NEW SYSTEMS TECHNOLOGY AND TRANSPORT POLICY

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"EQUALITY of opportunity for all" has been widely advocated as a fundamental goal that is essential to our society. In our modern world, this goal is directly related to the provision of relatively equal access to transportation for all residents in cities, towns, and rural areas.

After decades of dramatic economic and technological advances and a great increase in population, the mobility choices available to the great majority of the U.S. population remain remarkably limited. Within the more spatially compact cities of the early 1900s, for example, transport options of the city dweller included walking, bicycle, horseback, taxicab, streetcar, and the automobile. All of these modes were practical largely because destinations were relatively close to origins. There were more numerous and useful urban transport alternatives available in that era than there are today.

Families must have adequate mobility to allow them to commute to jobs, schools, shopping, and recreation. Today, urban mobility is almost synonymous with movement by private automobile. In the large majority of modern metropolises, persons without easy access to private automobiles are disadvantaged in a mobility sense and are thus impeded from a full participation in the society at large.

Private automobile ownership continues to increase, and more than one family in every four now owns more than one automobile. This kind of personal mobility is procured, however, at heavy and increasing private and social costs. Because there is no adequate, economic alternative for traveling around and within urban areas, many multicar owners are forced to bear the increasing burdens of insurance, licensing, taxes, and increased susceptibility to traffic accidents and fatalities. Automobile ownership requirements for urban living weighs especially heavily on the modest household budgets of the low- and moderate-income families. It is also a burden on the old and the young, who do not have ready access to automobiles or the disposable income for expensive modal substitutes such as taxicabs. In the typical middle-income urban household, moreover, the housewife must spend a disproportionate amount of her time each day as a chauffeur, driving her husband to the train or bus stop, her children to school, and herself to work or shopping or meetings.

The travel alternatives needed in suburbs and cities include the provision of public transportation services that can remove the burden of multicar ownership and required personal driving yet maintain approximately the convenience and flexibility in service that the private automobile provides. Just a few years ago, the prospects for such a practical alternative to the private automobile were not good. Conventional forms of bus or rail public transit simply were not feasible substitutes for automobiles in extended metropolitan areas.

More recently, however, stimulated in large part by converted federal efforts in research and development of new systems of urban transportation (1), several possibilities of new kinds of transportation services and systems are now available and are being explored for further development work. Each of these new concepts relies on advanced technology and management practices to decrease operating and capital costs of new systems, while improving service characteristics, in order to make them more nearly competitive with the private automobile in lower density, metropolitan areas characterized by diffuse travel patterns.

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Concurrent with these welcome developments in new systems and concepts, reported on in part by the papers in this Record, another public policy trend may be developing—one that could prove just as pernicious as the near exclusive reliance on the automobile for metropolitan area travel. Stated simply, the trend seems characterized by the tendency to throw good money after bad, to follow established and disastrous procedures in providing public transit service rather than to attempt significant changes.

The nation now stands on the threshold of a new era in federal assistance to urban transportation. The Urban Mass Transportation Assistance Act of 1970 provides a truly substantial federal monetary commitment—$10 billion over a 12-year period for broad assistance to urban mass transportation programs. The danger is that the great bulk of the new money will be used to salvage, prop up, subsidize, and reinforce the conventional transit modus operandi—to furnish a 1900 style of transit service for 1970 style of cities.

Because of individual and institutional inertial, the chances of success of the innovative over the conventional approaches to public transit services are not good, even though as amply shown by the papers in this Record many new systems and technologies are now available and ready for preliminary implementation in cities.

It seems exceedingly important, therefore, for policy-makers at all levels of government to avoid the comfortable, conventional ways of furnishing inferior public transportation services at high cost to the public purse. They should instead take a firm grasp on their fear of failure and their uneasiness with the unknown and attempt reasonable new approaches and services for the developing urban public travel markets in the coming decades.

These contentions are supported by a short synthesis of the recent and current status of urban transportation and by general estimates of future needs, priorities, and trends provided in the following paragraphs. As with most synopses, this one does not presume to be complete and comprehensive. It may, however, help to establish a useful context for the subsequent papers.

URBAN TRANSPORTATION IN PERSPECTIVE

An important fact that should not be overlooked is that the historical trend toward increased use of the automobile, a long-established phenomenon that has revolutionized all transportation in the United States, is continuing. The number of people per automobile in the nation has declined from 5.3 in 1930 to 2.5 in 1965 and no doubt will drop to about 1.8 in 1975. The number of people per licensed driver has declined from more than 3 in 1930 to fewer than 2 in 1965 and probably will drop to 1.5 in 1975.

