An Analysis of TDM Impacts on a Corridor Segment

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Presentation Overview

- Study Background
  - Review TDM Measures of Effectiveness
  - Review Selected Transportation Operations Performance Measures
- Study Objective and Hypothesis
- Study Methodology
  - Simulate impacts of employer-based programs affecting a segment of a corridor.
  - Data available from CTR
  - Data needed for CORSIM analysis
    - With TDM Scenario
    - The Without TDM Scenario
- CORSIM Analysis Preliminary Results

Study Background

This study seeks to establish the relationship between employer-based strategies and transportation system performance. The ultimate goal is the development of some methods or indices that measure the impacts of such programs on the overall transportation system and clearly communicate these impacts to policy makers and transportation decision makers.
Study Objective

This study will develop a methodology for measuring the impacts of employer-based TDM programs on transit system ridership and transportation system performance, in particular from the management and operations perspective.
Study Hypothesis

The hypothesis of the study is that a wide scale adoption of employer-based strategies is likely to have a noticeable difference on the transportation system at the local, corridor and regional levels.

Study Methodology

Simulate impacts of employer-based programs affecting a segment of I-5 in Seattle.

Simulate using CORSIM

Employer-based programs from the Washington State CTR program database

Now . . . to the nitty-gritty

How to create network scenarios with TDM? without TDM?
How to estimate impacts on network traffic with TDM? Without TDM?
How to compare the scenarios?
The CTR Program

- The CTR program was created by the 1991 legislature to reduce the economic and environmental degradation caused by the increasing number of commute trips made by employees in Washington State.
- To accomplish this, the CTR program works with employers to encourage employees to commute without driving alone every day.
- The program also encourages transportation service providers to expand the opportunities available to employees for commuting in ways other than driving alone.
- The results of these efforts are demonstrated in the daily choices made by more than 560,000 employees at the 1,114 worksites participating in CTR.

The CTR Program (cont.)

- Employers affected by the CTR law are required to submit an Employer Annual Report & Program Description form to report the summarized information of the programs they implemented.
- The affected employers are also required to measure employee commute behavior every two years to measure their progress toward their CTR goals.
- The employer annual report and employee biennial survey compose two databases that comprise information of employer's TDM performance and employee's travel behavior change.

The CTR Program (cont.)

- Information contained in the annual employer report includes:
  - Worksite description
  - Employee information
  - Program promotion information, include list of CTR programs implemented or promoted by the employer
  - Worksite characteristics
  - Worksite parking information and parking management
  - Financial incentive and subsidies
  - Site amenities
  - Work schedule policy
  - Other programs availability, include GRH, internal match, fleet vehicle, etc.
The CTR Program (cont.)

Information contained in the individual employee survey includes:
- work schedule,
- commute trip mode split,
- compressed work week schedule,
- teleworking schedule,
- travel distance,
- employee job title,
- and home zip code.

The databases are maintained and managed by Department of Public Transportation, Washington State DOT.

Transportation Network

- Seattle Downtown Area
  - High Density of employers participating in TDM programs in the area
    - Number of employers - 189
    - Number of employees - 63000
  - Planned improvements for the transportation network by the DOT
    - Pavement reconstruction and bottleneck improvement project on I-5

Map of Transportation Network
Traffic Analysis Tool

- FHWA Traffic Analysis Toolbox Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools
- The decision toolbox’s recommendation: Microscopic Simulation Software

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<tr>
<th>Decision Toolbox</th>
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<td>Criteria</td>
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<td>WEIGHTED TOTAL</td>
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Microscopic Simulation Software

- Advantages of using Microscopic
  - Second-by-second simulation for each vehicle
  - Customize vehicle fleet type and driver type to represent field conditions
  - Simulate interaction of traffic flow with roadway geometry
  - Calibrate the model to match existing traffic conditions
  - Graphical interface to visually observe and compare different scenarios
  - Requires large amount of data collection effort
Traffic Analysis Tool: CORSIM

CORSIM is a stochastic microsimulation tool which is being used by practitioners and researchers for the past 30 years to simulate and conduct various transportation related evaluations.

- Development of CORSIM being supported by FHWA and it is used by several state agencies including FDOT and WSDOT
- Comparable studies conducted in the past using CORSIM
- CORSIM Data was available for the Seattle region
- Research team has past experience and training in CORSIM

CORSIM Analysis

Evaluate the impact of TDM programs on the transportation network by comparing the performance of the network with TDM programs and without TDM programs

- Existing Traffic Volumes on the network = E
- Estimate traffic reduced by TDM programs = R
- Scenario A (with TDM)
  - Performance of the transportation network with existing traffic volume E
- Scenario B (without TDM)
  - Performance of the transportation network with traffic volume E + R
- Comparison of Scenario A and Scenario B

TDM Impact Area

Map showing impact areas related to TDM programs.
**Comparing a segment of I-5 with and without TDM**

- Scenario WITH TDM is the existing traffic conditions of a selected segment of I-5 (CORSIM Files from WSDOT)
- Scenario WITHOUT TDM will add the reduced trips, from the CTR data, to the existing traffic of the I-5 selected segment.

