Testing the Effectiveness of Bicycle and Pedestrian Access Improvements in Reducing Commute Vehicle Trips

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Abstract

DKS Associates has led the development of the tool called the ***TDM Effectiveness Evaluation Model*** (TEEM) to help the Washington State Department of Transportation evaluate transportation demand management (TDM) strategies. DKS has included in TEEM a method for evaluating the effect of improving bicycle and pedestrian access to employment sites through physical improvements. The tool was based on research conducted by DKS and OTAK on the existing level of bicycle and pedestrian accessibility for all employers in King County that are participating in the State's Commute Trip Reduction program. The research team developed an index of accessibility for both bicycle access and pedestrian access based on the extent of physical infrastructure to accommodate commuting by the two modes. Data on commute mode to work for all of the employees in the CTR database for King County was then correlated with the index values to produce a functional relation between the two. Estimates were also developed for the costs per acre of raising an index value one unit for an area. With these research results, it is possible to estimate the change in walk and bicycle commute mode shares that would result from a specified percentage increase in the index values and the cost of doing that. The new tool has been used to test the cost-effectiveness of bicycle and pedestrian improvements relative to other TDM options in the I-405 corridor of the Central Puget Sound region.

Overview

The Washington State Department of Transportation (WSDOT) sponsored research to construct a tool to evaluate the effectiveness of travel demand management and land-use strategies in reducing peak-period travel demand in heavily congested corridors. This paper reports on research performed by DKS Associates and Otak, Inc. on the effectiveness of physical infrastructure improvements for bicycle and pedestrian access in increasing bicycle and pedestrian commute travel. The research team developed an index of accessibility for both bicycle access and pedestrian access based on the extent of physical infrastructure to accommodate commuting by the two modes and correlated the indices with observed commute mode shares for bicycle and walking for employers in the WSDOT Commute Trip Reduction database. The results have been incorporated in the model that was developed for WSDOT to predict the effects of corridor TDM and land use strategies.

In recent years, TDM and land use actions have played significant roles in Environmental Impact Statements (EISs) and corridor studies in the Puget Sound region. Because of physical constraints, excess travel demand that cannot be accommodated by highway expansion and a need to maximize highway efficiency at peak periods; TDM was widely supported by advisory committees, public officials and citizens involved in those corridor studies.

WSDOT initiated the Implementing Corridor TDM Programs project collaboratively in order to support the development of a TDM and land use implementation plan(s) and contractual agreements to implement TDM in the SR 520 and I-405 corridors (and likely others in the future). Funding to conduct this project was provided by a Transportation Community System Preservation (TCSP) grant from the Federal Transit Administration (FTA) in 2001 with local match provided by WSDOT, and from a second TCSP grant from the Federal Highways Administration (FHWA) in 2002.

The model that has resulted from the Implementing Corridor TDM Programs project, known as the TDM Effectiveness Estimation Methodology or TEEM, was developed to support the analysis for the corridor studies. The model was developed to allow testing of twenty different strategies:

Mode Shift Support Strategies

1. Vanpooling
2. Alternative Mode Subsidy
3. Universal Transit Pass
4. VanShare
5. Guaranteed Ride Home

Parking Management Strategies

6. Restricted Parking Supply
7. Parking Pricing at Employment Sites

Alternative Work Schedules Strategies

8. Telecommuting
9. Compressed Work Week

Programmatic and Policy Support

10. CTR-Type Programs for Smaller Employers
11. Multi-Employer Transportation Management Associations (TMAs)

Marketing and Promotion

12. Marketing and Promotion

Bicycle and Pedestrian Facilities

13. Improved Bicycle Access
14. Improved Pedestrian Access

Non-Commute Strategies

15. Shopping Trips
16. Special Event Travel

Land Use Strategies

17. Increased Density Near Transit Corridors
18. Increased Mixed-Use Development
19. Increased Infill & Densification

Increased Transit Service

20. Increased Transit Service[1]

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[1] TEEM was not designed to be a tool for testing significant changes in transit service. Other tools are better suited for this purpose. TEEM can be used to test how changes in transit frequency can affect the vehicle trip rate over time.

Sixteen case studies were used to calibrate and test TEEM and to understand the potential for various TDM and land-use strategies in a variety of settings along the corridor. Documentation of the TEEM model and the project can be found in the final report (DKS Associates et al 2005).

