Transportation Demand Management

Planning, Development, and Implementation

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Transportation demand management (TDM) is the art of modifying travel behavior, usually to avoid more costly expansion of the transportation system. TDM is not a panacea, but it can help ease some transportation problems. TDM requires the cooperation of many actors, who may include developers; landowners; employers; business associations; and municipal, county, regional, and state levels of government. This article reviews new TDM organizational forms, including transportation management associations, trip reduction ordinances, and negotiated public-private agreements. More flexible approaches appear to work best. TDM evaluation is difficult, because reductions in trip generation rates, i.e., relative changes in travel demand, are not easy to measure. Evidence suggests that TDM can be applied in a wide variety of situations, with equally variable, and sometimes quite good, overall results. TDM strategies that often have proven to be effective include on-site employee transportation coordination, parking management provisions, and alternative work schedules.

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Until recently, developers often were not held responsible for the transportation system impacts of their projects (Cervero 1988). Occasionally, if major site-specific traffic impacts were identified, the developer might be required to provide mitigation in the form of traffic signalization or road improvements at the boundary of or within the area designated for development (Greenberg and Hecimovich 1984). This situation has changed dramatically within the past few years. Local traffic congestion and regional mobility are major issues in many parts of the country, particularly in suburban areas characterized by rapid economic growth and development (Pisarski 1987; Deakin 1988). Because of these changing conditions, the role of developers in transportation system management, planning, and operations is currently being redefined in many parts of the country.

Land developers and real estate speculators played an important role in building many of the early electric streetcar, subway, and elevated public transit lines in American cities (Warner 1962; Wachs 1984). With the advent of the federal interstate highway construction program in the 1950s, however, public subvention of urban transportation facilities supplanted the role of the private sector almost completely in most areas of surface transportation (Weiner 1988). More recently, it has become popular once again to consider the privatization and deregulation of transit, aviation, and other transportation services as a means of increasing the absolute size and relative efficiency of the transportation system (Lave 1985; Morrison and Winston 1989). To the extent that developers, employers, and other private actors are involved in determining the configuration or utilization of future transportation system improvements, a form of privatization, or public-private cooperation, may be said to be occurring (Lundqvist 1988).

The Function and Context of Transportation Demand Management

Historically, the most common approach to the mitigation of traffic congestion in the United States has been expansion of the transportation system, usually with the intention of staying one step ahead of travel demand. This simplified approach has many problems. For example, traditional travel demand forecasting methods fail to take latent demand into account. Travel demand often grows much faster than anticipated, and traffic congestion may occur much sooner than expected. In addition, construction costs for new highways have escalated in recent years. Public funding for new highway construction has not grown as rapidly. Some funds earmarked for new highway construction are being diverted to cover long-deferred maintenance of existing infrastructure, which is rapidly aging and deteriorating under heavy traffic loads. These factors exacerbate chronic highway capacity shortages, particularly in rapidly growing suburban areas. Further, social and environmental concerns, at least in some parts of the country, have led to the conclusion that expansion of the transportation system to accom-

modate increasing travel demand is no longer warranted as the fundamental premise of surface transportation policy and planning (Giuliano 1989).

During the 1970s transportation experts actively sought alternatives to highway expansion. They identified a wide variety of low cost measures, including strategies to increase transportation system capacity globally, to decrease transportation system capacity locally, to reduce travel demand, and combinations of all three. These disparate measures were eventually billed as transportation system management (TSM) techniques. Many problems were encountered in implementing TSM in this period. One key problem was the lack of interface between the public and private sectors, which made TSM approaches such as ridesharing difficult or impossible to implement (Engelen 1981; Roark 1981).

TDM differs from TSM in that its focus is exclusively on travel demand rather than on transportation supply. Travel demand management responds to changes in transportation supply; hence, the two approaches are complementary rather than competing strategies to achieve more efficient transportation system utilization. Table 1 shows how person-trips might be modified using two types of travel demand strategies. It presents land use- and transportation-oriented demand management responses to various aspects of travel behavior, as treated in the traditional four-step urban transportation planning process, with a temporal dimension added.

The specific strategy adopted will depend on the interests of the parties involved. Suburban residents often are concerned with quality-of-life issues (Harashina and Mutoh 1989). Developers are concerned about local economic growth and freedom of action in the exercise of private property rights (Kroll 1984). Planners should be concerned with maintaining high quality growth, as well as with providing community services in an equitable and efficient manner (Harris and King 1988). These actors may differ over local political issues associated with suburban traffic congestion and other external social and environmental effects of the development process (Banister 1989). The most common TDM approaches emphasize travel behavior modifications independent of location and land use. Efforts to change mode and time of travel for the work trip have been applied most often. The other approaches may be equally viable, but have been tested with far less frequency in practice.

TDM is appealing because it offers an opportunity to increase the efficiency of transportation systems at little or no cost (Bautz 1988). A successful TDM program may allow a higher density of development to occur, without

TABLE 1: Transportation demand management and travel behavior

Aspect of travel	TDM objective	TDM implementation strategies
Trip generation	Eliminate trip entirely.	*Land use:* growth control (eliminate specific activities associated with trip making). *Transportation:* telecommunications substitution for travel (telecommuting, teleshopping, teleconferencing) (eliminate trip making associated with specific activities).
Trip distribution	Shift trip from a more congested destination to a less congested one.	*Land use:* zoning restrictions that limit the density of development, type of land use, etc., thus shifting the location of activities within urban or regional areas. *Transportation:* trip chaining, satellite activity locations (satellite work locations, on-site daycare facilities, personal services, cafeterias, restaurants, etc.)
Mode choice	Shift trip from a lower-occupancy mode of travel (e.g., drive alone) to a higher-occupancy one.	*Land use:* increasing allowable density of development (to improve the market for high occupancy vehicle facilities). *Transportation:* mode-specific incentives and disincentives, such as parking pricing, carpool, vanpool, and transit subsidies; bicycle and pedestrian amenities; guaranteed ride home programs; etc.
Route selection (spatial)	Shift trip from a more congested route to a less congested one.	*Land use:* street quietening (removal of through traffic from residential streets through creation of permanent or temporary barriers). *Transportation:* smart highways and vehicles (technologies capable of the instantaneous delivery of current route information, including identification of the route with the shortest travel time, based on ambient traffic conditions before or during the trip).
Route selection (temporal)	Shift trip from a more congested time period to a less congested one.	*Land use:* mixed use development, jobs/housing balance (where different land uses exhibit different peaking characteristics of trip generation). *Transportation:* alternative work schedules (flexible work hours, staggered work shifts, and compressed work weeks).

