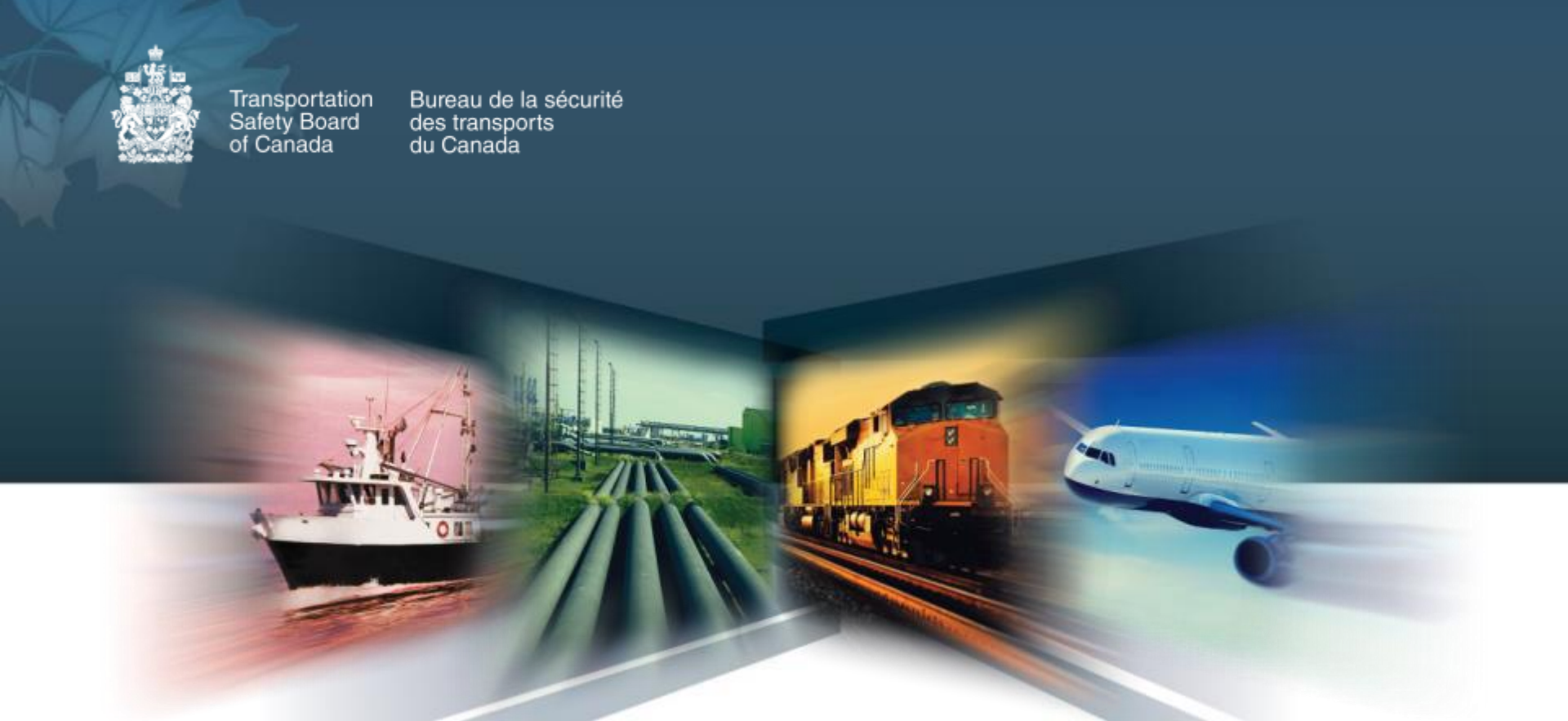
Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada



Extending the approach zone at passive level crossings: Improving train detection and driver decision-making

Christina (Missy) Rudin-Brown,
Jon J. Stuart, Don Mustard, Marilyn French-St.George, & Rob Johston

Canada

Outline -

1. Introduction
2. Accident description
3. Passive level crossing (LC) approach zones
4. Human factors issues that prolong train detection and decision-making
5. Current LC sightline requirements
6. Why and how to extend the approach zone?
7. Conclusions

