Quantifying Traffic Delay at the Waverley St Rail Crossing

*Case Study*

For decades the Waverley St rail crossing has caused significant traffic delays. TRAINFO worked with the City of Winnipeg to quantify these delays using our measurement method. To demonstrate our accuracy, we compared the results to the conventional modeling method. The results surprised us all.
**Introduction**

The rail crossing on Waverley St in Winnipeg, Manitoba is notorious for its frequent blockages and for causing regular traffic delays. Waverley St is a major north-south urban arterial roadway with two lanes per direction, an average daily traffic volume of 33,665 (about 16,832 per direction), and a posted speed limit of 60 km/h near the crossing. There is a double-track railroad crossing close to Taylor Ave. The railroad is a mainline track that has an average of 35 through trains per day and a maximum train speed of 35 mph. Figure 1 shows a picture of this crossing and the traffic queue during a blockage.

For decades this crossing has been vilified in the media and many Winnipeggers have loudly expressed their desire for an underpass. TRAINFO worked with the City of Winnipeg to quantify traffic delay at this location over a 91-day period (August 1, 2017 to October 31, 2017). Specifically, TRAINFO applied two methods to quantify traffic delay for northbound vehicles: the conventional modeling method and the new measurement method. This case study describes and compares the results of these methods.

![Figure 1: Waverley St Rail Crossing and Traffic Queue](image)

**Conventional Method vs Measurement Method for Quantifying Traffic Delays at Rail Crossings**

There are two approaches to quantify traffic delay at rail crossings: modeling and measurement. The modeling approach, a.k.a. the conventional method, is the default while the measurement approach is rarely used, primarily due to the lack of data [1]. The modeling approach applies traffic engineering theories to estimate traffic delays at rail crossings and relies on many incorrect assumptions (due to insufficient rail crossing blockage data, traffic volume data, and travel speed data) [2]. The measurement approach uses actual crossing blockage and traffic delay data to determine traffic delays at rail crossings. This approach removes the guesswork and provides accurate, reliable information. A technical brief explains these methods and is available for download here: http://trainfo.ca/congestion/.
The Modeling Method

Equation

The conventional method equation to calculate total vehicle delay per train, D, is [3]:

\[
D = \left(\frac{1}{2}\right) \times \frac{q \times T_G^2}{\left(1 - \frac{q}{d}\right)}
\]

Where,
- \(D\) = total vehicle-delay per train (minutes)
- \(q\) = vehicle arrival rate (vehicles per minute)
- \(T_G\) = gate down time (minutes)
- \(d\) = vehicle departure rate (vehicles per minute)

Inputs and Variables

Assumptions

- Average train length = 7,000 ft (industry average)
- Saturation flow rate = 1,900 vehicles per lane per hour (traffic engineering theory)
- Advanced warning time = 20 seconds (industry average)
- Clearance time = 10 seconds (industry average)
- Train volume = 35 trains per day (given by Transport Canada)
- Avg daily traffic volume = 16,832 vehicles per direction per day (given by City)
- Total traffic volume over 91 days = 1,531,712 (16,832 vehicles per day x 91 days)
- Total blockages = 3,185 trains (35 trains per day x 91-day study period)

Equation Variables

- \(q\) = 4.68 vehicles per minute (16,832 vpd / 3,600 min/day)
- \(d\) = 63.3 vehicles per minute (1,900 vplph x 2 lanes / 60 min/hr)
- \(T_G\) = 2.8 minutes (7,000 feet / 35 mph + 20 s + 10 s)

Results

\[
D = \left(\frac{1}{2}\right) \times \frac{4.68 \times 2.8^2}{\left(1 - \frac{4.68}{63.3}\right)} = 19.9 \text{ minutes vehicle delay per train}
\]

- Vehicle-delay per train = 19.9 minutes
- Total vehicle-delay over 91 days = 63,110 min (1,052 hr) (19.9 minutes per train x 3,185 trains)
- Average delay per vehicle = 0.04 min (2.4 seconds) (63,110 minutes / 1,531,712 vehicles)
The Measurement Method

Equation

The measurement method calculates total vehicle delay per train, D, as follows:

\[ D = \sum_{i=1}^{n} \left( \frac{\sum_{i=1}^{n} t_i - t_0}{n} \right) \times V \]

Where,

- \( D \) = total vehicle-delay per train
- \( t_0 \) = expected travel time with no train (as measured by Bluetooth sensors)
- \( t_i \) = actual travel time of vehicle, \( i \) (as measured by Bluetooth sensors)
- \( n \) = blockage event (as measured by train detection sensor)
- \( V \) = number of vehicles impacted by the crossing delay

Results

- Vehicle-delay per train = 86.7 minutes
- Total vehicle-delay over 91 days = 528,005 min (8,800 hr)
- Average delay per vehicle = 0.34 minutes (20.4 seconds)

This method detected 3,422 blockages (including through trains, switching movements, equipment malfunctions, and all other instances where the crossing was blocked) and the average gate down time was 5.9 minutes.

