LET'S ATTACK THE REAL URBAN TRANSPORTATION PROBLEM

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This paper examines different interpretations of the transportation problem and its solution and argues for an interpretation that takes as its point of departure the near term and the present supply of urban transportation resources and that gives greater weight to the economic forces influencing the behavior and performance of the urban transportation market. It suggests a range of noncapital and low-capital alternatives that reduce the demand for vehicle trips, increase the effective capacity of existing systems, or do both. Policy considerations and the advantages and obstacles of the low-cost approach are discussed, and policy implications are developed.

•THE DEMANDS for transportation services continue to strain the capacities of urban transportation systems, particularly during the peak hours. Transportation planning has consisted essentially of forecasting demands for 20- to 30-year periods, determining the capacities that would be needed to provide the desired levels of service, and designing systems accordingly. The planning approach, the institutions, and the financial assistance programs are geared to long-term, capital-intensive improvement programs that emphasize pure technologies, e.g., roads for private automobiles and rail transit systems operating on their own rights-of-way.

In the process of pursuing the Golden Age when a system scheduled for completion in the relatively distant future will provide optimum service, we tend to overlook the present and the immediate future. On the one hand, we overlook the capabilities of our present urban systems. As the result of previous investments, we have excess capacity in terms of both rights-of-way and vehicles during the off-peak, or 80 to 90 percent of the time. More surprising, we also have sufficient capacity during the peak periods to provide much higher levels of service if we would only use our transportation resources more efficiently (average automobile occupancy during the peak is 1.2 or less). On the other hand, we overlook the urban institutions (e.g., regulatory practices) and the characteristics of urban travel demand that contribute to poor performance (e.g., automobile travel tends to be highly concentrated in a relatively few corridors, especially during peak hours). An examination of the demand for and the supply of urban transportation services within the institutional setting reveals a continuum of alternatives to capital-intensive programs. They range from noncapital (e.g., charging economic prices for travel and parking in congested areas) to comparatively low-capital alternatives (e.g., separate rights-of-way for buses and possibly for car pools and consolidated pickup and delivery of small freight shipments) that could improve performance by reducing peak-hour demand or by increasing the people-carrying capacity of the system or by doing both. Not only would more efficient use be made of the existing system but also the suggested shift in emphasis would reduce damage to the environment, consume less energy, cause less disruption to urban form, expand the range of future options by preserving flexibility, and reduce future capital needs. In fact, unless existing systems are used efficiently, estimates cannot be made of the capacity needed for efficiency in the future and the levels of investment necessary to attain it.

OPPOSITE APPROACHES TO THE PROBLEM AND THE SOLUTION

Theory and Practice

Congestion has been considered the urban transportation problem in U.S. cities for more than 2 decades, particularly during the journey to work. To quote Meyer, Kain, and Wohl (1, p. 5):

> The focus is on the problem of moving passengers into and out of cities during the peak or rush hours, occurring morning and afternoons on weekdays. It is these movements that tax the capacity of existing urban transportation facilities and create the congestion and delays that most people associate with . . . the urban transportation problem.

In the same view, Netzer states (2, p. 138):

> The urban transportation problem, however, can be more narrowly defined. Public policy is concerned with travel at the times and along the routes that involve congestion and additional investment to improve service.

Creighton (3) is more comprehensive: "The urban transportation problem is the summation of things which people don't like about transportation." He places congestion at the top of the list, which includes noise, pollution, and accidents, and emphasizes "problem-reducing actions consisting of investments in new facilities . . . to provide new channels of movement."

In short, the problem is congestion, and the solution is additional capacity. [Some of the other difficulties associated with urban transportation are related to congestion. For a given number of vehicle-miles traveled, progress in reducing congestion will also reduce urban goods movement costs, environmental degradation, and fuel consumption and possibly improve the financial position of bus transit if improved service attracts more passengers. Pratsch gives an excellent discussion of the opportunities to significantly reduce peak-hour vehicle-miles of travel (VMT), congestion, air pollution, and energy consumption by comparatively modest increases in peak-hour automobile occupancy (4).]

Urban transportation planning in the United States has been oriented almost entirely toward long-range, capital-intensive programs to expand capacity, especially highway capacity. Based on 20- to 30-year forecasts of urban population, boundaries, and peak-hour travel volumes on the one hand and on the levels of transportation service specified to meet urban goals on the other hand, the estimation of future capacity and design requirements, present capacity and design deficiencies, engineering (construction) requirements to meet future demand, and "needs" or the dollar costs of improvements and additions to existing capacity was seen as a fairly straightforward process (5, 6, 7).

Results

The results of this approach to urban transportation planning are described in the 1972 National Transportation Report (8). Total federal expenditures on urban highway construction amounted to approximately $21 billion during the period from 1957 to 1970. The total street and highway mileage of municipalities was 560,000 miles in 1970, an increase of 30 percent from 1960. On the other hand, electric railway track mileage in 1970 was 2,100, a decrease of 32 percent since 1960, and round-trip motor bus route-miles were 112,700 or an increase of only 4 percent since 1960.

In contrast, the amounts obligated to make more efficient use of existing systems through fiscal year 1970 were $8 million under the Traffic Operations Program to Increase Capacity and Safety (TOPICS) funded by the Federal Highway Administration, while the amounts authorized for TOPICS were $200 million each year for 1970 and 1971 and $100 million each year for 1972 and 1973 (9). For the urban corridor demonstration projects, $2 million of obligations were shared evenly by FHWA and the Urban Mass Transportation Administration in 1970. Subsequently, an additional $12.2 million was obligated for the corridor program ($9.7 FHWA and $3.5 UMTA) and approximately $250 million for TOPICS during the fiscal years from 1971 to 1973. Adding the amounts authorized or obligated for bus purchases still leaves the federal contribution to efforts to make better use of existing facilities up through fiscal year 1973 at something less than $2 billion.

