportation disadvantaged, a study of reduced fares for senior citizens in Baltimore by the Mass Transit Administration of Maryland, and an analysis of low fares for the elderly in the state of Illinois.

Training Handicapped Persons to Use Transit

Many handicapped persons have difficulty in boarding and exiting transit vehicles and in moving about while inside. To determine what opportunities transit operators are providing for those with handicaps to learn how to use transit with a minimum of discomfort and risk, the respondents were asked whether they had lent vehicles either to agencies for the blind or to agencies dealing with other types of handicapped people, such as Easter Seal societies or clinics.

Twelve operators responded that they had lent vehicles to agencies for the blind for training purposes. The agencies were allowed to use the vehicles at their facilities so that the teaching could take place in familiar surroundings. Two more responded that they make buses available to groups of blind people at the bus storage area, and one indicated that groups of blind persons are not charged a fare when they use regular transit service for educational purposes. The Toronto Transit Commission has cooperated with the Canadian National Institute for the Blind by providing subway orientation tours.

Eighteen operators stated that they had lent their vehicles to other agencies for the handicapped for training purposes; two more provide vehicles at their own facilities for handicapped groups who wish to use them. As an example of how deeply involved some of the operators are, Metro Area Transit in Omaha provides assistance to the J. P. Lord School, the Eastern Nebraska Commission on Retardation, the Westside YMCA, and the Omaha school system. The program consists of instruction to teachers on how to train children to use a bus and then, at a later time, provision of a bus so that the children can practice what they have learned. This takes place 3 or 4 days per week for 3 weeks at each location, on an annual basis. Approximately 300 persons are assisted annually. Other successful programs of this type are operated by the Fort Wayne Public Transportation Corporation, the Niagara Frontier Transit System in Buffalo, the Tri-Met system in Portland, Oregon, and others.

Going even further, the Southeastern Pennsylvania Transportation Authority has donated an inoperative bus to the Widener School in Philadelphia, and New Orleans Public Service, Inc., cut a bus in half and placed it at the Crippled Children's Hospital for educational purposes.

Model Cities Programs for Increased Mobility

The Model Cities Program was developed as a means to allow cities to rehabilitate their worst areas through the efforts of the citizens of those areas. Inasmuch as transport is one of the key elements in the viability of an urban area, many Model Cities efforts have included improvements in mobility for area residents, especially those with either physical or economic restraints on their ability to travel. And in many instances, transit operators have been active in providing that mobility. For example, the Tucson Transit System provides regular transit services to Model Cities area residents on scheduled routes plus a special door-to-door service for low-income and handicapped persons. In Atlanta, MARTA operates the Model City Shuttle, which provides feeder service to regular transit routes, and on weekends an express service to a hospital, which is routed to provide increased accessibility for elderly citizens.

Communications With Interest Groups

The question on the survey form that received the largest number of positive responses was whether the transit operator participates in any local organizations that are concerned with the needs of the elderly and handicapped. Forty-six operators indicated that they are involved in such activities. This seems to indicate that many operators are aware of the need for increased specialized services, even though they may be unable to do much because of economic constraints.

Specialized Transit Services

Perhaps the most beneficial service that a transit operator can offer is a specialized service designed especially for elderly and handicapped persons. Normally, such services operate on a demand-responsive basis, offering door-through-door or at least door-to-door mobility. This type of service offers immediate benefits to elderly and handicapped persons in that it provides individualized mobility to those who have an intense need for that mobility.

Of the transit systems responding, a total of 15 have systems designed for the use of elderly and handicapped persons, and seven more such systems are in the planning or implementation process.

Because each service has been developed in response to local needs and to conform to local capabilities, the types of services offered vary greatly. In Ann Arbor, Michigan, the demand-responsive service is provided as a part of a general dial-a-ride system. One vehicle of the fleet is specially equipped with a wheelchair lift. Operation of the service as a part of a larger dial-a-ride system provides advantages, in that more sophisticated operational techniques may be used. For example, a rider need call only 2 hours before he or she wishes to ride instead of the 24 hours required in some other systems. A separate telephone number is maintained exclusively for use by handicapped patrons to ensure that they are able to contact the vehicle dispatcher. Service is offered to all areas in the city, but priority is given to trips to health care facilities and employment locations.

The Omaha Metro Area Transit operates a service that covers two counties and that is under contract to the Eastern Nebraska Community Office on Aging. The service uses three vans, and three more are being purchased. Some of these are equipped to accommodate wheelchairs. Criteria for determining who may use the service include age, income, and degree of immobility. Users are asked to contribute on an ability-to-pay basis.

Thirteen large vans are operated by St. Petersburg Transit in Florida. These vans are modified with extrahigh doors, lowered steps, and wheelchair lifts. Service is offered over a 13-mile^2 (33-km^2) area for anyone who is handicapped or more than 60 years old.

Some other transit systems operate demand-responsive systems that have not incorporated any specialized equipment but that can offer mobility to those with less severe handicaps because of the door-to-door character of the service. Ten operators reported operating a system of this nature. Examples are the system operated by South Coast Transit in Orange County, California, and the Haddonfield, New Jersey, Dial-A-Ride.

