An investigation of the relationship between mobility and environmental externalities at signalized intersections

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INTRODUCTION

- Transportation is a major contributor to energy consumption and emissions. Signalized intersections are often “hot spots” for excess fuel consumption and emissions at arterial.
- From traffic operational point of view, one of the cost-effective ways is to improve traffic system management with sustainable traffic control strategies.
- Traditional transportation system management mainly focuses on improving mobility and safety, with environmental concerns as afterthoughts or constraints. At signalized intersections, the traditional methods of delay-based signal optimization may not lead to “optimal” fuel usage and emissions.
- In this paper, the team developed a framework to find the relationship between control delay and emissions at the signalized intersection, which can be used for the multi-objective signal optimization in the future.

PROPOSED PROCEDURE

A traffic signal optimization tool, a microscopic simulation model, and an instantaneous emission and fuel consumption estimation module were integrated in this framework.

CASE DESIGN

The case study intersection is developed based on the example 3 from Chap16 of Highway Capacity Manual.
- 4-Leg intersection Modeled as Pre-timed Signal;
- 0.25 mile approach link, 45mph;
- One vehicle type-Passenger Car (ID=21 in MOVES);
- Urban unrestricted access links;
- Major road: East-West (E-W) direction.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>East Bound</th>
<th>West Bound</th>
<th>North Bound</th>
<th>South Bound</th>
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<tr>
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<td>L TR R L TR R L TR R</td>
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<tr>
<td>base</td>
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<td>175 840 70</td>
<td>60 270 90</td>
<td>100 510 20</td>
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<tr>
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<tr>
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<td>17 378 25</td>
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<tr>
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<td>233 760 93</td>
<td>50 294 76</td>
<td>158 444 32</td>
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<tr>
<td>Turning</td>
<td>704 540 336</td>
<td>388 543 155</td>
<td>84 210 126</td>
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</tr>
</tbody>
</table>

7 scenarios are generated to test the proposed procedure first. Then, the scenarios are extended to 30 with more flow ratios and other turning movement ratios.

RESULTS

1) Traffic Signal Optimization Tool

Traffic Signal Optimization Tool—Synchro is used to develop delay-based signal timings for different level of traffic volumes and obtain the control delay.

2) Traffic Micro Simulation Tool

Traffic Micro Simulation Tool—VISSIM is used to develop speed/acceleration profiles.

CONCLUSIONS

- The emission results from Synchro are much smaller than those from MOVES;
- For the single intersection, reducing delays will lead to the reduction of energy, CO2 and PM (linearly related);
- The relationship between control delay and other emissions, such as NOx, SO2 and CO, are not linear;
- For emissions such as NOx, SO2 and CO, the trend could be negative in the congested conditions;
- For a corridor with multiple intersections, there will be tradeoff of coordinated signal tuning for different intersections in terms of vehicle delay and emissions.