In spite of the mounting real costs of automobile ownership and operation, the basic costs per mile remain low enough to compete favorably with conventional public transportation costs, even excluding the benefits of convenience, comfort, and flexibility of service that the automobile provides. To attempt to meet such a proven, formidable competitor as the automobile with more of the same inferior conventional public transit service in modern cities seems to be the height or depth of futility and a waste of resources.

Recent and current economic, social, and spatial urbanization patterns tend strongly to favor and reinforce the automobile as the preferred mode of travel. Familiarity of these travel patterns and demand characteristics is essential if markets for new systems and services of public transportation are to be developed and exploited in the public interest.

Metropolitan Area Travel Patterns

Present demands for metropolitan area travel exhibit large variations both over time and among locations within the urban area. Trips related to the old city center or the central business district of a metropolitan area, for example, account for a small portion of total daily travel in metropolitan areas. Yet most current systems of conventional public transit are designed to serve, almost exclusively, these centrally oriented kinds of trips.

The great majority of metropolitan trips have widely scattered origins and destinations, and growing proportions of travel activity are in the suburban areas. Short trips

predominate; about half are less than 2.5 miles in length in most cities. The problems of urban center congestion and commuter flows into and out of centers have focused much of the traditional urban transportation debate on urban freeways, i. e., the development of rail or bus rapid transit alternatives for dealing with activity center circulation and corridor movements. Although the problems generated by the geographic and temporal concentration of the journey to work are important, they constitute only a part of the total urban transportation problem today.

The very uneven spread over space and time of urban transportation demands gives rise to several public transit problems. Urban transportation services, except to a very limited extent, cannot be stored or inventoried as can other utilities such as water supply. Over time, capacity imbalances that favor one area over another contribute to shifts of activity from poorly served areas to better served ones; this fact has contributed in part to the relative economic decline of central business districts in recent years.

Travel to the CBD is an important, if perhaps exaggerated, dimension of urban transportation demand. As stated previously, however, trips to the CBD are a relatively small and declining proportion of total metropolitan area travel. Cordon counts of trips entering a CBD often include both trips that have destinations in the CBD and trips that are simply passing through the CBD. For years, traffic engineers have been insisting that adequate bypass or inner belt highways could eliminate a large proportion of the persons, and an even larger proportion of the vehicles, entering the CBD. Data collected in the late 1950s confirmed much of that appraisal. The data indicate, for example, that of all vehicles entering the CBD those merely passing through represented 62 percent of the total in St. Louis, 67 percent in Philadelphia, and an average of 55 percent in 67 cities polled by the then Bureau of Public Roads (2).

Trends Toward Diffusion of Demand

In the future, travel to the CBD is expected to continue to increase. The increase will occur at substantially slower rates than will the increase in trips wholly between other parts of the urban region. The massive relocation of homes and jobs to suburban areas has created metropolitan areas less and less dependent on one major downtown for centralized activities and functions. Not only are residences, work places, and commerce widely scattered throughout a lower density urbanized matrix, but, as these areas mature, smaller, dispersed centers are forming to take the place of many former CBD functions. In some cases even these suburban activity concentrations are beginning to show some of the signs of congestion and decline common to the CBD.

Volumes of travel between most suburban origin and destination pairs tend to be low because the diffusion of activities throughout wide areas has increased the number and location of both. High-capacity, fixed-route systems of public transportation have been losing their relevancy for many applications because of this diffusion.

The observation, however, that in the foreseeable future the chief growth in the demand for transportation will be for trips between points outside central cities (where the bulk of employment and residential growth will occur) does not necessarily lead to the conclusion that better transportation service between central cities and suburbs, or even within central cities, is unimportant. On the contrary, the demand for such service may increase in some areas because of the changing composition of employment, the growing number of central city office jobs in great metropolitan centers, the middle-class flight to the suburbs, and the growth outside central cities of job opportunities for lower income central city residents. Such changes in the composition of jobs and residents can increase the demand for transportation between central city and suburb even if overall central city employment and population are relatively unchanged. Thus the quality of transportation, which is especially poor for some groups, is a distinct matter of concern. In particular, the concentration of the poor (characterized by low education and skills) in older core areas has been occurring at the same time that job opportunities have been relocated to suburban locations, and this is one of the more serious contemporary urban transportation problems.

