Evaluation of Demand-Management Strategies for Toledo's Year 2010 Transportation Plan

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This paper attempts to evaluate transportation system demand-management strategies—specifically, strategies to encourage transit and ridesharing—as a long-range solution to systemwide traffic congestion problems in the Toledo metropolitan area. The Toledo Metropolitan Area Council of Governments (TMACOG) has forecasted that there will be severe congestion on major arterials and on the freeway and expressway system by the year 2010, and financial resources to address the problem will be limited. Innovative transit system designs, auto pricing, and ridesharing incentives that have been implemented elsewhere in North America were investigated. Their applicability to the Toledo area was reviewed, and synergistic combinations of specific policies were developed for testing with computerized travel models. The results indicated that the most effective and economically efficient way to relieve forecasted congestion would be a policy that encourages both transit and ridesharing on a systemwide basis—through a high-frequency, multicentered, pulsing-scheduled transit system; a system of high-occupancy vehicle lanes; and use of auto pricing. The results of the evaluation also indicated that a combined transit/ridesharing-preferential strategy compares favorably with other strategies with respect to other objectives of TMACOG's long-range transportation plan—transit viability, economic development, safety, and maximization of social and environmental benefits. The study made a useful contribution in assisting TMACOG's Long Range Plan Task Force in the development of transit and ridesharing policies for its Year 2010 Transportation Plan.

Highway systems in most urban areas in the United States are in the "developed" stage. Also, financial resources available for construction of new or expanded highway facilities are meager, and right-of-way for accommodation of such facilities is scarce. It is anticipated that few new facilities will be built in the future.

Urban traffic congestion, however, continues to increase as a result of continuing urban sprawl and increasing dependence on the private vehicle for urban transportation. It is clear that traditional methods for solving urban congestion problems, which are primarily oriented toward improving highway system "supply" characteristics, will have limited applicability in the development of transportation systems to serve urban travel demand beyond the year 2000. Failure to maintain urban mobility in a cost-efficient manner could lead to degradation of urban lifestyles and regional economies.

As planners of the urban transportation system in the Toledo urban area began the process for development of a transportation plan for the year 2010, it was clear to them that they must broaden their search for long-range solutions to forecasted traffic-congestion problems. Greater emphasis would have to be placed on development of innovative strategies to increase the person-carrying capacity of the existing highway system. At the same time, the strategies would have to address the need to conserve energy and economic resources, preserve environmental quality and neighborhoods, and serve the mobility needs of an aging population.

As the Long Range Plan Task Force of the Toledo Metropolitan Area Council of Governments (TMACOG) proceeded to develop alternative transportation plans for computer testing and evaluation, the limits of financial capability for highway capital spending had already been recognized (*1*). Several potential system-oriented solutions related to travel demand management—particularly encouragement of transit and ridesharing—had been proposed at a "Charrette" (*2*). The Charrette was an intensive brainstorming session that brought together more than 100 key community leaders, transportation system users and providers, and government officials over a 24-hr period. Its purpose was to seek a consensus on solutions to transportation problems over the next 20 years. Solutions suggested at the Charrette included auto parking and pricing policies, a high-speed multicentered transit system with high levels of collection and distribution service to and from transit centers, and policies and systems to encourage ridesharing among commuters.

PURPOSE OF STUDY

The Long Range Plan Task Force sought information to help in evaluating the travel demand-management strategies proposed at the Charrette. Information was sought on the relative impacts of the strategies if they were to be implemented in the Toledo area. This study was undertaken to evaluate the relative merits of alternative strategies on a systemwide basis using TMACOG's computerized travel models to estimate travel impacts.

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STUDY PROCEDURE

The study procedure involved the following steps:

1. A review of the literature to become familiar with current knowledge and practice related to travel demand management and formulate strategies applicable in the Toledo area.
2. An evaluation of the severity of peak-period traffic congestion forecasted by TMACOG through the year 2010.
3. Formulation of alternative demand-management strategies to address forecasted peak-period traffic congestion problems.
4. Computer simulation of peak-period traffic on the highway system under each strategy to evaluate the impacts on peak period traffic congestion in 2010.
5. Analysis and evaluation of the alternative strategies, with special emphasis on their economic efficiency and ability to relieve forecasted peak-period traffic congestion.

LITERATURE REVIEW

A discussion of the insights gleaned from the literature review is presented in two parts: (a) modal strategies [transit and high-occupancy vehicles (HOVs)] and (b) pricing strategies (parking and road pricing).

Modal Strategies

Belobaba (*3*) has described a rapid transit bus system planned for the Ottawa, Canada, urban area. The area had a 1978 population of about 525,000, approximately the size of the Toledo area. The study concluded that a transportation policy that did not include transit operations on priority rights-of-way "would leave the transit system at the mercy of increased road congestion, resulting in lower operating speeds and, therefore, significantly higher operating costs." A rapid bus system was preferred over light rail because of the greater overall economic efficiency of a rapid bus system and the flexibility of buses to leave the rapid-transit right-of-way to provide same-vehicle line haul and feeder service. Bonsall (*4*) has indicated that Ottawa's busway system and supporting transit improvements have been an unqualified success—over 30 percent of all person-trips in the region and 60 percent of all downtown-destined peak-hour journeys were being made by public transit in 1985.

Fisher (*5*) concluded that a substantial change in the mode choice of commuters resulted from the opening of the full length of exclusive roadway for HOVs in the median of the Shirley Highway (in the Washington, D.C. area) and the initiation of eight new express bus routes. In remarks presented at the 65th Annual Meeting of the Transportation Research Board in January 1986, R. G. Sarros reported that at that time 70 percent of the persons moved inbound in the weekday a.m. rush period were transported in multioccupant vehicles on the two inbound HOV lanes, whereas only 30 percent were transported on the three inbound unrestricted lanes. When a transitway was built in the median of the six-lane Katy Freeway in Houston, Texas, over 40 percent of the total peak-hour, peak-direction person movement was taking place in the transitway (*6*). Capelle et al. (*7*) have indicated the advantages of a bus/HOV facility system: increase in freeway efficiency, reduced subsidies for transit, amenability to phasing over time, implementability in concert with freeway rehabilitation or other highway improvement projects, and an increase in the availability of federal funding because both highway and transit funding are available. Toledo has a unique opportunity to incorporate bus/HOV facility studies into its Interstate Highway Needs Study (*8*) scheduled to begin soon.

Nakadegawa (*9*, p. 1 and 9) and Schneider et al. (*10*) have presented transit system design concepts that can relieve traffic congestion not only in urban core areas but also in suburbia. Nakadegawa has proposed a multicentered timed-transfer system with frequent and swift bus service via exclusive busways that link employment and shopping centers with residential neighborhoods. Schneider et al. indicate that a timed-transfer or "pulsing-scheduled" transit system has enabled Edmonton, Canada, to serve both cross-town and radial commuting patterns. Travel times dropped by about 20 percent under the timed-transfer arrangement (*11*).

Priest and Walsh-Russo (*12*) have shown that although the decentralization trend in many metropolitan areas is well advanced, new trends are emerging that favor clustering of offices, some retail, and residential uses. Where transit has adapted to the multinucleated urban pattern, sustained ridership growth has been achieved. In Ottawa, Canada, a byproduct of the transitway system has been the clustering of high-rise apartments around several outlying stations (*13*). In Edmonton, Canada, shopping malls reported significant gains in sales following the opening of on-site transit centers, whereas competing retail centers without a transit facility were experiencing losses (*14*). These experiences indicate that coordination of transit and land development policies in the suburbs can result in both mobility and economic benefits.

