cies. Transportation Research, Vol. 14A, 1980, pp. 137-142.
37. A.D. May. Demand-Supply Modeling for Transportation System Management. TRB, Transportation Research Record 835, 1981, pp. 80-86.
38. T. Weldon and P.S. Parsonson. Cost Effectiveness of TRANSYT Computer Signal Settings. Transportation Engineering, Oct. 1977.
39. D. Ballou and L. Mohan. A Decision Model for Evaluating Transit Pricing Policies. Transportation Research A, Vol. 15A, 1981, pp. 125-138.
40. M. Kemp. Planning for Fare Changes: A Guide to Interpreting and Using Fare Elasticity Information for Transit Planners. Urban Institute, Washington, DC, Working Paper 1428-05, 1980.
41. N. Nihan and K. Holmesland. Use of the Box and Jenkins Time Series Technique in Traffic Forecasting. Transportation, Vol. 9, 1980, pp. 125-143.
42. G. Wang. An Intervention Analysis of Interrupted Urban Transit Time Series Data: Two Case Studies. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, 1981.
43. M. Kemp. A Simultaneous Equations Analysis of Route Demand and Supply, and Its Application to the San Diego Bus System. Urban Institute, Washington, DC, Research Paper 1470-2, 1981.
44. Y. Zahavi, M. Beckmann, and T. Golob. The UMOT/Urban Interactions. U.S. Department of Transportation, Rept. DOT-RSPA-DPB-10/7, 1981.
45. I. Heggie and P. Jones. Defining Domains for Models of Travel Demand. Transportation, Vol. 7, 1978, pp. 119-125.
46. C. Zimmerman. The Life Cycle Concept as a Tool for Travel Research. Transportation, Vol. 11, 1982, pp. 51-69.
47. J. Lee, E. Tamakloe, and T. Mulinazzi. A Public Transportation Needs Study for the Low Density Areas in a Five-State Region in the Midwest. U.S. Department of Transportation, Rept. USDOT-UMTA KS-11-0001, 1981.
48. Barton-Aschman Associates. Transportation Resources Analysis Study for Montgomery County, Maryland. Montgomery County Department of Transportation, Rockville, MD, 1978.
49. I. Andreasson. Volvo Approach to Computer-Aided Transportation Planning. TRB, Transportation Research Record 657, 1978, pp. 9-14.
50. K. Neels and M. Cheslow. Approaches for Improving Urban Travel Forecasts. Urban Institute, Washington, DC, Working Paper 5114-2-1, 1978.

Transit and Highway Operations and Management Techniques: State of the Practice

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The shift in emphasis in transportation planning toward a focus on shorter-term, lower-cost improvements is well documented. The need to adapt the procedures and analytical tools developed for planning of long-range, capital-intensive projects to this new environment is equally clear but certainly much less advanced. The purpose of this summary is to examine the travel-forecasting methods currently in general use for analysis of operations and management strategies and their impacts on travel demand. Four subjects are discussed: the identification of planning applications within each of the five context areas where analysis of operations and management may be important, a survey of methods currently used to examine these issues, some thoughts on gaps between the states of the art and the practice, and suggestions on priorities for the planning community in addressing these emerging planning issues.

CONTEXTS

The topic of this workshop--operations and management techniques--is as much (or more) a planning context as it is a methodology. Thus, it is useful to first identify planning activities within each of the context areas in which operations and management issues are important. To simplify the discussion, it is useful to combine context areas that are quite similar and discuss planning in three general contexts: strategic and long range, project, and microscale and systems operations.

Strategic and Long-Range Planning

The anticipation of major changes in society and in factors influencing the transportation environment--fuel prices, transit funding--is a task whose scope and importance likely exceeds that of any management and operations issue when viewed from a broad perspective. The increase in workforce participation by women, for example, and the accompanying changes in household income, automobile ownership, and family size have had impacts on travel behavior that are more significant than the cumulative effect of all transportation system management (TSM) actions and system operating plans that have been implemented.

