

## SEMINAR ON RESEARCH NEEDS IN TRANSIT OPERATIONS

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At the outset of the conference session on research needs in transit operations, an attempt was made to place transit operations within a fairly broad context to increase the likelihood that the full range of research needs related to operations would be discussed. Transit operations were defined to include the operations, in the sense of provision of transport service or capacity, of conventional and new technology, including both scheduled operations and demand-responsive systems. The specific objectives for the session, as suggested by the chairman, were as follows:

1. Identify both short- and long-term problems related to the provision of public transit service;
2. Evaluate current level of knowledge in order to identify needs for research to solve transit problems; and
3. Address problems of coordinating the desires and efforts of those performing research, those supporting research, and the potential users of the knowledge generated by research.

The relation of transit operations to a broad range of problems was discussed. Transit operations, in terms of service area, routes, schedules, and so forth, are directly related to the level of transit service provided within a metropolitan area. It is the level of service that directly determines the efficacy of the system from the standpoint of existing and potential users, and it is this aspect of operations that largely determines the proportion of the transport load in the area that the transit system accommodates. This is closely related to the necessity for capacity in other modes, such as highways, and in the long term to the need for expansion of those facilities. Level of service is also related to the spatial pattern of land uses and activities in a metropolitan area, in the sense that level of service and land use patterns will determine to a large extent transit demand. Also, the quality of transit and other transportation service in an area will tend to shape the spatial pattern of land uses in the area. Thus, transit operations include one of the most significant sets of decision variables under the control of the management and planners of transportation systems within a metropolitan area.

Operations are a prime determinant of the cost of providing transit service, and, because they largely determine the need for capital equipment as well as labor, most transit costs are determined by operating choices. These operations may be very much constrained by the characteristics of any shared facilities, such as the operation of buses on public roads. Also there are institutional constraints, as may be imposed by regulatory authorities and system charters, which may take the form of requirements to provide certain types of uneconomic services, limitations on fare levels, and labor agreements. The existing level of transport technology, of course, will to a large extent limit the options with respect to capital stock and operations, and there is little that an individual transit operator can do to change the state of technology.

Thus, transit operations seem to influence the attainment of objectives of various groups upon whom fall the effects of transit service. Operations are closely related

to adequacy of service from the standpoint of existing and potential users and to a large extent determine the effect, if any, that the transit system has on the general spatial and temporal pattern of activities in an area. They also are very important from the standpoint of the transit operator himself, largely determining the level of cost that is incurred and being the primary control variable in affecting the quantity demanded and hence the revenue.

## SEMINAR DISCUSSION

The seminar discussion, as edited by the session chairman, is presented in the remainder of this paper. Every effort has been made to include all significant discussion, although the order of presentation has been altered to group together discussions of identical topics. Material on short-term research needs is presented first, followed by discussion of long-term research needs.

### Short-Term Research Needs

There are 2 major sources of problems that call for immediate solution: the transit carriers and the public. The carriers are facing a financial crisis, in which they are unable to meet operating costs with revenues. Closely related to this is the problem of the public that depends on transit, a public that in many cases finds itself without any transit service whatsoever and in other cases often finds the service to be decreasing in quality and usefulness.

Despite efforts to control costs, and the transferring of responsibility for many costs (especially some capital costs) to others, transit operators find it increasingly difficult to meet costs for which they are responsible out of revenue. Hill expressed the view, which was shared by many, that operating subsidies will be necessary in more and more cities to augment existing capital grants and subsidies. This immediately raises a number of difficult questions regarding the appropriate nature and amount of subsidies and the way in which subsidized carriers should be monitored and evaluated in terms of the efficiency of their operations. Despite efforts to control costs, costs per unit of output (for example, per vehicle-mile) are increasing, primarily because of increases in wage rates and the increasing concentration of transit traffic during the peak hours, resulting in much unused labor and equipment time.

In view of these trends, the transit industry is extremely interested in any technological or institutional innovations that might reduce costs of operation. Bond described experiments using a new bus, which has much more capacity than existing buses, thereby spreading the essentially fixed labor cost of a driver over more units of output. He concluded that adequate data on transit operations to support studies of cost and demand are lacking and that they are needed if we are to be able to identify ways of improving the economic viability of transit. Much interest in this type of short-term, readily implemented innovation was expressed by representatives of transit carriers. Many participants felt that far too much emphasis is being placed on radically new technology, which would take many years to develop and implement, and that more emphasis should be placed on more evolutionary and easily implemented technological improvements that would be of immediate benefit to the transit industry. Even simple innovations, such as the use of 2-way radio on rail rapid transit lines, are not easily implemented. Craig and Schnell suggested that more research be devoted to the writing of specifications for the design and implementation of new subsystems on conventional transit lines.