As a result of substantial investments in rights-of-way and vehicles in the past (especially since World War II), we now have an impressive collection of assets. Excluding all of our freight systems and our urban transit, commuter rail, and potential commuter rail systems and concentrating only on our passenger motor vehicle systems, we had in our urban areas in 1972 560,000 miles of right-of-way, of which approximately 48,000 miles are major arterials and approximately 9,000 miles of those are freeways or expressways (10); 70 million automobiles, or slightly more than three-fourths of a total of 90 million registered in the United States (8); 175,000 taxicabs (8); 50,000 transit buses and trolley coaches (8); and 39,000 intercity buses, of which a large proportion probably could be used to provide commuter service (11).

The new facilities—i.e., the highways—constructed in urban areas during the past 2 decades have increased the range of mobility for automobile owners and have made it possible for people to commute longer distances and to enjoy higher average speeds during the off-peak hours. And although average peak-hour speeds frequently have been higher, the peak-hour users generally have not enjoyed for long the levels of service for which the facilities were designed and which the commuters anticipated, e.g., level of service A or B and volume capacity ratios ≤ 0.7 or from 0.7 to 0.8 respectively (12). Partly because of their propensities to attract traffic from other routes and to generate additional vehicle trips, levels of service regarded as high, acceptable, or even tolerable (i.e., level of service D and a volume-capacity ratio ≥ 0.9) have been maintained by continually adding to capacity (or by increasing effective capacity via traffic engineering improvements).

However, the gains from the urban highway program and from private automobile travel have been purchased at high social costs with respect to displacement of families and businesses and disruption of personal ties, damage to the environment and consequently to health, and consumption of fossil fuels. Moreover, these social costs have resulted in constraints to the highway solution. The constraints now exist in a number of forms, but especially in legislation passed within the last 10 years to mitigate the displacement and environmental impacts of transportation, in highly organized citizens' revolts against urban freeways, and in the evolving measures to conserve energy. We can safely assume that over the long run these constraints will become stiffer and that new constraints will be added.

Capital and Noncapital Approaches in the 1972 National Transportation Study

Two different approaches to improving transportation performance were highlighted in the 1970-1990 National Transportation (or Needs) Study, particularly in the treatment of urban transportation. The purpose of the study was to obtain estimates of 1980 and 1990 total capital needs (to include replacement as well as additional capacity) based on local goals, desired levels of service, and federal guidelines and to obtain proposed capital improvement program (CIP) priorities based on project costs and different levels of federal funding. The methodology employed in the study was based on the techniques used to estimate highway capacity needs (6). When the guidelines were prepared to assist the cities and states to respond to requests for urban public transportation information (13), it became apparent that

1. Given the desired levels of service, the cost estimates would be quite sensitive to the values assumed for key parameters such as average automobile occupancy, modal split, and the ratio of peak to off-peak travel; and
2. These parameter values would depend on a number of public policy and administrative decisions in each city with respect to the regulation of public transportation, to transit vis-a-vis automobile levels of service, to transportation pricing and financing, to parking policy and parking rates, to scheduling of work hours, and to many other local decisions relating to environmental quality, land uses, and urban form.

Consequently, the guidelines (13) requested the cities to consider to what extent their 1980 to 1990 goals and desired transportation service levels could be achieved—and their capital needs reduced—by a number of noncapital and low-capital alternatives. Noncapital alternatives were assumed to require no net investment to implement, for example, changes in transit regulations, staggering of work hours, changes in parking rates, and certain other pricing changes. Low-capital alternatives were assumed to require some capital costs but no additional rights-of-way, for example, traffic engineering changes, modification of streets and highways to give priority or exclusive use to buses, and the purchase of additional vehicles.

The information provided by the cities and states is found in the 1972 National Transportation Report (8). For urban areas of 50,000 population and more, the total unconstrained urban transportation capital needs reported for the period from 1970 to 1990 are $232 billion, of which 73 percent are highway needs (Table 1). For CIP alternative 3, the total urban transportation public capital expenditures proposed (Table 2) were slightly more than half the amount of the unconstrained needs. (Under alternative 3, the states and cities were requested to indicate their proposed CIPs for the period 1974-1990 under the high federal funding level of $140 billion, i.e., a federal matching ratio of 66⅔ percent for all eligible capital expenditures, no support for operating costs, and complete flexibility to allocate transportation funds between rural and urban areas, among local programs, and between modes. Alternative 2 provided the same level of funding as alternative 3, but allowed no flexibility to reallocate funds among programs. Alternative 1 also permitted no flexibility and provided $70 billion federal support.) However, for both the needs estimates and CIP alternative 3, the highway-transit mix is relatively constant; approximately three-fourths of the expenditures are proposed for highways. Similarly, the proportions of public transit funds to be devoted to rail transit—79 percent and 72 percent respectively—are roughly the same. The data given in the tables reveal the greater capital intensity of passenger travel in larger cities. Expenditures per capita are an increasing function of city size, and the percentage of rail to total transit needs and expenditures is higher in larger cities—especially those in the 1-million-and-more group.

To induce the urban planning groups to give serious consideration to the use of noncapital and low-capital alternatives and to get a better picture of the extent to which planners use (or even consider) nonbuilding solutions to urban transportation problems, a request was made that urban planning groups complete a table indicating whether they employed, attempted, or even contemplated the use of noncapital means to improve transportation performance (Fig. 1). A summary of the results is given in Table 3. The findings of the survey support the contention of this paper, i.e., that we have only scratched the surface in our attempts to employ nonconstruction alternatives—particularly economic incentives—to improve transportation. It is significant, however, that the most extensive use of noncapital alternatives to date has been in the most densely populated areas, where environmental and congestion problems are the worst and the costs of CIPs are the highest (1, 14).

