Transportation Demand Management: A Cautious Look

JEFFREY M. ZUPAN

Transportation demand management (TMD) strategies are discussed with an emphasis on some of the barriers to their success, particularly in the New York region. Coverage of TDM strategies is not exhaustive, but focuses on major strategies, such as alternative work hours, pooling, parking management, pricing, and land use. A methodology to select the potentially most effective TDM strategies is also presented.

The increase in congestion on the nation's roads over the past 20 years is well documented. As suburban areas developed and spread, the road network expanded as well, accommodating the increased demand for automobile travel. The cost of highway construction has become increasingly expensive, awareness of environmental impacts has grown, and opposition from neighbors to highway expansion has mounted. The result is that in many situations it is no longer possible to merely build one's way out of traffic congestion.

One reaction to this problem has been to search for transportation systems management (TSM) solutions, intended to increase the transportation supply with a minimum of construction. These relatively low-cost, low-environmental-impact measures are to provide more capacity on the road network or divert automobile users to transit, and include such measures as left-turn lanes, park-and-ride lots for transit, improved transit services, and preferential lanes for high-occupancy vehicles.

In the past few years, increasing attention has been paid to complementary measures that can reduce the demand on the road network by changing the choices made by drivers. These measures are collectively known as transportation demand management (TDM).

A further motivation to explore such measures comes with the Federal Clean Air Act Amendments of 1990 (CAAA), which mandates the use of a variety of TSM and TDM strategies, collectively called transportation control measures (TCMs), to reduce vehicle miles of travel and to increase passenger car occupancy in areas with poor air quality.

Against this backdrop, the New York Metropolitan Transportation Council (NYMTC) asked Regional Plan Association (RPA) to explore the use of TDM strategies in three highway corridors in their region, which covers New York City and five suburban counties. Corridors selected were Interstate 278 on Staten Island (the Staten Island Expressway), the Jericho Turnpike/Veterans Memorial Highway in the Long Island counties of Nassau and Suffolk, and Interstates 684 and 287 in Westchester County. The full report is available from RPA (*1*).

In many ways the motivation to explore TDM strategies in the New York region is no different from that in other parts of the country. Yet New York is unique in its density, the extent of its transit system, the duration of its peak periods of congestion, and perhaps in the willingness of its citizens to tolerate delay and inconvenience. The density of the region's core and inner ring of counties indicates many employers and, combined with diversity of industries, makes it more difficult to enlist all the employers in implementing TDM strategies.

TDM strategies will be discussed using the analysis of the three highway corridors in the New York region, with an emphasis on some of the barriers to TDM success. Coverage of TDM strategies will not be exhaustive, but will focus on major strategies, such as alternative work hours, pooling, parking management, pricing, and land use. A methodology to select the most effective TDM strategies is also presented.

ALTERNATIVE WORK SCHEDULES

An obvious means of reducing peak-hour congestion is to spread the peak. This can be done if employers are more flexible with their employees' working hours. However, such programs must be carefully considered to avoid internal inefficiencies, coordination problems, and lack of employee supervision. Care must also be taken because these programs may be incompatible with some other TDM approaches; for example, the probability of forming a carpool may shrink significantly if workers are not keeping the same hours.

There are a number of way of altering schedules. The option of working staggered hours requires employees to start and end work at different times and can have a pronounced effect on peak congestion, particularly at large sites with one employer. Flextime or variable-time programs form another option. The employee is required to be at work during a core period, say, 9:00 a.m. to 3:00 p.m., and can fulfill other obligations before or after those hours. In the New York region, many employers may need to participate for there to be a measurable effect, but the shift of employees to earlier or later hours may merely keep them in an equally congested part of the peak. The analysis performed in the NYMTC region is instructive. The analysis assumed that only workers commuting in single-occupant vehicles (SOVs) working at sites with over 100 employees would be subject to shifts of work times. This is consistent with the CAAA, which requires employers with over 100 employees at one site to consider such measures in their plan. This reduces the pool of potential

Regional Plan Association, 1211 Sixth Avenue, New York, N.Y. 10036-8703.

drivers by at least half in the three corridors studied. On the Staten Island Expressway it was found that 49 percent of the target SOVs would have to shift by 1 hr or more in the morning peak period to bring conditions to borderline Level of Service D and E. On Interstate 684 in Westchester County, 41 percent of the peak-30-min SOVs would need to move 1 hr earlier and the same number 1 hr later, with the second-highest-30-min peak moving SOVs 1 hr earlier. In the Long Island highway corridor studied, the hours adjoining the peak were also beyond Level of Service D, making a shift by an hour inadequate to relieve traffic sufficiently.