Conclusions

The information produced from the questionnaire does not represent the entire transit industry, since only APTA members were included and not all who received the questionnaire completed it. However, it does provide useful insights into the present level of activity. Many transit operators are providing vital services; many others have not been able to do so. The most heartening note is that so many are aware of the need for improvements in this area and are eager for guidance in how best to proceed.

UMTA'S PROPOSED RULE MAKING

Formulation of public policy has been a very difficult task. Although some steps have been taken to assist those with mobility limitation, the transit industry has not taken the lead in suggesting positive levels of service to be provided for handicapped persons. As private enterprises, some transit systems could not provide such services out of the fare box. Publicly owned transit authorities have not been able to undertake such services on an extensive basis because of the extraordinary costs involved.

UMTA changed all that in November 1974 by announcing public meetings on the preliminary rule making for transit regulations for the elderly and handicapped. This was the first step toward providing a long-term policy for the nation. Comments made at these public meetings and written materials submitted to UMTA provide a basis for determining the feelings of the affected groups. APTA offered its assistance in the form of a thorough and comprehensive supply of technical data and detailed requirements for such a regulation.

The next steps will include another announcement of a proposed final rule making and probably additional public hearings.

UMTA's task is not easy, and UMTA will receive few compliments from any interest groups. Doubtless, some representative of agencies for the elderly and handicapped will feel that UMTA is not moving fast enough to provide total accessibility and mobility to handicapped and elderly persons. Conversely, state departments of transportation, municipalities, and transit authorities may feel that UMTA is moving too fast without providing an indication of how the necessary funding for this additional accessibility and mobility will be accomplished. It is to UMTA's credit that this difficult project is being forcefully tackled and it behooves all interest groups to cooperate in providing rational, practical input to expedite the determination of feasible regulations.

APTA's response to the proposed UMTA regulations includes a great deal of data concerning the technical requirements for accessibility in fixed-guideway facilities as well as bus transportation facilities, and additional sections of the response refer to the details of accessibility for fixed-guideway vehicles and buses. Some of the details addressed are

1. Accessibility,
2. Lighting,
3. Entrances and exits,
4. Interior handrails and stanchions,
5. Floors and steps,
6. Priority seating,
7. Destination route signs,
8. Fare boxes, and
9. Public address systems.

The more difficult problem areas relate to

1. The coordination of all sources of transportation for elderly and handicapped persons,
2. Levels of service for elderly and handicapped persons, and
3. Funding.

Coordination of Transportation Services for the Elderly and Handicapped

Some studies made by the San Francisco Bay Area, Metropolitan Transportation Commission, state departments of transportation, and UMTA indicate from 200 to 600 individual sources of transportation for elderly and handicapped persons within some major metropolitan regions. Some of these services may be only a station wagon that the local Easter Seal Society or children's hospital uses to transport its patients. In other areas private sources such as the Handicabs of Milwaukee, Inc., which now has more than 115 vehicles to provide specialized services for all types of handicapped persons in the Milwaukee area, provide service.

There is no best way to coordinate all of the competing transportation services in all metropolitan areas. Delaware has had several years' experience in operating the Delaware Authority for Specialized Transportation (DAST) and its predecessor organization. DAST, which is discussed more thoroughly later, is certainly the most comprehensive statewide attempt to coordinate all transportation services for elderly and handicapped persons within the state. It takes a long time to accomplish the types of cooperation necessary to coordinate the funding for this type of service, but this is slowly being accomplished in Delaware.

Rhode Island and parts of Missouri have a form of coordinated service for elderly and handicapped persons. However, neither of these efforts is mandated by state law, nor do they have the complete moral and financial support of state and municipal organizations within their area of operation. Perhaps the proposed UMTA regulations will help to direct Rhode Island and Missouri toward a completely coordinated system of transportation services.

In Brevard County, Florida, the local transportation authority has assumed the responsibility for all specialized transportation services, and coordination of other locally provided services is just beginning.

Thus it appears that a state, region, or local transportation authority can assume the responsibility for the coordination of all transportation services for the elderly and handicapped, including the use of funds for such services from many types of sources.

All states, major metropolitan areas, and regions must begin to consider how this task can best be accomplished within their areas.

Levels of Service

In Delaware, DAST uses its own vehicles, or can contract for services provided by others. Services that formerly were provided by others DAST provides through funds from purchase of service contracts from medical, health, welfare, and social agencies. DAST's expansion is commensurate with funds provided. Thus, the levels of service are determined by the degree of cooperation and the sharing of funds available from the state of Delaware, transportation sources, and other sources.

The U.S. Department of Health, Education and Welfare has identified 64 sources of funds for providing transportation services. Most of these sources were from the Department of Health, Education and Welfare, although other sources were from the Department of Labor, the Office of Economic Opportunity, and the Department of Transportation.