impeding the mobility of the existing population, or requiring the construction of additional transportation facilities to serve the increased travel demand associated with urban growth. Despite its broad appeal to transportation professionals, TDM has some significant problems associated with program implementation. But new institutional arrangements have been identified that might increase the likelihood of success for many TSM and TDM strategies.

Roles and Responsibilities of the Public and Private Sectors

Developers, landowners, employers, and the business community at large influence individual travel behavior through the size, location, and types of economic activities involved in new and existing development. Public policy is increasingly geared toward issues related to traffic congestion, air pollution, and the overall quality of life in urban and suburban areas undergoing rapid economic growth and change (Owen 1988). A number of techniques have emerged that are designed to assist in traffic mitigation and resolution of conflicts over traffic congestion in the planning process (Oram 1987). Methods to coordinate private decisions on development with public decisions on transportation infrastructure investment and operations include the regulation, financing, and operation of various aspects of the transportation system (Lundqvist 1988). An illustrative typology of these TDM implementation strategies based on the degree of privatization using Lundqvist's terminology is shown in Table 2.

Regulation

If the transportation system has insufficient capacity to handle an increase in travel demand, development might be limited to an amount that can be served adequately by existing capacity. In addition, either individual travel behavior or the location of activities could be regulated. The regulation of travel behavior might also include restrictions on the use of private automobiles. Rationing the purchase of gasoline on odd or even days during energy shortages is a form of indirect regulation. Direct regulation of travel behavior has been avoided in the United States as economically and politically unjustifiable (Witheford 1989). While it was proposed as a method for reducing air pollution in perennial nonattainment areas such as Los Angeles in the early 1970s, it was never implemented (Myhre 1989).

Zoning ordinances specify types of land uses permitted, as well as the maximum allowable density of development. Growth management initiatives place limits on both the timing and extent of new development. Growth management strategies seek to limit growth to that which can be absorbed by the community, including existing or planned transportation infrastructure (Harris 1988). Regulations that reference the number of person or vehicle trips generated by a proposed new development are a more recent phenomenon, and are generally referred to as trip reduction ordinances.

TABLE 2: Transportation demand management and privatization

	Orientation		
Function	Private	Mixed	Public
Regulation	Transportation management association	Negotiated developer agreement	Trip reduction ordinance
Financing	Private	Public and private	Public
Operations	Employer ridesharing program	Brokerage services provider	Regional ridesharing program

Financing

Options other than regulatory control strategies are also available. For example, a development that will generate traffic in excess of transportation system capacity may be required to pay development impact fees (Cowart 1988). Suburban traffic congestion may be the result of inadequate design, insufficient capacity, or excessive demand. To the extent that capacity is the problem, additional financing may be necessary (Gakenheimer 1989). If inadequate capacity acts as a brake on economic growth, developers may wish to contribute on a voluntary basis to the cost of additional transportation infrastructure. Such apparently altruistic behavior may enhance the market value of private property, and may permit development at higher densities to occur. Benefit assessment districts, in which local landowners voluntarily tax themselves, often with matching funds provided by local governments, have also been used to provide the additional funding necessary for transportation in areas characterized by rapid economic growth (Heath et al. 1988). TDM financing may come from either the public or the private sector. Where developers contribute to TDM program funding, offsets for trip reduction may be appropriate where development impact fees are currently in force.

Operations

New or existing private development and the transportation system are not always perfectly matched in operational efficiency over the short term. Neither development impact fees nor growth management strategies influence the operation of the existing transportation system, at least not over the shorter term. Both types of strategies are aimed at new development, and fail to take into account the effects of existing development on transportation system utilization. This can create severe equity problems in dealing with existing traffic congestion. Thus, changes in the transportation system or in the development scheme might be offered, negotiated, and/or required as a condition of development and/or building occupancy.

Organization and Implementation of TDM Efforts

Several new organizational approaches to TDM implementation have been tested within the past decade, including transportation management associations, trip reduction ordinances, and negotiated agreements. While specific orientations may vary, all three approaches are intended to foster greater cooperation between the private and public sectors (see Table 2). Private efforts often focus on the formal incorporation of transportation management associations. Public efforts often include the formal enactment of trip reduction ordinances. Combined efforts sometimes are administered more informally. They may consist of negotiated agreements, often implemented through modification of existing development and occupancy permit review processes. All three approaches have been tried in practice, and have achieved success in some applications. Elements of all three may be useful in implementing comprehensive TDM programs.

Transportation Management Associations

One way in which the private sector can join with the public sector voluntarily in TDM implementation is through the formation of a transportation management association, or TMA (Schreffler and Meyer 1983). Most existing TMAs serve major employment activity centers. TMAs may include among their board members business associations, employers, building management companies, landowners, and developers (Dunphy and Lin 1990).