Morlok and Saltzman stated that, although technological changes such as operating larger vehicles might reduce unit costs during peak periods, they might also lead systems toward increasingly poorer service during both the peak and the base periods. This is particularly true where technological innovation cannot reduce manpower except by increasing labor productivity at the expense of quality of service. This may lead to a cycle where an innovation designed to reduce costs actually reduces the quality of service, which in turn reduces the number of riders and hence revenues, leading to a further reduction in costs through reduction in service and so on. Alternatives that attempt to increase revenue through tapping new markets and that obviate

the necessity for reducing costs, which might have the undesirable effect of simultaneously reducing the quality of services, should be explored.

Although little attention has been given to changing the institutional and regulatory constraints under which transit lines operate, there certainly are many options in this area that might reduce transit costs. One option would be the sharing of the labor, used to operate transit vehicles for passenger service, with intraurban freight carriers. This might be done by having a man operate a transit vehicle during the peak period in the morning, then using him to operate a pickup and delivery truck during the remaining hours of his workday. Another option, which would probably be much more difficult to institute, is to attempt to relax constraints on the employment of labor in 2 separate shifts. Although changing such institutional constraints may seem extremely difficult, other industries, such as the railroads, which have been faced with similarly precarious financial situations, have been able to implement some rather substantial changes in union agreements. An example is the elimination of firemen from diesel freight locomotives.

Although the tapping of new markets to increase revenue or the increasing of revenue through price changes would seem to be very attractive, a major obstacle is that very little is known about the response of the public to changes in service and fares. Although general estimates of fare elasticity have been developed, they do not seem to apply well in individual situations. Krambles presented 2 examples of situations in Chicago—on the Dan Ryan rail and O'Hare airport bus rapid transit routes—in which both fares and traffic have increased, presumably due to improvements in the service. He also discussed other cases where traffic has not responded according to the generally used rule of 30 percent fare elasticity. Both Krambles and Heathington cautioned against the use of aggregate data, such as those for the nation or an entire city, in the estimation of elasticity of demand with respect to service and price changes because many other factors are usually changing simultaneously and can drastically affect the conclusions. McDonald suggested that a major determinant of modal choice may be the status and symbolic characteristics of the modes, which would obviously favor the automobile now.

Couts presented some preliminary results from a study of the fare and level-of-service elasticity of demand for transit, based on data of patrons' behavior in Pittsburgh. One major conclusion is that people seem to value walking time 3 to 5 times as much as they value the time spent in the transit vehicle or in transferring between vehicles. This means that coverage of an area is extremely important for determining transit ridership and that coverage is much more important than the speed of the journey in the vehicle. That this is in contrast to conclusions reached on the basis of aggregate and crude analyses in the past further underscores the fact that very little is known about the effect of service and price changes on transit patronage. Maxman presented cases in which it would have been desirable to have better demand models for purposes of corridor planning.

Bingham presented some examples of the effect of certain service changes on the AC Transit system. Lower headways were introduced during the base period on some routes; however, it was found that, although riders increased their traveling, there was not a sufficient increase to make the service profitable. The AC Transit system has also experimented with advertising to build up the social acceptability of transit but has no way of assessing the effect of this factor. Bingham believes that many potential users of transit are unaware of the service available, so they do not consider the use of transit in their travel planning. Hill felt that convenience and an uninterrupted ride are important in determining ridership, but again no detailed studies of the importance of these factors have been carried out.

