

TRAINFO

Project Report

Quantifying the Safety Benefits of Rail Crossing Information Systems (RXIS)

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EXECUTIVE SUMMARY

Every day, millions of vehicles interact with rail crossings across Canada, creating frequent exposure to potential safety risk despite the relatively small number of reported collisions. Prior research suggests that repeated exposure to rail crossings may lead to driver complacency, distraction, and increased willingness to engage in risky behavior when warning systems are active. In this context, Rail Crossing Information Systems (RXIS) have emerged as a potential intervention to improve both operational efficiency and safety by providing advance, predictive information about crossing status and expected delay.

This study evaluates the safety impacts of RXIS deployments at two Canadian rail crossings: the Shaftesbury Boulevard crossing in Winnipeg, Manitoba, and the Westwood Street crossing in Coquitlam, British Columbia. Using five weeks of baseline data and five weeks of post-deployment data at each location, the analysis focuses on changes in vehicle delay, trespassing behavior, and near-miss timing during periods when crossing warning systems are active. Trespassing events—defined as vehicle interactions occurring while warning devices are active—were used as a surrogate measure of elevated safety risk, alongside near-miss time as an indicator of available clearance between vehicles and approaching trains.

Results show that RXIS deployment was associated with substantial and consistent reductions in vehicle delay at both crossings. Average daily vehicles delayed declined by approximately 26% at Westwood and 29% at Shaftesbury, with corresponding reductions of roughly 34% in average vehicle delay duration at both locations. These findings reinforce prior evidence that RXIS is effective at improving operational performance and reducing driver exposure to crossing-related delay.

Changes in trespassing behavior, however, were comparatively modest. Trespassing events declined by approximately 1% at Westwood and 5% at Shaftesbury following RXIS deployment. Statistical testing indicates that these reductions were not statistically significant at the 95% confidence level, and the observed changes fall within the range of normal day-to-day variability. Near-miss time showed minimal change, with a small decrease at Westwood and a slight increase at Shaftesbury.

Expanded analysis using data from 221 additional RXIS deployments across North America provides broader context for interpreting these findings. While the study locations exhibit trends that are directionally consistent with network-wide observations, they represent moderate outcomes relative to the wider distribution of results. Network-level analysis suggests that trespassing behavior is influenced more strongly by factors such as train speed, perceived legitimacy of delay, and temporal alignment with peak roadway demand than by delay duration alone.

Overall, the findings indicate that RXIS is highly effective at reducing vehicle delay and improving travel-time reliability at rail crossings, but that its isolated effect on trespassing behavior is limited and highly site-specific. Meaningful reductions in risky behavior are likely to require RXIS deployment in combination with complementary measures such as geometric improvements, targeted enforcement, or site-specific behavioral interventions. The results of this study should therefore be interpreted as evidence of operational benefit and conditional safety influence, rather than as proof of a universal or standalone safety solution.

DEFINITIONS

Table 1: Definitions and Key terms

Term	Definition
AADT (Annual Average Daily Traffic)	The average number of vehicles that pass a given point on a roadway per day over the course of a year, used as a standardized measure of roadway traffic volume.
DMS (Dynamic Message Sign)	A roadside electronic display used to provide real-time or predictive information to road users, including rail crossing status, expected delay, or recommended routing actions.
RXIS (Rail Crossing Information System)	An integrated system that combines rail-side sensors, predictive analytics, and traveler information outputs to provide advance and real-time information about rail crossing status, activation duration, and expected vehicle delay.
Trespassing Event	For the purposes of this study, any instance in which a vehicle enters or interacts with the rail crossing envelope while the crossing warning system is active, including circumvention of gates or warning devices.
Near Miss	An event characterized by a vehicle interacting with an active rail crossing within a short time window prior to the arrival of a train, measured as the elapsed time between a vehicle exiting the defined camera frame and a train entering that frame.
Rail Crossing Envelope	The defined spatial area encompassing the roadway, trackway, and immediate approach where interaction between vehicles and trains may occur, as specified for analytical detection and event classification.
Crossing Activation	A discrete event during which the rail crossing warning system is active, including the period when lights flash, gates are lowered, or other warning devices are engaged.
Crossing Activation Duration	The elapsed time between the activation and deactivation of the rail crossing warning system for a single crossing event.
Vehicle Delay	The additional travel time experienced by a vehicle due to an active rail crossing, calculated as the difference between observed travel time and expected free-flow travel time.
Near-Miss Time (seconds)	A quantitative safety surrogate defined as the time difference, in seconds, between a vehicle exiting the monitored crossing area and a train entering that same area.
Baseline Period	The pre-deployment observation window during which crossing behavior, traffic volumes, and safety metrics are measured prior to RXIS activation.
Post-Deployment Period	The observation window following RXIS activation and a defined user adjustment period, used to assess changes relative to baseline conditions.
Adjustment Period	A defined period following system activation during which road users become familiar with new information or signage, excluded from analytical comparison.
Statistical Significance	A determination that an observed change is unlikely to be due to random variation alone, evaluated in this study using a 95% confidence interval threshold.

Term	Definition
Poisson Rate Comparison	A statistical method used to compare the rate of discrete events (such as trespassing incidents) between two periods, assuming events occur independently over time.
Continuous Train Movement	A train movement that passes through a crossing without stopping, shunting, or switching, for which predictive activation and clearance estimates are applicable.
Non-Continuous Train Movement	A train movement involving stopping, switching, or shunting near a crossing, for which predictive timing may be limited and events are manually reviewed.
Traveler Information System (TIS)	Any system designed to provide advance or real-time information to road users to support trip planning, routing, or situational awareness.
Exposure	The frequency and duration of vehicle interactions with a rail crossing, reflecting the level of potential risk to road users.
Risk Proxy	A measurable indicator, such as trespassing frequency or near-miss time, used to infer relative safety risk in the absence of direct collision data.
Behavioral Compliance	The degree to which road users adhere to active warning systems and designated crossing controls during rail crossing interactions.

INTRODUCTION AND RESEARCH OBJECTIVES

Every day, more than 20 million vehicles interact with Canadian rail crossings (Transport Canada Grade Crossing Inventory, 2024). While only a small number of these interactions (159) result in accidents (2022, Transportation Safety Bureau of Canada), research from the University of Nebraska suggests that the frequency of interactions tends to breed complacency toward the true risks at crossings. The research indicates that a high percentage of drivers are distracted when approaching crossings and are prone to risky behavior when the warning systems are active.

Over the last six years, TRAINFO has deployed sensors at more than 150 crossings across North America, many of which feed data into Rail Crossing Information Systems (RXIS); Figure 1 illustrates a sample dynamic message sign (DMS) used as part of an RXIS deployment. TRAINFO has demonstrated the ability to reduce vehicle delay at crossings by up to 35% and overall vehicle–crossing interactions by up to 25%, at a fraction of the cost of grade separation. While reductions in total interactions may suggest improved safety, a more meaningful indicator is the change in vehicle interactions occurring while crossing warning systems are active. In addition to deploying RXIS, TRAINFO directly measures and quantifies these interactions during active warning periods.



Figure 1: Sample DMS Board as Part of an RXIS

With existing commitments between TRAINFO and the cities of Winnipeg and Coquitlam to deploy RXIS, Transport Canada and TRAINFO leveraged these locations to examine changes in vehicle interactions occurring while crossing warning systems are active. Changes in these interactions were used as a surrogate measure of grade crossing safety, reflecting driver behavior during periods of elevated risk. A reduction in interactions during active warning periods indicates improved driver attention and a corresponding reduction in risky behavior.

METHODOLOGY

The project methodology contained an element of bias: the crossings selected for the study were chosen based on convenience and budget—since TRAINFO already had independent contracts to deploy RXIS systems with the cities—rather than on trespassing characteristics. In particular, TRAINFO’s deployments focused on the Shaftesbury crossing in Winnipeg and the Westwood Street crossing in Coquitlam. As summarized in Table 1 (from Transport Canada’s Grade Crossing Inventory), both crossings experience significant freight rail and vehicle activity.

