RAIL-HIGHWAY CROSSING DELAY STUDY

FOR DOLTON AND RIVERDALE

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Hazel Crest, Illinois

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1. Introduction

Study Background and Purpose

The communities of Dolton and Riverdale are located approximately 22 miles south of downtown Chicago in the southern Cook County, Illinois). Reflecting their industrial heritage, railroads are major presence in those communities (Figure 2). There are major rail yards including Union Pacific (UP) Yard Center, Chessie Seaboard X (CSX) Barr Yard, Indiana Harbor Belt (IHB) Blue Island Yard, and Riverdale CSX Yard, generating and attracting significant number of freight trains each day.

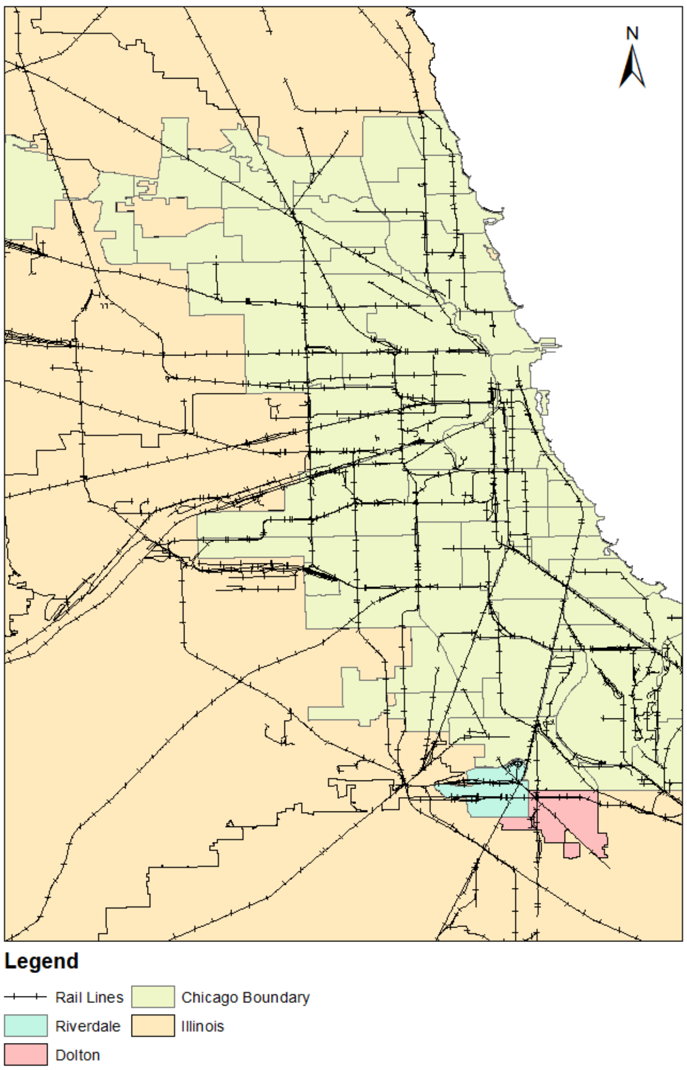

Figure 1 Location map of the study area

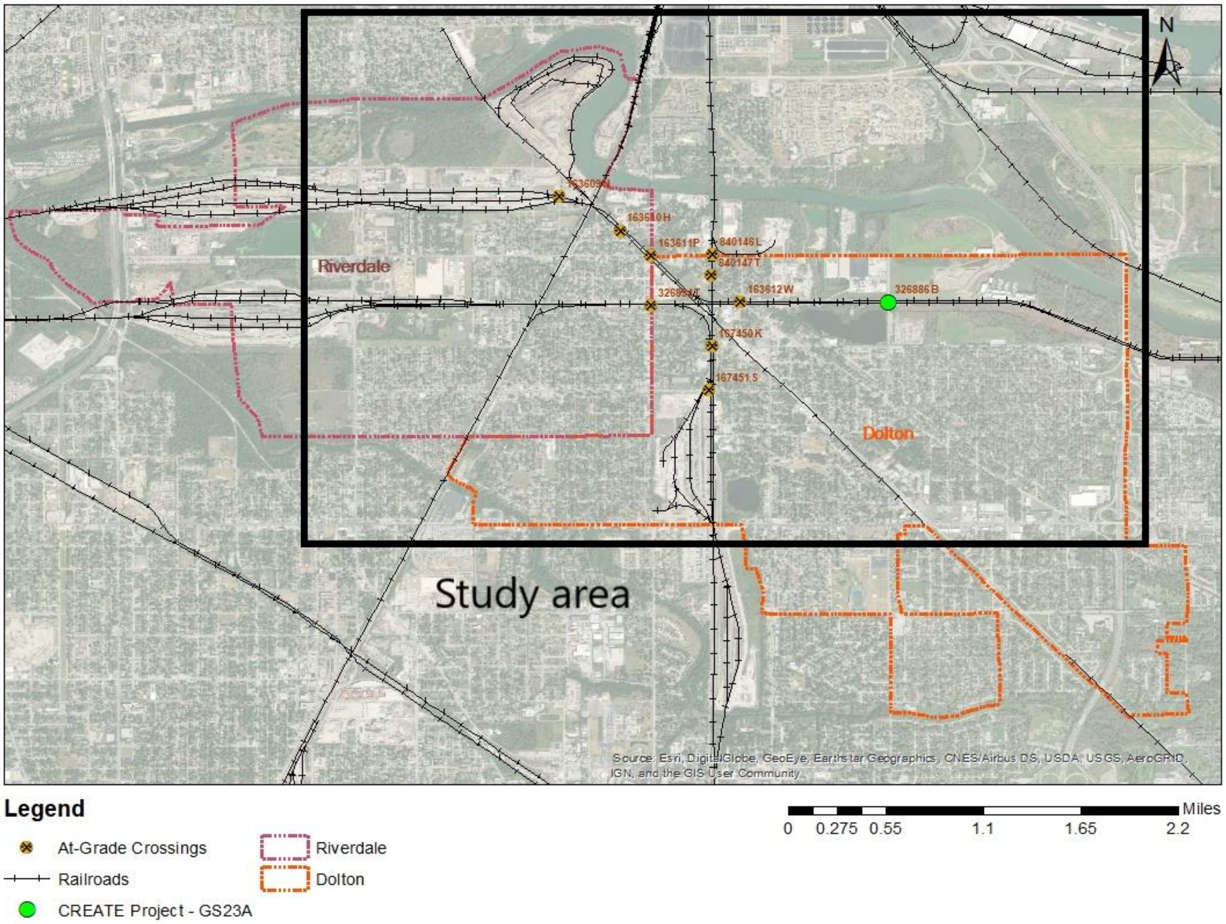

Figure 2. Study area map

There are a total of 11 at-grade rail crossings in the two communities that see a total of over 400 freight trains per day. Some of the rail crossings are close to the entrance of the rail yards and it is common for trains to move very slowly or come to a complete stop at those locations, further contributing to the long gate-down times and thus traffic delays. There are parts of Dolton that are surrounded by multiple train tracks, and it can be difficult to travel to or from the locations within those areas during the peak train traffic. Without a rigorous analysis, it is difficult to quantify the true impacts of the rail crossings in Dolton and Riverdale even though anecdotal information obtained from the meetings with the stakeholders and field observations suggest that these communities are experiencing significant delays on a daily basis.