Introduction -

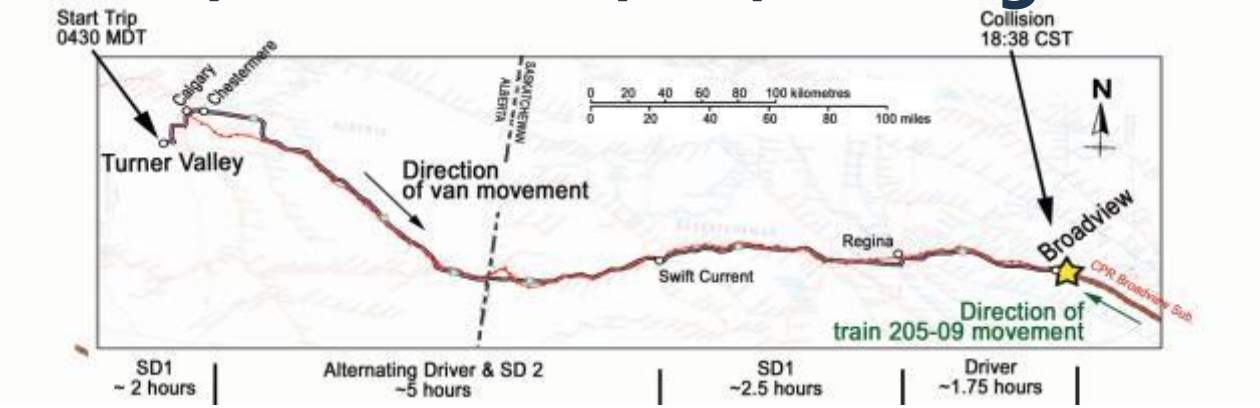
LC crashes relatively uncommon (<1% of road fatalities), BUT outcomes are devastating→ top priority worldwide

+16,000 public LCs in Canada → 10,628 (65.5%) "passive"

Between 2004 and 2013 there were 2,104 LC crashes; 31.5% occurred at passive LCs

Passive LCs ↑ crash risk and poorer driver compliance than active LCs **(TSB, 2011; Lenné et al., 2011; Rudin-Brown et al., 2012; Tey et al., 2011)**

Occurrence – R12W0182 – Broadview Subdivision, Broadview, SK, 09 August 2012



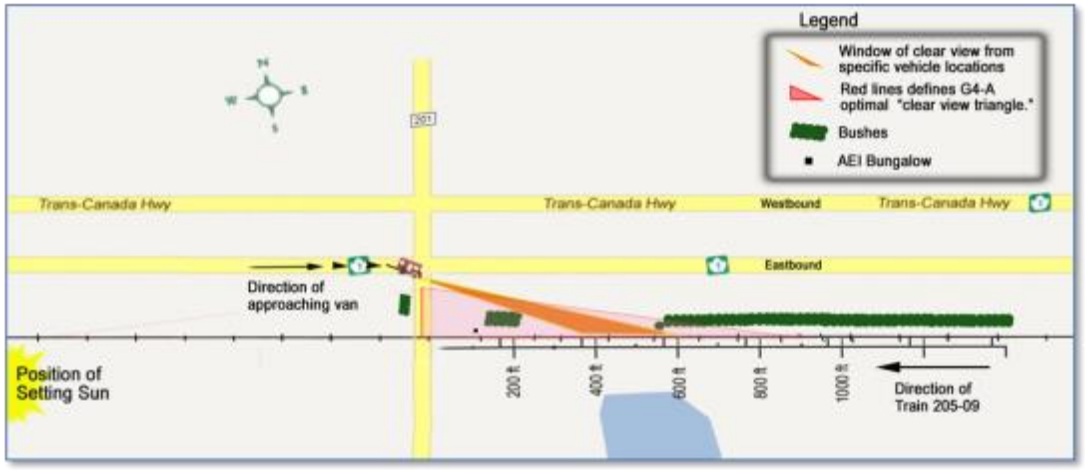


Figure 1. Accident site diagram.

