Increasing the Capacity of Urban Highways: The Role of Freeways

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An analysis of the supply and use of urban highways by functional class using the Highway Performance Monitoring System (HPMS) suggests that the potential for shifts in travel share from lower order facilities to freeways and expressways will increase as urban travel increases and urban population centers increase in size, and the greatest potential shifts will be in the suburbs of the largest urban areas. The results of an economic analysis suggest that, in general, a more optimum mix of highway facility types might be achieved by new capacity investments on freeways and expressways. On average, widening of freeways in large urban areas could be paid for by peak-period user charges ranging from 2.4 cents per vehicle mile in fringe areas to 8.9 cents per vehicle mile in the urban core. Analysis and inferences are presented that suggest that freeways/expressways have a powerful role to play in plans to expand urban highway system capacity, especially in heavily congested large urban areas, if public acceptance can be achieved. However, financing such improvements using the current tax structure, which relies heavily on motor fuel taxes, would not be equitable towards users who use the highway system during off-peak periods, when existing highway system capacity would suffice. Consequently, financing mechanisms which rely on road pricing, possibly using automated vehicle identification technology, should be investigated in plans to expand urban highway systems.

What will it cost to maintain today's quality of transportation service in urban areas for the next 20 years? What will be the best mix of new highway capacity by functional class? What financing mechanisms could be used to pay for investments in new capacity?

Questions such as these are being asked in efforts underway to examine the options for the Federal role in the post-Interstate era. It has been speculated that, to minimize traffic congestion, the optimum share of travel on limited access facilities is about 28 to 30 percent in rural areas; however, in urban areas, as density and size of an urban area increase, this optimum share increases, and the best service is provided with about 50 percent of travel on limited access facilities in the largest urban areas (*1*). This paper reviews current conditions of urban highway use, supply and level of service by functional class, and assesses the potential and economic efficiency of actions designed to shift travel between functional classes.

A 1987 FHWA study (*2*) indicated that significant amounts of new highway capacity will be needed in urban areas. Also, an economic analysis done by FHWA (*3*) to compare benefit-cost ratios of investments in new capacity revealed that, depending on functional class, each dollar invested in capacity improvements would return between $5 and $12 in benefits. The analysis indicated that investments in all functional classes would be cost-beneficial. However, the approach used in the study did not differentiate between higher-cost investments in the urban core and lower-cost investments in the fringe, and implicitly assumed that the shares of travel on each functional class would stay relatively the same in the future. Would investments designed to shift the share of travel between functional classes be even more cost-beneficial? We attempt to answer this question in this paper, by urban area size and by urban development density category (i.e., urban core vs. fringe).

Finally, we attempt to provide some scale of what it really costs to serve a vehicle mile of travel for the portion of a trip which uses new capacity. Such information could assist in choosing between alternative financing mechanisms, and in setting charges for facility users if tolls charged though mechanisms such as automated vehicle identification (AVI) technology were to be used to recover costs for new or widened facilities.

There are three parts to the analysis:

1. analysis of the current supply, use and level of service on urban highways;
2. analysis of the economic efficiency of new highway capacity on alternative facility classes at alternative levels of service; and
3. estimation of needed charges to users of new capacity, by type of investment and location within the urban area.

PART 1: SUPPLY, USE AND LEVEL OF SERVICE ANALYSIS

Analysis Procedures

This part of the study draws from and updates with more recent data the results of a previous study (*4*) of current conditions and recent trends in system supply and use by functional class. The study used sample data in FHWA's Highway Performance Monitoring System (HPMS) database (*5*), and sought to quantify the relationships between urban highway travel use, supply, and urban development characteristics (see Figure 1), using HPMS data. HPMS is a coordinated data base that requires annual reporting by state highway agencies to FHWA.

Use, supply and level of service information from HPMS data for a sample of 164 urbanized areas were cross-tabulated by urbanized area size, functional class, and urban development density characteristics. Urbanized areas were categorized into five groups: (1) 50,000–75,000 population, (2) 75,000–

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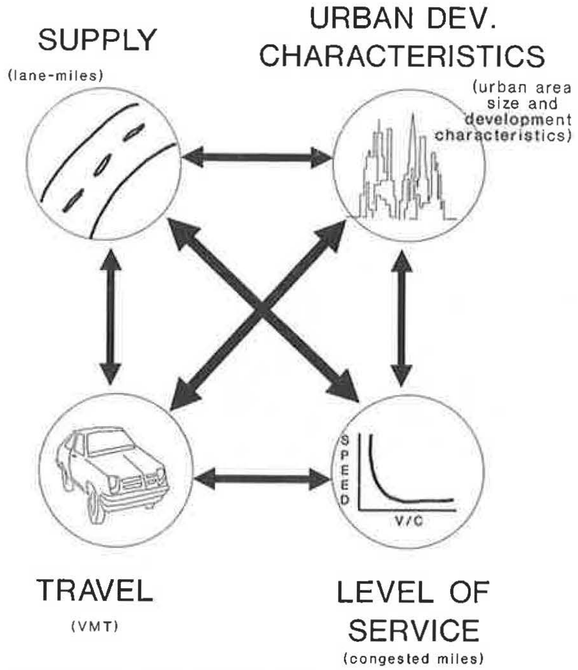

FIGURE 1 Overview of relationships investigated.

200,000 population, (3) 200,000–500,000 population, (4) 500,000 to 1 million population, and (5) more than 1 million population. Local street data are not included in HPMS. Non-local urban highways were categorized into four classes: (1) freeways and expressways, (2) other principal arterials, (3) minor arterials, and (4) collectors. Three urban development density categories were used: (1) urban core, (2) suburbs, and (3) urban fringe.

The representativeness of the sample urbanized areas used in the analysis is indicated by size category in Table 1. Although nearly half of the states were omitted from the analysis due to data limitations, only four of the 60 cells in the cross-tabulation (i.e., 5 urban area sizes × 4 functional classes × 3 density categories) contained less than 100 samples. It was therefore felt that the number of observations per cell was adequate for the analysis. Also, as indicated in Table 1, the distribution of urbanized areas within each population size group in the analysis closely matched the nationwide distribution for all urbanized areas.