Traffic impacts associated with rail crossings differ from those of traffic signals in some important ways. Unlike traffic signals, the timing, frequency, and duration of gate closures are unpredictable, which makes it difficult to make optimum travel decisions including route and departure time choices, Also, gate-down time can be much longer than the red phase of typical traffic signals, often creating long queues that are not found at traffic signals. Long queues take a long time to dissipate, and can affect the performance of the network for a prolonged period of time after the gate opens. Furthermore, the prospect of a long wait prompts some travelers to divert to other routes, possibly creating additional strain on the road network. In other words, the network disruptions caused by gate-down events can extend beyond the time and location of their occurrences. As such, it is reasonable to expect the impacts of rail crossings cannot be accurately estimated based on the duration of gate-down times alone. For this reason, presently, there is no established method to estimate the network-wide traffic impacts of rail crossings.

There may be some tools that can be deployed economically (relative to physical improvements such as grade separation) to help reduce the delay experienced by the travelers. These include informing travelers about on-going or upcoming gate-down events to help them make adjustments to their travel plans. While the proliferation of travel assistance services and apps have helped motorists better navigate traffic disruptions, they have not had similar impacts on alleviating delays associated with rail crossings. As such, there may be a considerable potential for improving traveler experiences by providing information on gate-down events. For example, providing an estimate of the duration of an on-going gate-down event using variable message signs placed near the rail crossings can help travelers make appropriate decisions on whether to divert to another route. If such information is provided through a web site or mobile devices, travelers can alter their travel plan before reaching the rail crossing.

To address these gaps in the knowledge, this study will aim to:

1. Estimate the traffic delay associated with at-grade rail crossings in Dolton and Riverdale
2. Analyze the effectiveness of possible mitigation measures that involve dissemination of real-time or near real-time information on traffic conditions

2. Rail Crossing Delays

There are not many studies that examined traffic impacts of rail crossings in a rigorous manner. De Gruyter and Currie (2016) provides a literature review of various impacts of at-grade rail crossings. They state that despite some past efforts, "(f)urther research in this area would therefore help to better understand the road vehicle delay impacts associated with rail-road grade separation". Powell's work (1982) is the earliest known example of using microsimulation to study the delay impacts of rail crossing. At the three rail crossings he studied, Powell estimated that rail crossings account for eight percent of total delay for the vehicles traveling across those crossings each day. It should be noted that Powel's study did not include network-wide impacts due to diversions. Rilett and Appiah (2008) used VISSIM software to conduct a microsimulation analysis of rail crossing delays. Notably, they tested the effectiveness of variable messaging signs, and found they can reduce the delay. Nguyen-Phuoc et al. (2017) used a two-layer approach – using microsimulation to estimate local delays at 152 rail crossings in Melbourne, Australia and feeding the data to a conventional four-step travel demand model to estimate the system-wide impacts. They found that the total delay on Melbourne's network during the morning peak (7 – 9 AM) increases by 0.7% when the delay at the rail crossings are included.

Protopapas et al. (2010) estimated the impacts of gate-down events for the Houston region in terms of delay and environmental effects. To estimate delays, they used an "impedance model" that take into accounts vehicle motions such as deceleration and acceleration because such information are required to estimate emission impacts. The methodology used in their study was aggregate in nature since their aim was to estimate region-wide impacts. In 2008, North Jersey Transportation Planning Authority commissioned a study to rank impacts of rail crossings in the northern New Jersey (Jacobs Engineering, 2008). While the study involved assessment of traffic impacts of various rail crossings in the study area, the methodology relied on traffic volumse and did not include the network wide effects or diversion of travelers.

In terms of the economic cost of traffic delays associated with rail crossings, Dodgson (1984) carried out cost-benefit analysis of five examples of grade separation projects in Ontario, Canada. He found that reduction in traffic delays is by far the largest source of benefits. He estimated that between 72% and 94% of total benefit of grade separation projects can be attributed to delay reduction.

Since there are nearly 2,000 at-grade rail crossings in northeastern Illinois, their impacts have been of a considerable interest to the state government and also the Chicago Metropolitan Agency for Planning (CMAP). A study by the Illinois Commerce Commission (ICC, 2002) estimated the delay associated with rail crossing in the northeastern Illinois using a 16-step methodology that calculate the gate-down times and reflect it on the delay experienced by motorists. Since the objective of the study was to assess the overall delay for the entire region, the methodology had to be relatively straightforward in terms of calculations involved. As such, the estimate provided by the ICC study does not take into account the effect of standing queues that develop during the gate closure or network-wide impacts. In 2011, ICC published an updated figures using the same methodology that showed a decrease of nearly 30% in the total estimated motorist delay (ICC, 2011).

In2015, CMAP published a technical report that document the findings from the effort to estimate the saturation flow rates based on the data collected at 17 sites in the CMAP region. They found that the saturation flow rate of 1,421 pcphpl more accurately reflect the field data than the 1,900 pcphpl value that is typically used in highway capacity analysis.

It is important to note that neither ICC's nor CMAP's efforts included the analysis of network-wide effects or investigated the effectiveness of mitigation strategies. In Dolton and Riverdale, rail crossings are located in close vicinity of each other, possibly compounding the delay by creating inaccessible areas during simultaneous gate-down events at multiple crossings. Also, as mentioned above, ICC's estimates do not take into account the standing queue that will be present (and will take some time to dissipate) after the gate is lifted. The aim of this present study is to shed light on the magnitude of those extra sources of delay and also study the effectiveness of some mitigation strategies.

3. Study Approach

In order to analyze impacts of rail crossings and also the effectiveness of mitigation measures, it is necessary to: 1) simulate the movements of individual vehicles on the study area road network to accurately estimate the effects of congestion and queueing, and 2) predict travel behavior changes that may result from the deployment of mitigation measures such as travel information provided via mobile devices. The second point is critical since our objective is to compare the current situation in which travelers has no information about when and where gate-down events can occur and how long they last against a condition in which travelers are provided such information in advance or during the trip. For example, to study the effects of providing information on gate-down events through mobile devices, it is necessary to simulate travel behavior changes after a trip has started (i.e. on-route travel decisions).