Pricing Strategies

Future travel demand can also be modified by disincentives to the inefficient use of single-occupant automobiles for work travel. Shoup (*15*) has shown that free employee parking rewards solo drivers. Letting employers pay their employees tax-exempt cash instead of giving them tax-exempt free parking, would eliminate free parking's almost irresistible invitation to drive alone to work, and use of transit and carpooling would increase. Fitch (*16*, pp. 122–146, 265–266) has indicated that if peak period motorists were to pay the full cost of their use of resources, the prices paid by them would be vastly greater. Highways are designed for peak-hour use, with extra lanes, ramps, and traffic control devices that would not be needed for the smaller volumes of off-peak traffic. But the cost of using the facility during the peak hour consists only of gasoline taxes, which are paid uniformly by peak and off-peak users. Failure to confront peak-hour motorists with the true cost of highway use encourages them to use a means of transportation with high resource costs. A well-documented example of road pricing is the Singapore area license plan (*17*). A license requirement was instituted for vehicles entering a core-area zone between 7:30 a.m. and 10:15 a.m., and a 100 percent increase in parking charges at public lots within the zone was instituted. As a result, the number of cars entering the zone in the a.m. peak period fell by 73 percent, and carpooling increased by 60 percent.

Road pricing is an effective and efficient way to reduce traffic volumes when and where they create problems of congestion. Unlike fuel taxes, the charges can be easily adjusted by time, location, and degree. Unlike parking taxes, they can affect inbound trips as well as trips going through the congested area. In the late 1970s, UMTA initiated a demonstration program to pay for implementation of the license approach (similar to Singapore's) in U.S. cities. However, only three cities requested preliminary studies of the approach, and in each of these cities, the studies were abandoned before completion because of objections from the public, the business community, and key decision makers (*18*). Major objections were that it would interfere with the right to travel, that it would harm business or business image, and that it discriminates against the poor.

While the license approach to road pricing ran aground in the United States because of political problems, the success of another form of road pricing—toll roads—indicates that motorists are prepared to pay for convenient roads. The technical capability now exists to collect road tolls without stopping traffic. Users of the 14.5-mi-long Dallas North Tollway will be given the option of attaching to their vehicles electronic identification devices that will enable toll bills to be paid by monthly check, like electric or telephone bills. This technology could be used to establish a flexible toll system on urban area highways (*19*). Motorists who want to use a main artery—or designated lanes on those arteries—during peak-use periods first would be required to install in their automobiles a transponder, a relatively inexpensive device that emits a unique electronic signal identifiable by a central computer. This would permit the electronic tallying of each vehicle's use and allow a monthly bill to be generated. The computer could establish toll rates depending on the level of use, and displays near highway entrances or low-wattage radio signals could be used to advise motorists of the toll rates.

The review of the literature established a convincing need for further investigation of innovative transit service concepts, ridesharing incentives, and transportation pricing policies with particular reference to the Toledo area. To formulate appropriate strategies for computer testing, it was important to first project the magnitude of the traffic-congestion problems on specific facilities through the year 2010. These projections are discussed in the next section.

PEAK-PERIOD CONGESTION FORECASTS

The population of the Toledo transportation study area in 1980 was about 567,000. TMACOG's forecasts through 2010 indicate a 12 percent increase in population to 635,000, whereas employment is forecasted to grow by 23 percent from 235,000 to 290,000. Because of this growth and the continuing shift of population and employment to suburban locations along with increasing dependence on private vehicles for intraurban transportation, TMACOG has forecasted an increase in total daily vehicle miles of travel (VMT) of over 40 percent systemwide.

Forecasts of traffic congestion on the existing highway system based on an all-or-nothing traffic assignment are presented in Figure 1. Levels of service (LOS) D, E, and F in the peak periods are indicated. The forecasts show that both the freeway system and the arterial street system will be severely congested by 2010 if no improvements are made to the existing highway system or if travel demand is not managed. Under an optimistic scenario, TMACOG has estimated that a total of about $200 million in highway funding (in 1985 dollars) will become available over the next 20 years to pay for highway capacity improvements. This funding is estimated to be adequate for construction of about 100 new highway lane miles if existing rights-of-way can be used. It is clear that, even if right-of-way is available, the projected highway funding will not be adequate to relieve the forecasted levels of traffic congestion on the numerous miles of congested streets and highways indicated in Figure 1.

FORMULATIONS OF ALTERNATIVE STRATEGIES

Three alternative demand-management strategies were formulated to address the peak-period congestion problems. Each alternative strategy represents a "boundary" condition. A boundary condition may be defined as the upper limit in the severity of a range of policy levels that decision makers may be expected to consider. Each of the three strategies was a combination of extreme policies designed to encourage use of a more efficient travel mode or modes during peak travel periods. In addition, a "traditional" strategy was defined involving no travel demand-management policies, for use in comparative evaluation.

The traditional strategy reflected current policies. These policies involve primarily the expansion of the capacity of highway facilities. Most of the segments of the freeway/expressway system forecasted to be congested by the year 2010 would be widened under this strategy, using all of the $200 million in highway funding that is anticipated to become available (see Figure 2). Current peak-period transit service levels would be maintained. Only slight increases in auto operating costs and downtown parking costs are projected, based on market forces; no pricing policies are included.

The first demand-management strategy was a "transit-preferential" strategy, which included an extremely high level of peak-period transit service and pricing policies to encourage transit use and discourage auto use. Express bus service would be provided on reserved rights-of-way between transit centers at which high-density development would be encouraged (see Figure 3). All new freeway lanes would be reserved for transit. Feeder bus service would be provided to the centers, and park-and-ride facilities would be provided at several outlying centers. Peak-period transit fares would be reduced to half their current levels, and auto pricing policies (using tolls and parking charges) would double the cost of using the auto for the peak-period work commute.

The second demand-management strategy was a "ridesharing-preferential" strategy. Ridesharing would be encouraged through systemwide implementation of HOV lanes. All new lanes added to the freeway system would be reserved for HOVs (see Figure 4). Pricing policies would be the same as those under the transit-preferential strategy.