To be effective beyond a local area, alternative work schedules require broad application. If there are dozens or even hundreds of employers in an area, agreement on the institution of alternative hours programs that could relieve congestion in an entire corridor would be difficult without a coordinator.

Another option is to institute a 4-day work week, with different employees off on different days of the week and working longer hours on their work days. Most employees would prefer Mondays or Fridays off, limiting the effectiveness of this approach. Four-day work weeks also pose a problem unique to areas where transit use is high, as in the New York region. If such a work week were available to employees who use transit, then weekday ridership on transit by those employees would be reduced 20 percent. Given the high fixed costs of transit, widespread use of the 4-day work week could be financially disastrous to transit systems. Much of the downturn in transit use after World War II can be traced to the abandonment of the 6-day work week.

With the advent of the personal computer telecommuting has gained acceptance. Over time, an increasing number of workers may not need to leave their home or neighborhood to travel to work. Whereas some estimates of the impact of telecommuting have been made, how it affects congestion remains uncertain. The application of telecommuting may come sooner to the New York region than elsewhere because of the difficult commute and the concentration of service, publishing, communications and information-sharing industries in the region. The danger to public transit is similar to the one posed by the 4-day work week, namely a reduction in transit ridership without the ability to trim costs proportionately.

RIDESHARING

Carpooling is perhaps the most widely considered TDM. The idea is clear: consolidate drivers of SOVs into fewer vehicles and congestion will be reduced. Carpools can be informal, formed by a group of individuals acting on their own, or they can be formal, formed deliberately by a public agency such as a state department of transportation, by one employer, or by an agency such as a transportation management association (TMA) that coordinates the activities of many employers. The driver and the automobile can be alternated to adjust expenses, and the participants are thereby able to reduce the cost of driving alone.

Carpooling is limited to those whose schedules are rigid and who have relatively long trips. In a recent survey by Beaton et al. in another paper in this Record, SOVs were found to have a median trip length of 15 mi and ridesharers, 38 mi. Relatively long trips are most efficient for carpooling because the time spent gathering the participants in one vehicle is small compared with the length of the trip. Most important, carpools require participants who have the same work schedule each day and are prepared to stick to it. If work schedules change because of unexpected overtime, having transit as a backup is necessary. After all, a carpool is essentially a public transit service with a frequency of one trip per day.

Carpoolers do not have the flexibility of running errands before and after work or during lunchtime, and having a car for daytime emergencies at home. Some employers have provided shuttle services to restaurants in suburban settings when a walk to lunch is not possible, but with limited success. Some employers also provide a guaranteed ride home in emergencies. Finally, carpools will only remain intact if participants are compatible.

State departments of transportation and county governments have actively sought to match potential carpoolers by computer. In an effort to create carpools, names, telephone numbers, home and work locations, work schedules, and personal characteristics (e.g., smoker/nonsmoker) have been amassed by advertising in local newspapers or by contacting large employers to survey their employees. Keeping files current is a problem because of residential and job turnover. If the average household moves once in 5 years, in a carpool of four persons one will change trip origin once every 2½ years. Job changes increase the frequency in which carpoolers turn over. Most of these efforts have had limited success because of the high cost of keeping files current and of follow up (*2*). Large employers are more successful in following up because potential carpoolers working at the same site are more likely to share rides, to know each other, to have a common employer, and to feel company pressure if the employer actively supports the carpool program. Other employer actions to encourage carpooling, such as the guaranteed ride home or preferential parking for carpools, have been tried. The effectiveness of the guaranteed ride home is difficult to measure, but it appears to have marginal use (*3*). The most successful method of employer-generated carpooling is a continuing, highly visible, well-staffed program. For employers to make that commitment they must believe that the costs will reap direct benefit.

In the case of vanpools, the vehicle is larger and holds a dozen or more persons. The van is provided by the employer or a vanpool brokerage agency, which provides insurance. Participants pay a monthly fee either to the brokerage agency or to the employer, who sometimes does not charge the full cost. In most cases one person is designated the driver, and that person, as compensation, has the use of the van on weekends.

The advantages and disadvantages of carpools also apply to vanpools. The cost to the individual is lower, but flexibility is sacrificed. Because of the large number of employees that must be collected, vanpools work best over distances of at least 20 mi. The large number of people involved in a vanpool makes compatibility less important but does not take care of the need for park-and-ride lots, because the most efficient way to arrange for morning pickups is to do it at one location. Vanpools, because they only work well for long distances, are not widely used. For example, in the suburban corridor of Route 1 in Mercer and Middlesex counties, New Jersey, only

four pockets of residential concentrations generated enough travel for vanpools. The need for park-and-ride lots could conflict with badly needed parking for transit. Care must be taken to sort out park-and-ride capital investment priorities.

