IMPROVING SAFETY AT RAILROAD HIGHWAY GRADE CROSSINGS

Presented by
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RAILROAD CROSSINGS
“Driver Decisions at Gated Rail-Highway Crossings”

Douglas L. Cooper and David R. Ragland
Traffic Safety Center
University of California, Berkeley

2008 Rail Corridor Safety Conference

May 14, 2008
## Number and Type of Crossings in California

<table>
<thead>
<tr>
<th>Type of Crossing</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>7,719</td>
</tr>
<tr>
<td>Private</td>
<td>4,777</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12,496</strong></td>
</tr>
</tbody>
</table>

Private crossing – scene of a fatal crash involving a low bed truck that became high centered
### Public At-Grade Crossing Warning Equipment (2005)

<table>
<thead>
<tr>
<th>Traffic Control Device Type</th>
<th>Number</th>
<th>Percentage</th>
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<tbody>
<tr>
<td><strong>Passive (43.2%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Signs or Signals</td>
<td>172</td>
<td>2.2%</td>
</tr>
<tr>
<td>Other Signs or Signals</td>
<td>17</td>
<td>0.2%</td>
</tr>
<tr>
<td>Crossbucks</td>
<td>2,805</td>
<td>36.3%</td>
</tr>
<tr>
<td>Stop Signs</td>
<td>307</td>
<td>4.0%</td>
</tr>
<tr>
<td>Special Signs or Warning</td>
<td>42</td>
<td>0.5%</td>
</tr>
<tr>
<td><strong>Active (56.8%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hwy Traffic Sig, Wigwags, or other Activated</td>
<td>270</td>
<td>3.5%</td>
</tr>
<tr>
<td>Flashing Lights</td>
<td>982</td>
<td>12.7%</td>
</tr>
<tr>
<td>All Other Gates</td>
<td>3,124</td>
<td>40.5%</td>
</tr>
<tr>
<td>4 Quad</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td><strong>Total Public At Grade</strong></td>
<td>7,719</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: FRA

### Warning Equipment For California Public Crossings With Crashes 2000-2004

<table>
<thead>
<tr>
<th>Control Device</th>
<th>Number of Train/Vehicle Crashes</th>
<th>Percentage of All Train/Vehicle Crashes</th>
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<tbody>
<tr>
<td>Gates</td>
<td>434</td>
<td>73.2%</td>
</tr>
<tr>
<td>Cantilever Flashing Lights</td>
<td>23</td>
<td>3.9%</td>
</tr>
<tr>
<td>Std Flashing Lights</td>
<td>46</td>
<td>7.8%</td>
</tr>
<tr>
<td>Wre Wag</td>
<td>5</td>
<td>0.8%</td>
</tr>
<tr>
<td>Hwy Traffic Sig</td>
<td>2</td>
<td>0.3%</td>
</tr>
<tr>
<td>Audible</td>
<td>2</td>
<td>0.3%</td>
</tr>
<tr>
<td>Cross Bucks</td>
<td>47</td>
<td>9.6%</td>
</tr>
<tr>
<td>Stop Signs</td>
<td>20</td>
<td>3.4%</td>
</tr>
<tr>
<td>Watchman</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Flagged by Crew</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>None</td>
<td>3</td>
<td>0.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>593</td>
<td>100%</td>
</tr>
</tbody>
</table>

The devices listed are the highest level of warning at a particular crossing. Thus a crossing with gates and flashing lights would be listed only under the "Gates" category. 
Source: FRA
Driver Behavior

Driver “Model” For Rail Crossing

- First, the driver makes a judgment about the time of arrival of the train.

- Second, the driver makes a judgment about the time needed to complete the crossing. The driver makes an allowance for error by including a “margin for error”, or a “buffer” to the total crossing time.