The Problem Reconsidered

Given our previous investments in urban transportation resources, the existing stocks of assets, the number and the range of noncapital and low-capital options open to us, and our failure to exploit these options except in a relatively small proportion of our cities and on an individual and ad hoc basis, we can clearly obtain substantial improvements in transportation performance without massive CIPs, particularly without doubling urban highway mileage by 1990 to 647,000 miles at a cost of $170 billion (1969 prices) to satisfy 1990 needs (8, 10).

To repeat, the conventional approach has not solved the problem. The reason it has failed is that the problem it is attacking—congestion—is but a symptom of our failure to attack the more basic problem—poor use of urban transportation resources. In other words, the problem involves not capacity but economics. The best example of this is the way we treat highway resources. When a capital improvement program is completed, the product—the highway—is not used very productively, for there is excess capacity during the peak hours as well as during the off-peak hours. As a case in point, the Washington, D.C., Metropolitan Council of Governments recently estimated that during the morning peak period every weekday the number of empty seats in passenger cars entering the District of Columbia exceeded the number of transit riders entering the city. There are other shortcomings to the emphasis on new facilities:

Table 1. 1970-1990 transportation needs by mode and per capita by urban area population size.

1990 Population Group	1970 Population (millions)	Highway Needs[a] Amount (millions)	Highway Needs[a] Percent	Public Transportation Needs Amount (millions)	Public Transportation Needs Percent	Public Transportation Needs Percent for Rail	Total Needs (millions)	Needs per Capita[b] Highway[a]	Needs per Capita[b] Transit	Needs per Capita[b] Total
Less than 2 million										
1 to 2 million	18.4	24,439	82	5,395	18	55	29,834	1,328	293	1,621
500,000 to 1 million	13.3	15,899	86	2,598	14	33	18,497	1,195	195	1,390
250,000 to 500,000	10.5	16,402	94	1,043	6	18	17,445	1,562	99	1,561
100,000 to 250,000	10.3	15,357	96	708	4	21	16,065	1,491	69	1,560
50,000 to 100,000	6.5	8,624	94	522	6	22	9,146	1,327	80	1,407
Subtotal	59.0	80,721	89	10,266	11		90,987	1,368	174	1,542
More than 2 million	66.0	89,081	63	52,063	37	87	141,144	1,350	789	2,139
Total	125.0	169,802	73	62,329	27	79	232,131	1,358	499	1,857

Note: Amounts are in 1969 dollars.

[a]Not including local roads or the cost of completing the Interstate System. [b]Based on 1970 population.

Table 2. 1970-1990 transportation expenditures under capital improvement alternative 3 by mode and per capita by urban area population size.

1990 Population Group	1970 Population (millions)	Highway Expenditures[a] Amount (millions)	Highway Expenditures[a] Percent	Public Transportation Expenditures Amount (millions)	Public Transportation Expenditures Percent	Public Transportation Expenditures Percent for Rail	Total Expenditures (millions)	Expenditures per Capita[b] Highway[a]	Expenditures per Capita[b] Transit	Expenditures per Capita[b] Total
Less than 2 million										
1 to 2 million	18.4	16,895	82	3,673	18	41	20,568	918	200	1,118
500,000 to 1 million	13.3	10,841	86	1,701	14	53	12,542	815	128	943
250,000 to 500,000	10.5	9,682	93	677	7	26	10,359	922	64	986
100,000 to 250,000	10.3	8,136	94	502	6	22	8,638	790	49	839
50,000 to 100,000	6.5	4,774	93	344	7	22	5,118	734	53	787
Subtotal	59.0	50,328	88	6,897	12		57,225	853	117	970
More than 2 million	66.0	45,907	66	23,997	34	81	69,904	696	364	1,060
Total	125.0	96,235	76	30,894	24	72	127,129	770	247	1,017

Note: Amounts are in 1969 dollars.

[a]Not including local roads or the cost of completing the Interstate System.
[b]Based on 1970 population.

Figure 1. Form for providing information on noncapital alternatives.

NAME OF URBANIZED AREA ________ STATE ________ CARD STATE AREA 2 4 | B | B B

ALTERNATIVE	CARD NO.	CONSIDERED IN PAST?[1]	ATTEMPTED IN PAST?[1]	PRESENTLY PRACTICED?[1]	PLANNED FOR FUTURE?[1]	IF PLANNED FOR FUTURE GIVE DATE
1. STAGGERING OF WORK HOURS	1	12	13	14	15	19 __ __ 16 17
2. MEASURES TO ENCOURAGE CAR POOLING		18	19	20	21	19 __ __ 22 23
3. BANNING PRIVATE AUTOMOBILES FROM THE CBD		24	25	26	27	19 __ __ 28 29
4. RAISING TOLLS ON TOLL BRIDGES AND TUNNELS DURING PEAK HOURS		30	31	32	33	19 __ __ 34 35
5. LOWERING TOLLS ON TOLL BRIDGES AND TUNNELS DURING OFF-PEAK HOURS		36	37	38	39	19 __ __ 40 41
6. INCREASING CBD DAYTIME PARKING RATES		42	43	44	45	19 __ __ 46 47
7. RAISING TRANSIT FARES DURING PEAK HOURS		48	49	50	51	19 __ __ 52 53
8. LOWERING TRANSIT FARES DURING OFF-PEAK HOURS		54	55	56	57	19 __ __ 58 59
9. UNRESTRICTED ENTRY OF TAXICABS		60	61	62	63	19 __ __ 64 65
10. UNRESTRICTED ENTRY OF JITNEYS		66	67	68	69	19 __ __ 70 71
11. RESERVED LANES FOR BUSES		72	73	74	75	19 __ __ 76 77
12. RESTRICTIONS ON CURBSIDE LOADING AND UNLOADING IN CONGESTED AREAS	2	12	13	14	15	19 __ __ 16 17
13. EVENING DELIVERY BY TRUCKS IN DOWNTOWN AREAS		18	19	20	21	19 __ __ 22 23
14. OTHER (DESCRIBE)						

[1]CODE ANSWERS: YES = 1, NO = 2

Table 3. Percentage of urban areas by 1990 population size practicing noncapital alternatives.