For the same reasons, subscription bus service or buspooling is even more limited. Typically, employers guarantee to cover a bus operator's costs, plus profit, and gather enough employees to participate to cover the expenses at a monthly fare attractive enough to attract solo drivers. The participants must join for a month or more to pay their share of the costs. The same benefits and limitations apply as described for carpools and vanpools. The need for park-and-ride lots is greater, but the importance of compatibility disappears. In rapidly growing corridors, subscription buses may eventually add trips and become regular route services.

Encouraging carpools and vanpools is somewhat different in the New York region than elsewhere. For example, only 15 percent of work trips to the Manhattan central business district (CBD) are made currently in automobiles. If encouragement is given to pooling to the CBD, it is more likely that the poolers will be drawn from public transit.

In low-density areas and for reverse commuting, especially from the lower-income areas of the region, the concept of pooling, with its lower costs, might be an important part of the transportation system. Many factors lower the possibility of pooling and suggest that high participation rates for pooling will be needed to relieve congestion substantially. An analysis of three roadway corridors in the New York region calculated that 38 to 90 percent of drivers of SOVs would need to form four-person carpools to bring the highway level of service to D. The market for carpooling is small because of the following factors:

1. Some of the vehicles on the road are trucks, which generate disproportionate congestion and are not carpool material.
2. Some vehicles already have many occupants.
3. Some vehicles carry people not destined for work and are inappropriate for pooling.
4. Some vehicles are passing through, not heading for an employment area.
5. Some SOVs transport sales people not destined for the same daily employment location.
6. Those who form carpools do not take all their vehicles off the road, because a vehicle is needed for the carpool itself.
7. Carpool formation is particularly difficult if large numbers of employees do not work at the same site; in the three corridors studied, 64 to 78 percent of the employees worked at sites with under 100 employees.

PARKING MANAGEMENT

Free parking provided by employers is a tremendous incentive to drive alone. Even in city centers where scarcity of land creates the market for parking charges, employers often pay the cost, which is seen as a business tax deduction by employers and a tax-free fringe benefit by the employee. Evidence (*4*) suggests that parking pricing is the most effective TDM strategy, although it remains difficult to assess since other strategies have usually been instituted at the same time, obscuring the impacts. Using preferential parking close to office buildings for carpools and vanpools is an approach, but having drivers of SOVs pay for parking while poolers do not is more effective. One approach is to pay every employee a transportation benefit while charging for parking at the site. The employees who pool, walk, bike, or use transit keep the benefit, whereas the employee who drives alone pays a modest fee. Those who cannot pool because of their job schedules would have a legitimate complaint. Free employee parking as an untaxed benefit remains the problem. Fairness will only come with a change in the tax code.

Limiting the number of parking spaces provided by the employer would be more effective (*5,6*). The ratio of parking spaces to office floor space, known as the parking ratio, has traditionally been set in suburban developments at four spaces per 1,000 ft^2 of office floor space, reflecting the assumptions that the average employee occupies 250 ft^2 and that one parking space is needed for each employee. These ratios are out of date because the average office space per employee has risen. Zoning must reflect this to avoid incentives for drivers of SOVs. Moreover, the use of nonofficial spaces needs to be strongly discouraged so that the number of spaces is not artificially expanded. Tailoring these parking ratios to the amount and availability of public transportation, with lower ratios where transit is widely available, could be an effective means of controlling unnecessary driving. Research in this area would be helpful.

Mandated parking ratios of four spaces per 1,000 ft^2 of floor space, particularly in suburban locations, are out of date. Financial institutions still look for this ratio and favor developers who use it. Data are needed to make the case that lower ratios are now good business in suburban settings. This suburban thinking can even pervade urban thinking. The city of Newark, with more transit service than any location in the New York region other than New York City, was for some time trying to require the same high 4:1,000 ratio.

PREFERENTIAL TREATMENT FOR HIGH-OCCUPANCY VEHICLES

Giving high-occupancy vehicles (HOVs) the advantage over SOVs on congested roadways is another category of TDM. HOV lanes can be very effective if enough HOVs use them. Otherwise, public pressure will mount to remove them, as drivers of SOVs find themselves stuck in traffic while a parallel lane appears to be underused. Another problem is enforcement; unless there is diligent enforcement, SOVs not physically separated will slip into the HOV lane, reducing its effectiveness. To prevent this, portable lane dividers can be inserted in the pavement daily, but that greatly increases the cost of operation.

