Radar Vehicle Detection Within Four Quadrant Gate Crossings

Dylan Horne

2014 Global Level Crossing Symposium
August 4-8, 2014
Urbana, IL
Problem Statement

- Increased exposure at grade crossings due to train frequencies and traffic volumes.
- Short throat storage at adjacent signalized intersections may lead to queuing on the track.
- Highway and rail vehicle collisions are costly in terms of damage and delay but ultimately in loss of life.
Current Solutions

- Closure / Consolidation
- Active Warning Devices
- Traffic Signal Preemption
- Four Quadrant Gates
- Grade Separation
Potential Solution

• Use vehicle detection to determine if a crossing is clear
  – Provides dynamic control of the exit gate

• Less delay between entry and exit gate descent

• Extends the exit gate delay only in the direction of a ‘trapped’ vehicle.
Radar Installation

1) Introduction

2) Literature Review

3) Methodology

4) Results

5) Conclusions

6) Acknowledgments
Federal Highway Administration Grants

1) Introduction

- Two grants totaling $1,263,800 to NC Department of Transportation
  - 7 Sites, 3 Currently

2) Literature Review

3) Methodology

4) Results

5) Conclusions

- Two phases of ITRE study:
  - Passive Portion
  - Active Portion

6) Acknowledgments
North Carolina Projects

1) Introduction

2) Literature Review

3) Methodology

4) Results

5) Conclusions

6) Acknowledgments

---

Detection Site
Goal: 90 mph Train Speed

---

Private Crossing Safety Initiative (PCSI) Projects totaling $1.3M will be constructed in Alamance, Cabarrus, Guilford, Orange, Rowan & Wake Counties. Projects subject to change based on availability of funds and approval of essential environmental documents.
Exit Gate Operating Modes (EGOM)

<table>
<thead>
<tr>
<th>Train Approach</th>
<th>Train Arrival Imminent (20 Sec Minimum)</th>
<th>Train Present</th>
<th>Train Clears Buffer Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locomotive Triggers Proximity Sensor</td>
<td>Equipment Response Time</td>
<td>Entrance Gate</td>
<td>Total Warning Time</td>
</tr>
<tr>
<td>No Left Turn Train, Yellow / Red Delay</td>
<td>Entrance Gate Descends</td>
<td>Entrance Gate Horizontal (5 Sec Minimum before Train Arrival)</td>
<td></td>
</tr>
<tr>
<td>Exit Gate Delayed (Timed or Failsafe Mode)</td>
<td>Exit Gate Descends</td>
<td>Exit Gate Horizontal</td>
<td></td>
</tr>
<tr>
<td>No Vehicle Detected Clearance Time</td>
<td>Exit Gate Descends</td>
<td>Exit Gate Horizontal</td>
<td></td>
</tr>
<tr>
<td>Vehicle Detected Exit Gate Delayed</td>
<td>Vehicle Clears Exit Gate Descends</td>
<td>Exit Gate Horizontal</td>
<td></td>
</tr>
</tbody>
</table>

1) Introduction

2) Literature Review

3) Methodology

4) Results

5) Conclusions

6) Acknowledgments

Modified from Hellman and Ngamdung


Radar Vehicle Detection Within Four Quadrant Gate Crossings

GLXS 2014

Global Level Crossing Safety and Trespass Prevention Symposium

University of Illinois at Urbana-Champaign

moffatt & nichol
## Sensor Types

<table>
<thead>
<tr>
<th></th>
<th>Inductive Loops</th>
<th>Radar</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical Uses</strong></td>
<td>Actuated Intersections</td>
<td>Freeway Volume Detection</td>
</tr>
<tr>
<td><strong>Railroad Applications</strong></td>
<td>Illinois HSR Connecticut NEC</td>
<td>Illinois Evaluation North Carolina</td>
</tr>
<tr>
<td><strong>Installation Location</strong></td>
<td>Embedded in Roadway</td>
<td>Mounted Overhead</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>May Cause Delay During Installation / Maintenance</td>
<td>Higher Purchase Cost</td>
</tr>
<tr>
<td><strong>Life Cycle</strong></td>
<td>4 to 6 years</td>
<td>10 years</td>
</tr>
<tr>
<td><strong>Redundant Coverage</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Illinois Evaluation</strong>*</td>
<td>No Missed Detections</td>
<td>No Missed Detections</td>
</tr>
</tbody>
</table>