Alternative	Entire Country	>2 Million	1 to 2 Million	500,000 to 1 Million	250,000 to 500,000	100,000 to 250,000	50,000 to 100,000
Staggering of work hours	25.7	35.7	53.3	48.3	21.6	22.6	18.8
Measures to encourage car pooling	6.8	14.3	13.3	6.9	2.7	6.0	6.8
Banning private automobiles from the CBD	0.7	0.0	0.0	0.0	2.7	1.2	0.0
Raising tolls on toll bridges and tunnels during peak hours	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lowering tolls on toll bridges and tunnels during off-peak hours	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Increasing CBD daytime parking rates	19.6	28.6	33.3	24.1	16.2	21.4	15.4
Raising transit fares during peak hours	0.3	7.1	0.0	0.0	0.0	0.0	0.0
Lowering transit fares during off-peak hours	3.7	42.9	6.7	0.0	2.7	3.6	0.0
Unrestricted entry at taxicabs	21.6	50.0	26.7	20.7	18.9	17.9	21.4
Unrestricted entry of jitneys	9.8	7.1	20.0	13.8	2.7	10.7	9.4
Reserved lanes for buses	7.8	50.0	20.0	13.8	8.1	4.8	1.7
Restrictions on curbside loading and unloading in congested areas	51.0	85.7	73.3	58.6	48.6	56.0	39.3
Evening delivery by trucks in downtown areas	9.1	21.4	20.0	10.3	10.8	6.0	7.7

1. Long lead times between initial planning and final completion;
2. Right-of-way and construction costs, which were conservatively estimated in 1968 to average $1.3 million per lane-mile for urban freeways (15);
3. High accident rates of motor vehicle travel (highway fatalities constitute 90 percent of total transportation fatalities) (8);
4. High energy costs required for the construction of highways as well as for motor vehicle travel (roughly 45 percent of total vehicle-miles traveled are in urbanized areas, where congestion and delays waste fossil fuels) (8);
5. Propensity of new facilities to generate additional trips (and to encourage traffic-generating land uses); and
6. High environmental costs associated with highway construction and with motor vehicle travel.

With regard to environmental costs, air quality has declined to dangerous levels in many areas, and motor vehicles now account for roughly one-third of the total nitrogen oxides, one-half of the hydrocarbons, and two-thirds of the carbon monoxide. These pollutants are emitted mostly on 10 to 15 percent of our land area (8). Traffic noise is now viewed as the most annoying kind of unwanted sound, and it exceeds that from any other source throughout the greater part of urban areas. Forty-five decibels are sufficient to interfere with conversation, but traffic-produced median levels of 73 decibels at night were found in cities tested by the Environmental Protection Agency (16). Large amounts of urban land are devoted to the movement and parking of vehicles. The acquisition prices of rights-of-way have increased sharply in recent years, and the opportunity costs in the form of open space and parkland sacrificed have been sufficiently high to arouse considerable opposition and organized resistance.

The Solution Reconsidered

Apparently a major shift in transportation policy and methodology is to attempt to significantly improve levels of service by better management of transportation systems. Until quite recently, this approach has received very little attention in government (especially at the federal level). The philosophy of transportation agencies, their organization (especially state and local highway departments), their financial assistance programs (both absolute amounts of funds and matching shares), and the planning process (methodologies, technical manuals, training programs) all have minimized or ignored the potential for improving transport services by making more efficient use of previous investments. The urban planning literature also reflects the capital bias. For example, Creighton emphasizes that he is not concerned with improvements in management, administration, regulation, and education, although he acknowledges (2, pp. 14-16), "These are probably the most important kinds of actions which can be taken because they are related most directly to the social, economic and governmental nature of the problems."

As suggested earlier, the means to achieve increased efficiency are many and varied. The key is to treat as variables what we have regarded previously as givens, parameters, or constraints—i.e., average automobile occupancy, work hours, modal split, transit levels of service, economic regulations, prices, and even modes or variations of existing modes (for example, the jitney and subscription bus service). Although these are commonly viewed as "institutions," which change over the long run (if at all), such changes are virtually the only means of achieving very much in the way of better service in the short run when the scale of the physical plant—the rights-of-way—is fixed. Moreover, we are in a period of changing institutions, partly as a result of the 1975 air quality standards set by the Environmental Protection Agency and the energy situation.

Before we examine some suggested low-cost improvements, we should consider some factors that contribute to congestion during the journey to work. Congestion occurs because the demand for transportation services is highly concentrated in terms of time periods, routes, and directions. In developing alternatives to reduce congestion, we must identify the journey-to-work characteristics that produce this concentration.

1. Hours of employment coincide for most people (e.g., 9 to 5). The result is that the vast majority of work trips occur during 1 or 2 hours in the morning and again in the afternoon.
2. Places of residence and employment typically are separated, leading to commuting to work.
3. The automobile is used for most work trips, more than 82 percent nationally (8).
4. Individuals tend to drive to work by themselves. Automobile occupancies average 1.2 to 1.5 per car, depending on the city. More than half of the automobiles carry only 1 person (8).
5. Most workers commute along a relatively small number of corridors to their places of employment.
6. Automobiles as well as all motor vehicles impose external costs on others, chiefly, air pollution, noise, and higher time and operating costs.
7. Most motorists underestimate or are not conscious of their commuting costs (including depreciation) or costs that are external to them.
8. Public transportation (and car pools as well) is unavailable, inconvenient, or considered demeaning by many people.

Paradoxically, some urban travel characteristics that contribute to congestion can be used to alleviate it, e.g., low average automobile occupancy and travel peaking. The following section describes a number of techniques that may be used to restructure the demand-supply relations that create congestion and to improve transportation performance.