All this suggests that more research on the determinants of demand for transit service is absolutely essential to rational planning. There was a general feeling that the demonstration program of the Urban Mass Transportation Administration (UMTA) has been of some help in this regard but that the effects of changes have not been identified and presented in a manner that makes it possible to readily use the conclusions generally. Morlok stated that closer monitoring of the demonstration projects would be necessary in order to obtain data that are useful for purposes of identifying the factors

that influence transit use. Clearly this is essential for purposes of modeling or developing an ability to predict the effect of service changes on demand and revenue. Heathington further pointed out that it is generally not possible to identify the effect of one change if simultaneously many other changes are being introduced. Yet, very often in past demonstrations many changes have been introduced at the same time. Rather, it is necessary for changes to be introduced one at a time; the system must be allowed to respond and settle down, and the effect of the change must be identified before another change is introduced. There is, therefore, a greater need for care in designing transit demonstrations so that they will yield information on the efficacy of improvements, which can be generalized to other situations. Without this, the demonstrations are really of little value from the standpoint of increasing knowledge that would be useful to other transit operators.

Another possible approach to understanding the demand for transit service would be to survey both current riders and potential riders. Although this may yield information as to what is needed to increase ridership, it was felt that the results of this type of survey are somewhat suspect.

A major problem in carrying out any changes in transit service, regardless of the method used, is the substantial difficulty in changing the schedule or route structure of a transit system, or both. The difficulty is not in implementation; it is found in the substantial expense and time required to plan for the change, in making up the new schedule, and in assessing its impact on costs and riders. Currently, the entire process is often carried out manually, requiring many man-months of effort to institute a route change or a substantial schedule change on even a moderate-sized system. Although computer models have performed some of these functions, the models have not been entirely successful and do not perform the entire task. This is in marked contrast to the airline industry, where computer models for route structure planning, scheduling, crew and vehicle assignment, and maintenance scheduling have been developed and are now widely marketed and used. It would seem that much research with the potential for very substantial payoffs could be directed toward the development of such management and planning decision-aiding tools.

There was much discussion of transit problems and research needs from the standpoint of existing or potential users. One major source of problems from the standpoint of the user is that transit service in most cities is deteriorating in some respects, such as elimination of some routes or reduction in the frequency of service (especially during the off-peak periods) in others. As Coutts pointed out, another source of difficulties is the changing pattern of activities in urban areas. As the population and industry are spread out more thinly, the pattern of trip origins and destinations becomes much more diffused, resulting in a relatively low potential volume for many transit routes. Also, the advent of the automobile, and its convenience for shopping, multiple-person, and linked trips (trips with many destinations), has resulted in a shift of most nonpeak travel away from transit.

Large-vehicle systems, such as conventional bus and rail transit, do not seem particularly appropriate for the provision of transit service in low-density areas. An obvious alternative is the operation of small vehicles, where vehicle trips are made in response to demands. An example of this is the dial-a-bus system (of which there are many variations in form and name), in which a small vehicle is operated between the actual origins and destinations of travelers in much the same manner as is a taxicab. Riders wishing service call a central dispatcher who then assigns a vehicle to pick up the rider. The primary difference between taxicabs and dial-a-bus is that, with the latter system, vehicles are somewhat larger and are dispatched such that many travelers share the same vehicle trip, which reduces costs. The cost of dial-a-bus lies between the cost of conventional taxicab and conventional mass transit. Much research is now under way on these systems, and a few are nearing the implementation stage. Craig mentioned that some examples of this type of system already exist, such as in Manhasset, Long Island, and Mansfield, Ohio, and that these seem to be successful from a financial standpoint.

In a lengthy discussion, the merits of such small vehicle demand-responsive systems were questioned. Krambles and Hill, in particular, presented many of the reasons why

jitney operations (which are similar to dial-a-bus but do not involve call-in service) have been curtailed or prohibited in many cities. They stated that jitney operators generally choose to provide service in the same areas as the most profitable transit lines, simply diverting transit passengers and revenues and generally operating unsafe vehicles and being unwilling to provide service in low-density areas and at times of low demand. If dial-a-bus is introduced, history might be repeated.

Some members of the transit industry went further and stated that they do not feel jitney or dial-a-bus service—even with good management—has any real place in the larger metropolitan areas. Because it is not really a mass transit service in the form of operating high-capacity vehicles on high-volume routes, their firms have no real interest in this type of transit service. Although it is not clear to what extent these views are shared within the industry, this discussion clearly indicated that it may be very difficult to institute a dial-a-bus service in a metropolitan area that has an existing transit service, much less coordinate the 2 services.