Demand Variations Over Time

Urban travel volumes, of course, show marked variations with time of day. Demand peaks occur twice daily, reflecting the influence of work trips in the early morning and return trips to home in the late afternoon.

If all trip purposes and travel modes are considered, roughly 45 percent of all trips in large urban areas occur during the 6 hours of peak demand—6 to 9 a.m. and 3 to 6 p.m. Usually about 10 percent of all daily person trips take place during a single peak hour from 5 to 6 p.m. The peak of travel in the morning is twice the average hourly travel; in the evening rush hour, it is 2.5 times the average. The pronounced number of work trips centering on the CBD causes a higher degree of peaking to occur there than in a predominantly residential suburb where work trips are a smaller share of the daily total.

Public transportation shows even more pronounced peaking than does travel by private automobiles; as much as 25 percent of traffic is accommodated by this mode in the peak hour. The higher peaking of transit usage places strains on capacity during the rush hour, and excess capacity occurs at other times of the day. The same phenomenon is, of course, seen in street and freeway traffic, leading to serious peak-hour capacity problems as well as off-peak underutilization.

Decline of Demand for Conventional Transit Services

Recently, ridership on conventional transit has been restricted increasingly to travel between work and home. This growing specialization in heavily peaked work trips, together with the steady outward trend of urban employment locations and decreasing residential densities, is the basis of many of the financial problems of conventional transit. In serving decreasingly relevant functions, transit has shown steadily worsening trends of patronage and profits reflected by statistics that threaten to go off the bottom of the charts. These curves, of course, have been interpreted in highway studies to support the highway construction programs, on the theory that fewer and fewer persons want public transportation (3).

Studies of user demand for travel and user preferences for travel modes have concentrated on the effects of elements such as relative speeds; purposes of trips; household-income levels; and linkages of residences to places of work, shopping, recreation, and other destinations. Gravity models and other quasi-scientific devices are used to project relationships between origins and destinations and the average length of trips. The latter is an important consideration because the average length of trip is a major determinant of the amount of transportation facilities required.

Gravity models and variants thereof depend on assumptions of free-flowing transportation. Projections based on gravity models tend to be self-fulfilling in that transportation facilities created in growing metropolitan areas themselves tend to generate traffic. At least one checkup on traffic projections, however, suggests that conventional projections of travel demand might be a dubious base for determining investment in urban transportation facilities. References to projections made by the Washington, D.C., area mass transportation study in 1957 of volume of travel into the District show that in 1965 the variable associated with an increase in travel demand, including suburban population and downtown employment, had increased substantially over projected levels. However, travel across District lines had fallen short of projections by approximately 25 percent.

Several things had happened to throw the projections off. The principal factor was that certain highways, projected in 1957 to be completed by 1965, actually had not been completed. In their absence, alternative utility locational patterns and travel linkages emerged, and the average length of trip was considerably below that projected in 1957. There is no reason to believe that the region was any worse off in 1965 regarding income and productivity, employment growth, or even travel congestion than it would have been if all highways projected for completion by 1965 had in fact been completed.

State highway departments and the federal agencies have until relatively recently paid little attention to the special design problems of urban transportation (this situation is changing) and have tended to adhere to the principle of building as cheaply as possible

regardless of social costs imposed on urban communities at large. There seems to have been an assumption that, because nearly everybody of consequence owns an automobile, there is a single-minded public devotion to perpetual construction of highways.

Growing public appreciation of the social costs imposed by past policies of highway design and construction (particularly damages to existing neighborhoods and aesthetic values) and growing public protests can, however, be expected to hasten the change in attitude already under way among highway administrators and concerned public officials.

As yet, however, forms of public transportation relevant to the characteristics of modern urban travel demands simply have not been developed, and their absence leaves a significant gap in the alternatives available for urban mobility. New departures need to be sought that will serve the fundamental characteristics of widely dispersed origins and destinations, predominantly short trips, and individual or small group service.

NEW TRANSPORTATION SYSTEMS FOR URBAN MOBILITY: SERVICE REQUIREMENTS

The intraurban transportation problems of each metropolitan area are likely to be peculiar to that area. The problems derive from the area's size, density, growth rates and trends, configuration, topography, composition of employment and other constellations of activity, income levels, existing transportation systems, organizational and political structure, and the quality of planning and community leadership. (Important distinctions exist not only among metropolitan areas but also among kinds of transportation services.) Urban transportation problems, therefore, cannot be discussed as though they were solely a choice between private automobiles and conventional public transportation, or some sort of combination of only those two types of services.