TMAs have increased rapidly in recent years. As of August 1989, there were 53 TMAs located in 14 different states across the United States. Five of these (10 percent) were formed prior to 1984. Half of those surveyed (50 percent) were created between 1984 and 1988, and fully 40 percent came into existence in the year 1989 alone. About 40 percent of all TMAs identified through 1989 were concentrated in California (Wright 1989). Data on 51 of the 53 known TMAs in the United States have been summarized in matrix form by Wright in the *TMA Directory* (1989). I analyzed these data to try to identify the relationship, if any, between TDM implementation and TMA initiation. I formulated the following hypotheses based on a priori theoretical expectations (1 through 4)) and practical experience (5):

1. TMAs should be inspired by issues of direct interest to participants in TMA formation.
2. Private sector TMAs should derive a greater portion of their financial support from private sector sources.
3. Private sector TMAs may be smaller in size than public sector TMAs, because of greater private sector skepticism regarding TMA cost effectiveness and efficiency.
4. Private sector TMAs should be more likely to offer incentives based on the principle of direct self-interest.
5. Private sector TMAs should exhibit less interest in TDM evaluation. TDM performance monitoring usually documents external social and environmental benefits, which may be of less value to private than to public sector interests.

Sixty-six percent of all TMAs were initiated at the request of employers or the local business community, 56 percent were sponsored by state and local government, and 45 percent were created at the behest of developers or private landowners (Table 3). Many TMAs were initiated by more than one group, with a slight bias toward the private sector. Overall, 16 percent of surveyed TMAs were initiated by the public sector only, 43 percent were initiated by the private sector only, and 41 percent were initiated by representatives from both the public and private sectors. The most common reason given for TMA initiation was traffic congestion. Developers and landowners were more likely to initiate TMAs in response to growth and land use issues, presumably of direct interest to them. State and local governments were more likely to mention traffic congestion, trip reduction ordinances (TROs), and air quality as reasons for TMA initiation, all different forms of "public goods." Employers and business associations mentioned parking management more often as a reason, once again of most direct interest to this group. This information would seem to confirm hypothesis 1.

Surveyed TMAs relied more often on public funding than on membership dues or other sources of financing. None were financed by dedicated tax revenues at the time the directory was published. Developer TMAs were more likely to be financed by membership dues, while government-initiated TMAs were more likely to be financed through public subvention. This finding would seem to confirm hypothesis 2. Mean annual budgets for developer TMAs were smaller than those for employer TMAs. Public sector TMAs had the largest mean annual budgets. This would seem to support hypothesis 3.

In general, TDM program components offered by or through TMAs tended to focus more on information services (carpool-matching assistance, bus information, transportation management plans, etc.), and less on direct modal incentives or parking management strategies. Developer-initiated TMAs were more likely to offer alternative work schedules, shuttle services, HOV preferential parking, and carpool and vanpool incentives. Government-initiated TMAs were more likely to offer carpool- and vanpool-matching services, transit information, transportation management plans, parking management services, and transit incentives. Employer-initiated TMAs were more likely to offer employer relocation services and guaranteed ride-home programs. In general, TDM program elements seemed to be offered by TMAs on the basis of least cost and greatest gain principles. TMA initiators were thus favored by the TDM program components they implemented, confirming hypothesis 4.

Developer-initiated TMAs were most likely, and employer-initiated TMAs least likely, to evaluate TDM pro-

TABLE 3: Transportation management associations—principal activities by initiation source

TMA Activities	Initiator(s)[a] Developer/land owner (%)	Employer/business community (%)	State/local government (%)	Average (%)
Reasons for initiation[a]				
Traffic congestion	70	77	86	75
Growth/land use	96	62	69	69
Trip reduction ordinance	22	9	28	24
Air quality	9	18	24	14
Parking management issues	4	18	17	14
Incorporated	48	47	38	43
Staffing				
Full time	61	65	55	63
Part time	35	15	14	18
Participation				
Voluntary	74	65	55	63
Mandatory	0	0	7	4
Financing[a]				
Public assistance	61	65	76	69
Member dues	70	50	41	49
Other sources	13	24	24	20
TDM program elements[a]				
Carpool/vanpool matching services	57	56	62	59
Transit information	52	47	55	55
Transportation management plan	30	47	48	43
Alternative work schedules	39	32	38	33
Parking management services	22	27	28	29
Shuttle services	26	21	21	24
Employer relocation services	9	12	10	12
High occupancy vehicle preferential parking	17	9	10	12
Transit incentives	13	6	17	12
Carpool/vanpool incentives	22	6	10	12
Guaranteed ride home programs	9	12	10	10
Evaluation efforts[a]				
Baseline surveys	30	15	21	18
Follow-up surveys	22	12	17	14
Focus groups	13	0	7	6
Mean annual budget	$143k	$190k	$309k	$249k
Number of observations	23	34	29	51

a. Multiple response possible.
Source: Wright 1989.

gram results through baseline surveys, follow-up surveys, and focus groups. The employer data support hypothesis 5, while the developer data contradict it. It was odd that developers were most interested in TDM evaluation, given that they spent less money than other initiators on TMA implementation. This finding suggests that developers and landowners may be more skeptical about potential TMA success than either employers or public agencies, a conclusion that reinforces hypothesis 3.

TMA financing, operations, and evaluation vary considerably with the identity of TMA initiators. Additional information on TMA regulation might be useful in assessing TMA potential. TMA leadership is an important concern. Some experts believe that TMAs should include public sector representation on the board with full voting rights. Others seem to think that TMAs should be completely privatized operations. It is not always clear whether specific TMAs are intended to serve as lobbying or advocacy groups, or as providers of transportation services. Some do both. At this point, TMAs appear to be oriented slightly toward the private sector, though not overwhelmingly so.

Trip Reduction Ordinances

A municipal, county, regional, or state regulation requiring any form of developer or employer participation in TDM implementation often is referred to as a trip reduction ordinance (TRO). TRO may be a misnomer in some cases, since trip reduction is not always specified as a goal or objective of regulations that bear this name. Nonetheless, it is the most common name used for TDM regulatory requirements, and is retained here for consistency.