One important area for strategic and long-range planning of operating strategies, however, is transit system management. Changes in land use patterns, commuting trends, demographic characteristics, and funding availability create a continuously changing travel market and operating environment in which the transit agency must operate with acceptable effectiveness and economy. The implementation of operating policies, fare structures, and financing mechanisms is an effort that often extends over several years. Five-year transit development plans have typically called for staged implementation of new policies, although their focus has often been more on service expansion. More recently, several transit agencies have undertaken comprehensive assessments of their future operations in order to develop operating strategies that will maintain or improve their service quality and financial stability. An important and difficult task in these planning efforts is the estimation of patronage changes

that would occur in response to alternative fare and service changes.

Project Planning

Several types of project-planning activities involve systems-management and operations issues. One obvious context is the development of TSM projects themselves. Actions found within this category range from traffic signal coordination to park-and-ride lots and congestion-bypass lanes for buses and other high-occupancy-vehicle (HOV) traffic. Similarly, supporting analyses of travel impacts range from traffic engineering of individual intersections to elaborate and expensive model projections of transit patronage and traffic volumes. Since the smaller-scale projects also fall within the microscale and operations context, they will be treated in that discussion. The larger-scale projects--busways and other HOV priority facilities--are included here as project-planning issues.

Management and operations issues are important in the project-planning context from two perspectives. First, the operating plan for a new facility may significantly affect its merits as a wise investment of capital funds. The operating plan for Interstate 66 within the Washington, D.C., beltway is an excellent example. The cost-effectiveness and environmental impacts of the four-lane facility reserved in the peak hours for buses and other HOV traffic are substantially different from those of an alternative design that might have included six to eight lanes open to general traffic. Similarly large differences in project merit can be found for major transit facilities in variations of feeder bus and park-and-ride strategies, fare policies, and busway operating plans. Second, a comprehensive application of TSM actions serves as the basis for evaluation of project merit. It is assumed that a project is justified when, compared with a no-build situation, the project produces benefits that more than offset its costs; the analysis of an optimized no-build alternative is of equal importance to the assessment of the options to build. The comprehensive TSM alternative required by UMTA in analyses of major transit alternatives is an example of this role for system operations planning.

Microscale and Operations Planning

Planning for transportation facilities and services in small subareas or for specific transit routes is clearly the setting in which most operations and management issues arise. Planning tasks in this category include the assessment of traffic engineering actions and transit route characteristics to improve access to (and minimize impacts of) major new developments, reduction and elimination of unproductive transit routes and route segments, provision of services to special user groups, and such relatively new strategies as parking management and automobile restrictions. Analytical support of these planning activities varies markedly in the degree to which it involves travel demand consideration.

PLANNING METHODS

Since the planning contexts identified above represent ongoing planning activities at the local and state levels, analyses are being done--at least in a general sense--to support the decisions being made. In some cases, the analytical support is an elaborate and extensive effort using complex modeling techniques and computer software. In other situations, the analytical work consists of professional judgment based loosely on rules of thumb and/or past experience. This section attempts to summarize the analytical work typically associated with management and operations planning in each of the context areas.

Strategic/Long-Range Planning

Several transit agencies (1-3) are currently assessing alternative service plans for implementation over a 5-10-year period. The intent of the studies is to develop alternative sets of transit service standards that represent a range of (bus) service levels. To provide upper management officials and board members with enough data to choose among the options, the studies are developing a range of cost and impact data, operating costs, patronage, farebox revenues, geographic coverage, and service characteristics (average headways, fares, route spacing, etc.) for a number of local jurisdictions and subareas. Since the decision at hand is the selection of general service standards to serve as policy guidance for service and fare changes, the detail in which the final results are presented is quite aggregate. More detailed analysis and data, if needed, would be developed in later operations planning and implementation efforts.