Dual Matrix Radar Detection

1) Introduction

2) Literature Review

3) Methodology

4) Results

5) Conclusions

6) Acknowledgments

Radar Vehicle Detection Within Four Quadrant Gate Crossings
1) Introduction

2) Literature Review

3) Methodology

4) Results

5) Conclusions

6) Acknowledgments

Camera Image

Radar Vehicle Detection Within Four Quadrant Gate Crossings
Delayed Exit Gate

1) Introduction

2) Literature Review

3) Methodology

4) Results

5) Conclusions

6) Acknowledgments

Radar Vehicle Detection Within Four Quadrant Gate Crossings
Gate Operations & Radar Detection Counts

Stages of Crossing Activation

1) Introduction
2) Literature Review
3) Methodology
4) Results
5) Conclusions
6) Acknowledgments

Activation: From Train Detection on Approach to First Car Crossing Rail

Radar Vehicle Detection Within Four Quadrant Gate Crossings
Detection Classification and Anomalies

1. Successful Detection
2. Missed Detection
3. Critical Failure
4. False Detection
   - Phantom Detection
   - Rain or Snow Detection
   - Adjacent Lane Detection

Introduction

Literature Review

Methodology

Results

Conclusions

Acknowledgments
Mebane: 5th Street

1) Introduction
2) Literature Review
3) Methodology
4) Results
5) Conclusions
6) Acknowledgments

<table>
<thead>
<tr>
<th>City</th>
<th>Mebane, NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing Number</td>
<td>735 472 D</td>
</tr>
<tr>
<td>Road Name</td>
<td>5th Street</td>
</tr>
<tr>
<td>Local Land Use</td>
<td>Commercial</td>
</tr>
<tr>
<td>Warning Devices</td>
<td>4QG, 2 Cantilevers, 12 Flashing Pairs, Preemption</td>
</tr>
<tr>
<td>Number of Tracks</td>
<td>1 Main</td>
</tr>
<tr>
<td>Number of Daily Trains / Speed</td>
<td>16 @ 60 mph</td>
</tr>
<tr>
<td>Number of Highway Lanes / Speed</td>
<td>3 NB, 2 SB @ 35 mph</td>
</tr>
<tr>
<td>ADT (year)</td>
<td>12,290 (2010)</td>
</tr>
<tr>
<td>Collisions (year)</td>
<td>7 (10, 10, 05, 87, 81, 80, 78)</td>
</tr>
</tbody>
</table>

Radar Vehicle Detection Within Four Quadrant Gate Crossings
Durham: Ellis Road

1) Introduction

2) Literature Review

3) Methodology

4) Results

5) Conclusions

6) Acknowledgments

<table>
<thead>
<tr>
<th>City</th>
<th>Durham, NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing Number</td>
<td>735 236 Y</td>
</tr>
<tr>
<td>Road Name</td>
<td>Ellis Road</td>
</tr>
<tr>
<td>Local Land Use</td>
<td>Industrial: Heavy Vehicles</td>
</tr>
<tr>
<td>Warning Devices</td>
<td>4QG, 1 Cantilever, 7 Flashing Pairs, Preemption</td>
</tr>
<tr>
<td>Number of Tracks</td>
<td>1 Main, 1 Siding, 1 Yard</td>
</tr>
<tr>
<td>Number of Daily Trains / Speed</td>
<td>16 @ 60 mph</td>
</tr>
<tr>
<td>Number of Highway Lanes / Speed</td>
<td>2 NB, 1 SB @ 35 mph</td>
</tr>
<tr>
<td>ADT (year)</td>
<td>5,866 (2010)</td>
</tr>
<tr>
<td>Collisions (year)</td>
<td>12 (10, 09, 08, 06, 02, 01, 98, 87, 79, 79, 79, 75)</td>
</tr>
</tbody>
</table>

Radar Vehicle Detection Within Four Quadrant Gate Crossings
Elon: Williamson Avenue