Denver, Seattle, and Baltimore are among the cities that are scheduled to provide a number of vehicles for such transportation services. Service provided by these vehicles and coordination of all other types of transportation services should add to the information on the necessary levels of service for supplying adequate mobility in typical cities across the United States.

Funding

Recognizing the value of coordinating the 64 sources of transportation funds mentioned earlier, APTA has recommended that the levels of service to be provided to nonambulatory handicapped users should be subject to the approval of the administrator, and on granting such approval the administrator shall enter into an agreement for the affected public transportation system operator, regional transportation operating agency, or metropolitan planning organization, as appropriate, to provide 80 percent of the capital costs of all vehicles, equipment, and facilities necessary to provide the levels of service for nonambulatory handicapped users and coordination efforts required by the administrator and in addition 100 percent of the net deficit that may result from the provisions of approved special services and 100 percent of the administrative and operating costs for the required coordination effort.

Use of the funds from HEW and other agencies should reduce the transit operation deficits to a much more reasonable level, which would then be funded by the Department of Transportation.

COROLLARY ACTIVITIES AND DATA

DAST—An Authority Approach to Specialized Transportation

The Delaware Authority for Specialized Transportation is a successful local approach to the funding and operation of specialized transportation on a statewide basis. Although DAST has only been providing such service since December 1974, its predecessor, the Delaware Interagency Motor Service, Inc. (DIMS), a private nonprofit corporation, began service in the summer of 1971. It was originally created to fill the gap created when volunteers left for summer vacations. The Greater Wilmington Development Council, the Delaware Red Cross, and the New Castle County Ambulance Service banded together to hire college students for the summer to fill in the void of volunteer transportation services. Approximately 600 trips per month were performed in New Castle County from June 12 to August 1971. By 1972 there was a mandate for year-round statewide service, and 24,000 trips were made. In 1973 there were 33,000 trips, and 90,000 trips in 1974. The DIMS fleet grew to 36 vehicles including nine-passenger station wagons, 12-passenger vans, 16 and 20-passenger minibuses, and orthopedic and special care vehicles. Dispatching was performed manually without the aid of two-way radio equipment. DIMS grew to serving 35 agencies and more than 6,000 individual clients per month. The approach used by DIMS was unique. It mandated all agencies, public and private, to use one method of service delivery. It had limited success in reducing duplication. One major accomplishment of DIMS was recognition and membership in the Delaware United Fund (UF) in 1972. Through its United Fund affiliation, DIMS was able to work with other UF agencies to provide better transport service at reduced expenses.

Throughout DIMS' 3-year history, purchase of service contracts was the primary source of funds. All service was provided to contract member agencies, who in turn made client referrals. No requests were taken from private individuals, only from agencies. This provided a means of authenticating need, allowed for accountability, and avoided direct conflict or competition with public carriers. The system has worked well except that it does not provide for the full range of medical and social transportation services. Governmental (federal, state, and local) programs accounted for 81 percent of DIMS' revenues in 1974. These funds came from Title 19 (Medicaid), Titles 3 and 7, plus vocational rehabilitation and public health contracts. Private agencies such as the Easter Seal Society, American Cancer Society, the Alfred I. duPont Institute, United Cerebral Palsy, and the YMCA made up the bulk of the private agencies who also contract for service. Revenues made DIMS 80 percent self-supporting. Private foundations, private citizens, the United Fund, and small local government grants have provided the subsidy to fill in the additional cash needs.

DIMS was proud that only 10 percent of its resources were expended on administrative costs. Ninety percent of all funds are put into operations to provide maximum service.

With such a seemingly positive situation, why would it be desirable to take a private agency and transform it into a public authority? There are several reasons.

1. DIMS was becoming overloaded. Demand was outstripping resources. Unless DIMS was expanded, either the quality of service would have to be sacrificed or requests for service would have to be denied in great quantities.

2. DIMS' financial base was limited. DIMS always operated hand-to-mouth. Expansion was impossible because of lack of capital for equipment and operations. An authority also offered tax breaks unavailable to a private nonprofit organization (tax-free fuel and Centrex telephone systems for example).

3. An authority provided legitimacy. As a private, nonprofit organization, DIMS had little weight in dealing with public and private agencies. But, as an authority, there would be a legislative mandate, concurrence and support by the governor, aid and assistance from state, local, and federal agencies, and a sense of permanency and mission.

These factors prompted the DIMS board and staff, the office of the governor, the state Department of Highways and Transportation, the United Fund, other interested agencies and individuals, and several legislators to draft an act to create an authority for specialized transportation. The act was drafted with the intent of keeping the one provider-multiuser concept of DIMS, expanding the scope and level of specialized service, mandating interface with public carriers whenever possible, and stressing the ideal of providing the best possible service by use of the most economical mode for the citizens of Delaware. Through the act, the legislators and executives made a commitment to provide specialized services to Delaware residents who are unable to provide or obtain transportation service themselves. When the General Assembly signed the act into law, an appropriation for start-up funding for the authority was also passed.

DAST will continue service under the basic format of DIMS. Member client agencies will be served by DAST, and they will be responsible for all refunds and client-screening. Screening clients is still deemed necessary to fulfill the accountability mandates. The authorizations required will curtail abuses and will allow for clear coordination of service and reduced duplication.