Development of the Bicycle and Pedestrian Access Indices

Before developing indices for bicycle and pedestrian access, the research team conducted a review of other similar efforts. In research for the Florida Department of Transportation, Landis et al (2001) developed a method to objectively quantify "pedestrians' perception of safety and comfort in the roadside environment." Their methodology used surveys from 75 people walking a roadway course to quantify how well a roadway accommodates pedestrian travel. Their *Pedestrian Level of Service* calculation includes consideration of sidewalk width, outside roadway lane width, and presence of on-street parking among other factors. While the methodology provided a reasonable method for assessing the desirability of a route for walking at a single point, it did not provide a method for assessing the desirability of an area.

Moudon et al (2001) developed a GIS based methodology to identify the potential latent demand for pedestrian trips within an activity area. The methodology relies primarily on identification of land uses that are functionally complementary for pedestrian travel and spatially close enough for pedestrian activity. Their methodology provides a useful way to assess the potential for pedestrian travel but focuses primarily on non-work travel and on the land uses rather than the physical facilities.

Dill (2004) produced a review of a range of measures of connectivity for bicycling and walking. In her research, she reviewed measures of existing characteristics and their correlation with observed bicycle and pedestrian activity. She identified street network density, connected node ratio, intersection density and link-node ration as the most promising measures. She then demonstrated how these would be calculated for a study area in Portland, Oregon. While these factors clearly had high explanatory power for predicting bicycle and pedestrian travel, they did not capture the types of improvements that are likely to be made to improve access for these modes in already-developed areas. Most of the factors that Dill identified are correlated with the area types that our research team used to stratify the employers and employment areas in our analysis.

The research team developed an index of accessibility for both bicycle access and pedestrian access based on the extent of physical infrastructure to accommodate commuting by the two modes. The details of the research conducted can be found in Roberts (2004). The team used aerial photos and GIS data on sidewalk networks and bicycle routes and trails to classify each zone according to the indices. A sample of the GIS data used is illustrated in Figure 1. Data on commute mode to work for all of the employees in the Commute Trip Reduction (CTR) Program database for King County was then correlated with the index values to produce a functional relation between the two. Employers of 100 or more in Washington are required by state law to develop a program for trip reduction designed to achieve area goals for trip reduction. As part of the program, the employers are required to survey their employees on bi-annual basis to determine commute mode shares by all modes including walk and bicycle. For the four-county Puget Sound Region, 876 employment sites were included in the database. The employee surveys for these sites were used as the sources of bicycle and walk commute mode share for analysis zones in the study area.

Estimates were also developed for the costs per acre of raising an index value one unit for an area. With these research results, it was possible to estimate the change in walk and bicycle commute mode shares that could result form a specified percentage increase in the index values and the cost of doing that.

For bicycle travel potential, the presence of the following facilities was considered:

- Bicycle system (on street lanes and routes) completeness within 6 miles of the TAZ boundaries
- Multi-use pathways in existence within 6 miles of the TAZ boundaries
- Where known, the presence of bicycle facilities such as bike storage lockers, racks, showers, etc. and the presence of bicycle friendly programs and outreach efforts contribute to the conduciveness of the setting to bicycle travel

For pedestrian travel potential, the presence of the following facilities was considered:

- Sidewalk system completeness
- Signalized intersections with crosswalks and pedestrian improvements at intersections
- Transit stops in the vicinity
- The setting's general conduciveness to pedestrian travel (i.e. area is an attractive place to walk, street trees exist, driveway cuts are minimized, buildings are oriented to the street, etc.)

The resulting indices were as follows:

<u>Bicycle Index Description</u>

Level 6 (Highest Level of Completeness of Facilities Exists)

- Bicycle lanes are striped and present on 90 percent of the major roads (arterial and collector streets) in the study area
- Multi-use trail facilities are available within the study area or within proximity and there are connections between the trail and CTR sites
- Bicycling facilities are available such as lockers, showers, etc. (where known)
- Setting characteristics and conditions are "excellent" for bicycle travel

Level 5 (High Level of Existing Facilities)

- Bicycle system appears to be 70 to 90 percent complete.
- Trails exist in the vicinity and appear to be actively used for commuting purposes
- Bicycle support facilities may exist
- The general setting exhibits "good" to "excellent" conditions and characteristics conducive to bicycling.