To satisfy all these conditions, this study used a dynamic travel assignment (DTA) model (Chu et al. 2011). In the traditional "static" approach to route choice modeling, macroscopic volume-delay functions are used to estimate link travel times. This approach typically results in route choice decisions based on predetermined travel times over each link and also between origin-destination pairs that are calculated by summing link travel times. In effect, this treats route choice process as if travelers know the actual travel time of each link and also times to reach the destination via various alternative routes before they start their journeys, which is of course not the case in the real world. Errors associated with such method may be tolerable in general planning applications, but it is critical in this study as we are interested in how choice of route may change over time as information about delays caused by rail crossings are made available, As described in this Chapter, DTA, which was developed to analyze just such "dynamic" route choice process, allows us to make realistic comparisons between the current and mitigated conditions.

Study Area and Road Network

As shown in Figure 2, the study area encompass parts of Dolton and Riverdale. The eastern boundary of the study area is the I-94 Expressway. The study area extends up to, but not including the I-94 interchanges. This is because any delay at the interchanges are unlikely to be substantially affected by the rail crossings. However, by including the road segments leading up to the interchanges, any diversion from one interchange to another will be captured in the analysis. Also, including freeways in the study network will introduce significant amount of external traffic, which would add uncertainty over the travel data.

The southern boundary of the study area is defined by Sibley Boulevard (Illinois 83). Sibley Boulevard is grade-separated over the railroad tracks and functions as a major east-west thoroughfare that provides reliable access.

The study area is bounded on the north by West 127th and East 130th streets. These streets provide east-west access without a rail crossing (via South Indiana Avenue along Little Calumet River) and is a possible diversion route.

The western boundary is formed by Halsted Street, which provides valuable north-south access without a rail crossing. Halsted Street and Sibley Boulevard are important surface streets that provide local travelers a reliable way to travel in a car while avoiding rail crossings. Other major roadways in the study area, including Indiana Avenue, Lincoln Avenue, and 142nd Street all have at least one rail crossing.

A total of eight rail crossings, listed below are included in the study:

- 138th St, Dolton, Chicago
- Lincoln Ave, Dolton
- 142nd St, Dolton
- E 144th St, Dolton
- Indiana Ave near 140th St, Dolton and Riverdale
- Cottage Grove Ave, Dolton
- Indiana Ave and 138th St, Dolton, Riverdale, Chicago
- Lincoln Ave and Park Ave, Dolton

Figure 3 shows the road network that was used in the DTA simulations. While there are three other rail crossings in the study area (137th St., South Perry Ave., and South Park Ave near 138th St.) they are not represented in the network since they involve low-volume streets and also are not likely to be used as diversion routes. School Street was included in the network despite its local and low volume characteristics since it provides grade-separated access over the IHB rail track, possibly serving as a diversion route. However, to the north of 138th St., School St. connects with a network of residential streets without a direct access to an arterial. As such, in a manner that is analogous to centroid connectors used in travel demand forecasting models, a hypothetical "generic connector" was added to the network to reflect the access provided by those residential streets.

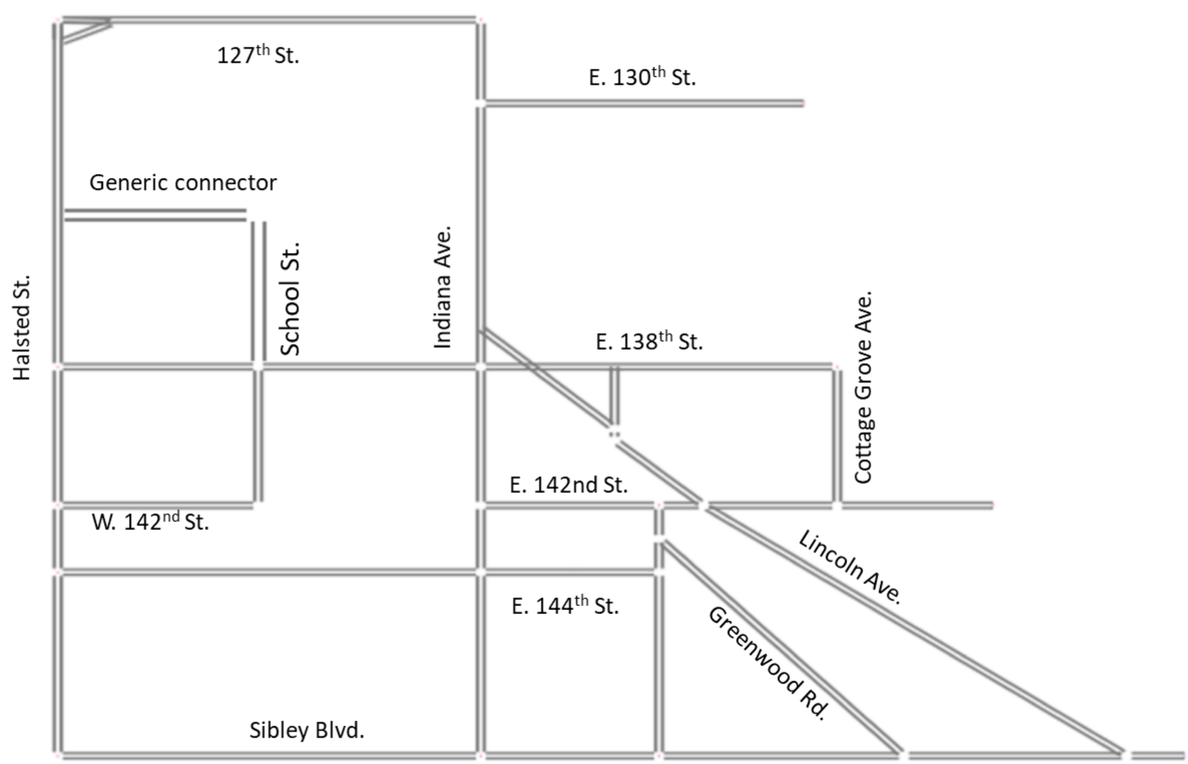

Figure 3 Coded network

Dynamic Traffic Assignment Tool

The software used to carry out the DTA is INTEGRATION 2.40, which is a microscopic DTA modeling tool developed by Dr. Hesham Rakha and his colleagues at Virginia Tech (Rakha, 2014, 2014b)[1], INTEGRATION 2.40 is capable of performing 10 different types of traffic assignment methods, each reflecting different circumstances and route choice behaviors, which is an attractive feature for this study. While INTEGRATION is capable of simulating varying vehicle acceleration behaviors, and past studies have examined effects of rail crossings on vehicle dynamics (Protopapas et al. 2010, Powell 1982, CMAP 2015), default setting was used in this study. This is because, as the CMAP study suggests, the effect of rail crossings on vehicle acceleration is highly dependent on individual crossing's geometry and road conditions, and thus may affect the generalizability of the findings from this study.