Occurrence – R12W0182 – Broadview Subdivision, Broadview, SK, 09 August 2012

Driver's view west (~30 m)

Driver's view east (~40 m)

Occurrence – R12W0182 – Broadview Subdivision, Broadview, SK, 09 August 2012

Driver's view south from highway

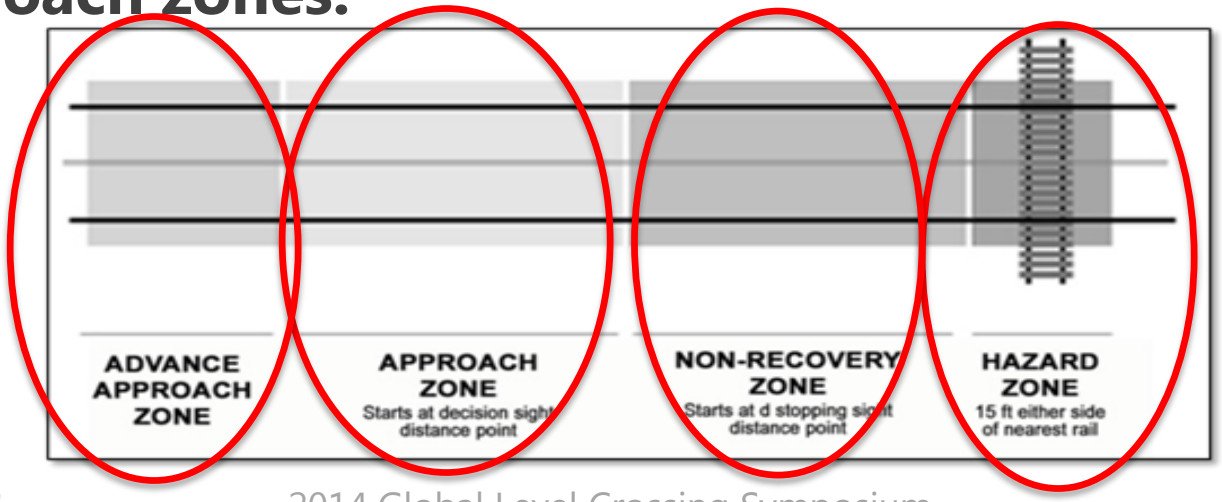
Driver's view east (~5 - 10 m)

Approach zones

4 distinct zones to effectively describe drivers' information and decision-making needs during approach to *passive* LCs

comprehensive task analysis of appropriate / inappropriate behavior / information needs at passive LCs

4 approach zones:



Human factors issues that can prolong train detection and driver decision–making

1. **Obstructed sightlines and train conspicuity:**
   - **Sightlines can be limited by roadway features → e.g., overgrown vegetation**
   - **Also road vehicle features → large window pillars and rear- and side-view mirrors**
   - **Even if no physical obstructions → locomotive / freight car conspicuity can impair train detection**
   - **Post-incident site survey and forward locomotive video showed brush alongside tracks → partially obstructed driver's view of tracks and approaching train**

Driver's view east (~40 m)

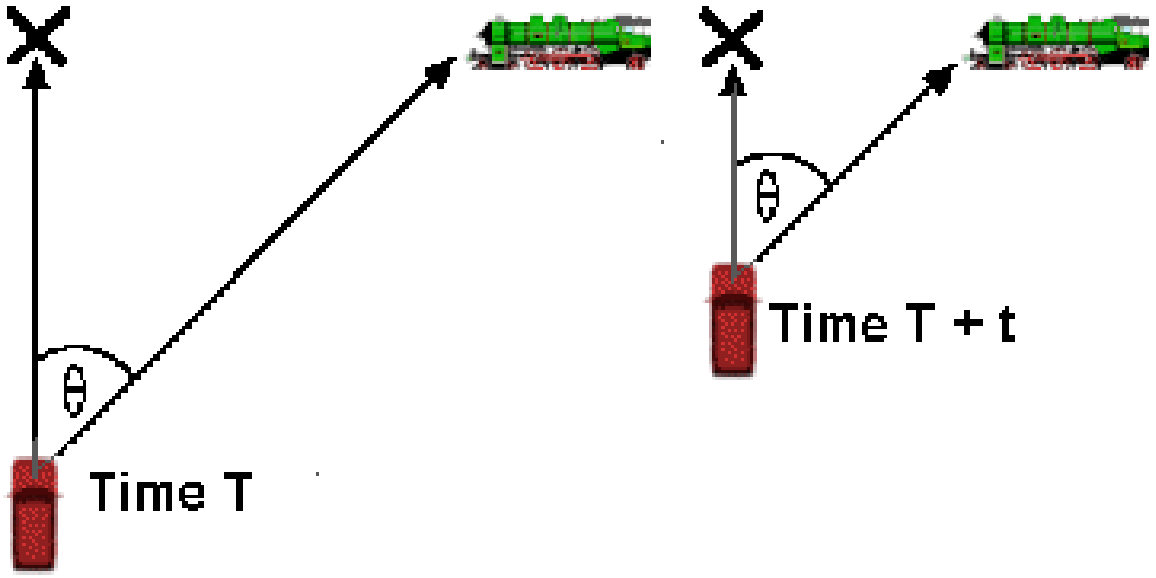
Human factors issues that can prolong train detection and driver decision–making

