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MEMORANDUM

To: Mike Nilsson

From: Bonnie Nelson and Phil Olmstead

Date: April 2, 2010

Subject: Relationship Between TDM and Parking Demand

Overview

The memo provides a summary of various transportation demand management (TDM) measures that have been proven to reducing single occupancy vehicle trips, and, consequently, the demand for parking. Considerable national research has been done to link TDM measures with auto trip making. Logically, this would translate into lower auto ownership and lower parking demand. However, there has been little research done to directly link the provision of TDM programs and parking demand. In this memo we summarize available research, which we will translate in a later task, into a menu of potential options for reducing parking demand in new development.

This memo does not attempt to present an exhaustive list of TDM measures, nor does it cover many of macro-level policy initiatives (i.e. smart growth land use policies, congestion pricing, or major transit infrastructure improvements) that can also be implemented to reduce automobile trips. Instead, this memo offers a focused analysis of measures that are especially applicable for developers of office, commercial, and residential projects. The first section discusses the relationship between density/auto ownership and vehicle miles traveled, which has been analyzed in a number of urban regions including Los Angeles. This section presents a strong case that dense development by itself reduces both auto ownership and vehicle miles traveled. The second section highlights specific TDM measures and, depending on the available research, their measured effectiveness. Finally, the third section highlights a number of case studies where TDM measures have been successful, with particular attention paid to the private and institutional sector.

Relationship between Residential Density and Auto Travel

Research has conclusively demonstrated that there is a direct link between density of residential development and the degree to which residents travel by automobile. In short, the higher the residential density, the less people drive. This is a crucial point to remember in regards to TDM programs and parking demand evaluations. TDM measures can help to reduce automobile travel and parking demand on a smaller scale (i.e. by employer, by institution, etc.), but larger land use policy initiatives that seek to focus residential growth in certain areas have the potential reduce daily auto trips and vehicle miles traveled on a much more extensive scale. Figures 1 and 2 below illustrate this direct relationship between increased residential density and reduced auto

travel. Figure 1 shows an analysis of annual VMT in the San Francisco, Chicago, and the Los Angeles regions and its link to residential density. For example, in the Los Angeles region (which includes the City of Glendale) at 5 households per acre, annual VMT per household is roughly 25,000. However, as density increases to 100 households per residential acre the annual VMT per household decreases dramatically to roughly 5,000.

Figure 1. Driving vs. Residential Density in Three Metropolitan Regions[1]

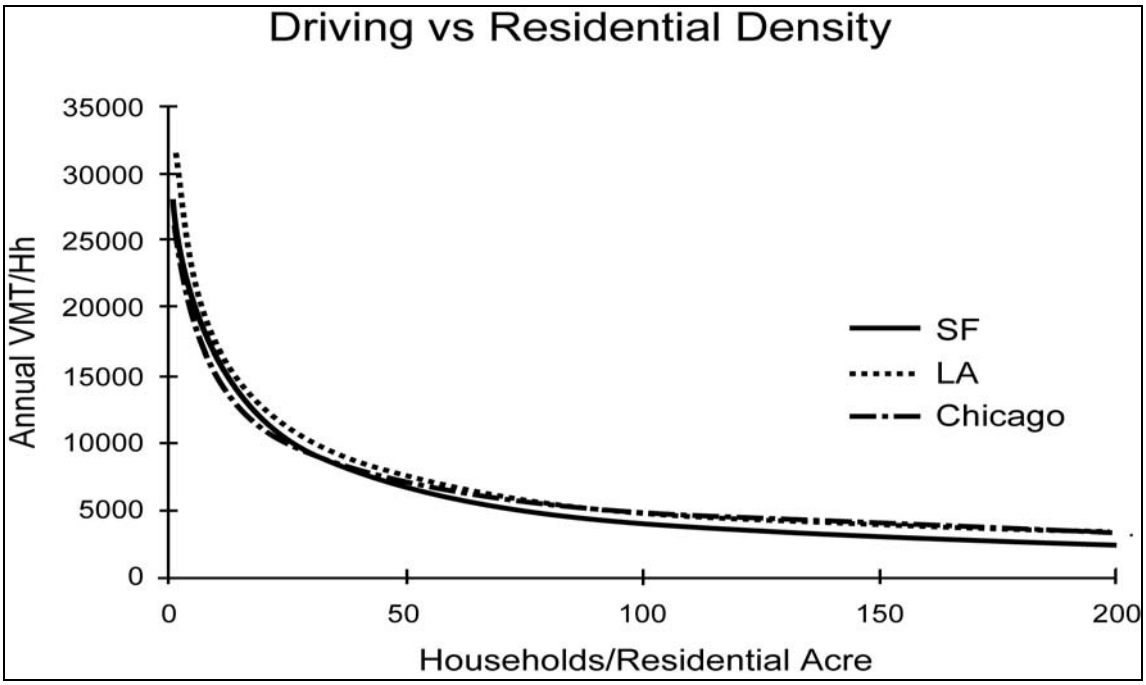
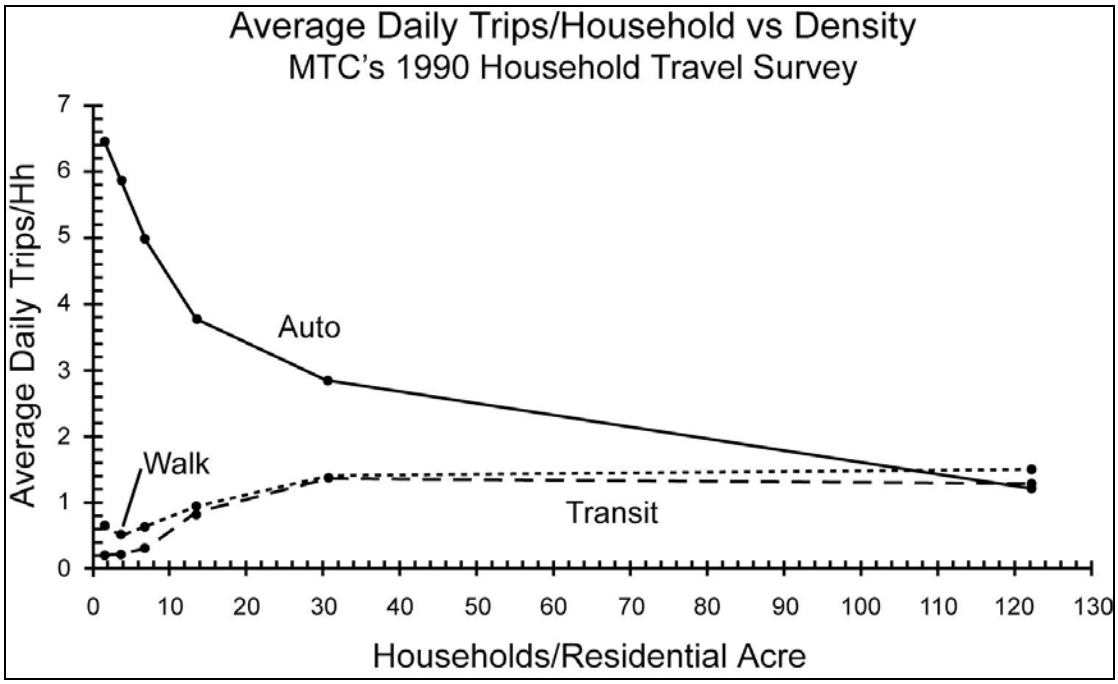


Figure 2 illustrates similar results from the Bay Area's Household Travel Survey. It likewise reveals that as residential density increases, the number of daily household auto trips decreases. For example, at a density of 2 households per acre, the average household makes roughly 6 automobile trips per day. At 100 households per acre, however, the number of daily automobile trips drops to less than two. Furthermore, this study illustrates that as density increases, so do the number of daily trips by transit and walking. In fact, at more than 120 households per acre, the number of daily household transit and walking trips exceeds the number of daily household automobile trips. Needless to say, these land use effects can have dramatic implications for the level of parking demand in a municipality.