Preferential treatment for HOVs can take many forms. The simplest is a reserved lane on an urban street for buses, and possibly for carpools and vanpools. SOVs are only permitted in the lane to make turns. Because the curb lane is used, agreements must be made with merchants concerned with losing street parking for their customers. On major arterial roads reserved lanes are often made using an extra lane or shoulder for short segments.

An HOV lane on a limited-access highway must contend with the problem of weaving created by the need to reach the lane from the entrance ramps or the need to reach exits. This is a serious problem if ramps are closely spaced. If the HOV lane is taken from mixed traffic, the possibility that the mixed traffic lanes will be backed up and block the entrance to the HOV must be examined beforehand.

A contraflow lane is an HOV lane taken from the traffic flowing in the opposite direction. This can be done if the lane removed does not cause traffic congestion in the minor-flow direction. Great care must be taken to minimize the danger of head-on collisions. Driver training is important and limits the vehicles to buses. Contraflow lanes work best if the volume of HOV traffic is sufficient to be self-enforcing. The exclusive bus lane on the approach to the Lincoln Tunnel is the best example of such a facility. Contraflow lanes to be used in each direction for morning and afternoon peaks can be made with reversible lanes. New designs have been devised to improve the feasibility of such a facility (*7*).

HOV lanes can be constructed as separate facilities adjacent to existing or new highways. If exclusively for buses, these facilities are known as busways. They are very expensive but eliminate the safety and enforcement problems and do not reduce the capacity for mixed traffic.

HOV measures require careful analysis and education of the driving public. Before such measures are endorsed, it must be certain that the HOV lane will have enough vehicles to gain and keep political support. Such estimates cannot be based on wishful thinking regarding the shift of riders to pooling or transit. Moreover, careful analysis is needed to ensure that excessive weaving to and from exits and upstream gridlock will not occur.

"Dual-dual" limited-access highways provide a special opportunity to segregate HOVs from SOVs. This is now planned for a segment of the New Jersey Turnpike. Urban street HOV lanes must be presented to merchants on the basis of bringing more shoppers downtown. Contraflow HOV lanes must have large enough HOV volumes to be self-enforcing, and there must be a well-thought-through plan to handle lane breakdowns. Finally, once implemented, HOV lanes must be continually enforced.

CONGESTION PRICING

The increasing scarcity of roadway space, the difficulty and undesirability of expanding that space, and the need for transportation funding are leading to greater attention to congestion pricing. The basic principle is that where and when a commodity is most scarce, its use should be curbed through increased prices that lower the demand for that commodity in that place and time. In the case of roadways, higher fees could be imposed during peak hours and on portions of a roadway network that are the most congested. Higher fees for SOVs might also be incorporated. Congestion pricing has the potential to

1. Reduce the need for new highway capacity,
2. Improve air quality,
3. Relieve peak traffic congestion,
4. Increase the use of high-occupancy vehicles,
5. Reduce automobile use in highly congested urban environments,
6. Raise revenue for much needed transportation improvements, and
7. Establish a rational pricing system following sound economic principles.

Resistance to paying more, especially if the goods have been free until now, is the biggest problem to overcome; how to collect the fee has been the technical stumbling block. Where tolls are in place (already a crude form of congestion pricing), the problem is somewhat simplified. If tolls are to vary by time of day (or day of the week), the greatest problem appears to be disputes that might occur between the driver and the toll-taker about the time of changeover to or from a higher toll. This operational issue is now eased by the use of electronic toll and traffic management (ETTM) capabilities using prepaid toll media. Such a technology is now being tested by the Port Authority and the New Jersey Turnpike Authority in the New York region and elsewhere (*8*). Congestion pricing might also be tried on the currently free East River bridges leading to Manhattan, where the imposition of tolls is being considered, coupled with ETTM. Eventually, its use at locations other than at river crossings or current toll barriers would make a comprehensive system of congestion pricing possible in the New York area.

The upcoming challenge will be to set charges high enough to influence travel yet in a way that is consistent and equitable throughout the region. Moreover, mechanisms to evaluate and choose how to spend the funds, and of ensuring accountability of those expenditures, will need to be established to provide the public with assurances that the funds will be wisely spent. In the absence of these assurances, public acceptance, a prerequisite for congestion pricing, will not occur.

A serious examination of congestion pricing in the region would require a sophisticated analysis. Alternate pricing schedules by time of day, day of week, vehicle occupancy, vehicle type (automobile, small truck, tractor-trailer) would need to be tested. The impacts on traffic congestion and of potential revenue would be estimated for each pricing plan tested.

