REPORT OF THE PANEL ON ECONOMICS

Prepared for the Office of Technology Assessment

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Introduction

A high level of dissatisfaction with urban transportation is indicated by the growing interest in maintaining, improving and expanding systems, despite the precipitous decline in transit [1] usage over the past two decades. That interest is demonstrated by the increasing number of communities which are subsidizing transit out of general tax funds, and the number which are giving serious consideration to installing fixed .guideway systems or otherwise expanding transit to something more than buses traveling in mixed traffic.

The dissatisfaction stems from both the disadvantages of present private automobiles and the deficiencies of existing transit.

Auto disadvantages include high capital and operating costs, the large amounts of space required for movement and parking,[2] contribution to the nation's air pollution (50 percent or more of the total), and (of recent special concern) high energy requirements, accounting for about 50 percent of the nation's petroleum consumption. Typically, congestion in urban places increases as automobiles use increases, but attempts to relieve congestion by building more roadways, at progressively higher costs, only promote still more auto travel and a new round of congestion.[3] The other main complaint against private automobile transportation is its failure to serve those who cannot afford automobiles or who, for reason of age or physical condition, cannot drive.

Meanwhile, it becomes increasingly apparent that existing transit forms are not suitable for the emergmg requirements of many urban areas. The two principal proven technologies available are heavy, large-volume rail transit and buses operating either in mixed traffic or on exclusive rights-of -what~. In addition there is "light rail transit, " the trolley car, or adaptations thereof, which is still being used in several American cities and in many European cities.

Heavy rail hardware still leaves someth!ng to be desired, as is shown by the long record of problems with the BART system in the San Francisco Bay Area. Even more serious, recent cost estimates of the new systems indicate that their full average long-run costs per passenger mile may be higher than the comparable costs of private automobile transportation. If this is so, there are two implications. First, the main rationale for building a heavy rail transit system must rest on any indirect cost advantages it, may have over private automobiles, such as lower pollution, lower fuel consumption per passenger, and less diversion of land from other purposes. Second, there is a great need for lower cost, more adaptable, fixed guideway technology.

An even more basic problem lies in the fact that large rail systems-six now existing, one under construction (Washington, D.C, area), and two which have recently broken ground (Atlanta and Baltimore),

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1 Transit here means *public transit*—mass transportation facilities available to the general public. Transit rides per year declined from approximately 17.2 billion in 1950 to 9.4 billion in 1965 to 6.7 billion in 1973. The annual rate of decline *in* 1950-1973 was about 4 percent in both periods. Between 1960 and 1970, the proportion of the labor force going to work by automobile rose from 64 percent to 78 percent. The proportion using rail transit fell from 3.8 percent to 3 percent, and bus, 8 percent to 5.5 percent (American Transit Association, reported in the United States Statistical Abstract, 1974, Table 949).

2 De pnding on assumptions concerning the average number of passengers per vehicle, the average journey-to-work at about 20 mph requires by automobile roughly six to 45 times as much road space per personas by transit bus, and 10 to 90 times as much road space as travel by multiple-unit rail car. The differentials are even greater at higher speeds. Lyle C. Fitch and Associates, *Urban Transportation* and *Public Policy* (Chandler Publishing Company, 1964, p. 14).

3 Part of the difficulty lies in the fact that street networks and access roadways of already built-up communities cannot be readily enlarged to handle the increasing volumes of traffic generated by arterials.

have been designed primarily to carry passengers from residential suburbs to concentrated central business districts. Population and employment in most of the larger central cities have been declining recently, so that this function promises to be decreasingly important. Also rapid rail transit does not meet the needs of central city residents who commute, or might commute, to dispersed places of employment either in or outside central cities.

Buses have also suffered from design deficiencies, though desi n improvements are appearing. Buses in mixed traffic are slowedEy traffic congestion, and by loading-unloading delays. Exclusive rights-of-way enable faster service, but right-of-way requirements for buses are greater than for automatically guided vehicles of the same width. The necessity of a driver for each vehicle is a major cost.

For suburban transportation needs, nothing has appeared which meets the need for random access as well as the private motor vehicle, although special services have developed to meet special needs: school buses, commuter buses and trains for channelized, mostly journey-to-work, movement.

Light rail systems (LRV) still remain in a few American cities, operating essentially as streetcars, competing with buses and auto traffic on the same roadways. UMTA'S Standard Light Rail Vehicle (SLRV) program will provide modern versions of the time-honored streetcar for San Francisco, Boston and other cities considering such equipment. It is possible some of the innovations being introduced in European cities by LRV systems may be employed in various ways as means of bridging the gap between rapid rail and buses and automobiles, following innovations already induced in several European cities.

Suburban taxi service tends to be erratic and expensive. Fares and regulations are usually designed to further the monopolistic positions of the politically potent taxi interests rather than to promote competition in the interests of the riding public. An exception is the D.C. taxi system, which is one of the cheapest in the country and indicates some of the possibilities of competitive taxi service.

Dial-a-ride systems are proving moderately successful in some communities, providing a service with fares somewhere between taxis and buses, but usually requiring substantial public subsidies. Jitneys, which still might perform a useful function, have long since been driven out of existence in most areas by a combination of taxi and transit interests.[4]

The need in urban transportation, therfore, is not only for new and improved technologies per se but also for concepts of systems which can serve unmet needs of the kinds described above, which can fit into already developed areas and into new urban communities, and which are financially and administratively feasible.

Personal rapid transit, its advocates claim, can meet such criteria. If so, it holds out great promise for improving intra-urban transportation, the convenience of urban living, and the quality of the urban environment.[5]

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[4] Regulatory commissions, which purpose to regulate the various modes, have little concern with quality of service or with encouraging technological innovation or with adapting existing services, such as bus routes, to changing needs and demands.

[5] *Definition of PRT.* P RT here refers to a system of small automated vehicles which travel on exclusive guideways and are designed to carry one person, or a small group of people traveling together by choice, from origin to destination without intermediate stops.

PRT is essentially a metropolitan-scale concept in that it would link all parts of a metropolitan area instead of linking only central cities to suburbs—the essential function of presentday rail and express bus intra-urban transit systems. PRT service thus would approach more closely the level of automobile service than do present transit services.

Chapter 1: Changing Transportation Needs

POPULATION SHIFTS IN URBAN AREAS

In the postwar period, central cities have been losing much of the manufacturing and other goods-handling activities which historically concentrated in cities. The reasons stem largely from the development of private motor vehicle transportation; these activities have gravitated to the periphery where land is cheaper, congestion less, and taxes lower. Older central cities which attained the status of national or regional capitals have continued, until recently, to provide a congenial climate for certain specialized manufacturing, cultural, recreational, and educational functions and, most notably, corporate and management functions and their attendant services. Office industries became the predominant economic activity of the large central cities. Central cities which were not management centers have tended to decline throughout the postwar period.

Middle-class white collar workers who man the office industries have been leaving central cities for residences in the suburbs. This exodus has reached flood tide. Table 1 reveals what has been happening in the 1960s and 1970s.

In brief, in the 1960s central cities of all United States metropolitan areas gained 3.3 million blacks and 19,000 whites; suburbs gained 14.7 million whites and 0.8 million blacks; the numbers of blacks and whites locating in metropolitan areas were respectively 109 percent of the total black population increase [1] and 78 percent of the white population increase.

In the period 1970-1973, central cities lost 2.2 million whites and 121,000 blacks; 139 percent of the black population increase, but only 3 percent of the white population increase, located in metropolitan areas.

One of the most striking developments is the fact that in 1970–1973 the increase in the number of white residents of the country's metropolitan areas dwindled to near zero, in contrast to the 1960's when 78 percent of the white increase located in metropolitan areas. A large proportion of the white increase apparently has located in rural areas; [2] some of it is probably in exurban counties outside the existing SMAS and ma~' be commuting to work in the SNIAS.

In the 1960s there was no net central city-to-suburban white shift for all metropolitan areas, though the central cities of the 24 largest metropolitan areas lost approximately 2 million whites who were replaced by an equivalent number of blacks.

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1 The fact that the numher of blacks locating in metropolitan areas was 9 percent greater than the total population increase is explained by the migration from non-metropolitan areas to metropolitan areas.

2 U.S. Bureau of the Census, Mobility *of the Population of the United States, March 1970–March 1974*, Current Population Reports, Series P-25, No. 273.

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‘1’ABLE *I.—Location of Black-white Population Increases, 1960-70 and* 1970-73

	19s0-70		1970-73	
	Number (thousands)	Percent of total increase	Number (thousands)	Percent of total increase
Black population increase:				
United States	3, 708	100.0	609	100.0
Metropolitan areas	4, 031	108.7	849	139.4
Central cities	3, 267	88.1	728	119.5
Suburbs	764	20.6	121	19.9
Nonmetropolitan areas	–323	–8. 7	–240	–39. 4
U.S. annual rate of increase, percent		1.8		. 9
White population increase:				
United States	18, 917	100.0	1, 825	100.0
Metropolitan areas	14, 755	78.0		
Central cities			–2, 2;;	– 12? :
Suburbs	14, 7;:	77 :	2, 276	124.8
Nonmetropolitan areas	4, 162	22.0	1, 774	97.2
U.S. annual rate of increase, percent		1.3		. 4
Total opulation increase:				
T?nited States	22, 625	100.0	2, 434	100.0
Metropolitan areas	18, 786	83.0	900	37.0
Central cities	3, 286	14.5	–1, 497	–61. 5
Suburbs	15, 500	68.5	2, 397	98.5
Nonmetropolitan areas	3, 839	17, 0	1, 534	63.0
U.S. annual rate of increase, percent		1.2		.4

Source: U.S. Bureau of the Census, Currant Population Reports: Special Studies, Series P-23, No, 48, “The Social and Economic Status of the Black Population in the United States, 1!)73,” July 1974; and series P-25, No. 537 ,“Population Estimates and Projections, ” Estimates of the Population of Metropolitan areas, 1972 and 1973, and Components of Change Since 1970.

