SIGNALIZED T-INTERSECTION SAFETY REVIEW

Mark Halpin, Transportation Planner, City of Port Moody
Sean O’Sullivan, Traffic Operations Engineer, City of Coquitlam
Matthew Chan, Traffic Engineer, Parsons
Project Team

PROJECT STEERING COMMITTEE
- Jarrod Mitchell, AScT, Project Manager, City of Coquitlam
- Bernard Tung, AScT, Traffic Technologist, City of Coquitlam
- Erik Lam, Traffic Engineering Technologist, City of Port Coquitlam
- Mark Halpin, Transportation Planner, City of Port Moody
- Allison Wong, P.Eng., MBA, Road Safety Engineer, ICBC

SENIOR ADVISORS
- Jamie Umpleby, P.Eng., Director of Public Works, City of Coquitlam
- Dan Mooney, AScT, Manager of Roads and Traffic Operations, City of Coquitlam
- Sean O’Sullivan, P.Eng., Traffic Operations Engineer, City of Coquitlam

CONSULTANT TEAM
- Tim Murphy, AScT, MBA, PMP, Eng.L., P.L. (Eng.), Project Manager, Parsons
- Julian Rozental, P.Eng., Senior Road Safety Engineer, J. Rozental Consultancy
- Matthew Chan, P.Eng., Road Safety Engineer, Parsons
- Adrian Lee, EIT, Transportation Engineer, Parsons
Presentation Outline

- Introduction
  - Objectives
  - Issues
- Methodology
  - Literature Review
  - Jurisdictional Survey
  - Screening of T-intersections
  - In–Service Site Reviews
- Safety Toolbox
- Summary
Safety Review Objectives

- The objectives of this safety review were to:
  - Improve safety and mitigate pedestrian / vehicle conflicts and crashes at signalized T-intersections, by
  - Identifying, evaluating, and recommending suitable countermeasures

- Currently, there are 76 signalized T-intersections within the Tri-Cities area:
  - City of Coquitlam – 47 intersections
  - City of Port Coquitlam – 17 intersections
  - City of Port Moody – 12 intersections
Key Issues

Key issues affecting safety at signalized intersections are:

- Operational performance
- Design characteristics:
  - Crossing sight distance
  - Lane width / road width
  - Right-turn treatments
  - Left-turn treatments
- Pedestrian visibility
- Traffic control visibility
- Pavement marking visibility
- Access management near the intersection
A scan of available literature was undertaken to identify emerging practices for the design and safety improvement for signalized intersections.

Six primary transportation engineering literature references were identified and reviewed. These reference were from:

- Texas Transportation Institute
- California Department of Transportation
- City of Vancouver
- Michigan Department of Transportation
- Pasadena, California
- America WALKS
Jurisdictional Survey

• An environmental scan of four selected jurisdictions was also conducted to identify what safety measures are being applied locally in British Columbia.

• The four selected jurisdictions were:
  • City of Vancouver
  • City of Richmond
  • District of Saanich
  • City of Kamloops
## Traffic Signal Safety Measures

<table>
<thead>
<tr>
<th>Traffic Signal Safety Measures</th>
<th>Vancouver</th>
<th>Richmond</th>
<th>Saanich</th>
<th>Kamloops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slower walking speed</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Peak hour pedestrian recall in high activity pedestrian areas</td>
<td>x</td>
<td>x</td>
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<td></td>
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<tr>
<td>Full time recall / fixed time pedestrian intervals</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
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<tr>
<td>Audible pedestrian signals</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>New or upgraded intersection lighting</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Pedestrian countdown signals</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Bicycle signals</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicycle signal detection</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Leading pedestrian interval</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedestrian-only phase (Scramble)</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Protected left turn phase</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>All red clearance</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Animated Eyes on Pedestrian signals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blank out signs</td>
<td>x</td>
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</table>
## Intersection Design Safety Measures