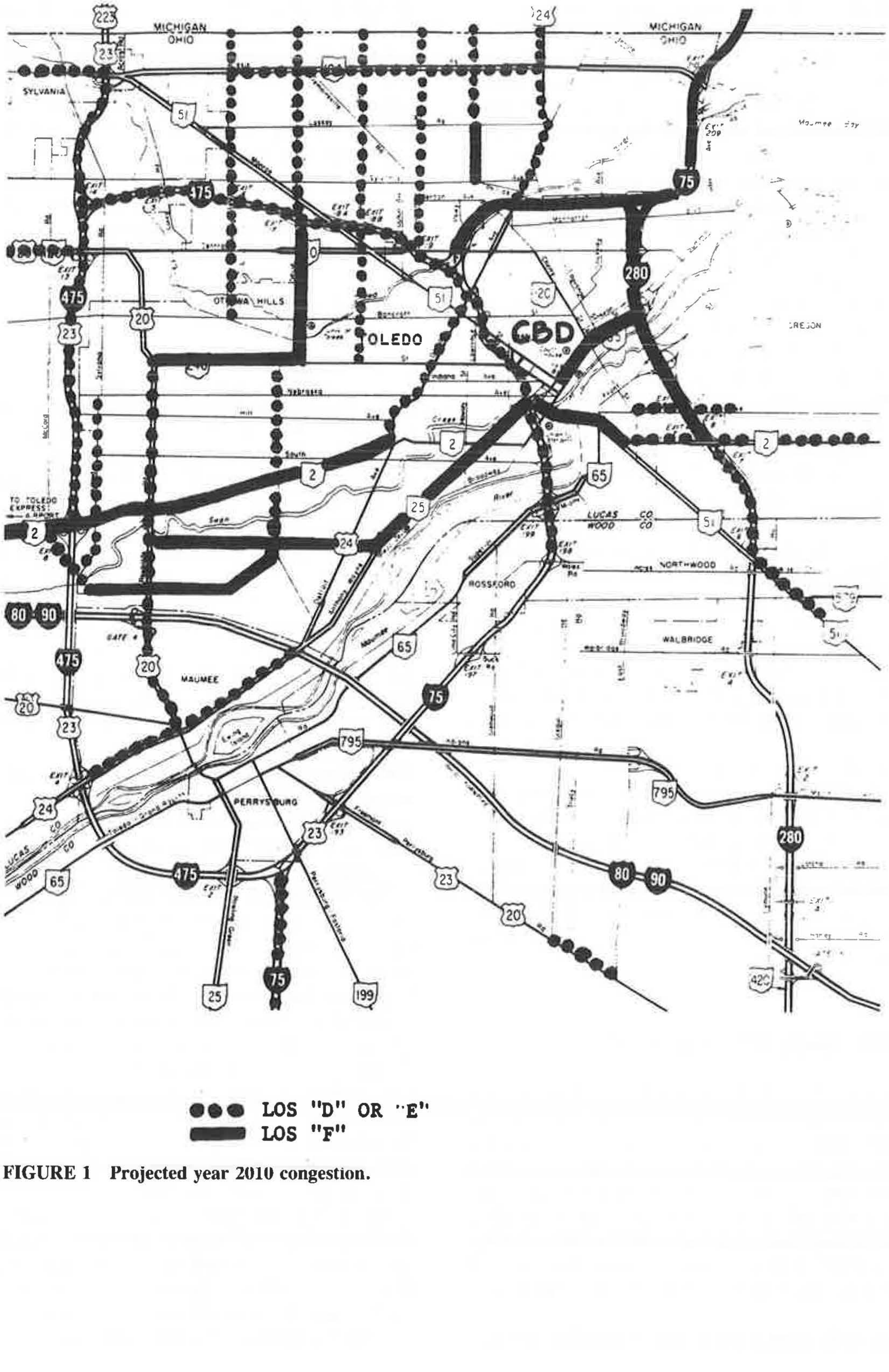
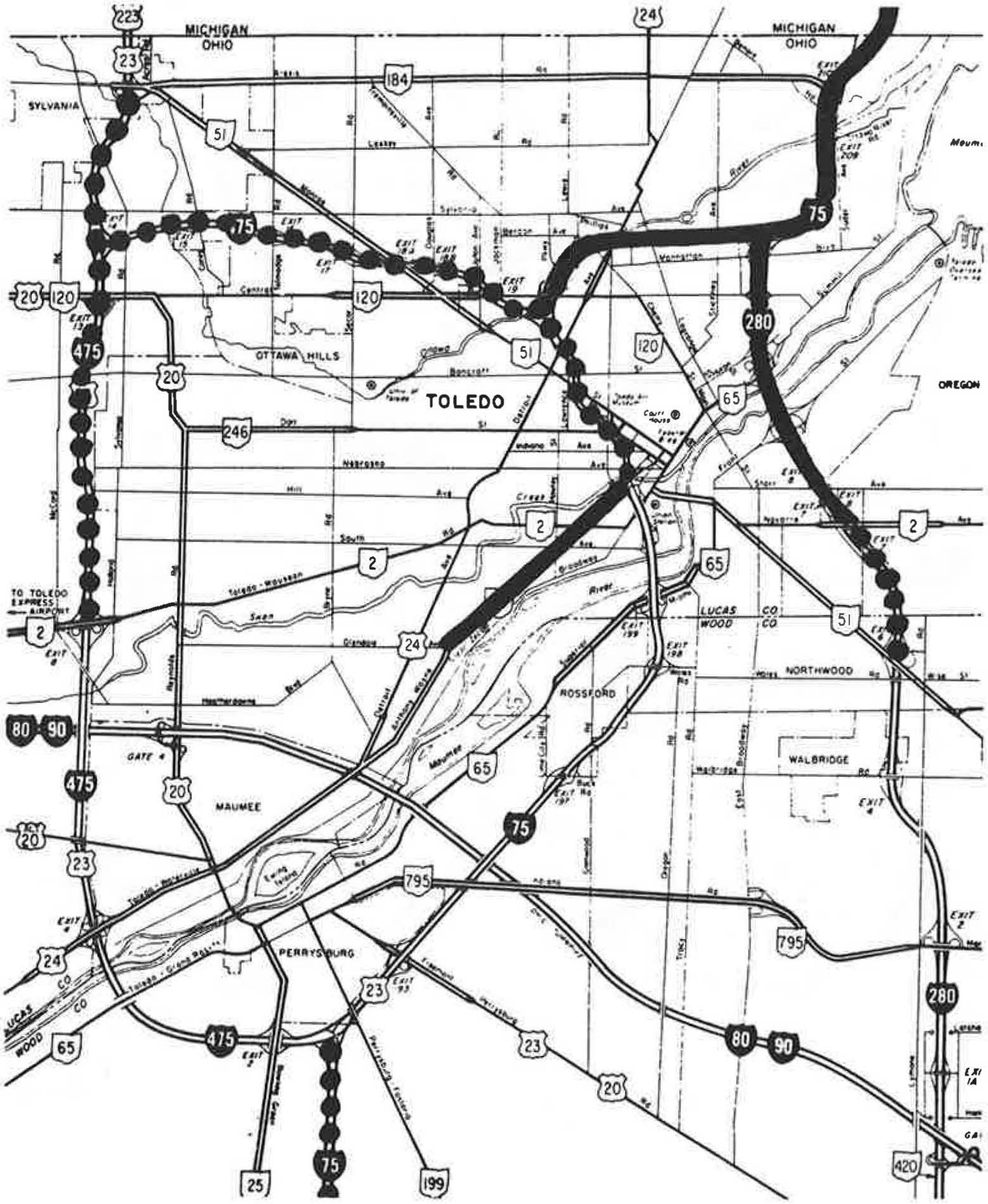


FIGURE 1 Projected year 2010 congestion.



●●● LOS "D" OR "E"

▬ LOS "F"

FIGURE 2 Projected year 2010 congestion on freeways and expressways.