Also significant was the rise, in 1970–1973, of black migration into metropolitan areas, and the greater degree of concentration in central cities.

These and other data also indicate:

- Significant shifts of economic activity from metropolitan to non-metropolitan areas;
- Shifts in the functions of metropolitan areas and their central” cities;
- Shifts in the location of political power, with blacks gaining in central cities and whites strengthening their numerical position elsewhere, which in turn affects the politics of mass transportation systems; and
- Decreasing concentration of population and lower land-use densities in urban areas.

The implications of these data for intra-urban travel patterns are not yet clear. The substantial shift of white populations from central cities to suburbs may increase journey-to-work travel from suburbs to central cities, in the historic commutation pattern, but there is as yet little indication of such a development.

Much depends on what will happen to employment in central cities. Employment declined in a number of the larger central cities in the early 1970s, when even white collar employment began slipping. New York City, for example, lost in the 1970 recession all the employment it had gained during the 1960s, and the decline has continued and accelerated during the 1974–1975 recession. There are indications that the boom in office industries, which has recently sustained large-city economies, may be over as (1) corporations and governments prune their managerial and white collar staffs; (2) corporations shift white collar functions out of central cities into suburbs, following the flight from central cities of middle-class whites; (3) computers replace clerical workers; and (4) electronic communications replace vis-~-vis conferences.

With all the recent metropolitan growth in employment and population locating in the suburbs, increases in intra-urban travel demand likewise are concentrated in the suburbs, but suburban development has been predicated almost entirely upon automobile transportation. The decentralized pattern of suburban settlement, with no systematic planning, has tended to scatter activity centers. Accordingly, urban residents require a "random access" form of transportation capable of carrying different members of a suburban family in different directions to different activities at different times. Of the available modes,. the automobile can best meet such requirements, though it has great disadvantages for those who cannot drive, and only the fact that suburban housewives serve as family chauffeurs enables many suburban families to carry on their multiple activities.

As Anthony Downs and others have shown,[3] urban sprawl magnifies the length and the number of vehicle trips needed to serve the urban population, in addition to being costly in other respects. Urban designers hold that more systematic planning can improve both the efficiency and the aesthetic qualit~' of urban development; [4] for example, the Regional Plan Association of New York has suggested a plan of polynucleated settlement in the New l"ork region, with more concentrated activity centers. One objective is reduction in overall transportation requirements (particularly length of trip), and arrangements whereby a larger proportion of person trips can be served by mass transportation. Other planners argue that the travel reduction made possible by even highly structured land-use development may not exceed 10 percent.[5] In any case, such patterns have gained little support from either consumers or developers thus far.

Fifteen years ago it was still thought, and hoped, that transportation planning in itself could rationalize urban settlement patterns, at least to the extent of allowing choices among different patterns predicated upon different transportation systems (combinations of modes). This belief turned out to be unrealistic for several reasons. First, attempts to formulate models which would show the relationship between transportation systems and land-use development proved

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s Real Estate Research Corporation, '*The Costs of Sprawl*, Vol. 2, prepared for the Council on Environmental Quality and other federal government agencies (U SGPO, 1974).

4 Wilfred Owens, The Accessible City, (The Brookings Institution, 1972).

5 The Year 2000 Plan for the Washington Metropolitan Area, drawn up by the National Capital Planning Commission in the late 1950's is a case-in point.

abortive. Second, several broad-scale regional plans which were formulated for New York, Washington, and other areas, and which rested heavily on specific transportation systems for their realization, failed to attract general support.[5] One reason lies in the fractionated local governments characteristic of American metropolitan areas, which make development of a consensus about regional land-use policy almost impossible, since some jurisdictions in an area are likely to be disadvantaged compared to others when such regional schemes are imposed. Third, planning and development dynamics in this country make It difficult to use transportation for purposes of implementing large-scale land-use plans; the tendency is for transportation to respond to development, rather than to be used as a force for guiding it. The one thing on which there is general agreement is that every residence, place of business and other activity center must be accessible by motor

Whiie the growth in transportation demand is heavily concentrated in the suburbs, many of the central cities still suffer from transportation deficiencies and are seeking to improve both internal transportation and links to suburban areas. The main objective is to save and expand central cities, most of which are declining in both residential population and jobs."

The new heavy rail transportation systems under construction or in planning (such as the San Francisco Bay Area,' Washington, D. C., an: Atlanta systems) have been designed primarily to ferry white collar suburbanites to central city jobs, and thus to save and expand central cities. Thus, the Bay Area system was sold by a group of downtown San Francisco businessmen anxious to preserve the dominance of the central city in the Bay Area.[8]

In view of the sharp decline of traffic on the five older heavy rail systems (New York, Chicago, Philadelphia, Cleveland and Boston) and the failure of those systems to prevent recent central city decline (though they doubtless delayed it), many critics think the new systems may turn out to be quixotic rear-guard efforts. Only time will tell.

The new transit systems have not been designed for the reverse commute—hauling central city workers to suburban jobs. It has been claimed that lack of transportation facilities in the past has prevented large numbers of urban dwellers, predominantly unskilled, from reaching available jobs in suburban factories and other employment centers, [8] but the notion that more adequate transportation would have promoted higher employment of central-city slum dwellers has never been verified.l"

There are numerous kinds of needs for special services, such as hauling people from large parking facilities and rapid transit stations to work places in central business districts, circulation in central

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6 Some cities, particularly cities of the south and southwest, are still growing. Although a majority of the 25 largest central cities declined in population in the period 1970-1973, several increased, including Houston, Miami and San Diego (large increases), and Dallas, Buffalo, Seattle, Milwaukee and Newark (small increases).

7 The Bay Area system is in operation but several facilities are still under construction and extensions, such as to the Oakland and San Francisco airports, are still under study.

8 Stephen Zwerling, *Mass Transit and the Politics of Technology, a Study of BAR T and the San Francisco Bay Area (New* York: Praeger, 1974).

9 John F. Kain and John R. Meyer, "Transportation and Poverty," *The Public Interest*, Winter 1970.

10 There is considerable evidence that the journey to suburban jobs of non-whites is considerably longer, on the average, than that of whites. But this is a problem of housing location, not of transportation per *se*.

business districts, university campuses, and new towns and new business centers, and intra-airport transportation, which need improved transportation technologies. And finally there are the special needs of the aged, the poor, and others who do not drive. The aged and the poor, particularly, are concentrated in the central cities.

DEMAND FOR TRANSIT BY INDIVIDUALS

The choice of a potential traveler between transit and auto depends on a number of factors having to do with (1) the circumstances of the individual and his household, and (2) the comparative advantages which he perceives between the transit ride and the automobile ride. The main factors are summarized in the following expression in which:

Subscripts ~ and *a* **refer to transit and automobile, respectively,**
DE= The decision respecting a particular trip,
1= Household income,
C= Number of cars owned by household members,
H= Number of drivers in household,
2'7'= Time required for trip, including walking at both ends,
V!l'=Variation in times required for individual trips
CE= Convenience, as measured by accessibility and average waiting time,
CO= Comfort,
SA= **Safety, referring both to vehicular safety and personal security,**
OF= **Other factors,**
P= hloney cost to the would-be traveler of a trip or series of trips.

$$DE=f(I,C,H),\left(\frac{TT_a}{TT_t}\frac{VT_a}{VT_t}\frac{CE_a}{CE_t}\frac{CO_a}{CO_t}\frac{SA_a}{SA_t}\frac{OF_a}{OF_t}\frac{P_a}{P_t}\right)$$

This expression assumes that the individual's choice is between auto and transit for making a particular trip. He may have other options, such as not making the trip at all, or utilizing still other means of transportation, including walking.

In comparison with auto, most transit is slower, less convenient, and less comfortable. Long-run costs and the larger social advantages of one mode over another, such as pollution, environmental damage, and so on, will not ordinarily influence modal choice save for individuals with a strong personal commitment to environmental or other social values.

Rising family income levels are also an important factor in the transit decision. Although the evidence is not conclusive! a number of studies indicate that, above a certain level, income increases will reduce the demand for transit, i.e., the income elasticity is negative.11

Although the out-of-pocket cost of making a transit trip is only one factor in the transit choice, it is nonetheless true that if transit is to attract riders who have a choice, the price of transit rides must be sufficiently lower than auto-trip costs to offset transit's relati~Te disadvantages.

As long as transit systems were forced to pay their own way, they were subjected to a competitive disadvantage against heavilj- subsidized automobiles, which contributed to their rapid decline in patronage over the ~-ears.l[z]

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11 See George W. Hilton, *Federal Transit Subsidies: The Urban Mass Transit* Assistance *Program*, **(American Enterprise Institute for Policy Research, 1974), p. 119.**

19 See Fitch, *op. cit.*, especially chapter 4; T. E. Kuhn, Public *Enterprise Economics and Transport Problems* **(University of California Press, 1962); John R. Meyer et al,** *The Urban Transportation Problem* **(Harvard University Press, 1965); Martin** Wohl, *Transportation Investment Planning* **(D. C. Heath & Company, 1972), especially chapter 3.**

The familiar vicious cycle of increasing costs + rising fares + reduced patronage + falling revenues was dramatic evidence that transit patronage is sensitive to fare levels. The old rule of thumb is that a given increase of x percent in fares will reduce patronage by $ percent. But it is also well known that peak-hour travel, which typically is dominated by the journey-to-work, is less sensitive to fare changes than off-peak travel, when recreational, social and other trip purposes are more important. This has led to proposals for multi-fare systems, with higher fares in peak hours and lower fares in off-peak. Until recently, this idea has been resisted by transit operators, but an increasing number of systems are reducing fares for off-peak and/or Sunday and holiday travel, with encouraging results.