Level 4 (Medium Level of Existing)

- Bicycle system appears to be 50 to 70 percent complete.
- Trails exist in the vicinity
- Bicycle support facilities may exist
- The general setting exhibits "moderate" to “good" conditions and characteristics conducive to bicycle travel.

Level 3 (Medium Level of Existing Facilities)

- Bicycle system appears to be 30 to 50 percent complete.
- Some trails exist in the vicinity
- Bicycle support facilities may or may not exist
- The general setting exhibits "moderate" to "lacking" conditions and characteristics conducive to bicycle travel.

Level 2 (Low Level of Existing Facilities)

- Bicycle system appears to be 10 percent to 30 percent complete.
- Minimal trails in the vicinity (but may be in surrounding TAZs).
- Bicycle support facilities are minimal or nonexistent.

- The general setting exhibits "lacking" to "insufficient" conditions and characteristics for bicycle travel (and in some cases, conditions may not be conducive to bicycle travel).

Level 1 (Lowest Level of Existing Facilities Present)
- Bicycle system appears to be 10 percent or less, or in many cases nonexistent.
- No trails exist in the vicinity.
- Bicycle support facilities do not exist.
- The general setting exhibits "insufficient" conditions and characteristics for bicycle travel (and in most cases, conditions are not conducive to bicycle travel).

Pedestrian Index Description

Level 6 (Highest Level of Facilities Exists)
- Sidewalk system appears to be fully complete (90 percent or more of the streets have sidewalks) in the TAZ (or study area) and connections between CTR sites and adjacent sidewalks in the street rights-of-way are clear and convenient.
- Signalized intersections and/or mid-block crossings with pedestrian improvements (crosswalks, refuge islands, etc.) are present at 90 percent or more a majority of intersections in the TAZ.
- Bus stops and transit facilities exist most frequently.
- The general setting and character of streets appear to provide an "excellent" environment conducive to pedestrian travel (wide sidewalks and/or separation from vehicles, street trees, landscaping, buildings to the street, minimal driveway conflicts, etc.).

Level 5 (High Level of Facilities Exists)
- Sidewalk system appears to be 70 to 90 percent complete.
- Signalized intersections and pedestrian improvements at intersections appear to be 70 to 90 percent available.
- Bus stops/transit facilities exist more frequently than in levels 1-4.
- The general setting exhibits "good" to "excellent" conditions and characteristics conducive to pedestrian travel.

Level 4 (Medium Level of Facilities Exists)
- Sidewalk system appears to be 50 to 70 percent complete.
- Signalized intersections and pedestrian improvements at intersections appear to be 50 to 70 percent available.
- Bus stops/transit facilities exist more frequently than in levels 1-3
- The general setting exhibits "moderate" to “good" conditions and characteristics conducive to pedestrian travel.

Level 3 (Medium to Low Level of Facilities Exists)
- Sidewalk system appears to be 30 to 50 percent complete.
- Signalized intersections and pedestrian improvements at intersections appear to be 30 to 50 percent available.
- Bus stops/transit facilities exist more frequently than in levels 1-2
- The general setting exhibits "moderate" to "lacking" conditions and characteristics conducive to pedestrian travel.

Level 2 (Low Level of Facilities Exists)
- Sidewalk system appears to be 10 percent to 30 percent complete.
- Signalized intersections and pedestrian improvements at intersections appear to be 10 to 30 percent available.
- Bus stops and transit facilities are very minimal (or in adjacent TAZs).

- The general setting exhibits "lacking" to "insufficient" conditions and characteristics for pedestrian travel (and in some cases, conditions may not be conducive to pedestrian travel).

Level 1 (Lowest Level of Facilities Exists)
- Sidewalk system appears to be 10 percent or less, or in many cases nonexistent.
- Signalized intersections and pedestrian improvements at intersections appear to be less than 10 percent available or non existent.
- Bus stops and transit facilities are non existent.
- The general setting exhibits "insufficient" conditions and characteristics for pedestrian travel (and in most cases, conditions are not conducive to pedestrian travel).

An example of an area with a Pedestrian index value of 4 (Medium Level of Facilities Exists) is provided in Figure 2.