Table 2: Grade Crossing Statistics for Project Crossings

	Shaftesbury Blvd – 13118 Winnipeg, MB	Westwood St – 20629 Coquitlam, MB
Trains Per-Day	35	42
AADT	10,975	28,000

Beyond overall traffic and train volumes, each crossing presents distinct contextual characteristics relevant to the analysis. The Shaftesbury crossing, illustrated in Figure 2, intersects an active transportation corridor with frequent cyclist and pedestrian use. The Westwood crossing, shown in Figure 3, is located adjacent to the CP Port Coquitlam marshalling and switching yard. Crossings in proximity to rail yards typically experience longer activation durations and more frequent stopping, shunting, and switching movements, which can influence both operational performance and user behavior.

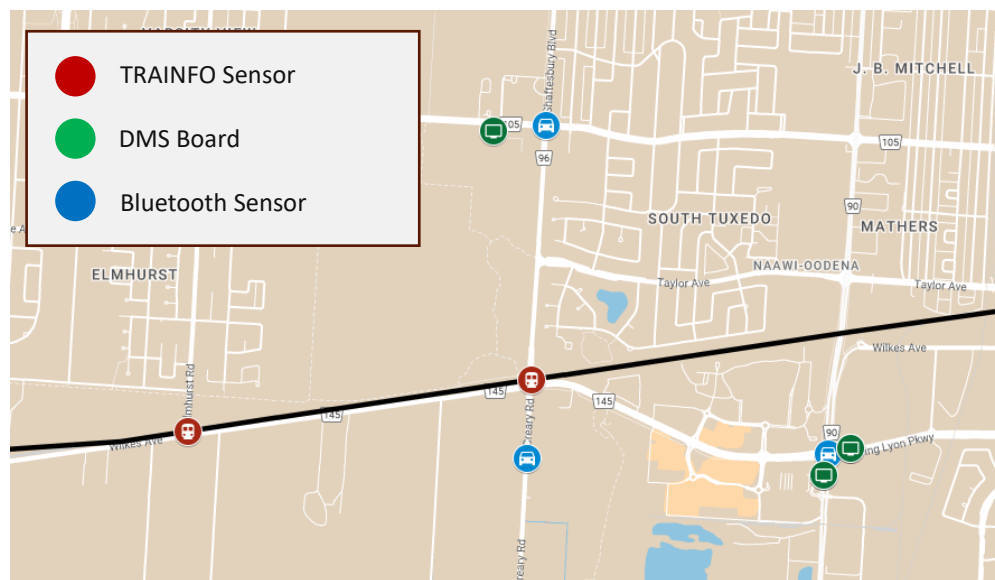


Figure 2: Deployment Design for the City of Winnipeg

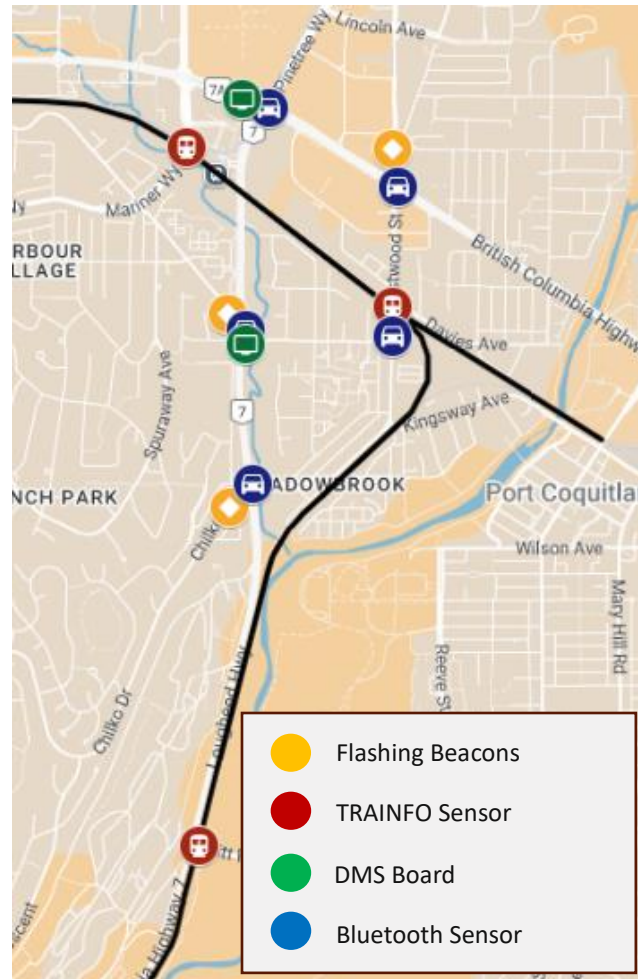


Figure 3: Deployment Design for the City of Coquitlam

While figures 2 and 3 show the location of the equipment installed at the respective crossings, Table 2 describes the equipment being installed.

Table 3: Description of Equipment Being Deployed In Participating Projects

Equipment	Description
TRAINFO Sensors	Sensors monitoring the status of the crossings, the characteristic movements of trains, and the interactions of vehicles with the crossing.
Bluetooth Sensors	Sensors measuring vehicle travel time between two points.
DMS Boards	Boards at a fixed point on the road providing predicted and current status of a given crossing, as well as the expected vehicle delay (Figure 4).
Flashing Beacons	Beacons paired with a placard identifying at a fixed point on the road providing the predicted and current status of a given rail crossing (Figure 5).



Figure 4: TRINFO Deployed Flashing Beacon



Figure 5: TRINFO Deployed DMS Board

With the crossing selection and RXIS implementation being fixed variables in this study, the methodology specific to the study included the following activities:

- Collection of baseline data
- Implementation of RXIS
- Collection of post deployment data
- Evaluation of results

Collection of Baseline Data

At both crossings, as with all TRAINFO deployments, five weeks of baseline data were collected. TRAINFO has found that after this period, the statistics stabilize—a pattern observed in both the least and most volatile crossing scenarios. This report does not detail TRAINFO’s proprietary methodology for evaluating data stability and confidence; however, the approach is primarily based on a blend of the Gap Statistic (optimizing for the minimum data required to stabilize the mean, mode, and median of a sample) and confidence intervals.

The following summarizes the baseline data collected:

- **Avg. Daily Traffic Volume** – Average number of vehicles interacting with the crossing daily
- **Avg. Daily Cyclist Volume** – Average number of cyclists interacting with the crossing daily
- **Avg. Daily Pedestrian Volume** – Average number of pedestrians interacting with the crossing daily
- **Avg. Daily Crossing Activations** – Average number of times the crossing warning system was activated in a day
- **Avg. Daily Vehicles Delayed** – Average number of vehicles delayed by active crossings in a day
- **Avg. Daily Vehicle Trespass Events** – Average number of vehicles interacting with the crossing while the warning system was active
- **Avg. Near-Miss Time (seconds)** – Average time between a vehicle leaving the camera frame and a train entering the frame
- **Avg. Vehicle Delay (minutes)** – Average difference between recorded and expected travel times for vehicles impacted by an active crossing

Implementation of RXIS

While the baseline data collection was occurring, the implementation of the RXIS proceeded. The implementation consisted of the following tasks:

- Installation of DMS boards and beacons
- Calibration of traffic prediction models
- Integration testing between roadside signage and TRAINFO Platform
- Communication with the public

Installation of DMS Boards and Beacons

The locations of the DMS boards and flashing beacons were selected based on a traffic analysis conducted by TRAINFO in collaboration with the respective cities. This analysis identified the origin and destination (OD) points influencing traffic demand at each crossing. Each OD pair was evaluated to determine alternate routes where travel time could be reduced relative to the original OD path affected by an average-duration crossing activation. The evaluation identified reroute locations where roadside signs and beacons could be used to divert vehicles away from an active crossing (see Figures 2 and 3 for board and beacon locations). Installation work was carried out by city technicians with support from TRAINFO’s Customer Success team.