[1] John Holtzclaw (2000). "As Seen From the Air. Convenient Neighborhood, Skip the Car." http://www.sierraclub.org/sprawl/transportation/holtzclaw-awma.pdf

Figure 2. Average Daily Trips/Household vs. Density[2]



Evaluation of specific TDM measures

Figure 3 below outlines the TDM measures discussed in this memo. The TDM measures are organized into six basic categories: parking, financial incentives, trip consolidation, scheduling, promotion, and multi-modal infrastructure. Each of these TDM measures has been selected because of its applicability for office or commercial developers, but many are also relevant for residential development, as indicated in the figure. Each TDM measure is outlined in more detail with a short description and summation of available research on its effectiveness.

[2] MTC Household Travel Survey and Data - http://www.mtc.ca.gov/maps_and_data/datamart/survey/

Figure 3. List of Selected TDM Measures

Potential TDM Measures for Office/Commercial Developments		Summary of TDM Measure	Applicable to Residential Development
Parking			
	Unbundled Parking	Charge seperately for cost of parking and the cost of residential/commercial space.	X
	Pricing parking	Pricing parking for commuters.	
	Reduced/Eliminated Minimums		X
Financial Incentives			
	Subsidized Transit	Provide free or highly reduced transit passes.	X
	Parking Cash-out	Employees who do not drive to work are offered a cash value equal to the parking subsidy.	
	Commuter benefit programs	Use tax-free dollars to pay for commuting expenses.	
	Free HOV/Carpool Parking	Free parking for HOV or carpools.	
Automobile Trip Consolidation			
	Carpool/Vanpool	Shared use of private vehicle or rented/purchased vans.	X
	Rideshare Matching Services	Help commuters find travel partners and share costs.	X
	Guaranteed Ride Home	Provide occasional subsidized rides to commuters to help deal with unexpected conditions.	
	Shuttle services	Shuttle service to/from location and public transit facilities.	X
Scheduling			
	Telecommute	Use of telecommunications to substitute for physical travel.	
	Flextime	Employees are allowed some flexibility in their daily work schedules.	
	Compressed work week	Employees work fewer but longer days.	
	Staggered shifts	Shifts are staggered to reduce the number of employees arriving and leaving at one time.	
Promotion			
	Marketing	Determining consumer needs/preferences, creating appropriate products, and promoting their use.	X
	Travel Training	Provide individualized training on transit, ridesharing, carsharing, and bicycle systems.	X
	Transportation Coordinator	Professionals who implement TDM programs.	X
Multi-modal Infrastructure			
	Carsharing	Provide access and/or reduced fees for car sharing facilities.	X
	Bikesharing	Provide access and/or reduced fees for bike sharing facilities.	X
	On-site amenities	Provide showers/lockers, bicycle parking, and child care services for employees.	X

Parking

Unbundled Parking

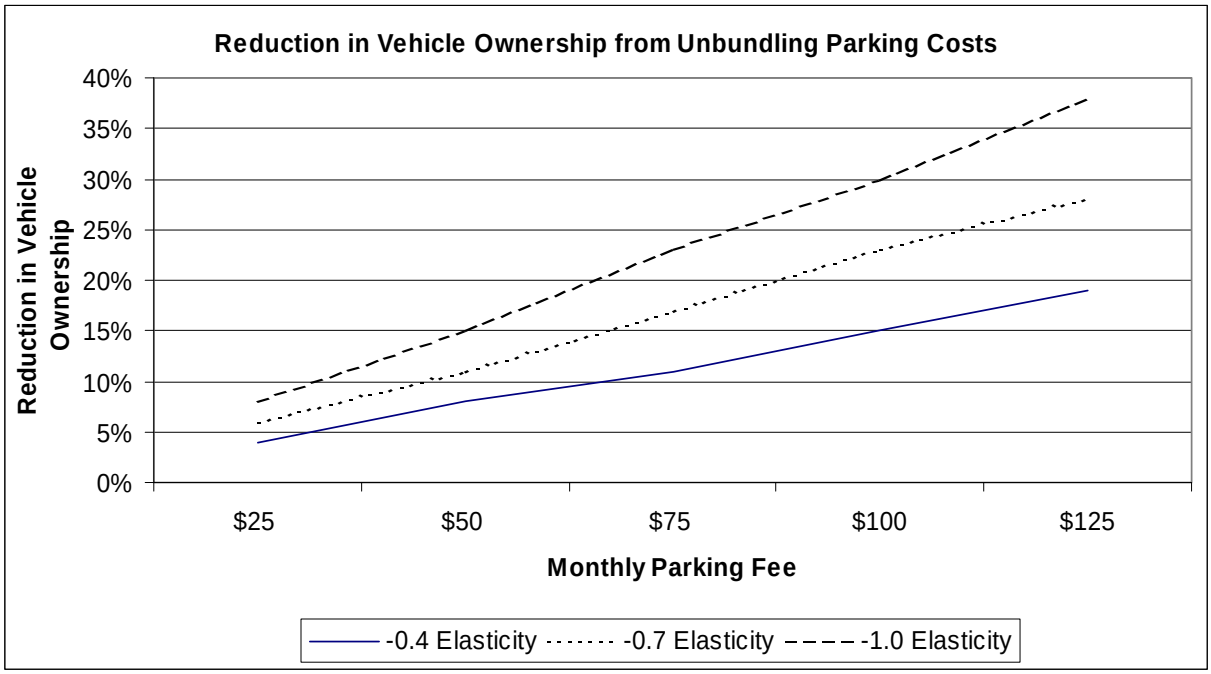
Description: Parking costs are generally subsumed into the sale or rental price of housing and commercial space. By unbundling parking, it is sold or rented separately, thereby making the costs specifically related to parking more conspicuous.

Summary of research: According to a study by Todd Litman, unbundling residential parking can significantly reduce household vehicle ownership.[3] Studies reveal that the elasticity of vehicle ownership with respect to vehicle operating costs is typically -0.4 to -1.0. In other words, a 10 percent increase in total vehicle operating costs reduces vehicle ownership 4 to 10 percent.[4]

Average income households spend an average of $3,800 annually per vehicle.[5] Assuming that residential parking spaces have a monthly cost of $100, and a very conservative vehicle price elasticity of demand factor of -0.4, the unbundling of residential parking costs would decrease vehicle ownership by 15 percent (Figure 4). This decrease would likely result in a proportionate reduction in residential-based vehicle trips.

