Outcome Assessment using Connected Vehicle Data to Justify Signal Investments to Decision Makers

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$32M Net User Cost Benefit

PennDOT Web Application Suite

Corridor Analysis Procedure

1) Corridor Selection

2) Analysis Date Selection

3) Time Selection

a) Alphabetical selection
Corridors are listed alphabetically (a) for Travel Time and Travel Delay Monitor: A county selection (b) is used for Arterial Ranking.

b) County selection
Travel Time defaults for the integration of timing plan data (a), while Arterial Ranking allows selection of specific hour ranges (b). Travel Delay Monitor displays hours within the date selection.

Arterial Ranking Tool

Arterial Ranking displays arterial performance as Reliability vs. Central Tendency in the graph in the lower left hand corner of the figure above.

Arterial Ranking also outputs this one-dimensional graph, displaying the reliability of the corridor using the difference of the 75th and 25th percentiles and the ideal travel time.

Arterial Ranking also outputs this one-dimensional graph, displaying the variance of the corridor travel time from the ideal travel time.

Travel Time Comparison Tool

Travel Time outputs cumulative frequency diagrams. The vertical blue line represents the ideal travel time, no stoppage and following the speed limit.

Travel Delay Monitor

The travel delay monitor displays cumulative congested miles over time. Rush hour times can often be identified, as shown in the figure below for I-476 and I-95 ramps.

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Equation and Calculation Analysis

User Cost Benefit

The hourly volumes were estimated by the following equation

\[ v_i = \frac{AADT_i}{d} \]

where:

- \( v_i \) = estimated volume for hour \( i \)
- AADT = annual average daily traffic
- \( k_i \) = hourly vehicle percentages from (1)
- \( d \) = directional distribution (assumed to be 0.5)

The difference in travel time for each hour, before and after the adaptive signal deployment was calculated using the following equation:

\[ \Delta T = T_{before} - T_{after} \]

where:

- \( T_{before} \) = median travel time during the before period for hour \( i \)
- \( T_{after} \) = median travel time during the after period for hour \( i \)

The user benefit for trucks during each hour was then calculated as

\[ \Delta u_{benefit} = \frac{\Delta T \times T_{VOT} \times 0.87}{1000} \]

where:

- \( \Delta u_{benefit} \) = user benefit for trucks during each hour
- \( T_{VOT} \) = time value of money for commercial vehicles, $94.04/veh-hr

CO2 Emissions Reduction

Changes in carbon dioxide (CO2) emissions were computed using the method adopted by (1). Using conversion factors from the U.S. Environmental Protection Agency and the frequency of travel, 0.87 gal of gasoline per hour. This number was conservatively used to determine the fuel consumption:

\[ \text{fuel} = \Delta T \times v_i \times 0.87 \]

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The following equation compares the CO2 emissions income. The U.S. Environmental Protection Agency estimates the amount of CO2 emitted when a gallon of gasoline burns to 199 lbs/gal (5). CO2 emissio...n (7) and the cost of CO2 was determined using this equation:

\[ \text{CC} = \frac{\text{CO2 emissions}}{199} \]

The USEPA also estimates the social cost of CO2, $34/mton (5) and the cost of CO2 was determined using this equation:

\[ \text{CC} = \frac{\text{CO2 emissions}}{199} \]

In summary, the net user benefit from the five corridors was determined to be $32 million. In addition, carbon dioxide emissions were reduced by over 10,000 tons - an evergreen savings of nearly $378,000.

Summary of Annual CO2 Emission Reductions for the Adaptive Signals

<table>
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<tr>
<th>Corridor</th>
<th>Weekday</th>
<th>Weekend</th>
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<th>Weekend</th>
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<td>Total</td>
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<td>$275,000</td>
</tr>
</tbody>
</table>

1) 2013 Pennsylvania Public Health
2) 2013 Urban Mobility Symposium
3) TRB, 2013, 8495-91, 303-311
4) TRB, 2013, 8495-91, 303-311
5) 2011 AASHTO, Statewide

$32 Million total benefit
$275,000 CO2 savings
10,000 tons CO2 reduced