Another important feature of INTEGRATION 2.40 is optimization of signal timings. All the simulations were performed utilizing INTEGRATION's signal timing optimization without considering the coordinated signal timings. In other words, each signal is optimized in isolation without considering the effects on other signals, This was necessary since it was not possible to collect necessary signal operations data for each of 21 signals in the study area. In the simulation, timing of each signal was optimized every 5 minutes.

Data

For conducting DTA simulations in INTEGRATION, following input data were developed.

- Roadway network
- Trip origins and destinations
- Gate-down event locations, frequencies, and durations

This section discusses the process and assumptions used to prepare each of these input data.

Network

Road geometry (i.e. link length and number of lanes), speed limits, and signal phases were obtained from field visits and online map sites. The network consists of a total of 100 links and 37 nodes of which 21 are signalized. Fifteen of those 37 nodes are coded as

[1] An overview of INTEGRATION 2.40 can be found at https://sites.google.com/a/vt.edu/hrakha/software

origin/destination nodes that can generate or attract trips (see Figure 4). In other words, trips cannot originate or terminate at other 22 (path thru) nodes. The total network length is 50.8 miles measured in center-line length, and 72.2 lane miles.

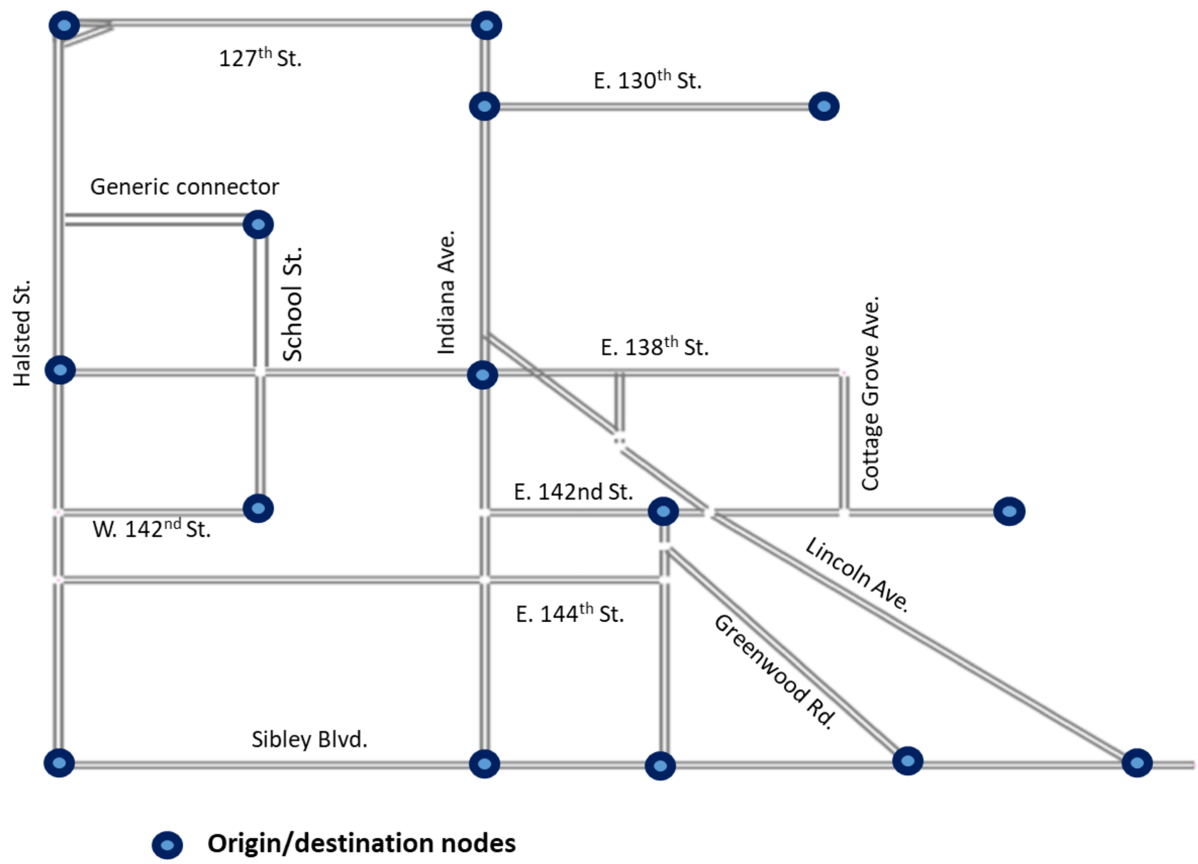

Figure 4. Origin/destination nodes

As noted earlier, the effect of rail crossings on vehicle acceleration was not taken into account in this study. Therefore, the analysis does not take into account the effect of rail crossings on the saturation flow rate. In the simulation, the default saturation flow rate for INTEGRATION, 2,000 pcphpl, is used for all the links (including those at rail crossings). Speed limit for each road segment was used as the free-flow speed.

Trip origins and destinations

Since INTEGRATION only performs traffic assignment, underlying travel demand, or the origins and destinations of the trips made by travelers, must be supplied as inputs to the model.

The starting point of constructing the origin and destination matrix for the study area was the person trip productions and attractions tables obtained from the CMAP. Table 1 provides the description of the tables obtained from CMAP (CMAP, 2018). Of these tables, those containing airport trips and transit trips, mf10, mf14, mf42, and mf43, were excluded from the calculation of origins and destinations as they are not significantly affected by the rail crossings in the study area.

Since these tables contain person trips over 24-hour period, the first step was to create separate tables representing each of the eight analysis time periods (or "time of day") used by CMAP. Then, person trips had to be divided by the vehicle occupancy factors to produce vehicle trip tables for respective time periods. Finally, the trips in tables from mf 1 to mf9 were summed for respective time periods to produce eight vehicle trip tables.

The factors for converting the 24-hour tables into tables for specific time periods were taken from the CMAP model document (CMAP 2014). Essentially, the factors shown in Table 2 were matched to each of the 10 tables based on the characteristic of the trips that are represented in the latter. For example, the factors for HBW to non CBD were used to convert mf1 table into eight separate time of day tables. A similar approach was used to determine the appropriate auto occupancy factors for each of the tables for each time period. Table 3 and Table 4 show the final factors used to convert the 24-hour person trip tables into time of day vehicle trip tables.