[3] Victoria Transport Policy Institute (2009), *Parking Requirement Impacts on Housing Affordability,* http://www.vtpi.org/park-hou.pdf
[4] Victoria Transport Policy Institute (2009), *Transportation Elasticities,* http://www.vtpi.org/tdm/tdm11.htm
[5] Bureau of Labor Statistics (2003), *Consumer Expenditure Survey, 2002*, www.bls.gov

Figure 4. Reduction in Vehicle Ownership from Unbundling Parking Costs[6]



Pricing Parking

Description: Many employment centers, retail developments, and residential developments offer parking for free. By charging motorists for parking one can reduce vehicle trips, recover parking facility costs, and generate additional revenue.

Summary of research: The reduction in employee vehicle trips from public parking pricing varies both in the amount charged for parking and in the type of location the pricing is implemented. For example, parking pricing has a much more profound effect in denser areas where more alternative mode choices are present and as a result, vehicle trips face greater reductions in those districts. A number of studies have documented the travel impacts of pricing parking:

- Price elasticity of vehicle travel with respect to parking price ranges from -0.1 to -0.3 (a 10 percent increase in parking charges reduces vehicle trips by 1-3 percent), depending on demographic, geographic, travel choice and trip characteristics[7].

- Figure 6 summarizes a study that showed how minimum employee parking charges affected VMT, trips taken, and trip delay in four California regions. In the San Diego region, a $3 employee parking charge reduced VMT by 2.4 percent and trip delay by 7 percent.[8]

[6] Victoria Transport Policy Institute (2009), *Parking Requirement Impacts on Housing Affordability,* http://www.vtpi.org/park-hou.pdf
[7] Erin Vaca and J. Richard Kuzmyak (2005), *Parking Pricing and Fees*, Chapter 13, TCRP Report 95, Transit Cooperative Research Program, Transportation Research Board, Federal Transit Administration (www.trb.org/publications/tcrp/tcrp_rpt_95c13.pdf). Accessed on Victoria Transport Policy Institute, http://www.vtpi.org/tdm/tdm26.htm
[8] Greig Harvey and Elizabeth Deakin (1997), "The STEP Analysis Package: Description and Application Examples," Appendix B, in Apogee Research, *Guidance on the Use of Market Mechanisms to Reduce Transportation Emissions*, USEPA (Washington DC; www.epa.gov/omswww/market.htm). Accessed on Victoria Transport Policy Institute, http://www.vtpi.org/tdm/tdm26.htm

Figure 5. Vehicle Trips Reduced by Increased Daily Parking Fees[9]

Worksite Setting	$1.50	$3.00	$4.50	$6.00
Low Density Suburb	6.5%	15.1%	25.3%	36.1%
Activity Center	12.3%	25.1%	37.0%	46.8%
Regional CBD/Corridor	17.5%	31.8%	42.6%	50.0%

Source: Comsis Corporation, 1993 (in 2010 dollars)

Figure 6. Impacts of Employee Parking Fees

Region	Price	VMT	Trips	Delay
Bay Area	$1	-0.8%	-0.9%	-2.7%
	$3	-2.1%	-2.4%	-7.0%
Sacramento	$1	-1.0%	-1.1%	-2.5%
	$3	-2.6%	-2.8%	-6.5%
San Diego	$1	-0.9%	-1.0%	-2.5%
	$3	-2.4%	-2.6%	-7.0%
South Coast	$1	-0.9%	-1.1%	-2.9%
	$3	-2.5%	-2.8%	-8.5%

Source: Harvey and Deakin, 1997, Table B.7, in 1991 U.S. dollars;
Accessed at VTPI, http://www.vtpi.org/tdm/tdm26.htm

Reduced/Eliminated Minimum Parking Requirements

Description: In almost every city, the zoning code sets parking minimums for each land use in order to meet peak parking demand. Most cities' minimum parking requirements for new development typically take into account only two variables: land use type and the size (or intensity) of the development. For example, a minimum of 10 parking spaces per 1,000 square feet of restaurant space. By eliminating or reducing these minimums one can reduce costs associated with parking facility development, as well as influence demand for single occupancy vehicle trips.

Summary of research: Research shows that there is an indirect link between reduced minimum parking requirements and a decline in vehicle trips. Setting minimum parking requirements often results in lower parking prices, as the supply of parking exceeds demand, which in turn increases vehicle ownership. As mentioned above, studies reveal that the elasticity of vehicle ownership with respect to price is typically -0.4 to -1.0.

Average income households in the US spend an average of $3,800 annually per vehicle.[10] Therefore, if one assumes that a hypothetical residential parking space has an annualized cost of $800 per year, parking costs would add 21 percent to vehicle costs for an average income household. If we assume a vehicle price elasticity of -0.7 (Figure 7), residential minimum parking requirements that exceed the actual demand for parking increase vehicle ownership about 15 percent. The resulting increase in vehicle ownership produces more residential-based vehicle trips. Conversely, decreasing or eliminating residential parking requirements would result in a proportionate reduction in residential-based vehicle trips.

[9] Victoria Transport Policy Institute (2008), *Land Use Impacts on Transport*, http://www.vtpi.org/landtravel.pdf
[10] Bureau of Labor Statistics (2003), *Consumer Expenditure Survey, 2002*, www.bls.gov

Figure 7. Vehicle Ownership Reductions from Residential Parking Pricing[11]

Annual (Monthly) Fee	-0.4 Elasticity	-0.7 Elasticity	-1.0 Elasticity
$300 ($25)	4%	6%	8%
$600 ($50)	8%	11%	15%
$900 ($75)	11%	17%	23%
$1,200 ($100)	15%	23%	30%
$1,500 ($125)	19%	28%	38%

Financial Incentives

Subsidized Transit

Description: Growing numbers of transit agencies have teamed with universities, employers, building developers, or entire districts or neighborhoods to provide universal or subsidized transit to certain riders (students, employees, etc). This subsidy typically provides unlimited transit rides on local or regional transit providers for a low monthly fee, often absorbed entirely by the employer, school, or developers.

Summary of Research: Figure 8 shows the drive-alone and transit mode splits before and after subsidized transit pass implementation in different locations. These studies show reductions in drive-alone mode share of 4 percent to 42 percent, with an average reduction of 19 percent. In addition, these case studies show a wide range of increased transit mode share of between 25 percent and 145 percent with an average rise of 95 percent.

Figure 8. Employee Mode Splits Before/After Implementation of Subsidized Transit Passes

Location	Drive Alone to work			Transit to work		
Municipalities	*Before*	*After*	*% Change*	*Before*	*After*	*% Change*
Santa Clara (County)[12]	76%	60%	27%	11%	27%	145%
Bellevue, Washington (Downtown)[13]	81%	57%	42%	13%	18%	38%
Ann Arbor, Michigan (Downtown)[14]	N/A	N/A	4%	20%	25%	25%
Universities						
UCLA (faculty and staff)[15]	46%	42%	9%	9%	20%	122%
Univ. of Washington, Seattle (faculty)[16]	60%	47%	22%	11%	27%	145%

[11] Victoria Transport Policy Institute (2009), *Parking Requirement Impacts on Housing Affordability,* http://www.vtpi.org/park-hou.pdf
[12] Santa Clara Valley Transportation Authority (1997). *Eco Pass Pilot Program Survey Summary of Findings*.
[13] King County Metro (2000) *FlexPass: Excellence in Commute Reduction, Eight Years and Counting*. www.commuterchallenge.org/cc/newsmar01_flexpass.html
[14] Christopher White, Jonathan Levine, and Moira Zellner (2002). *Impacts of an Employer-Based Transit Pass Program: The Go Pass in Ann Arbor, Michigan*. www.apta.com/research/info/briefings/documents/white.pdf
[15] Jeffrey Brown, Daniel Baldwin Hess, and Donald Shoup (2003). *Fare-Free Public Transit at Universities*. http://shoup.bol.ucla.edu/FareFreePublicTransitAtUniversities.pdf