Recognizing these facts, the National Mass Transportation Assistance Act of 1974 states that continued increases in the cost of transit to the user, particularly low-income persons, are undesirable and that therefore it is a goal to hold down transit fares. The Act also in effect provides that, as a condition for federal financial assistance, operators must reduce fares by at least 50 percent to elderly and handicapped persons during off-peak hours.

The effect of sharply reducing fares was dramatically demonstrated in Atlanta when, in 1972, bus fares were reduced from 40 cents to 15 cents. In the following 12 months, ridership increased 30.2 percent. An estimated 63.7 percent of the increase represented diversions from automobiles.[13] Since that time, ridership has continued growing, and there were sharp increases during the energy shortage in the first quarter of 1974.

One principal reason for the transit price disadvantage concerns the perceived price of automobile transportation in households which own automobiles. Once a car is purchased, a user contemplating a particular trip presumably will take into account only the out-of-pocket costs, mainly gasoline, tolls and parking charges. Costs which accrue over a longer run, such as repair costs and depreciation, will get less consideration; and those which are largely a function of time, such as insurance and garage costs, will not be considered at all. Presumably, the only time when such costs are taken into account is when the decision is made to acquire a car for a specific purpose that could otherwise be provided by transit—usually the journey to work.

The automobile enjoys a number of other price-cost advantages, in that its cost to users does not fully reflect its cost to the public. First, it is well established that the cost of providing road space in congested urban areas usually exceeds the user charges paid by motorists m the form of taxes and tolls. In addition, many of the costs of controlling traffic and otherwise serving automobiles, including costs of protection against theft, are typically met from general taxation rather than from specific automobile charges. Motorists using road space and traffic and other services are in effect subsidized from other sources. Second, automobiles impose a number of indirect costs not paid by the motorist, which are borne by the public at large or by other motorists. These typically include air and noise pollution and congestion costs.

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13 Metropolitan Atlanta Rapid Transit Authority, *Analysis of Transit Passenger Data*, October 1973.

Such costs are not communicated by the system of pricing for automobile travel in congested centers. The main user charges, aside from tolls and parking charges, are gasoline taxes. But, considered as a charge for the use of roads, the gasoline tax is a highly inefficient instrument in that the charge is the same under all conditions—for high-cost roads and low-cost roads, for peak-hour travel when the supply of road space is scarce and at slack periods when it is plentiful. Parking fees aside, it does not cost the motorist any more to drive in downtown traffic on high-valued land than on empty suburban streets or on lower-valued land. (Flat-rate transit fares are subject to the same limitations.) In crowded urban centers automobile use is held in check by congestion and the competition for parking space.

In summary, the private-car owner seldom keeps any true accounts, ordinarily pal's nothing extra for more expensive rights-of-way, does the driving himself, and thinks that his heavy bills for depreciation and insurance have no connection with the individual decision to take the car because his payment for these items is annual and not related to each trip. Neither does he take into account as a cost for the trip the cost to the community of road and parking space, policing and maintenance. He thus makes his decision on what for him may be a rational basis but which is for the total economy a fallacious comparison.[14]

Given that automobile use in congested urban places is heavily subsidized, the economic remedy is to raise the cost of driving an automobile in congestion-prone areas, and at congestion-prone times, to the point where congestion will be eliminated.[15] The revenues from such charges would in some measure meet the costs which previously have been subsidized. The main rationale of "anti-congestion pricing," however, is not to raise revenue. It is rather to tailor the demand for road space to the supply thereof, so that vehicles can move freely in the urban network.

The extent to which raising auto-user charges would shift patronage to transit has never been thoroughl~- tested; there is a need for more research and field experimentation m this area. Some shifts have been observed recently, as the cost of automobiles and motor fuel and other auto operating costs have risen. Several studies indicate that, raising the out-of-pocket costs of automobile trips is more effective in shifting travel from auto to transit than is lowering transit fares.[16]

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[14] Fitch, *op. cit.*, pp. 22-3.

[15] A number of technical means of imposing such charges have been suggested. Some employ electric vehicle identification technology. Setting parking charges at levels which discourage driving into congestion-prone areas is the only measure much used to date. Although parking charges are a rather crude instrument of control, properly used they are much better than nothing. (See Transportation Research Record, Number 494, *Problems in Implementing Roadway Pricing.*)

[16] A Rand Corporation report argues that, for diversions of automobiles exceeding 5 percent, disincentives to auto driving are about three times as effective as transit subsidies. B. F. Goeller et al, *San Diego Clean Air Project Summary Report*, Report R-1362-SD, Rand Corporation, 1973. Cited in Hilton, *op cit.*, p. 110.

Computations by Moses and Williamson with Chicago data of the late 1950s indicated that increase of direct user charges of 48 cents would divert some 40 percent of commuting motorists to other modes of travel. See Leon N. Moses and Harold F. Williamson, Jr., "Value of Time, Choice of Mode, and the Subsidy Issue in Urban Transportation," *Journal of Political Economy*, June 1963. Owing to limitations in the data and analytical technique, the findings are only suggestive, not conclusive; in any cm?, the ante has gone up considerably in the ensuing 15 years.

But while anti-congestion pricing has the support of a band of economists and transportation planners, it is anathema to politicians and the motoring public. The public has accepted the principle of special tolls and charges only as a means of paying for something visible, such as bridges and turnpikes, and staunchly resists paying for something which historically has been free, especially since they cannot see what they are paying for.

In the face of pubic opposition to raising auto-user charges to levels more nearly approximating full economic and social costs of auto driving, the only recourse, if transit is to be economically competitive, is to subsidize transit. Subsidies may take the form of **improved service,** or lower fares, or both. The level at which subsidies should be set to get the best economic results is an unsettled issue.

In principle, the subsidy per trip should be reasonably uniform for all competing transportation modes. In other words, if for historical reasons (good or bad) one mode of transportation is being subsidized by a certain amount per passenger trip, competing modes should be subsidized by at least roughly corresponding amounts per trip.:'

The difficulty of applying this principle is that the amounts of subsidy for automobile trips vary according to a number of factors, including the time at whicE the trip is taken. Second, the automobile subsidy includes a variety of indirect costs, some of which are not quantitatively measurable. The notion of matching subsidies therefore cannot be applied with and de ree of precision, though it is a useful principle to keep in mind.1

The principle most widely accepted, until recently, is that capital costs of transit should be met by public subsidies, leaving only operating expenses for the fare box. There is no particular economic reason for distinguishing between capital and operating costs, so far as subsidies are concerned, and the distinction does have the disadvantage of encouraging investments in capital intensive improvements, such as automated controls, not necessarily because they reduce the total cost of trips but only because they hold down operating costs and hence fares. (The computation of tradeoffs between capital and labor is discussed in a following section.)

The principal *ration d'i%v* for basing fares on operating expenses is not so much economic as political—the hope that public resistance to fare increases will dampen wage demands of transit labor. The hope has proved futile, and the resistance to operating subsidies is crumbling.

A number of jurisdictions are makin funds available to cover transit operating deficits. The Federal 8 rban Mass Transportation Assistance Act of *1974* for the first time provided federal funds for transit operating subsidies.

Unless the conditions for such grants are spelled out very carefully, they may be dissipated by labor demands and wasteful management practices. Such difficulties are always encountered by subsidies for

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[17] Fitch, op. *cit.*, pp. 156ff.

[18] A formula sometimes suggested calls for transit subsidies sufficient to make transit fares equal to the out-of-pocket costs of automobile operation. The formula is faulty on two counts. First, out-of-pocket auto operating costs per passenger vary widely depending on the number of passengers, the amounts of tolls and parking charges paid by the particular vehicle, and other variable factors. Second, the amount cf the transit subsidy under this formula has no necessary relation to the amount of automobile subsidy; the transit subsidy might be much higher or much lower, depending on circumstances.

operating expenses,. though the difficulties maybe minimized by having flat grants for major service units, rather than simply picking up the bill for operating deficits.[19]

Some communities have been experimenting with zero fares (Seattle, for instance, and, as above noted, Atlanta's system has used revenues from a special sales tax to reduce fares to 15 **cents,** thereby stimulating patronage. The main objection to very low transit fares is that they. encourage the use of facilities whose marginal costs (costs of hauling additional passengers) are likely to be relatively high in peak hours, though they may be relatively low in off-peak hours.

Once an expensive transit system, particularly one using exclusive rights-of-way is in place, fares should be set low enough to insure its full utilization, even though subsidies for operating costs, as well as capital costs, may be required. The economist's rule that fares should not go below incremental (or marginal) costs may be breached if (1) the social benefits of additional travel, made possible by low fares, are thought to justify the additional subsidies required, or if (2) the alternative is greater automobile use and resulting financial and social costs which would exceed the amounts of transit subsidies.

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19 This suggests as a starting point, a simple flat grant per transit passenger trip. Such a grant would at once avoid incentives to wasteful management and would encourage service improvements and ether efforts to increase patronage, thereby increasing the amounts of grants.