Calibration of Traffic Prediction Models

TRAINFO guarantees the following prediction performance for all continuous moving trains (i.e., trains that do not stop, shunt, or switch at a crossing):

- **Crossing activation time** – within ± 1 minute, >90% of the time
- **Crossing deactivation time** – within ± 1 minute, >90% of the time
- **Vehicle travel time** – within ± 1 minute for >90% of vehicles

During the five-week data collection period, TRAINFO's AI models were trained and validated to ensure they achieved the identified performance criteria. Model training for each crossing was validated by a TRAINFO Customer Support Engineer (CSE).

For non-continuous train movements—where TRAINFO predictions do not apply—CSEs manually reviewed each detected event over the entire five-week period to confirm proper flagging and to ensure there were no false positives. For false negatives, CSEs performed a spot check of 100 randomly selected detection events.



Figure 6: Non-Continuous Train – Left image shows frame at time 0, and right image shows frame 5 seconds later

Integration Testing Between Roadside Signage and TRAINFO Platform

Successful integration of a traveller information system depends on reliable communication between system components and the timely delivery of information. This process is evaluated through completion of system “handshakes” and measurement of associated latency. In the deployment of TRAINFO's RXIS, three distinct handshakes are required to deliver traveller information to the field (Figure 7):

- 1) From TRAINFO Sensor to TRAINFO Cloud
- 2) From TRAINFO Cloud to DMS/Beacon Cloud
- 3) From DMS/Beacon Cloud to DMS/Beacon in the Field

For each TRAINFO deployment, **Handshake 1** is tested during the five-week data collection period. Sensors log each communication attempt with the TRAINFO cloud, while the cloud records successful receptions. These logs are reviewed weekly to verify that 100% of handshakes are successfully received and completed within 0.75 seconds.

Handshake 2 is conducted outside individual deployments as part of routine system maintenance with TRAINFO's integration partners. Logs are reviewed monthly by both parties to confirm that all handshakes are successfully received and completed within 0.25 seconds.

Handshake 3 is verified following installation of the DMS boards and flashing beacons through two tests. First, messages are transmitted while field technicians are onsite to confirm receipt at the devices. Second, automated test messages are sent hourly between midnight and 4:00 a.m., with sign logs cross-validated against server records to confirm that 100% of handshakes are completed within 0.75 seconds.

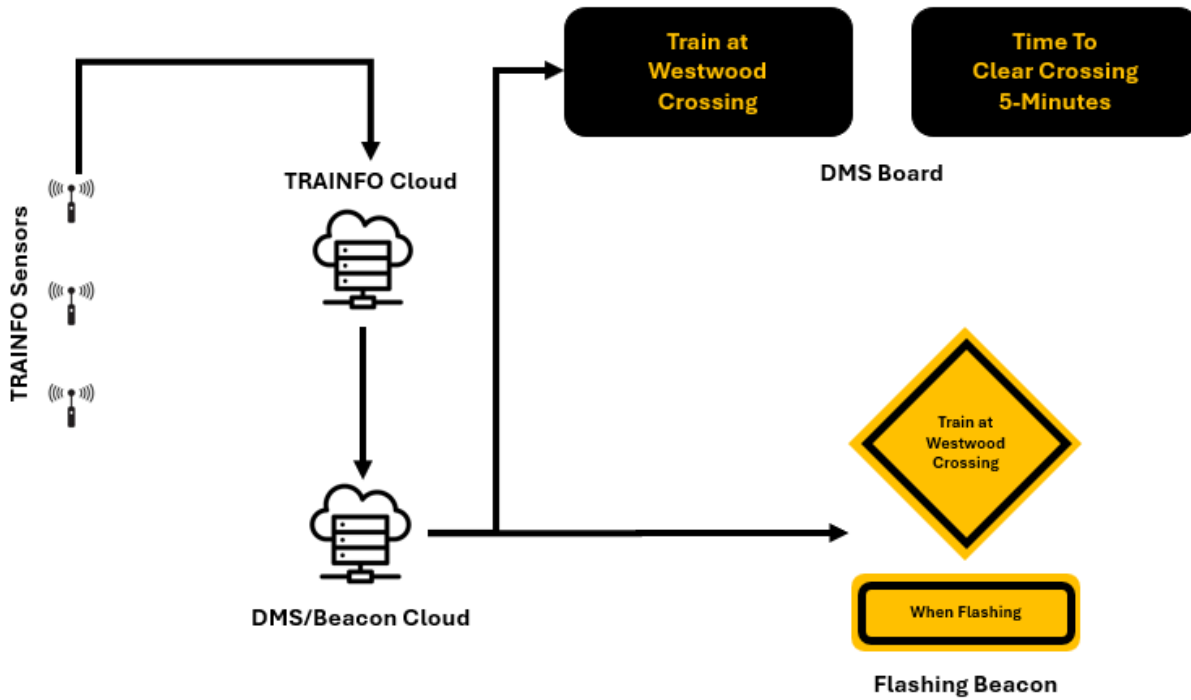


Figure 7: RXIS Integration Points

Communication with the Public

Prior to going live, like all TRAINFO deployments, TRAINFO coordinated with the cities of Winnipeg and Coquitlam to release public information about the RXIS. The public information included the following information:

- Where are the signs and beacons
- What will be shown on the signs and beacons
- What reroute behaviour is suggested to be taken
- When will the system to go-live
- Who to contact in the event of an issue

One-week after public communication, the system was activated and in full operational state.

Collection of Post Deployment Data

Before post-deployment data collection began, a four-week adjustment period was observed to allow road users to become familiar with the function of the RXIS and the available reroute options. Following this period, five weeks of post-deployment data were collected.

The following summarizes the data collected to establish the post-deployment condition:

- **Avg. Daily Traffic Volume** – Average number of vehicles interacting with the crossing daily
- **Avg. Daily Cyclist Volume** – Average number of cyclists interacting with the crossing daily
- **Avg. Daily Pedestrian Volume** – Average number of pedestrians interacting with the crossing daily
- **Avg. Daily Crossing Activations** – Average number of times the crossing warning system was activated in a day
- **Avg. Daily Vehicles Delayed** – Average number of vehicles delayed by active crossings in a day
- **Avg. Daily Vehicle Trespass Events** – Average number of vehicles interacting with the crossing while the warning system was active
- **Avg. Near-Miss Time (seconds)** – Average time between a vehicle leaving the image frame and a train entering the frame
- **Avg. Vehicle Delay (minutes)** – Average difference between recorded and expected travel times for vehicles impacted by an active crossing

EVALUATION OF RESULTS

We evaluated results using both baseline and post-deployment data. Baseline data were analyzed to characterize existing trespassing behavior, while post-deployment data were used to assess the effectiveness of the Rail Crossing Information System (RXIS) in reducing trespassing events.

Under the Transport Canada–administered Railway Safety Act, trespassing is defined in Section 26 as follows:

“No person shall, without lawful authority, enter on land on which a line work is situated or land immediately adjoining such land.”

In keeping with this definition, and for the purposes of this project, a trespassing event is defined as:

“Any pedestrian or vehicle entering the railway right-of-way beyond the designated public grade-crossing envelope, including the circumvention of active warning devices.”

Trespassing events were measured using anonymized machine-vision detection, with the grade-crossing envelope provided to the system as a defined capture area. Any instance of a person or vehicle entering this capture area was recorded as a trespass event for analytical counting purposes, independent of the duration of presence.

Because the RXIS intervention is not expected to materially influence pedestrian or cyclist behavior and is primarily intended to affect driver decision-making, pedestrian and cyclist events were excluded from the results.

Evaluation of Baseline Data

A review of the baseline conditions (Table 3) raised several important questions regarding the observed safety outcomes at the Shaftesbury and Westwood crossings.

1. Disproportionately high trespassing at Shaftesbury.

Despite lower average daily traffic volumes and fewer total crossing activations, the Shaftesbury crossing experiences a substantially higher rate of trespassing events. Approximately 12% of activations at Shaftesbury involve trespassing, compared to only 3.9% at Westwood. This suggests that factors beyond traffic volume may be contributing to increased risk-taking at this location.