Information on TROs was collected in the state of California by the California Department of Transportation (1990), and on a national basis through the combined efforts of the Association for Commuter Transportation, the author, and Jesse Glazer, a recognized expert on ridesharing. From these various data sources, an upper limit of 58 separate TROs in 46 independent jurisdictions was identified. A rather amazing 67 percent of all TROs were concentrated in the state of California (Sanford 1990). Multiple TROs in single jurisdictions usually applied to different locations within the jurisdiction, different types of regulated activities (e.g., new and existing development), or both. Of the 46 separate jurisdictions represented, two were states, three were regional air quality management districts, four were counties, and thirty-seven were municipalities. Nine representative examples of municipal, county, and regional TROs are shown in Tables 4 and 5. These examples were chosen to represent the full range of TRO jurisdictions, applications, objectives, requirements, and enforcement provisions.

The main goal of most TROs (65 percent) is to mitigate existing traffic congestion. Some TROs (13 percent) are aimed at mitigating future traffic congestion. A few (15 percent) have more comprehensive goals, including improved air quality and reduced energy consumption (Vigna 1987). Three of the TROs identified in California are in fact development impact fee ordinances, designed to collect funds for street improvements rather than to foster TDM implementation. County and regional TROs tend to be oriented toward air quality improvements more often than traffic mitigation.

Most TROs (76 percent) apply to both new and existing development, at least in some form. This finding is surprising. A common concern about TROs has been that existing development often escapes inclusion within their regulatory purview. Just a few TROs (15 percent) are limited in application to new development only. It is true that some TROs apply to existing development only when such existing development significantly expands the scope of its activities (e.g., Minnetonka and Pasadena, see Table 4). Limited exemptions for existing development may be viewed sympathetically by local citizens and policymakers. Such exemptions may lead to poor TDM performance, however, since existing development thereby receives a "free ride," a result TROs usually are intended to avoid. A relatively few TROs are purely voluntary in nature, calling for increased awareness and participation on the part of the private sector, with no mechanism for performance monitoring, program evaluation, or enforcement.

Size is almost always used as a criterion for determining the applicability of a TRO to specific types of activities. Size may be specified in terms of gross floor area, number of employees, number of peak trips generated, and so forth. A minimum size requirement usually is designed to reduce hardships on small businesses, or to limit monitoring and enforcement costs to the jurisdiction. Size restrictions are sometimes implemented in discrete steps over time, often with the intention of bringing larger employers and developers on line with implementation sooner. Size restrictions seem to be falling over time as well; smaller and smaller developments and employers are being covered by TROs, though often with less stringent requirements than those for larger activities. Local TROs show wide variations in specific applications; sometimes they include new development only, or new and existing development only, or large development only, or office and industrial development only, or residential development only, and so forth. Most county and regional TROs cover all developments of a certain size, whether new or existing, within their regulatory purview.

TRO regulatory requirements vary considerably from one jurisdiction to another, but generally they include the provision of a TDM or transportation management plan. TDM plans may include the identification of specific incentives and amenities that will be offered to employees, the planned timing of TDM program implementation, and specific performance standards to be achieved. TDM plans generally must be updated on a regular basis, most often annually. If periodic TDM program evaluations show that program objectives are not being achieved, further action may be required. Experience indicates that two to five years may be necessary to achieve full results from TDM programs. TDM programs generally must be managed by a professionally trained employee transportation coordinator (ETC), who must be located on site. For larger firms and new development projects of increasing size and complexity, TRO requirements tend to become more comprehensive and detailed in performance expectations.

Of the 46 TROs, 50 percent included mandatory TDM strategies only, 15 percent included voluntary TDM strategies only, and 35 percent showed both mandatory and voluntary compliance measures. Of the 46 TROs, 13 percent listed supply-side (TSM) measures only, 35 percent listed demand-side (TDM) measures only, and 49 percent listed both TSM and TDM measures. TROs that were exclusively TSM- or TDM-oriented tended to emphasize mandatory compliance measures only. TROs that combined elements of both TSM and TDM tended to include both mandatory and voluntary compliance measures, and hence were probably more flexible policy instruments.

Enforcement provisions vary widely among TROs, from none at all to fines and penalties for specific code violations. Fines vary from $500 per month (North Brunswick, see Table 4) to $25,000 per day (South Coast

TABLE 4: Trip reduction ordinances—municipal examples

Jurisdiction	Application	Objectives	Requirements	Enforcement
Bellevue, WA	Non-CBD: new development only; 5,000+ sq. ft. (office); 12,500+ sq. ft. (professional services); 30,000+ sq. ft. (manufacturing); 60,000+ sq. ft. (hospitals, retail); 16 or more units (multifamily). CBD: all developments with 150 or more employees.	Increase ridesharing and transit share of commute trips to 18 percent; further reduce traffic congestion through flexible work hours programs.	Post and distribute information; provide coordinator, preferential parking, financial incentives, and guaranteed ride-home program, among others, depending on size of development. CBD: coordinated with Bellevue TMA and Seattle Metro. Action plan required; maximum annual expenditures $45/ employee in third and fourth years.	Not explicitly stated. Violations might be subject to fines or other penalties, however.
Minnetonka, MN (I-394 District)	New development exceeding 25,000 sq. ft. in gross floor area; expansion of existing development greater than 10 percent of GFA and 25,000 sq. ft. total; any development that would generate more than two p.m. peak trips per 1,000 sq. ft. of GFA.	Ensure reasonable traffic operations; encourage high quality development standards; protect environment; promote neighborhood stability; promote flexibility in development, more efficient use of land, alternative housing, energy conservation.	Master development plan. Traffic impact study. Estimate trip generation; identify road system improvements required, if any; develop traffic mitigation plan in consultation with the city that may include urban design, incentives, etc.	Required as a condition for certain land uses within the I-394 District, as defined in the Zoning Ordinance, Section 300, as amended.
North Brunswick, NJ	Existing businesses with 50 or more employees, except certain uses (mainly retail). New development: all residential development of 20 or more units, without preliminary subdivision approval; all nonresidential development of 15,000+ sq. ft. GFA; all planned developments.	Address traffic problems.	Employers: annual survey, report (all); traffic reduction plan (100+ employees). Residential: survey (all); vanpool parking (50–350 units); park-and-ride lot (351 or more units). Nonresidential: traffic reduction plan aimed at 70 percent drive-alone mode split; annual survey, report; transitions to employer requirements; complex plans must be maintained.	Failure to submit original surveys, reports, traffic reduction plans, or required revisions to any of the above is a violation, subject to a fine of $500 per month until such time as compliance is achieved.
Pasadena, CA	All new development that would employ 100 or more employees. All existing development planning to increase its GFA by 25 percent or more and that would employ 100 or more employees.	To discourage single-occupant vehicle trips and reduce peak demand on local streets, parking facilities, and transit systems.	Carpool preferential parking spaces (10 percent), matching services, secure bicycle parking, posting information (100–499 employees); all of the above, carpool loading areas, bus stops, vanpool facilities, and TSM plan (500 or more employees).	Failure to comply may result in the denial of certificates of occupancy, future building permits, or conditional use permits; failure to achieve objectives activates stricter contingency measures.