Chapter 2: Demand for Transit Service of State and Local Jurisdictions

ABILITY AND WILLINGNESS TO FINANCE TRANSIT INNOVATION AND DEVELOPMENT

From the standpoint of the community at large, there are a number of reasons for subsidizing transit service:

- To balance the subsidies, direct and indirect, already extended to automobile driving in congested urban centers, as discussed in the preceding section.
- To reduce the high social-environmental costs of and the large amounts of space required by automobile transportation.
- To avoid the necessity of building even more expensive highways.
- To provide such service for those physically or financially unable to drive automobiles.
- To stimulate the growth, or arrest the decline, of central cities or other built-up areas.
- To stimulate patterns of urban growth more efficient than the '(sprawl" patterns of development associated with the primary reliance on the automobile.

If transit is to be subsidized, why should not the subsidies be paid by governments of the states and localities where transit is used rather than by the federal government?

One reason is that the federal government is already heavily subsidizing highway construction and transit subsidies are needed to redress the balance.

Second, a premise of American federalism, by now generally accepted, is that the federal government is superior as a revenue collector to the state and local governments, and that it should use this power to assist lower levels of government to meet their responsibilities. This is the premise underlying the increasing grants-m-aid to state and local governments, and the recently instituted concept of revenue sharing.

Third, governments responsible for urban areas are already pressed by a multitude of competing demands and are hurting financially. Many are already subsidizing existing transit services.

State and local governments account for over 80 percent of domestic government purchases of goods and services in the United States. Total expenditures went from $49.6 billion in 1960 to $206 billion in 1974, an annual increase of 9.9 percent compounded. By comparison, the annual increase rate of the Gross National Product was 7.6 percent. State-local expenditures were 9.8 percent of the GNP in 1960 and 14.7 percent in 1974. An increasing proportion of state-local expenditures has been financed by federal grants-in-aid: 13 percent in 1960 and 21 percent in 1974.

In general, state-local government as measured by employment, grew more rapidly than any other major economic sector in the period 1960-74, and the rate of inflation was greater in the state-local government sector than in any other economic sector. (The high inflation rate was due in large part to the extraordinary increase of employee compensation rates.)

Tough state and local governments, as a class, were not pinched for revenues during the 1960s and early 1970s, the recent rapid increase of state-local taxes has stiffened taxpayer resistance to further tax, and hence expenditure, increases. Suc resistance, coupled with revenue declines resulting from the economic recession, have forced many state-local governments to retrench and to begin reducing personnel. Capital improvements are one of the first casualties.

Governments of large cities, where major transit deficiencies lie, are another matter. Their revenues have been constrained, and their costs increased., by the fact that they have become concentration centers for minority and poverty-prone groups while losing large numbers of middle-class, predominantly white, residents. In recent ears, most large cities have lost population and jobs, and most have high rates of unemployment.

Saddled with the burfens of providing special assistance and services for poverty-prone populations, they were forced to retrench earlier than other governments. After an upward surge in the early 1960s, their expenditure increases began leveling off.[1] Most large cities have been financially strapped for years. New York City, for example, faces a budget deficit of some $650 million in the current fiscal year and a larger gap in the coming fiscal year. Cleveland and Detroit were, and most other large cities recently have been, forced to follow suit.

STATE AND LOCAL GOVERNMENT TRANSIT SUPPORT

Although a few state governments (including New York, New Jersey, Connecticut, Massachusetts) are contributing to mass transit support, political forces in various states can be expected to severely limit state financial support, for the simple reason that people in areas not directly served by transit see little reason for helping finance transit. Only in areas where suburbs make common cause with central cities can there be hope of getting substantial state funds. This throws the financial burdens back on the metropolitan areas themselves. Both states and municipalities, as noted above, will be strapped for funds in the foreseeable future, with little likelihood that they will make heavy additional expenditures for new transit systems.

A survey by the American Transit Association put total state-local subsidies in 1972 at $454 million. Among communities already subsidizing transit, New York City contributes several hundred million dollars a year, including funds for operating subsidies. The state of New York is contributing some $100 million to help preserve the 35 cent transit fare. The communities served by the Boston MBTA have long shared MBTA deficits; recently the state of Massachusetts has undertaken to meet half the MBTA deficit. A number of jurisdic-

1 New York City was an exception: its expenditures accelerated in the latter 1960s owing partly to an exuberant administration, partly to the strength of the municipal unions in collective bargaining.

tions impose special property, sales or payroll taxes specifically for transit. Thus the Twin Cities XITA is empowered to impose a special property tax (replacing an earlier tax on automobiles). Atlanta imposes a special sales tax.

8 Only one area, the San Francisco Bay Area, undertook to raise funds from its own sources for a large new transit system. BART District voters in 1962 approved a bond issue of $792 million thereby obligating themselves to pay debt service from property taxes.[2] As time went on and cost escalated, residents accepted a .5 percent sales tax earmarked for BART. Still later state gasoline tax revenues were diverted to transit purposes, including support of BART.[3]

DEMAND FOR FEDERAL FINANCIAL ASSISTANCE

In the late 1950s, the American Municipal Association launched a campaign for federal grants for transit expansion and improvement. The campaign was impelled by—

- Increasing congestion in central cities, brought about in part by the new arterials constructed to bring vehicles into cities.
- The high cost of providing road space in cities, and the greater space economies of mass transportation, which can handle several times as many passengers per lane [4] as can private autos.
- The large amounts of funds supplied bv federal and state governments for highway construction and maintenance, in particular the resources of the Federal Highway Trust Fund established by the Highway Act of 1956. Municipal officials and transit proponents claimed! with considerable justification, that federal subsidies runmng up to 90 percent of costs inevitably distorted state-local decisions, skewing them toward highways instead of exclusive right-of-way transit.

After considerable pulling and hauling, the first federal legislation to provide significant capital assistance was passed in 1964. A trickle of funds has steadily increased, and the federal government now provides financing for a large proportion of expenditures for transit equipment, mainly buses, in the country today. The annual grants, by year, for the period 1965–73, are as follows:

Fiscal year:	UMTA capital (? % (% 8)
1965	$52
1966	106
1967	121
1968	122
1969	148
1970	133
1971	284
1972	491
1973	871

With funds authorized by the Urban Mass Transportation Assistance Act of 1974, the total authorization for assistance over the next six years stands at $11.8 billion.

Z At the time it was hoped that farw would cover a substantial part of the debt service.

$ BART received support from still other sources. The tunnel under the bay was financed by revenues from Bay Bridge motor vehicle tolls. The federal government has also contributed to various elements of the system.

t An arterial highway lane can handle about 1,803 cars per hour—2,400 people assuming a load factor of 1.33; buses can move 6,000-7,000 people per lane per hour; and rail transit up to 40,~ Per how.

MAGNITUDE OF POTENTIAL TRANSIT NEEDS

The concept of transit "needs" is ambiguous because of the difficulty of defining seeds. " "Needs" is a relative concept, which depends on the communit 's income level and the priority accorded transportation compare to other community "needs". From the community level, the amount of federal or state financing available is also an important factor in the community's perception of its own 'heeds."

In this discussion, the term "mass transportation needs" refers, first, to mass transportation facilities and services which, if instituted, are projected to yield benefits exceeding their costs. Since this condition might be met by several different transportation systems, or combinations of modes, in a particular community, a second condition is required—that the transportation facility chosen is the most cost-effective, which is to say the most economical, means of meeting that particular travel demand. The choice of a rail transit facility over alternative modes, for example, is taken to mean a comparative analysis has been made of all means of satisfying the articular set of travel demands, and that rail transit is considered to Ee economically referable, all things considered.

In practice, thorough projections of benefits and costs are not often undertaken. In any case, they are subject to wide margins of error, and so are projections of needs. To take one instance, the projections underlying the San Francisco Bay Area urban rail system (BART) were controversial from the beginning; many transportation experts doubted that the volume of travel and other benefits projected for the system would actually materialize. Costs escalated over the planning and construction period, and finally turned out to be about double the amount projected at the time the voters approved the project. Similarly the Washington, D.C. system is costing several times as much as had been projected when decisions to proceed with it were taken. It is likely that neither system would have been undertaken if accurate cost projections had been available for making decisions. The planned Atlanta rail system is a "need," as defined by local advocates who have convinced the community to proceed with the project, whose costs are estimated at $1.4 billion but will doubtless go much higher if they follow the precedents of the BART and WMATA systems. Again the decision may well have been taken out of a failure to foresee ultimate costs.

Given the lack of adequate cost-benefit data and other information for sound decisions, estimates of transit "needs" must rest mainly on what community officials and planners say they plan to spend for transit, if stipulated amounts of outside assistance are forthcoming. All large new systems now under serious consideration are predicated on the assumption that the federal government will put up a large share of the capital costs; present legislation now provides for up to 80 percent. The lower the level of federal assistance expected, the less will be the serious demand for a transit system and equipment. The BART system was remarkable in being financed largely by local funds.

Recent surveys by the Institute of Public Administration for the Department of Transportation indicate that the perceived need for transit facilities, on the part of state-local transportation planners, is in the magnitude of $33 billion over the next ten-year period. By comparison, the congressional fund authorization now stands at $11.8 billion, which on an 80-20 sharing basis would fund approximately $14.6 billion expenditures, less than half the indicated "need." The discrepancuy- is greater than these figures show because of the certainty that costs will continue rising. Assume they rise at the rate of 10 percent per year; the minimum amount necessary" to carry out the "needs" program is at least $53 billion. In summary, the relative data are—

	Billion
Estimated transit "needs" over next 10 yrs. (1975 dollars)	$33.0
Minimum current dollar costs of meeting "needs," assuming annual cost inflation of 10 percent	53.0
Outstanding Federal authorization	11.8
Amount of funding supportable by Federal authorization (80 percent matching)	14.6

Comparative Costs of Transit Modes

Central to policy choices in the field of urban transportation are the comparative costs of various levels of service and various transportation modes. Yet, in this field, there is little solid information on which to base judgment. Different transit systems now operating show substantial variations in operating and maintenance costs, and great differences in capital costs. New systems such as the BART and WMATA have grossly overrun original projected costs, owing partly to inflation and partly to unanticipated developments. NTew demonstration systems, notably Morgantown, have had even more difficulty with cost overruns.[5]

The situation is further complicated by the fact that, whereas art of the costs involved in a transit choice are measurable by standard statistical and accounting procedures, part of them—in particular many of the all-important social and environmental costs—are not amenable to quantitative measurement in dollar terms.