Previous research and guidance from Transport Canada, the Federal Railroad Administration, and Operation Lifesaver identify several environmental and behavioral factors commonly associated with trespassing at rail crossings. These include crossing geometry, pedestrian desire lines, surrounding land use, visibility conditions, and user behavior.

Crossing geometry—such as skewed track angles, wide crossing footprints, or longer gate-down times—has been shown to increase perceived delay and user frustration, which can lead to non-compliant behavior, including bypassing designated crossing paths. Pedestrian desire lines, often formed by nearby origins and destinations such as transit stops, commercial properties, or residential areas, can encourage informal crossing behavior when designated routes are perceived as indirect or inconvenient. Transport Canada and Operation Lifesaver both note that repeated informal use can normalize trespassing over time.

Surrounding land use influences the volume and type of users interacting with a crossing, with mixed-use or pedestrian-oriented areas more likely to generate informal crossing behavior. Visibility conditions—including sightlines to approaching trains, warning devices, and gate arms—also affect user decision-making; limited visibility or misperceived train approach times can lead users to incorrectly judge crossing safety despite active warnings. Finally, user behavior, including familiarity with the crossing, perceived enforcement, and observed behavior of other users, plays a significant role in reinforcing compliance or non-compliance, as documented in both Canadian and U.S. rail safety studies.

2. Shorter near-miss times at Shaftesbury.

Near-miss events at Shaftesbury occur with approximately half the available clearance time observed at Westwood. This indicates that users at Shaftesbury are entering the crossing later relative to train arrival, which may reflect reduced situational awareness, impaired sightlines, habituation to train delays, or a greater willingness to accept risk. These behavioral or environmental factors may be compounding the safety risk associated with higher trespassing rates.

3. Interpreting the significance of trespassing frequency.

While the absolute number of trespassing events initially appeared modest, their proportion relative to total activations raises a broader question: what constitutes a *significant* level of trespassing from a safety and risk-management perspective? Even infrequent trespassing events may be considered significant if they consistently coincide with short near-miss times, repeated behavior patterns, or site-specific conditions that elevate the likelihood of severe outcomes.

Taken together, these observations suggest that Shaftesbury exhibits a distinct risk profile driven less by exposure (traffic volume) and more by behavioral and contextual factors. Further analysis should focus on identifying the physical, operational, and human-factors drivers contributing to elevated trespassing frequency and reduced safety margins at this crossing.

Table 4: Baseline Statistics for Crossings

	Coquitlam, BC Westwood St Crossing (20629)	Winnipeg, MB Shaftesbury St Crossing (13118)
Avg. Daily Traffic Volume	30,610	20,647
Avg. Daily Cyclist Volume	1,836	121
Avg. Daily Pedestrian Volumes	482	35
Avg. Daily Crossing Activations	33	24
Avg Vehicles Delayed (daily)	4,904	1,604
Avg Vehicle Delay (min)	3.01	3.19
Avg Trespass Events (daily-vehicles)	1.3	2.9
Avg Near Miss Time	10.13 sec	4.95 sec

To address Question 1—why the Shaftesbury crossing experiences nearly three times the frequency of trespassing events—we first examined the distribution of crossing activation durations (Figure 8 and Figure 9). While the average activation times at Westwood (5.47 minutes) and Shaftesbury (5.23 minutes) are comparable, the variability in activation duration differs substantially between the two locations. Westwood exhibits a much wider range of activation times, whereas Shaftesbury’s activations are more tightly clustered around the mean.

Based on this variability, our initial hypothesis was that the greater uncertainty at Westwood would lead to increased driver impatience and frustration, thereby resulting in higher rates of trespassing behavior. Longer or less predictable wait times are commonly associated with risk-taking behavior at crossings, as users may attempt to anticipate train arrival or assume atypical delays.

However, the observed trespassing rates contradict this expectation. Despite its greater activation variability, Westwood exhibits a significantly lower proportion of trespassing events (3.9%) compared to Shaftesbury (12%). This finding suggests that activation duration alone—whether measured by average length or variability—is insufficient to explain the elevated trespassing frequency at Shaftesbury. Instead, it points to the influence of other site-specific factors, such as crossing geometry, visibility, surrounding land use, habitual user behavior, or perceived enforcement and risk, which may play a more dominant role in shaping crossing decisions at this location.