The travel forecasts needed in these efforts are determined by several considerations. In addition to systemwide transit ridership projections, patronage estimates are needed in sufficient detail to (a) identify riders in different fare zones so that alternative fare policies can be represented and accurate fare revenue calculations can be done, (b) permit the analyst to equilibrate transit supply and demand, and (c) summarize ridership impacts by jurisdiction or subarea for evaluation purposes.

These planning efforts have varied significantly in their analytical support. At one extreme, a number of transit agencies have used the traditional modeling approach, coding a full transit network and employing the network-analysis, mode-choice estimation, and transit-assignment phases of the model set for each of the service options. This method has enabled the analysts to equilibrate service and ridership within their specified minimum and maximum loading standards, provided access to a wealth of evaluation data at a fine geographic level, made available a variety of mechanisms to represent fare policies, and involved a significant level of effort in time and money.

This detail was achieved only with a significant investment of time, staff, and computer costs, however. Further, the fare policies explored were quite limited in their variety and complexity, and the results presented to local decisionmakers were (and should have been) significantly more aggregated than those produced in the analysis. Consequently, some doubt exists that the level of detail and effort in which the analysis was performed was appropriate for the nature of the decision at hand.

At the other extreme, one transit agency has estimated impacts on patronage and revenues on the basis of past experience with service and fare changes. The analysis has consisted of adjustments to existing transit volumes obtained from passenger counts and an on-board survey. The adjustments have been made at the district level, and with fewer than 20 districts in the region, are quite aggregate. Each fare and service policy combination is translated into changes from existing conditions and is used with an elasticity derived from before-and-after counts taken around past fare and service changes to derive patronage and revenue impacts. Application of these elasticities has been done with some reference, largely judgmental, to the comparative levels of service, accessibility to transit,

and socioeconomic conditions that prevail in the before-and-after data and in each district.

Again, some doubt exists as to the appropriateness of this approach for strategic service planning. The heavy reliance on the good judgment of the analyst together with the very general nature of the results leave many prospective users with reservations as to its accuracy.

Between these two extremes are several cases in which transit operators have derived (or intend to derive) simplified patronage models from their conventional model sets. The simplifications mainly involve concentration on one behavioral change (mode choice alone, foregoing route-choice analyses) and conversion to an incremental structure that examines changes in service characteristics rather than their absolute values.

Project Planning

The development of an operating plan for new transportation facilities is a key, although often overlooked, part of planning for new highway and transit facilities. Although operations and management of the transit system is an obvious concept, operations and management of highway facilities is a relatively new idea--and in many cases a missed opportunity. Ramp metering, contraflow operations, reversible lanes, and time-of-day restrictions offer a range of options for true management of highway facilities that are at least as important in their planning and development as alignment, numbers of lanes, and interchange locations.

Recent planning efforts for new highway facilities have shown a rapid evolution in their sophistication. Several have examined HOV-lane alternatives during highway location studies and have documented these options in an environmental impact statement (EIS) (4-6). The analyses have relied on sketch methods, primarily the incremental logit (pivot-point) approach to estimating changes in transit and carpool or vanpool volumes. The sketch analysis might be considered inappropriate for the level of detail with which other aspects of the alternatives were analyzed and for support of the detailed environmental work (noise, air quality, etc.) presented in the EIS. However, the approach was effectively determined by the general lack of resources--time, appropriate staff, and data--available at the relatively late stage of the project development process. The conventional focus on structural, drainage, and geometric design issues somewhat minimized the opportunity for a more involved analysis of travel demand issues.

Similar problems can be identified in planning studies for major new transit facilities. Although UMTA's procedures have for some time provided for a specific, detailed analysis of alternatives, the rigor with which operations and management issues are treated has varied significantly. Again, many of these difficulties are most easily seen in the development of operating plans for busways and HOV lanes. A busway with stations and access ramps presents a virtually limitless number of potential operating strategies. At one extreme, all collector and line-haul services can be integrated, and each bus will provide a one-seat ride from residential areas to the downtown and make few, if any, station stops along the way. At the other extreme, the collection and distribution functions can be fully separated, and trunk-line buses will operate only on the guideway, making frequent station stops to allow transfers to and from a supporting network of feeder buses. Combinations of these two types of service can be used to match transit service to the specific travel patterns in a corridor.