Cross-tabulated data for the years 1982 through 1987 were obtained for non-local roadways with respect to the following characteristics:

- *Highway use:* Share of daily vehicle miles of travel carried by each functional class, and intensity of use (VMT per lane-mile) daily.
- *Supply:* Share of lane miles by functional class, and supply density in lane miles per 10,000 population (population data from the 1980 Census were used).
- *Level of service:* Share of route miles with peak hour volume-to-capacity ratio greater than 0.85.

Inferences

Share of Travel by Functional Class

About two-thirds of the total (non-local) travel in urbanized areas of all sizes is carried by the two highest functional classes of facilities (i.e., freeways/expressways and other principal arterials) (see Figure 2). As urban area size increases, however, the proportion carried by freeways/expressways alone increases from under 20 percent in the smallest areas to about 40 percent in the largest. From this pattern we may infer that as urbanized areas grow in the future there will be a tendency toward higher use of freeways and expressways.

Effect of Supply on Travel Shares

While the share of travel on freeways and expressways increases from medium size areas to the largest size areas, the share of supply shows a slight decline (Figure 3). This suggests that in large urbanized areas (greater than 1 million population) relatively lower levels of freeway and expressway supply are constraining further increase in use of such facilities. From this we might conclude that higher-order facilities have the potential to carry a larger share of urban travel than they currently do.

Figure 4 tends to confirm the pattern seen in Figures 2 and 3. This is a plot of supply and use of freeways/expressways on a per capita basis. Freeway/expressway use per capita (seen on the left) remains relatively constant in areas above 200,000

TABLE 1 REPRESENTATIVENESS OF SAMPLE

	Number of Areas		Percent of Areas	
	All	Sample	All	Sample
<75,000 population	111	41	29.8%	25.0%
75,000-200,000 population	146	71	39.1%	43.3%
200,000-500,000 population	62	28	16.6%	17.1%
1/2-1 million population	24	10	6.4%	6.1%
>1 million population	30	14	8.0%	8.5%
Total	373	164	100.0%	100.0%

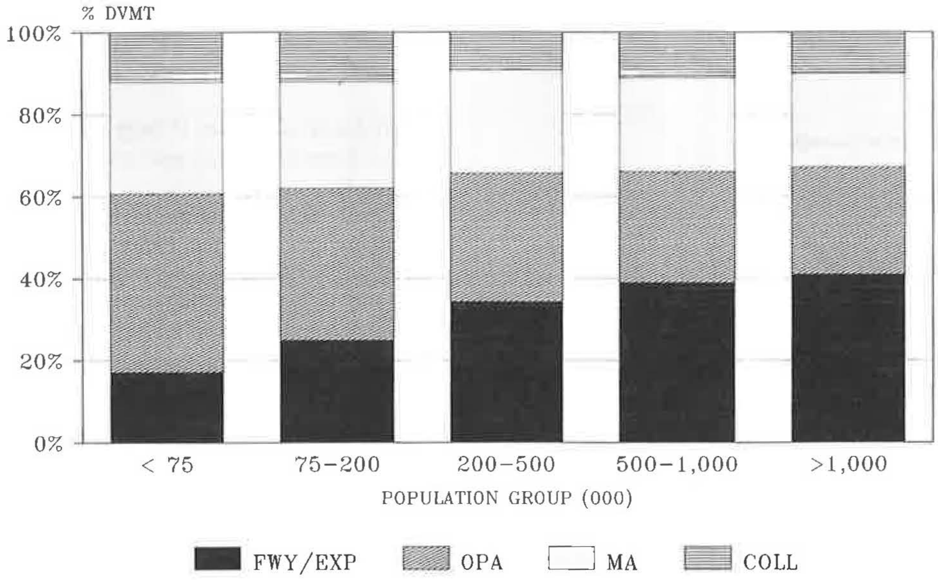

FIGURE 2 Share of daily travel by functional class and urbanized area size (1987).

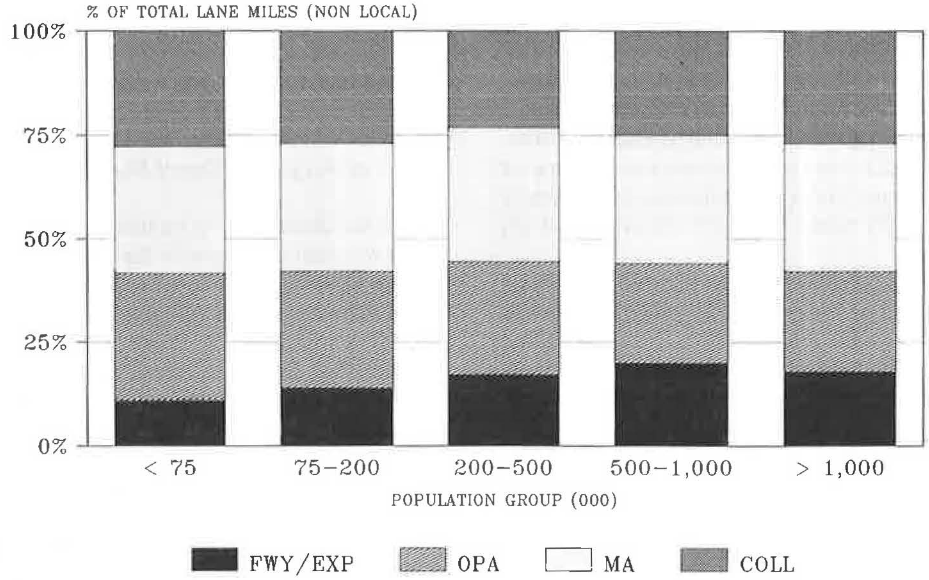

FIGURE 3 Share of supply by functional class and urbanized area size (1987).

population despite the sharp drop in supply per capita (seen on the right) in these areas as urban area size increases. This suggests that there is a preference to use higher-order facilities in the largest urbanized areas because, among other things, these facilities afford the user greater connectivity or accommodate longer trips.