Filename Format	Contents	Total trips (2015)
mf1.txt P/A	Home-based work auto person trips	5,769,201
mf2.txt P/A	Home-based other auto person trips	9,183,491
mf3.txt O/D	Non-home based auto person trips	5,502,088
mf4.txt O/D	B-plate Truck vehicle trips	1,748,336
mf5.txt O/D	Light Truck vehicle trips	281,672
mf6.txt O/D	Medium Truck vehicle trips	262,244
mf7.txt O/D	Heavy Truck vehicle trips	454,201
mf8.txt O/D	Auto Point of Entry vehicle trips	255,176
mf9.txt O/D	Truck Point of Entry vehicle trips	109,361
mf10.txt O/D	Airport Trip vehicle trips	69,530
mf14.txt (P/A)	Home-based work transit person trips	647,181
mf42.txt (P/A)	Home-based other transit person trips	578,509
mf43.txt O/D	Non-home based transit person trips	182,362

Table 1. Trip priductions and attractions tables (Source: CMAP)

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8
HBW to CBD	0.147	0.197	0.460	0.053	0.077	0.029	0.022	0.015
HBW from CBD	0.128	0.002	0.010	0.002	0.064	0.138	0.459	0.197
HBW to nonCBD	0.142	0.199	0.408	0.054	0.106	0.042	0.030	0.018
HBW from nonCBD	0.121	0.005	0.015	0.007	0.119	0.252	0.374	0.107
HBW to airports	0.245	0.134	0.258	0.043	0.144	0.139	0.023	0.016
HBW from airports	0.302	0.054	0.040	0.003	0.091	0.222	0.196	0.090
HBO to home	0.188	0.004	0.024	0.030	0.236	0.187	0.167	0.163
HBO from home	0.043	0.039	0.211	0.085	0.246	0.101	0.145	0.129
NHB	0.053	0.008	0.055	0.062	0.431	0.173	0.133	0.084

Table 2 CMAP Time period factors (CMAP, 2014)

		Time of Day Factors							
Matrix	Heavy vehicle factors	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8
mf1	1	*0.142	*0.199	*0.408	*0.054	*0.119	*0.252	*0.374	*0.107
mf2	1	*0.188	*0.039	*0.211	*0.085	*0.246	*0.187	*0.167	*0.163
mf3	1	*0.053	*0.008	*0.055	*0.062	*0.431	*0.173	*0.133	*0.084
mf4	1	*0.053	*0.008	*0.055	*0.062	*0.431	*0.173	*0.133	*0.084
mf5	1	*0.053	*0.008	*0.055	*0.062	*0.431	*0.173	*0.133	*0.084
mf6	2	*0.053	*0.008	*0.055	*0.062	*0.431	*0.173	*0.133	*0.084
mf7	3	*0.053	*0.008	*0.055	*0.062	*0.431	*0.173	*0.133	*0.084
mf8	1	*0.053	*0.008	*0.055	*0.062	*0.431	*0.173	*0.133	*0.084
mf9	3	*0.053	*0.008	*0.055	*0.062	*0.431	*0.173	*0.133	*0.084
mf10	1	*0.302	*0.134	*0.258	*0.043	*0.144	*0.222	*0.196	*0.09

Table 3 Time of day factors used

	Auto Occupancy Factors							
Matrix	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8
mf1	/1.08	/1.06	/1.03	/1.01	/1.04	/1.07	/1.06	/1.07
mf2	/1.38	/1.23	/1.17	/1.23	/1.49	/1.52	/1.76	/1.68
mf3	/1.4	/1.1	/1.13	/1.14	/1.17	/1.18	/1.21	/1.34
mf4	/1.4	/1.1	/1.13	/1.14	/1.17	/1.18	/1.21	/1.34
mf5	/1.4	/1.1	/1.13	/1.14	/1.17	/1.18	/1.21	/1.34
mf6	/1.4	/1.1	/1.13	/1.14	/1.17	/1.18	/1.21	/1.34
mf7	/1.4	/1.1	/1.13	/1.14	/1.17	/1.18	/1.21	/1.34
mf8	/1.4	/1.1	/1.13	/1.14	/1.17	/1.18	/1.21	/1.34
mf9	/1.4	/1.1	/1.13	/1.14	/1.17	/1.18	/1.21	/1.34
mf10	/1.08	/1.06	/1.03	/1.01	/1.04	/1.07	/1.06	/1.07

Table 4 Auto occupancy factors used

Since the data from CMAP included the entire CMAP planning area, once the time of day vehicle trip tables were prepared, the data for appropriate set of traffic analysis zones (TAZs) that matches the study area had to be extracted. As shown in Figure 5, the boundary that was used to select the TAZs encompasses significantly larger area than the actual study area. In fact, both Dolton and Riverdale are completely enclosed within the TAZ boundary. This is because the simulation must capture trips that do not originate or end in the study area since such “through trips” are part of the traffic that use the roads in the study area.

For example, the trips going from TAZ 283 in the northwest corner of the boundary to TAZ 776 in the southeast corner do not stop within the study area, but may use roads within the study area and thus are affected by the rail crossings in terms of the choice of the route and also contribute to congestion on the roads and intersections. As such, the TAZ boundary was set rather conservatively, resulting in a total of 49 TAZs.