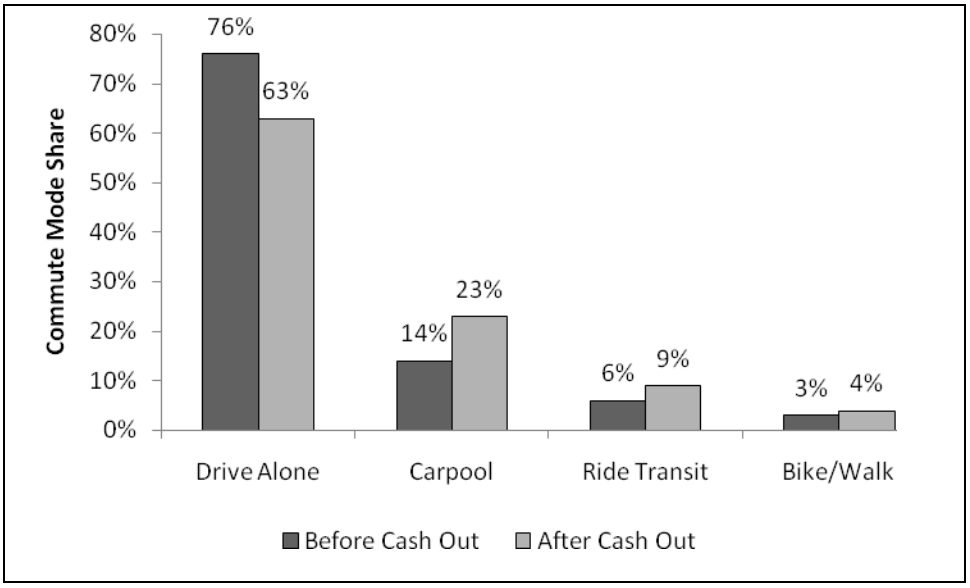
Univ. of Washington, Seattle (staff)	44%	39%	11%	25%	36%	44%
Average Percent Change	**-**	**-**	**19%**	**-**	**-**	**87%**

Parking Cash Out

Description: The majority of employers provide free or reduced price parking for their employees. Under a parking cash-out requirement, employers are allowed to continue this practice on the condition that they offer the cash value of the parking subsidy to any employee who does not drive to work.

Summary of Research: Research performed by Donald Shoup found that single-occupancy vehicle trips declined by 17 percent and other modes increased significantly (carpooling by 64 percent, transit by 50 percent, and walking/biking by 33 percent) after a parking cash-out program was introduced at various urban and suburban worksites with varying levels of transit service. These findings are illustrated in Figure 9. These mode shifts resulted in an average 12 percent fewer vehicle miles traveled (VMT) per year per employee. This reduction is equivalent to removing one of every eight cars driven to work.[17] The analysis found that reductions in auto trips tend to increase over time, as more employees find opportunities to reduce their driving and take advantage of the parking cash-out "fringe benefit."

Figure 9. Parking Cash-Out Impacts on Mode Choice[18]



Commuter Benefit Programs

Description: Employers allow employees to use tax-free dollars to pay for commuting expenses.

Summary of Research: The Commuter Check program in the Bay Area conducted a survey of its program in 1994. Approximately 1,800 survey cards were completed and returned by employees

[16] University of Washington Facilities Services, *The U-PASS Online and Telephone Survey Report (2006)*, www.washington.edu/commuterservices/programs/upass/reports.php
[17] Donald C. Shoup, *Evaluating the Effects of Cashing Out Employer-Paid Parking: Eight Case Studies*, http://www.arb.ca.gov/research/apr/past/93-308a.pdf
[18] Ibid

from 149 employers. Key findings of the survey were summarized by the Victoria Policy Transport Institute as follows[19]:

- About a third (31 percent) of the employees who receive Commuter Checks increased their use of transit. These employees reported an average increase of 3.24 transit trips per week. New transit trips were reported for both commuting and non-work purposes.

- The increase in transit use as a result of Commuter Check was more pronounced at employers outside San Francisco. Employees outside San Francisco reported an increase in transit commute trips of 48 percent compared to 25 percent in San Francisco.

- An estimated 17 million vehicle miles were removed from Bay Area roads in 1994 due to Commuter Check, and an estimated 61 million tons of pollutants were avoided.

- A large majority (79 percent) of respondents noted improved opinions of their employer as a result of receiving Commuter Checks, a third (35 percent) noted reduced stress from not driving to work or driving less often, and a third (33 percent) said job satisfaction had improved. Improvements in on-time arrival and productivity were also noted.

Ridesharing Assistance and Incentives

Carpool, Vanpool, and Ridesharing

Description: Shared use of vehicles and the matching of commuter trips to reduce vehicle trips.

Summary of research: Experience indicates that ridesharing programs typically attract 5-15 percent of commute trips if they offer only information and encouragement, and 10-30 percent if they also offer financial incentives such as parking cash out or vanpool subsidies.[20]

Rideshare programs that include incentives such as HOV priority and parking cash-out often reduce affected commute trips by 10-30 percent.[21] If implemented without such incentives travel impacts are usually smaller. A study conducted by Reid Ewing concluded that ridesharing programs can reduce daily vehicle commute trips to specific worksites by 5-15 percent, and up to 20 percent or more if implemented with parking pricing.[22]

Because rideshare passengers tend to have relatively long commutes, mileage reductions can be relatively large. For example, if ridesharing reduces 5 percent of commute trips it may reduce 10 percent of vehicle miles because the trips that are reduced are twice as long as average. Rideshare programs can typically reduce up to 8.3 percent of commute VMT, up to 3.6 percent of total regional VMT, and up to 1.8 percent of regional vehicle trips.[23]

Guaranteed Ride Home

Description: These programs provide an occasional subsidized ride to commuters who use alternative modes, but need a ride home in unforeseen circumstances.

Summary of research: Several studies have found that GRH home programs result in greater use of alternative modes. The Victoria Transport Policy Institute summarized these studies: “One

[19] Victoria Transport Policy Institute, http://www.vtpi.org/tdm/tdm8.htm
[20] Bryon York and David Fabricatore (2001), *Puget Sound Vanpool Market Assessment*, www.wsdot.wa.gov.
[21] Philip Winters and Daniel Rudge (1995), *Commute Alternatives Educational Outreach*, www.cutr.eng.usf.edu.
[22] Reid Ewing (1993), *TDM, Growth Management, and the Other Four Out of Five Trips.*
[23] Apogee (1994), *Costs and Cost Effectiveness of Transportation Control Measures; A Review and Analysis of the Literature*, National Association of Regional Councils (www.narc.org). Accessed at VTPI, http://www.vtpi.org/tdm/tdm34.htm
TDM Resource Center (1996), *Transportation Demand Management; A Guide to Including TDM Strategies in Major Investment Studies and in Planning for Other Transportation Projects*, Office of Urban Mobility, WSDOT (www.wsdot.wa.gov).

study found that the existence of a GRH program is among the most important factors determining the effectiveness of TDM programs.[24] Another survey of commuters found that 59 percent of rideshare and transit patrons consider GRH important in their decision to use alternative modes.[25] Finally, another survey found that the availability of GRH has a value roughly equivalent to subsidized transit fares at a fraction of the cost."[26]

Scheduling

Telecommuting

Description: The use of telecommunications to substitute for physical travel.