Development of Effectiveness Factors for Bicycle and Pedestrian Improvements

The relationships between the index values and the commute mode share for each mode are illustrated in Tables 1 and 2. Index values of "6" were only found in downtown Seattle and there are special circumstances there that cannot be achieved in other parts of the region. In recognition of this uniqueness, the values for "6" were not entered into the table and TEEM will not allow the analyst to change the value for a zone to 6.

Cost Analysis

The project team estimated the costs of achieving an increase in an activity area's pedestrian accessibility index and bicycle accessibility index by one level of the index (i.e. areas classified at Level 1 can be reclassified as Level 2; areas classified as Level 2 can be reclassified as Level 3; etc.) The cost investment would cover the capital cost of adding the following physical features to an area to increase pedestrian and bicycle mobility. (Estimated costs below are based on broad assumptions of typical work that would occur to complete the necessary improvements. Costs reflect a 2004 dollar value and have been adjusted to fit regional pricing for construction.)

Pedestrian Travel
- Sidewalk system completeness (extending and/or widening sidewalks)
- Additional signalized intersections with crosswalks and pedestrian improvements at intersections
- Additional transit stops in the vicinity
- Enhancing the setting's general conduciveness to pedestrian travel (i.e. additional street trees, reduced driveway cuts, etc.)

Bicycle Travel
- Bicycle system improvements (adding on street lanes and/or shoulders in rural areas)
- Extending/adding multi-use pathways

To determine the cost of increasing an areas index classification by one level, the project team plotted aerial photos of 3 TAZ areas in each level of the index. They then estimated the level of physical facilities needed in each area to achieve the next highest level of the index (i.e. from 1 to 2, from 2 to 3, from 3 to 4, from 4 to 5, and from 5 to 6) and calculated the potential capital construction costs of providing these facilities.

Construction cost estimates were derived based on the following planning-level unit costs:

- Multi-use pathways/trails: $1,056,000 per mile
- Bicycle shoulders/striping: $350,000 per mile
- Street retrofit/curbing moved/bike lanes added: $1,000,000 per mile
- New sidewalks (6 feet average): $850,000 per mile one side; $1,700,000 per mile both sides
- Existing sidewalk widening/repairs: $850,000 per mile both sides
- Signalized intersection improvements with crosswalks, curb cuts, etc. $300,000 per intersection
- Minor intersection modifications: $50,000 per intersection
- Bus stops: $50,000 per location
- Miscellaneous streetscape enhancements/driveway cut consolidation, etc. $250,000 per mile

Costs for pedestrian and bicycle improvements for each TAZ were calculated and then divided by the total number of acres in each TAZ to get a per acre cost for improvements. The per acre costs for each TAZ were then averaged to determine one overall average per acre cost for pedestrian facility improvements and one overall average per acre cost of bicycle facility improvements. The construction costs per acre were then increased by 50 percent to cover the additional costs of administration, design, permitting, environmental work, and contingencies. The resulting costs per acre were as follows:

- Pedestrian Improvements: $42,125 per acre
- Bicycle Improvements: $14,595 per acre

These estimates include all costs that might be associated with increasing an area's index classification by one level. For pedestrian improvements, the $42,125 per acre estimated capital cost translates to a total cost of $234,748 per acre for an assumed 20-year life of the improvements/facilities. For bicycle improvements, the $14,595 per acre estimated capital cost translates to a total cost of $81,318 per acre for an assumed 20-year life of the improvements/facilities.

I-405 Corridor Test Results

The results from the research were incorporated into the TEEM model and used to test the potential effectiveness of increasing pedestrian and bicycle access broadly throughout the I-405 corridor. In testing the impact of increasing the index for bicycle access and pedestrian access by one unit in every zone, the bicycle improvements increased the non-motorized mode share to work by 7%. The pedestrian improvements increased the non-motorized mode share for work trips by 24%. The base non-motorized mode share for work trips in the corridor was 1.7%. Increasing the index for both bicycle and pedestrian access by one unit each resulted in a 30% increase in non-motorized commute trips.

While the percentage increase in non-motorized commute travel was significant in the I-405 test, the annualized cost associated with reducing peak period travel was significantly higher than other strategies tested. One reason for this is that the full cost of the bicycle and pedestrian improvement were attributed to the reduction of commute travel only. The same improvements would likely provide significant non-work travel benefits, as well as recreational opportunities, but since the available CTR data only included commute trips, the methodology developed for the project could not quantify non-work travel benefits.