**WITH TDM Scenario Data from WSDOT**

- CORSIM simulation data for the year 2004
  - AM peak and PM peak period traffic volumes on freeway mainline
  - On-ramps and Off-ramps volumes and location
  - Existing Carpool volume
  - Segment roadway geometry information
  - Origin-Destination of the existing volume
  - Calibration of the network
The WITHOUT TDM Scenario

- Introduction
- TDM Trip Reduction Estimation
  - Step 1: Evaluate the impact of Telecommuting and Compressed Work Week
  - Step 2: Estimate the impact of Employer TDM Support Strategies
  - Step 3: Estimate the impact of Parking and Financial subsidies
  - Step 4: Estimate the number of trips shifted out of peak period due to the Flexible Work Hours
- Trip Distribution
- Trip Assignment
- Preliminary Results

WITHOUT TDM Scenario Introduction

- Objective
  - Provide link traffic flow change due to TDM programs as input to CORSIM micro traffic simulation model
- Methodologies regarding
  - Estimating TDM reduced vehicle trips at employer level
  - Distributing the estimated reduced vehicle trips to the Worksite-Home pairs
  - Assigning the reduced vehicle trips to the highway network
- Output includes
  - Number of reduced vehicle trips for each worksite
  - Traffic flow change for each on and off ramp of I-5 within the study area
  - On and off ramp ID for each reduced vehicle trip

TDM Trip Reduction Estimation

Literature Review

- Models Review
  - Air Resources Board (California) Cost Effective Model
  - Washington State TDM Effectiveness Estimation Methodology (TEEM) Model
  - Environmental Protection Agency (EPA) COMMUTER Model
  - CUTR Worksite Trip Reduction Model
- Major Characteristics of These Models
  - Focus on predicting or estimating the possible travel behavior change currently or in the future based on projected social economic data and TDM programs
TDM Trip Reduction Estimation

**Summary**

- **Our Research Goal**
  - Quantitative analysis of the effect of the TDM programs

- **Our Data**
  - Washington State Commuter Trip Reduction Database provides
  - Detailed description of TDM strategies implementation
  - Corresponding travel behavior survey data

- **Our Methodology**
  - Tracing back the situation without TDM by estimating the travel behavior without TDM
  - Comparing the scenarios with and without TDM to analyze the quantitative impact of TDM programs
  - Based on EPA's COMMUTER model

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TDM Trip Reduction Estimation
Washington State Commute Trip Reduction Database

- Washington State Commute Trip Reduction Database
  - Employer Annual Report
    - Employer basic information
    - Alternative work hours strategies
    - Employer TDM support strategies
    - Parking and financial subsidies or incentives
  - Employee Biennial Travel Behavior Survey
    - Work schedule
    - Commute trip mode
    - Job type
    - Home ZIP code

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TDM Trip Reduction Estimation
Definition

- **TDM**
  - Alternative Work Hours: Reduce a person trip
  - Employer TDM Support Strategies: Reduce the drive alone trip
  - Parking and Financial Subsidy: Reduce the drive alone trip
  - Flexible Work Hours: Shift vehicle trip out of peak period

- **With TDM**
  - Some or all of the TDM programs are implemented by the employer
  - Vehicle trips with TDM can be calculated directly from Washington state employee biennial survey data

- **Without TDM**
  - Some or all of the TDM programs are not implemented by the employer
  - Develop a procedure to calculate vehicle trips without TDM based on EPA COMMUTER model and Washington CTR data
TDM Trip Reduction Estimation
Vehicle Trips and Mode Shares With TDM

- Treat all non-respondents as drive alone, calculating the Vehicle Trips with TDM
  \[\text{Vehicle Trip}_{\text{With TDM}} = \text{Non-respondents} + \text{Drive Alone} + \text{Motorcycle} + \text{Carpool}_2 + \text{Carpool}_3 + \text{Carpool}_4 + \text{Carpool}_5 + \text{Vanpool}/6\]

- Treat all non-respondents as drive alone, calculating the Mode Shares with TDM

TDM Trip Reduction Estimation
Vehicle Trips Without TDM

Step 1: Evaluate the impact of Telecommuting and Compressed Work Week

- The Telecommuting and Compressed Work Week are treated as direct results of TDM. The employees on Telecommuting and CWW are added back to calculate the number of person trips if they were not allowed

  \[\text{Revised Person Trip} = \text{Non-respondents} + \text{Drive Alone} + \text{Motorcycle} + \text{CWW} + \text{Telecommuter}\]