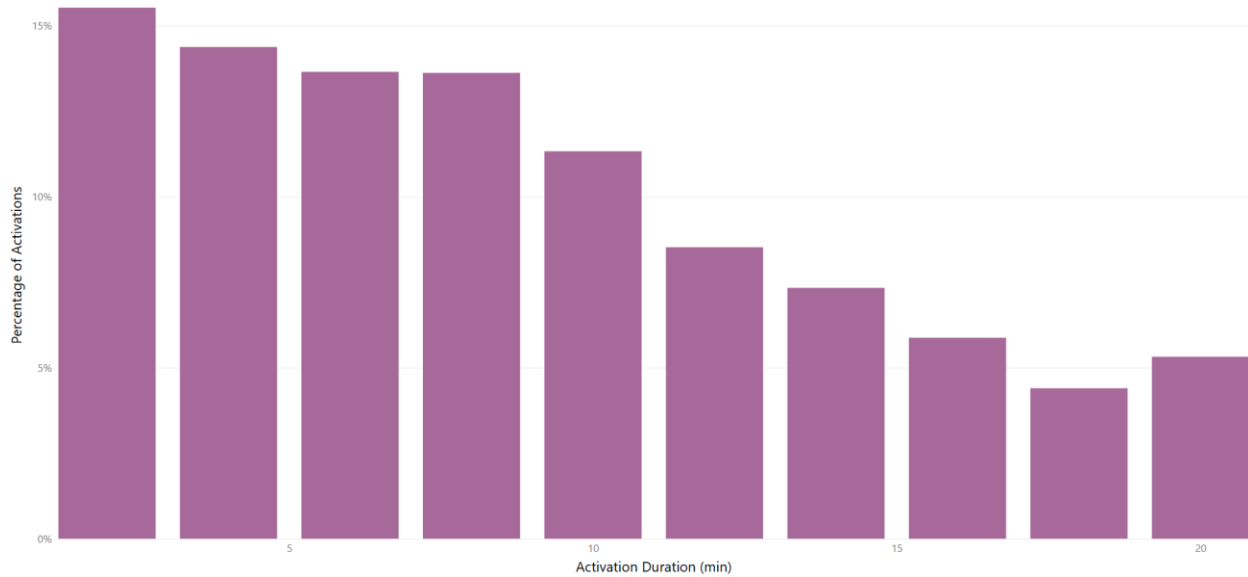


Figure 8: Westwood Crossing - Crossing Activation Distribution

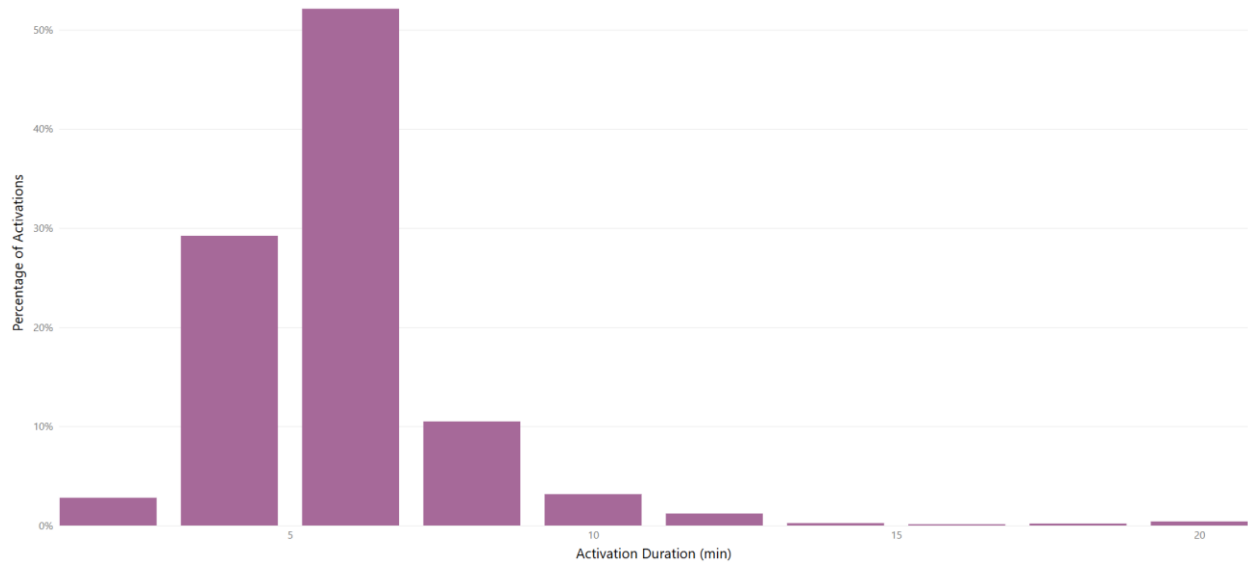


Figure 9: Shaftesbury Crossing - Crossing Activation Distribution

Next, we evaluated the distribution of crossing activations and activation durations by hour of day. As shown in Figure 10, the Westwood crossing experiences a higher concentration of activations during peak traffic periods; however, these peak-period activations are generally of shorter duration. Longer activation events at Westwood occur predominantly during off-peak hours, when traffic volumes and user exposure are lower.

In contrast, the Shaftesbury crossing (Figure 11) exhibits a relatively uniform distribution of both activation frequency and activation duration across all hours of the day. Neither the number of events nor their duration shows a strong dependence on peak or off-peak traffic periods.

This temporal pattern helps explain why the higher volume and greater variability of activity at the Westwood crossing do not translate into increased trespassing behavior. At Westwood, longer and more uncertain delays tend to occur when user exposure is reduced, whereas periods of high exposure are associated with shorter, more predictable activations.

At Shaftesbury, however, the consistent exposure to moderate-length activations throughout the day does not, on its own, account for the substantially higher trespassing rate observed at this location. As a result, while time-of-day effects help rule out traffic-driven volatility as the primary driver of trespassing at Westwood, they do not explain the elevated trespassing frequency at Shaftesbury. Further investigation is therefore required to identify the site-specific physical, behavioral, or contextual factors contributing to this disparity.

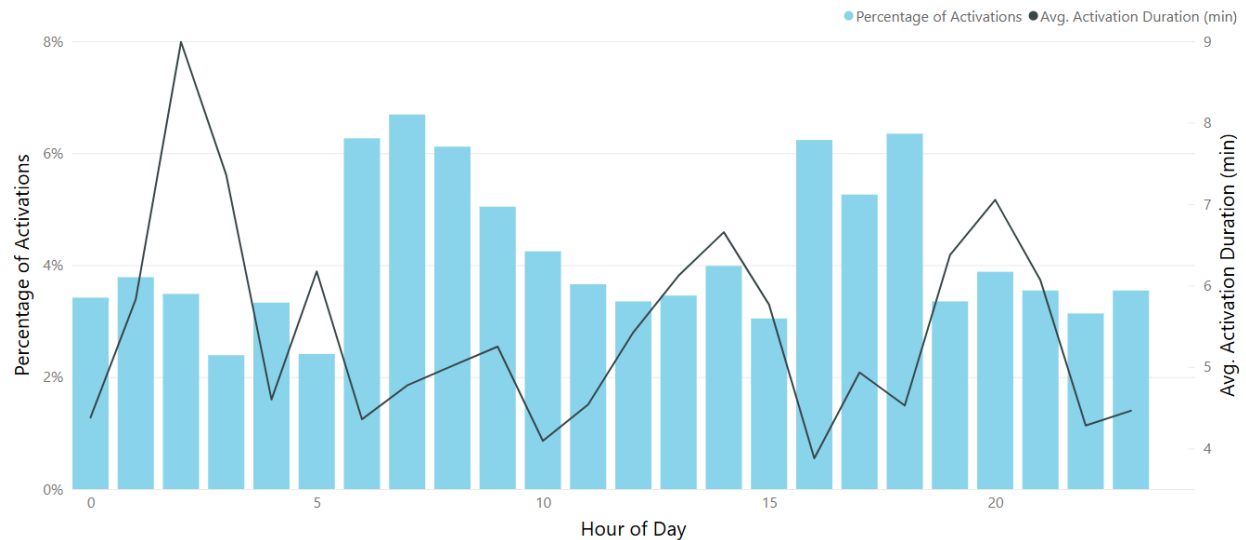


Figure 10: Westwood Crossing - Distribution of Crossing Activations and Durations By Hour of Day

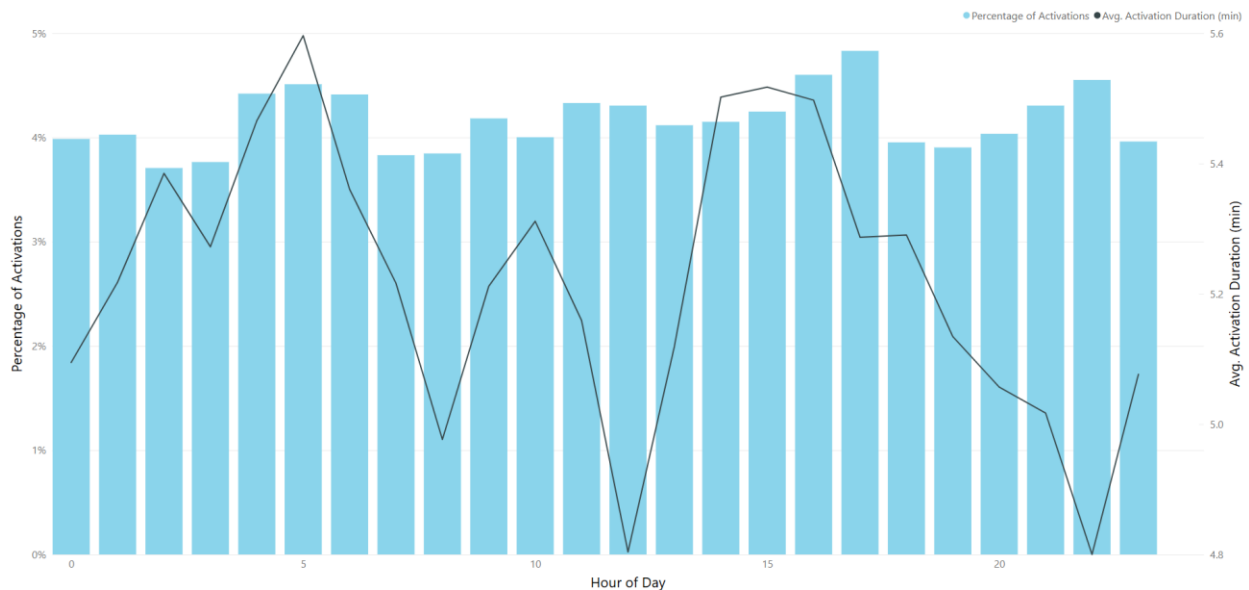


Figure 11: Shaftesbury Crossing - Distribution of Crossing Activations and Durations By Hour of Day

To investigate Question 2—what is driving the near-miss time to be approximately half as long at the Shaftesbury crossing—we examined the distribution of near-miss behavior by location. As shown in Figure 12, near-miss times at Shaftesbury display a high degree of consistency, with values tightly clustered around a shorter clearance window. In contrast, near-miss times at Westwood exhibit greater variability and a broader distribution.

This consistency at Shaftesbury suggests that near-miss events are not occurring randomly but are instead influenced by a persistent underlying factor that shapes user behavior at this location. Rather than reacting to isolated conditions or sporadic delays, users at Shaftesbury appear to be entering the crossing at a consistently later point relative to train arrival, resulting in systematically reduced safety margins.