One important distinction, for example, is between small cities (500,000 population or less) and large metropolitan centers. The small cities see their main problem as one of providing adequate road space and parking facilities. This much of the problem, for most small cities, is quite manageable if the cities remain small. The principal deficiencies in such cities are likely to affect those citizens who cannot drive or afford to own private automobiles. In small cities, public transportation is now usually limited to school trips and work trips to the center.

The characteristics of conventional transit and rail commutation systems make it difficult for these systems to carry people from highly concentrated residential areas in older city cores to highly dispersed job locations in the suburbs. Even where public transit is available, this service is frequently costly in both time and money. Thus conventional transit may require a 2-hour journey each way from the Watts section of Los Angeles to major employment centers in the metropolitan area; in Pittsburgh it may take 2 hours from the Hill district, a low-income black residential area, to O'Hare Township Industrial Park, a rapidly developing industrial area (the trip by automobile takes 20 min).

Although this sort of dilemma is classified as a transportation deficiency, the primary solution in the long run should take the form of either moving jobs closer to people or making it possible for people to move closer to jobs. As things now stand, locating any large number of new jobs suitable for low-skilled people in or near ghetto areas is likely to be costly and impracticable. The second solution is currently blocked by suburban barriers against blacks, other minority groups, and the poor in general.

Many situations that appear to be solely transportation deficiencies may be resolved by nontransportation measures. Where such alternatives exist, transportation solutions may be more costly; in some cases they should be regarded only as temporary expedients. One of the most common examples is the separation of central-city ghettos from the suburban-located industrial jobs that ghetto residents might perform.

Many of the problems that now appear so formidable may well be solved in the future by the battery of antipoverty and related measures designed to raise the productivity and cultural status of currently disadvantaged groups. This suggests that public transportation solutions, perhaps, should be regarded as temporary and ameliorative. Moreover, the solution to some urban transportation problems may lie in changing the conditions and controls under which different modes operate rather than in creating new technology alone.

Private vehicles, given the considerable improvements that are possible with continued development effort, will probably be the major service for urban mobility for years to come. However, a failure of public transportation to provide a full range of services in the future will deprive much of the population of mobility and choice if trends such as those previously described are allowed to continue unchanged.

The forms of future public transportation that are needed are not, however, merely refinements of the narrowly conceived functions of rail rapid transit or express bus service for commuters or minimal local bus service for the elderly and indigent who lack resources or capabilities for choice. The potential for meeting a great many of the needs for urban transportation services by new kinds of public services does exist. These means may be at hand for providing such services through functional innovation and application of advanced technology in new systems concepts.

The requirements for new transportation services are based not only on the anticipated changes in urban travel demand characteristics, but also on a recognition of the fundamental changes that are occurring within urban society as a result of rising personal incomes, shifts in economic emphasis from goods to services, social and psychological attitudes, government financing and taxing policies, and many other dynamic variables. Thus, there should be an emphasis on service and performance characteristics, such as convenience, comfort, cost, and travel time, in programs for new public transportation services.

Adequacy and ubiquity of coverage for needed services are the first concerns in developing new transportation systems. Ideally, a set of new urban transportation systems should complement one another, as well as the existing transportation modes, in providing mobility for all urban dwellers. Combinations and variations of the same basic kinds of systems might serve all cities—present and future—regardless of size, arrangement, and other characteristics. The combined systems could provide service between all origins and destinations within urban areas.

Automobiles, buses, taxis, and rail transit systems perform many services well, and they will undoubtedly be improved by the application of existing technology and by evolutionary technical advances. It is not reasonable to expect that new future systems will replace all existing systems. Instead, the priorities for new systems should be to provide (a) service where none is currently available, (b) better service where present service is deficient, and (c) new alternatives for those who are adequately served today but who will require improved services in the future.

Of many possible new system developments that could help meet these priorities in the near future, the following three general system examples constitute a representative cross section. The type of service that each provides is described briefly. More detailed research is reported on in subsequent papers in this volume.

Demand-Actuated System

Demand-actuated public transit systems (4) have routes and schedules that are both flexible and ubiquitous. The dial-a-bus or dial-a-ride is a hybrid between an ordinary bus and a taxi. It picks up passengers at their doors or at a nearby bus stop shortly after they have telephoned for service. A central computer, part of the system for monitoring the location of each vehicle, keeps track of the location of the vehicles, the passenger loads, and the destinations. It selects the right vehicle and dispatches it to the caller according to an established optimal routing program. Thus, the system readily links many origins to many destinations. The diffused pattern of trip origins and destinations that this system most readily serves is dominant in low-density suburbs.