This dialogue suggested a number of important areas for research that probably have not been studied in most of the work related to the dial-a-bus concept. One is the institutional problems associated with implementing such a service wherever it might be appropriate and the need for changing many existing regulations against jitneys, which would prohibit such service. Of course, these changes would have to be made in a manner that provides for the new service yet still protects the interest of the conventional mass transit operator where that is proper. It also suggests that the integration of dial-a-bus service and conventional transit service may be extremely difficult, not only from a technical standpoint but also from an institutional-organizational standpoint. Means for implementing such coordination must be carefully developed.

Of course, the overriding concern should be the development of a public transit system that balances the needs or desires of various groups for public transit service and the cost to society of providing that service. Morlok commented that each technology should be used where it is most efficient and that the overall system should be integrated in such a manner that the resulting total service is optimized. Although strong views seem to be held regarding the viability of both conventional transit service and dial-a-bus service, the conflict among these views suggests that much more needs to be learned regarding these 2 types of service, and their ability to complement one another, before rational planning and integration can be undertaken.

Bingham stated that there was little question that the transit industry could meet the requirements of the Environmental Protection Act in terms of vehicle emissions. Morlok suggested that this Act, and others like it, may have the effect of forcing a shift in travel in urban areas away from the automobile, which contributes as much as 75 percent of some pollutants to the atmosphere. If this occurs, where will the trips go—to transit, to destinations within walking distance, or will they be eliminated? Stoner wondered whether this will require enforced reductions in automobile use and perhaps rearrangement of land use patterns.

A major conclusion on which all participants agreed is that more resources need to be devoted to research in mass transit, especially research directed toward solutions to problems that can be implemented in the short term. Bond pointed out that mass transit carriers receive very little funds for research, in contrast to the massive amount of money distributed to state highway departments and their agencies for research. Federal policy in this matter seems to be inconsistent with the objective of providing adequate mobility services for all. Even those funds that are spent on transit seem to be misallocated, in the opinion of many, with far too much being devoted to the development of new technology that will be available only in the long term and that may not be of value then. Some of these funds should be used to solve short-term problems.

A closely related problem is that of attracting well-trained men and women to the transit industry. Many of the participants knew of cases where young college graduates interested in the transit industry were unable to find suitable employment. Although some of this difficulty may simply stem from a desire on the part of the college graduate to have a position of authority and responsibility before he has sufficient experience, the transit industry is clearly lagging behind other industries in attracting and retaining well-trained personnel. If some federal funds were distributed to transit

firms for research and operations planning, many of these well-trained and highly motivated persons could be hired and their talents used to improve the industry. Without such funds, the amount of money that can be spent by any individual firm for planning and research personnel is negligible. Furthermore, if such talent cannot be brought into the industry and research and planning staffs cannot be expanded, much of the research and techniques developed by the current UMTA program will not find use in the industry.

### Long-Term Research Needs in Transit Operations

The discussion of long-term research needs was considerably shorter than that dealing with short-term research needs. Perhaps this reflects the greater difficulty in identifying and being specific about long-term research needs, but probably it reflects the general concern for the viability of the transit industry in the short term.

Morlok raised the question of whether there would be any role for transit in its conventional form in the distant future. Clearly, land use patterns have changed markedly in the past and are continuing to change, and the daily pattern of human activities is changing toward less emphasis on work and the work trip and to a greater dispersal of origins and destinations. Technological advancements may make it possible for people to work at home and to work shorter weeks; therefore, the demand for transportation in the future may be radically different than it is now. If it is radically different, then existing technologies may be inappropriate in the future. Coutts suggested that, if it is desired to accommodate large portions of urban area trips on conventional transit, altered land use patterns may be necessary. Heathington raised the question of whether we should provide options in transport mode, in view of the fact that no choice is offered in many other public services, such as water and telephone. Why retain wasteful competition? Stoner further suggested that land use patterns might be altered so as to reduce the demand for transportation.

Because transportation is so inextricably intertwined with the spatial and temporal patterns of activities in metropolitan areas, long-term research should be undertaken jointly by the U.S. Departments of Housing and Urban Development, of Health, Education and Welfare, and of Transportation. Clearly the programs and policies of one will drastically affect the efficacy of programs and policies of the other.

There was widespread agreement that the development of radically new transport technologies should only follow the identification of a need for such new technology, based on expectations of travel demands in the future. Krambles and Craig expressed a concern that the federal government may be spending far too much of its resources on new technology, without knowing whether new technology will in fact be useful in the future. Craig suggested that much of the new technology may in fact be inferior to some existing technology, in particular comparing some of the newly developed people-mover systems with the PCC streetcar design of the 1930s. He felt that we have in many cases lost sight of our goals of providing mobility efficiently and have wasted much effort in attempting to develop new technology for its own sake rather than for meeting real needs.