TAXONOMY OF NONCAPITAL AND LOW-CAPITAL ALTERNATIVES

Noncapital and low-capital alternatives may be grouped into 2 broad categories: demand-oriented programs that take the capacity of a system as given and seek to reduce the number of vehicle trips (or at least peak-period vehicle trips) and capacity or supply-oriented programs that seek to increase the people-moving capabilities of a system.

Demand-Oriented Alternatives

1. Pricing—Increasing the price of peak-hour travel will reduce the demand for peak-hour trips. There are strong economic grounds for raising the price of peak-hour travel to levels commensurate with marginal social costs (principally the additional travel time costs created by congestion, but also the related operating, risk, air

pollution, and noise costs) by means of self-canceling tickets, toll changes on existing toll facilities, and higher parking charges (20, 21, 22, 23).

2. Spreading Travel Peaks—If the total number of passenger and vehicle trips per day is accepted as given, peak volumes can be reduced by measures to reduce certain nonwork trips (e.g., afternoon baseball games), by staggering of work hours, and by gliding time. As the 4-day work week gains acceptance, 4 days of work can be spread over 5 or 6 days (24, 25, 26).

3. Group Riding—If the number of peak person trips is accepted as given, increasing average vehicle occupancy by car pooling and bus pooling would reduce the number of motor vehicle trips (19, 27).

4. Improving Urban Public Transportation—An unknown but potentially large proportion of automobile commuters can be attracted to public transportation by improved service. For example, express bus service can reduce line-haul times; subscription service, changes in schedules and routes, and more imaginative use of taxis, jitneys, and demand-responsive vehicles can facilitate collection and distribution; better coordination and integration can facilitate transfers between modes and service areas of different transit companies; dismanteling of most of the economic regulations can increase innovation, reward private initiative and risk, and ease the restrictions that limit the number of taxicabs and prohibit jitney operations; and service improvements combined with more aggressive marketing can improve the public image (19, 28, 29).

5. Restructuring Commuter Rail—Satisfactory commuter service and some reduction in automobile commuting can be achieved in corridors in many U.S. metropolitan areas by the initiation of commuter rail service on existing track, use of idle rolling stock, and provision of parking lots (30, 31, 32).

6. Improving Urban Goods Movement—In some cases the interference between freight and passenger movements can be decreased (and freight costs lowered) by a reduction in the number of urban truck trips. Ways to reduce truck trips include consolidating terminals and coordinating pickup and delivery, rescheduling the times that freight is picked up and delivered, restricting curbside loading and unloading, and using special routes or lanes for trucks (33, 34, 35).

7. Facilitating Bicycle Travel—Use of the bicycle for the journey to work can be encouraged by the provision of bicycle lanes on streets, secure storage areas for bicycles at transit stations and places of employment, and buses and rail cars that accommodate bicycles (36).

Capacity-Oriented Alternatives

8. Improving Traffic Operations—The effective vehicle capacity can be increased by traffic engineering, e.g., reversible lanes and coordinated and computerized signals, and traffic regulation, e.g., banning of curbside parking during peak hours (37).

9. Using Larger Public Transportation Vehicles—The passenger capacity of streets and highways can be further augmented by the use of larger vehicles. For example, articulated and double-decked buses have long been in service in Germany and the United Kingdom respectively (38).

10. Giving Priority to High-Capacity Vehicles—Giving priority to high-capacity vehicles (i.e., buses, or possibly buses and car pools) can provide high-speed passenger capacity (i.e., 50,000 to 60,000 seated passengers per hour per lane) sufficient to serve the demand in almost any radial corridor in any U.S. city (19, 39).

POLICY CONSIDERATIONS IN CHOOSING AMONG ALTERNATIVES

Because so little attention has been devoted to low-capital improvements to transportation, the state of the art of planning and the understanding of policy considerations are primitive. This section will discuss factors that should be considered in developing noncapital and low-capital improvement programs. These considerations are also applicable to more capital-oriented programs.

Energy and Environmental Implications

During the period from 1965 to 1970, motor VMT and their expenditures increased at the annual average rate of 4.2 percent; at that rate, they would double every 17 years (8). Gasoline consumption has grown at a rate of 5 to 6 percent, or a doubling every 12 to 14 years (40). The 1972 National Transportation Report forecast a rate of growth of VMT of 3.8 percent for the 1970 to 1980 period, or a doubling every 20 years. Rates of growth of this magnitude are not compatible with the world's dwindling supplies of fossil fuels and the present national policies to conserve energy.

Alternatives 1, 3, 4, 5, 6, 7, and 10 would have the effect of reducing VMT; alternative 1 would offer the most potent tool. Alternatives 2 and 8 would tend to increase average speeds and thus, other things being equal, would generate additional vehicle trips. Because reducing VMT is fundamental to transportation environmental and energy goals, the emphasis should be placed on noncapital alternatives that would reduce or at least not increase VMT.

Complementarity and Substitutability

Not nearly enough is known about the interrelations among the alternatives recommended in this paper. No city has attempted some of the alternatives (e.g., pricing and the 4-day work week), much less all of them collectively. Nevertheless, 2 types of relations are evident.

There are strong complementarities or synergistic effects among the alternatives. On the demand side, measures to correct the price-cost distortion among modes (i.e., higher prices for automobile driving and parking, especially the journey to work) would encourage peak spreading through encouraging nonwork trip-makers to travel during off-peak hours and by providing greater incentive to stagger work hours. Those measures would also encourage car pooling and would divert more riders to public transportation. The demand for public transportation would also be increased by changes in the regulatory environment, by better marketing, and by measures to improve transit speed, whether by service improvements (e.g., express bus operations) or by improvements on the supply side (e.g., reserved lanes for buses and car pools) or both. Reducing interference between passenger and freight vehicles could improve the travel times of both and would reduce freight delivery costs.

