Efficient and Safe Signal Phasing for Bicycle Movements at Signalized Intersections – May 2015 Update

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Overview

• Background of Bike Signals
• Current Study – Sparks NV Bike Signal
  • Solutions
  • Controller / Simulation Implementation
  • Results – Current Operation
  • Solution #3 – Discussion, Upcoming Investigation

• Safety Issues with Signal Face
  • Summary and Commentary

• Off Topic – Bike Coordination
Background

- As more and more people bike in the U.S., integration of bicycle signals are recommended.

- Several cities in the U.S. has started experimenting with these signals.

- But to efficiently combine both bicycle and traffic signals to work together, can be a challenge.
Background

- Safety of bicyclist and motorists.
  - Can curb non-compliance.
  - Bike signals are new, culturally different, and many will be unfamiliar with it.
Non-Compliant Biker
Sparks NV, Bicycle Signal
Sparks NV, Bicycle Signal

- **Overlap “A”** = $\phi_1$
- **Overlap “B”** = $\phi_4$

Diagram of E. McCarran Blvd with directions and signals labeled.
Sparks NV, Bicycle Signal

- Current Operation not running efficiently.
- Called or not called, bicycle signal face will always have a green.
- Adjacent right traffic right turn will unnecessarily wait longer.
Current Operation
Solution One

- If possible, use the controller’s omit feature.

- Bike and Pedestrian call are tied together.

- Two overlaps.
Solution One

• When either Ped or Bike Called.

<table>
<thead>
<tr>
<th></th>
<th>φ₁</th>
<th>φ₂</th>
<th>φ₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>φ₅</td>
<td>↓</td>
<td>φ₆</td>
<td>↑</td>
</tr>
</tbody>
</table>

Overlap A =

Overlap B =

• When both Ped or Bike are not Called.

<table>
<thead>
<tr>
<th></th>
<th>φ₁</th>
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<td>φ₅</td>
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<td>φ₆</td>
<td>↑</td>
</tr>
</tbody>
</table>

Overlap A =

Overlap B =

φ₄ + φ₁

φ₄ + φ₈
Solution Two

- Bike and Pedestrian call are tied together.
- Two overlaps.
Solution Two

- When either Ped or Bike Called.

<table>
<thead>
<tr>
<th>φ1</th>
<th>φ2</th>
<th>φ3</th>
<th>[Ped or Bike]φ12</th>
<th>φ4</th>
</tr>
</thead>
<tbody>
<tr>
<td>φ5</td>
<td>φ6</td>
<td>φ3</td>
<td>[Ped or Bike]φ12</td>
<td>φ4</td>
</tr>
</tbody>
</table>

Overlap A = \( φ1 + φ4 \)

Overlap B = \( φ12 + φ4 \)

- When both Ped or Bike are not Called.

<table>
<thead>
<tr>
<th>φ1</th>
<th>φ2</th>
<th>φ3</th>
<th>[Ped or Bike]φ12</th>
<th>φ4</th>
</tr>
</thead>
<tbody>
<tr>
<td>φ5</td>
<td>φ6</td>
<td>φ3</td>
<td>[Ped or Bike]φ12</td>
<td>φ4</td>
</tr>
</tbody>
</table>

Overlap A = \( φ1 + φ4 \)

Overlap B = \( φ12 + φ4 \)
Solution Three

- Bike and Pedestrian call are not tied together.
- Time allocation for Bike and Pedestrian.
- Three overlaps.
Solution Three

- When Pedestrian is Called.

<table>
<thead>
<tr>
<th>φ1</th>
<th>φ2</th>
<th>φ3</th>
<th>φ9</th>
<th>φ12</th>
<th>φ4</th>
</tr>
</thead>
<tbody>
<tr>
<td>φ5</td>
<td>φ6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Overlap A = \( \phi_1 + \phi_4 \)
- Overlap B = \( \phi_{12} + \phi_9 + \phi_4 \)
- Overlap C = \( \phi_9 \)
Solution Three

- When Bike is Called.