Summary of research: According to studies in 2007,[27] the effects of telecommuting depend on several factors: type of job or activity, telecommunications service quality, employer support, employee needs and preferences, and promotion. According to some estimates up to 50 percent of all jobs produce information-related goods that are suitable for telecommuting[28], but the actual portion of employees who can telecommute appears to be much lower. Telecommuting can significantly reduce participating employees' commute travel. For example, a twice-a-week telecommuting reduces commute trips by 40 percent.

Telecommuting tends to be particularly attractive to longer-distance commuters, so VMT reductions tend to be relatively high. For example, a telecommuting program that reduces 10 percent of vehicle trips may reduce 15 percent of vehicle mileage if participants have longer than average commutes. One study found that neighborhood telecommuting centers reduce commute VMT by about 50 percent, but provide smaller emission reductions since even short automobile trips produce heavy pollution due to cold starts[29].

Flextime, Compressed Work Week, and Staggered Shifts

Description: Alternative work schedules typically allow or require employees to start and/or leave work outside of peak hours.

Summary of research: Flextime reduces peak period congestion directly, and can make ridesharing and transit use more feasible.[30] Staggered shifts can reduce peak-period trips, particularly around large employment centers. A study by Reid Ewing estimates that flextime and telecommuting together can reduce peak-hour vehicle commute trips by 20-50 percent.[31]

Flexible work schedules can also reduce total vehicle travel. One survey of commuters found that it could reduce vehicle trips by up to 8 percent if 50 percent of employees are participating in the

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[24] Comsis Corporation (1994), *A Survey and Analysis of Employee Responses to Employer-Sponsored Trip Reduction Incentive Programs*, California Air Resources Board (www.arb.ca.gov).
[25] K.T. Analytics (1992), *TDM Status Report; Guaranteed Ride Home*, Federal Transit Administration, USDOT (www.fta.dot.gov/library/planning/tdmstatus/FTAGUAR2.HTM).
[26] John D. Hunt and JDP McMillan (1998), *A Stated Preference Examination of Attitudes Towards Carpooling to Work in Calgary*, Transportation Research Board Annual Meeting (www.trb.org).
[27] TIAX (2007), *The Energy and Greenhouse Gas Emissions Impact of Telecommuting and e-Commerce*, Consumer Electronics Association (www.ce.org); at www.ce.org/Energy_and_Greenhouse_Gas_Emissions_Impact_CEA_July_2007.pdf. Accessed at VTPI, http://www.vtpi.org/tdm/tdm43.htm
Mei-Po Kwan and Martin Dijst (2007), "Interaction Between ICT (Information and Communications Technologies) and Human Activity-Travel Behavior," Special Issue,*Transportation Research Record A*, Vol. 41, Issue 2 (www.elsevier.com/locate/tra), February 2007, pp. 121-204.
[28] Jack Nilles (1996), "What Does Telework Really Do To Us?," *World Transport Policy and Practice*, Vol. 2, No. 1/2, 1996, pp. 15-23. Accessed at VTPI, http://www.vtpi.org/tdm/tdm43.htm
[29] Dennis Henderson and Patricia Mokhtarian (1996), "Impacts of Center-Based Telecommuting on Travel and Emissions: Analysis of the Puget Sound Demonstration Project," *Transportation Research D*, Vol. 1, No. 1, pp. 29-45. Accessed at VTPI, http://www.vtpi.org/tdm/tdm43.htm
[30] Alyssa Freas and Stuart Anderson (1991), *Effects of Variable Work Hour Programs on Ridesharing and Organizational Effectiveness, Transportation Research Record 1321*.
[31] Reid Ewing (1993), *TDM, Growth Management, and the Other Four Out of Five Trips*

program, making it among the most effective commute trip reduction strategies considered in that study.[32]

Another analysis estimates that compressed work weeks can reduce up to 0.6 percent of VMT and up to 0.5 percent of vehicle trips in a region.[33] However, other research indicates that compressed work weeks may provide modest reductions in total vehicle travel, in part because participants make additional vehicle trips during their non-work days.[34] Compressed work weeks may also encourage some employees to move further from worksites or to drive rather than rideshare.

Promotion

Marketing, Travel Training, and Transportation Coordinator

Description: The use of marketing is a crucial component of TDM implementation, as it ensures that potential consumers are aware of the products available to them. Travel training refers to the use of personalized marketing programs to proactively offer information and incentives for all transportation choices available in a given neighborhood, not just one mode. Transportation coordinators are professionals whose role it is to promote and administer TDM programs.

Summary of research: The Victoria Transport Policy Institute summarizes that latest studies that have shown that marketing and promotion activities can increase the utilization and effectiveness of TDM programs and strategies:

- A survey of commuters found that exposure to commute trip reduction program information was the single most important factor contributing to mode shifting.[35]

- One study identified specific factors that affect TDM program effectiveness, noting that the presence of a transportation coordinator is important if a worksite is located outside a major business district, but are less critical in a central business district.[36]

- Given adequate resources, marketing programs can often increase use of alternative modes by 10-25 percent and reduce automobile use by 5-15 percent.[37]

- One study estimates that marketing increases the effectiveness of other TDM strategies by up to 3 percent.[38]

- The TravelSmart program found that marketing programs can reduce automobile travel by 6-14 percent. One study found even larger travel reductions from “travel feedback

[32] Center for Urban Transportation Research (1998), *A Market-Based Approach to Cost-Effective Trip Reduction Program Design*, http://ntl.bts.gov/lib/3000/3600/3633/cashdoc.pdf.
[33] Apogee (1994), *Costs and Cost Effectiveness of Transportation Control Measures; A Review and Analysis of the Literature*, National Association of Regional Councils (www.narc.org).
[34] Amy Ho and Jakki Stewart (1992), “Case Study on Impact of 4/40 Compressed Workweek Program on Trip Reduction,” *Transportation Research Record 1346*, TRB (www.trb.org), pp. 25-32 and Genevieve Giuliano (1995), “The Weakening Transportation-Land Use Connection, *ACCESS*, Vol. 6, University of California Transportation Center (www.uctc.net), Spring 1995, pp. 3-11.
[35] Edward P. Weber, David Nice, Nicholas P. Lovrich (2000), “Understanding Urban Commuters: How Are Non-SOV Commuters Different from SOV Commuters?” *Transportation Quarterly*, Vol. 54, No. 2, Spring 2000, pp. 105-115. Accessed at VTPI, http://www.vtpi.org/tdm/tdm23.htm
[36] Sara Hendricks and Ajay Joshi (2004), *Commuter Choice Program Case Study Development and Analysis*, Center for Urban Transportation Research (www.nctr.usf.edu/pdf/527-06.pdf). Accessed at VTPI, http://www.vtpi.org/tdm/tdm23.htm
[37] Victoria Transport Policy Institute, http://www.vtpi.org/tdm/tdm23.htm
[38] John Shadoff (1996), *Transportation Demand Management; A Guide for Including TDM Strategies in Major Investment Studies and in Planning for Other Transportation Projects*, Office of Urban Mobility, WSDOT (www.wsdot.wa.gov/Mobility). Accessed at VTPI, http://www.vtpi.org/tdm/tdm23.htm

programs" in Japan, with 50 percent increases in transit travel and 18 percent reductions in automobile travel among affected populations.[39]