Cost comparisons are relevant, moreover, only if they involve alternative means of accomplishing approximately the same objective. While transportation systems featuring different modes (auto, express bus, rail transit, automated guideway group rapid transit, or personal rapid transit) may serve community travel needs, such diflerent systems in fact ordinarily perform somewhat different tasks and cause their service areas to develop in somewhat different ways.

Given the public apathy toward transit generally (as evidenced by the secular decline in transit patronage), transit development can be justified only if it promises to be substantially cheaper in out-of-pocket costs, or has the clear advantage of providing superior service.

Preceding studies have established, however, that the advantage of existing transit over auto is in the line haul, where large numbers of people can be carried along a corridor. Here, transit's potential advantages can be realized, including economies as to right-of-way, space required for vehicles, capital costs of vehicles, operating and maintenance costs, and fuel consumption. On the other hand, transit has a number of disadvantages, such as the fact that economies

[5] The Morgantown Automated Guideway Demonstration Project, first projected by West Virginia University to cost $18 million, has thus far cost $64 million for little more than half the system originally planned.

depend on a relatively high load factor, and the need for paid drivers or for costly automatic guidance and control systems. A subtle competitive disadvantage is in the previously discussed peculiarities of the automobile pricing system which hide a substantial part of automobile transportation costs.

The Economic Panel is therefore unable to present a systematic picture of costs, particularly operating and maintenance costs of the newer guideway systems. More information on this subject is one of the greatest needs for future policy decisions. Some light on general parameters may be shed, and perhaps some illusions dispelled, by the following data and conjectures.

The most recent comparative estimates that came to the attention of the Economics Panerwere from a study now being completed by Douglas B. Lee, a member of the panel. Lee's comparative cost data are based on the Washington metropolitan area. The first set of figures indicate the following "average long run" cost per passenger mile of three modes, assuming that each mode is utilized to 20 percent of capacity.

Average estimated long-run costs per passenger mile-auto, rail, and bus

Mode:	*Ce?lt8* per mile
Rail rapid, half in subway.	
Rail rapid, all above surface-	: :
Automobile (1.2 riders)	
Bus, in mixed traffic_	; :

The picture changes, however, if we assume that the respective s stems are built for, and charged against, peak-hour travel, which in tte Washington area is dominated by the journey-to-work. Transit vehicles are assumed to be loaded to full seated capacity.

Estimated cost of *peak hour travel on exclusive rights of way, auto, rail, and bus per passenger mile*

Mode:	*centa per* **mile**
Rail rapid, surface	29
Bus, on exclusive right-of-way	
Automobile (1.2 riders)	%
Automobiles (3 riders)_	35

The broad relations shown by the above figures are believed to be generally valid though absolute figures for different systems will, of course, vary.[6] The following observations are of particular interest. "

. Where average loading is 20 percent of capacity, rail rapid costs per mile are by far the highest cost mode. But when facilities are provided exclusively for peak-hour travel, the auto is by far the most costly *unless* the average number of passengers can be substantially increased.

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6 The relation between auto and heavy rail transit costs for eak-hour travel corresponds with computations made from cost estimates prepared for the $ ashington Mass Transportation Study in 1958 of the costs for handling peak-hour trafic by three modes—with automobiles and rail rapid transit each requiring new roadways, and express buses requiring reserved lanes and other special facilities. The per-passenger-mile figures were :

	Cent8 per mile
Automobile (1.5 riders)	1:.:
Rapid rail	
Express bus	318

(Fitch and Associates, *op. cit.,* p. 266.) The substantial differences between these figures and Lee's figures reflect both the extraordinary inflation between 195S and 1973, and the fact that the 1958 figures omit some elements included by Lee, notably environmental costs.

- Bus costs are relatively low when buses utilize existing roadways, where they are impeded by competing traf%c. Improving bus service by exclusive rights-of-way increases costs.
- Bus and rapid rail operating costs per mile are approximately equal. Where buses operate on exclusive rights-of-way, total costs per mile are approximately equal to those of rail on surface.
- About 60 percent of bus costs are in labor, and about 40 percent (two-thirds of the labor costs) are in bus drivers. (Some systems report substantially higher proportions.)
- Rapid rail is fastest, but is disadvantaged by the time and effort required to get to the relatively few stations.
- Buses destined downtown. and rapid rail. are disadvantaged by difficulties of distributing passengers to'destinations.

RANGE OF TRADEOFFS BETWEEN AUTOMATION AND LABOR

A subject of great interest among transit engineers and operators has to do with automation as a means of reducing transit labor requirements. Bus operators in particular, plagued by high ratios of operator costs to total operating and maintenance costs, collective bargaining and rising wage rates, and the always-present threat of strikes, find the idea of automation appealing. The automatic elevator is often cited as evidence that automation can produce substantial savings by replacing operating personnel.

Ignoring for the moment the politica and labor relations problems of substituting automatic controls for union labor, however, the economics of automation involve a tradeoff between labor required for a less automated system (all transit involves some degree of automation) and the amount of capital *and labor* required for a more automated system. Automation requires high-skilled labor for maintenance which at least partially offsets the greater labor requirements of less automated systems. The central question concerns the amount which can be economically invested in automation for the purpose of reducing personnel requirements.

Assume: (a) drivers compensation beginning at $15,000 a year, increasing at the rate of 7% a year; (b) a 15-year life for automated equipment; and (c) a discount rate of 7%. Under these assumptions, the present value of the driver's compensation, for 15 years, is approximately $136,000, which is the limit of an investment in automation to replace one driver (or equivalent employee). Various assumptions as to the rate of wage inflation and the level of discount (interest) rates yield the following results.

Initial wage--$l5,000 a year

Annual rate of wage increase	Discount rate (percent)	Break+ men point for labor-saving investment in automation
5 percent. ------------ --- ------ --- ----- _ ----	7	$117,274
7 percent-- -------------------- -- _ ----------		136, 700
10 percent- -------------------- -------------	;	172, 700
7 percent- -------------------- --------------	10	90,200
10 percent- -------------------- -------------	10	114, 000

54-370 O - 75 - 21

The break-even point varies directly with the level of wages and fringe benefits and the rate at which they increase, and inversely with the levels of interest rates: high interest rates raise the cost of capital equipment.

With these data we can make some illustrative conjectures respecting the benefits and costs of complete automation. We begin with an actual bus transit operation in a major city, with 2,OOO buses. It employs—

3,300 operating personnel.
700 maintenance personnel.

The number of personnel required is thus two per bus, 1.65 for operations, and .35 for maintenance.

An engineering group with recent experience in automated guideway construction estimates that the cost of complete automation, including equipment for both guideways and vehicles, is approximately equal to that if unequipped vehicles. The cost of a present-day 50-passenger bus (weighmg 15,000 pounds) is a about $60,000. Assuming that automation costs another $60,000 we have a benchmark for evaluating the possibilities of tradeoff, using the data presented in the preceding table of breakeven points.

An automated system itself requires extensive maintenance, both because of the complexities of the control technology and the very high performance standards required to keep the system in continuous safe operation. Referring back to the personnel requirements of the above-cited bus system, assume that automation could reduce the number of operating personnel required by two-thirds, but that an additional .5 man per vehicle would be required for maintenance. These assumptions would reduce the labor force to 2,800 for a saving of 1,200 or .6 employees per vehicle. Reference to the above table shows a positive payoff for an investment of $60,000 to eliminate one position. For example, assume for the eliminated position:

Starting compensation of $15,000, increasing at an average rate of 5 percent per year;
A discount rate of 7 percent; and
A 15-year life for equipment.

The discounted cost of .6 of a position is approximately (.6X $117,272) $70,400; the benefit-cost ratio is ($70,400-$60,000) l.17—not a large margin in view of the many uncertainties.

If it were possible to bring the operating and maintenance staff down to one per vehicle, the benefit-cost ratio under these assumptions would be 1.9. But observation of present systems, and consideration of union pressures and other factors, make it appear unlikely that any such figures can be achieved. The semi-automated Lindenwold line, with 75 cars, employs a maintenance force of 76 for vehicles and 55 for right-of-way, power, signals, communications, and stations—a total of 1.75 per vehicle. Another 117 (1.56 per vehicle) are employed in operations—police, passenger agents, operators, revenue collectors. The total is 3.31 per vehicle, 1.31 more than that of the bus system referred to.

The above statements, to reiterate, are only conjectural. But they do argue against blind faith that complete automation can signficantly reduce transit labor costs. Automation must depend on otYer rationales such as greater safety in operation, increased comfort (as through controlled acceleration and deceleration), and lower headways (making it possible to increase the flow of vehicles on a guideway).

Finally, a high degree of automation is required for personal rapid transit, if this is to be an ultimate objective of transit R&D.