<table>
<thead>
<tr>
<th></th>
<th>φ1</th>
<th>φ2</th>
<th></th>
<th></th>
<th>φ9</th>
<th>φ12</th>
<th>φ4</th>
</tr>
</thead>
<tbody>
<tr>
<td>φ5</td>
<td>←</td>
<td>↑</td>
<td>φ3</td>
<td>←</td>
<td>←</td>
<td></td>
<td></td>
</tr>
<tr>
<td>φ6</td>
<td>↓</td>
<td>↓</td>
<td>φ3</td>
<td>↑</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Overlap A =</th>
<th></th>
<th>φ1 + φ4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overlap B =</td>
<td></td>
<td>φ12 + φ9 + φ4</td>
</tr>
<tr>
<td></td>
<td>Overlap C =</td>
<td></td>
<td>φ9</td>
</tr>
</tbody>
</table>
### Solution Three

- **When None are Called.**

<table>
<thead>
<tr>
<th>Overlap A =</th>
<th>Overlap B =</th>
<th>Overlap C =</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \phi_1 + \phi_4 )</td>
<td>( \phi_{12} + \phi_9 + \phi_4 )</td>
<td>( \phi_9 )</td>
</tr>
</tbody>
</table>

**Diagram:**
- \( \phi_1 \) and \( \phi_2 \) flow from left to right.
- \( \phi_5 \) and \( \phi_6 \) flow from top to bottom.
- \( \phi_3 \) is restricted by red crosses.
- \( \phi_9 \) is restricted by red crosses.
- \( \phi_{12} \) is restricted by red crosses.
Controller Implementation

- Before Implementing in field, solutions must work in signal controllers.
- Solution #3, only sequence put in the controller.
- Two Controllers, Naztec & Eagle.
Solution #3 was successfully programmed.

However, Sparks NV does not use this controller.
Eagle Controller

- City of Sparks use this controller.
- Harder to program in my opinion...
  - User manual wasn’t user friendly.
- Solution #3 was successfully programmed.
Implementation into Simulation

- Traffic simulation programmed to be used is Vissim.
- All information regarding the intersection must accurately be added to simulation.
  - Traffic movement, Speed, Signal Phases, Detectors, etc.
  - Number of lanes, detailing the road curvature, etc.
Hardware Needed

- Controller Interface Device
  - Shows the output signals from the controller.
Communication File

- Relays the information between the controller and the simulation program.
Intersection Data

- Current intersection data was obtained from the City of Sparks.
  - Split timings, pedestrian times, max green time, time before reduction...

- Intersection is Coordinated.
  - Intersection has a cycle length.

- But for this analysis, it will be treated as an isolated intersection.
Issues

- Current operation is first tried and implemented into the controller and simulation.
- Vehicle Signal and Vehicle Detector communicated fine.
- But...
- Was not able to get Pedestrian Detector to communicate.
Vissim RBC Controller

- Implemented Current Operation into Vissim.
  - All timing and coordinated data.
- And this method works!
- Was able to run an evaluation to determine queue length, delay, etc.
- Ran Evaluation period for one hour.
Traffic movements and speed was counted so that the results would accurately representative of the intersection.