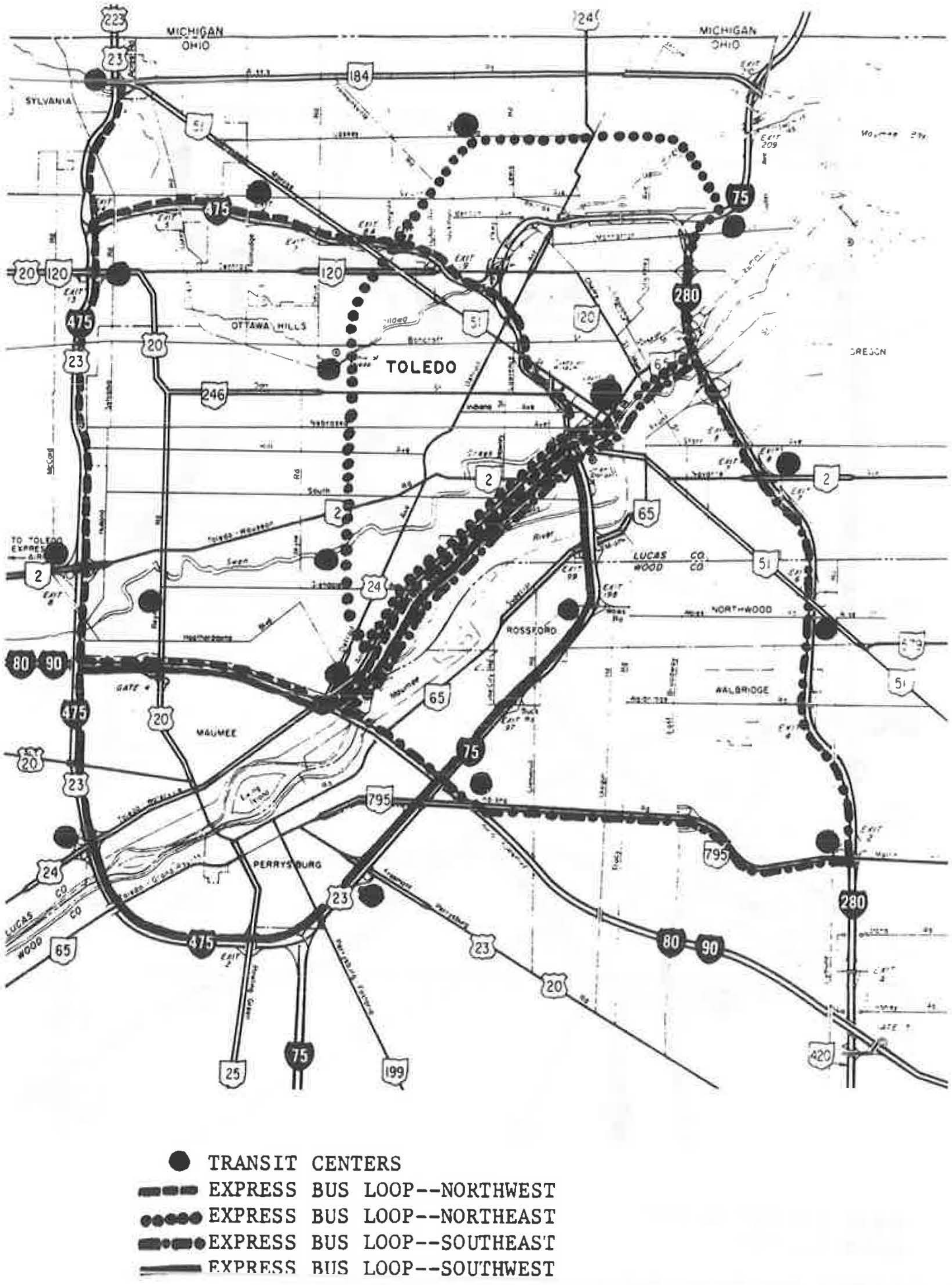


FIGURE 3 Multicentered transit system.

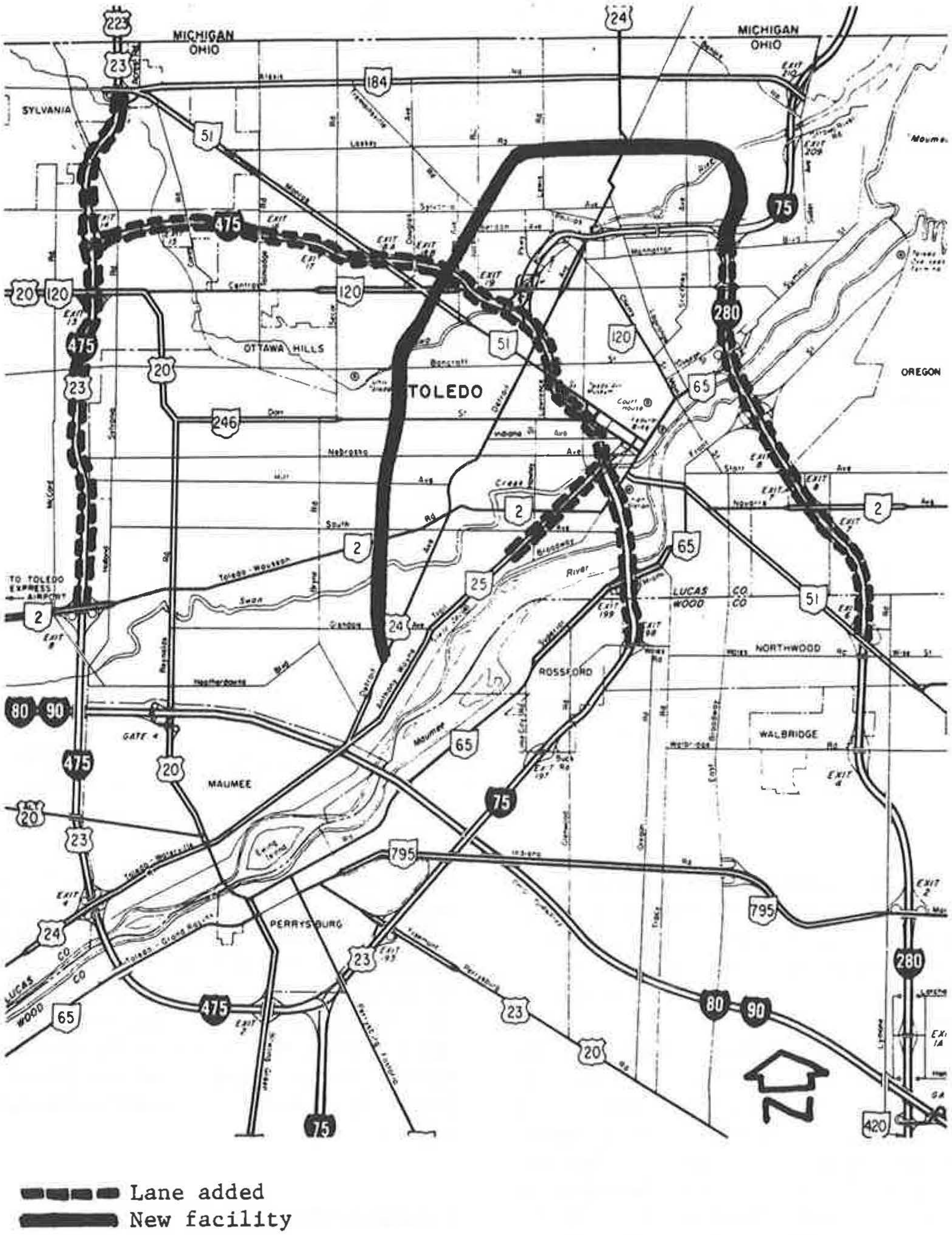


FIGURE 4 HOV lane system.

The third demand-management strategy was a combination of the first two. This "transit/ridesharing-preferential" strategy included the multicentered transit system of the transit-preferential strategy, with express bus service operating on the HOV lane system of the ridesharing-preferential strategy. Pricing policies were the same as those under the first two strategies.