COSTS OF AUTOMATED GUIDEWAY AND PRT SYSTEMS

At the time of this report, only two automated guideway systems more complex than simple loops or shuttles had been installed—Airtrans at the Dallas/Fort Worth Airport and the Morgantown demonstration system at Morgantown, West Virginia. The Airtrans system had not yet s%haken down, " so that no data were available on the number of operating and maintenance personnel which would be required after the shake-down period.

The Morgantown system was not yet in operation. Engineers of The Boeing Company, main contractors for the system estimated roughly that the capital costs would break down approximately as follows: right-of-way, 50 percent; vehicles, 25 percent; automatic control system, 25 percent.

Vehicles cost about $113,000 apiece, or roughly $13 a pound for an 8800-pound vehicle with a capacity of 20 (8 seated, 12 standing). Boeing engineers expressed the opinion that production in modest volume might reduce costs to roughly $10 per pound, or $85,000-$90,000 per vehicle (1974 dollars).

The fact that the development costs of the Morgantown system were greatly over original projections ($64 million has been spent on little more than half a system originally projected to cost $18 million) indicates the hazards of projecting development costs of new technologies, let alone ultimate capital and operating costs of actual systems deriving therefrom.

The point is demonstrated also in the great differences in the projected costs of constructing, equipping and operating a PRT system. The following table gives comparative data from three recent analyses: one by the Aerospace Corporation of a system projected for Los Angeles; [7] one done for the U.S. Department of Transportation of a hypothetical town (Plastictown); [8] and one by a consortium of firms headed by DeLeuw, Cather and Company, for a system projected for the Twin Cities area.[9]

The data for the last study concern a so-called "high performance personal rapid transit", elsewhere referred to as "group rapid transit", which is between the present generation of SLT systems and true PRT. The vehicles are 8-passenger instead of 4 to 6–passenger.

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[7] Results summarized in Economics and Science Planting, Inc, *Public Transportation* Service *Quality—Some program .4 lternatives*, a report prepared for the Urban Mass Transportation Administration, Department of Transportation, March 1975.

[8] *Ibid*.

[9] *Automated Small Vehicle Fixed Guideway Systems Study*, Twin Cities Metropolitan Area Transit Commission Study, March 1975. Page VII-18.

TABLE 2.—*Comparison of HCPRT Co Es ima*

	Los Angeles		Plastictown (hypothetical 1990 city)	Twin Cities
Analyst	(1)		(2)	(3)
System length (miles)	638		825	
Number of stations	1, 084		1, 600	
Per station cost (thousands)[4]	$17 -$225		$600	[5] $120–$2, 200
Guideway width (feet)	2½		10	
Guideway costs (millions per mile elevated)	1. 1		1. 1	2. 3–3. 7
Vehicle weight (pounds)	1, 800		3, 000	
Per vehicle cost (thousands)	$9. 8		$10	$100–
Modal split (percent)	10	20	14	
Patronage (passengers per day thousands)	[illegible]	2, 000	700	
Average trip length (miles)	10	10	6	
Cost per passenger-trip	. 04	[6] $0. 78	[6] $2. 60	
Cost per occupied car mile	156	. 117	. 65	
Cost per passenger-trip mile	. 104	. 078	. 43	

[1] Aerospace.
[2] DOT-TSC.
[3] De Leuw Cather.
[4] Costs of first 2 columns are in 1973 dollars; last column, January 1975 dollars.
[5] Depending on type and location of station.
[6] All costs are based on full recovery of investment as well as operating expenses.

Sources: "Public Transportation Service Quality—Some Program Alternatives," a report prepared for the Urban Mass Transportation Administration; March 1975, by Economics and Science Planning, Inc. and "Automated Small Vehicle Fixed Guideway Systems Study," Twin Cities Metropolitan Area Transit Commission Study, March 1975.

Even allowing for the fact that the cost data are on somewhat different bases, the respective projections differ greatly; vehicle cost estimates, for example, are an order of magnitude apart. It may be pointed out, however, that the $10,000 per vehicle cost estimates for PRT systems are in the cost range of high-performance automobiles, although the performance reliability for PRT vehicles would need to be much higher than for private automobiles, in addition to which PRT systems would require highly complex control systems.

The Twin Cities study vehicle cost projection is in the range of the actual cost of the considerably larger Morgantown vehicles. There is no apparent reason for the great difference between the vehicle cost estimates; if anything, the more complex pure PRT vehicles should be more costly.

There are no comparable estimates of operating costs, but data published by Aerospace engineers appear unrealistically low. One Aerospace-sponsored study cites a vehicle operating cost figure of 1.9¢ per occupied vehicle mile.[10] Average occupied mileage per vehicle is estimated at 20,000; annual vehicle operating costs thus would be $380 (1971 dollars). But if one assumes one maintenance man for five vehicles (probably a conservative estimate in view of the experience of present systems), at $10,000, the annual labor cost for maintenance alone would be $2,0OO per vehicle, or 10¢ per occupied vehicle mile for maintenance alone. Another $1,000 for fuel and operating labor costs, which seems not unreasonable, would bring total operating costs to 15¢ per mile.

Assume (a) a more realistic, but still conservative, vehicle capital cost of $25,000, (b) a 20-year life for vehicles, and (c) an interest rate of .08 percent per annum. The annual amortization charge per vehicle is $2,546, or 12.74¢ per mile. This brings the total figure for vehicle operating and capital costs to 27.7¢ per occupied mile, compared with the Aerospace projection of 15.6¢ for *total* costs, including operating and capital amortization costs of guideways and stations, shown in Table 2.

These projections and conjectures are cited only to demonstrate the unsatisfactory state of PRT cost data at the present time.

OTHER QUESTIONS ABOUT PRT

Assuming that PRT systems are technically possible, a number of other critical questions respecting them arise which cannot be answered with information now available. More extensive engineering and economic studies may narrow the range of cost projections, utilization projections, etc., but no amount of paper analysis can take the place of actual hardware development and testing, and experimentation on a substantial scale.

Critical questions include the following:

- Can PRT systems provide cheaper transportation than private automobiles? It would seem that the more nearly PRT approximates the kind of random access capability afforded by the private automobile, the more likely it is to exceed automobile-

10 Leon R. Bush, *The Economics of High-Capacity PRT Systems*, a paper presented at the National Conference on Personal Rapid Transit, November 1971.

level costs. The proper comparison is not with the present generation of automobiles but with the future generation which will be on hand by the time PRT systems can be developed and installed, and which (if present trends continue) will be lighter and more economical. There appears to be no reason why automobiles designed for urban use should be bigger or heavier than PRT vehicles, and accordingly there is no a parent reason why they should require more energy [11] PRT as the major disadvantage of requiring higher performance vehicles and complex control systems, both of which would be costly and woufd require a high level of maintenance.

. How many automobiles could be replaced by PRT vehicles? For peak-hour work trips, the number of PRT vehicles required will be some fraction of the number of automobiles, which is approximately the reciprocal of the number of rush-hour work trips they can make. Presumptively the average is between one and two, meaning that each PRT vehicle can replace no more than one to two automobiles. In off-peak hours some PRT vehicles can be employed for off-peak travel, replacing still other automobiles. t he ones replaced, however, wou1 presumptively be only those whose use is limited to the urban area served by PRT. There would seem to be an outside limit on the number of automobiles that could be replaced per PRT vehicle.

. What is the tradeoff between storing automobiles in parking lots or garages near work places, and the alternate of storing PRT vehicles in other areas where land maybe cheaper? Back-and-forth movement of empty PRT vehicles would offset part of the presumptively more expensive storage of automobiles near activity centers.

. How much social cost would PRT impose on neighborhoods in the form of noise, unsightly guideways, disruption of on-going activities, alteration of buildings, etc. ? Despite claims to the contrary, the structure for an elevated guideway in high density areas would have to carry at least as much weig t as a single-lane guideway designed for automobiles, since it would have to support moderately heavy vehicles running at short headways.

. How much road space could PRT eliminate? What with continuing urban decentralization and lower, but more homogeneous, land use densities, there will be less need for transit lines or freeways to provide access to areas of high concentration. Roadways will still be needed for motor vehicle access, goods movement, and other purposes, so that the possibilities for tradeoffs appear to be limited.

. How good a substitute is PRT for the private automobile, particularly in less densely populated areas? A PRT rid with ines spaced one-half mile apart, for example, would require trips of up to one-half mile to reach a PRT station.[12]

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11 Probably PRT vehicles would utilize a different form of energy, for example, electricity instead Of gasoline.

12 A person located in the center of a square of a grid ½ mile on aside is [2(.25)3] .6, or.% mile, as the crow flies, from the intersections of the grid, where PRT stations would be located. If he has totravel along streets laid out parallel angles to the grid, he would have to travel ½ mile to reach an intersection.

. What are the tradeoffs between PRT and various substitute transportation systems and modes? Three possible alternatives, as yet little utilized, are the following:

Uncoupled grid systems with transit vehicles running back and forth on the rows and columns of the grid, so that a traveler starting from any intersection on the grid could reach any other intersection, with only one change of vehicle. One of the advantages is that different types of vehicles might be used on the various lines of the grid, depending on travel densities, local physical conditions, and already existing facilities.

Utilization of small rental automobiles, perhaps electrically powered, which could be procured expeditiously for trips between points in the service area. (Amsterdam is reported to be experimenting with such a system, which would have the advantage of (1) utilizing existing roadways and (2) avoiding the need for high-cost guidance and control systems.)

Para-transit modes, for example, dial-a-bus systems.

Chapter 3: Justification for Transit Research and Development

What criteria can be used to decide upon the amounts of research and development funds which the Congress should appropriate to further transit expansion and improvement? As with many such questions, there are no formulae which give definite answers, partly because the benefits of R&D expenditures may not be immediately discernible, may take a different form than those originally anticipated, and may accrue to society at large instead of a particular corporation or government agency in a form which can be measured.