TABLE 4. (*Continued*)

Jurisdiction	Application	Objectives	Requirements	Enforcement
Pleasanton, CA	All employers, business complexes, activity centers, and the city government.	To reduce peak-hour traffic by a minimum of 45 percent (from an assumed base of 100 percent drive-alone), staged over a four-year period; and to maintain Level of Service C[a] on all city streets and at all city intersections for as long as possible. Peak hours are 7:30 a.m. to 8:30 a.m. and 4:30 p.m. to 5:30 p.m.	Annual employee commute survey (all). Information program and annual report (10+ employees). TSM program targeting 45 percent reduction (50+ employees). Employer TSM program coordination, required tenant participation, and the provision of a complex coordinator (business, activity centers).	Failure to make progress may require revision of the TSM plan. Failure to meet requirements (in good faith) may result in penalties of up to $250 per day.

a. "Level of service C" is the typical traffic engineering standard for road design, in which traffic is neither free-flowing, nor heavily congested, but rather sees full, efficient utilization, with a minimum of delay.
Source: California Department of Transportation 1990.

Air Quality Management District, see Table 5). In at least one jurisdiction, failure to comply with the ordinance may be treated as a criminal misdemeanor (Sacramento County, see Table 5). More typically, failure to comply is a straightforward violation of the civil code. Failure to perform in trip reduction requirements rarely is treated as a violation, at least not initially. In most cases, only "wilful" disregard of implementation requirements for agreed-upon policies, programs, or plans, within specified time periods, is treated as a direct violation. Total fines in excess of $100,000 have been levied in Southern California against individual firms determined to be out of compliance, but this type of penalty is rare. The intent of most TROs is to encourage participation, rather than to punish laggards, or to generate revenues. Developers have been active in supporting the creation of several major TROs, including those in Bellevue, Washington; Pleasanton, California; and the South Coast Air Basin of Southern California. This support has usually grown out of concern over horizontal equity issues in the provision of transportation infrastructure investments and improvements in the vicinity of new and existing developments.

Negotiated Agreements

Developers often interact with planners in the negotiation of development agreements; petitions for variances in local zoning regulations; rezoning requests; and applications for the approval of large, complex, planned-unit, or mixed-use developments. Such agreements may include traffic mitigation measures as conditions for development. While negotiated agreements may provide freedom of action to both planners and developers, they also offer opportunities for the abuse of power and arbitrariness in outcomes for individuals or firms. If private sector interest is insufficient to generate a working TMA, and local community concerns are not quite strong enough to gain passage of a TRO, it may be possible for planners to introduce TDM into the development process through informally negotiated agreements. Large developments, because of their complexity, often require variances from local zoning ordinances, building codes, and so forth. It is the moment when the developer applies for or expresses interest in such variances that is often the critical stage for taking urban design and transportation system characteristics into account as part of the overall development review process. This is usually the ideal point at which to discuss TDM as an integral part of a specific development plan.

An example of a TDM program based on negotiated agreements is that of Montgomery County, Maryland (Hekimian 1986). This case illustrates the advantages and disadvantages of using negotiated agreements in TDM implementation. Associated with a TRO and several TMAs, the Montgomery County trip-reduction program clearly demonstrates the principles on which a policy of negotiated agreements can and should be based. This case reveals the creativity that can enter into the design of TDM programs in a more flexible and individualized format (Table 6). With 23 negotiated agreements in force in Montgomery County as of September 1, 1988, 74 separate TDM concessions had been negotiated. These negotiations yielded an average of 3.2 "concessions" (specific types of TDM program components or incentives) per agreement, which varied by type of development from 2.5 for residential developments, to 3.0 for mixed use developments, and 3.5 for office developments. The types of program components negotiated in Montgomery County are in many cases sophisticated and even unusual; they include shuttle services to Metrorail stations, residential and commercial park-and-ride lots, guaranteed ride-home programs (free taxi vouchers for transit users and carpoolers, to be used only in the event of unanticipated overtime or personal emergencies), pedestrian