- Andrew Amey summarized the Atlanta's Clean Air Campaign, Cash for Commuters program: "In 2003, commuters were offered a reward of $3 a day for every day that they used a commute alternative (transit, carpool, vanpool, telecommute, walk, bike or compressed work week) to get to work. The incentive was offered to travelers for a 90-day period. Participants in the trial had to have previously been a single-occupant vehicle driver. Follow-up surveys indicated that 74 percent of participants continued to use a commute alternative 3-6 months after they stopped receiving the cash incentive. At 9-12 months after the rewards ceased, 64 percent continued to use commute alternatives."[40]

Multi-modal Infrastructure

Car Sharing

Description: Provide access and/or reduced fees for car sharing programs, which allow people to have on-demand access to a shared fleet of vehicles on an as-needed basis.

Summary of research: According to the Transportation Research Board, each car-sharing vehicle takes nearly 15 private cars off the road – a net reduction of almost 14 vehicles.[41] Additionally, according to the Transportation Research Board, the average reduction in vehicle ownership in North American cities with carsharing programs was 20 percent. This study also citied research which found that the impacts of carsharing can increase over time as the program expands and/or gains wider visibility and familiarity among target markets (for example: in Seattle, WA the 2001 impact of car sharing was a 6 percent reduction in vehicle ownership but by 2004 the program had resulted in a 15 percent reduction in vehicle ownership).

A UC Berkeley study of San Francisco's City CarShare found that members drive nearly 50 percent less after joining. The study also found that when people joined the car-sharing organization, nearly 30 percent reduced their household vehicle ownership and two-thirds avoided purchasing another car.

Bicycle Sharing

Description: Bike sharing is a form of bike rental where people can have access to a shared fleet of bicycles on an as-needed basis.

Summary of research: Successful bike sharing programs have resulted in automobile to bike mode shifts as large as 5 percent to 8 percent in the areas they serve.[42] Impacts may be lower if conditions are not conducive to bicycling (few available bicycles in the system, insufficient network of dedicated bike routes, and/or climate conditions not conducive to bicycling).

In general, bike share programs are not utilized for regular commuter trips: since there is a per-use fee, regular bicycle commuters will ultimately purchase their own bicycle. Instead, bike-share programs are a "supportive" mode in that that they provide on-demand and close to door-to-door travel for short, unscheduled trips that are too far to walk and not well-served by transit. Similar to

[39] Satoshi Fujii and Ayako Taniguchi (2006), "Determinants Of The Effectiveness Of Travel Feedback Programs—A Review Of Communicative Mobility Management Measures For Changing Travel Behaviour In Japan," *Transport Policy*. (www.elsevier.com/locate/tranpol), Volume 13, Issue 5, pp. 339-348. Accessed at VTPI, http://www.vtpi.org/tdm/tdm23.htm

[40] Andrew Amey (2010), "A Game of Incentives," *TDM Review – Winter 2010*. http://data.memberclicks.com/site/asct/TDM_Review_Winter_2010.pdf

[41] Transportation Research Board (2005), *Car-Sharing: Where and How it Succeeds*, Transit Cooperative Research Program Report 108. http://onlinepubs.trb.org/Onlinepubs/tcrp/tcrp_rpt_108.pdf

[42] Victoria Transport Policy Institute (2008), *Public Bike Systems: Automated Bike Rentals for Short Utilitarian Trips*, http://www.vtpi.org/tdm/tdm126.htm. Note: this research does not state if the shift from automobile trips to bicycle trips is for commute or non-commute trips, nor does the research state at what time of day do these trips occur, i.e. peak or non peak trips.

car-sharing programs, bike sharing programs – while not used primarily for commuting – play an important role in the transportation system by allowing commuters to travel by transit knowing that they will have multiple travel options available to them during the workday.

On-site amenities

Description: The provision of amenities at travel destinations that are designed to encourage the use of alternative modes.

Summary of research: In 2009, the City of New York approved the "Bicycle Access Bill," which requires indoor, secure, long-term bicycle parking in new multi-family residential, community facility, and commercial buildings. In developing this zoning amendment, numerous studies were conducted by the Department of City Planning (DCP) to evaluate the bicycle travel patterns in New York. These studies found that "the lack of a safe and secure bicycle parking facility is a leading factor preventing people from cycling to work."[43] This is one of the most comprehensive bicycle parking policies in the country. The text amendment provides for bicycle parking and storage both at home and in the workplace, with standards that serve the needs of cyclists while providing flexibility to accommodate the needs of development.

Case studies of TDM programs

Outlined below is a summary of programs throughout the country that have demonstrated quantifiable success with their TDM measures.

Seattle Children's Hospital – Seattle, WA

Seattle Children's Hospital, located in the northeast area of Seattle, has one of the more successful institutional transportation programs in the country. Since the mid 1990s Seattle Children's Hospital has utilized TDM measures to reduce the number of employees driving to work alone, including: marketing and promotional campaigns, on-site amenities like bicycle parking and locker rooms, free vanpool/carpool parking while charging for single driver parking, a variety of financial incentives (i.e.100 percent subsidized FlexPass, 100 percent subsidized vanpool fare, and 100 percent walk-on ferry pass for commuting), Guaranteed Ride Home services, and carsharing. These measures have had a substantial impact, as only 38 percent of employees currently drive alone to work, as compared to 73 percent in 1995. Of those 62 percent who do not drive alone, 20 percent carpool, 10 percent vanpool, 18 percent come by bus or Children's shuttle, 6 percent commute by bike, and 5 percent walk to work.[44]

In 2007 the hospital began developing a Major Institution Master Plan that will guide campus development for the next 20 years. One major element of that Master Plan is a Comprehensive Transportation Plan (CTP). The CTP includes a Transportation Management Plan (TMP) to mitigate vehicle traffic related to master plan expansion by shifting even more employees and visitors from single-occupancy vehicles to bicycling, walking, shuttles and transit. In addition, the CTP includes a substantial investment in transportation infrastructure improvements outside the hospital campus. The major Transportation Management Plan elements, as described in the TMP, are[45]:

- Robust shuttle-to-transit system linking Children's to regional transit hubs
    - Expected outcome: 19 percent reduction in net new PM peak-hour vehicle trips by 2028

[43] NYC Department of Planning, http://www.nyc.gov/html/dcp/html/bicycle_parking/index.shtml
[44] King County Commute Services, http://www.kingcounty.gov/transportation/CommuteSolutions/GreatPrograms/ChildrensHospital.aspx
[45] Seattle Children's Hospital, http://masterplan.seattlechildrens.org/transportation.aspx