First, base data would need to be assembled on the use of the highway network in the region by time of day, vehicle occupancy, and vehicle classification. A base would be established from which changes resulting from pricing scenarios on traffic and revenue could be calculated.

Next, price elasticities would need to be estimated. The likelihood of shifts of traffic, not only to different time periods, but also to different modes (transit) would have to be considered, as well as the elimination of some traffic. For each pricing scenario a series of impacts would need to be determined, including vehicle hours of delay reduced, distribution of vehicle miles traveled at varying levels of service, emission reductions, and revenue gained and lost by type of user (SOV, carpooler, truck).

Most important, an assessment of the barriers to implementation would be required, including legal, institutional, and public acceptance. On the basis of that assessment, a plan would be prepared providing the next steps to implementation of congestion pricing if the study results indicate the value of this approach. This plan would need to outline a public information and outreach program. Such a program to study

congestion pricing under the auspices of the RPA is now under consideration by the transportation agencies in the New York region.

LAND USE AND ZONING

The density, location, and type of developed land determine how people will travel. Much needs to be done to make it more likely that the choice of public transportation or driving in a pool will be made. Residential and employment densities above certain levels are necessary to support public transit. No attempt will be made to review these findings in detail; they are available elsewhere (*9*). Residential densities of above five dwellings per net acre, corresponding to gross densities of at least 3,000 people/mi^2, are the minimum needed to support public transit. If residential developments are located near existing transit routes, their potential to dampen SOV travel increases. Nonresidential densities are equally important. The clustering of economic activities in a downtown core area of at least 5 million ft^2 is necessary to support minimum bus service. Express buses require closer to 20 million ft^2. Activities clustered near train stations in such central areas are similarly critical to improving transit's market share. In recent years developments have been built well below these thresholds.

Higher residential densities as a way of encouraging transit use must contend with the housing preferences of the region's households. Although most Americans (and most New Yorkers) appear to prefer lower-density housing, this does not mean that everyone does. The aging of the population, smaller household size, two-worker households, and the general trend away from the traditional family unit all suggest the need for new housing types. Moreover, many people equate higher-density housing with older, less attractive housing. Zoning mechanisms to cluster higher-density housing near transit stops suitable for a wide range of people are an unmet challenge.

Larger and more compact employment locations near transit are also needed. Employment locations must take advantage of the confluence of many transit lines to widen their source of commuters. Employees' personal preferences play a smaller role here than they do in residential developments. Yet, whether the area is residential or not, the issue is municipal zoning. The ratable chase, intended to keep local property tax rates as low as possible, encourages "clean" office buildings and low-density housing to minimize school costs. Mechanisms need to be developed to enable zoning to occur across municipal boundaries and take advantage of the existing transit infrastructure. Otherwise automobile-oriented development and the ensuing traffic congestion will remain, or become, the norm.

The designs of new developments have provided for the automobile driver and ignored the needs of transit riders, bicyclists, and pedestrians. This was dramatically shown by a recent analysis of over 250 designs submitted to the International City Design Competition: only 12 percent of the designs provided transit-friendly features (*10*). To remedy these shortcomings and make transit a more realistic option, buildings could be clustered to make it possible for a bus to serve more people with one stop, bus stops could be closer to building entrances with sharply reduced building setbacks, sidewalks could connect buildings with bus stops, bus shelters and bus stop signs could be provided, and pull-offs for buses could be designed into the roadway system. Bicycle lockers and shower facilities could also be required. Present local zoning does not mandate such steps. Model local zoning ordinances need to be developed and followed to put these transit-friendly concepts into zoning regulations. With these regulations in place, drivers clogging the highways of the region could begin to shift toward transit, bicycling, and walking. Transit-friendly designs require a model zoning ordinance if they are to take hold in the New York region. The Department of Transportation should take the lead in presenting one to each municipality that complains of a traffic problem created or exacerbated by automobile-oriented zoning. It is in DOT's interest, because new highways are more expensive than good design.

Mixed-use development is a land use concept that might have an important role in reducing trip making and therefore highway congestion. The idea is to provide both home and work sites within the same complex. With shortened trips, opportunities are made for more nonmechanized travel such as bicycling and walking. Most workers would live in the same development. The MSM Regional Council in Princeton recently sponsored a study that indicated that mixed-use development, other TDM measures, and location of growth to more urban settings could reduce traffic generated by the incremental growth by over 50 percent (*11*). These estimates are based on an extensive peer review process, and further research to determine empirical impacts is needed.