Recent Shifts in Travel Shares

As total travel increases over time in the larger urbanized areas (with over 200,000 population), there is a tendency for it to shift toward freeways/expressways. Over the 6 years from 1982 through 1987, the percent of the daily VMT carried on freeways/expressways generally increased except in the smallest areas (Figure 5). The implication is that, as travel continues to increase in the future, there is a potential for freeways/expressways to carry a larger share of that travel, provided that supply constraints are not a factor.

Congestion and Travel Shares

Figure 6 shows freeway/expressway travel (intensity of use) in daily VMT per lane-mile and congestion levels expressed as a percentage of route-miles with peak-hour volume-to-capacity (V/C) ratios greater than .85. While the intensity of use triples from the smallest to the largest urbanized areas, the proportion of congested route-miles increases sixfold.

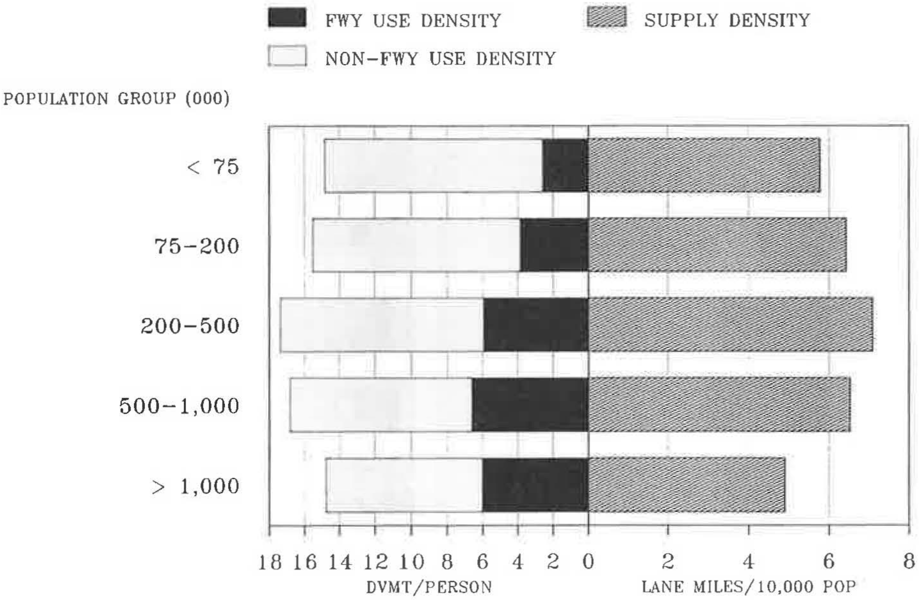

FIGURE 4 **Freeway/expressway supply and use density by urban area size group (1987)**

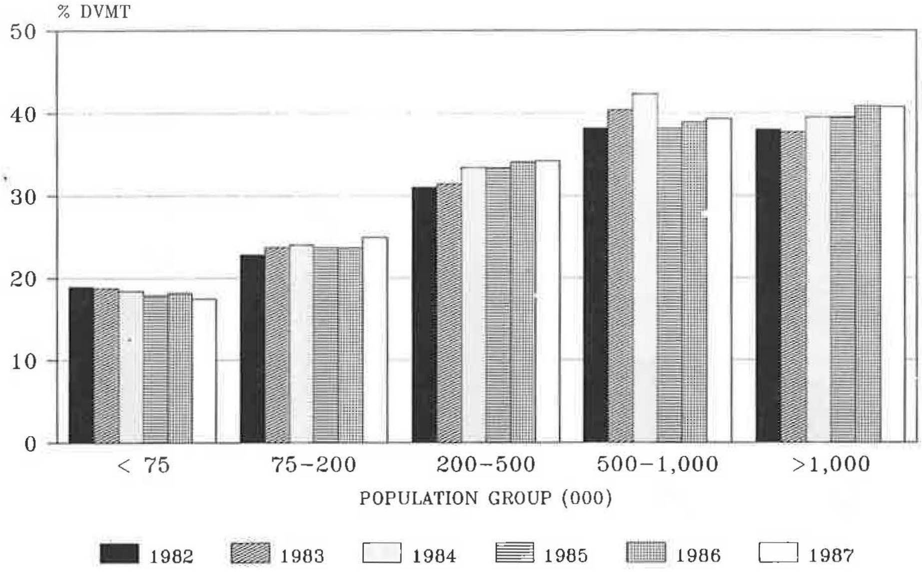

FIGURE 5 **Share of daily travel carried by freeways and expressways, 1982–1987.**

The increase in freeway/expressway travel shares with increasing urbanized area size, in spite of sharply increasing congestion, may be due in part to the relatively higher congestion levels on competing arterial facilities. Figure 7 shows congestion levels for four functional classes of facility by urban area size group. Except in the largest urban areas (over 1 million population), other principal arterials experience higher congestion levels than freeways/expressways. The exception in the largest areas may be explained by the preference to use freeways/expressways for longer trips or the greater connectivity between widely separated locations afforded by these facilities.