TABLE 5: Trip reduction ordinances—county and regional examples

Jurisdiction	Application	Objectives	Requirements	Enforcement
Maricopa County, AZ	Employers with 100 or more employees.	A 5-percent reduction in the percentage of employees who drive alone in each of the first and second year of program implementation.	Provide employees with information; participate in a baseline survey; prepare a TDM plan that includes designation of an employee transportation coordinator (ETC) and specific programs and reduction measures to be used.	Increased civil penalties under the Clean Air Act of 1970, as amended, though not necessarily for nonattainment of objectives per se.
Montgomery County, MD	Employers with 25 or more employees. Any proposed subdivision or optional method development for which additional transportation facilities or traffic alleviation measures are necessary for approval.	Increase transportation system capacity; reduce existing and future levels of traffic congestion; reduce air and noise pollution; promote traffic safety and pedestrian access. Must conform with annual growth policy.	Formation of an advisory committee to work with planning director and to oversee the preparation and execution of traffic mitigation plans by employers, and the negotiation of traffic mitigation agreements with developers.	Failure to submit a plan is a violation on the part of employers; failure to comply with an agreement is a violation on the part of developers.
Sacramento County, CA	Employers with 100 or more employees at a common business location. Developments expected to house 500 or more employees.	Reduce the number of employee vehicle trips in order to reduce peak hour congestion; delay need for major transportation facility improvements; reduce future air pollution concentrations.	Employers: provide information on commute alternatives; matching services; on-site coordinator; carpool preferential parking spaces. Developers: provide carpool passenger loading area; at least 15-percent carpool preferential parking spaces; showers and lockers for bicyclists, joggers, and walkers; and transit shelters, as appropriate.	Employers: failure to apply for a permit or to implement any requirements is a misdemeanor, with fines of up to $500, imprisonment for not more than six months, or both. Developers: issuance of application for permits, plans, variances, etc., is contingent on meeting all requirements.
South Coast Air Quality Management District, CA	Employers with 100 or more employees within the counties of Los Angeles, Orange, and Riverside, and the nondesert portion of San Bernardino.	Reduce auto emissions from vehicles used to commute by increasing average vehicle ridership (AVR) between 6:00 a.m. and 10:00 a.m. on weekdays. AVR targets vary from 1.3 to 1.75, depending on the firm's location within the region.	Submit plan (prepared by a trained coordinator) specifying measures to achieve target AVR, including the designation of a trained coordinator, the identification of all measures currently being used that influence employee travel behavior, a verifiable estimate of current AVR, and a list of specific incentives the employer will undertake to meet the AVR objective, if necessary. Plans are to be updated and resubmitted annually.	Failure to meet target AVR is not a violation. Failure to submit a plan or annual update, or to offer any incentive in an approved plan, is a violation, subject to penalties as outlined in Article 3, Chapter 4, Part 4, of Division 26 of the Health and Safety Code.

Source: California Department of Transportation 1990.

TABLE 6: Negotiated developer agreements—trip reduction programs in Montgomery County, Maryland

Types of development affected	Total number of negotiated agreements	Trip reduction requirements[a]	Typical program components[a]
Residential	4	NT (3) None[b]	Residence-based carpool matching programs (2) Shuttles to Metrorail stations (2) Park-and-ride lots Subsidized vanpools Commuter association Transportation management coordinator Bus shelters Subsidized transit fares
Office	14	NT (8) None (5)[b] AVR	Subsidized transit fares (7) Employer-based carpool matching programs (6) Reserved carpool/vanpool parking spaces (6) Subsidized vanpools (4) Shuttles to metrorail stations (3) On-site ridesharing promotional programs (3) Transportation management coordinators (2) Free emergency ride-home programs (2) Employee parking fees (2) Reduced employee parking supply (2) Park-and-ride lots (2) Reduced parking fees for carpools/vanpools Prohibition of employer-subsidized parking Annual payment to county ridesharing fund Bus shelters Transportation information center Express bus service Shuttle bus service Commuter rail easement Alternative work hours Pedestrian walkway
Mixed use	5	NT (2) None (2)[b] AVR	Employer-based carpool matching programs (2) Transportation management coordinators (2) Subsidized vanpools (2) Subsidized transit fares (2) Free emergency ride-home programs (2) Reserved carpool/vanpool parking spaces Rent reduction for tenants who walk to work Bus shelters Prohibition of employer-subsidized parking Retail-oriented transportation information kiosk
Total	23	NT (13) None (8)[b] AVR (2)	

a. NT = Number of trips. A specified number of vehicle trips attracted to the site per day to be reduced upon occupancy and implementation of the program, varying from 10 to 400 trips among the 13 developments so far affected, depending on the size of the development, the anticipated rate of trip generation, and other factors.
AVR = Average vehicle ridership. The standard employed so far has been 30-percent participation in public transit and an average of 1.3 persons per private vehicle for the remaining 70 percent.
(n) = Number of negotiated agreements affected by a specific requirement or incorporating a particular program component.

b. Specific trip reduction requirements are called for in the ordinance only when local streets currently are operating at or above capacity. In some cases, TDM programs were negotiated with developers who legally were not required to reduce trips. No trip reduction requirements were included in those agreements.

Source: Hekimian, A. J. Maryland-National Capital Park and Planning Commission, Silver Spring, Maryland. Based on a summary of all developer agreements negotiated as of September 1, 1988.

walkways, commuter rail easements, rent reductions for commuters who walk to work, and mandatory parking pricing strategies combined with significant parking supply limitations. A very knowledgeable negotiator would be required in order to come up with some of these ideas, let alone incorporate them into a contract requiring a commitment from the private sector to perform them as legally binding contractual obligations.

The Montgomery County TDM negotiated agreements are not always completely clear on performance expectations. Some agreements specify trip reduction as the primary goal, others average vehicle ridership with a transit component, and still others have no explicit measure of trip reduction performance. Part of the reason for this wide variation has to do with legal requirements and limitations. Only those developments located in areas where transportation system capacity is deemed inadequate can be required to mitigate traffic. In such cases, the developer has two choices:

1. Finance the construction of sufficient transportation system capacity to support all new trips generated by the development; or
2. Implement a comprehensive TDM program that is entirely open to negotiation, but that must achieve an equivalent reduction in the number of trips generated by existing travel demand, *prior to development or occupancy permit approval.*

These developers must mitigate all of the anticipated traffic impacts associated with their project. To ensure a reasonable expectation of this outcome, developers must post a bond sufficient to finance the operation of the TDM program negotiated with the county for at least 10 years. The bond is forfeited in its entirety if the TDM program is not implemented as required within the specified time frame.