Local government units have shown their interest and support. New Castle, Kent, and Sussex County governments either have or are in the process of pledging local funds as operating money for transportation programs for the elderly and handicapped. All three counties have also stressed the need for nonemergency ambulance service to relieve the burden on existing ambulance services. Delaware's Emergency Trauma Care System has been impeded by the growing number of routine transports that have to be performed by emergency vehicles. In New Castle County alone, 14,000 such runs were performed by the New Castle County Ambulance System. These runs are expensive, impede emergency reaction time, and create backlogs of discharged patients who cannot be moved from a medical facility because of lack of stretcher transport resources.

A further goal of the authority will be the creation of advisory councils composed of consumers, sponsoring contract agencies, and other service providers under the system. For the system to be truly demand responsive, the real needs and concerns of all involved with it must be known and appreciated.

The United Fund of Delaware has taken a positive stance on DAST and United Fund agencies. It is the UF's policy that any agency requesting money for vehicle purchases must justify completely why the vehicle is necessary for client transport as opposed to contracting for service with DAST. The Fund wants to stop the proliferation of vehicles and the headache that upkeep and insurance create. It is acknowledged there are some instances when immediate access to a vehicle is required and as such DAST would not fill the need, but generally, agencies can utilize DAST's services. This is especially true given the several modes of service available under DAST. One point is continually mentioned by social service agencies: Now that DAST is functioning, they can get out of the transportation business of operating small, uncoordinated fleets. They much prefer to contract for service and let experienced transport people provide the needed services.

The DAST concept is not the ultimate answer. Although it is novel, it does offer a pragmatic solution for the state of Delaware. The basic concept of interagency cooperation in specialized transportation services was proved successful with DIMS. Now, DAST has solid public support and new horizons of funding and service. As such, DAST and programs like it are important to the field of specialized transportation.

Oakland, California, Demand-Responsive Conference

In November 1974 the Transportation Research Board and the American Public Transit Association sponsored the Fifth Annual International Conference on Demand-Responsive Transportation Systems (3). At the conference, major emphasis was placed on the use of taxicabs in transporting elderly and handicapped persons. One of the themes of the conference was the necessity of using all modes of transportation to effectively maximize urban mobility. Representatives of the taxicab industry discussed the magnitude of the services currently provided by U.S. taxicab companies. They also pointed out that taxicabs, which provide demand-responsive services, are similar to the systems that are being "discovered" by municipalities across the country but that are subsidized. In some areas of the country, taxicab companies and municipalities or transit authorities have entered contractual agreements wherein taxis provide demand-responsive service for particular areas of a region for the general public or segments of the elderly and handicapped population. Under such circumstances, these contractual arrangements can be as cost effective as other types of services offered to the general public or handicapped persons.

Other issues discussed were the regulatory problems of the taxi industry, the potential of taxicabs for providing innovative paratransit services, computerized taxicab-dispatching systems, and design and use of diversified-use vehicles. Handicabs, of Milwaukee, Inc., a specialized transportation service for the elderly and handicapped, was discussed as were UMTA's service development projects related to mobility of the elderly and handicapped.

Florida State University Fourth Annual Transportation Conference

The theme of the conference at Florida State University was Toward a Unification of National and State Policy in Action on the Transportation Disadvantaged. The speakers represented a wide diversity of backgrounds and spoke on many aspects of transportation of elderly and handicapped persons in both rural and urban environments. Representatives from DAST and the Department of Health, Education and Welfare spoke.

Findings were presented from a study on transportation for elderly and handicapped conducted by the Administration on Aging and the Department of Transportation that revealed the great number of transportation services for elderly and handicapped persons that are available across the United States and that, because many of these services are funded for a 1 or 2-year period, a disservice occurs to the elderly and handicapped persons when this funding is terminated. Also discussed was the fact that a large proportion of handicapped persons are not physically able to use regular route transportation and thus need specialized demand-responsive service. The costs of such service might vary from $4 to $8 per person per ride, and many of the figures quoted did not include depreciation of equipment or the administrative costs attributable to such service.

A panel of seven consumers of transportation for elderly and handicapped persons articulated their needs, which could only be fulfilled by personalized door-through-door transportation and in many cases with attendant assistance.

Other speakers spoke on the social responsibility of providing a higher level of service for elderly and handicapped persons, but each speaker referred to the economic aspects of the service supplied and the fact that taxpayers have to agree to the funds to be expended for such service.

Transportation for the Elderly and Handicapped in Gothenburg, Sweden

Gothenburg, Sweden, is an excellent example of the type of social responsibility and coordination of services that can be provided for elderly and handicapped persons. Prior to 1967, transportation for elderly and handicapped persons was provided by private welfare agencies in Gothenburg. The city council then made the decision that the Gothenburg Transit Authority would be responsible for such services.