In conclusion, it seems as though any long-term research program in urban transportation must be one that is coordinated with, if not an integral part of, research related to the general character of urban society in the future. The future seems so uncertain in terms of the spatial pattern of land uses and activities within metropolitan areas, the mix between work and leisure time, needs to curtail certain activities (such as automobile use) in order to maintain a high-quality environment, and changes in the distribution of income to provide a more equitable distribution for all that very long-term research on transport needs and technologies can only be rationally considered within a much broader context.

### CONCLUSIONS

As would be expected, there really was no general consensus on priorities among the various research topics suggested during the session. However, there seemed to be substantial agreement among many participants regarding the high priority of the following research areas:

1. Given the general feeling of high priority associated with research that would yield short-term payoff, there was general agreement that we really know very little about the response of travelers to changes in transit operations. Clearly, such response must be known to adequately evaluate various alternatives, such as changing prices, changing frequency of service, introduction of new routes, and introduction of dial-a-ride service. Existing knowledge of demand functions is based on aggregate analyses and often leads to erroneous predictions in specific situations.

One valuable tool for increasing our knowledge of demand is the demonstration or experiment. More care must go into the design of experiments so that the effect of each individual change is clearly identified. The experiment must be monitored until the system settles down to a new stable pattern, so that the effects are accurately identified and measured. These demonstrations should be consciously designed and monitored to provide information that will be helpful in estimating the demand for public transit, in a manner that enables use of the conclusions in other situations.

2. Much research is warranted in the identification and evaluation of various options within the context of conventional transit technology. Such options include increasing the size of vehicles, sharing of labor costs between passenger and freight movements, and innovative labor agreements that would cut down on labor costs. Also, much research is needed on the guidance of transit lines in the implementation of more sophisticated technology, particularly in the writing of specifications and the introduction of new subsystems.

3. There seems to be little consensus on the efficacy of innovative transport technology, such as the dial-a-bus. Much research is needed on the financial and operational aspects of such systems and on the institutional problems of implementing them or perhaps incorporating them within existing mass transit operations.

4. Making substantial changes in the operations or service of a conventional mass transit system seems to be a very time-consuming and expensive process, primarily because of the lack of tools and techniques (such as computer models) to aid management and planners in the design and implementation of such changes. Although some very useful work has been conducted in the area of operator assignment and vehicle scheduling, there needs to be developed a comprehensive set of transit management and planning tools that would deal with various problems, ranging from route structure and service area planning to detailed scheduling and maintenance. Those related to broader questions should clearly be compatible with the planning models developed by the Bureau of Public Roads and used primarily for highway planning.

5. Although there was general agreement that short-term problems are of much higher priority than long-term questions in terms of research needs, it was generally agreed that the future role of transit in its conventional form is very much in question because conclusions depend so heavily on the future form of metropolitan areas and activities within them. A long-term joint research program between the U.S. Department of Transportation and the U.S. Department of Housing and Urban Development was suggested, with transport needs as defined in that research being the basis for any long-term planning and technological research and development effort undertaken in the sphere of transportation.

6. Even in the short run, if the travel demands of urban areas are to be met well, there must be substantial cooperation among all agencies and the various modes. The Federal Highway Administration and UMTA are cooperating now on many projects, and this cooperation must be continued and expanded at the local level if the present system is to be well matched to current and future needs. Much research is needed on the best use of available road capacity, the reservation of lanes, priority treatment for buses and streetcars, and coordinated freeway-parking-transit schemes. Provided that an attitude of cooperation rather than of competition prevails, much improvement can probably be achieved quickly and at little cost.

7. To be able to use the results of research conducted by UMTA and other agencies concerned with transit and urban mobility, the transit industry must develop staffs that understand how to make use of the results of this research. Also, such staffs are needed in order to plan specific changes within individual metropolitan areas. In order to do this, the transit industry needs research and planning money, perhaps distributed

in a manner similar to that distributed to state highway departments and their agencies. This will enable the transit industry to attract the talent that is now coming from universities under the UMTA research and training program. Without such research funds and the development of such staffs, much of the research currently being undertaken might not be used.