There are no data with which cost-benefit analyses can be constructed. The cost of obtaining specified results in this field cannot be computed in advance within wide limits. Estimates of the cost of developing PRT technology, for example, run up to $250 million; its benefits, at the present stage, are, in the view of most of the members of this committee, unpredictable.

R&D expenditures in this field, therefore, are essentially an exercise in decision-making under conditions of uncertainty. In such situations, however, there are rules for promoting desirable outcomes and reducing the probability and impact of bad decisions.[1]

The following considerations and suggestions set forth in a concluding section aim at these objectives.

R&D EXPENDITURES IN THE UNITED STATES

Estimated research and development outlays in the United States were $13.7 billion in 1960 and $32.1 billion in 1974. Defense and space expenditures, however, accounted for 55 percent of total R&D *in* 1960 and 38 percent in 1974. The federal government supplied 64 percent of R&D funds in 1960, and 53 percent in 1974. Industry funds supplied 32 percent in 1960 and 40 percent in 1974.

In the defense area, R&D expenditures were 16 percent of U.S. defense expenditures in 1960, and 12 percent in 1974. Industr~-supplied R&D funds amounted to 6 percent of U.S. private domestic investment in both 1960 and 1974,[2]

CONSIDERATIONS BEARING ON TRANSIT R & D

The following considerations bear upon the needed R&D effort in transit, and particularly for the automated guideway program:

- Industry interest in the field of transit has been greater than in many other fields, because of the hopes in the 1960s that a market would develop for new transit forms which would be lighter and more flexible than traditional heavy rail systems and avoid the disadvantages of buses operating on highways

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[1] See Ruth P. Mack, *Planning on Uncertainty; Decision-Making in Business and Government Administration*. New York: John Wiley & Sons, 1971.

[2] Source of data: U.S. National Science Foundation, reported in *Statistical Abstract of the United States, 1974,* pp. 530-2.

and streets. Several variations of automated guideway transit systems were developed and exhibited in prototype form at DOT's 1972 transportation exposition. (Transpo-72). But the market never materialized. Outside of several airports and amusement parks, there were no commercial applications of light-weight AGT systems in the United States. Industry is losing interest in the field.

. Technological development in the field of transit is similar to that of government technological applications generally. It is difficult to stimulate demand for products which have not yet been developed; private industry, uncertain as to the needs and potentia for technological applications in a field dominated by government, hesitates to undertake large R&D expenditures.

. Expenditures for transit R&D were of the ma f cent of total Federal capital rants between PY 1966 and FY 1973, but for FY 1974 andfY 1975, R&D has amounted to somewhat less than 5% of capital grants.

. As indicated earlier, the Federal government is already committed to spend nearly $12 billion in transit improvement over the next half dozen years. Total transit needs over the nexit decade are projected at $33 billion; and as much as $60 billion over the next two decades. (These projections are in 1975 dollars.) The Economics Panel's opinion is that expenditures of as much as 5 percent of the amount of projected grants for mass transit improvement would be a modest investment in improved transit technology to realize the greatest possible benefits from transit development expenditures. The amount would be equivalent to some $600 million R&D, as a corollary to the present congressional authorization of $11.8 billion. The panel points out also that it is imperative that, for the huge transit development program to benefit from technological advance, the advance must be made early in the program. The panel therefore recommends accelerating the R&D program for automated guideway transit systems, and undertaking the exploration of several technologies. We emphasize that if the results of such research are not forthcoming early, their potential benefits will almost certainly be greatly reduced since a large share of the nation's future urban growth will occur in the next two decades.

Having indicated the *amount* that may be justified, however, the panel wishes to add that productive expenditure of transit R&D funds will require much better management of UMTA'S R&D program than has characterized the program in the past. Some speci!c suggestions and recommendations toward this end are made in the final section.

- A s reviously mentioned, the two chief technologies now avaif'able are rail systems (with some distinction between "light" and "heavy") and bus. A number of communities, including the Twin Cities and Denver are interested in automated guideway (GRT) systems with lower capital and operating costs and greater flexibility than the heavy rail systems which have dominated transit development recently. While GRT capacities are less than those of heavy rail systems, the capacity specified by UMTA—15,000 per lane per hour—is adequate for nearly every corridor **in** United States urban areas today **not** already served by **mass** transit.

- The magnitude of the potential benefit of R&D is suggested by the following comparisons. The **costs** of the Washington **mass** transit system will **come** between $45 and $50 million per mile for **a** two-track system, with the **cost** of the above-grade por**tion** of the METRO system trackage estimated **at** $11.7 million **a** mile. The target figure for UMTA'S GRT project is $3.0 million for above-grade, single lane guideway, **or** $6.0 million per mile for **a** two-track guideway, and $8.0 million **a mile** for the complete system.

Recognizing that these **two sets** of figures **are not** strictly **com**parable (the WMATA guideway figure includes land **costs,** for **exam**ple), the UMTA target **is a cost** figure of **no more than half, perhaps ress, of the cost of present heavy rail systems. however it should be emphasized that such savings apply only to systems which can be constructed above ground. Once It becomes necessary to put** AGT underground, guideway **costs** may approach those of **conventional rail systems. More research is needed respecting the problems of deploying GRT in already built-up areas.**

Another question lies in the area of operating costs. While the weight of the so-called light transit vehicles may be less than that of conventional buses and rail cars, the weight per passenger of systems developed thus far approaches that of conventional systems. Without a reduction of per passenger weight it will not be possible to reduce energy costs of operation. Table 3, below, shows the comparative weights of various transit vehicles.

TABLE 3.—*Comparative weights of various transit uehicles*

	Lm~ty	Area (Sq. feet)	Empty weight (pounds)	Weight per sq. foot	Maximum passenger load 1	Loaded weight per passenger z
BART. ----------------	75.0	787.5	59, 000	75	240	395
Lindenwold -- -----------	67.5	675.0	72, 000	108	169	600
Washin ton Metro ----- --	75.0	765.0	72, 000	94	221	475
Ford 8A T--------------	24.7	165.5	12, 500	75	48	410
Mor antown-- ----------	15.5	103.8	8, 600	83	21	565
AIR?I'RANS (Dallas/ Fort Worth Airport) ---	21.0	147.0	14, 000	95	60	403
Westinghouse (Seattle-Tacoma Airport) - _ ----	30.5	265.4	20, 500	77	120	340

1 Based on maximum possible loading.
z Ratio equals loaded weight divided by the number of passengers.

. Another **measure of potential return on transit** R&D lies **in the possibility of reducing the needs for urban arterial highways for peak-hour transit. The cost of a six-lane highway, in an area with an average population density of 6,000 per square mile, is of the rnagnitucle of $25–$30 million per mile, of which $14–$16 million is for construction. The capacity of such a freeway assuming average loading of 1.2 persons per auto, is less than** the target capacity specified by UMTA for the automatic guideway project.. If UMTA'S cost targets of $4 million per one-way system mile could be achieved, a saving from reducing highway construction by one mile would pay for four miles of two-lane transit line, of somewhat greater capacity. Land costs for GRT would also be lower.

- The hoped-for payoffs of R&D are two. First is a much deeper knowledge of the nature of transportation needs in present and developing urban communities and the technologies by which needs may be most effectively served. Second are improved technologies which can meet future as well as present transit needs in many urban areas. At the least, there is bright hope for improvement of propulsion systems, braking systems and other hardware which will improve the serviceability and comfort of the next generation or transit vehicles. Further in the future is the potential of a true personal rapid transit technology, which should go far toward overcoming the disadvantages of and inadequacies which characterize today's urban transportation systems.
- The panel warns that transit R&D is a high-risk investment. It is not yet certain that quantum advances are possible. In the panel's estimation, however, the potential payoffs of a well-managed R&D program justify the risk.

GENERAL RAD POLICY

The Economics Panel concurs with R&D expenditures of up to 5 percent of federal appropriations for transit, providing that program objectives are more clearly defined and more emphasis is given to the purposes to be served by different transit modes, the environment in which they must operate, and the kinds of new technological developments most needed.

The Economics Panel is concerned with the lack of knowled e respecting specific transit needs in American cities, how new technologies might be adapted to already built-up areas without incurring the enormous costs of going underground, and how they most effectively serve new developing areas. One panel member expresses his concern as follows:

> Deployment studies should be the main focus of PRT research because it is not certain that present hardware development objectives, even if they achieve fractional headways, would be useful for major metropolitan systems in the United States. Extensive research and development in improving the suspension, propulsion, and control hardware on PRT systems wou Yd seem to be premature until it is clear that they would be useful when perfected,
>
> Application studies should be conducted across a wide range of cit)' sizes, densities and configurations. In each case, actual PRT systems should be laid out and planned on the assumption that technological im movements can be made available. Simulation studies should be conducted to the extent necessary to determine best control of system strategies, vehicle deplo~'ment strategies, best highwa~' planning strategies, etc. The results would provide better insights into such matters as:
>
> 1. The headway required for transit vehicles to be effective under different situations; (Perhaps fractional second headways are not needed after all.)
> 2. The number of stations required under different conditions;
> 3. The number of tracks needed and the dimensions of stations in central business districts, outlying residential areas, and other major commercial areas;
> 4. The line spacings appropriate under different city sizes, densities, and configurations;
> 5. Research on public acceptability of new hardware in various areas in actual cities.

Another panel member believes that great emphasis in UMTA'S overall program should be on rationalizing urban transportation policy in such a way as to create a climate that is conducive to the success and growth of transit alternatives.