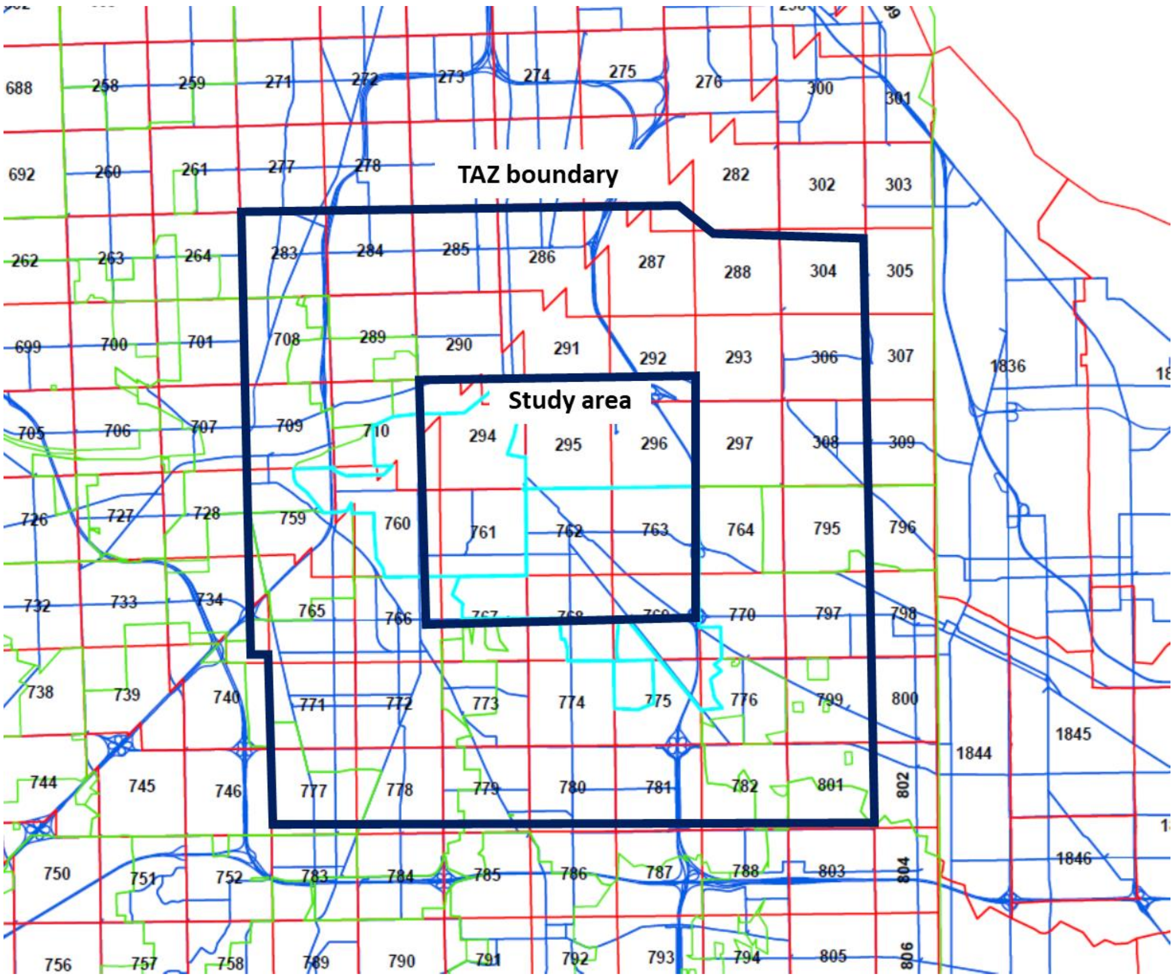

Figure 5. Boundary for selecting CMAP TAZs

After selecting TAZs and extracting the data from the time of day vehicle trip tables for those TAZs, the next step was to translate the trip origins and destinations that are expressed in the TAZ geography to the 15 origin and destination nodes in the network, This process required a number of judgements as to which trips between TAZs are likely to use any road segment within the study area. For example, trips from TAZ 288 to 304, which are located in the northeastern corner of the TAZ boundary outside of the study area, are unlikely to use any road segment within the study area, and thus should be excluded from the DTA simulation. For some origin-destination pairs, half of the trips were used in the simulation inputs. These judgments were made on case-by-case basis based on the examination of the road network and traffic volumes that would indicate whether or not there are major alternative routes outside of the study area connecting the origin destination pair in question.

The last step in the development of the origin-destination inputs for simulation was to consider through traffic volumes for major roadways including Sibley Blvd, E. 130th St. E. 142nd St. and Halsted St., These roadways provide direct access to the I-94 Expressway or are major arterials. As such, they are used by travelers from broader areas, possibly beyond the TAZ boundary. Thus, during the model calibration process, trips were added to some of the origin/destination nodes to reflect the volume of such through traffic based on the comparison of simulated link volumes against the AADT reported in the IDOT traffic data site (Illinois Department of Transportation, 2019) and the data collected by the UTC team.

Calibration and validation

Once the network and origin-destination inputs are coded, INTEGRATION was run without any gate-down events to check the accuracy of the input data and the traffic assignment. The actual daily volumes shown in Figure 6 were obtained from the IDOT web site "Getting Around Illinois" (Illinois Department of Transportation, 2019) and field data collected by the study team. The numbers show that the match between model results and actual volumes are generally good, with some notable exceptions that will be discussed later. The closeness of the overall amounts of traffic on the network, which can be judged by the sum of the volumes at the cordons of the study area, for both simulated and actual data, suggests that the trip origins and destinations data used in the model are appropriate[2].

[2] During the validation, 10,092 and 8,172 trips were added to the origins and destinations connecting Sibley/Halsted intersection and 127th St./Halsted intersection and Sibley/Halsted intersection and E.130th Interchange for I-94, respectively, to correct observed discrepancies between the simulation and traffic counts.

However, there are large difference between the model estimate and traffic counts on Sibley Blvd , Lincoln Ave., and Indiana Ave. north of E.138 St. The first is an underestimation and the latter two are overestimations. This suggests that model was assigning too much of the traffic destined to the southeastern part of the study area (e.g. the Sibley Blvd interchange for I-94) on Lincoln Ave. This is understandable since Lincoln Ave., rather than Sibley Blvd, is the shortest path for most traffic heading toward the southeastern corner. In reality, however, local travelers avoid Lincoln Ave. since it is not a reliable travel route due to multiple rail crossings, and prefer to use Sibley Blvd.