Further, the measurement facilitates a much deeper analysis and understanding of traffic delay at rail crossings. Figure 2 shows a probability density function that provides the distribution of crossing blockages based on the blockage duration and the vehicle-delay caused by these blockage durations. Total vehicle-delay is represented by the area under the “Minutes of Vehicle Delay” curve (orange line). Figure 3 shows the same data except plotted as a cumulative density function. These figures show that a large proportion of vehicle-delay is caused by a relatively small number of blockages. For instance, 30% of total delay is caused by 15% of blockages (i.e., blockages of 10 minutes or longer). Further, the 23 longest blockages, representing those of 19 minutes or longer, caused more delay than the 1,385 shortest blockages, representing those of 5 minutes or shorter.
Figure 2: Probability density function of number of crossing blockages and minutes of vehicle-delay based on the measurement method

Figure 3: Cumulative density function of total vehicle-delay and crossing blockage duration based on the measurement method
Comparison & Summary

The measurement method is based on ground truth data and significantly outperforms the conventional modeling method. Overall the measurement method finds that traffic delay at the Waverley St crossing is more than 700% higher compared to the conventional method. Table 1 compares key metrics between each method.

Table 1: Comparison of key performance metrics between the conventional and new method

<table>
<thead>
<tr>
<th>Metric</th>
<th>Conventional Modeling Method</th>
<th>TRAINFO Measurement Method</th>
<th>Percent Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of blockages (over 91 days)</td>
<td>3,185</td>
<td>3,422</td>
<td>+7.4%</td>
</tr>
<tr>
<td>Total blockage duration (over 91 days)</td>
<td>148.6 hours</td>
<td>336.5 hours</td>
<td>+126.4%</td>
</tr>
<tr>
<td>Average vehicle-delay per blockage</td>
<td>19.9 minutes</td>
<td>86.7 minutes</td>
<td>+335.7%</td>
</tr>
<tr>
<td>Average delay per vehicle</td>
<td>2.4 seconds</td>
<td>20.4 seconds</td>
<td>+750.0%</td>
</tr>
<tr>
<td>Total vehicle-delay (over 91 days)</td>
<td>1,052 hours</td>
<td>8,800 hours</td>
<td>+736.5%</td>
</tr>
</tbody>
</table>

The measurement method also provides superior insight into the nature of traffic delay at rail crossings. For instance, the measurement method finds the following at the Waverley St crossing:

- 30% of total delay is caused by blockages of 10 minutes or longer (these comprise 15% of total blockages).
- Blockages lasting 19 minutes or longer (of which there were 23) caused more delay than 1,385 blockages lasting less than 5 minutes.

These advanced findings indicate that a significant amount of traffic delay can be addressed if long blockages can be predicted to re-route drivers around the crossing.

The crossing on Waverley St is a fairly predictable location relative to many other crossings. There are usually one to two blockages per hour caused mainly by through moving trains with a consistent blockage duration. Evidence of this predictability can be seen by the approximate bell-shaped curve of blockage distributions shown in Figure 2. In theory, this consistency provides highly favourable conditions for the conventional modeling method. Despite these conditions, the method still underestimates vehicle-delay by over 700%. In general, the accuracy of this method is expected to decrease at crossings where the blockages are more random.

Conclusion

Until recently, the conventional modeling method was the primary approach for quantifying traffic delay at rail crossings. TRAINFO’s new, affordable technologies are providing a superior alternative to help truly understand traffic delay at rail crossings. This understanding helps traffic engineers confidently respond to public complaints and prioritize investment strategies.
References


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Whitepaper  Traffic Delay at Rail Crossings: The #2 Source of Non-Recurring Traffic Congestion in America?

Technical Brief  Quantifying Traffic Delay at Rail Crossings: Modeling Method vs Measurement Method

Case Study  How the City of Vancouver Used Trainfo to Understand Increased Train Volumes in the City

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