Evaluation of Red Clearance Extension Designs with Hardware-in-the-loop Simulation

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NWS Voyage™ Red Clearance Extension

- Can extend red clearance interval if a call is placed during the last 50% of the yellow change interval or any time during the red clearance interval.

- Red clearance extension timer ranges from 0 to 25.5 seconds and can be disabled based on time of day operations.
Experimental Scenarios

- Downstream Detection (DD)
  - DD (existing condition)

- Smart Upstream Speed-Conditional Detection (SUSCD)
  - SUSCD at 125 Ft
  - SUSCD at 215 Ft
  - SUSCD at 475 Ft
US 30 at Cornelius Pass
Hardware-In-The-Loop Simulation

**CONTROLLER**

**CID**

- **SUSCD Strategy**
  - \( t = 0 \)
  - \( T = SCD \) timer
  - A vehicle crosses leading edge of the first loop
  - Set \( t = t_1 \)

- **DD Strategy**
  - \( t = 0 \)
  - A vehicle occupies downstream detector

**INPUT DATA**

- Link Alignment
- Turning Volumes
- Detector Location
- Speed Profile

**MICROSIMULATION MODEL**

- **Microsim**
- Econolite 2070 ATC
- McCain NIATT

**OUTPUT DATA**

- Vehicle Position Data
- Signal Changes
- Nodal Analysis
- Controller Logs

**DATA REDUCTION**

(R semi-automated framework)

**Step 1.** Retrieve data for Run i (1 ≤ i ≤ 30)
**Step 2.** Match signal changes data with controller log files
**Step 3.** Map Extensions
**Step 4.** Set \( G_1 \) as the first green time before extension and \( G_2 \) the first green time after extension.
**Step 5.** Load vehicle position data files
**Step 6.** Subset data within \( (G_1, G_2) \)
**Step 7.** Plot ETSD merging all data sets.
**Step 8.** Go to next run.

- Enhanced Time-Space Diagram (ETSD)

**RESULT**
Hardware-In-The-Loop Simulation

- Econolite ATC 2070
- McCain-NIATT Controller Interface Device (CID II)
Controller Data

- Voyage BIN files
  - Actual ODOT timings that currently run in the field
- Red Extension Logs
  - Time (beginning and end) of red extensions
  - 1 second resolution
VISSIM Data

• FZP – Vehicle Record
  • Position data (and so much more) for each vehicle in the network
  • 1/10\textsuperscript{th} of a second resolution

• LSA – Signal Changes
  • Chronologically sorted file of the signal changes
  • 1/10\textsuperscript{th} of a second resolution
US 30 and Cornelius Pass Road – Satellite Image
US 30 and Cornelius Pass Road – VISSIM Model
Signal Indication Changes and Red Extensions

Run 23 - Phase 2

Red Extension
Red Extension
Red Extension

Red Intervals

Yellow Intervals

Green Intervals

Time
Duration = 1500 - 2100
Enhanced Time Space Diagram

- Green Time
- Yellow Time
- Red Time

Distance (m)

0 10 20 30 40 50

Time (s)

Vehicle’s Front Bumper Trajectory
Vehicle’s Rear Bumper Trajectory
Red Clearance Extension (RCE)
Detection Area

Intersection Boundary
Stop Line

Oregon State University
Detected Vehicles with High Risk of Collison (VHRCs)

(a) Late Yellow Indication Entry

(b) Red light runner
Accuracy – Correct Calls

(a) Correct Call

(b) Incorrect Call (Non VHRC)

(c) Incorrect Call (Triggered by Another)
Accuracy – Correct Detection

(f) Correct Detection (Detected VHRC)

(g) Incorrect Detection (Undetected VHRC)

(h) Disregarded VHRC
## Accuracy Measurement

<table>
<thead>
<tr>
<th>VHRC</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>A VHRC is detected and a RCE is triggered (True Positive)</td>
<td>A VHRC is not detected and a RCE is not triggered (False Negative)</td>
</tr>
<tr>
<td>No</td>
<td>A RLE is triggered by a non VHRC (False Positive)</td>
<td>A RCE is not triggered and there is no VHRC (True Negative)</td>
</tr>
</tbody>
</table>
## Efficiency measurement

<table>
<thead>
<tr>
<th>Position</th>
<th>Definition</th>
<th>Crash Prevention Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream of Stop Line</td>
<td>VHRC has not reached the stop line at red onset</td>
<td>Highly Effective</td>
</tr>
<tr>
<td>At Stop Line</td>
<td>VHRC reached stop line at red onset</td>
<td>Less Effective</td>
</tr>
<tr>
<td>Downstream of Stop Line</td>
<td>VHRC passed the stop line at red onset</td>
<td>Not Effective</td>
</tr>
</tbody>
</table>
Example of a Detected VHRC in the DD System

(a) DD
Example of a Detected VHRC in the SUSCD at 125 ft

(b) SUSCD at 125 ft
Example of a Detected VHRC in the SUSCD at 215 ft
Example of a Detected VHRC in the SUSCD at 475 ft
Operational Measurements for Detection Strategies

- SUSCD at 475 ft.
- SUSCD at 215 ft.
- SUSCD at 125 ft.
- DD

Vehicle Delay (s) vs. Stop Delay (s)
Comparison of Accuracy, Efficiency, and Operational Measurements in Detection Systems

<table>
<thead>
<tr>
<th>Distance</th>
<th>Correct Detection</th>
<th>Correct Call</th>
<th>Highly Effective</th>
<th>Mean Vehicle Delay</th>
<th>Mean Stop Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUSCD 475 ft.</td>
<td>49.3%</td>
<td>8.5%</td>
<td>100%</td>
<td>13.31s</td>
<td>5.56s</td>
</tr>
<tr>
<td>SUSCD 215 ft.</td>
<td>23.1%</td>
<td>18.3%</td>
<td>97.3%</td>
<td>13.1s</td>
<td>5.36s</td>
</tr>
<tr>
<td>SUSCD 125 ft.</td>
<td>65.1%</td>
<td>28.4%</td>
<td>75.5%</td>
<td>13.03s</td>
<td>5.32s</td>
</tr>
<tr>
<td>DD</td>
<td>67%</td>
<td>38.6%</td>
<td>17.7%</td>
<td>13.08s</td>
<td>5.35s</td>
</tr>
</tbody>
</table>

- Correct Detection
- Correct Call
- Highly Effective
- Mean Vehicle Delay
- Mean Stop Delay
System Alternatives

- The DD alternative provided higher accuracy than the SUSDC systems.
- The SUSCD systems provided higher efficiency than the DD system.
- The average vehicle delay was relatively low for each alternative.

While the SUSCD systems have a higher rate of false prediction, they introduced the potential for a more robust RLE.
Opportunities for Future Work

• HIL simulations of additional RLE system designs
  • Alternative detection placement
  • Refine RLE prediction logic

• Field Evaluation of alternative vehicle detection strategies
  • Evaluate SUSCD system in the field
  • Evaluate RLE system leveraging wide area detection
Journal Articles


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