Eligibility for such service is determined by the social and welfare department of the city. To be eligible the applicant must be a resident of Gothenburg and be certified by a doctor as handicapped. Persons receiving such eligibility can request as many trips per month as they wish for school or medical treatment. In addition, they may request up to eight leisure trips per month. No fare is charged for school or medical trips. However, there is a fare of 30 cents for work and leisure trips.

The Gothenburg Transit Authority has an arrangement with the local taxicab companies for purchasing transportation service. In 1973 approximately $^7/_8$ of the trips provided elderly and handicapped persons were accomplished by taxicab. The remaining trips were handled by a division of the transportation authority, which now has a fleet of 40 special vehicles and a staff of 85 people to accomplish approximately 105,000 trips per year.

The average cost per trip including all administrative costs, drivers, maintenance, and capital depreciation is approximately $8 for the specialized vehicles and $4 for taxis.

CONCLUSIONS AND RECOMMENDATIONS

1. Very little implementation of transportation of elderly and handicapped persons has occurred to date.
2. There is a social need to provide more mobility for elderly and handicapped per persons.
3. The U.S. Department of Transportation's proposed rule making on regulations for transportation for the elderly and handicapped is a giant step toward the formulation of a uniform policy for implementing transportation for elderly and handicapped persons.
4. Improving bus accessibility can benefit the speed, comfort, and safety of boarding and alighting of able-bodied, handicapped, and elderly persons.
5. Total access to all vehicles at all times for persons with all types of handicaps presents many operational difficulties and would be extremely expensive.
6. Some types of fixed-route bus service are not practical for transporting wheelchair users.
7. It is possible that the utilization of the Department of Transportation Section 16b2 funds could cause the profileration of competing inefficient transportation services for elderly and handicapped persons, rather than the coordinated type of transportation required under the proposed rule making. However, careful administration and approval of the applications for such funds could complement the purposes of the proposed rule making.
8. The organization, successes, and failures of each principal transportation service that has been provided for elderly and/or handicapped persons must be more completely and succinctly tabulated. The study for the Administration on Aging and the Department of Transportation has done an excellent job of beginning this work. Some of the work done by the Department of Health, Education and Welfare and others indicates that it is possible to obtain the cooperation of many of the existing transportation services for elderly and handicapped persons and to combine them into a coordinated network.
9. Delaware, Rhode Island, and portions of Missouri have proved that it is possible to supply coordinated service within a region. Such services should be encouraged, and everything possible should be done to coordinate their funding.
10. In many cases, transit systems and authorities are willing to undertake the

coordination and participate in the implementation of additional transportation services for elderly and handicapped persons, provided that public approval generates sufficient funding. The success of the Brevard County, Florida, Transportation Authority in such activities demonstrates the value of this type of approach.

11. The transit industry, in conjunction with the Departments of Transportation and Health, Education and Welfare, should initiate a series of conversations designed to implement the use of funds from many sources for the coordinated supply of effective transportation for elderly and handicapped persons.

12. Because of its character as a pilot example of successful coordination of transportation services, the Delaware Authority for Specialized Transportation should receive administrative and financial assistance from the Department of Transportation and other interested federal agencies to coordinate transportation for elderly and handicapped persons.

REFERENCES

1. Summary of Special Reduced Fares and Procedures (For the Blind, Handicapped, Unemployed and Welfare Recipients). American Public Transit Association, 1972.
2. J. B. Schnell. Public Transportation and Transportation Needs of the Elderly and Handicapped. American Public Transit Association, Jan. 1974.
3. Demand-Responsive Transportation Systems and Services. TRB Special Rept. 154, 1975.
4. R. I. Hollis. Notes on the California Taxi Industry Providing Demand Responsive Services. California Department of Transportation.
5. C. Stewart. State of the Art on Wheelchair Lifts and Securements. California Department of Transportation.
6. J. H. Davidson. Computer Oriented Taxicab Dispatching Systems. Yellow Cab Co., Los Angeles.
7. G. W. Heinle. Interim Report on Service to the Elderly and Handicapped. Southern California Rapid Transit District, Los Angeles, Oct. 1974.
8. Report on Service for the Elderly and Handicapped: Problems and Positive Solutions. Transit Advisory Committee, Southern California Association of Governments, Nov. 20, 1974.
9. J. C. Falcocchio and E. J. Cantilli. Transportation and the Disadvantaged. D.C. Heath and Co., Lexington, Mass., 1974.
10. M. S. Gelich et al. Design for the Handicapped in Elevated Transportation Systems. Univ. of Illinois at Chicago Circle, Research Rept. 11.
11. Proceedings, Fourth Annual Transportation Conference. Florida State Univ., Dec. 2-4, 1974.