References

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Moudon, Anne; Paul Hess; Julie Matlick; and Nicholas Pergakes; "Pedestrian Location Identification Tools: Identifying Suburban Areas with Potentially High Latent Demand for Pedestrian Travel," November 2001.

Dill, Jennifer; "Measuring Network Connectivity for Bicycling and Walking," prepared for the Transportation Research Board Annual Meeting, January 2004.

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FIGURE 1 GIS Sidewalk Layer for Bellevue

FIGURE 2 Sample Aerial of Level 4 Pedestrian Access

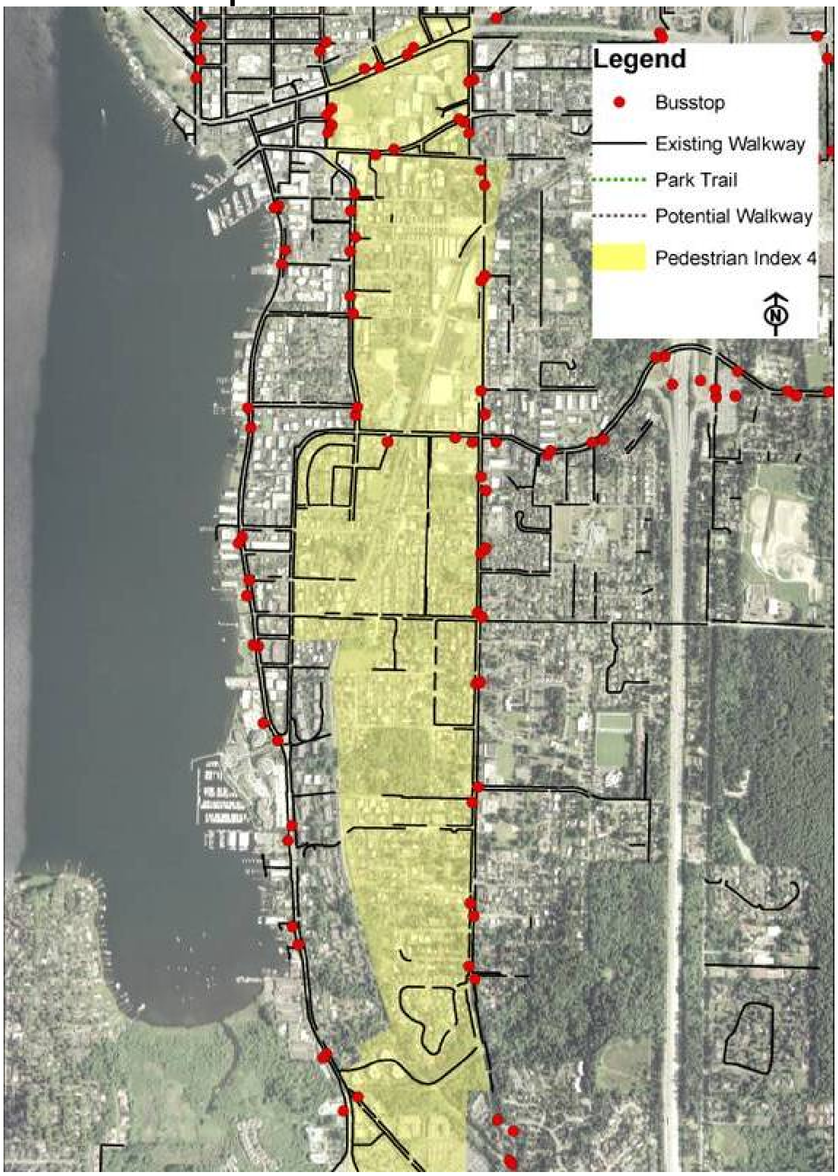

TABLE 1 – Bicycle Mode Share by Index Value

Index Value	1	2	3	4	5
Urban	NA	0.6%	1.0%	1.5%	1.9%
Suburban and Rural	0.2%	0.4%	0.5%	0.6%	0.7%
Industrial	0.0%	0.1%	0.2%	0.5%	1.4%

TABLE 2 – Pedestrian Mode Share by Index Value

Index Value	1	2	3	4	5
Urban	NA	0.2%	1.6%	2.9%	4.2%
Suburban and Rural	0.1%	0.4%	0.8%	1.1%	1.4%
Industrial	0.1%	0.3%	0.7%	1.7%	4.2%