The presence of this stable behavioral pattern leads the research team to conclude that a site-specific variable—such as sightline limitations, crossing geometry, perceived train speed, or habitual user expectations—is likely driving near-miss behavior at Shaftesbury. Identifying and isolating this variable is critical, as it may be contributing simultaneously to both the higher trespassing frequency and the reduced near-miss times observed at this crossing.

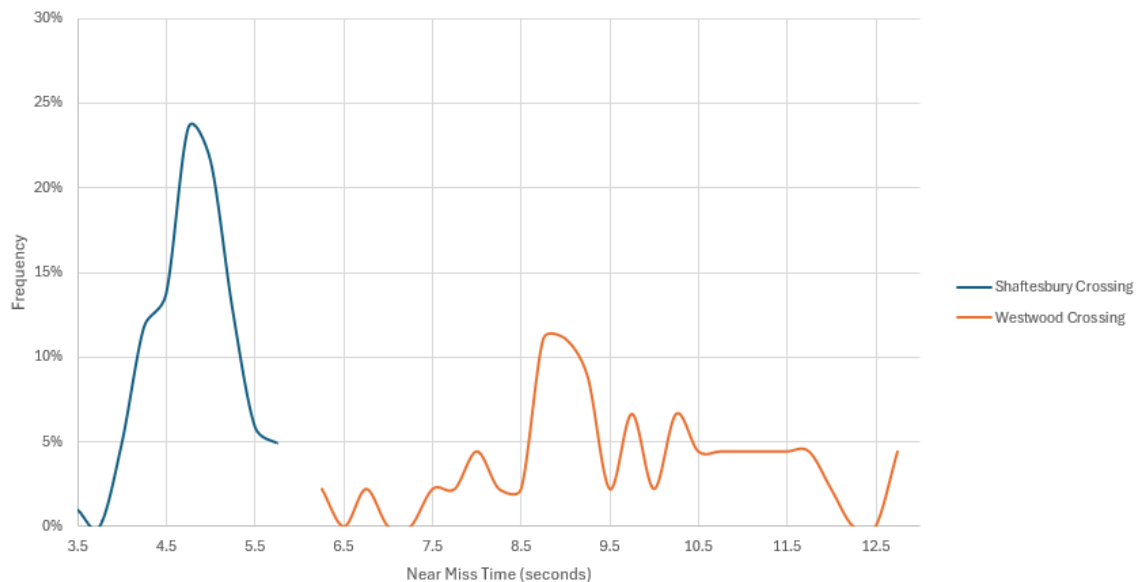


Figure 12: Distribution of Near Miss Time (seconds)

Train operating speeds at the Shaftesbury crossing are consistently higher than those observed at the Westwood crossing (Figures 13 and 14). Given that trespassing is defined as vehicle interaction with an active crossing, higher train speeds inherently reduce the available time between warning system activation and train arrival. As a result, faster train movements compress the clearance window and increase the likelihood of shorter near-miss times when trespassing occurs.

An examination of the subset of events involving trespassing vehicles confirms this relationship. Near-miss time is shown to be strongly correlated with train speed at both locations. At the Shaftesbury crossing, the correlation coefficient is approximately 0.92, while at the Westwood crossing it is approximately 0.87, indicating a strong inverse relationship between train speed and available near-miss time.

These findings suggest that train speed is a primary mechanical driver of reduced near-miss times, particularly at Shaftesbury. When combined with consistent trespassing behavior at this location, higher operating speeds amplify the severity of safety risk by systematically reducing reaction and clearance time. While train speed alone does not explain why trespassing occurs more frequently at Shaftesbury, it does provide a compelling explanation for why near-miss events at this crossing are both shorter in duration and more consistent than those observed at Westwood.

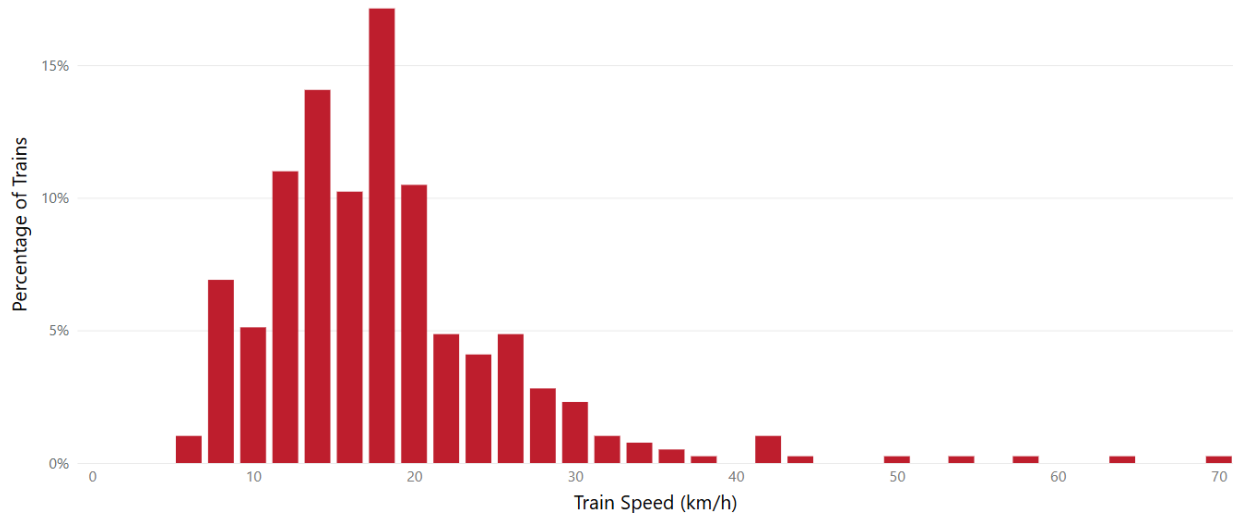


Figure 13: Westwood Crossing - Distribution of Train

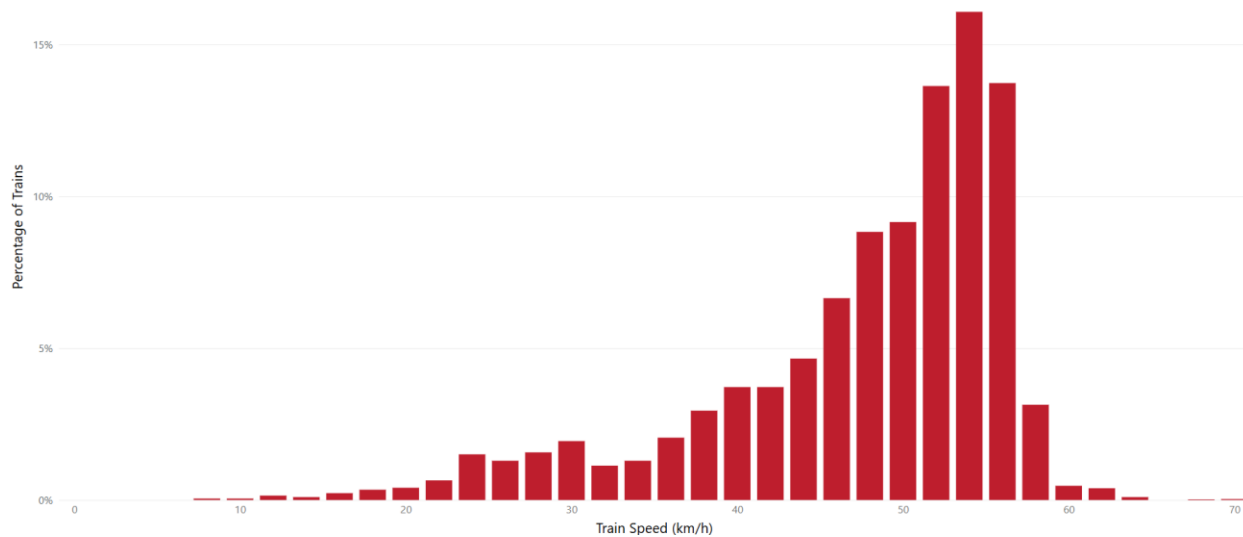


Figure 14: Shaftesbury Crossing - Distribution of Train Speed

In considering Question 3—what constitutes a *significant* amount of trespassing—we conducted a targeted review of relevant safety literature and regulatory guidance. While no universally accepted quantitative thresholds were identified, several authoritative sources provide consistent qualitative direction:

- Federal Railroad Administration (FRA)** — The FRA’s Office of Safety Analysis emphasizes that *persistent, repeated trespassing at specific locations* is prioritized for mitigation, even when absolute event counts are relatively small. The focus is placed on patterns of behavior rather than raw frequency alone (FRA, 2022).
- Transport Canada** — Transport Canada’s Rail Safety Improvement Program (RSIP) Guidelines indicate that *one or two trespass-related incidents may be sufficient* to justify intervention or funding when the crossing is located in a sensitive context, such as near schools, pedestrian corridors, or residential areas (Transport Canada, 2024).