There is also substitutability among some of the alternatives, and trade-offs would be required if those alternatives are implemented simultaneously. Programs to stagger work hours may complicate efforts to increase vehicle occupancy. On the other hand, gliding time facilitates car pooling and reduces the 15- and 30-minute transit peak demands by permitting employees to rearrange working hours. Transit improvement programs may divert commuters from car pools and other transit modes as well as commuters who drive alone. The effects of these and other conflicts can be mitigated by increasing the size of the area and the number of people affected to expand the range of choice (e.g., southwest Washington, D.C.) and by careful planning. Or, one alternative (e.g., group riding) may preclude the need for others. Greater reliance on economic incentives and the market would assist individuals in making the proper trade-offs (e.g., between car pools and buses). Obviously, the alternatives selected and their manner of implementation would vary among and within cities.

Cost Comparisons

Because of their disparate nature (e.g., staggered hours vis-a-vis commuter rail), alternatives cannot be compared on a passenger or seat-mile basis. Studies recently completed for the U.S. Department of Transportation provide rough comparisons. Table 4 (19) gives operating costs of the various highway alternatives, and Figure 2 (18) shows passenger trip-miles per vehicle-hour related to costs. Table 5 gives costs of commuter rail (43) and implementation costs associated with reserving a freeway lane for buses and for constructing an exclusive bus lane (18). Revising transit regulations, changing work schedules, and certain improvements to facilitate bicycle travel are even cheaper to initiate and administer.

Table 4. Travel time savings and cost characteristics of busways in 7 urban areas.

Site	Busway Length (miles)	Time Saving: Bus Over Automobile: Amount (min)	Time Saving: Bus Over Automobile: Percent	Time Saving: Bus Over Former Bus: Amount (min)	Time Saving: Bus Over Former Bus: Percent	Costs (dollars): Implementation	Costs (dollars): Operating (attributable to exclusive lane)
Freeway							
New Jersey I-495	2.5	na[a]	na	10	na	750,000[c]	171,000/year
Long Island Expressway	2	15	85	na	na	50,000 (est.)	500/day (est.)
Boston Southeast Expressway	8.4	7.5	42	14	58	50,000 (est.)	500/day (est.)
Specially constructed							
Washington, D.C., Shirley Highway a.m.	9	13	33	na	na	620,000/mile	Insignificant from prior costs
p.m.	9	20	54	na	na		
Arterial							
Louisville Third Street[b]	2	Slower	Slower	5.5 to 12[d]	13 to 28[d]	30,000 (est.)	Insignificant from prior costs
Indianapolis College Avenue	na	na	na	na	na	Very low	Insignificant from prior costs
San Juan Fernandez Juncos and Ponce de Leon	10.4	na	na	30	38	100,000 plus staff time	Insignificant from prior costs

[a]Not available.
[b]Increases in speeds were noted for all eastbound traffic whether traveling the bus lane or not.
[c]Not representative because of post-setting equipment.
[d]For total bus route; data are not available for the portion of the trip on the exclusive bus lane.

Figure 2. Relation of passenger trip-miles per vehicle-hour and costs.

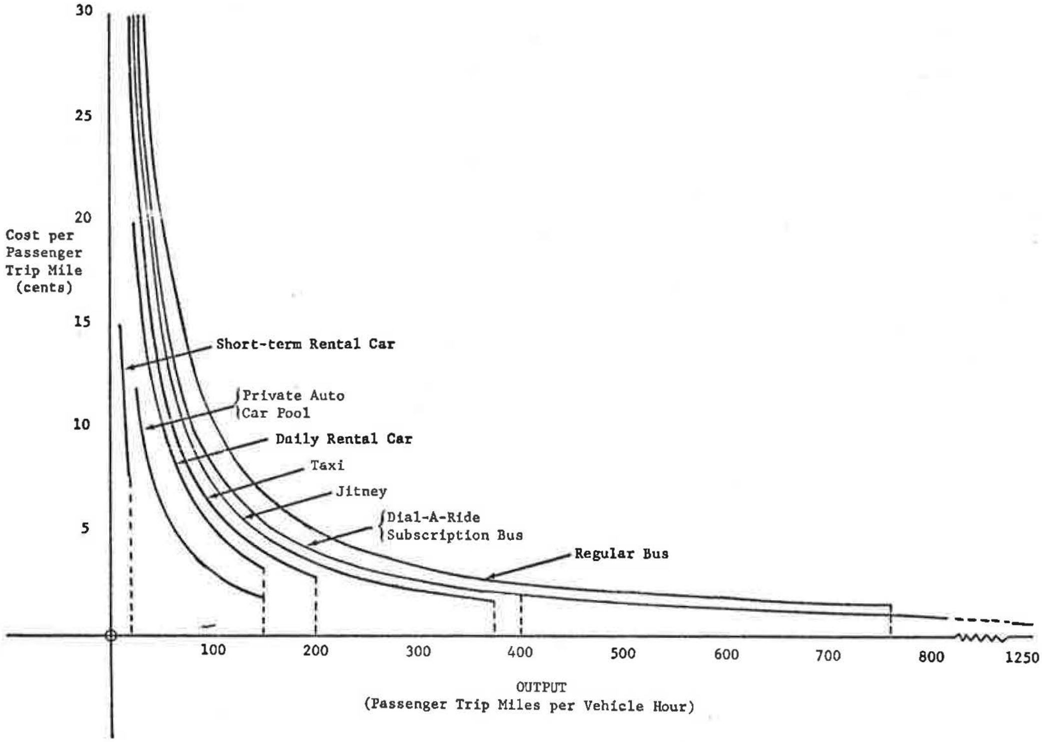

Table 5. Costs of highway alternatives and commuter rail.

Alternative	Operating Cost per Seat-Mile, Including Depreciation (cents): Range	Avg
Automobile	12 to 18	14.2
Car pool	2 to 3	2.4
Bus pool	1 to 4	1.8
Bus transit	1.5 to 4	1.8
Commuter rail	3 to 40[a]	5.3

[a]Per passenger-mile.

