Operating Signals for Transit
Signal Design Toolbox

Key Terms
Stop Location – Near Side
Near-Side, Pull-Out Stop
Stop Location – Far Side
Far-Side, In-Lane Stop
Stop Location – Mid-Block

≥200′
Transit Lane
Transitway
Transit Approach Lane / Queue Bypass
Queue Jump
Transit Signals

Louvered signal

Transit Signal Head
Active Transit
Signal Priority

Toolbox
Using Signals to Give Transit Priority

• Use TSP to support project goals
• Combine TSP with geometric treatments
• Avoid penalizing pedestrians
• Consider predictability for all users
When do I give active priority?

(Rules of thumb!)

• Buses per hour: (typically fewer than 15 per hour)
• v/c ratio? (0.5 – 0.7, may work up to 0.9)
• Behind the schedule, or always? (policy decision)
Typical Active TSP
Typical Active TSP
Typical Active TSP
Bus to Signal

- Fleet
- Emitter
- Signal Cabinet
- Loop Detector
- Optical Detection Receiver
- Markings
- Boardings Data
- Bus Stops
- Runtime Data
• Optical detection
• Loop detection (in-ground)
• Emitter / Receiver
• AVL / GPS-based
• TMC software & roadside hardware
• Emitter / Receiver

Bus to Center
Green Extension

Applications
• Typically far-side or no stop location
• Mixed travel, transit lane, or transitway
• May use advance detection

Benefits & Challenges
• Relatively simple to implement
• Doesn’t affect pedestrian crossing time (on thru street)
Before
Green Extension
Green Extension
Green Extension
Green Reallocation

Benefits & Challenges
- Doesn’t change red / green allocation
- Shortens cross-street pedestrian crossing time

Applications
- Near-side, far-side, or no stop location;
- Mixed travel, transit lane, or transitway
- Requires advance detection

Typical Green Phase
(5s) 36s 19s

TSP called
Before
Before
Before
Before
Green Allocation
Green Allocation
Green Allocation
Green Allocation
Red Truncation

Applications
• Far-side stop / no stop
• Congested locations / long queues
• High-turning movement counts

Benefits & Challenges
• Metering queue length in front of transit
• Difficult to model and implement
• Pedestrian crossing time on cross-street shortened
Before
Before
Before
Before
Red Truncation
Red Truncation
Red Truncation
Red Truncation
Red Truncation
Upstream Green Truncation

Applications
• Near- or Far-side Pull-Out stops
• Bus Turns or Merges
• Generally mixed travel conditions

Benefits & Challenges
• Where remerge from stop is a common delay culprit
• No impact to people walking; may impact unprotected bike facilities
Reverse Queue Jump
Before
Before
Upstream Green Truncation
Upstream Green Truncation
Upstream Green Truncation
Phase Insertion

Applications
- Near-side pull-out stops
- Transit Approach Lanes / Queue Jumps, Transit Lanes

Benefits & Challenges
- Flexible actuation / detection
- Can co-implement with LPI / LBI.

Queue Jump Lane
General Travel Lane

Typical Phase Length

19s
24s
41s
36s
Phase Reservice

Benefits & Challenges

• Addresses known problems, and requires minimal change to existing phasing
• May impact pedestrian crossing time with conflicting movements

Applications

• Any stop location type
• Bus turns & Queue Jumps
• Transit Lanes, Transitways, or Mixed Travel

Typical Phase Length
Transit-Friendly Signal Progression

Passive / Fixed Timing Strategies
Timing Corridors for Transit

• Reduce Signal Cycle Length
• Increase Transit Green Time
• Time Progressions to Transit Green Wave / Safe Speeds
• Let the bus go straight!
Corridor-Based Timing
Balanced Signal Timing

- Reduce average delay to people walking & biking
- Opportunity for speed management / safety benefit
- Opportunity for transit-friendly progression
One-way progression

Signal Blocks
One-way progression

Progression
Speed = 20mph
One-way progression – Before

Progression
Speed = 20mph
One-way progression – After

Progression
Speed = 13-15mph
One-way progression

Progression
Speed = 13-15mph
Two-Way Progression
Two-Way Progression
Two-Way Progression
Two-Way Progression
Two-Way Progression
Two-Way Progression
Two-Way Progression – Speed Mgmt
Shorter Cycle Lengths can help control speeding, reduce delay penalty

- Fill “gaps” in the platoon with slower progression speed
- Use small clusters / signal blocks to disincentivize speeding (decrease “unconstrained arrivals”)
- Shorter Cycle Length reduces network delay
Longer Cycle Lengths can offset delay during peak hours