1) Introduction

2) Literature Review

3) Methodology

4) Results

5) Conclusions

6) Acknowledgments

<table>
<thead>
<tr>
<th>City</th>
<th>Elon, NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing Number</td>
<td>722 995 V</td>
</tr>
<tr>
<td>Road Name</td>
<td>Williamson Avenue</td>
</tr>
<tr>
<td>Local Land Use</td>
<td>University: Pedestrians</td>
</tr>
<tr>
<td>Warning Devices</td>
<td>4QG, 2 Cantilevers, 12 Flashing Pairs, Preemption</td>
</tr>
<tr>
<td>Number of Tracks</td>
<td>1 Main</td>
</tr>
<tr>
<td>Number of Daily Trains / Speed</td>
<td>16 @ 60 mph</td>
</tr>
<tr>
<td>Number of Highway Lanes / Speed</td>
<td>1 NB, 2 SB @ 20 mph</td>
</tr>
<tr>
<td>ADT (year)</td>
<td>6,805 (2010)</td>
</tr>
<tr>
<td>Collisions (year)</td>
<td>1 (84)</td>
</tr>
</tbody>
</table>

Radar Vehicle Detection Within Four Quadrant Gate Crossings
### Vehicle Detection

<table>
<thead>
<tr>
<th>Car / Truck</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
<th>Stage 5-8</th>
<th>Activations</th>
<th>Violating Vehicles *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durham</td>
<td>75 / 3</td>
<td>41 / 4</td>
<td>1 / 0</td>
<td>1 / 0</td>
<td>None</td>
<td>294</td>
<td>43 / 4 16%</td>
</tr>
<tr>
<td>Elon</td>
<td>125 / 0</td>
<td>41 / 0</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>311</td>
<td>41 / 0 13%</td>
</tr>
<tr>
<td>Mebane</td>
<td>107 / 2</td>
<td>66 / 4</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>147</td>
<td>66 / 4 48%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>307 / 5</td>
<td>148 / 8</td>
<td>1 / 0</td>
<td>1 / 0</td>
<td>None</td>
<td>752</td>
<td>150 / 8 21%</td>
</tr>
</tbody>
</table>

*Violating Vehicles cross after the start down of the entrance gate
Percentage is the number of activations with a violating vehicle
Detection Classification and Anomalies

<table>
<thead>
<tr>
<th></th>
<th>Successful Detection</th>
<th>Missed Detection</th>
<th>False Detection</th>
<th>Phantom Detection</th>
<th>Rain or Snow Detection</th>
<th>Adjacent Lane Detection</th>
<th>Critical Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durham</td>
<td>125</td>
<td>0</td>
<td>3(^1)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Elon</td>
<td>166</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Mebane</td>
<td>179</td>
<td>0</td>
<td>3(^2)</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>470</strong></td>
<td><strong>0</strong></td>
<td><strong>7</strong></td>
<td><strong>0</strong></td>
<td><strong>1</strong></td>
<td><strong>3</strong></td>
<td><strong>0</strong></td>
</tr>
<tr>
<td>% of Total</td>
<td>98.5%</td>
<td>0.0%</td>
<td>1.5%</td>
<td>0.0%</td>
<td>0.2%</td>
<td>0.6%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

False detection issue resolved by adjusting:
1 Radar mounting angle
2 Radar sensitivity
Conclusions

• 10 Seconds between entrance gate down and exit gate start down

• 15 Seconds between gates fully deployed and train arrival

• Radar detection system is very reliable
  – No Missed Detections
  – 98.5% Successful detections
  – False detection issues were resolved
Conclusions

- 1 in 5 Activations have a violating vehicle
- 1 in 3 Vehicles that arrive during an activation violate the active warning devices
- Currently collecting active data for comparison
Acknowledgments

1) Introduction

2) Literature Review

3) Methodology

4) Results

5) Conclusions

6) Acknowledgments

- Drew Thomas, PE  NCDOT
- Richard Mullinax, PE, PTOE  NCDOT
- Don Hudson  NCDOT
- Tom Hilleary  Island Radar
- Paul Worley, CPM  NCDOT
- Norfolk Southern Corporation
Dylan Horne

THANK YOU!

Moffatt & Nichol
dhorne@moffattnichol.com
919.781.4626

www.moffattnichol.com