For example, full cost pricing-especially during peak periods— of existing transportation would have much more impact on urban transit than the most exotic, attractive and functional new technology. Anything less would leave UMTA with an increasingly expensive sector to subsidize, less flexibility in responding to urban transit needs, and little opportunity to introduce new technology into a friendly environment.

Another panel member also questions the priority of more hardware R&D at this stage. He says:

The main (research) issue is whether there exists a set of transit performance characteristics that, at any non-negative price, and at existing or expected automobile trip prices, wil 1 lead significant numbers of persons to choose transit rather than automobiles for urban trip s during congested portions of the day.

It would seem, then, that the requisite research would divide rather naturally into the following parts:

1. The first part would be some sort of a parametric simulation to determine if any vector of transit characteristics, including price, exists which might have some chance of attracting large volumes of riders, with or without changing the price structure for automobile trips.

2. If such a vector is found, the second step would be to undertake the hardware and system research required to determine whether a system with the desired characteristics can be produced and operated at costs which would make it consistent with acceptable fares and subsidies.

3. If a system appears technically feasible, the third stage of research would be to desi n and deploy that system in an environment in which both the technical anJdemand characteristics of the system could be tested. The purpose of this step would be to validate both the market simulation and the technical research. If the system proved effective, further deployments could be executed.

The major difficulty with the research program outlined by the panel report is the inadequate emphasis on demand and the excessive emphasis on the hardware and system side. There is little point in designing new hardware or systems unless there is some indication that the system would attract riders at some economically reasonable price.

SUGGESTIONS FOR TRANSIT RESEARCH MANAGEMENT

Various members of the Economics Panel sumgested that the UMTA R&D program in the past has lacked focus and direction and that more attention should be given to improving research management and to strategies for encouraging the development and adoption of new transit technologies. The panel lacked time to formulate a comrehensive set of suggestions, but contributed a number of suggestions For improving research management.

Broader Views of Transit Functions.—As to UMTA'S proposed research on automated guideway transit, the Economics Panel has expressed four main concerns.

- It was generally felt that the proposed GRT development program, which will select one of three quite different technologies for actual development and demonstration, will incur the risk of freezing GRT technology before the principal alternatives have been sufficiently explored.

- **There is some danger in the proposal that the firm selected to build the prototype system in Phase 2 of the GRT project will gain a monopolistic position in the transit supply field. Such a development, it is felt, would be prejudicial to the interest of both potential future transit suppliers and the urban areas which are the potential customers for new transit technologies.**
- **The proposed technique of selecting firms for R&D does not afford sufficient incentive for firms to develop products in the hope of marketing them thereafter. Partly because of disillusionment over the failure to develop a market for new technologies, firms tend to regard R&D projects as ends in themselves, from which to extract as much profit as possible. Such an attitude is not conducive to the innovative, yet practical, product development at which American industry presumably excels.**
- **The Economics Panel wishes particularly to emphasize demonstration projects should not be exploited for political purposes of the incumbent administration, nor for public relations purposes of the supplier or of UMTA. Both the Morgantown demonstration project and the BART system have suffered as a result of pressure to rush them along and to open them prematurely.**

Specific Long-Term Objectives.—The present "HPPRT" program, is felt to be lacking in specific long-term objectives. A principal objective mentioned by UMTA is the ultimate development of PRT technologies, It is not clear how the proposed project would contribute to this long-term objective, or what the next steps would be. Also, there is no plan for utilizing the results of R&D thus far, nor the results of the proposed project, The most pressing present needs, on the other hand, are ones to which light-weight GRT systems may be applicable.

Increasing Incentive for Suppliers.—UMTA should examine the possibility of aggregating markets for transit systems and transit hardware as a means of increasing incentive for suppliers to undertake R&D on their own and enable realization of economies of large-scale production. Market aggregation could be achieved in several ways. One way is to induce several communities with similar needs to contract with a supplier or suppliers for specific items, which may range from whole systems to specific hardware. Such a buyer consortium would presumably use mutually agreed-upon specifications in soliciting bids from suppliers. (The following recommendation has to do with the development of specifications for such purposes.) UMTA'S position as a major source of funds for transit development places it in a strategic position to encourage such consortiums.

Specifications.—One of **the objectives of the research program should be the development of specifications for automated transit systems and components thereof. It was noted that many elements of transit technology are still in the experimental stage. (Even the rail systems which have recently begun operating, notably Lindenwold and BART, have experienced much trouble with design and performance of various hardware components.)**

- Primary attention should be given to developing specifications for requirements of transit systems overall, environmental aspects (for example, designs which can be adapted to already built-up areas), and hardware components.
- Also needed are better evaluation criteria for determining whether performance specifications have been met.

Deployment Dernomtrationx.—Once a new technology has been developed, UMTA should take the responsibility for seeing that it is adequately tested and demonstrated in real-use situations. This involves projects which will put the technology to actual use. For example, the next round of development in GRT systems might be utilized to meet some such common need as connecting a large parking area to a central business district. University campuses offer a good testin ground for transit development. The unfortunate experience with Morgantowm should not preclude deployment demonstrations on other campuses.

Incremental Building. -Such deployment demonstrations may serve as building blocks for testing larger systems. For example, a technology which has proved successful on, say, a university campus might be employed next in a small urban community as a second development stage, and in a still larger community as a third stage. Or transit systems may be built incrementally, perhaps in $100-million units rather than billion-dollar units. In this connection, the experience of Toronto, which started with a four-mile line along Yonge Street, is instructive, Baltimore and Buffalo are using such a strategy at the Present time.[1]

Continue and Expand Present Systems.-UMTA should make sure that the utmost benefit is derived from projects already mounted. This means learning all Possible from the Morgantown. Dallas-Fort Worth, BART, and other new systems. In particular, a' system such as Morgantown should not be written off as an unfortunate mistake but should be continued and, if possible, expanded to the point of making the project useful for learning purposes as well as for practical **DurDoses.**

Personal Ravid Transit.—Finallv, it should be recorded that one member of the' Economics Panel, ~. 'Edward Anderson, feels strongly that personal rapid transit is so promising, and the need for it so imperative, that a significant portion of federal transit R&D should concentrate on bringing the technology and planning methodology to fruition within the shortest practical time consistent with good management practice. He believes that the concept is feasible technologically. Other members of the panel are skeptical about the possibility of developing dependable, economically feasible PRT within the foreseeable future.

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[1] **One panel member objects that "the deployment demonstrations suggested simply do not contemplate the kind of environment necessary to make the necessary market tests."**

APPENDIX

COMPOSITION OF THE PANEL ON ECONOMICS

Dr. Lyle C. Fitch, Chairman
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Lyle C. Fitch is president of the Institute of Public Administration, the nation's oldest nonprofit governmental research and consulting organization. He has held numerous municipal, state and federal offices, including City Administrator of New York City. He holds a Ph.D. in economics from Columbia University and has taught at Columbia, City University of New York, Wesleyan University, and elsewhere, In 1961 he directed a study of federal urban transportation policy, commissioned by HHFA and the Bureau of Public Roads, which provided important inputs to the first federal urban mass transportation act.

Dr. J. Edward Anderson
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J. Edward Anderson, Ph. D., P. E., Professor of Mechanical Engineering, University of Minnesota, on leave as consultant to Regional Transportation District, Denver, Colorado. BSME, Iowa State University, 1949; MSME, ~Tniversitlr of ~~innesota, 195,5; Ph. D., Massachusetts **Institute of Technology, 1962. General Chairman, International Conference on Personal Rapid Transit. Editor,** *Personal Rapid Transit. Personal Rapid Transit II.*

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hlr. Deen has served as principal-in-charge of comprehensive transit and urban transportation studies in many large cities of the world including Washington, D. C., Atlanta, Baltimore, Caracas, Honolulu, and Sao Paulo. He formerly was director of planning for the federal agency which developed plans for the l$rashington Nfetro now under construction. His writings have been published in most of the professional journals in the urban transportation field.

Dr. Paul K. Dygert
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Dr. Dygert has engaged in teaching, research, and consulting in transportation economics and financing. Recently he undertook a financial feasibility analysis for a proposed personal rapid transit system, and conducted a study for urban mass transportation needs and financing which the Secretary of Transportation transmitted to the Congress in July 1974. He has also undertaken transportation studies for international, state, and local agencies.

Dr. Aaron J. Gellman
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Dr. Gellman, since 1972, has headed his own research consulting firm and has servdd as adjunct professor in the Transportation and Regional Science Division of the Wharton School of Business, L"niversity of Pennsylvania. Formerly, he was vice president for planning at The Budd Company, Philadelphia. B.A,—Economics, L'niversity of Virginia, i$lBA-Transportation, I_~niversity of Chicago and Ph.D.—Economics, M.1.T.

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Mr. Hicko~ has been responsible for market lanning and development for ound transportation since the inception of L{V's commitment to this area. Ee has been closely associated with the development of the AIRTRANS system at the Dallas/Fort Worth Airport and the licensing of this technology in both Japan and France. He has lectured extensively on automated transit.

Dr. Douglas B. Lee
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Dr. Lee was formerly at the University of California, Berkeley, where he taught City Planning and conducted research in the comparative costs of urban transportation modes. After a year's work on Fairfax County's land-use planning program, he will join the faculty of the University of Iowa.

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Sumner Myers, a graduate of M. I. T., is a director of Urban Systems Studies for the Institute of Public Administration in Washington, D.C. and the author of numerous publications on technological innovation and transportation. He was a participant in HUD's study of transportation technology and editorial advisor for the final report, *TomorrotL$s Transportation.*