<table>
<thead>
<tr>
<th>MOVEMENT</th>
<th>Average Queue Lenght (ft)</th>
<th>Max Queue Length (ft)</th>
<th>Vehicle Count</th>
<th>Average Delay (Sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1: WB Nichols Blvd@351.3-2: WB Nichols Blvd@81.4</td>
<td>55.49</td>
<td>176.7</td>
<td>32</td>
<td>50.24</td>
</tr>
<tr>
<td>1-1: WB Nichols Blvd@351.3-3: NB McCarran Blvd@46.9</td>
<td>55.49</td>
<td>176.7</td>
<td>69</td>
<td>74.75</td>
</tr>
<tr>
<td>1-1: WB Nichols Blvd@351.3-7: SB McCarran Blvd@231.8</td>
<td>55.49</td>
<td>176.7</td>
<td>160</td>
<td>52.86</td>
</tr>
<tr>
<td>1-4: SB McCarran Blvd@244.6-2: WB Nichols Blvd@81.4</td>
<td>27.78</td>
<td>220.04</td>
<td>50</td>
<td>18.59</td>
</tr>
<tr>
<td>1-4: SB McCarran Blvd@244.6-7: SB McCarran Blvd@231.8</td>
<td>27.78</td>
<td>220.04</td>
<td>706</td>
<td>18.24</td>
</tr>
<tr>
<td>1-5: NB McCarran Blvd@346.6-3: NB McCarran Blvd@46.9</td>
<td>84.42</td>
<td>607.46</td>
<td>1763</td>
<td>21.67</td>
</tr>
<tr>
<td>1-5: NB McCarran Blvd@346.6-6: EB Nichols Blvd@103.6</td>
<td>23.35</td>
<td>469.81</td>
<td>217</td>
<td>18.83</td>
</tr>
<tr>
<td>1-10: SB McCarran Left Turn Lane@63.6-6: EB Nichols Blvd@103.6</td>
<td>5.4</td>
<td>83.68</td>
<td>24</td>
<td>49.68</td>
</tr>
<tr>
<td>1-11: EB Nichols Blvd@30.8-3: NB McCarran Blvd@46.9</td>
<td>45.49</td>
<td>231.55</td>
<td>67</td>
<td>77.06</td>
</tr>
<tr>
<td>1-11: EB Nichols Blvd@30.8-6: EB Nichols Blvd@103.6</td>
<td>45.49</td>
<td>231.55</td>
<td>69</td>
<td>75.29</td>
</tr>
<tr>
<td>1-11: EB Nichols Blvd@30.8-7: SB McCarran Blvd@231.8</td>
<td>45.49</td>
<td>231.55</td>
<td>20</td>
<td>83.29</td>
</tr>
<tr>
<td>1-12: WB Nichols Blvd Bike Lane@351.8-15: WB Nichols Blvd Bike Lane@99.2</td>
<td>0.73</td>
<td>10.81</td>
<td>5</td>
<td>60.13</td>
</tr>
<tr>
<td>1-14: EB Nichols Blvd Bike Lane@349.5-13: EB Nichols Blvd Bike Lane@138.0</td>
<td>0.83</td>
<td>17.53</td>
<td>8</td>
<td>44.52</td>
</tr>
<tr>
<td>1-10007: NB McCarran Left Turn Connector@165.8-2: WB Nichols Blvd@81.4</td>
<td>20.4</td>
<td>130.95</td>
<td>57</td>
<td>71.65</td>
</tr>
</tbody>
</table>
Solution #3 - Upcoming

- Will keep same cycle length, but the split from phase 4, must be allocated carefully.
- The delay for westbound right should be lower. However, there isn’t a high right turn movement.
- Eventually will investigate when there is a high right turn movement.
Solution #3 - Upcoming

- Until the pedestrian detector is solved between the controller and simulation, will implement solution into Vissim RBC.
- Would like follow up with another seminar in the Fall.
Signal Safety

- After installing these bicycle signals, hazards may arise from the lack of knowledge among users at an intersection.

- Misinterpretation or miscomprehension may cause accidents between motorist and bicyclist.
Potential Hazard with Signal Faces
Potential Hazard with Signal Faces

- Current signal face setup does not show any prohibition to a bicyclist.
  - Bicyclist can mistakenly turn right or left into oncoming traffic.
The Interim memorandum approval for optional use of a bicycle signal face also permits the use of these signal faces. But, drivers may misread this and turn into oncoming bicyclist because there are other traffic signals that utilize these arrows.
Potential Hazard with Signal Faces
Potential Hazard with Signal Faces

- Use of signal faces unfamiliar to drivers.
Potential Hazard with Signal Faces

- Place bike signals where drivers can’t see.
Bicycle Coordination?
Questions?