- Innovative bicycle programs including Flexbike (shared bicycle program) and Company Bikes which offers free bicycles to employees committed to cycling at least two days per week
    - Expected outcome: Increase in the percentage of employees who commute by bicycle from 6 percent (2007) to 10 percent by 2028
- Increased financial rewards for employees who commute without driving alone
    - Expected outcome: 17 percent reduction in net new PM peak-hour vehicle trips in 2028
- Campus design and near-site improvements to encourage alternative transportation
    - Expected outcome: A more attractive, safe and pleasant development that encourages walking, bicycling and transit use
- Intelligent Transportation Systems (ITS) for NE 45th Street / Montlake Boulevard / Sand Point Way NE to optimize the performance of key intersections and reduce vehicle delay and travel time
    - Expected outcome: 5 to 10 percent reduction in delay and travel time
- Contributions to capital projects that will improve the Northeast Seattle transportation network
    - Expected outcome: Currently unfunded improvements in the Northeast Seattle transportation network will receive substantial financial support
- Investments in walkable and bikeable Northeast Seattle
    - Expected outcome: Significant reductions in vehicle/bicycle crashes, and greater numbers of cyclists and pedestrians in the area
- Out-of-area parking
    - Expected outcome: Every 100 cars parked in off-site, out-of-area facilities will result in a 5 percent reduction in traffic impacts surrounding the hospital

Genentech Corporation – South San Francisco, CA

Genentech Corporation is a major bio-technology company headquartered in South San Francisco, California. When it sought to expand in 2005-2006, Genentech was able to work with the City of South San Francisco to lower its minimum parking ratios by agreeing to implement a Parking Cash Out program and to meet specific, year-on-year mode split goals.

Currently, Genentech offers a cash (in lieu of parking) subsidy of $5 per day for all employees who do not drive alone the firm's campus East of US-101. This incentive for leaving the car at home is part of an ambitious and comprehensive transportation demand management program that includes a 100 percent subsidy for employee public transit expenses (this is in addition to the payments for not-driving), an online ridesharing service that helps employees find other commuters to share rides on an as-needed basis, active and customized marketing to employees, and frequent surveys to measure employees' individual and collective progress in reducing vehicle trips to the Genentech campus.

Genentech initially implemented these TDM measures in order to comply with the City of South San Francisco's trip reduction ordinance, and to secure a valuable reduction in the amount of off-street parking required, when the company expanded by constructing new offices on several of its existing surface parking lots. Based on other development agreements in the area, Genentech would otherwise likely have been required to maintain a minimum parking ratio of between 3 and 4 parking stalls per 1000 sq. ft. of development. With the TDM elements and mode split requirements in its Master Plan, Genentech was able to reduce that to between 2.75 and 0.9 stalls/sq. ft. depending on building type/use.

This approach has proven to be successful and advantageous to all parties involved. Genentech is able to maximize profitable use of its 200 acres and saved between $25 to $50 million in capital cost by delaying or completely eliminating the need for additional parking structures. The City wound up with a larger and more profitable local company while minimizing the negative impacts

associated with increased trip generation such as local traffic congestion and air pollution. Lastly, the employees receive a myriad of commute benefit programs that support employee quality of life and that feed back into employees' productivity, recruitment and retention.

As a result of its binding TDM commitments, between February 2006 and October 2008, Genentech reduced its drive alone rate from 77.8 percent to 64.8 percent. That amounts to a 17 percent decline in less than three years.

WaterGarden Office Complex – Santa Monica, CA

The WaterGarden is a major office complex in Santa Monica, California that consists of four buildings containing some 1.2 million square feet of occupied floor area. The Complex has a three-level underground parking garage and is served by several LA Metro and Santa Monica Big Blue Bus Lines.

Currently, 24 tenants of the WaterGarden Complex are subject to the City's Transportation Demand Management (TDM) ordinance (Ordinance 1604), which requires and enforces compliance with the state parking cashout law (AB 2109). All Santa Monica employers with 50 or more employees are required to develop and submit annually, for City approval, an Emission Reduction Plan (ERP). Those employers subject to the State Parking Cashout Law are required to include and implement a parking cashout program as part of their site specific ERP. Employers who fail to include cashout in their Plan, or who fail to implement the plan in its entirety are subject to an initial warning notice, followed by fines of $5.00 per employee per day that the program is not in effect. If employers remain non-complaint their Santa Monica business license may be revoked.

As a required element of its initial development agreement with the City, the WaterGarden developed and implemented a site-wide TDM program. The WaterGarden TDM program is staffed by a full time Employee Transportation Coordinator, who:

- Provides carpool match lists to help commuters find carpool partners.
- Assists with vanpool placement
- Provides transit route, schedule and pass information
- Sells discounted transit passes to site employees
- Helps tenants establish and administer Guaranteed Ride Home (GRH) programs for their employees,
- Helps on site employers comply with the City's TDM Ordinance (1604)
- Other program elements include preferential and discounted parking for carpools and vanpools, and provision of bicycle racks.

According to the initial development agreement, "the TDM Program Goal shall be deemed to be satisfied if the trips going to and from the Project during the peak hour period occurring between 4:00 PM and 6:00 PM is not greater than 80 percent of the projected trips from General Office and 95 percent of the projected trips from other uses."[46]

Traffic counts conducted by a contractor at WaterGarden over five weekdays in 2009 (as required in the development agreement) confirmed that actual vehicle traffic entering and exiting the site during the peak hour (857 vehicle trips) was just 56 percent of the 1,533 vehicle trips established as the TDM goal in the development agreement.

[46] Note that the Development Agreement specifies that the "projected" trip generation shall be calculated by multiplying the floor space for each land use by site specific trip generation factors, as follows: Restaurant (6.14 trips/hr; Medical Office (3.89 trips/hr); Retail (4.98 trips/hr); Health Club (1.50 trips/hr); Bank (4.98 trips/hr); General Office (1.38 trips/hr).

This result is not uncommon for Santa Monica. A study by Southern California employers by Donald Shoup of UCLA found that the share of commuters driving alone to the two Santa Monica employers surveyed declined by 7-8 percent after implementation of parking cashout programs at each employment site.[47]

Kaiser Permanente – Oakland, CA

Kaiser Permanente, ALTRANS, and the City of Oakland are collectively implementing a TDM program for the Oakland Medical Center (OMC). The OMC TDM program must meet mandatory targets: Kaiser needs to maintain a SOV rate equal or lower than 76.2 percent and an alternative mode rate equal or higher than 23.8 percent in order to maintain the baseline mode split. In order to meet those targets, the TDM program includes a variety of measures, including:

- BART shuttle
- Commuter subsidy program
- Commuter spending account
- Guaranteed Ride Home
- Commuter Club
- City Carshare
- Car rentals
- Transit Buddy program
- Free carpool parking
- Vanpools
- On-line rideshare matching
- Bicycle and pedestrian guidelines, maps, and bicycle parking
- Commuter services office
- Marketing and promotional campaigns

To monitor progress, an annual employee survey is administered. Key findings of the 2009 employee survey include:

- The SOV rate is 63.4 percent among day shift commuters. The alternative mode rate is 36.5 percent. The percentage of day shift drive alone commuters decreased by 11.4 percent from 2008 to 2009. There is a 12.8 percent reduction of day shift drive alone commuters from 2006 to 2009.

- The reduction in drive alone day shift commuters is matched by substantial increases in day shift alternative commute mode use. There were increases in the use of BART, carpool, walking, bus, drop-off, and bicycle and motorcycle/moped use.

- The SOV rate is 73.5 percent among evening/night shift commuters. The alternative mode rate is 26.4 percent. There is a 4.7 percent reduction of evening/night shift drive alone commuters from 2008 to 2009.