Pedestrian pockets, or transit opportunity districts, are designed almost from scratch to encourage transit, biking, and walking (*12*). To determine whether such designs could preclude the need for additional highway capacity, 1000 Friends of Oregon is sponsoring a study, Land Use/Transportation/Air Quality (LUTRAQ), to apply these principles to a fast-growing area in Portland.

Growth management is a more ambitious land use strategy to limit congestion. A number of jurisdictions around the country have tied development approvals to the provision of adequate facilities, including transportation. Developer impact fees have been established in some cases to provide funding for the construction of transportation facilities.

RESEARCH NEEDS

It is clear that much more work needs to be done to understand the effectiveness of TDM strategies. A recent Transportation Research Circular (*13*) on research problems in the area highlights a number of important avenues to pursue. These include research on pricing and parking, the relevance of free parking to development potential, TDM effectiveness measured through formal evaluations, impacts of variable work hours on transit and HOV use, assessment of transportation management associations, and the relationship between ridesharing and employer size.

WHO MUST TAKE THE LEAD IN TDM?

Table 1 shows many TDM strategies and those likely to have a lead role in each. Whereas many agencies and institutions

TABLE 1 TDM: WHO DOES WHAT?

TDM Strategy	Actions Required By:
Alternative work schedules	Employer, TMA
staggered	
flex	
4 day	
telecommuting	Employer, Improved technology
Carpools	
informal	Individuals
formal	Employer, TMA, county or state
Vanpools	As above, van brokerage companies
Subscription bus	Employer, TMA, county, transit operator
Parking management	
preferential parking	Employer
parking pricing	Employer
parking ratios	County or municipality, developer
park and ride	County or state, transit operator
Preferential road treatments	DOT, road authority, municipality
Congestion pricing	DOT, toll road authority
Transit	
transitchek	Transit brokerage agency, transit operator, employer
employer subsidized transit	Employer, transit operator, TMA
employer sponsored transit	Employer, transit operator, TMA
transit coordinator	Employer, transit operator, TMA
Land Use and Zoning	
higher densities	Municipality
transit-friendly design	Municipality, DOT
mixed use development	Municipality, county
growth management	County and state
Trip Reduction Ordinances	Municipality
Transportation Management Associations	Employers, state, county

play a role, the most frequently noted is the employer. Employers must see that TDM strategies are in their self-interest or there is little chance for success. Many levels of government are also represented.

There is a question whether the municipalities have enough economic self-interest to create change. The toughest municipal actions would be changing development and zoning. The role of the TMA is the hardest to define. TMAs could be involved in almost every strategy. Yet, because they are funded primarily by the private sector, they may be limited in what they can do, which explains their spotty success.

EVALUATING TDM STRATEGIES

A fully systematic and comprehensive process to evaluate the effectiveness of TDM strategies is not available. The closest to it are recent studies by Comsis Corporation (*14*) commissioned by the Federal Highway Administration (1990) and a study by K. T. Analytics for the former Urban Mass Transportation Administration (now the Federal Transit Administration) (*4*). The Comsis study compiled data from 11 TDM programs around the country. The biggest difficulty encountered was the absence of before-and-after data on traffic counts, or vehicle occupancies, making it impossible to determine any changes in congestion that could be attributed to the TDM strategies. The presence of other factors, and the variability of traffic counts from day to day, compounded the problem. However, it was possible to devise an index, vehicle trips per 100 travelers, and estimate its change. Many useful insights were drawn:

1. Locally targeted strategies could relieve congestion in spot locations such as entrances to developments, but their impact on wider congestion problems was difficult to measure and thought to be small;
2. Areawide TDM programs, rather than those covering specific companies or with narrowly drawn geography, have the most potential for congestion relief;
3. Establishment of performance objectives, rather than a prescription of specific actions, inspired greater innovation and success;
4. Voluntary actions were much less likely to lead to success than mandated actions;
5. Economic self-interest inspired successful actions;