- Third, the driver makes a decision to cross or not to cross based on a sense of whether the crossing time is less than the anticipated time of arrival of the train.
Judging Time To Arrival

1. Detecting speed or time to collision from changes in an object’s size has been shown to be difficult.

2. In general, human vision underestimates the speed of large objects.

Rate of Change in Viewing Angle vs. Time-To-Collision

θ = Object’s Visual Angle
In general, human vision underestimates the speed of large objects.
Train is less than 20 seconds away
Railroad – Highway Crossing Crash Counter Measures
Railroad Crossing Crash Counter Measures

- Preemption of signals
- Medians
- Quad Gates
- Pre-signals
- Arresting Barriers/Long Arm Gates
- Multiple track warnings
- Automated Enforcement
- Pedestrian Path Treatments
- Bicycle Crossing Treatments

Raised Medians or Barriers
Raised Mountable Median Barriers

Quad Gates

- Courtland, IL
- Source: QuickKurb
Four-quadrant gate HSR crossing in Gardner, Illinois
Source: Ms. Anya A. Carroll, Principal Investigator
Acting Deputy Director, Office of Surface Transportation Programs,
Volpe Center

Vehicle presence detection
Source: Design of Traffic Signal Improvements Next to Railroad Crossings – Recent Experiences in Southern California
Presignals
Pre signal stays Red during preemption
Queue Cutters

Queue cutter signal turns red when vehicle queue over the downstream detectors

Source: Railroad – Highway Grade Crossing Handbook
Queue cutter signal in advance of tracks
Source: Railroad – Highway Grade Crossing Handbook

Queue cutter signal can be a significant Distance away from the track
Source: Design of Traffic Signal Improvements Next to Railroad Crossings – Recent Experiences in Southern California
Barrier Gates

J. VanHoff Photo
Vehicle Arresting Barrier
Chenoa, IL Installation

Photo: David Moses

Multiple Track Warnings
Traffic Signal Preemption

Railroad Signal Preemptions

- Required if crossing close to the intersection (200 foot rule)
- Best to evaluate queues in the field
- Peak period conditions
- Can use software such as Synchro or Vissim
Example of location where queue becomes longer than 200 feet

Source: Design of Traffic Signal Improvements Next to Railroad Crossings – Recent Experiences in Southern California

Tracks cleared of traffic before gates close by preempted signal turning green
Adjacent traffic signal in all-red flash or green for parallel street

**Advance Pre-emption**

- Traffic signal is notified of an approaching train prior to the railroad warning devices (50-60 seconds)
- Used to serve phases that need to be served before pre-emption begins
- Suppress phases that cannot be served during pre-emption (pedestrians)
- Improves safety of separation event
Preemption Time Line
Source: Sean Skehan, City of Los Angeles
Advance Pre-emption

- LADOT Advance Pre-emption Form Checks:
- Design vehicle approaching the track has its front end past the RR warning devices before the devices start flashing and;
- There is enough time for a conflicting design vehicle to clear the intersection + enough time for the design vehicle to clear the track

NTSB finding on railroad crossing crash

*Source: Urban Transportation Monitor*
Train Track

Left-turning vehicle is able to go past the end of the gate.
Left-turn signal was in Flashing red mode during Preemption sequence

Key NTSB Recommendations

- Prohibit all-red flash option during railroad hold interval – California Department of Transportation
- Add raised median on crossing approaches – City of Burbank, CA
- Limit use of all-red flash mode to situations in which they permit drivers to stop and proceed with caution – National Committee on UTCD
- NTSB report posted at:
Automated Enforcement
Automated Enforcement at a Railroad Crossing

Quiet Zone Crossings
Quiet zone treatments

- Reference to Code of Federal Regulations (49 CFR Part 222) -- quiet zones established in conjunction with restrictions on train horns at certain highway-rail grade crossings

- TCDs used as part of a quiet zone shall comply with MUTCD

Supplemental Safety Measures

- Four quadrant gates
- Gates with medians
- Gates with channelization
- Close crossing
No Train Horn Sign and Quad Gates

Medians on crossing approaches
Quiet Zone in San Diego
Proposed Improvements

- Median Extensions
- Exit Gates
- On-way Streets
- Pedestrian Gates
- Constant Warning Time on BNSF
- Queue Cutter Signals
- Pre-Signals
- Advance Preemption
- Vehicle Presence-Based Track Clearance Green