- The most popular incentives among day shift employees that would encourage alternative commute mode usage are:
    - Monthly subsidy (31.0 percent)
    - Help finding a carpool match (17.2 percent)
    - Guaranteed Ride Home program (14.7 percent)
    - Preferred parking for carpools/vanpools (8.9 percent)

[47] Shoup, Donald. 1997a. "Evaluating the Effects of Cashing Out Employer-Paid Parking: Eight Case Studies." *Transport* Policy 4(4): 201-216.

Stanford University – Stanford, CA

Stanford University is about 40 miles south of San Francisco near the town of Palo Alto, a predominantly suburban area. While the vast majority of students live on campus, many do own cars. Furthermore, Stanford employees have historically driven alone to the campus. In 2000 the Santa Clara Board of Supervisors approved the Stanford University General Use Permit which placed a number of conditions upon Stanford's proposed growth. One of these conditions was that the university mitigates the transportation impacts of its proposed new development and growth. In short, Stanford agreed to mitigate the transportation impacts so that there would be "no net new commute trips" from a 2001 baseline measurement of trips. In order to meet this goal Stanford greatly expanded its existing TDM program to offer the following services:[48]

- Commute Club
  - Up to $282/year in Clean Air Cash or Carpool Credit
  - Reserved parking spaces for all carpools/vanpools
  - Complimentary daily parking passes for carpoolers
  - Vanpool subsidies
  - Online ridematching service
  - Commuter buddy program
  - Pretax payroll deduction for transit passes, Caltrain parking, and commuter checks
  - Refer-a-friend program pays you $50
  - Emergency Ride Home
  - Up to $96 a year in Zipcar driving credit
  - Up to 12 free hourly car rental vouchers
  - Exclusive member gifts
- Eco Transit Pass
- Free Marguerite shuttle
- Vehicle Rentals
- Charter Bus services
- Commute planning service
- Flex scheduling
- Bicycle Program

As a result of its TDM program, the mode splits for university employees have changed dramatically. As shown in Figure 10, drive alone mode split decreased from 72 percent in 2002 to 51.9 percent in 2007, while the Caltrain mode split increased from 4 percent in 2002 to 17.7 in 2007 (a 343 percent increase).

[48] Stanford University Parking & Transportation Services, http://transportation.stanford.edu/alt_transportation/Programs.shtml

Figure 10. Stanford University Employee Mode Splits[49]

Primary Mode	2002	2003	2004	2005	2006	2007	% Change (02-07)
Bicycle	7.0%	9.3%	9.6%	9.9%	10.3%	11.8%	68.6%
Caltrain	4.0%	9.9%	11.7%	14.3%	15.8%	17.7%	342.5%
Carpool	10.0%	9.2%	9.8%	9.7%	10.0%	9.4%	-6.0%
Drive Alone	72.0%	65.8%	63.6%	57.8%	54.4%	51.9%	-27.9%
Marguerite/Bus	4.0%	2.8%	2.9%	4.2%	4.8%	4.9%	22.5%
Other	n/a	n/a	n/a	1.3%	1.4%	1.2%	n/a
Vanpool	1.0%	0.6%	0.6%	0.5%	0.4%	0.3%	-70.0%
Walk	2.0%	2.3%	1.9%	2.2%	2.8%	2.9%	45.0%

Furthermore, for all university commuters (not just employees), survey data has shown that the drive-alone rate has dropped from 48.9 percent in 2003 to 35.8 percent in 2007. Finally, Stanford has seen an increase in Commute Club participation of 82 percent and a decrease in commuter parking permits sales of 7-11 percent.

Lloyd District TMA – Portland, OR

Initiated in 1995, the Lloyd District Transportation Management Association (TMA) is a non-profit business association representing large and small employers in the Lloyd District. Portland's Lloyd District is comprised of approximately 650 businesses and 21,000 employees with the Lloyd TMA having 75 member businesses and approximately 9,000 employees. These businesses invest over approximately $1 million annually to commute trip reduction programs in the district. TMA programs include the Passport Annual Transit Pass, carpool matching services, bicycle and pedestrian improvement and promotion, and carsharing.

Participating Lloyd TMA businesses pay no dues. Instead the association is funded through three sources:

- A Business Improvement District that is a "fee/assessment" on property owners. The BID then provides membership to all businesses located in buildings paying the assessment. The BID generates 40 percent of the TMA's budget.

- Parking meter revenue which supplements the BID and is targeted toward programs that serve business and employee needs. This accounts for one-third of the budget.

- Commissions on the sales of transit passes. The TMA receives 3 percent on all transit passes sold to businesses through the TMA and/or its Transportation Store. In 2005, the TMA sold over $1.2 million in transit passes, and therefore received about $36,000 in commissions (comprising 16 percent of the TMA budget).

The state of Oregon also has a Business Energy Tax Credit (BETC) that businesses can take advantage of for investments they make in employee transportation programs that result in measurable reductions in single occupancy vehicle (SOV) trips. Businesses can receive a 35 percent business income tax credit for investments in transit subsidy programs. The Lloyd TMA

[49] Brodie Hamilton (2008), "The TDM Experience at Stanford University," TDM Review, http://transportation.stanford.edu/pdf/TDM_2_2008.pdf

works with member businesses to transfer credits to the association. The TMA then packages the combined credits and sells them on the open market to companies in Oregon that have made profits (thus receiving a tax credit, much like air quality credits).

The Lloyd District has seen a remarkable decline in drive-alone commute trips coupled with a rapid rise in bus and light rail use. Since the baseline figures began in 1997, the drive alone rate among all Lloyd District employees (including employees of both TMA member companies and non-member companies) has fallen more than 30 percent. The percentage of drive alone trips has decreased from the previous year in 9 of the last 10 years. Meanwhile, transit ridership has increased more than 87 percent over the same period. Figure 11 highlights the results of the Lloyd TMA's latest employee survey results.

Figure 11. 2008 Employee Commute Choice Survey Results[50]

Commute Method	Total Trips	Total Auto Trips	% of Trips (1997)	% of Trips (2008)	% Change
Drive Alone	10123	10123	60.0%	40.5%	-32.5%
Carpool/Vanpool	2603	1301	16.0%	10.3%	-35.6%
Bus/MAX	9847	0	21.0%	39.4%	87.6%
Bicycle	1200	0	3.0%	4.8%	60.0%
Walk	596	0	2.0%	2.4%	20.0%
Telecommute	374	0	0.0%	1.5%	n/a
Compressed Work Week	267	0	1.0%	1.1%	10.0%
Total Weekly Trips	25010	11424	100%	100%	-54.3%

Summary of Initial Research

Benchmarking, performance monitoring, and enforcement of TDM programs is inconsistent between jurisdictions and institutions, thereby making evaluation of TDM measures and their efficacy challenging. It appears that there is a growing body of research that has been able to document the impacts of specific TDM strategies. Furthermore, as private developments and major institutions continue to implement TDM measures, and document their results, there are a number of case studies of successful programs for other cities to learn from. Additional research would allow Nelson\Nygaard to update some of these findings and/or locate additional relevant case studies.

[50] Lloyd District TMA Annual Report 2009, http://www.lloydtma.org/sites/default/files/Assembled2009AnnualReportFINAL.pdf?phpMyAdmin=EaodZMqf31HUtOaSZxXs78ftULa