Demand and Equilibrium

Implementation of some of those alternatives will set in motion market forces that, after a period of adjustment, will reduce somewhat the improvements in congestion and travel time. Thus, staggering work hours, car pooling, and increasing public transportation use will reduce peak automobile volumes and increase average speeds. The reduction in travel time will mean that the average cost or price of peak-hour automobile travel will be lower, and at the new reduced price some trips that previously had been taken during the off-peak will be attracted to the peak. Similarly, some commuters who previously had used public transportation or car pools will choose to drive their cars because the price is now below the threshold necessary to induce them to make such a change. The volumes that occur at the new equilibria will depend on the elasticities of demand, the alternatives used, and the effectiveness of implementation. To prevent such erosion of the gains from these alternatives, some means must be found to ration the available capacity, particularly during the peak hours. One means is restrictions of various types, including cutbacks in the supply of fuel available. Economic means (for example, peak-hour tolls and higher commuter parking rates) have the advantage of being less arbitrary, of allowing greater choice, and of permitting people to express their preferences on the basis of willingness to pay. The chief problem is to gain public acceptance (the equity issue can be resolved by providing alternatives so that no one is penalized).

Over time, the demand for transportation services changes in response to changes in income, population density and distribution, and tastes. The levels of service will depend on the patterns of demand in terms of mode, time of day, route, direction of travel, and the degree of capacity utilization in terms of these factors. Based on historical experience, the number of automobile trips will probably have to be restrained at least during peak hours if high service levels are to be maintained without investment in additional capacity. As noted earlier, if the emphasis is on the movement of persons rather than vehicles, capacity will be sufficient in all but perhaps the most heavily traveled corridors to provide high-quality passenger transport. What the emphasis should be, of course, is a policy issue, which will include environmental, energy, demand, supply, and cost considerations.

ADVANTAGES AND OBSTACLES

Advantages

The strongest argument for the approach suggested here is that it explicitly addresses the congestion problem, the question of economic efficiency, and other interpretations of "the urban transportation problem." The author is convinced this is the only approach that offers at this point any real hope because it employs a more diverse and sharper set of tools than other approaches he has seen and deals explicitly with the underlying market forces. Other advantages are discussed below.

Potential for Service Improvements—Dramatic changes in peak travel times can be achieved if these alternatives (or even a subset of them) are employed simultaneously on an areawide basis, particularly if they are accompanied by some form of congestion pricing and higher commuter parking charges.

Range of Choice—These alternatives would provide urban travelers with a greater range of choice in terms of price and service characteristics, particularly commuters who now have (or who perceive that they have) no other choice than to drive alone. Some of the alternatives, for example, relaxing constraints on taxi and jitney operations, would improve mobility for inner-city residents and in addition provide employment opportunities for drivers.

Transit Subsidies—Implementing para-transit alternatives (e.g., replacing low-patronage bus routes with shared-taxi and jitney services and diverting some bus travelers to lower cost subscription services and thereby reducing bus peak demands) might reduce or eliminate the need for subsidies on some routes.

Medium- and Small-Sized Communities—Given the funds available for subsidies under the present transit programs and those likely under future transit programs, many communities are not large enough to generate the demand necessary to sustain a conventional bus transit system. For such communities the choice appears to be public transportation in the form of para-transit (and possibly commuter rail for new towns) or no public transportation.

Cost—The costs of the alternatives are quite low except for improvements involving actual construction of reserved lanes, and even those costs are modest on a passenger or seat-mile basis relative to automobile-highway and rail transit alternatives.

Time—Not including planning time, the time to implement the improvements described here is a matter of months, sometimes weeks, in contrast to a minimum of several years for capital programs (or sometimes not at all, as in the case of the San Francisco Embarcadero Freeway).

Energy and Environment—Although the proposals advanced here are oriented primarily toward improving efficiency and reducing congestion, they are the same proposals advanced to improve environmental quality and conserve energy, particularly the proposals that reduce VMT. Moreover, these alternatives are much less damaging to the environment than capital-intensive programs.

Flexibility—Because of the pace of change in urban values and goals and developments in transportation technology, flexibility is a quality that will become increasingly important. By their very nature, capital improvement programs tend to be irreversible. In contrast, noncapital and low-capital alternatives increase the range of future options.

Future Capital Programs—Low-capital alternatives could reduce substantially the amounts of capital needed in the future to improve transportation service. Moreover, this approach would provide some of the information we now lack for long-range planning. How much are people willing to pay for (i.e., how much do they value) different types of transportation service? After an "optimum" solution is achieved in the short run, how much (and what kind of) investment is needed to achieve a long-run optimum?

Obstacles

The obstacles to low-capital improvements are primarily institutional, or at least progress is retarded by institutional rigidities.

Construction Orientation—Our construction orientation is not surprising, given our heritage: a subcontinent where until the 1940s the transportation problem was seen as one of providing links between cities or between farm and market. Now that we have extensive urban highway systems in various stages of completion, we have difficulty conceiving of the problem as being something other than capacity and the solution as being something other than a choice among capital-intensive, "pure" technologies, i.e., highway (automobile) or transit (rail). This bias is reflected in the professional literature, in textbooks, in college and university curricula, in short courses conducted by professional organizations, and in governmental studies and programs.

Aid Programs—Existing aid programs, particularly federal, are capital oriented. With the exception of TOPICS (which will not receive separate funding after 1975), no ongoing federal program finances technical studies or capital grants or operating programs oriented toward noncapital improvements.

Organizational-Jurisdictional—At the metropolitan level, normally no metropolitan-wide central agency has authority for all aspects of transportation planning, financing, administration, and regulation. Mayors do not have the power to bring all the actors together, and full cooperation is usually impossible to attain. At the U.S. Department of Transportation, responsibility for ground transportation is split between FHWA and UMTA. Low-capital projects frequently need funds from both administrations, but each has its own goals, priorities, procedures, and time schedules, making an integrated program difficult. To date, there have been little concentrated effort and no central focus for noncapital and low-capital programs.