2. Unchanged retinal image:

- peripheral visual field detects rate of expanding flow patterns associated with changing speed → important in visually guided tasks (e.g., driving)
- driver looking ahead at road on collision course with an object approaching from the side → no retinal image motion

Human factors issues that can prolong train detection and driver decision–making

2. Unchanged retinal image:



http://www.visualexpert.com/Resources/trainaccidents.html

Human factors issues that can prolong train detection and driver decision–making

3. **Train horn audibility:**
   - **Present regulatory requirements specify minimum required sound level of 96 dB(A).**
   - **Described as "secondary alerting system" because effectiveness limited by dampening of sound by vehicle's shell and by horn mounting configuration**
   - **Campervan's shell, closed windows, ambient noise and background conversation reduced train horn audibility by increasing noise level to > 96 dB(A)**
   - **Likely not perceptible in campervan on gravel road**

Human factors issues that can prolong train detection and driver decision–making

4. **Faulty activation of schema / mental model:**
   - **Expectations and knowledge about a given situation**
   - **Internal, largely unconscious, representations or "mental short cuts"**
   - **Develop within an individual over time, with experience; can be to particular LC or *type* of LC**
   - **Many drivers have "negative expectancy" at LCs**
   - **When drivers receive info they expect, tend to react quickly and error-free, BUT**
   - **When receive info that violates expectancies (or 'schema' or 'mental model'), tend to react slowly or inappropriately**

Human factors issues that can prolong train detection and driver decision–making

5. Distraction / inattention

- Significant cause of traffic crashes
- Has been identified as contributing factor to LC crashes
- Engagement in secondary tasks at LCs common (Ngamdung & daSilva, 2012; 2013)
- Can be cognitive (thought) distractions
- Conversation with passengers at critical time during approach

Human factors issues that can prolong train detection and driver decision–making

6. Impairment from fatigue

- **Fatigue → approx. 20% of fatal road crashes (CCMTA, 2010).**

  slows reaction time, decreases vigilance, impairs decision-making ability, poor judgment, distraction and loss of awareness in critical situations

- **Impairment from fatigue can also exacerbate other conditions.**

  evidence that fatigue increases one's potential to be distracted (Anderson & Horne, 2006)

- **Driver had woken up 2.25 hours earlier than usual (at 3:45 am); this is 3.25 hours less than that recommended for teens.**
- **Supervisory driver had been awake for 22.75 hours at time of accident.**

Human factors issues that can prolong train detection and driver decision–making

7. Hazard perception

- Ability to perceive and identify specific, relevant hazards in the environment.
- On average, young novice drivers slower to detect hazards, and identify fewer hazards, than more experienced drivers (Lee, 2007).
- Probably due to less flexible visual search strategies.
- Learner driver was one week from 16th birthday; driving legally with supervisory driver.

Current passive LC sightline requirements

- **G4-A guideline specifies that a triangle-shaped clear view area should be maintained in each quadrant of the crossing.**