TRAFFIC IMPACT ANALYSIS

The four transportation strategies described in the previous section were computer simulated using TMACOG's computerized travel models (*20*, *21*) and projected 2010 socioeconomic forecasts by traffic zone (*22*). Because the demand-management strategies were designed primarily to modify commuter travel demand, the analysis focused on the work trip. Separate runs of the mode-choice model were made for each strategy for work trips, but not for nonwork trip purposes; it was assumed that the demand-management strategies would have only minor effects on nonwork vehicular travel. Appropriate percentages of daily travel (*23*) were used to get peak-period shares of daily vehicle trips for the various trip purposes. The peak periods were defined as the 3 hours in the morning and the 3 hours in the afternoon with the highest traffic volumes, approximately 6:30 a.m. to 9:30 a.m. and 3:00 p.m. to 6:00 p.m. Results are summarized in Table 1.

TABLE 1 YEAR 2010 PEAK-PERIOD TRAVEL DEMAND

		Alternative Strategies		
	Traditional	Transit-Pref.	Rideshare-Pref.	Transit/R'share
Peak Period Work Travel:				
Person trips:				
Auto driver	257,524	169,314	193,669	165,117
Auto Passenger	61,208	68,189	99,762	77,690
Transit	12,090	93,319	37,392	88,015
Total person trips	330,822	330,822	330,823	330,822
Vehicle trips	257,524	169,314	193,669	165,117
Peak Period Total Vehicular Travel:				
Home-based work	257,524	169,314	193,669	165,117
Home-based non-work (31% of daily)	236,780	571,484	571,484	571,484
Non-home based (35% of daily)	184,149			
Truck & External (33% of daily)	150,555			
Total vehicle trips	829,008	740,798	765,153	736,601
% Change from traditional strategy		-10.6%	-7.7%	-11.1%

As shown in the table the combined transit/ridesharing-preferential strategy was the most effective of the three demand-management strategies with respect to reducing peak-period vehicular travel. Work vehicle trips were reduced by 36 percent, and total vehicle trips for all trip purposes were reduced by over 11 percent.

To estimate the impacts of these vehicular travel reductions on highway facility performance, peak-period vehicle trips were assigned to the highway network using an all-or-nothing traffic assignment. The assignment results were used to assess the impact of each strategy on traffic volumes that had previously been projected in 2010 if no improvements or demand-management policies were implemented (see Figure 1). The analysis focused on impacts in the vicinity of major activity centers. The results are presented in Figures 5 through 7. As shown in the figures, the demand-management strategies resulted in significant reductions in highway traffic volumes. Since the traditional strategy did not involve any policies to modify travel demand, no change in previously forecasted traffic volumes would result from the strategy; therefore a special traffic assignment was not needed.

EVALUATION OF ALTERNATIVES

The seven objectives adopted by TMACOG for its Year 2010 Plan (*24*) were economic efficiency, reduced traffic congestion, transit viability, economic development, safety, maximization of beneficial social impacts, and maximization of beneficial environmental impacts. The computer model estimates described in the previous section were used to develop quantitative information to evaluate the alternative strategies with respect to the first two objectives, traffic congestion relief and economic efficiency. The strategies were evaluated with respect to the remaining five objectives by comparing them based on indicators of the relative order of magnitude of their impacts with respect to the five objectives. In the next three subsections the evaluation results are presented with respect to (a) congestion relief, (b) economic efficiency, and (c) other impacts.

Congestion Analysis

As indicated in Table 1, a significant reduction in overall peak-period vehicular travel demand can be achieved by the alternative demand-management strategies. The combined transit/ridesharing-preferential strategy has the greatest impact on travel demand, reducing systemwide vehicular travel during peak periods by over 11 percent. The transit-preferential strategy has only slightly less impact, reducing travel by 10.6 percent, and the ridesharing-preferential strategy is the least effective, reducing overall travel by about 7.7 percent.

Vehicular travel demand must be viewed in relation to highway facility supply in order to assess traffic congestion levels. Because the alternative strategies involved varying levels of both travel demand and highway capacity available for unrestricted auto use, the ratios of volume to capacity were estimated for each strategy to evaluate congestion levels. The evaluation focused on five major activity centers that were

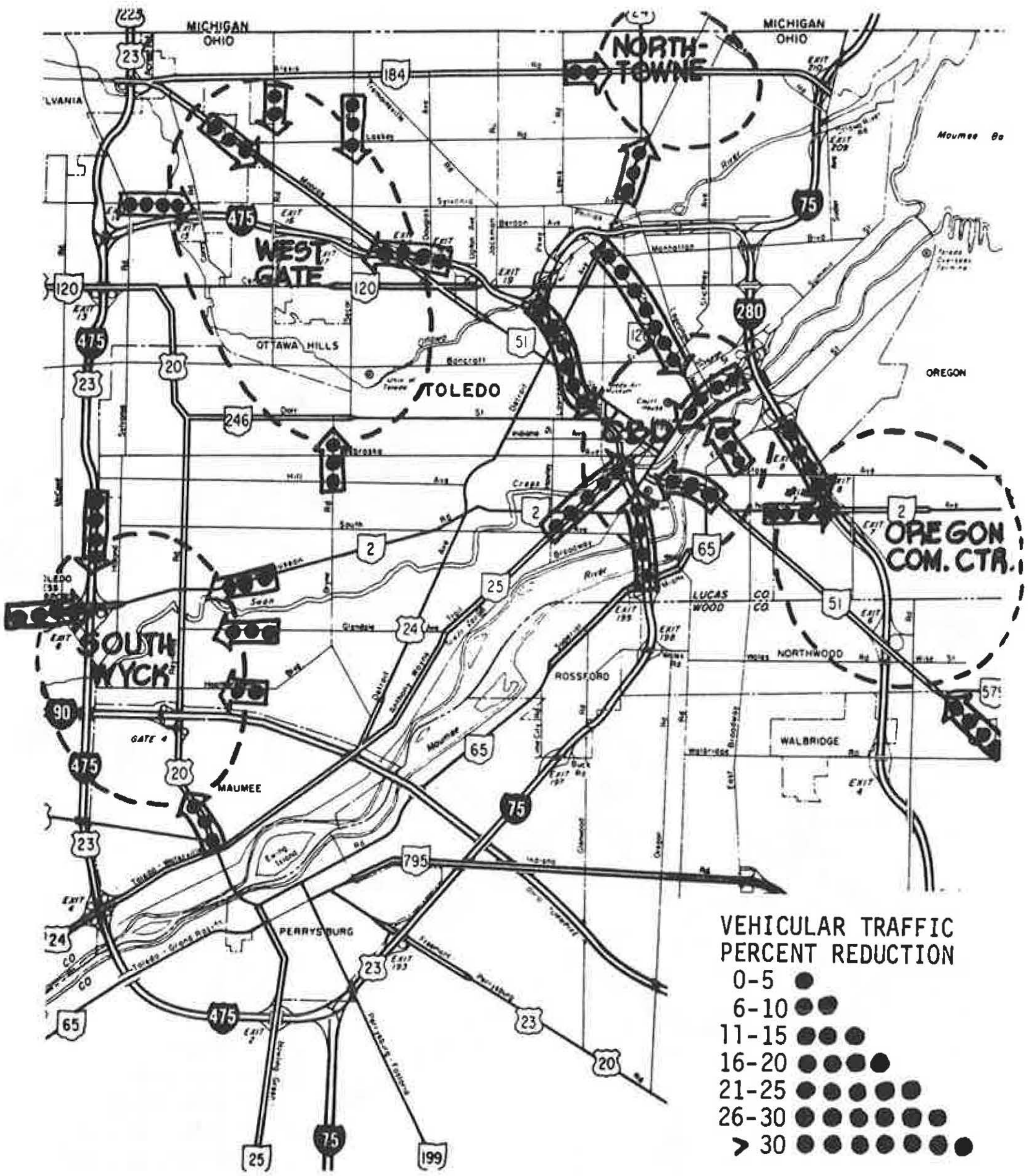


FIGURE 5 Vehicular traffic impacts in the vicinity of major activity centers—transit-preferential strategy.