EVALUATING THE RELEVANCE OF SPECIALIZED UNIVERSITY COURSES IN PUBLIC TRANSPORTATION

Thomas D. Larson, Paul A. Liguori, and Robert D. Pashek,
Pennsylvania Transportation Institute, Pennsylvania State University

ABRIDGMENT

As the transit industry begins to attract more university graduates, it becomes important to examine the relation between university transportation course offerings and the transit industry's job requirements. From an evaluation of university transportation courses and programs can come information concerning the direction such programs must take to provide the most effective employees. Twelve public transit properties and five state departments of transportation were contacted by telephone and mail surveys to identify organizational needs and problem areas. Faculty members were contacted at several universities, and business, transportation, and civil engineering programs were reviewed. Recent university graduates employed in public transit activities were surveyed by a questionnaire regarding the relevance of their transportation education to their jobs. The results of the research show that, for most public transit industry jobs, universities are providing graduates with the proper training and capabilities. Also found was a strong demand for additional short courses and seminars that would enable industry personnel to keep abreast of the newest methods, techniques, and topics of interest to the industry. The data generated should be useful to universities and federal and state agencies in evaluating their position with respect to public transit education.

•WHEN the Urban Mass Transportation Administration was created, federal funds became available to public transit properties. In addition to the increased federal funds, increased state and local funding also became available to public transit properties. In recent discussions with key personnel at eight transit properties, six (Boston, Cleveland, Los Angeles, Oakland, St. Louis, and San Diego) indicated that they were receiving or expected to receive in the near future subsidy money under new funding programs.

Since the introduction of governmental funding, progress has been made toward breaking the declining revenue, service, and personnel cycle. Public transit properties have recently been able to hire trained people, which had been sorely needed in the past. Universities are a major source of trained personnel for the transit industry, and such personnel will be needed in increasing numbers as the industry continues to grow.

This project was aimed at investigating the relevance of university transportation course offerings to the solution of the problems facing the public transit professional. The underlying concern was whether the university training received by graduates properly prepares them for the responsibilities of employment in the public transit industry. Certainly, university training cannot be geared toward the specific job requirements of an entry-level position at a particular employment area. However, course content and program design should address transit needs.

In addition to investigating university course offerings, we also investigated approaches that could be added to existing programs. The possibility of adding work-study programs, short courses, or seminars to formal university training was considered in the overall evaluation.

Public transit properties and state departments of transportation were contacted to identify the problems, universities were contacted to identify the courses offered, and recent graduates in the public transit industry were contacted to rate the relevance of the courses to the problems the graduate faces.

Management personnel at 12 transit properties and five state departments of transportation were contacted by telephone and mail to identify the problems facing the person employed in the transit industry. Intergovernmental coordination, urban transportation planning, transit marketing, public relations and communications, human relations, and financial analysis were noted by transit managers as the key problem areas their employees face.

Preliminary research was conducted into the small package carrier group, but the results were disappointing. It was extremely difficult to determine the proper individuals to contact. Those who were eventually contacted either were unreceptive to the project or did not feel that university transportation training had a place in their industry and did not care to talk further on the matter. On-the-job training was noted as the only way to learn the highly specialized job requirements.

A major finding of the research was that both transit management and recent graduates felt the need for a more general education. Both groups felt that exposure to the overall transportation environment was at least as important as training in the technical areas of transportation. In addition to the engineering and business courses offered, courses in areas such as intergovernmental coordination, public affairs, and administration were recommended by the graduates. Further, those with an engineering background expressed a desire to take several business courses, and business students desired several engineering courses.

Several of the universities contacted offer such a variety of courses and encourage students to take as many courses outside of their major field as their program and interests allow. Based on the findings of the surveys, universities that offer transit courses but that do not encourage students to take political science, public affairs, and other related courses should consider adding several such courses to the existing transit program.

University transportation programs are capable of meeting the requirements of the transit industry. Included in the range of civil engineering courses available to students are urban transportation planning, transport policy, transportation systems planning, public transit systems, and transport administration. Several of the key courses available in a business logistics program are systems management and control, transportation laws and procedures, urban transit and urban development transport, and public policy and transit management.

The response to the questionnaire sent to 162 recent college graduates working in the transit industry suggests that university transportation course offerings are relevant. For the most part, the courses were called useful in day-to-day job responsibilities, and the techniques taught in the classroom were applicable to the job situation. However, there were several areas in which many graduates felt they had received a poor education. Of the 162 questionnaires mailed to recent graduates, 91 were returned, 47 of which came from graduates of a civil engineering or business logistics program within the last 5 years. The average graduate reported 3 years' work experience in the transit industry, 2.75 of which were completed in the current job location. The key areas noted as relevant by the graduates were degree and ease of application of education to day-to-day problems and the advantage a graduate of a transportation program has over coworkers with similar job responsibilities but without a transportation education.

Intergovernmental coordination, public relations and communications, administration, and technical aspects of public transit all received a high percentage of poor ratings for the education received.

The evaluation of civil engineering courses showed that they have a very high degree of usefulness. Only one course, public transit systems, was given a poor rating. Three of the eight graduates who had taken this course felt it was a waste of time. Public transit systems was also most often selected as the course graduates had not taken but now felt that they should have taken! A definite desire for including several business logistics courses in a civil engineering program was noted in the responses. Courses such as public transit management and economics of transportation were often noted by the respondents as possible additions to a civil engineering program.