Constant Warning Time Circuitry

Constant warning time circuitry adjusts for train speed and causes the crossing signals to always operate for the same amount of time before the train reaches the crossing, regardless of train speed. A motion detector simply detects the train operation, but does not adjust for train speed so that the amount of warning time varies based on train speed.
Comprehensive Quiet Zone Presentation

- “Design of Traffic Signal Improvements Next to Railroad Crossings – Recent Experiences in Southern California
- Eric Hankinson, P.E., President, RailPros Inc.
- May 13, 2008
- http://www.techtransfer.berkeley.edu/railroad08downloads/

Conducting Effective Crossing Diagnostics

Defining Roles, Responsibilities, and Objectives

Presented by:
Kurt Anderson
May 13, 2008
What is the Diagnostic Team’s Purpose?

**RR-Hwy Grade Crossing Handbook**

“To evaluate the crossing as to its deficiencies and develop judgmental consensus as to the recommended improvements.”

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**Diagnostic Team Roles & Responsibilities**

**Highway Authority/Regulatory Agency**

- Advise types of vehicles, volumes and speeds
- Proposed plans for roadway improvements
- Knowledge of traffic control systems, signs and markings for highway-rail grade crossings
- Advise team of specific policy & administrative rules regarding modification of devices
Diagnostic Team Roles & Responsibilities (Contd)

**Railroad**
- Advise team of RR operations at the crossing including volumes and speeds
- Advise team of RR circuitry and RR design requirements
- Advise team of proposed RR improvements
- Knowledge of traffic control systems, signs and markings for highway-rail grade crossings

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**Figure 6. Sample Questionnaire for Diagnostic Team Evaluation**

**LOCATIONAL DATA:**
- Street Name: __________________________ City: __________________________
- Railroad: __________________________ Crossing Number: __________________________

**VEHICLE DATA:**
- No. of Approach Lanes: ______ Approach Speed Limit: ______ AADT: ______
- Approach Curvature: ______ Approach Gradient: ______

**TRAIN DATA:**
- No. of Tracks: ______ Train Speed Limit: ______ Trains Per Day: ______
- Track Gradients: ______

**SECTION I — Distance Approach and Advance Warning**
1. Is advance warning of railroad crossing available? If so, what devices are used?
2. Do advance warning devices alert drivers to the presence of the crossing and allow time to react to approaching train traffic?
3. Do approach grades, roadway curvature, or obstructions limit the view of advance warning devices? ____ If so, how?
4. Are advance warning devices readable under night, rainy, snowy, or foggy conditions? ______

**SECTION II — Immediate Highway Approach**
1. What maximum safe approach speed will existing sight distance support?
2. Is that speed equal to or above the speed limit on that part of the highway?
3. If not, what has been done, or reasonably could be done, to bring this to the driver’s attention?
4. What restrictive obstructions to sight distance might be removed?
5. Do approach grades or roadway curvature restrict the driver’s view of the crossing?
6. Are railroad crossing signals or other active warning devices operating properly and visible to adequately warn drivers of approaching trains?
A train at this point allows vehicles at "B" to safely proceed across grade crossing.

Table 5. Distances in Feet to Establish Study Positions for Diagnostic Team Evaluation

<table>
<thead>
<tr>
<th>Design vehicle speed (miles per hour)</th>
<th>Distance from stop lines to cone A (feet)</th>
<th>Distance from stop lines to cone B (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>400</td>
<td>220</td>
</tr>
<tr>
<td>40</td>
<td>500</td>
<td>320</td>
</tr>
<tr>
<td>55</td>
<td>600</td>
<td>420</td>
</tr>
<tr>
<td>65</td>
<td>700</td>
<td>520</td>
</tr>
<tr>
<td>75</td>
<td>800</td>
<td>620</td>
</tr>
<tr>
<td>85</td>
<td>900</td>
<td>720</td>
</tr>
</tbody>
</table>

* Note: The distance from the stop line is assumed to be 21 feet from nearest rail, or 1 foot from the grade if one is present.