<table>
<thead>
<tr>
<th>AM Peak</th>
<th>Before</th>
</tr>
</thead>
<tbody>
<tr>
<td>S Edmunds St</td>
<td>60</td>
</tr>
<tr>
<td>S Ferdinand St</td>
<td>60</td>
</tr>
<tr>
<td>S Hudson St</td>
<td>60</td>
</tr>
<tr>
<td>39th Ave S</td>
<td>60</td>
</tr>
<tr>
<td>Brandon St</td>
<td>60</td>
</tr>
<tr>
<td>S Orcas St</td>
<td>60</td>
</tr>
<tr>
<td>S Kenny St</td>
<td>60</td>
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</table>
Longer Cycle Lengths can offset delay during peak hours

<table>
<thead>
<tr>
<th>Street</th>
<th>AM Peak</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>S Edmunds St</td>
<td></td>
<td>60</td>
<td>120</td>
</tr>
<tr>
<td>S Ferdinand St</td>
<td></td>
<td>60</td>
<td>120</td>
</tr>
<tr>
<td>S Hudson St</td>
<td></td>
<td>60</td>
<td>120</td>
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Longer Cycle Lengths can offset delay during peak hours

<table>
<thead>
<tr>
<th>Street</th>
<th>Off-Peak</th>
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</thead>
<tbody>
<tr>
<td>S Edmunds St</td>
<td>Before</td>
</tr>
<tr>
<td>S Ferdinand St</td>
<td>60</td>
</tr>
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<td>60</td>
</tr>
<tr>
<td>S Kenny St</td>
<td>60</td>
</tr>
</tbody>
</table>
## Rainier Ave S, Seattle

### Motor Vehicle Travel Times

<table>
<thead>
<tr>
<th>Direction</th>
<th>Before</th>
<th>After</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>07:52</td>
<td>08:47</td>
<td>+ :55</td>
</tr>
<tr>
<td>SB</td>
<td>09:39</td>
<td>10:59</td>
<td>+ 1:20</td>
</tr>
</tbody>
</table>

### Transit Travel Times

<table>
<thead>
<tr>
<th>Direction</th>
<th>Before</th>
<th>After</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>19:32</td>
<td>16:31</td>
<td>- 3:01</td>
</tr>
<tr>
<td>SB</td>
<td>15:34</td>
<td>15:36</td>
<td>+ :02</td>
</tr>
</tbody>
</table>

### Motor Vehicle Speeding ↓ 40%

### High-End Speeding (over 40mph) ↓ 75%
Identify Sources of Delay

“What’s the problem I want to solve?”
Identifying Sources of Delay

• Dwell-time Delay at Stops
• Intersections: Turn Delay
• Intersections: Queue Length Delay
• Remerge Delay
Identifying Sources of Delay

• Stop / Dwell Delay
  • “Doors open to Doors Close”
  • 25th / 50th / 75th percentile dwell
  • May not capture remerge delay

• Intersection / Signal Delay
  • Setting AVL waypoints / frequency

• Runtime
  • May include Queue Delay
Delay by Segment

- AM Peak
- SB Speeds North of F
- Speeds Down 7% South of Flatbush
- Down 4% at Flatbush
Intersection Delay: Time-Lapse

Total delay instances: 38
Cumulative delay (sec): 419.0
## Intersection Delay: Time-Lapse

### Quantifying delay at a single stop

<table>
<thead>
<tr>
<th>Broadway / 14th St SB</th>
<th>Weekday 7:30am - 5pm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of buses (southbound)</td>
<td>315</td>
</tr>
<tr>
<td>Number of buses delayed</td>
<td>110 (35%)</td>
</tr>
<tr>
<td>Maximum delay per bus</td>
<td>77s</td>
</tr>
<tr>
<td>Cumulative delay of southbound buses</td>
<td>26m 30s</td>
</tr>
<tr>
<td>Avg delay per delayed bus</td>
<td>14.5s</td>
</tr>
<tr>
<td>Avg delay across all buses</td>
<td>5.0s</td>
</tr>
<tr>
<td>Total daily southbound ridership</td>
<td>3,470</td>
</tr>
<tr>
<td><strong>Total customer delay per day</strong></td>
<td><strong>4.9 hours</strong></td>
</tr>
</tbody>
</table>
Stop / Dwell Delay

- From Pull-Out to In-Lane Stops + Passive TSP
- Increase Signal Offsets
- Active TSP (far-side)
- Queue Jump (near- or far-side)
Stop / Dwell Delay
Stop / Dwell Delay
Turning Vehicle Delay

✓ Transit Approach Lane + Active / Passive TSP
✓ Right Turn Pocket + Split Phase
✓ Dropped Transit Lane
✓ Turn Prohibitions
Split Phase / Leading (Bus) Interval
Split Phase / Leading (Bus) Interval
Split Phase / Leading (Bus) Interval
Queue Length Delay

- Transit Lane + Active / Passive TSP
- Shared Right Turn / Transit Lane
- Traffic Metering (Forced Turns, Green Truncation)
Turn Prohibitions

• Reroute Before
• Reroute After
• Right-Left-Left
• Three Rights