Share of Travel, Supply, and Congestion Levels by Urban Development Density

The share of travel and share of supply of freeways/expressways are considerably lower in the suburbs than in either the urban core or the fringe of urbanized areas of all sizes. Figures 8 and 9 show these patterns of supply and use respectively. These data suggest that the currently perceived congestion problems in the suburbs are at least partly the result of lower levels of freeway/expressway supply, and correspondingly lower travel shares for freeways/expressways in the suburbs, when compared to other development density categories in the

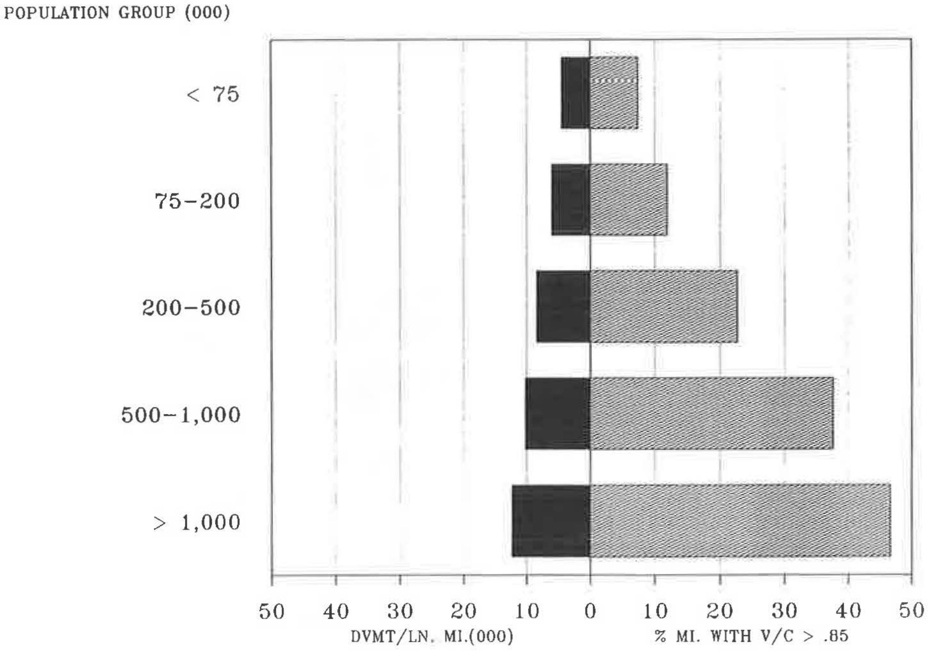

FIGURE 6 Freeway/expressway intensity of use and congestion levels by urbanized area size (1987).

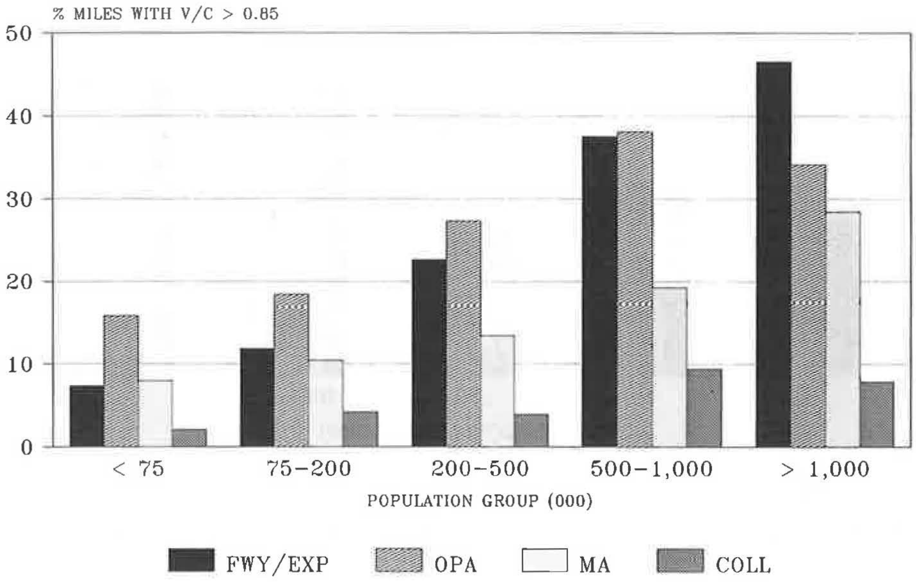

FIGURE 7 Level of service by functional class and urbanized area size (1987).

urbanized areas. This would imply that there is a potential to shift significant shares of travel in the suburbs to freeways/expressways if supply levels in the suburbs are increased to levels comparable to those in the core and fringe. Congestion levels on freeways/expressways (as shown in Figure 10) in the suburbs are comparable to those in the urban core, giving some credence to the perception of "suburban gridlock" in these areas.

The pattern of consistently increasing congestion on freeways/expressways as urbanized area size increases (Figure 10) is not matched by the pattern of congestion levels on other principal arterials (Figure 11). Arterials show a dropoff in congestion levels as urbanized area population increases beyond 1 million. An inference that can be drawn from these patterns is that there is a propensity for freeway/expressway travel in large areas despite the more severe congestion levels on these facilities relative to those on other principal arterials. One explanation may be that the more direct connection between widely separated locations afforded by the network of high-order facilities in the large urbanized areas is preferable to

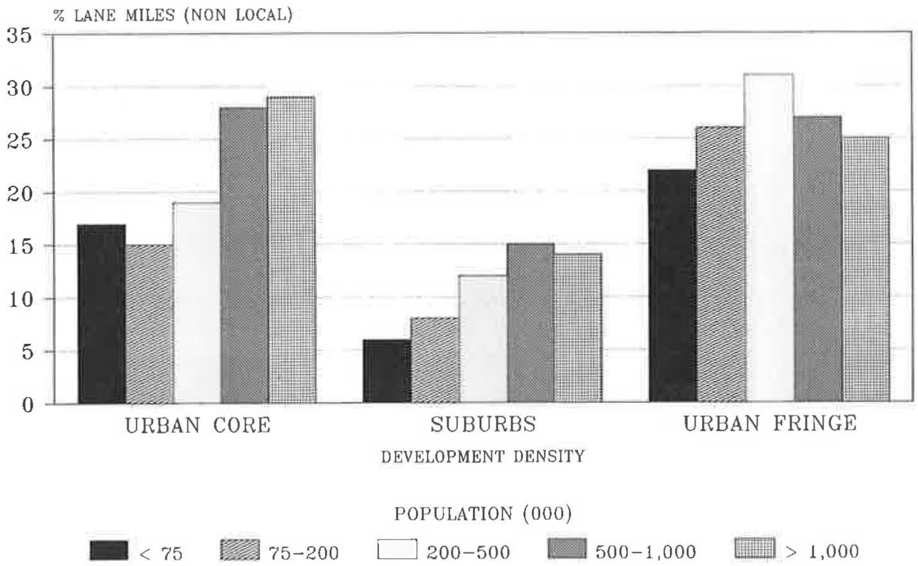

FIGURE 8 Freeway/expressway share of supply by development density (1987).