Approach Zone Considerations

- Driver awareness of the crossing
- Visibility of the crossing
- Effectiveness of advance warning signs and signals
- Geometric features of the roadway

Non-Recovery Zone Considerations

- Driver awareness of approaching trains.
- Driver dependence on crossing signals.
- Obstruction of view of train’s approach.
- Roadway geometrics diverting driver attention.
- Potential location of standing railroad cars.
- Possibility of removal of sight obstructions.
- Availability of information for stop or go decision by the driver.
Crossing Zone Considerations

- Sight distance down the tracks.
- Pavement markings at the crossing.
- Conditions conducive to vehicles becoming stalled or stopped on the crossing.
- Operation of vehicles required by law to stop at the crossing.
- Signs and signals as fixed object hazards.
- Pedestrian usage.
Factors to Consider

- **Closure/Consolidation**
  - Proximity of Adjacent Crossings (incl. type & warning device)
  - Alternate Routes
  - Emergency Response
  - Bus Route (School, Transit)

- **Safety History**
  - ✔ Highway Volumes
  - ✔ Type of Hwy Traffic (Bus, Haz Mat, % Trucks)
  - ✔ Pedestrians
Factors to Consider (Contd)

✓ Type of Railroad Traffic & Volumes
   - Night/Day
   - Through/Switch
   - Freight/Passenger/Haz Mat

✓ Number & Type of Tracks
   - Mainline
   - Sidings
   - Industrial Lead/Track

✓ Number & Type of Highway Lanes
   - Through
   - Parking
   - Turn
Factors to Consider (Contd)

- Visual Obstructions
- Visual Clutter
- Angle of Crossing
- Alignments
  - Highway Horizontal
  - Highway Vertical
  - Railroad Horizontal
- Nearby Devices (resulting in queues on tracks)
  - Stop/Yield Signs
  - Traffic Signals
  - Storage Distance

Signage conflicts
Factors to Consider (Contd)

✔ Existing Traffic Control Devices
  ❖ Advance Warning Signs
  ❖ Pavement Markings
  ❖ Crossbucks
  ❖ Yield Signs
  ❖ Stop Signs
  ❖ Flashing Light Signals (Mast Mounted/Cantilever)
  ❖ Gates
  ❖ Circuitry

✔ Sight Distance
  ❖ Stopping Sight Distance (SSD)
  ❖ Clearing Sight Distance (CSD)

Keep Clear Markings
Bicycles at Railroad Grade Crossings

Railroad Xings at 90 degrees

Source: MUTCD
Railroad Crossing for Bikes

Warnings and Behavior: A Study of Pedestrian Behavior at Grade Crossings

Gavin Huntley-Fenner, Ph.D.
Managing Scientist
Exponent, Inc.
May, 2008
**Counter-trend: Pedestrian incidents markedly increased**

- Pedestrian incidents have increased by 20%
- Constitute between 10% and 20% of all incidents

**Pattern of pedestrian incidents - counter intuitive**

- Similar numbers of motor vehicle incidents at gates & crossbucks
- 10x more pedestrian incidents with gated crossings than with crossbucks

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A study by the State of Illinois showed that pedestrian gates alone have a low compliance rate when pedestrians can easily circumvent them.
Train Tracks

Source: Railroad-Highway Grade Crossing Handbook
Arm block travel lanes and sidewalk.

Source: Railroad-Highway Grade Crossing Handbook
Compilation of Pedestrian Safety Devices In Use at Grade Crossings

Federal Railroad Administration


Source: Compilation of Pedestrian Safety Devices in Use at Grade Crossings
Pedestrian Arm

Source: Compilation of Pedestrian Safety Devices in Use at Grade Crossings

2009 MUTCD

PROPOSED CHANGES TO PARTS 8 and 10
HIGHWAY-RAIL GRADE CROSSINGS
LIGHT RAIL - TRANSIT GRADE CROSSINGS

Rick Campbell
Chairman
Railroad & Light Rail Transit Technical Committee
National Committee on Uniform Traffic Control Devices

May 14, 2008
Revisions to Part 8 – Traffic Controls for Highway-Rail Crossings

STOP or YIELD signs shall be posted at all passive grade crossings

- STOP or YIELD signs shall be posted at all passive grade crossings.
- STOP or YIELD signs shall be posted at 2.8 m (9 ft) from the edge of the roadway.
- 50 mm (2 in) white or red retroreflective strip on front.
- 0.6 m (2 ft) max. edge of roadway.
- 150 mm (6 in) white retroreflective strip on back of support.