The evaluation of business logistics courses showed that the courses taken were often useful. However, not so many graduates took business logistics courses as took civil engineering courses. Also, the number of respondents with a business logistics education who felt they should have taken civil engineering courses was smaller than the number of civil engineering graduates who noted a desire to take business logistics courses.

One of the goals of this research was to determine whether sufficient demand existed for the addition of work-study programs to university transportation education. Transit management was highly in favor of such an addition. From the responses, 41 graduates favored work-study programs, and only four were opposed. The suggested length of time for a work-study program ranged from 10 weeks to more than a year. Two major problems standing in the way of this addition are funding and the distance between many universities and a public transit property or state DOT office. The funding problem is one that deserves the attention of all.

The last two questions dealt with topics for short courses or seminars. A list was presented of nine course titles with no other description given. On this basis, more than half of the graduates indicated a preference for attendance at one or more of the short courses or seminars. When they were asked to suggest topics that they felt seminars should address, 16 additional topics were listed.

A wide range of topics were suggested in the responses to the questionnaires: transportation and the environment, transportation and energy, system planning—transit or highway, new planning techniques, and citizen participation. The major finding was the high degree of interest in seminars shown by both management and recent graduates.

OPERATIONAL PLANNING OF FIXED-ROUTE AND DEMAND-RESPONSIVE BUS SYSTEMS IN THE GREATER LAFAYETTE, INDIANA, AREA

Antoine G. Hobeika, Virginia Polytechnic Institute and State University; and
Gilbert T. Satterly, Purdue University

ABRIDGMENT

Many small urban areas in the United States are evaluating implementation of a demand-responsive transportation system in addition to the conventional bus system. This paper suggests the proper combination of the two modes, fixed-route and demand-responsive systems, that best serves the demand at a level of service required by the customer. The greater Lafayette area is used as a case study. A simplified procedure was developed to design the fixed route of the bus system of the greater Lafayette area. The level of service was measured by the total time the users spend on the bus system. Computer simulation was used to duplicate the operations of the demand-responsive system in the real world. The system operates on a many-to-many basis, i.e., many origins to many destinations, and is dispatched by computer. Cost comparisons of the two systems provided the feasible operation of the two bus modes for various demand levels under the same level of service. The results show that the fixed-route system best serves the high demand, i.e., more than 90 persons per hour. The demand-responsive system best serves the lower demand. No generalization of the results could be reached at this point in time, except for small urban areas similar in size and in structure to the greater Lafayette area.

•MANY small urban areas in the United States are trying to revive bus transportation by implementing, in addition to the conventional fixed-route, fixed-schedule bus system, a demand-responsive transportation (DRT) system, which has attributes similar to those of the automobile. This paper addresses the combination of the fixed-route and demand-responsive systems that best serves the various demand levels in the greater Lafayette, Indiana, area at a level of service required by the customer.

Combined, the two modes, fixed-route and DRT, provide a feasible alternative for bus public transportation in small urban areas. They serve different demand levels. For a defined service area the demand level for public transportation varies at different times of the day. It increases sharply at certain times, usually during the home-to-work and work-to-home travel periods, and it decreases and levels off at other periods. The proper application of each of the two modes to best serve the various demand levels remains a problem to the transit planners. No real analysis and experimentation have been done to determine the proper combination of the two modes. Most of the DRT experiments have been done in service areas that did not include a fixed-route bus system, or the DRT has been implemented to serve part of an area that is already covered by a fixed-route bus system. This study investigated the application of a fixed-route bus system during the peak periods and the many-to-many DRT system during the off-peak periods in the greater Lafayette area. The number of vehicles required by each mode to operate at a certain level of service was determined. Consequently, the cost analysis of the two systems determined the feasibility of their operation.

FIXED-ROUTE SYSTEM

The routes for the fixed-route system were designed to provide 30-min headways on the entire system. The route coverage was such that no part of the entire area was more than $\frac{1}{4}$ mile (0.4 km) from a bus route. Average operating speed of the buses was assumed to be 12 mph (19 km/h). Fifteen buses were required to provide the service.

The level of service provided by the bus system was defined as equal to total service time divided by direct travel time by automobile. Total service time for the bus system is composed of bus travel time and user waiting and walking time.

The value of the level of service offered by the selected fixed-route bus system was 2.35.

DEMAND-RESPONSIVE TRANSPORTATION SYSTEM

Real-world operation of a DRT system was computer simulated. The system was designed on a many-to-many basis, i.e., many origins to many destinations, and vehicles were computer dispatched. The objective of the simulation was to estimate the number of vehicles required for specific operating conditions and quality of service. The results were used in a cost comparison of the DRT and fixed-route systems, which led to a decision on the utility of the DRT system. The input variables were the number of vehicles and the demand level. The level of service was output based on these two parameters.

Specifically, we isolated the effect of each of these three parameters on the performance of the system by conducting a series of computer simulations to study the effect of

1. The number of vehicles on the level of service with the demand level held constant,
2. The demand level on the level of service with the number of vehicles held constant, and
3. The demand level on number of vehicles with the level of service held constant (this was achieved after conducting a number of experiments with different combinations of demand level and number of vehicles).