of concern to policy makers. Ratios of volume to capacity (*V/C*) were developed for cordonlines around each of the five centers. The results are presented in Table 2. As indicated in the table, cordonline peak-hour *V/C* ratios were developed for the peak direction of travel. Traffic volumes in the peak hour in the peak direction were estimated based on the appropriate hourly distribution of travel on arterials (*23*). Capacity estimates were based on maximum volume that can be served at LOS C. The results of the analysis indicated that *V/C* ratios at LOS C would be lowest under the combined transit/ridesharing-preferential alternative, ranging from 0.92 to 1.08. It should be noted that, although traffic volumes are lowest under the transit-preferential alternative, the highway capacity added under this alternative is not available for auto use, since new lanes are reserved for buses. Consequently, *V/C* ratios are generally higher than for the other two demand-management alternatives, which allow use of added lanes by HOVs. It should also be noted that the *V/C* ratios represent average conditions along each cordonline. Actual *V/C* on specific facilities, or on specific lanes in the case of facilities with reserved lanes for HOVs, could be higher or lower than the average cordonline *V/C*.

Based on the *V/C* estimates in Table 2, it may be concluded that the combined transit/ridesharing strategy shows the greatest promise for relieving the forecasted congestion in the year 2010.

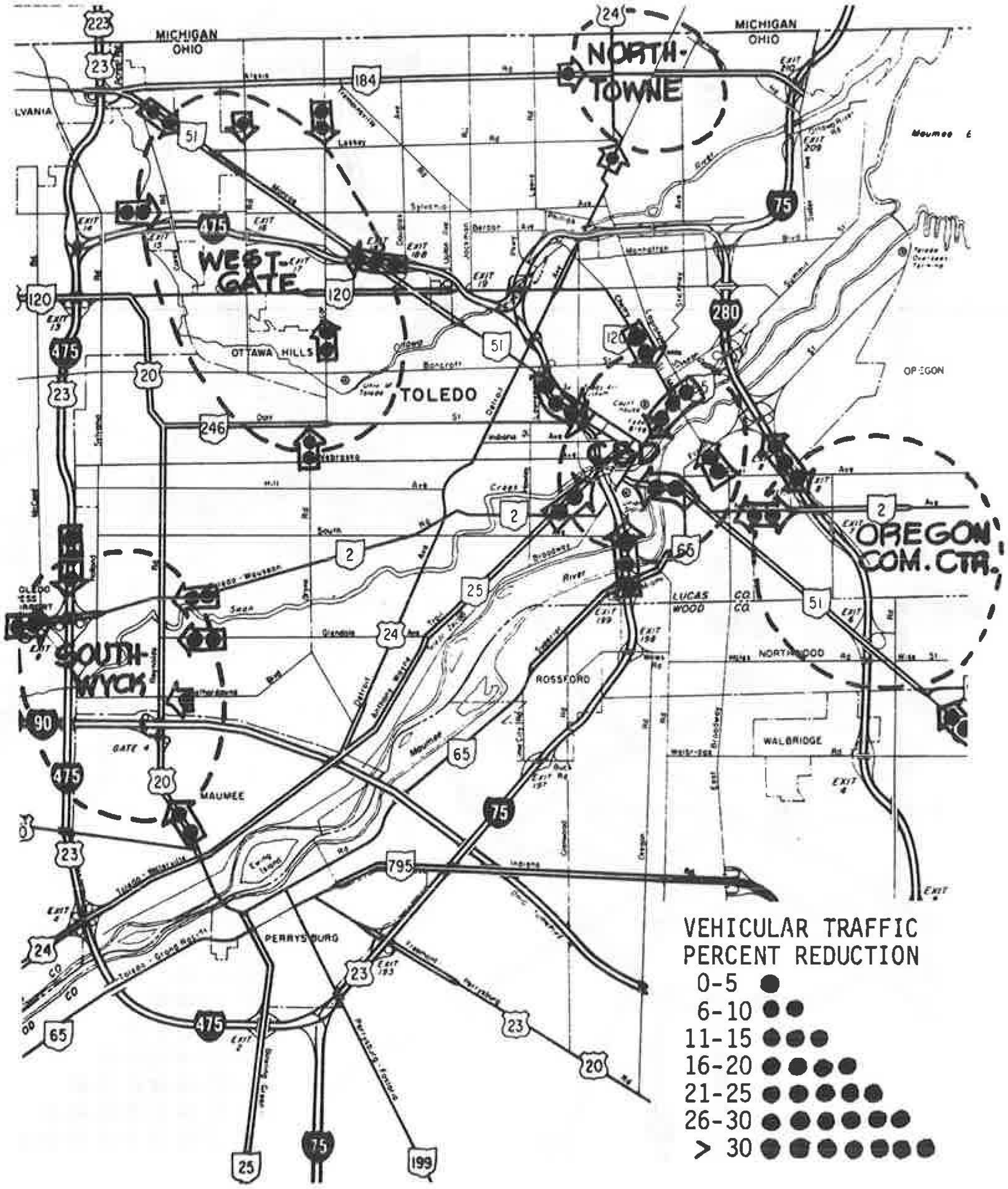


FIGURE 6 Vehicular traffic impacts in the vicinity of major activity centers—ridesharing-preferential strategy.

Economic Efficiency Analysis

The approach in economic efficiency evaluation is to compute total dollar costs of all economic resources used in the production of goods or services. In this analysis, the "service" to be produced through the transportation system is the satisfaction of work travel needs during the peak travel periods of the weekday in 2010 and beyond. Only resources that have dollar market values are considered "economic" resources. Thus, commuter travel time is generally not an economic resource (because most employees are not paid for the time they spend in getting to work) and has not been considered in the analysis.

Also, only "escapable" costs are considered in the analysis. For example, costs for auto ownership are not considered to be "escapable" because it is assumed that most solo-driver commuters who are induced to shift their travel mode to riding transit or carpooling will still need their cars for nonwork trips.