Because the operating plan contributes heavily to the costs and effectiveness of the facility, the process used to identify the most effective operating scheme is critical. In some cases, however, minimal resources have been reserved for refinement of the operating plan originally assumed for the project and little scrutiny has been given to the operating assumptions when initial transit patronage estimates become available (7,8). The addition of carpools and vanpools to the facility further complicates the operating plan development by introducing such issues as minimum occupancy requirements and potential capacity problems.

Later project development efforts have devoted more consideration to operations analyses in project planning, however. The recent analysis of the extension of the HOV lanes on Shirley Highway in Washington's Virginia suburbs included a significant effort to project changes in mode and route choices (9). Full applications of mode-choice and traffic-assignment models for each design alternative (facility length and interchange locations) were used to develop detailed estimates of traffic volumes, transit patronage, and user costs. Careful attention was given to the representation of highway congestion on both the general traffic lanes and connecting arterials. Diversions of HOV traffic from the Shirley Highway HOV lane to the I-66 reserved lanes were explicitly addressed in the route-choice analysis. Efforts are currently under way to refine this process in preparation for analyses of other potential HOV facilities in the region (10).

Recent transit guideway planning has also included significantly greater effort for the development of operating plans. One study (11) structured a three-stage process for plan development that proceeded from a conceptual definition through an initial detailed specification to a final plan that was revised and refined to match the patronage levels and travel patterns in the corridor. The final operating plan for the busway included a mix of express services focused on the center city and local busway services stopping at busway stations served by feeder buses. The process significantly increased the reliability of the service, patronage, and cost estimates in that it ensured that these estimates reflect an appropriate, efficient operating scheme for the facility.

Microscale and Operations Planning

The final context area includes most activities associated with operations and management analyses. Nearly all TSM actions fall in this area, as does the day-to-day management of transit systems. To structure the discussion, it is useful to identify three major groups of activities in this context area:

1. Transit operations,
2. Traffic engineering, and
3. Ridesharing and paratransit.

Transit operations planning might be further categorized into route-level planning and farebox revenue forecasting. Summaries of current practice in both of these areas have recently been prepared through surveys of selected transit agencies (12,13). Route-level demand forecasting is done largely through very simple methods: professional judgment, comparisons with similar routes, rules of thumb, and applications of elasticities. Most of these applications are associated with system expansion (new routes or significant extensions) or major route changes (splitting or combining routes). System contractions (elimination of routes, reduced

hours of service) are nearly always assessed with data on existing ridership rather than with a forecast of patronage changes. Minor system changes (headway adjustments) are typically undertaken in response to perceived loading problems (too many or too few riders) and are also based on existing ridership rather than on projections.

A common observation among the transit agencies was that they need only a general indication of the ridership potential of system expansion proposals. Consequently, they find most useful techniques for estimating transit demand to be those that require the least time and cost to apply and still provide reasonable results. In many cases, the agencies seek to increase the reliability of the analysis by employing several of the simple methods to get a range of projections and use judgment to reach some conclusion on the most likely outcome. Reliability in general does not appear to be a chief concern, however. The most striking indication of this lack of emphasis is that follow-up data are almost never used to verify the accuracy of the projections. This suggests that the agencies view route-level planning as an ongoing effort in which any inaccuracies introduced now can be corrected in the near future at little (or at least acceptable) cost to the agency. The costs of being wrong in the forecasts are not sufficient to warrant more sophisticated analysis, even assuming that added sophistication produces greater reliability.

Fare analyses are usually done at the system, rather than route, level. Again, simple approaches dominate and the Simpson-Curtin shrinkage ratio (10 percent fare increase leads to a 3 percent patronage loss) continues as an (unofficial) industry standard. Adjustments to the ratio based on local experience are the most common refinement in the process. Again, the use of a seemingly crude method (crude in the sense that it is extremely aggregate and assumes widespread transferability) can be explained by the context in which it has been applied. Most fare changes have been increments within the existing fare structure rather than major revisions of the structure. Further, until recently the relative costs of transit and automobile travel have not fluctuated significantly in real terms; both are lagging behind general inflation. Consequently, a simple rule of thumb based on similar past fare increases has been an adequate guide for most fare changes.