Performance Monitoring and Program Evaluation

One critical obstacle to the significant allocation of resources to TDM program implementation from either the public or private sectors is the great uncertainty concerning the likelihood of success and expected magnitude of TDM program impacts. A number of recent studies funded by the U.S. Department of Transportation have looked into these issues (e.g., Bhatt and Higgens 1989; Kuzmyak and Schreffler 1990). Evaluations of TDM program effectiveness can be based on the level of effort made, or the level of success achieved, or both. Level of effort is usually identified in terms of policies, programs, and other actions to be implemented over a certain time period. Occasionally, level of effort may be measured in terms of the level of financial commitment made (e.g., dollars spent on TDM implementation per employee per year). For existing development, the level of success may be gauged in terms of measured changes in travel demand before and after a program is implemented. For new development, level of success is usually gauged by differences between actual performance (with TDM) and anticipated performance (without TDM). Level of success can be defined in terms of the site-specific or regional rate of personal or vehicle trip generation, the relative frequency with which different modes of travel are chosen (mode split), or the timing and location of site-specific trip generation in comparison with the timing and location of critical and/or congested transportation system components.

Kuzmyak and Schreffler (1990) compared TDM evaluation studies across the United States, focusing on spatial and programmatic variations in measured TDM impacts. The principal evaluation criterion used in this study was mode split, or the percentage of employees using particular modes of travel to work. Vehicle trips, the theoretically preferred output measure, was discarded because of lack of data, inability to control for external changes in ambient conditions (e.g., regional economic growth and development), and measurement problems associated with significant variations in daily traffic observed in many real world applications. Regional impacts of TDM programs have tended to be slight or negligible (*Urban Transportation Monitor* 1988). Kuzmyak and Schreffler (1990) found that TDM impacts across activity centers were larger (-2.4 percent to -17.8 percent in drive-alone mode split), and that TDM impacts across individual firms were even larger (-5.5 percent to -47.6 percent in drive-alone mode split). The best markets for TDM tend to be located in exactly those areas with the greatest levels of traffic congestion and air pollution. TDM impacts on regional traffic delay (and possibly localized hazardous air pollution) will be much greater than measured changes in regional vehicle miles of travel under these circumstances.

Parking management, particularly parking pricing, has been found to have the largest and most consistent impacts among TDM program elements (Bhatt and Higgens 1989). This finding is consistent with expectations drawn from the important theoretical and empirical work of Shoup on the impact of parking pricing on mode choice (Shoup 1982; Surber et al. 1984; Mehranian et al. 1987). However, implementing comprehensive parking management strategies is much more difficult than simply raising the price (Feeney 1989). Over 90 percent of all U.S. workers—including many downtown employees (Higgens 1989)—pay absolutely nothing for parking (Ferguson 1990b). Most firms have a much clearer idea of the number of parking spaces they provide free of charge to their employees than they do of the cost of providing such "free" employee parking spaces (Ferguson 1990a).

Interestingly, firms that have recently relocated are more likely to offer free parking to all employees, as a recruitment or retention device, while firms that have been in one place for a longer period of time are more likely to offer ridesharing incentives, as a means of reducing parking demand (Ferguson 1989a and 1989b). This dynamic temporal effect is illustrated numerically

TABLE 7: The influence of employer incentives on the duration of mode choice in downtown Los Angeles

	Mode choice		
	Transit	Carpool	Drive alone
Mean duration of mode choice, in months	50.3	37.9	50.1
Estimated change in mode duration due to:			
Transit incentives[a]	+6.2	−2.6	−2.9
Carpool incentives[b]	+4.7	+11.8	+9.5
Drive alone incentives[c]	−10.0	−5.8	−5.3

a. Typically, free or subsidized monthly bus passes.
b. Preferential parking for car/vanpools, the provision of trained ridesharing coordinators located on site, and car/vanpool subsidies.
c. Free parking for all employees, as opposed to free or subsidized parking for some employees or none at all.
Source: Ferguson 1989b.

in Table 7 and graphically in Figure 1. As these results on the dynamics of mode choice in downtown Los Angeles illustrate, parking supply seems to be sticky, with successful ridesharing programs freeing up parking spaces, which then are used by solo drivers instead of being sold or traded to other firms and their employees. This finding suggests that parking supply is too high at current market prices, perhaps because of local parking requirements in zoning ordinances. Income tax exemptions for employee parking at the state and federal level may also assist in perpetuating the strongest mode-specific incentive of all, free parking for employees who drive alone to work in private automobiles on a daily basis.

Other key TDM program components may include the provision of a trained employee transportation coordinator located on site for carpool and vanpool matching (Ferguson 1990a), the provision of subsidized transit passes and cash carpool incentives, and the coordination of alternative work schedules with other strategies to prevent conflicts with carpool formation or bus schedules