The economic resource costs were computed in 1985 dollars for each transportation strategy as follows:

- *Highway user costs.* Costs were based on vehicular operating and accident costs.
- *Highway facility costs.* All lane widening and new facility costs are considered "escapable" costs because it is assumed that all highway capacity improvements are needed mainly to serve peak-period travel volumes, and off-peak volumes can

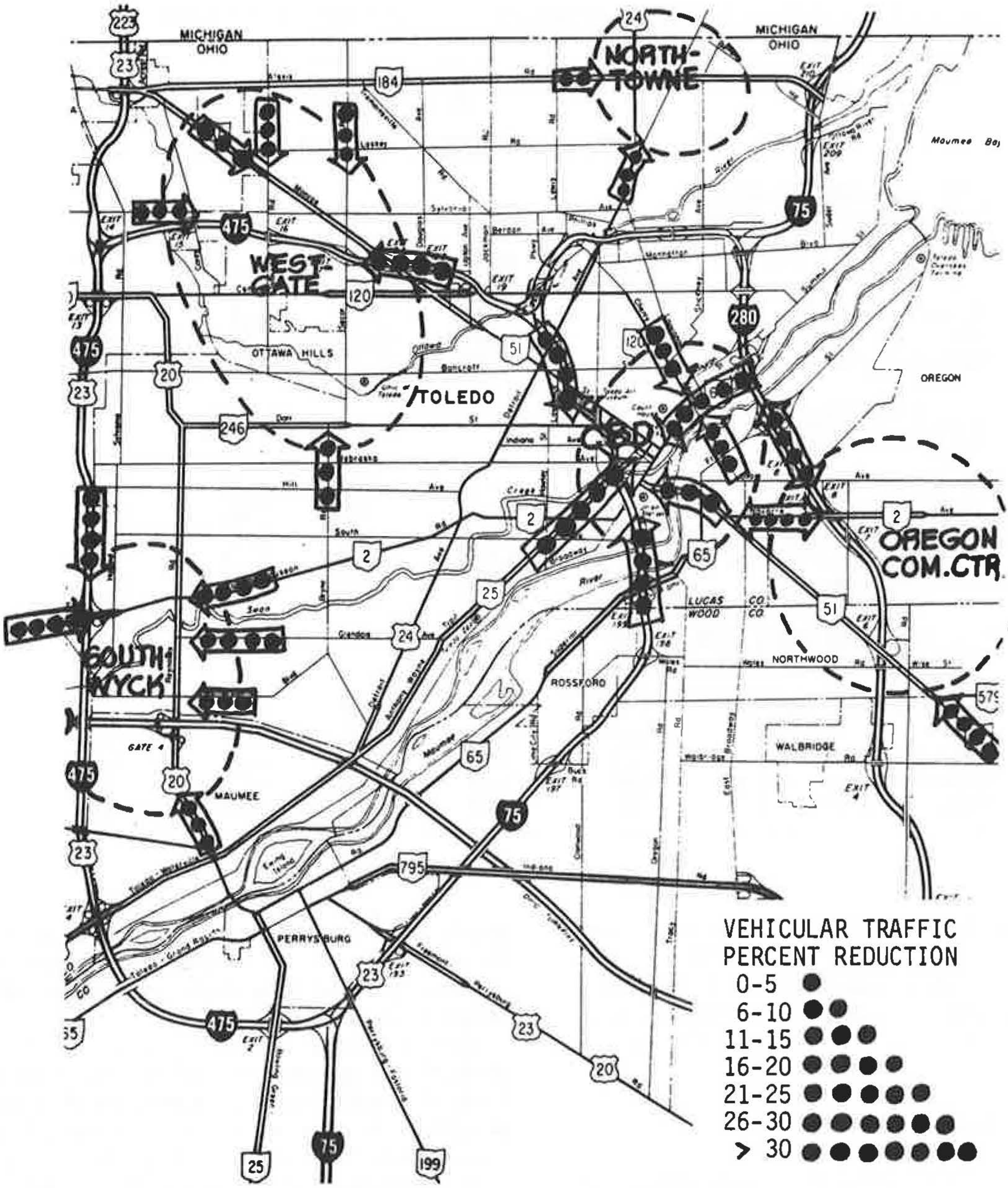


FIGURE 7 Vehicular traffic impacts in the vicinity of major activity centers—combined transit/ridesharing-preferential strategy.

be handled by existing facilities. The highway maintenance costs related to commuter work travel are estimated based on average annual maintenance costs.

- *Parking costs.* Only those parking spaces needed to serve commuters (not those for visitors) are considered "escapable." Both capital costs and maintenance costs are included.
- *Transit costs.* Capital costs of all buses needed for the system that exceed the number of buses needed for off-peak transit service are considered "escapable" costs. Operation and maintenance costs were estimated for peak-period service. Park-and-ride facility capital and maintenance costs are included. Busway/HOV-lane costs and metered freeway ramp bypass costs are reported as highway facility costs under the second bulleted item.
- *Employer/agency costs.* These include costs incurred by private employers and by government agencies for rideshare matching services and for administering a commuter parking management program.

Economic resource costs were computed for each of the five components of the transportation system (see Table 3). As shown in the table, highway user costs and employee parking costs are reduced considerably as a result of the travel demand strategies, whereas highway facility costs are slightly higher owing to specialized treatments for HOVs. Total annual resource cost is lowest for the transit/ridesharing-preferential strategy, amounting to $1.71 per work-person trip. This cost is over 16 percent lower than the cost per work-person trip

TABLE 2 YEAR 2010 HIGHWAY PERFORMANCE IN THE VICINITY OF MAJOR ACTIVITY CENTERS

	Major Activity Centers				
	Downtown	Southwyck	Westgate	Northtowne	Oregon
Cordonline traffic volumes (peak hour, peak direction):					
Do-nothing alternative	20,199	11,988	13,040	2,655	6,569
Traditional	20,199	11,988	13,040	2,655	6,569
Transit preferential	16,577	10,718	11,069	2,382	5,393
Ridesharing preferential	17,991	10,948	12,059	2,555	5,745
Combined alternative	16,584	10,320	11,064	2,370	5,390
Cordonline directional hourly capacity (LOS C):					
Do-nothing alternative	15,020	8,805	10,015	2,265	5,137
Traditional	17,950	9,556	11,216	2,265	5,888
Transit preferential	15,020	8,805	10,015	2,265	5,137
Ridesharing preferential	17,950	9,556	11,216	2,265	5,888
Combined alternative	17,950	9,556	11,216	2,265	5,888
Cordonline peak hour, peak direction volume-to-capacity ratios (at LOS C):					
Do-nothing alternative	1.34	1.36	1.30	1.17	1.28
Traditional	1.12	1.25	1.16	1.17	1.11
Transit preferential	1.10	1.22	1.11	1.05	1.05
Ridesharing preferential	1.00	1.15	1.08	1.12	0.98
Combined alternative	0.92	1.08	0.99	1.05	0.92

of $2.05 under the traditional strategy. It should be noted that these costs exclude the value of travel time. If travel delay costs are included, the cost difference would be even greater because vehicular travel delays are much greater under the traditional strategy as a result of higher *V/C* ratios.

Analysis of Other Impacts

Relative performance of the alternative strategies with respect to the five remaining plan objectives was assessed by comparing them with one another based on performance indicators (see Table 4). The performance indicators were developed from the travel-demand, highway-performance, and economic-resource cost estimates presented in Tables 1 through 3. Transit system costs per peak-period rider and peak-period ridership levels were selected as indicators of transit viability. Assuming that economic development potential would be enhanced by lower levels of congestion, the weighted average *V/C* ratio for the five major activity centers was selected as the indicator of performance with respect to economic development. Indicators selected to evaluate safety were (a) VMT per work-person trip served, which measures relative exposure to probability of an accident, and (b) congestion levels, which tend to reduce the severity of accidents (because of lower speeds) but increase their probability. Indicators selected to evaluate social benefits were the extent of transit coverage and its level of service, which would benefit the transportation disadvantaged (i.e., the elderly, handicapped, poor, and others unable to drive). Finally, daily work VMT in peak periods was used as an indicator of negative environmental impacts such as air pollution, noise, and consumption of nonrenewable energy resources.

The four alternative strategies were evaluated comparatively, that is, the strategies with the lowest and the highest levels of performance were identified with respect to each objective, and the remaining two were identified as being "intermediate" in performance level. As indicated in Table 4, the combined transit/ridersharing-preferential strategy performed at the highest level while the traditional strategy performed at the lowest level with respect to all five objectives.