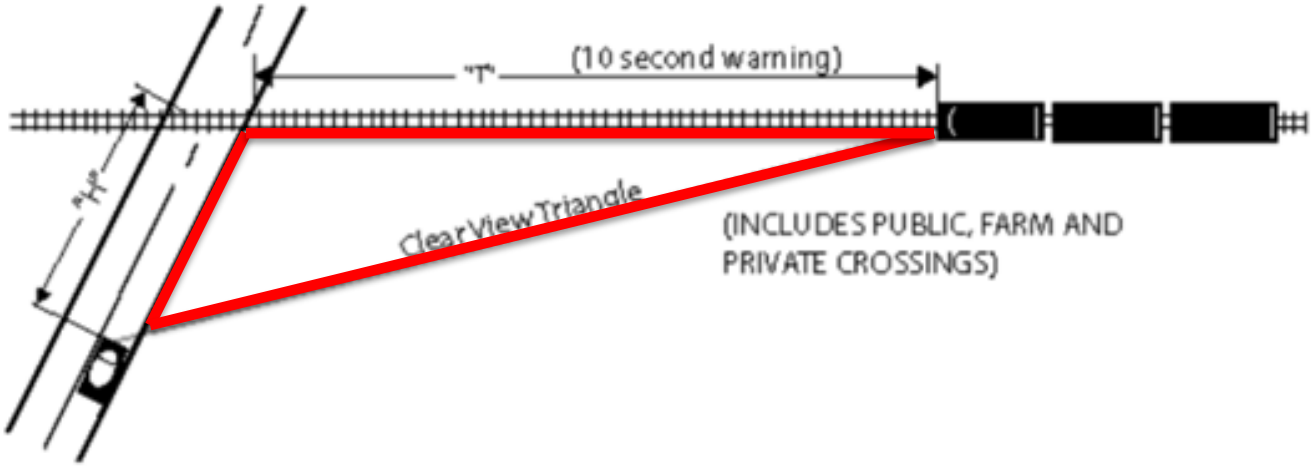


Figure 3. Diagram of minimum sightline requirements for passive level crossings (from Transport Canada Guideline G4-A, 2009)

Why extend the approach zone?

- As drivers approach a passive LC, they must complete a number of physical and cognitive tasks.
- Some factors subject to seasonal or time-of-day variations.
- Other factors are always present and need to be overcome by efforts to ensure that the train is conspicuous when the driver is assessing crossing risk.
- Also → need to consider driver <u>perception response time</u> (PRT).

Perception response time (PRT)

- PRT = period between the appearance of a (usually visual) stimulus and the driver's physical reaction to it. (TAC, 2007)
- Figure used in accident reconstruction ~1.5 s.
- In experimental studies of PRT, data collected in situations where drivers would likely be abnormally alert, and PRT could be expected to be faster than usual.
- Also does not consider drivers that did not respond in time.

Driver PRT used in LC design and sightline maintenance requirements

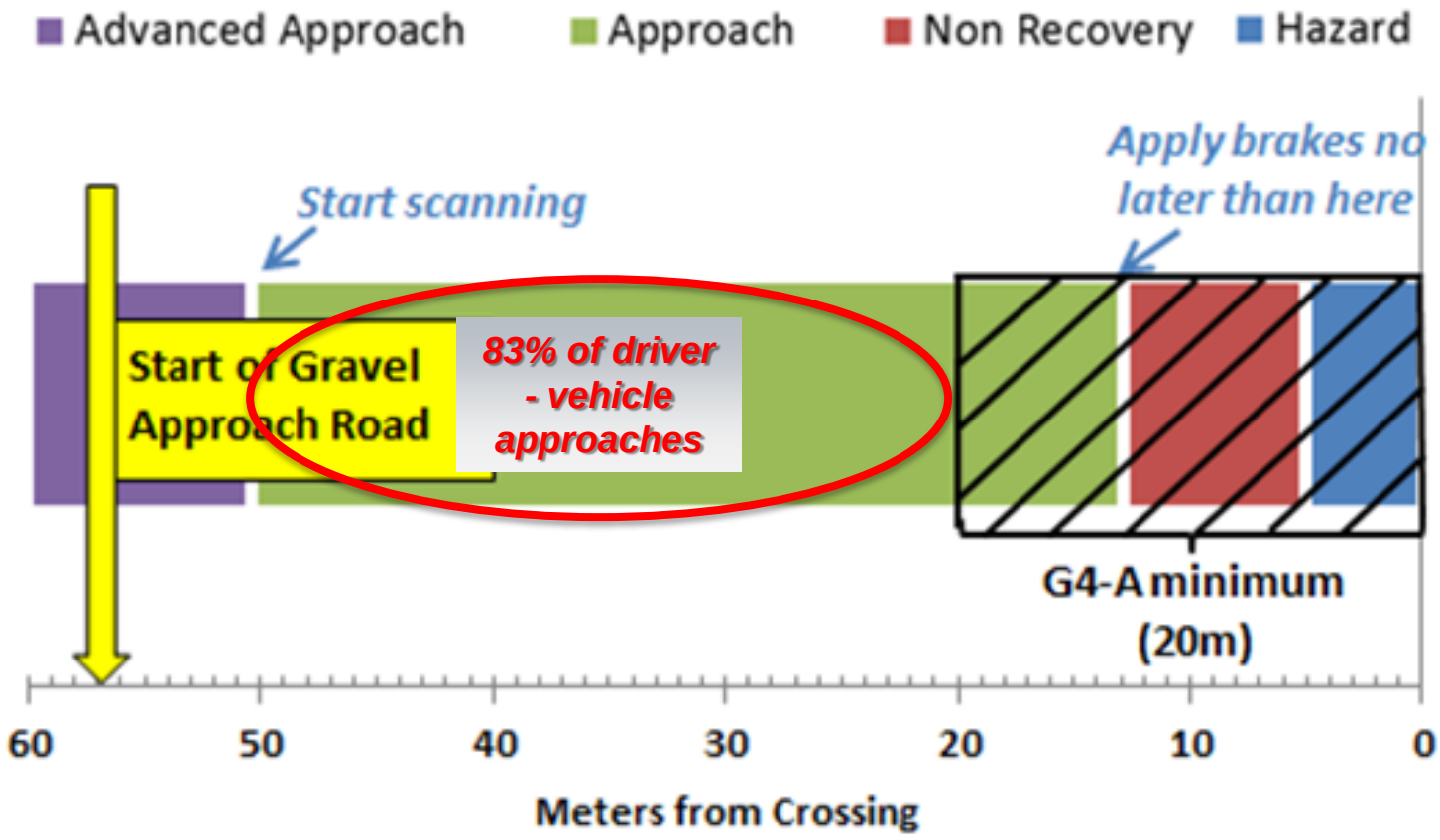
- **Driver PRT estimate currently used to calculate stopping sight distance (SSD) and minimum passive (crossbucks only) LC sightline requirements (the 'G4A guideline') is *2.5 s*.**
- **Based on assumptions that train horn is heard or active collision indicators (brake lights from a car ahead and/or automated railway crossing lights) appear *in front* of the driver.**
- **However, these assumptions do not always apply when approaching a passive LC protected by crossbucks alone.**