TABLE 2 TDM SOLUTIONS

Strategy	Area Suitability	Travel Impacts				TDM Costs			TDM Acceptance				Ease of Implementation Index
		SOV Reduction	*Peak Trip Reduction*	*VMT Reduction*	*Transit Impact*	*Employee Cost*	*Employer Cost*	*Public Capital Cost*	*Employee*	*Employer*	*Municipal*	*Political*	
Alternate Work Schedules													
Staggered	U,S	none	high	none	none	same	higher	none	high	low	high	high	3
Flex–time	U,S	negative	high	negative	negative	same	higher	none	high	low	high	high	4
4 day week	U,S	medium	medium	high	highly neg	lower	unknown	none	medium	low	high	medium	3
Telecommuting	U,S	positive	positive	positive	highly neg	lower	unknown	none	unknown	unknown	high	medium	unknown
Carpools	S	high	medium	medium	negative	lower	varies	none	low	medium	high	high	3
Vanpools	S	medium	low	low	negative	lower	higher	none	low	low	high	high	2
Subscription Buses	S	low	low	low	positive	lower	higher	none	low	low	high	medium	2
Parking Management													
Preferential Pkng	S	low	low	low	none	same	higher	none	low	low	high	high	2
Parking pricing	U,S	medium	medium	medium	low	higher	same	none	negative	low	negative	negative	1
Parking ratios	U,S	medium	medium	medium	positive	same	lower	none	negative	unknown	negative	negative	2
Park – Rides	U,S	medium	medium	medium	positive	varies	n.a.	higher	medium	medium	varies	high	4
Preferential HOV lanes	U,S	medium	medium	medium	positive	same	n.a.	higher	varies	varies	high	varies	4
Congestion Pricing	U,S	medium	high	medium	positive	varies	n.a.	lower	low	low	unknown	negative	unknown
Transit													
Transitchek	U,S	medium	medium	medium	medium	lower	same	none	high	medium	high	high	5
Employer sponsored	U,S	low	low	low	low	varies	higher	none	medium	low	high	high	4
Employer subsidized	U,S	low	low	low	low	varies	higher	none	medium	low	high	high	5
Land Use – Zoning													
Higher densities	S	medium	medium	high	high	n.a.	varies	lower	n.a.	n.a	negative	negative	2
Transit – Friendly Design	S	medium	medium	medium	medium	same	same	lower	medium	low	varies	positive	4
Mixed Use Development	S	unknown	unknown	medium	unknown	lower	unknown	lower	unknown	unknown	varies	positive	4
Growth management	S	unknown	unknown	unknown	unknown	same	unknown	lower	unknown	unknown	varies	varies	3
Trip Reduction Ordinances	S	high	high	high	low/medium	varies	higher	n.a.	low	negative	varies	varies	4
Transportation Mgmt Assoc	U,S	varies	varies	varies	unknown	same	higher	n.a.	n.a.	varies	n.a.	positive	n.a.

Suitability index U – Urban Areas S – Suburban Areas N A not applicable
Ease of Implementation Index 1 (difficult) to 5 (easy) N A not applicable

6. Realistic alternatives to the SOV must be present for changes to occur; and
7. No legal areawide mechanisms have yet been devised in the absence of success through voluntary actions.

Similarly, Pratt (*15*) concludes that

> . . . for success, TDM must include carrots, sticks and employer participation; traffic reduction for tough TDM programs in the suburbs may be around 10 percent; successful traffic mitigation with travel demand management alone is unlikely; a 10 percent improvement in efficiency is worthwhile; TDM won't solve all our problems; and it is a viable partner in the overall traffic mitigation toll kit.

WHICH STRATEGIES TO USE?

In Table 2 an attempt is made to characterize various features and impacts of the strategies that have been discussed. It must be understood that these characterizations are difficult to make and represent one person's best guess from a careful reading of the literature, which often does not inform these judgments. First, the suitability of a strategy for urban or suburban areas is given, "U" indicating urban and "S" suburban. For strategies that are likely to affect traditional transit negatively, only suburban locations are indicated as suitable. The characterizations of travel impacts are high, medium, and low corresponding to greater than 10 percent, 2 to 10 percent, and less than 2 percent, respectively. If the direction of the impact is known but the magnitude cannot even be guessed, a positive or negative indication is given. Employee commuting costs and employer costs are described as higher or lower or the same in most cases. The acceptance criteria reflect the projected reaction to a strategy. If the reaction depends on the specific situation, "varies" is indicated. Finally, an overall rating of ease of implementation is provided, with 5 a high score and 1 the low score. Although no answer is intended with this matrix, some tentative conclusions are suggested by grouping the strategies in the following categories:

1. Strategies that have a positive impact on congestion, no major negative impact, and are generally acceptable: Strategies falling in this category for both urban and suburban locations are staggered work hours, flextime, park-and-ride lots, HOV lanes (although acceptance will vary), and "transitchek." Strategies appropriate to suburban areas include only carpools, vanpools, transit-friendly designs, and trip reduction ordinances (acceptance will vary here too). This group of strategies should be actively pursued in most instances.
2. Strategies that reduce congestion, have little negative impact on transit, but do not have wide acceptance: For both urban and suburban locations this group includes parking pricing, parking ratios, congestion pricing, and higher densities in suburban locations. Resistance to paying more, to restrictions of choice, and to prescriptive local land uses will need to be lessened if these strategies are to become effective means of reducing congestion.
3. Strategies with little impact on congestion, little negative impact on transit, and are generally acceptable: These strategies, which include subscription buses, preferential parking, and employer-sponsored and employer-subsidized transit services, may have a place in particular situations, do not represent a major strategy to reduce congestion, and should be recognized for their limitations.
4. Strategies that will reduce congestion, are generally acceptable, but will negatively affect transit: Four-day work weeks and telecommuting are in this category. These two strategies are likely to gain popularity independent of specific public policies, and the impacts on transit will need to be closely monitored.
5. Strategies for which too little is known or which are too difficult to assess to determine their value in reducing congestion: Mixed-use developments, growth management, and TMAs are in this category.