Summary

Figure 8 graphically presents the performance of the four strategies. Performance against the seven objectives is represented by four indicators of major importance to allow easier assimilation of the information for subjective evaluation by decision makers. The selected measures were as follows:

- *Percentage by which cordonline traffic volumes at major activity centers exceed LOS C capacity*, indicating congestion relief and economic development potential of each strategy.
- *VMT per work-person trip*, indicating safety and environmental impacts of each strategy.
- *Transit system cost per rider*, indicating transit viability and social benefits of each strategy.

TABLE 3 ANNUAL ECONOMIC RESOURCE COSTS

	Traditional	Transit-Pref.	Rideshare-Pref.	Transit/R'share
Highway user costs:				
Vehicle operation	$58.9	38.7	44.3	37.8
Accident cost	6.5	4.3	4.9	4.2
Sub-total	65.4	43.0	49.2	42.0
Highway facility costs:				
Construction	23.3	28.4	28.4	28.4
Operation & maintenance	5.9	3.9	4.4	3.8
Sub-total	29.2	32.3	32.8	32.2
Employee parking costs:				
Construction	30.0	19.7	22.0	19.2
Operation & maintenance	42.2	27.6	31.2	21.5
Sub-total	72.0	47.3	53.2	40.7
Transit system costs:				
Buses and garage space	3.8	15.5	8.4	14.3
Service operation & maint.	5.8	14.5	8.9	13.7
Park-and-ride construction	0.0	0.7	0.0	0.7
Park-and-ride maintenance	0.0	1.4	0.0	1.4
Sub-total	9.6	32.1	17.3	30.1
Employer/agency costs:				
Ridesharing matching	0.1	0.1	3.9	1.6
Parking management	0.0	0.1	0.1	0.1
Sub-total	0.1	0.2	4.0	1.7
TOTAL RESOURCE COST	176.3	154.9	156.5	146.7
COST PER WORK TRIP (dollars)	2.05	1.81	1.82	1.71

- *Economic resource cost per work trip*, indicating economic efficiency of each strategy.

The lower the magnitude of each indicator, the better the performance of the alternative. Figure 8 shows clearly that the combined transit/ridesharing-preferential strategy performs the best (i.e., has the lowest values with respect to every indicator), whereas the traditional strategy has the worst performance (i.e., has the highest values with respect to every indicator). The transit-preferential strategy generally performs better than the ridesharing-preferential strategy with respect to every indicator except percent over capacity.

CONCLUSIONS AND RECOMMENDATIONS

The evaluation of the four alternative strategies indicates that a combined strategy to encourage both ridesharing and transit use during peak periods can reduce forecasted levels of congestion significantly and at the same time provide effective performance with respect to TMACOG's other plan objectives. Therefore, the following recommendations were developed and adopted by TMACOG's Long Range Plan Task Force:

- A more detailed study should be conducted to examine the need, design, priority, and staging of a multicentered rapid-transit bus system with timed transfers and feeder bus service; land use policies should be examined to encourage high-density mixed-use development at transit centers to maximize transit system viability.
- Commuter parking policies and road pricing policies should be developed to eliminate the current incentives for solo driving.
- A study of the feasibility of an HOV lane system should be undertaken in conjunction with TMACOG's currently proposed Interstate Highway Needs Study (*8*).

Further research is recommended with respect to the following issues:

- Impact of demand-management strategies (including pricing) on mode choice for nonwork trip purposes and peak spreading.

TABLE 4 RELATIVE PERFORMANCE WITH RESPECT TO OTHER OBJECTIVES

			Alternative Strategies		
		Traditional	Transit Pref.	R'share Pref.	Transit/ R'Share
1.	Transit viability:				
	Work peak period ridership daily	12,090	93,319	37,392	88,015
	System cost per rider	$ 3.05	$ 1.32	$ 1.78	$ 1.32
	Relative assessment	Lowest	Highest	Intermed.	Highest
2.	Economic development potential:				
	Average V/C for activity centers	1.16	1.12	1.05	0.98
	Relative Assessment	Lowest	Intermed.	Intermed.	Highest
3.	Safety:				
	VMT per work person trip*	6.85	4.50	5.15	4.39
	Average V/C for activity centers*	1.16	1.12	1.05	0.98
	Relative assessment	Lowest	Intermed.	Intermed.	Highest
4.	Social benefits:				
	Transit coverage and LOS	Minimum	Maximum	Minimum	Maximum
	Relative assessment	Lowest	Intermed.	Intermed.	Highest
5.	Environmental benefits:				
	Daily work VMT in peak periods**	2.27 mil.	1.49 mil.	1.70 mil.	1.45 mil.
	Relative assessment	Lowest	Intermed.	Intermed.	Highest

* Accident rates are directly proportional to VMT and congestion levels.

** Carbon monoxide, hydrocarbon and nitrogen oxide emissions are directly proportional to VMT.

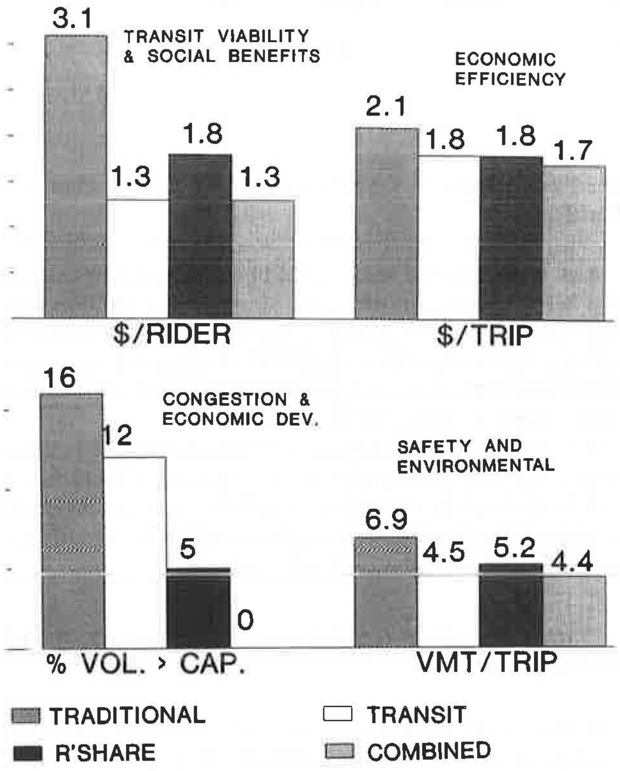


FIGURE 8 Indicators of performance.

- Impacts of demand-management strategies on noneconomic resource costs (e.g., travel time and delay costs).
- Development of technical procedures to guide transportation planners in the analysis and evaluation of the impacts of systemwide strategies to manage travel demand.
- Development of solutions to technical and institutional problems relating to road pricing, including procedures to quantify perceived adverse impacts of road pricing and development of methods to ameliorate adverse impacts.

It should be noted that the risks in implementing the combined transit/ridesharing system in conjunction with pricing policies are quite high, and the hurdles to be overcome with respect to road pricing in particular are immense. If the Toledo area, or any other metropolitan area, is to achieve success in implementing the concept, demonstration funding will be required from state or federal levels of government. A state or federal demonstration program is suggested to provide technical and funding assistance to metropolitan areas that show interest in implementing innovative combinations of transit, ridesharing, and pricing policies to meet the challenge for urban transportation in the 21st century.

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