Why extend the approach zone?

- At passive LCs equipped with crossbucks only, the vehicle driver must scan in both directions for approaching trains.
- Must also overcome human factors issues affecting train detection.
- Long & Nitsch (2007) → drivers stopped at intersections of uncontrolled major cross streets.
  - total refocusing interval to go from front to one side (0.74 s) and then to other side and back to the front (1.08 s) = approximately *1.82 s*.
- Therefore, more realistic PRT for sightline maintenance and design would be approximately 4.3 to 4.5 s
  - 2.5 s + 0.74 s + 1.08 s = 4.32 s

Why extend the approach zone?

Accident crossing:



How to extend the approach zone?

- **Improve sightline visibility**
  - **Important to consider any unintended consequences**
- **Lower legal speed limit of road vehicles**
  - **Should not be used in isolation**
- **Install traffic calming devices**
  - **Not always feasible(e.g., speed bumps)**
- **Install stop signs**
  - **May generate other risks**
  - **Also need enforcement**

How to extend the approach zone?

- **Develop low-cost active alert systems**

Hellman, A.D., & Ngamdung, T. (2010). Low-Cost Warning Device Industry Assessment. U.S. DOT FRA Report number DOT/FRA/ORD-10/06.

How to extend the approach zone?

"Walk Light" grade crossing warning systems – TC E-39

Conclusions

Current use of 2.5 s PRT in minimum sightline distance for passive LCs underestimates distance and time necessary for drivers to visually search for trains in two directions and initiate a response.

In Broadview accident,

- **close proximity of highway → limited opportunities to warn drivers of:**
  1. **sightline limitations, and**
  2. **need for drivers to use significant caution**

To enable sufficient time for scanning → more realistic PRT used in sightline maintenance and LC design would be ~4.5 s.

Factors influencing driver's late detection of the train:

1. Perceived clear view of the tracks from the highway,
2. Limited sightlines available once the vehicle turned onto the gravel approach road,
3. Driver's limited knowledge and appreciation of the risks associated with negotiating a passive LC equipped only with crossbucks, and
4. Driver's expectation that there would be no train at the LC likely influenced the driver's failure to perceive the train in time to stop.

Thank you.

missy.rudin-brown@tsb.gc.ca