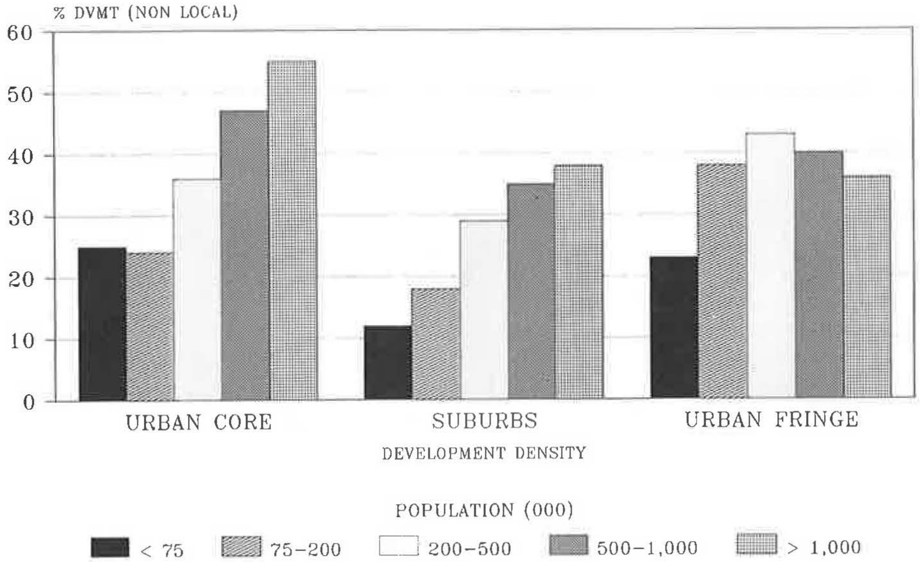

FIGURE 9 Freeway/expressway share of use by development density (1987).

the lower level of connectivity of other principal arterials, especially in light of the generally longer trip lengths as urbanized areas increase in size.

PART 2: ANALYSIS OF ECONOMIC EFFICIENCY OF NEW CAPACITY

Analysis Procedures

For this portion of the analysis, the four functional classes used earlier were reduced to the following three facility classes to conform with sources of data (*6*) used in the analysis: (1) freeways/expressways, (2) other principal arterials, and (3) collectors. The "collector" facility class combined the minor arterial and collector classes used earlier. The analysis was done for large (750,000 to 2 million population) urban areas for which nationwide average travel characteristics were available (*6*). Also, two alternative levels of service (LOS) were evaluated—LOS C and LOS D. New capacity additions for two urban development density categories—urban core and fringe—were compared. The effect of right-of-way availability was assessed by comparing two types of investment: new facilities on new rights-of-way, and widening of existing facilities.

The comparative economic efficiency of alternative functional classes was evaluated by estimating total cost per VMT

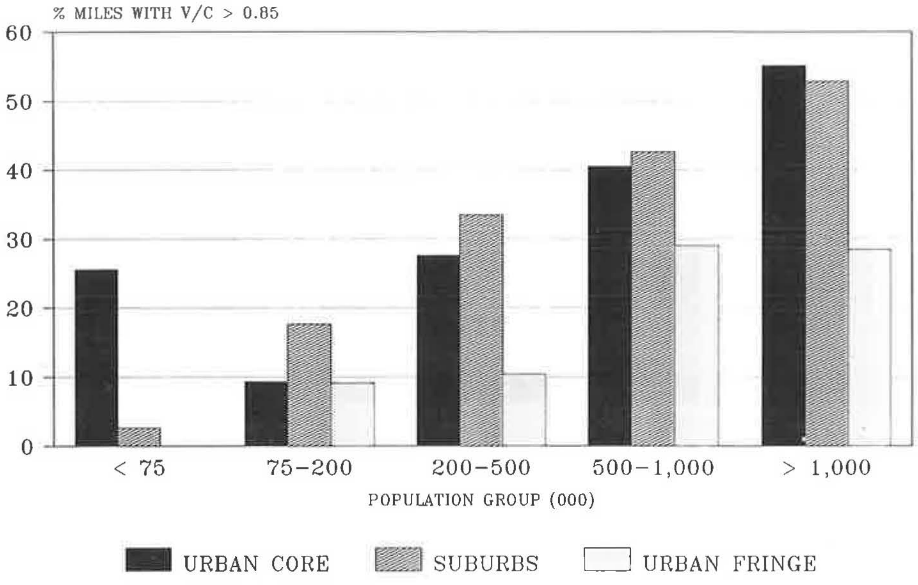

FIGURE 10 Level of service on freeways/expressways by development density (1987).