Lack of Information—Most planners are not aware of the full range of alternatives available to them. If they are, they lack sufficient information to evaluate some of them, for example, economic incentives.

Lack of Methodologies—We have numerous manuals on trip generation, modal split, and network assignment. Although there are technical reports on many of the alternatives described here, the first technical manual for field use was published early in 1973 (27).

Momentum of Capital Programs—The conventional approach, including ongoing programs involving annual expenditures of several billion dollars of federal funds matched by state and local expenditures, has generated considerable momentum.

Delivery Delays for New Buses—Although the production of new automobiles exceeds the demand and inventories are accumulating of both domestically produced and imported cars, several months to a year are required for a transit agency to obtain a new bus. This time lag was particularly painful for transit bus operators during the 1973-1974 energy crisis because they were not in a position to fully take advantage of the increase in demand for bus travel.

Vested Interests—Probably the greatest opposition will be from those who have a stake in the status quo (or at least who perceive that they do). For example, transit operators and some elected officials will resist changes in economic regulations to permit greater use of para-transit, and similarly for labor unions. By the same token, highway departments will resist having their construction programs curtailed.

Lack of Sex Appeal—Low-cost improvements do not have the exotic flavor of SSTs, TLVs, TACVs, DARTs, and PRTs or even METROs and BARTs. More aggressive marketing is needed to tailor service to meet local demand and to promote the principle of noncapital alternatives at all levels of government.

CONCLUSIONS AND POLICY IMPLICATIONS

Conclusions

This paper suggests an alternative definition of the urban transportation problem and alternative means of dealing with the congestion issue, especially with respect to the journey to work. The principal conclusions are the following.

1. The urban transportation problem is an economic problem: poor use of our present transportation resources to deal with today's transportation issues.

2. The setting of urban transportation has changed in the past decade or so. As a result of the Interstate program and other urban highway improvements (not to mention rail transit systems in operation or nearing completion), we now have at least the rights-of-way for extensive urban transportation systems in our cities and unused capacity during the peak hours (e.g., underused railroad track, empty seats in private automobiles, and potential bus lanes).

3. We are discovering that we have the capability to improve urban transportation service—in many cases reducing average trip times by one-half or more—in the near term and with public sector outlays, which are modest by means of a rich and diverse set of opportunities, to use urban transportation systems more effectively. Even more surprising, for a large share of journey-to-work trips, it may be that the only way to achieve better service is to devote fewer resources to transportation, for the primary concern—congestion—is created by an excessive number of motor vehicle trips during the time period in question. People will be able to travel at higher speeds only as the ratio of passenger trips to vehicle trips increases during the peak hours.

4. Private individuals and local governments have shown considerable initiative in implementing low-cost improvements. Although some of the recent successes in the United States have been federally sponsored, e.g., the Shirley Highway exclusive bus lane, others have not, e.g., the exclusive bus lanes in Puerto Rico, demand-responsive service in Davenport, Iowa, and numerous bus-pool and car-pool projects (18, 19).

5. Increased transportation efficiency appears to be occurring for reasons other than the sole purpose of providing better service or increasing revenues. The proposals advanced here are also advanced in the interests of energy conservation and of meeting air quality standards. These and other influences (e.g., the opposition of citizens to urban freeways) are gaining momentum and may exert more force than transportation or efficiency considerations per se.

6. To say that we are on the threshold of a revolution in our theory and practice regarding urban transportation may be an exaggeration. Certainly the textbooks and the thrust of government programs do not support such a view. Yet the alternatives discussed in this paper have their real-world counterparts in terms of individual commuters, entrepreneurs, and local government. Examined in isolation, they do not suggest major changes in urban transportation. Taken collectively, they imply a major shift in emphasis, particularly if they were planned and implemented as a group in any given city as part of a "continuing, comprehensive, cooperative transportation planning process." In 1990, we may look back and conclude that a major shift in emphasis from capital-intensive to noncapital solutions did indeed take place in the 1970s (41).

Policy Implications

1. The conventional wisdom concerning the urban transportation problem, the solution, the role of government (particularly federal), the role of the private sector, and the question of incentives need to be reexamined. The emphasis should be on near-term, noncapital, and low-capital alternatives, and a new set of concepts and methodologies should be developed. The basic building blocks would include the full range of alternatives available, greater attention to environmental and energy considerations, greater emphasis on economics and on market forces, improved methods of forecasting travel demand, and more emphasis on citizen participation.

2. A federal program consistent with the approach recommended here involves changing the past direction almost 180 degrees. The suggested shift in emphasis offers greater potential for achieving the official U. S. Department of Transportation goals of economic efficiency, environmental quality, safety, and facilitation of local determination than the present long-term, capital-intensive orientation.

3. The elements of an urban transportation program that emphasize making more efficient use of present systems would include the following:

a. Aid programs that make implementation of low-capital programs a prerequisite for obtaining CIP funds and that make much larger amounts of funds available for local planning, implementation, and administration of noncapital and low-capital improvements;

b. Promotion of user charges, fares, and prices that reflect the economic cost (including external costs) of transportation services;

c. Assistance in reducing the institutional constraints, particularly those concerned with economic regulations and support of labor rules and practices that inhibit public transportation;

d. Amending the federal highway code to permit cities to charge congestion tolls on federal-aid facilities;

e. Research and demonstration in the whole area of low-cost improvements, with emphasis on support of local initiative;

f. Development of methodologies to assist urban planning groups in evaluating and implementing low-cost improvements;

g. Revising the urban transportation planning process to give first priority to near-term, low-cost improvements and to link them with long-term, capital-intensive programs;

h. Dissemination of information, especially technical manuals and experience gained from application of new ideas; and

i. Marketing efforts to promote the low-capital approach to urban transportation.

These are bold changes. Even in a period of changing orthodoxies, a program of this nature will be a significant departure from the past.

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