- Operation Lifesaver** — Operation Lifesaver identifies trespass “hotspots” based on *repeated behaviors*—for example, habitual shortcuts or daily commuter actions—rather than incident totals alone, highlighting the importance of behavioral consistency and predictability (Operation Lifesaver, 2023).

Across the broader literature, no quantitative or statistical method was identified that definitively classifies trespassing frequency as *significant* or *insignificant*. Instead, significance is consistently framed in terms of persistence, context, and risk amplification, rather than absolute counts. This suggests that even a small number of trespassing events may be considered significant when they occur repeatedly at the same location, coincide with reduced safety margins, or are associated with site-specific characteristics that elevate the likelihood of severe outcomes.

Evaluation of Post Deployment Data

An examination of the post-deployment data indicates that the effectiveness of a Rail Crossing Information System (RXIS) in reducing trespassing behavior is inconclusive. Table 4 summarizes the change in in vehicle interactions and shows both crossings experienced substantial reductions in the number of vehicles delayed following deployment, but the corresponding changes in trespassing frequency were comparatively small.

Table 5: Change in Statistics from Baseline

	Coquitlam, BC Westwood St Crossing (20629)	Winnipeg, MB Shaftesbury St Crossing (13118)
Avg. Daily Traffic Volume	+3%	+1%
Avg. Daily Cyclist Volume	+10%	+15%
Avg. Daily Pedestrian Volumes	+21%	+19%
Avg. Daily Crossing Activations	-1%	0%
Avg Vehicles Delayed (daily)	-26%	-29%
Avg Vehicle Delay (min)	-34%	-34%
Avg Trespass Events (daily-vehicles)	-1%	-5%
Avg Near Miss Time	-2%	+2%

At both the Westwood and Shaftesbury crossings, RXIS deployment was associated with large reductions in vehicle delay but only modest changes in trespassing behavior. At Westwood, vehicle delays decreased by approximately 26%, while trespassing declined by about 1%; at Shaftesbury, vehicle delays were reduced by approximately 29%, while trespassing declined by roughly 5%. Statistical evaluation of trespassing rates using a Poisson rate comparison indicated that these reductions were not statistically significant at the 95% confidence level. The estimated rate ratio for trespassing at Westwood was approximately 0.99 (95% CI: ~0.66–1.50), and at Shaftesbury was approximately 0.95 (95% CI: ~0.72–1.14), with both confidence intervals including unity.

The range of plausible outcomes for trespassing at both locations remains broad, meaning the observed reductions are small relative to the normal day-to-day variation in this behavior. As a result, while the direction of change is favorable, the available data do not allow the analysis to confirm with high confidence that the reductions in trespassing were caused by the RXIS deployment rather than by natural variability. These results suggest that, although RXIS deployment appears effective at improving operational efficiency and reducing vehicle delay, it does not, on its own, produce a commensurate reduction in trespassing behavior. This finding reinforces the earlier conclusion that trespassing is likely driven by persistent behavioral and site-specific factors that are not sufficiently influenced by delay-reduction alone.

Accordingly, while RXIS may contribute to broader safety improvements by reducing exposure and frustration, additional measures—such as geometric modifications, targeted enforcement, or behavioral interventions—may be required to meaningfully reduce trespassing at high-risk crossings.

In this context, the relationship between delay reduction and trespassing outcomes remains weak. Further analysis indicates that there is very little correlation between changes in the number of vehicles delayed and changes in trespassing frequency following RXIS deployment. However, the absolute level of trespassing observed at both crossings may itself be relatively low, raising the question of whether the measured changes are meaningful from a safety or risk-management perspective.

The absence of a quantitative framework to classify trespassing frequency as *significant* or *insignificant* limits the ability to draw definitive conclusions regarding RXIS effectiveness. Without such a classification, small observed changes in trespassing may reflect normal variability rather than a true treatment effect. Establishing a quantitative significance threshold would allow post-deployment results to be interpreted more conclusively, either by confirming a measurable impact or by demonstrating a statistically insignificant effect.

Additionally, given the scale of the rail network—comprising hundreds of thousands of grade crossings across North America—generalizing RXIS effectiveness based on observations from only two crossings is not statistically or operationally defensible. The findings presented here should therefore be interpreted as site-specific case studies rather than evidence of network-wide performance.

TRAINFO manages a network of more than 300 RXIS deployments across North America, and, during the course of this project, completed RXIS projects with 10 other agencies. Using these resources provides an opportunity to contextualize findings from the study locations in Winnipeg and Coquitlam without replicating the full study methodology at additional sites. To assess how representative the project crossings are of the broader network of rail crossings, summary data from TRAINFO's network covering a two-year period (November 1, 2023 to November 1, 2025) was analyzed for 221 crossings.

The analysis focused on two primary questions: (1) how the operational characteristics of the study crossings compare to those observed across the broader network, and (2) how patterns of trespassing and near-miss events at the study locations align with other RXIS deployment locations. The results provide important context for interpreting the site-specific observations from the study and support broader inferences about how crossing operations, user perception, and timing influence risky behavior at rail crossings.

Question 1 – How do the operational characteristics of the study crossings compare to those observed across the broader network?

To address this question, key operational metrics from the study crossings were compared against aggregated network-wide averages, including train speed, crossing activation duration, activation frequency, vehicle delay, trespass events, and near-miss timing. The comparison highlights both structural similarities and meaningful deviations between the study locations and the broader network. These differences provide important context for understanding how localized operating conditions may influence roadway user experience and observed safety outcomes.

- Train speeds at the Westwood crossing are substantially lower than the network average, indicating localized operational or geometric constraints.
- Average crossing activation durations at both Shaftesbury and Westwood exceed the network average by more than 30 seconds.
- Both study crossings experience significantly higher numbers of daily crossing activations compared to the network.
- The network as a whole shows fewer vehicles delayed per day, which is consistent with its lower frequency of activations and shorter average activation durations.
- Despite fewer activations, the average number of vehicles impacted per activation is higher across the network than at Shaftesbury and Westwood. As shown in Figure 15, activation durations exhibit limited hourly variance, while activation frequency shows distinct peaks—suggesting that peak rail activity aligns with peak roadway demand (AADT) at the network level.
- Trespass events occur more frequently across the network than at either study crossing, even though the network experiences fewer daily activations.
- Near-miss time at Shaftesbury closely aligns with the network average, consistent with similar observed train speeds, while Westwood exhibits elevated near-miss time, likely influenced by lower train speeds and longer activation durations.