As financial planning assumes greater importance, however, it is fairly clear that some changes will be needed in fare analyses. To the extent that significant changes in fare structures are contemplated, more sophistication will be needed in identifying individual transit markets, representing alternative fare structures and levels, and assessing the ridership and revenue impacts within each market. Some movement can therefore be expected away from simple aggregate methods to the more detailed and involved methods that have traditionally been used in longer-range regionwide planning efforts.

Traffic engineering activities encompass a wide variety of specific actions; they range from analyses of individual intersections to studies of traffic flow on freeway or arterial facilities and evaluation of circulation patterns in a subarea (14,15). At the intersection level, standard manually applied techniques are routine. Large-scale analyses of arterial segments and subareas are also often done on an individual intersection basis. Some risk is apparent in this approach when used for large-scale facilities in that significant changes in levels of service on a facility can cause broad changes in travel patterns and traffic impacts. For example, alleviation of significant queuing problems along one segment of an arterial can introduce similar problems at downstream locations where they did not previously exist. Similarly, significant travel-time improvements can cause changes in route choices that could lead to a significant diversion of traffic from other highway segments to the improved facility.

Techniques are available to examine these issues and they are used fairly regularly for large-scale applications, e.g., major CBD circulation analyses or studies of important, heavily congested facilities (15). These applications are typically done by consultants and represent a setting that is quite different from the more routine issues addressed by a typical traffic engineer in a local jurisdiction. Limitations on the ability of the engineer to use the more sophisticated techniques when appropriate appear to include poor access to facilities with which to apply computer software and limited availability of data on travel patterns beyond traffic counts on street segments. Some movement toward improved integration of planning and traffic engineering methods can be seen in the various manual procedures packaged as the quick-response methods (16). A number of these methods provide low-cost, quick-turnaround ways of estimating travel patterns and examining the impacts of traffic flow improvements and new developments.

A variety of approaches have been identified for the assessment of various ridesharing and paratransit programs. Potential demand for paratransit service has been analyzed through noncommittal surveys in which respondents identify their likely frequency of use and the analyst adjusts the results to correct for the upward bias inherent in the noncommittal responses (17). In distinct contrast, other methods have been proposed for use of traditional modeling techniques and software to estimate paratransit patronage (18).

By far the most common approach, however, is reference to published summaries of past implementation experience tempered with professional judgment (14). Reliance on this approach is largely explained by the comparatively recent emergence of ridesharing and paratransit programs. With relatively few programs in operation, the information available on successes, failures, and their causes is somewhat limited. Development of in-depth understanding and analytical models of the programs' impacts is consequently also limited.

The nature of ridesharing and paratransit programs suggests that the standard approach to their analysis may not be significantly less rigorous than is appropriate, however. The programs are typically implemented with specific objectives, are targeted toward specific travel markets, and begin as modest, low-cost operations. These conditions suggest that general ideas on the likely impacts and cost of such programs are sufficient to proceed with relatively low-risk implementation. Thus, collection of data on implemented programs and the setting in which they are introduced may continue to be the most common and appropriate approach to the analysis of these programs. Several compilations of this nature are available and are finding widespread application (19).

GAPS: STATE OF THE ART VERSUS STATE OF THE PRACTICE

Awareness

In many instances, the most significant discrepancies between available methods and current practice can be attributed to a lack of awareness of the need and/or opportunity to do a particular analysis. For

example, transit agencies often find their planning staffs focusing on short-range route-level problems while broader questions on longer-term service policies and financial health often remain unanswered. Similarly, the need for a true operating plan for highway facilities is somewhat unrecognized. The de facto operating plans that result may well lead to a very inefficient use of scarce transportation resources.