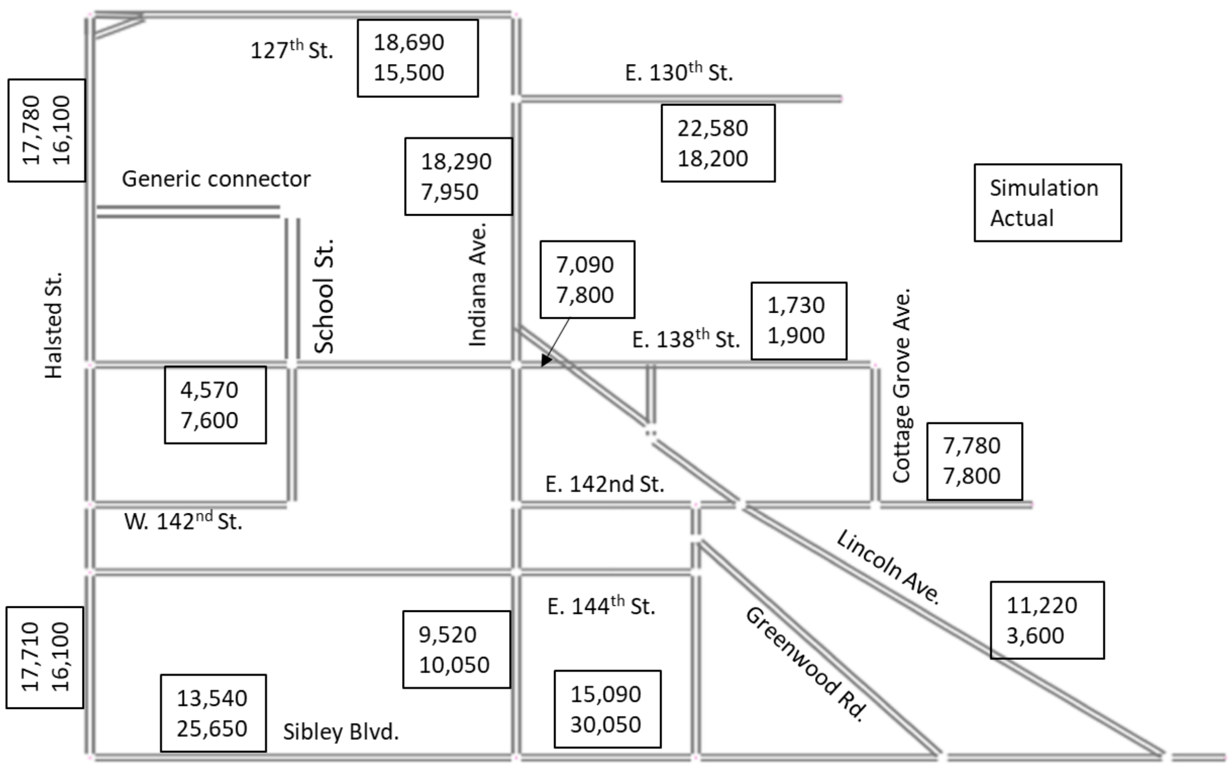

Figure 6. Comparison of simulated and actual traffic volumes (passenger cars per day)

Gate-down events

Data on gate-down frequencies and durations were obtained from the recordings made by time-capture cameras placed at or near each rail crossing except for the Cottage Grove. A more detailed description and data obtained from the recordings is provided in the Quiet

Zone Study for Dolton and Riverdale (Urban Transportation Center, 2020). Below is an excerpt from the Quiet Zone Study Report that provides an overview of the rail crossings[3].

Site	Daily Trains	Night Trains	Motor Vehicles	Percent Heavy Vehicles	Pedestrians		Bicycles
					Adults	Children	
Lincoln and Park, Dolton	61	29	3342	6.1	50	20	8
142nd St., Dolton	27	14	7257	2.4	68	42	17
138th St. Dolton	13	9	1867	10.6	30	5	2
144th St., Dolton	43	27	4613	1.3	47	16	10
Indiana Ave. near 140th St, Dolton, Riverdale	47	25	5590	3.6	88	4	10
Indiana Ave. at 138th St., Dolton, Riverdale, Chicago	44	22	9282	5.5	97	8	3
Lincoln Ave, Dolton	15	9	3449	5.5	20	4	0
137th St., Riverdale	43	22	997	2.5	42	11	8

Table 5 An overview of rail crossings in the study area (Source: Urban Transportation Center, 2020)

In the simulations, the gate-down frequency and duration at Cottage Grove rail crossing were assumed to be the same as those observed at Lincoln and Park that is approximately 3,200 feet to the west, on the same IHB track.

Figure 8 shows the frequency of gate-down events for all eight rail crossings combined during the day time, i.e. 7am to 7pm. The figure shows that gate-down events are somewhat consistently distributed throughout the time period. It appears that gate-down events are less frequent during the afternoon, but picks up after 6pm.

[3] The crossing at 137th St. is not included in the present study

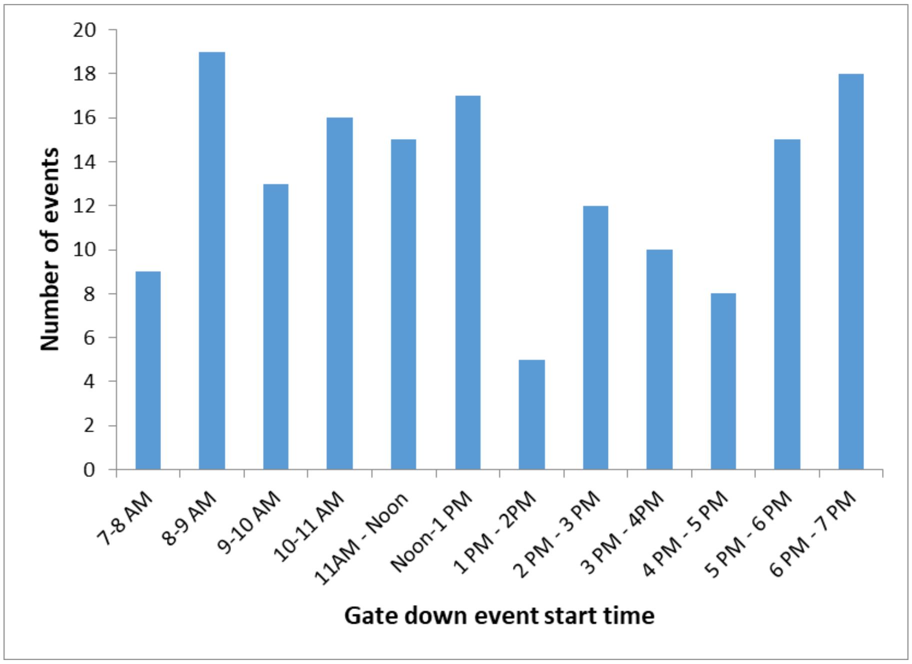

Figure 7 Distribution of gate-down event start times (all crossings)

The total gate-down times (Figure 8), which is calculated by summing the durations of all the gate-down events during each time period, show a similar pattern but with even greater consistency across the time period. The figure also shows that in terms of the total gate-down time, 6 PM to 7 PM is the highest, followed by 8 AM to 9 AM and Noon to 1 PM. These are popular time periods for travel, and obviously not the ideal periods to have rail crossings being closed for a prolonged duration. Since there are eight crossings in the data set, the total recorded time during each 1 hour time period was 8 hours. During 6 PM to 7 PM, the sum of gate closure times was approximately 2 hours. This means that gates were down about 25% of time (2hours/8 hours) across the rail crossings in the study area.

Figure 9 shows that while most gate-down events are relatively short, there are still significant number of rather long gate-down durations. A total of 19 gate-down events were longer than 12 minutes, which is 12% of the total events. There were three occasions that exceeded 21 minutes with the longest duration of 42 minutes occurring at the Park and Lincoln crossing in the evening.