Table 6: Comparison of Crossing Statistics for Study Sites and Broader Crossing Network

	Network Crossings	Shaftesbury Crossing	Westwood Crossing
Avg Train Speed	46	49	18
Avg Crossing Activation Duration	4.64	5.23	5.47
Avg Number of Crossing Activations Per-Day per crossing	9.45	24	33
Avg Vehicles Delayed (daily)	1,259	1,604	4,904
Avg Vehicle Delay (min)	4.2	3.19	3.09
Avg Trespass Events (daily-vehicles)	4.21	2.9	1.3
Avg Near Miss Time	4.91	4.95	9.51
Avg Train Speed	46	49	18

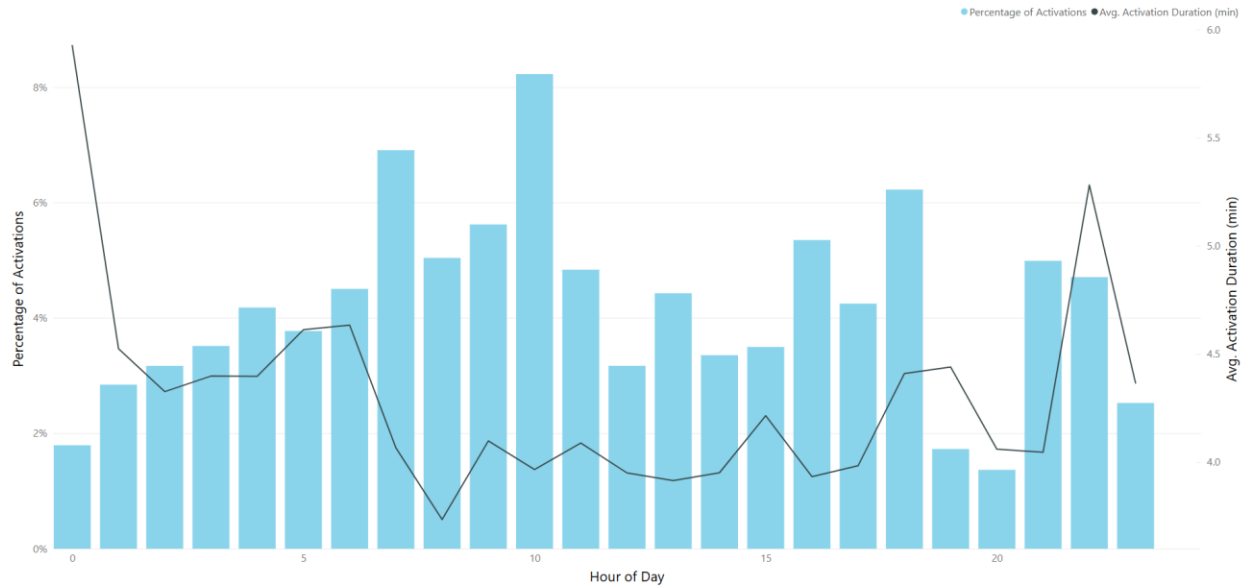


Figure 15: Network Crossings - Distribution of Crossing Activations and Durations By Hour of Day

Trespassing behavior at rail crossings appears to be more strongly influenced by user perception of delay legitimacy, train speed, and temporal alignment with peak roadway demand than by crossing activation frequency or duration alone. Crossings with slower, more predictable operations and clearer cause-and-effect between warning activation and train arrival exhibit lower trespassing rates, even when delays are longer. Conversely, higher train speeds and peak-period activations may increase risk-taking behavior despite shorter delays.

Question 2: How do the patterns of trespassing and near-miss events at the study locations align with network-wide behavior?

In addressing how the study locations align with broader network behavior, it's clear from the expanded dataset that the Winnipeg and Coquitlam crossings do reflect the general direction of network-wide trends. Both sites showed reductions in trespass events and near-miss times that are directionally consistent with what we observe across the broader set of crossings. However, when we look at Table 6 and compare the magnitude of changes, we see that the study locations tend to show more moderate improvements in trespassing and near-miss outcomes compared to some other crossings in the expanded sample.

For instance, while Coquitlam and Winnipeg showed only modest reductions in trespassing (1% and 5% respectively), other crossings saw more substantial decreases, and in some cases, larger variability in near-miss times. This tells us that while the patterns at the original study sites are indeed representative in terms of direction, they do not capture the full range of outcomes seen across the network. In other words, the study crossings show a more moderate level of improvement, whereas other crossings may show either more pronounced or more varied changes.

Answering the questions ***How do the operational characteristics of the study crossings compare to those observed across the broader network*** and ***How do the patterns of trespassing and near-miss events at the study locations align with network-wide behavior?*** illustrates that while the Winnipeg and Coquitlam crossings show a directional alignment with network-wide trends, they do not fully represent the broader range of outcomes observed across the entire dataset. The findings indicate that there is significant variability in how different crossings respond to RXIS implementation, with some locations experiencing more pronounced safety improvements. This broader context underscores that while initial results from two crossings provided valuable insights, they are not sufficient to draw sweeping conclusions. In fact, the expanded analysis reveals that there could be greater opportunities to enhance safety at other crossings than those initially studied.

Table 7: Change in Statistics from Baseline – Additional Crossings

	Coquitlam, BC Westwood St Crossing (20629)	Winnipeg, MB Shaftesbury St Crossing (13118)	Salt Lake City, UT 900 West Crossing (8053835N)	Chattanooga, TN Hamill Road Crossing (841993J)	Franklin Park, IL 25 th Ave Crossing (3272138C)	Catoosa County, GA Graysville Rd Crossing (340548H)
Avg. Daily Traffic Volume	+3%	+1%	-1%	-10%	+3%	-2%
Avg. Daily Cyclist Volume	+10%	+15%	+4%	+7%	NA	NA
Avg. Daily Pedestrian Volumes	+21%	+19%	+1%	+2%	NA	NA
Avg. Daily Crossing Activations	-1%	0%	+3%	+5%	-4%	+6%
Avg Vehicles Delayed (daily)	-26%	-29%	-22%	-24%	-32%	-16%
Avg Vehicle Delay (min)	-34%	-34%	-31%	-33%	-41%	-19%
Avg Trespass Events (daily-vehicles)	-1%	-5%	-25%	-12%	-24%	-13%
Avg Near Miss Time	-2%	+2%	+15%	+2%	+20%	+35%

CONCLUSION

This study evaluated the safety impacts of Rail Crossing Information Systems (RXIS) through detailed before-and-after analysis at two Canadian rail crossings and contextualized those findings using data from a broader network of deployments. The results demonstrate that RXIS consistently delivers significant operational benefits by reducing vehicle delay and improving travel-time predictability at rail crossings. These reductions meaningfully decrease driver exposure to crossing-related delay and have the potential to mitigate frustration and uncertainty associated with frequent or unpredictable rail activity.

However, the analysis also shows that reductions in vehicle delay do not automatically translate into proportional reductions in risky behavior. Changes in trespassing frequency and near-miss timing following RXIS deployment were small and not statistically significant at the study locations, indicating that trespassing is influenced by other factors. These other factors could include persistent behavioral, perceptual, and site-specific factors that extend beyond delay alone. Train speed, crossing geometry, visibility, habitual user behavior, and the perceived legitimacy of waiting appear to play a role in shaping risk-taking decisions at crossings.

The broader network analysis reinforces this conclusion. While RXIS deployments across North America generally exhibit directionally consistent trends—reduced delay accompanied by modest improvements in trespassing—the magnitude of safety outcomes varies substantially by location. This variability suggests that RXIS should be viewed as an enabling safety technology whose effectiveness depends on local context, rather than as a uniform or standalone intervention.

These findings have implications for the application of similar traveler-information technologies, including in-vehicle or mobile-based alerts such as rail crossing notifications delivered through navigation platforms (e.g., Waze or comparable services). Technologies that provide advance awareness of crossing status or expected delay are likely to produce benefits similar to RXIS in terms of delay reduction and improved trip planning. However, based on the results of this study, such technologies should not be expected to independently produce large or consistent reductions in trespassing or near-miss behavior. Without a clear visual or physical cue tied to the crossing environment, mobile alerts may be even less effective at influencing last-moment decision-making during active warning periods.

Taken together, the evidence suggests that traveler-information systems are most effective when deployed as part of a broader, layered safety strategy. RXIS and comparable technologies can play a valuable role in reducing exposure and improving situational awareness, but meaningful and sustained reductions in risky behavior will likely require integration with physical design changes, enforcement strategies, and targeted behavioral interventions tailored to site-specific risk factors. Future research should focus on defining quantitative thresholds for significant trespassing, identifying the contextual variables that amplify or suppress risky behavior, and evaluating how combinations of interventions perform relative to single-technology deployments.