<table>
<thead>
<tr>
<th>Intersection Design Safety Measures</th>
<th>Vancouver</th>
<th>Richmond</th>
<th>Saanich</th>
<th>Kamloops</th>
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</thead>
<tbody>
<tr>
<td>Bike box</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Removal of right turn slip lane (pork chop island)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
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<tr>
<td>Install pork chop island</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Refuge island</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
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<tr>
<td>Two stage pedestrian crossing</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remove bus stop</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Reduced turning radius as determined by design vehicle</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Directional curb ramp and separated pedestrian push buttons</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Driveway access management</td>
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<td></td>
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<td>x</td>
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<td>Corner bulges</td>
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<td>x</td>
<td>x</td>
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<tr>
<td>Raised crosswalks</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raised intersections</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Yield to pedestrians signing</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Prohibited right turn on red</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Roundabout</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>
Preliminary Screening for Study Intersections

Crash Frequency (2009-2013)

Pedestrian Involved Crash Frequency (2009-2013)
Location of Selected Study Intersections

- Coquitlam T-Intersection Safety Review
  - Intersections for review for the Coquitlam T-Intersection Safety Review
  - All changes saved in Drive
  - Add layer  Share
  - Coquitlam
    - Individual styles
      1. Pineatre Way & Anson Ave
      2. Austin Ave & Gatenby St
      3. Austin Ave & Laurentian C... 4. Chilko Dr & Riverview Dr... 5. Clarke Rd & Glenayre Dr
      6. Johnson Street & South... 7. Guildford Way & Town Ct... 8. Johnson St & Parkway Blvd
      9. Coquit Lake Ave & Banting...
  - Port Moody
    - Individual styles
      10. Harvest Hwy & Doo... 11. Clarke St & Moody St
      12. Unruhl Way & Guildford...
  - Port Coquitlam
    - Individual styles
      13. Coquit Meridian Rd & Co... 14. Pitt River Rd & Reeve St
      15. Ottawa St & Nicola Ave
      16. Lougheed Hwy & Otta...
Sample In-Service Intersection Review

**Existing Conditions**

**Observations**

- Visibility of pedestrian crosswalk may be limited by foliage.
- Pavement markings are faded.
- South gutter is on downhill (East) side of pedestrian crossing, creates puddles right in front of pedestrian path if clogged. Also may be a pedestrian "splashing" hazard.

**Summary of Issues**

- Visibility of pedestrian crosswalk at night time may be limited by thick tree foliage.
- Pavement markings are faded.
- South gutter is on downhill (East) side of pedestrian crossing, may create puddles right in front of pedestrian path if clogged. Also may be a pedestrian "splashing" nuisance.
- High pedestrian traffic precinct.

**Potential Mitigation Measures**

- Implement leading pedestrian interval to improve pedestrian safety.
- Trim back foliage along south side of Austin Avenue.
- Change crosswalk markings to zebra striping.
- Install anti-skid treatment on approaches.

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**AM Peak Hour Traffic Volumes**

- EBL: 0.78 AM, 0.34 PM
- EBT: 0.17 AM, 0.50 PM
- WBT/R: 0.60 AM, 0.27 PM
- SBL: 0.33 AM, 0.56 PM
- SBR: 0.59 AM, 0.32 PM
- Overall: - AM, 11.3 PM

**Level of Service**

- EBL: E AM, A PM
- EBT: A AM, A PM
- WBT/R: A AM, A PM
- SBL: C AM, D PM
- SBR: C AM, A PM
- Overall: B AM, A PM
Existing Conditions Information

<table>
<thead>
<tr>
<th>Type</th>
<th>Shown</th>
<th>Not Shown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclist</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Left Turn Opening</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Off Road</td>
<td>5</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>10</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>Rear End</td>
<td>3</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Right Angle</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Side Swipe</td>
<td>7</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Head On</td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>11</td>
<td>31</td>
</tr>
</tbody>
</table>