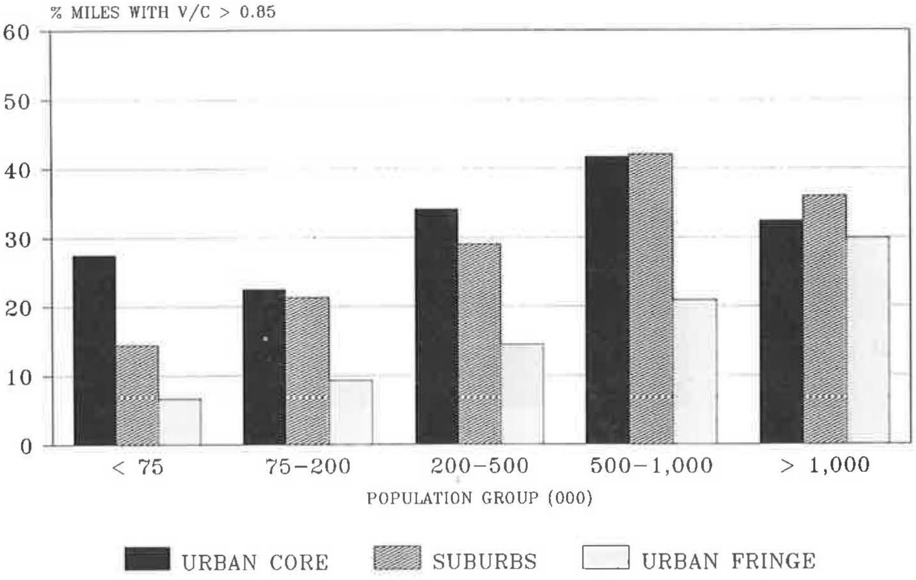

FIGURE 11 Level of service on other principal arterials by development density (1987).

served on each functional class. Total cost per VMT was obtained by aggregating highway facility costs per VMT and user costs per VMT. The lower the total cost per VMT, the greater is the economic efficiency of the facility class or level of service.

A basic assumption in the analysis is that the major part of a trip between any two zones of an urban area may be served by any of the three alternative facility types. An assumption is made that highway system volumes are currently at capacity conditions for acceptable LOS (either LOS C or LOS D, depending on the urban area's system performance standards). As trips between the zones increase, the decision maker may be faced with the question: Which facility type should be widened, or constructed on new alignment, assuming that the only consideration is economic efficiency? For example, if peak-hour vehicle trips from zone A to zone B increase by about 3,000, this increase may be served by 2 freeway lanes, or 4 arterial lanes, or 6 collector lanes.

Which investment would be the most efficient economically? The analysis assumes that the urban area's entire highway system currently operates at capacity and that the three facility type alternatives can be provided to serve areawide increases in travel between all pairs of zones. Lane requirements to serve projected increases in VMT can be developed on an areawide basis, if we assume that the new capacity to be provided will balance (i.e., be exactly equal to) the increase in volume of travel to be served. We may then compare the systemwide capacity improvement alternatives by simply using a single lane mile of each facility type to represent systemwide increases in capacity, and by using design service volume per lane of the facility to represent the volume of traffic served on the improvements. Costs per VMT served can then be estimated for each facility type to make comparisons between them.

The analysis procedure is presented in the flow chart in Figure 12. The procedure assumes, for purposes of illustration, that projected increases in traffic on the urban highway system will need to be served entirely by new capacity, either on new facilities or on widened existing facilities. Peak-hour traffic served by new or widened facilities is assumed to equal its hourly service volume at the selected LOS (C or D). Traffic served during the peak periods of the day and off-peak periods is then estimated based on time-of-day travel percentages and directional split percentages for the location within the urban area by urban area size, obtained from NCHRP 187 (*6*).

The total cost of travel over each lane-mile was obtained by adding estimates of user costs and facility costs. User costs considered were travel time, vehicle operating, and accident costs. Procedures used to estimate these user costs are documented elsewhere (*7–9*). Facility costs considered included life-cycle costs (i.e., annualized capital costs for a 20-year life at 10 percent interest) and facility operation and maintenance costs. The estimates of capital costs per lane-mile used in the analysis are presented in Table 2. Facility and user costs per VMT served were then calculated by dividing them by VMT served annually.

Inferences

Comparative Costs Per VMT—Large Urban Areas

Tables 3 and 4 present estimates of costs per VMT served on new capacity in large urban areas, at LOS D and at LOS C. The results indicate that:

- On average, freeways/expressways provide the most economically efficient mobility service for a given urban development density, level of service, and type of construction (i.e., new facility or widening) in large urban areas. The lowest total cost per VMT is 41.9 cents, on added freeway/expressway lanes for widening projects in the fringe, at LOS D.
- Generally, it is more economically efficient to design new capacity to operate at LOS C than at LOS D, with one excep-