COST ANALYSIS

The cost analysis determined the feasibility of operating the two modes under different demand levels at a required level of service. The mean level-of-service value that was considered acceptable to the public is 2.2 to 2.5 times the mean direct automobile travel time. The cost analysis of the different operations was investigated at this level of service, but the measure of service for the two systems is not quite the same except in terms of time consumption. The DRT system offers door-to-door service, comfortable waiting times, and no walking. It offers a better service than fixed-route bus system even when the time spent by the users on both systems is the same. However, the value of walking to the bus stop and waiting on the street is a qualitative measure and is difficult to include in the calculation of the measure of service. Therefore, this research considered only the total time spent by the users on the system in comparing the levels of service offered by the two modes.

The cost of a bus system depends mainly on the number of buses in operation. Drivers' wages and the operating cost of the vehicles constitute the major component of the total system cost. In the case of DRT systems, the cost of dispatching and the cost of computer assignment add another component to the total cost. Before the cost of the two systems can be compared, the number of buses required to serve the various demand levels must be determined.

The design of the two systems revealed the number of buses needed to serve the various demand levels at a certain level of service. The results are given below for a 2.2 to 2.5 mean level of service.

System	Demand (passengers per hour)	Number of Vehicles
Fixed-route	151 to 750	15
DRT	150	14
DRT	120	12
DRT	90	10
DRT	60	8
DRT	30	5

These figures show that, for a demand greater than 150 persons per hour, the fixed-route bus system requires fewer buses than the DRT to provide the same level of service. Consequently, it will cost less than the DRT because of its less sophisticated control systems. The high demands—greater than 150 persons per hour—occur during the peak hours of the day in the greater Lafayette area. Therefore, the fixed-route system provides a better alternative during these hours.

For a demand of fewer than 150 persons per hour, the DRT system requires fewer than 15 buses to provide the same level of service. However the total system cost could be less than, equal to, or greater than that of the fixed-route system, depending on the number of DRT vehicles in operation. This is mainly due to the additional administrative and operative cost required by the DRT system. The cost analysis investigated the break-even point between the cost of the two systems, that is, the number of DRT vehicles in operation that would produce the same total cost as the 15 buses in the fixed-route system. Below that number of vehicles the DRT system would provide a better alternative than the fixed-route system.

Hence, the cost analysis investigated the operating cost per hour of the following systems:

1. A 15-bus system operating on the developed fixed routes of the greater Lafayette area and
2. A number of DRT vehicles that would be equivalent in cost to the fixed-route system.

The cost analysis indicated that 10 DRT vehicles would produce the equivalent cost of 15 fixed-route buses. The demand served by 10 DRT vehicles would be equal to 90 calls per hour for the required level of service. Therefore the DRT system would be better for demands less than or equal to 90 calls per hour.

CONCLUSIONS

The results of this study identify the best operation in the greater Lafayette area for the two transit modes, the fixed-route bus and the DRT, for the different demand levels at a required level of service. These results for the prescribed level of service are as follows:

Demand (passengers per hour)	Number of Vehicles	Type of System
91 to 750	15	Fixed-route
90	10	DRT
60	8	DRT
30	5	DRT

From these results it can be concluded that the fixed-route system is better for high demands, and DRT offers a better and less costly service for low demands. This conclusion is valid only when the concept of level of service as defined is used as a yardstick for comparison of the two systems, that is, if the time spent by the users on the bus system compared to their automobile travel time is used as the criterion.

The results are applicable specifically to the greater Lafayette area. However, in areas that have the same size and structure as greater Lafayette, the results might be used.

The study has confined its analysis to the many-to-many DRT system with computer dispatching.

REFERENCE

1. A. G. Hobeika. Operational Planning of Fixed-Route and Demand-Responsive Bus Systems in Greater Lafayette Area. Purdue Univ., Joint Highway Research Project Rept. 22, Sept. 1973.

SPONSORSHIP OF THIS RECORD

GROUP 1—TRANSPORTATION SYSTEMS PLANNING AND ADMINISTRATION
Charles V. Wootan, Texas A&M University, chairman

PUBLIC TRANSPORTATION SECTION
Douglas F. Haist, Wisconsin Department of Transportation, chairman

Committee on Public Transportation Planning and Development
Kenneth W. Heathington, University of Tennessee, chairman
Alan L. Bingham, Daniel M. Brown, Robert C. Buchanan, Robert A. Burco, John L. Crain, George Cronin, James P. Curry, Frank W. Davis, John W. Dickey, James C. Echols, Ronald J. Fisher, William K. Fowler, G. E. Gray, David T. Hartgen, F. Norman Hill, William T. Howard, Eugene J. Lessieu, Stephen G. McConahey, B. Thomas Moore, William T. Olsen, Joseph F. Rice, Gilbert T. Satterly, Jr., George M. Smerk, Donald R. Spivack, Edward Weiner, John D. Wells

W. Campbell Graeub, Transportation Research Board staff

The organizational units and the chairmen and members are as of December 31, 1974.