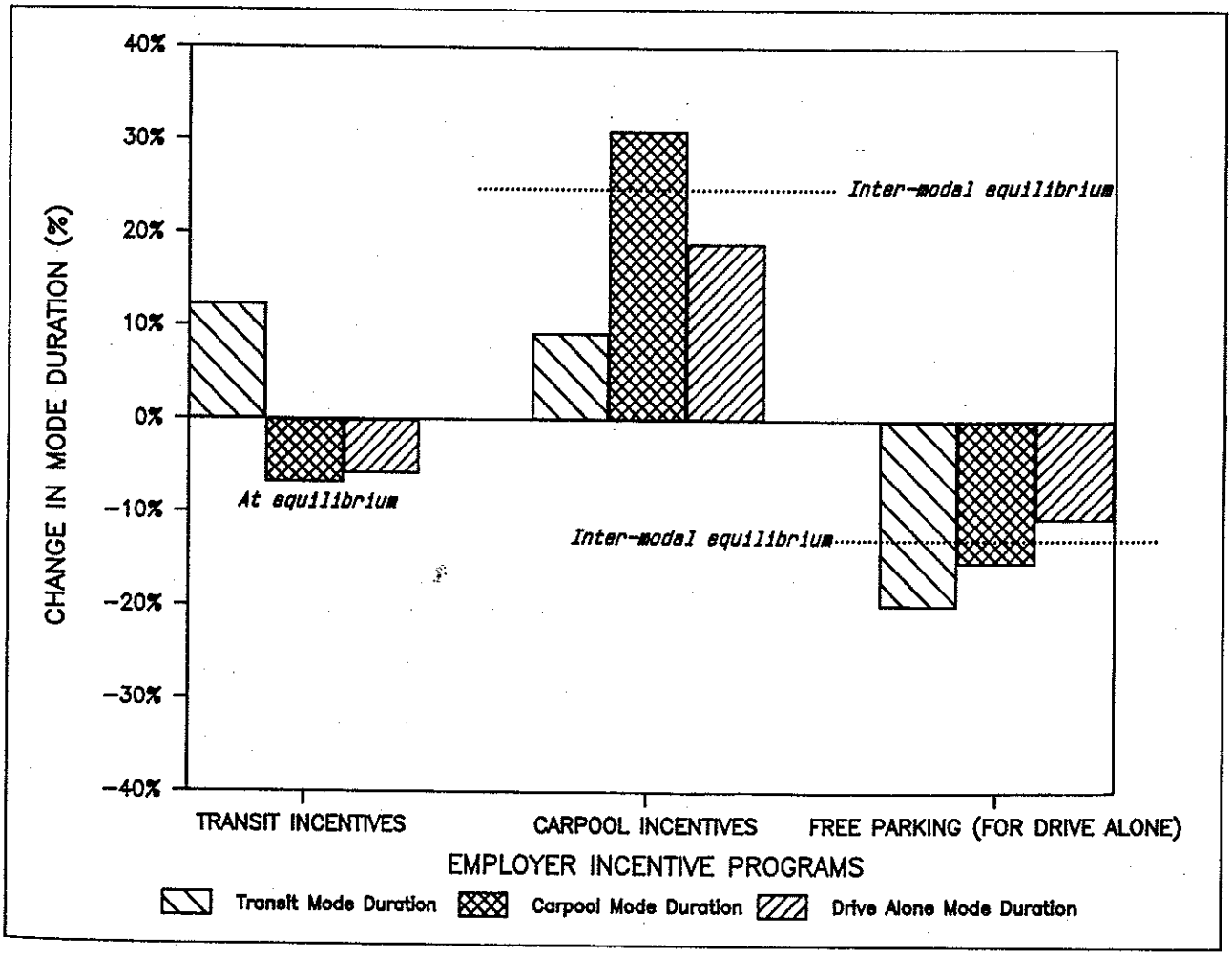

FIGURE 1: The influence of employer incentives on the duration of mode choice in downtown Los Angeles.

(Ferguson 1990a, Cervero and Griesenbeck 1988). These other types of TDM offerings tend to show much weaker and less consistent results than those associated with parking management. If and when parking management is not feasible for immediate implementation, other types of incentives must be sought, however. Comprehensive TDM programs that identify groups of compatible incentives and amenities may have greater impacts than specific types of incentives offered in isolation. Measuring the separate effects of individual TDM strategies employed in comprehensive programs would be difficult to accomplish. Organizational survey sampling methods might be used, if sufficient variation among TDM policies of firms located in similar settings (e.g., a single employment activity center) were available (Ferguson 1990c).

Additional research is needed on TDM program evaluation. There is too little information available on the success of TDM programs implemented through TMAs, TROs, and negotiated agreements. Most current TDM evaluations tend to stress the achievement of site-specific vehicle occupancy, with emphasis on mode choice for the work trip. This type of evaluation is relevant and feasible, but may not capture all of the potential benefits of TDM (Richardson and Gordon 1989). As with standard methodologies for predicting trip generation rates, assuming that a fixed proportion of person trips will be made by solo-occupant private autos, new methodologies are needed for identifying trip reduction rates associated with different types of TDM organizational and implementation strategies. This information is required to integrate TDM more carefully into public and private planning and development processes at the local and regional levels.

Developers, Planners, and TDM

Does TDM work? The answer is an unqualified yes. Is TDM the complete solution to the latest version of the urban and suburban transportation problem? The answer is an equally unqualified no. The only other clear message concerning TDM implementation that can be derived from this research is that it is a very "messy" business, requiring cooperation and support from many different groups within the community in order to achieve any measurable success.

TDM is the implementation of short-term incentive and disincentive programs that incorporate, directly or indirectly, the external social and environmental costs of individual travel decisions. TDM provides a "bridge" between short-term economic policies, such as road or parking pricing and long-term economic policies, such as land use planning and zoning. Inadequate pricing signals are the primary cause of traffic congestion in urban areas. If proper marginal cost pricing signals were given to consumers of transportation services, travel behavior would be modified, and the extent of both actual and perceived urban and suburban traffic congestion would be reduced. TDM is not a substitute for pricing, nor can it replace the need for adequate long-range infrastructure planning and land development policies and procedures. TDM is primarily an organizational issue, linking short-term direct and indirect pricing mechanisms with long-term community development goals and objectives. TDM is useful in addressing regional mobility concerns, but is rarely effective when implemented simply as a regional planning tool. The cooperation and participation of the private sector is necessary to make TDM work for even one employer or community.

Developers should become much more involved in TDM program implementation at the very outset of project planning. Amenities to encourage travel modes other than the private automobile should be made part of the initial layout of new activity centers. Retrofitting existing developments to provide bus shelters, carpool parking spaces, or secure bicycle parking areas is far less efficient than providing these facilities during the initial construction phase. Well-funded, fully staffed, on-site TDM programs should be in place prior to the occupation of new facilities, so that newly arrived commuters are provided with alternatives before they have established daily travel patterns. Planners can assist in making TDM an integral part of the development process through active encouragement of the formation of TMAs, the enactment of TROs, and negotiation of developer agreements that incorporate TDM concepts in project design. The result should be a more efficient transportation system, a less stressful and traffic-congested population, and more competitive local and regional economic activities, at the margin. This result may be less than obvious to the naked eye. It nonetheless lies at the very heart of good planning.

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