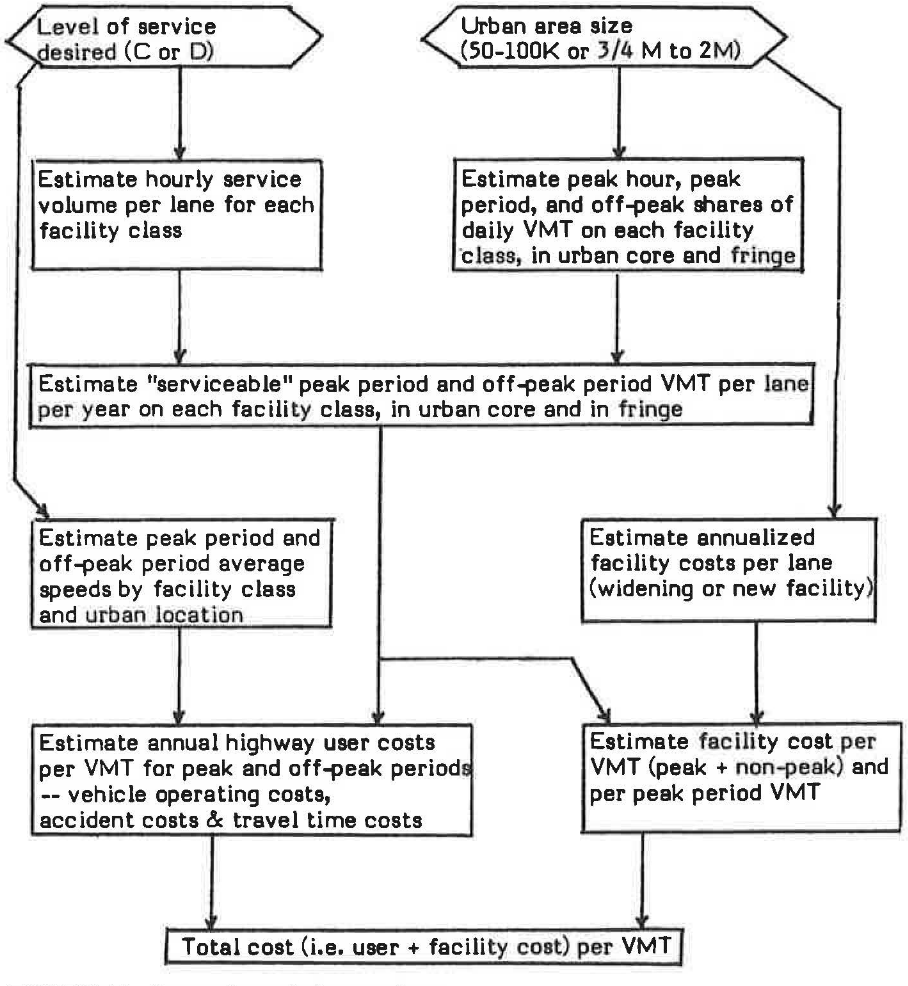

FIGURE 12 Economic analysis procedure.

TABLE 2 CAPITAL COSTS PER LANE-MILE FOR LARGE URBAN AREA (MILLIONS OF DOLLARS)

	New Facility 1/	Widening 2/
Core radial:		
Freeway:	10.10	5.0
Arterial	3.76	2.0
Collector	1.90	1.0
Fringe crosstown:		
Freeway	5.00	1.56
Arterial	2.00	0.74
Collector	1.00	0.29

1/ Estimated on the basis of nationwide new capacity cost estimates in Reference 2.

2/ Source: Reference 10

TABLE 3 COSTS IN THE CORES OF LARGE URBAN AREAS (CENTS PER VMT)

		Fwy/Exp	O.P.Art	Collector
New Facilities				
LOS D	User costs	44.6	94.2	128.1
	Facility costs	23.0	20.5	17.1
	Total	67.6	114.7	145.2
LOS C	User costs	40.8	80.2	100.5
	Facility costs	28.3	22.9	19.5
	Total	69.1	103.1	120.0
Widening				
LOS D	User costs	44.6	94.2	128.1
	Facility costs	11.5	11.0	9.1
	Total	56.1	105.2	137.2
LOS C	User costs	40.8	80.2	100.5
	Facility costs	14.1	12.3	10.4
	Total	54.9	92.5	110.9

TABLE 4 COSTS ON THE FRINGES OF LARGE URBAN AREAS (CENTS PER VMT)

		Fwy/Exp	O.P.Art	Collector
New Facilities				
LOS D	User costs	40.8	82.7	94.3
	Facility costs	9.6	9.0	8.0
	Total	50.4	91.7	102.3
LOS C	User costs	38.2	71.5	80.3
	Facility costs	11.4	10.1	9.1
	Total	49.6	81.6	89.4
Widening				
LOS D	User costs	40.8	82.7	94.3
	Facility costs	3.1	3.4	2.5
	Total	43.9	86.1	96.8
LOS C	User costs	38.2	71.5	80.3
	Facility costs	3.7	3.9	2.9
	Total	41.9	75.4	83.2

tion—new freeways and expressways provided in the urban core.

- Facility costs per VMT are a significant portion of total costs in the urban core (about 40 percent for new freeway/expressway facilities at LOS C), but are a smaller portion of total costs in the fringe (about 23 percent for new freeway/expressway facilities at LOS C).

Comparative Costs per VMT—Excluding Travel Time Costs

Since there is considerable disagreement regarding the translation of travel time savings into monetary benefits, the sensitivity of results to value of time was evaluated by excluding travel time costs from the previously computed costs per VMT. Table 5 indicates that, even if travel time costs are excluded, freeway/expressway costs per VMT are lower than those for lower-order facilities, irrespective of development density characteristics, right-of-way availability (i.e., new facilities vs. widening), and LOS at which the new capacity will operate.

PART 3: ESTIMATION OF NEEDED USER CHARGES

Analysis Procedures

If financing through user charges is desired, systemwide capacity improvements, such as the improvements considered in this economic analysis, may be financed by two basic types of user charges: (1) a motor fuel tax, or (2) road pricing. Road pricing may be implemented by using a variety of tools, such as area-wide licenses required for downtown travel in peak periods, conventional toll booths, or electronic pricing using automated vehicle identification (AVI) technology. Several trends are converging to make road pricing a serious consideration as a revenue source for expansion of transportation capacity (*12*). New technology will help enhance political acceptability of road pricing, as toll booths and the delays they usually involve are replaced by speedier automated collection.

In this part of the analysis, an attempt is made to provide some scale to the level of charges which would be needed to pay for new capacity under two pricing schemes—implementation of tolls either throughout the day or during peak periods only.

Where road pricing systems are feasible to recover the costs for providing expanded system capacity, the "fair" charges per VMT would be equal to the facility life-cycle costs per VMT. In cases where lanes are added to existing facilities, this amount may be divided by the total number of lanes after widening to get user charges, because users of *all* lanes (not just the added lane) can share in paying the cost. User charges for widened facilities were estimated assuming a typical urban highway widening from two lanes in each direction to three lanes in each direction, i.e. a 50 percent increase in capacity, which roughly corresponds to the approximately 50 percent increase in traffic projected by several urban areas over the next 20 years.

For comparison with user charges currently recovered from existing system users, the current average gasoline tax was converted to cents per VMT on each functional class as follows. Average state motor fuel tax receipts were estimated at 12 cents per gallon, based on 1986 adjusted net gallonage receipts, annual VMT, and average miles travelled per gallon of fuel consumed, from *Highway Statistics—1986* (*11*). Total tax receipts per gallon were then estimated at 21 cents, including the 9 cent federal tax. Actual user charges by facility type in cents per VMT were then estimated based on an estimated gas mileage of 30 miles per gallon (MPG) on urban freeways/expressways and 15 MPG on other principal arterials and collectors (*9*).