Analytical Skills

The shift in emphasis from long-range large-scale issues toward short-term management and operations has been accompanied by some shift in the location of supporting analyses. Staffs of transit operators, city planning and public works departments, and city and county traffic engineers are responsible for these emerging activities, whereas regional planning staffs often remain somewhat removed. One result is that analytical skills maintained by the regional planning staffs are not well focused on management and operations issues faced by staff at the local agencies. Since many of these issues involve travel demand considerations, an opportunity is missed to use skills available locally in increasingly important analyses.

Computing Facilities

A parallel situation often exists with regard to the computing facilities available to local staffs. Although the need for analyses has decentralized, local agency staffs often have poor access to the centralized computing capabilities typically maintained at the central planning agency. The remoteness and usually lengthy turnaround time associated with the central facility are particularly unsuited for many management and operations analyses. The numerous small-scale issues and variety of alternative solutions found in many short-term contexts require inexpensive, quick-turn-around processing of a large number of analyses. To the extent that this access is not available and that central staffs cannot accomplish these localized analyses for the various agencies in their regions, a significant limitation may exist on the ability of local agencies to expand their analytical capabilities.

Data

Similar observations can be made on the data maintained by regional planning agencies and its potential usefulness to local staffs. Growth projections, land use and demographic data, and travel forecasts available at the central agency can be quite valuable to planners in local jurisdictions. Provisions for ready access to this information are important if it is to be used in a timely fashion.

Analytical Methods

Finally, in a number of contexts, the available techniques appear insufficient for the analyses required. In some cases, this problem reflects the relative newness of the situation. Experience with employer-based ridesharing programs is still very limited and consequently data, understanding, and analytical methods for this strategy remain equally limited. In other cases, the problem appears to be more one of failure to adapt existing techniques to new situations: The use of detailed coded networks to analyze strategic transit service options reflects the lack of an alternative approach more than it indicates the suitability of the network-based analysis.

A number of examples of the need to improve specific analytical capabilities are as follows:

1. Sketch-planning techniques for strategic financial and service planning for transit agencies;
2. Representation of level-of-service improvements caused by HOV facilities, their effect on route and mode choices, and the equilibration of supply and demand impacts;
3. More informed applications of simplified methods for route-level demand forecasting that specifically recognize the existence of various travel markets and the differences in their travel behavior; and
4. Analytical summaries of experience with TSM actions that attempt to draw conclusions on potential impacts and appropriate applications in addition to the more common case-study presentations.

PRIORITIES

These discrepancies between the state of the art and current practice suggest a number of priorities for the transportation planning community in general and travel demand specialists in particular.

First, it is imperative that closer association be established with transportation professionals (traffic engineers, city planners, transit operations staff), whose responsibilities increasingly involve travel demand issues. Planners and planning agencies must reassess their roles and their skills to identify specific contributions they can make to management and operations analyses. The benefits in terms of the usefulness of these activities to the relevance and vitality of the planning agencies are obvious.

Second, more attention must be given to upgrading the capabilities of transportation professionals at local jurisdictions and transit agencies. Better access to central planning staffs, data bases, and computing capabilities would in many contexts be a significant improvement. The continued development of case studies documenting successful applications of various analytical techniques to real-world management problems is also an important focus in this regard. The use of microcomputer technology to enhance local capabilities may also be appropriate.

Finally, it is important to continue the collection, synthesis, and distribution of information on various management and operations strategies as they are implemented. This documentation can play a key role in enhancing the awareness of the opportunities provided by various strategies, in improving our understanding of their impacts and appropriate uses, and, where appropriate, in developing new planning tools to support their analysis.