TDM Trip Reduction Estimation
Vehicle Trips Without TDM

Step 2: Estimate the impact of Employer TDM Support Strategies

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Starting Mode Share (With TDM)
- Carpool: 11%
- Vanpool: 5%
- Transit: 18%
- Bicycle: 3%

Revised Mode Share (Without TDM)
- Carpool: 9%
- Vanpool: 4%
- Transit: 13%
- Bicycle: 2%
Step 3: Estimate the impact of Parking and Financial subsidies

- Assumption
  - Without TDM program, parking for all modes is free
  - Subsidy or incentives for alternative modes are direct results of TDM
  - Travel time change is 0

- Calculating the changed mode share due to the travel cost change

\[
p(m) = \frac{p'(m)}{e^{-\Delta U(m)}(1 - p'(m))} + p'(m)
\]

where:
- \(p(m)\) = the new share of mode \(m\) (Without TDM)
- \(p'(m)\) = original share of mode \(m\) (With TDM)
- \(\Delta U(m)\) = the change in disutility of mode \(m\) (\(\Delta U(m) = a*(\text{Changed travel time}) + b*(\text{Changed travel cost})\))

Step 4: Estimate the number of trips shifted out of peak period due to the Flexible Work Hours

Number Daily Vehicle Trips Shifted, Peak to Off-peak =

\[
\text{Total Affected Employment} \times \frac{\text{Percent of Employment that is Office}}{2} \times 22\% \text{ Participate in Program} \times \frac{\text{Percent of Trips Shifted (based on length of peak period)}}{\text{Current Private Vehicle Mode Share}}
\]

TDM Trip Reduction Estimation

Vehicle Trips without TDM =

Revised person trip * (R-DriveAlone + R-Motorcycle + R-Carpool2/2 + R-Carpool3/3 + R-Carpool4/4 + R-Carpool5/5 + R-Vanpool/6) + Vehicle Trips Shifted out of Peak Period

Total Number of Reduced Vehicle Trips =

Vehicle Trips without TDM

Vehicle Trips with TDM
Trip Distribution

- **Objective**
  - Find origin and destination for each reduced trip

- **Assumption**
  - The reduced trips are derived from the non drive alone trips

- **Distribute the reduced trips to Worksite-Home pairs proportionally according to the percentage of non drive alone trips**

<table>
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<tr>
<th>Worksite</th>
<th>HomeZIP</th>
<th>Non Drive Alone Trips</th>
<th>Worksite HomeZIP</th>
<th>Total Non Drive Alone Trips</th>
<th>Percentage</th>
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Trip Assignment

- **Create a transportation network of five counties, including King, Island, Snohomish, Kitsap, and Pierce, based on the Census Tiger Line road data**

- **Geocode the geographic location of worksites based on their street address**

- **Use the centroid of the ZIP to represent the home location**

- **Find the shortest path between the worksite-home pairs based on the link length**

- **Assign the traffic based on the so-called All-or-Nothing traffic assignment approach**

- **Final results include the changed traffic flow on each on and off ramp of I-5 and the on and off ramp ID for each reduced trip**
### Preliminary Results

Ramp traffic flow for PM peak period (Worksite to Home)

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<th>On Ramp</th>
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*Note: Original Flow and Change values are hypothetical.*
CORSIM Analysis

- Existing Traffic Volumes on the network: WSDOT
- Estimate traffic reduced by TDM: CTR database
- Comparison of Scenario A and Scenario B: CORSIM

CORSIM Analysis

- Scenario A (with TDM)
  - Performance of the transportation network with existing traffic volume
- Scenario B (Without TDM)
  - Performance of the transportation network with existing traffic volume + Traffic volume reduced by TDM programs
- Comparison of Scenario A and Scenario B

Performance Measures

- Delay in vehicle-hours and seconds per vehicle
- Average Speed in mph
- Fuel Consumption in gallons
- Emissions in grams/mile
- Extent of Congestion
  - Spatial
  - Temporal
Performance Measures

- Spatial Extent of Congestion
  - Length of roadway within a predefined area and time period for which average travel time are 30% longer than unconstrained travel time

- Temporal Extent of Congestion
  - The time duration during which more than 20% of the roadway sections in a predefined area are congested

Source: NTOC Performance measurement Initiative - Final Report

Performance Measures
Delay in vehicle-mins

Performance Measures
Delay in secs/vehicle

Links on SB I-5 Freeway Mainline

Scenario A (with TDM) — Scenario B (without TDM)