See notes.
Passive Crossing
Red lettering allowed on Crossbuck signs

Supplemental plaques describing the type of control shall be used with advance warning signs
LOOK signs may be mounted on a separate sign post

This change was needed because other changes require other signs to be placed on the Cross buck assembly and there would be insufficient space for the LOOK sign.

Stop lines shall be used on paved roadways at crossings controlled by active devices
Stripes on gate arms shall be vertical

Where gates are located in the median, additional median width may be required to provide the minimum clearance for the counterweight supports.

100 mm (4 in) MAX. ABOVE GROUND LEVEL

Back-up power should be provided for signals with railroad preemption
Grade crossings within or in close proximity to roundabouts, traffic circles, or circular intersections

- Engineering study required to evaluate potential queuing
- If queues impact crossing, provisions shall be made to clear highway traffic from the crossing before train arrivals
- Recommend not constructing a roundabout if there is a railroad close enough that the queue from the roundabout will crossing the tracks

Railroad Xing

When a long train uses the crossing, traffic backs up into the roundabout all traffic comes to a standstill
Train through a roundabout. This is for a light rail operation.

Traffic Control Signal Warrant 9
(MUTCD Part 4)

✓ Provides for the installation of a traffic control signal at an intersection where a highway-rail grade crossing is adjacent to the intersection.

✓ Utilized where traffic volumes are low enough not to warrant a traffic control signal in existing warrants 1 through 8.

✓ Provides a means to clear vehicles from the track with an approaching train through interconnection and preemption.
Downstream Stop Control

New Chapter on Pathway-Rail Grade Crossings
Recent Publications on Railroad Crossings

ITE Recommended Practice on Railroad Preemption
GUIDANCE ON TRAFFIC CONTROL DEVICES AT HIGHWAY-RAIL GRADE CROSSINGS

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
HIGHWAY-RAIL GRADE CROSSING TECHNICAL WORKING GROUP (TWG)

NOVEMBER 2002

http://www.ite.org/bookstore/gradecrossing/lo_res_RR_BOOK.pdf

http://cms.transportation.org/sites/scote/docs/twgreport.pdf
Investigating the Role of Driver Decision Styles in Highway-Rail Crossing Accidents

Final Report

December 2003

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Eppley Department of Industrial and Systems Engineering
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Mounir Rahim
Eppley Department of Industrial and Systems Engineering
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Recent FRA/Volpe Publications

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Hellman et al</td>
<td>Evaluation of the School Street Four-Quadrant Gate/In-Cab Signaling Grade Crossing System</td>
<td>DOT-VNTSC-FRA-03-04</td>
<td>DOT/FRA/ORD-07/06</td>
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<td>San Joaquin, California, High-Speed Rail Grade Crossing Data Acquisition: Characteristics, Methodology and Risk Assessment</td>
<td>DOT-VNTSC-FRA-06-02</td>
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<td>Railroad Infrastructure Trespass Detection Systems Research in Pittsford, New York</td>
<td>DOT-VNTSC-FRA-05-07</td>
<td>DOT/FRA/ORD-06/03</td>
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<tr>
<td>Sposato et al</td>
<td>Public Education and Enforcement Research Study</td>
<td>DOT-VNTSC-FRA-06-03</td>
<td>DOT/FRA/ORD-06/27</td>
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Source: Ms. Anya A. Carroll, Principal Investigator
Acting Deputy Director, Office of Surface Transportation Programs, Volpe Center
Upcoming Publications & Examples

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<td>Sposato et al</td>
<td>Success Factors in the Reduction of Highway-Rail Grade Crossing Incidents from 1994 to 2003</td>
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<td>Illinois Four-Quadrant Gate Analysis</td>
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