REFERENCES

1. Future Bus System Options for Dade County. Metropolitan Dade County Transit Agency, Miami, FL, 1982.
2. Transit Service Options. Northeast Ohio Areawide Coordinating Agency, Cleveland, OH, Work Statement, 1982.
3. Public Transportation in the St. Louis Region: Phase One--Current Status, Problems, and Opportunities. East-West Gateway Coordinating Council, St. Louis, MO; Multisystems, Inc., Cambridge, MA, 1981.
4. Draft Environmental Impact Statement: Interstate 97. Maryland Department of Transportation, BWI Airport; FHWA, 1980.
5. Draft Environmental Impact Statement: US 50. Maryland Department of Transportation, BWI Airport; FHWA, 1980.

6. Draft Environmental Impact Statement: Interstate 676. Pennsylvania Department of Transportation, Harrisburg; FHWA, 1979.
7. Draft Environmental Impact Statement: Guadalupe Corridor Alternatives Analysis. Santa Clara County Transit District; UMTA, 1981.
8. Draft Environmental Impact Statement: Prospective Interstate Substitution Improvements in North-East Sacramento, California. Sacramento Area Council of Governments, Sacramento, CA; UMTA, 1981.
9. Draft Environmental Impact Statement: Shirley Highway HOV-Lane Extension. Virginia Department of Highways and Transportation, Richmond; FHWA, 1982.
10. Development and Integration of a High Occupancy Vehicle Model into the Long Range Planning Process. FHWA (project statement), 1981.
11. Draft Environmental Impact Statement: North Corridor Alternatives Analysis. Maryland Mass Transit Administration, Baltimore, MD; UMTA, 1982.
12. Multisystems, Inc. Route-Level Demand Models: A Review. UMTA, 1982.
13. Transportation Systems Center. Financial Forecasting in the Transit Industry: A Summary of Current Practice. UMTA, 1982.
14. J. Roark. Experiences in Transportation System Management. NCHRP, Synthesis of Highway Practice 81, 1981.
15. ADOT Demonstration Project: TSM Planning with Microcomputers--Phase I Final Report. UMTA, 1982.
16. Comsis Corporation. Quick-Response Urban Travel Estimation Techniques and Transferable Parameters: User's Guide. NCHRP, Rept. 187, 1978.
17. D.T. Hartgen. Forecasting Demand for Improved-Quality Transit Service with Small-Sample Surveys. New York State Department of Transportation, Albany, Preliminary Res. Rept. 51, 1973.
18. Multisystems, Inc. Modeling Demand Responsive Feeder Systems in the UTPS Framework. UMTA, 1978.
19. Barton-Aschman Associates, Inc. Traveller Response to Transportation System Changes. FHWA, 1981.

Research Needs

1. Traffic engineering

   a. Retrain traffic engineers: use of travel-analysis methods and coordination with planners
   b. Apply microcomputer technology
   c. Provide technical assistance in learning to apply new methods

2. Parking management

   a. Perform before-and-after studies
   b. Validate methods
   c. Incorporate parking supply into network model

3. Transit route and service planning

   a. Provide technical assistance
   b. Train personnel in planning methods
   c. Develop better packaging of techniques
   d. Validate sketch-planning methods
   e. Develop analysis methods for service substitute planning

4. Fare policy

   a. Investigate fare-collection techniques
   b. Study market segments and long-term versus short-term effects

5. Ridesharing

   a. Collect better before-and-after data
   b. Study ridesharing process
   c. Develop methods to analyze impacts of ridesharing alternatives

6. HOV priorities

   a. Investigate techniques and validation
   b. Improve dissemination (information broker)

7. Before-and-after data on automobile restraints

8. Specialized transit services

   a. Collect better before-and-after data
   b. Develop better understanding of process
   c. Develop methods to analyze impacts

9. Empirical research on demand management

10. Dissemination of experience with high-density area circulator systems

11. Local rural service

    a. Estimate impacts of rural service alternatives
    b. Determine effects of deregulation
    c. Study benefits and costs

12. Demand-responsive service

    a. Study check-point service
    b. Provide technical assistance
    c. Make before-and-after studies

13. Before-and-after data on reconstruction diversion

14. Improved coordination between planners and maintenance personnel in facility rehabilitation

15. Goods-movement data