AM Peak Hour Traffic Volumes

PM Peak Hour Traffic Volumes

<table>
<thead>
<tr>
<th>Movement</th>
<th>V/C Ratio</th>
<th>Control Delay</th>
<th>Level of Service</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AM</td>
<td>PM</td>
<td>AM</td>
</tr>
<tr>
<td>EBL</td>
<td>0.78</td>
<td>0.34</td>
<td>56.4</td>
</tr>
<tr>
<td>EBT</td>
<td>0.17</td>
<td>0.50</td>
<td>4.0</td>
</tr>
<tr>
<td>WBT/R</td>
<td>0.60</td>
<td>0.27</td>
<td>7.1</td>
</tr>
<tr>
<td>SBL</td>
<td>0.33</td>
<td>0.56</td>
<td>31.4</td>
</tr>
<tr>
<td>SBR</td>
<td>0.59</td>
<td>0.32</td>
<td>31.2</td>
</tr>
<tr>
<td>Overall</td>
<td>-</td>
<td>-</td>
<td>11.3</td>
</tr>
</tbody>
</table>
Site Observations

- Visibility of pedestrian crosswalk may be limited by foliage.
- Pavement markings are faded.
- South gutter is on downhill (east) side of pedestrian crossing, creates puddles right in pedestrian path if clogged. Also may be a pedestrian "splashing" hazard.
**Issues and Potential Mitigations**

<table>
<thead>
<tr>
<th>Summary of Issues</th>
<th>Potential Mitigation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility of pedestrian crosswalk at night time may be limited by thick tree foliage.</td>
<td>Implement leading pedestrian interval to improve pedestrian safety.</td>
</tr>
<tr>
<td>Pavement markings are faded.</td>
<td>Trim back foliage along south side of Austin Avenue.</td>
</tr>
<tr>
<td>South gutter is on downhill (East) side of pedestrian crossing, may create puddles right in front of pedestrian path if clogged. Also may be a pedestrian “splashing” nuisance.</td>
<td>Change crosswalk markings to zebra striping.</td>
</tr>
<tr>
<td>High pedestrian traffic precinct.</td>
<td>Install anti-slip treatment on approaches.</td>
</tr>
</tbody>
</table>
Sample Safety Toolbox Measures

- Corner Bulges
- Reduced Curb Radius
- Smart Channel RT Lane
- High-Visibility Crosswalk
- Audible Pedestrian Signals
- Pedestrian Countdown Timers
- Leading Pedestrian Interval
- Two staged Crosswalks
- Pedestrian Scramble
- Animated Eyes Pedestrian Signals
- Bike Lane Markings
- Vertical Separation of Signal Heads
Each Safety Measure in the Toolbox included the following information to assist Traffic Engineering staff to select an appropriate solution to a safety issue:

- Description of Safety Measure
- Current Use in the Tri-Cities
- Application Considerations
- Safety Benefits
- Crash Reduction Factor
- Approximate Cost
Corner Bulges

Safety Benefits:
- Improves motorist visibility of pedestrians
- Improves motorist yield compliance
- Reduces speed of turning vehicles
- Encourages pedestrians to cross at designated crossings
- Increases sidewalk space
- Decreases crossing distances for pedestrians
- Can increase green space
- Improves sight lines for pedestrians
- Can be combined with beautification elements and rainwater management treatments
- Improves safety for pedestrians, cyclists and motorists by restricting parking within corner clearance area

- Collision Reduction Factor: 30 - 50% of pedestrian crashes
- Moderate cost
Reduced Curb Radius

Safety Benefits:
- Reduces speed of turning vehicles
- Increases sidewalk space
- Decreases crossing distances for pedestrians
- Collision Reduction Factor – Unknown
- Moderate cost
Smart Channel Right Turn

- **Collision Reduction Factor:**
  - 50% rear end crashes, and
  - 40% of merging crashes
- **Moderate to high cost**

**Safety Benefits:**
- Smart Channel Right Turn lanes intersect the crossing street at a reduced angle making it easier for drivers to look over their shoulder to judge the gaps in cross-street traffic, especially for older drivers.
- Reduces speed of turning vehicles.
- Reduces the incidence of rear end crashes.
High – Visibility Crosswalk

Safety Benefits:
- Enhances visibility of crosswalk, even in night time conditions
- Heightens motorist awareness of potential for crossing pedestrians
- Collision Reduction Factor – Unknown, as previous studies have diverse and contradictory findings
- Low to moderate cost
Audible Pedestrian Signals

