C and D Line TSP Optimization Project

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ITE/IMSA
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Existing TSP System
Vehicle-to-Infrastructure (V2I) Architecture

LEGEND
KC Owned and Operated
Traffic Agency Owned and Operated
Existing TSP System
Roadside Equipment

Wireless Access Point  McCain TPRG  Interface Panel  Stretch Cabinet
Current King County TSP System

- Operating at 200+ intersections
  - Rapid Ride corridors (A, B, C, D, E, F)
  - Other high-ridership corridors (44, 101, 120)

- Measured Benefits
  - Signal delay reduced up to 14% [E-Line]
  - Average travel time reduced 5% [E-Line]
  - Reduced variability (Improved reliability) [C-Line]
TSP Retiming Effort

• Focused on improving performance on routes and lines with existing TSP
• Seek to use more targeted approach for granting priority
• Allows us to use more aggressive priority treatments
• Completed A Line, B Line, and Route 101 retiming in 2015 and 2016
• Completed C Line and D Line retiming in 2018
C Line TSP Intersections

D Line TSP Intersections
TSP Basics

Red Truncation

Green Extension
Tiers of TSP Strategies

- Tier 1 – No priority
- Tier 2 – Green extensions only
- Tier 3 – Green extension and red truncation. AKA partial priority
- Tier 4 – Phase skipping, Green Extension, and Red Truncation. AKA Full Priority
TSP Strategies - City Constraints

- Cannot shorten any minimum or clearance intervals (vehicle or ped)
- Need to yield to emergency vehicle preempt
- Recovery period needs to be provided

Recovery strategy depends on controller type
TSP as a Performance Management Tool

• Current TSP Strategy
  – Speed-focused
  – Try to give every bus TSP
  – Schedule reflects TSP
  – Traditional TSP timings:
    - Green Extension
    - Early Green
TSP as a Performance Management Tool

• New TSP Strategy
  – Reliability-focused
  – Certain selected buses request higher levels of TSP, including phase skipping.
    - Late buses
    - Peak hour, peak direction buses
    - Buses entering problem areas of congestion
  – Future consideration: full buses request higher level of TSP
    - Need full APC deployment on all coaches. Currently only 40% of buses have APC capability.
TSP as a Performance Management Tool

- Enhanced TSP timings:
  - Phase skipping
  - Priority at near-side stops
- When available: traditional TSP for on-time buses
Factors considered:

- V/C Ratios
- Time of Day
- Bus Lateness
- Overall Bus Delay
- Existing Bus Lane
- Existing Bus Queue Jump
- Pedestrian Volumes
- Urban Village designation
Decision Matrix

- SDOT created table of V/C Ratios using Synchro Models
- TSP has been shown to be most effective when V/C are between 0.6 and 0.9
Decision Matrix

Working through all the factors collaboratively we would fill out the decision matrix for each intersection and direction. This process took approximately 15 minutes per location. We would get three to four intersections done per one hour long meeting.

<table>
<thead>
<tr>
<th>Movement</th>
<th>Direction</th>
<th>Intersection</th>
<th>Morning Peak Specify Interval</th>
<th>Midday Specify Interval</th>
<th>Afternoon Peak Specify Interval</th>
<th>Nighttime Specify Interval</th>
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<tbody>
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## Decision Matrix

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Field Implementation

- SDOT and Metro engineers worked together to implement and test timing in the field
- Post-implementation intersections were monitored for performance
- Tweaks were made to resolve any issues.
Results

• Reduced missed headways by 3% to 30% in peaks
• Maintained travel times despite increases in traffic and ridership
C Line: Percentage of buses not meeting headway standards

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
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<tbody>
<tr>
<td>AM In</td>
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<td>AM Out</td>
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<td>MD In</td>
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<td>MD Out</td>
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<td>10%</td>
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<tr>
<td>PM In</td>
<td>25%</td>
<td>20%</td>
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<tr>
<td>PM Out</td>
<td>25%</td>
<td>20%</td>
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<td>OTHER In</td>
<td>15%</td>
<td>10%</td>
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<tr>
<td>OTHER Out</td>
<td>15%</td>
<td>10%</td>
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</table>
D Line: Percentage of buses not meeting headway standards

Before

After
Headway Improvements

• C Line: 30% fewer buses late in the PM peak, 3% fewer buses late in the AM
• D Line: 6% Fewer buses late in the PM, 4% fewer buses late in the AM
Other impacts

- Overall delay and travel time were not significantly impacted
- TSP was already optimized to improve travel time and reduce delay
- Purpose of this optimization effort was to improve headway reliability.
Integrating TSP with adaptive signal timing

• SCOOT has ability to modify timing based on TSP call
  – Extensions, truncations, phase skipping
  – Arrival times are configurable
  – Recovery is configurable, including lockout
• BUT
  – Timing modifications are dynamically calculated
Integrating TSP with adaptive signal timing

- Can use logic to determine priority
  - Lateness threshold
  - Degree of saturation
  - Wide variety of options for prioritization
  - Did not want to compromise overall corridor performance

- Implemented pilot program on 1st Ave N and Mercer St
  - Northbound left turn is prioritized. Bus activates early green or red truncation on arrival.
1st and Mercer: Bus Reliability Improvements

• First stage of pilot: made passive improvements by increasing green time for all cycles of northbound left turn (bus movement)

• Second stage of pilot: Implement TSP and increase green time for bus movement only when bus is there
SCOOT Pilot Results

• First Stage (Passive signal timing changes) saw improvements for bus delay but significant increases in general purpose vehicle delay on Mercer.

• Second State (Active TSP) saw greater improvement for bus delay with minimal increase in general purpose vehicle delay.
Conclusions

• Targeting late and peak hour buses can significantly improve reliability on bus routes
• Precision in targeting buses in need of priority allows us to use more aggressive signal timing intervention
• Transit priority integration with advanced adaptive signal timing systems is effective and possible
Future work

• Expand the SCOOT TSP pilot program to other intersections
• Use targeted TSP approach on E Line, F Line
• Implement center to center next generation TSP system
Existing TSP System
Existing TSP System

Wireless Access Point  McCain TPRG  Interface Panel  Stretch Cabinet

Roadside Equipment
NextGen TSP System - Project Goals and Features

- Increase transit data accuracy, reliability, and availability
- Reduce roadside equipment
  - Reduced capital costs
  - Reduced maintenance
- Leverage existing communications networks and cellular communication
- TSP message generation will occur centrally, rather than at the roadside
- Two configurations:
  - Center-to-Infrastructure (C2I)
  - Center-to-Center (C2C)
NextGen TSP System – C2I

- TSP request message serviced by detector card
NextGen TSP System – C2C

- TSP request message serviced by jurisdiction’s signal system