It is often argued that new capacity is usually needed only to serve peak-period users, and therefore the costs of adding new capacity should be allocated to peak users alone, even though the added lanes may be used both in peak as well as off-peak periods. Therefore, facility costs per peak-period VMT served were also computed, by dividing facility costs

TABLE 5 TOTAL COSTS EXCLUDING TRAVEL TIME COSTS (CENTS PER VMT)

		Fwy/Exp	O.P.Art	
Collector				
Large Urban Areas: Core				
New Facilities	LOS D	42.1	51.5	54.0
	LOS C	45.3	50.7	50.5
Widening	LOS D	30.6	42.0	46.0
	LOS C	31.2	40.1	41.5
Large Urban Areas: Fringe				
New Facilities	LOS D	28.5	39.4	39.1
	LOS C	29.1	37.6	36.9
Widening	LOS D	22.0	33.8	33.6
	LOS C	21.4	31.3	30.7

by peak VMT served on each facility type. The resulting costs per VMT are the needed user charges where road pricing is sought to be applied only to peak users.

Inferences

User Charges On Improved Facilities Only

Table 6 focuses on needed user charges per VMT for LOS D service in large urban areas when only improved facilities are tolled. The estimates indicate that user charges per VMT generally increase with facility class and are lower in the fringe than in the city center. Where road pricing is feasible and all users are charged, freeway/expressway user charges at design LOS D would range from 1.0 cent per VMT for a typical facility widening in the fringe to 23.0 cents per VMT for a typical new facility in the core. Where road pricing is feasible and is applied only to peak-period users, the new capacity user charges per VMT are more than double the charges when all users share the costs. These figures indicate the magnitude of the cross-subsidy between off-peak users and peak-period users of expanded highway facilities in cases when facility expansion is actually needed only to serve peak-period users.

Table 6 also presents user charges that are actually generated by the current gasoline tax in terms of cents per VMT on the facility. The relatively low levels of actual charges under the current tax structure indicate that users of new capacity (generally peak-period users) are heavily subsidized by users of existing capacity (generally off-peak users). Needed user charges for peak-period travel on widened freeways/expressways in the core of large urban areas, for LOS D design, could be as high as 8.9 cents per VMT when the charges are applied only to peak-period users. On the other hand, under the current tax structure, less than 1 cent per VMT would be recovered. In the fringe, the comparable costs are 2.4 cents per VMT with only peak-period users sharing costs, versus less than 1.0 cent per VMT under the current tax structure.

CONCLUSIONS

The analysis of current supply and use of urban highway facilities suggests that there is a tendency for freeways/expressways to carry a larger share of travel as travel demand and urban area size increase. However, relatively lower levels of freeway/expressway supply in the largest urban areas appear to be constraining further increases in share of travel on such facilities. The potential to shift significant shares of travel to freeways/expressways is greater in the largest urban areas and in the suburbs.

The economic analysis of alternative new capacity investments indicates that, given the extent and size of the freeway system currently in place, it is usually more cost-efficient to provide new highway capacity on freeways/expressways. Also it is usually more economically efficient to design new capacity to operate at LOS C rather than at LOS D.

The results from the analysis of needed user charges suggest that travellers for whom the existing system provides adequate service (mainly off-peak users) heavily subsidize travellers who need new capacity (mainly peak-period users). Where road pricing is feasible on improved facilities only, the needed user charge in the typical situation (e.g., widening a four-lane freeway to six lanes in the urban fringe to provide LOS D service) would be about 1.0 cent per vehicle mile if both peak and off-peak users share the costs, and 2.4 cents per vehicle

TABLE 6 USER CHARGES NEEDED ON IMPROVED FACILITIES IN LARGE URBAN AREAS AT LOS D (CENTS PER VMT)

		Fwy/Exp	O.P.Art	Collector
New Facilities				
Core:	All users charged	23.0	20.5	17.1
	Only peak users charged	53.2	50.7	37.8
Fringe:	All users charged	9.6	9.0	8.0
	Only peak users charged	22.1	23.8	19.3
Widening				
Core:	All users charged	3.8	3.7	3.0
	Only peak users charged	8.9	9.1	6.7
Fringe:	All users charged	1.0	1.1	0.8
	Only peak users charged	2.4	3.0	2.0
Charges with current tax structure				
Core and fringe		0.7	1.4	1.4

mile if only peak-period users bear the costs. On the other hand, the needed user charge to pay for a *new* freeway in the fringe of a large urban area could be as high as 9.6 cents per vehicle mile if both peak and off-peak users share costs, and 22.1 cents per vehicle mile if only peak-period users bear the costs.

Implications for Urban Highway Policy

The analysis and inferences presented in this paper suggest that, if public acceptance can be achieved, freeways/expressways have a powerful role to play in plans to expand urban highway system capacity, especially in heavily congested large urban areas, because of their superior economic efficiency relative to lower-order functional classes. However, financing such improvements using the current tax structure, which relies heavily on motor fuel taxes, would not be equitable towards users who use the highway system during off-peak periods, when existing highway system capacity would suffice. Consequently, financing mechanisms that rely on road pricing, possibly using AVI technology, should be investigated in plans to expand urban highway systems. AVI technology will help enhance political acceptability of road pricing as toll booths and the delays they involve are replaced by speedier automated collection. This technology will also facilitate the implementation of differential tolls by time of day. Availability of public transit options and preferential pricing for high occupancy vehicles (HOV) could make pricing more acceptable politically, while facilitating shifts in travel mode.

Recommendations for Further Research

The economic analysis focused on traditional types of highway facilities. It excluded consideration of HOV facilities, transitways, and non-highway type facilities (e.g., light rail, heavy rail, bikeways, etc.). Further research is needed to make comparisons with such alternative investment types. Also, the sensitivity of the results to some of the simplifying assumptions made for the analysis need to the investigated.

The analysis of supply, use, and level of service was based on data aggregated by urbanized area size group. Individual urbanized areas were not analyzed. The patterns, trends, and relationships developed in this study need to be verified based on more detailed data from individual case study urbanized areas.

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