Safety Benefits:

- Provides crossing assistance to pedestrians with vision impairment at signalized intersections
- Improves safety for visually impaired pedestrians
- As more of the vehicle fleet converts to hybrid fuel technology, the ability of vision impaired pedestrians to judge safe crossing opportunities by engine noise may be affected

- Crash Reduction Factor – Unknown
- Cost - Moderate
Pedestrian Countdown Timers

Safety Benefits:

- Pedestrian countdown signals have been shown to reduce all crashes at signalized intersections
- Increase the incidence of pedestrians completing their crossing before the end of the “flashing don’t walk” interval

- Crash Reduction Factor – Unknown (perhaps up to 25%)
- Cost - Moderate
Adjust Pedestrian Interval Timings

Safety Benefits:
- Reduces the incident for pedestrian / vehicle conflicts at the intersection as the pedestrian has temporal separation from the vehicle.
- Accommodates a greater spectrum of the pedestrian population to achieve a safe crossing.

- Crash Reduction Factor – Unknown
- Cost - Moderate

<table>
<thead>
<tr>
<th>User Type</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking (elderly)</td>
<td>0.9 m/s</td>
</tr>
<tr>
<td>Walking (Typical)</td>
<td>1.1 m/s</td>
</tr>
<tr>
<td>Manual Wheelchair</td>
<td>1.6 m/s</td>
</tr>
<tr>
<td>Jogging</td>
<td>2.8 m/s (10 km/h)</td>
</tr>
<tr>
<td>Power Wheelchair</td>
<td>3.0 m/s (11 km/h)</td>
</tr>
</tbody>
</table>
Leading Pedestrian Interval

Safety Benefits:
- Provides pedestrians with a head start to begin their crossing before vehicles begin turning, making pedestrians more visible to motorists
- Reduces conflicts between pedestrians and turning vehicles

- Crash Reduction Factor – Unknown locally (59% of pedestrian crashes, TRB)
- Cost - Low
Two Stage Crosswalks

Safety Benefits:

- Reduces the incident for pedestrian / vehicle conflicts at the intersection as the pedestrian has separation from vehicular traffic
- Accommodates a greater spectrum of the pedestrian population to achieve a safe crossing of wide roadways
- Crash Reduction Factor – 20% to 60% of pedestrian crashes
- Cost - High
Pedestrian Scramble

Safety Benefits:

- Provides an exclusive pedestrian phase with no concurrent traffic movements to reduce conflicts between pedestrians and vehicles
- The benefits of this treatment may not extend to visually impaired pedestrians
- Crash Reduction Factor – 50% of pedestrian crashes (TTI)
- Cost - High
Animated Eyes Pedestrian Signals

Safety Benefits:

- Animated Eyes pedestrian signals remind pedestrians of the need to be wary of vehicles turning across a crosswalk even during the WALK display at a signalized intersection.

- Crash Reduction Factor – Unknown
- Cost - Moderate
Bicycle Lane Markings

Safety Benefits:

- Bicycle crossing lane markings at the signalized intersection provide clear delineation to motorists when they are about to enter a potential conflict area with cyclists.
- Crash Reduction Factor – 10% to 50% of bicycle crashes.
- Cost – High with dedicated signals and actuation.
Vertical Separation of Signal Heads

Safety Benefits:

- Motorists waiting to turn at the intersection should be able to view pedestrian signal heads in activation and realize pedestrians may be crossing in the intersection, before starting a turning maneuver.

- Vertical separation of signal heads can expect to reduce pedestrian / left turning vehicle related crashes by as much as 20%.
Summary

- Literature Review
- Environmental Scan
- Pre-screened 76 signalized T-intersections
- Examined 16 signalized T-intersections
  - Key issues and potential mitigation measures were identified
- Safety Toolbox
  - Identified 21 Safety Toolbox Measures for Tri-Cities
  - Not to be used blindly
  - Engineering judgement
  - New technologies
  - New methods