SUMMARY AND CONCLUSIONS

Much of the discussion about TDM in recent years has pointed out that none of these actions by themselves can solve traffic congestion problems. Even the full range of TDM strategies can only be partly successful in reducing congestion. In the long run, a conscious effort to reduce automobile dependence by clustering new development and providing incentives to shift existing developments to make transit, walking, and biking more reasonable choices for more people will be needed to prevent traffic congestion from reaching intolerable levels. The evidence presented indicates that a major public purpose would need to be understood by most citizens before voluntary actions could approach the needed traffic reductions. This is not to suggest that the most promising of TDM measures should not be pursued, and pursued vigorously.

The convenience, privacy, independence, and flexibility provided by the single-occupant automobile is difficult to match. Traffic congestion, a concern to many and a topic of daily conversation, has not yet proven to be a deterrent for most people to choose another option. The price of driving is not unreasonable for most commuters, and the willingness to raise that price to attack air pollution, energy shortages, and traffic congestion has been absent.

In a democratic society, the idea of artificially affecting individual choices for the greater good is not an easy concept to put in place. And without a clear and present danger as motivation, TDM may become just another transportation acronym.

REFERENCES

1. *Transportation Demand Management in the New York Region*. Regional Plan Association, New York City, July 1991.
2. S. Beroldo. Ridematching System Effectiveness: A Coast to Coast Perspective. In *Transportation Research Record 1321*, TRB, National Research Council, Washington, D.C., 1991.
3. C. Polena and L. J. Glazer, An Examination of Eleven Guaranteed-Ride-Home Programs Nationwide. In *Transportation Research Record 1321*, TRB, National Research Council, Washington, D.C., 1991.
4. K. T. Analytics, Inc. *Assessment of Travel Demand Approaches at Suburban Activity Centers*, NTIS PB89-231856, July 1989.
5. R. Dowling. Factors Affecting TDM Program Effectiveness at Six San Francisco Medical Institutions. In *Transportation Research Record 1321*, TRB, National Research Council, Washington, D.C., 1991.

6. S. J. Frederick and K. L. Kenyon, The Difficulty with the Easy Ride Project: Obstacles to Voluntary Ridesharing in the Suburbs. In *Transportation Research Record 1321*, TRB, National Research Council, Washington, D.C., 1991.
7. C. M. Poe. Movable Concrete Barrier Approach to the Design and Operation of a Contraflow HOV Lane, In *Transportation Research Record 1299*, TRB, National Research Council, Washington, D.C., 1991.
8. L. Yermack. *ETTM In The New York/New Jersey Metropolitan Area*. Triborough Bridge and Tunnel Authority, New York City, 1990.
9. Pushkarev and J. M. Zupan. *Public Transportation and Land Use Policy*. Indiana University Press, 1977.
10. E. Beimborn, H. Rabinowitz, C. Mrotek, and S. Yan. Transit-Sensitive Suburban Land Use Design: Results of a Competition. In *Transportation Research Record 1297*, TRB, National Research Council, Washington, D.C., 1991.
11. Howard, Stein-Hudson Associates. *The Impact of Various Land Use Strategies on Suburban Mobility*. Mercer-Somerset-Middlesex Regional Council, May 1991.
12. Calthorpe and Associates. *Transit Opportunity Districts*, 1991.
13. *Transportation Research Circular 379: Research Problem Statements: Ridesharing and Transportation Demand Management*. TRB, National Research Council, Washington, D.C., Sept. 1991.
14. Comsis Corporation. *Evaluation of Travel Demand Management Measures to Relieve Congestion*. Report FHWA-SA-90-005. FHWA, U.S. Department of Transportation, Feb. 1990.
15. R. H. Pratt. *Planning Solutions—TDM and Beyond*. In *Transportation Research Circular 359: Traffic Congestion and Suburban Activity Centers*. TRB, National Research Council, Washington, D.C., 1990.

Publication of this paper sponsored by Task Force on Transportation Demand Management.