The cost of a taxi ride can be reduced by sharing the ride, and basically the dial-a-bus system is designed to accomplish this reduction. Data suggest that, depending on demand, door-to-door transit can serve its passengers almost as fast as a private taxi but at one-quarter to one-half the price and at only slightly more than the fare for a conventional bus.

A major point is that the dial-a-bus might do what no other transit system now does—accommodate door-to-door travel demand at the time of the demand. This means that the system would attract more off-peak business than does conventional transit. If

it does attract enough passengers, the off-peak revenue would help dial-a-bus avoid the same financial problems of conventional transit, which is used heavily only 3 or 4 hours per day. It could also help reduce dependence on automobiles, particularly the second car in urban households.

The report by Stevens and Bacalis on modification of such services in a new town and case study reports by Gustafson, Curd, and Golob on economic analyses and user preferences for such demand-actuated systems discuss most informatively the future practicality of demand-actuated systems. Potential demand for similar kinds of service in Canada is discussed by Archer and Shortreed.

Extended Area Systems

Extended area systems consist of small vehicles, each carrying about the same number of persons as an automobile. These vehicles travel over an exclusive right-of-way or guideway network, either routed over a standard network or automatically routed individually from origin to destination at network stations.

"Personal rapid transit" would provide travelers the important advantages of minimum waiting time at the origin station and private, secure accommodations. At the heart of the concept is the premise that personal transit would serve a metropolis, except perhaps for its lowest density outskirts, with a network or grid of transit lines, each perhaps a mile or two apart. This would provide accessibility and service to the profusion of origins and destinations in metropolitan areas by being more responsive to the requirements of varying population densities and future land-use patterns.

Basic issues concerning the feasibility of personal rapid transit systems, as for all new systems, are not limited merely to technological ones; they include the questions of cost and safety as well. These questions cannot be answered with absolute precision at this time, but indications are that personal rapid transit can be many times safer than the private automobile and yet cost no more than modern transit systems proposed in areas of low- to medium-volume travel demands.

The case of personal rapid transit is advocated in the paper by Sobey and Cone, and an analysis of a particular system of dual-mode transport is presented by Fichter.

Major Activity Center Systems

In all major activity centers—such as a large shopping district, a new community, an airport, an exhibition area, an industrial park, universities, or other places where large numbers of people congregate in a limited space—the movement of people and goods is today noticeably inadequate. There are several types of automated circulation systems that offer the potential for moving large numbers of people over short trips in a relatively small area. They are capable of doing so safely, comfortably, economically, and with a minimum of waiting. Because modal separation is imperative under the congested conditions of travel in activity centers, such systems must nearly always operate on some kind of exclusive guideway.

Three principal types of automated circulation systems are moving belts, "capsule transit," and network cab transit. Horizontal conveyor belts have been in use for a long time. Although they have many advantages—such as low cost, no waiting, and no operators—these belts move slowly. Capsule transit systems involve small cars or individual capsules propelled by belts or rollers or cables. Network cab transit also uses individual cars or automatically controlled capsules.

Major activity center circulation systems concepts and technologies are discussed in the papers by Stern and Maund, and Harmathy describes a novel automatic circulation system.

Finally, methods for preliminary evaluation of proposed new urban transportation systems are presented by Ayres, McKenna, and Walker. Hamilton argues for more rapid implementation of large-scale dual-mode systems rather than for continuation of the more generally assumed incremental, less capital intensive approach to provisions of new systems and technologies.

CONCLUSION

The papers contained in this Record and research on similar topics reported elsewhere make it abundantly clear that the necessary technologies and skills for these systems, or variants thereof, already exist. Much more work needs to be done, however, before the benefits of these new systems and transport service concepts can be realized in local communities.

As with any new undertaking, departures from previous tradition, especially in a tradition-minded field such as public transit, entails considerable unknowns and even risks. Relatively large public and private investments, even for dial-a-ride systems, must be made. In such instances, risk-sharing seems reasonable, and to most people the logical agency to support such risks is the federal government. An increased federal effort and a neutralized policy that does not simply put more dollars into old ratholes but stimulates innovative experiment and testing and demonstration are greatly needed if a range of urban mobility services is to be provided that is in accord with the needs of the people and the capabilities of this nation.

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