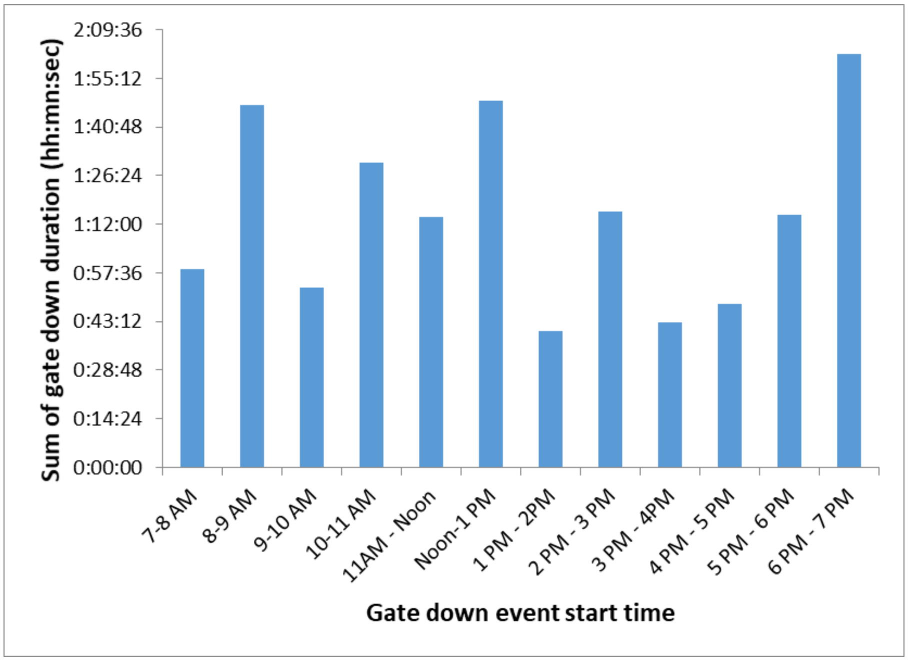

Figure 8 Distribution of sum of gate-down duration by start times (all crossings)

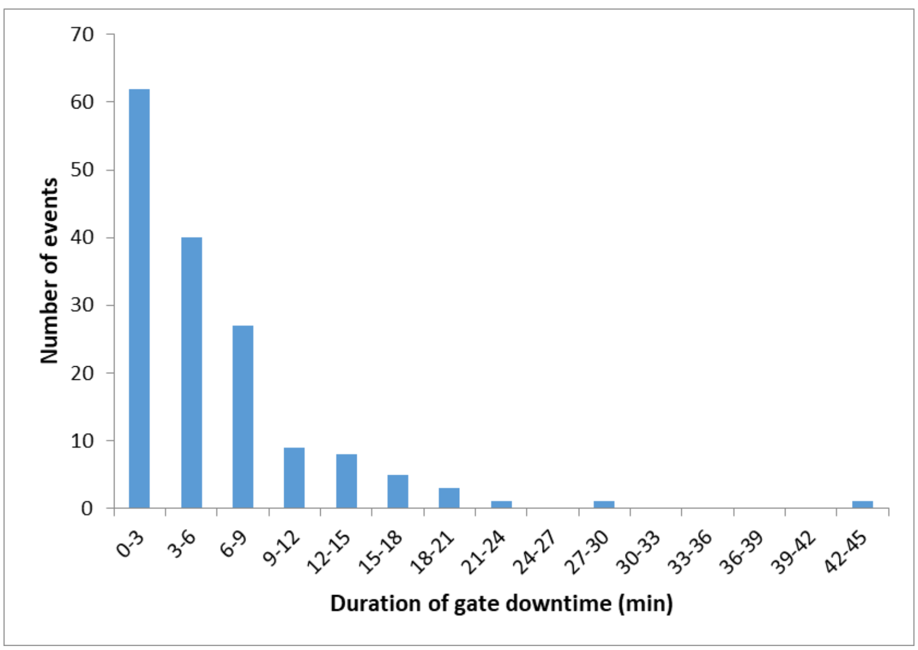

Figure 9 Distribution of gate-down durations (all crossings)

Simulations

Scenarios

To determine the impacts of rail crossings, the traffic conditions with gate-down events need to be compared against those without gate closures. The latter (hypothetical) condition will be referred to as "Baseline" and the former, which reflects the condition experienced by the travelers in the study area today, will be called "Existing" condition. In addition, this study will investigate the conditions with various non-physical mitigations designed to alleviate the impacts of rail crossings, including provision of travel condition information via web sites or mobile devices.

The timing of travel decision making and availability of information on traffic condition to facilitate the assessment of routing options are different under each of the aforementioned scenarios. For example, under the Baseline and Existing conditions, travelers have very little information on current or anticipated travel times before and during the trip. If they are stopped by a gate closure, they would wait in the queue until the gate opens.

With the advent of travel information services such as Google Map, information disseminated to travelers are becoming more up-to-date. However, it is reasonable to expect that the proportion of travelers who can benefit from the disseminated information depends on how quickly the data on traffic conditions are collected, analyzed, and disseminated in relation to the actual time it takes to complete trips. If the dissemination of information is too slow, many of the local trips would end before any useful information on traffic conditions reach them.

If up-to-date information on gate closures are disseminated frequently (in relation to the lengths of local trips), a greater share of travelers can benefit from it. Such scenario can happen if travel assisting services continue to evolve and get faster and faster. The most advanced mitigation considered in the study involves dissemination of up-to-date information to travelers via mobile devices, which, at this time, is considered the state-of-the–art.

Upon considering possible variations in the availability and quality of up-to-date traffic information and dissemination options, following five scenarios were developed.

Scenario 1 (Baseline): In this scenario, no gate-down events occurs. Travelers do not have any up-to-date information on traffic condition before or during the trip.

Scenario 2(Existing): In this scenario, gate-down events are simulated according to the data collected form the crossings in the study area. Travelers do not have any up-to-date information on traffic condition before or during the trip.

Scenario 3 (Pre-trip decisions with 30 minutes update): In this scenario, travelers are able to obtain up-to-date traffic information every 30 minutes prior to the start of the trip. It reflects a situation, for example, in which a traveler can consult traffic reports on the TV or home computer while making route choice decisions. But, once the traveler starts the trip, it is impossible to obtain information on traffic conditions.

Scenario 4 (Pre-trip decisions with 10 minute update): This scenario is the same as Scenario 3 except that traffic information is updated every 10 minutes instead of 30 minutes.

Scenario 5 (On-route decisions with 2 minute update): In this scenario, up-to-date traffic information is disseminated every two minutes via mobile devices. This allows travelers to assess the situation almost continuously and make route choice decisions before and also during the trip.

Traffic assignment methods

INTEGRATION is capable of simulating a number of different route choice processes utilized by travelers, which allows the program to simulate the scenarios described above. Following is a list of 10 options for the traffic assignment method that are available in INTEGRATION[4].

[4] For detailed explanation of the algorithm and assumptions behind each method, refer to Rakha, 2014b.

- Option 1: Time-Dependent Method of Successive Averages
- Option 2: Time-Dependent Sub-Population Feedback Assignment
- Option 3: Time-Dependent Individual Feedback Assignment
- Option 4: Time-Dependent Dynamic Traffic Assignment
- Option 5: Time-Dependent Frank-Wolf Algorithm
- Option 6: Time-Dependent External Routing 1
- Option 7: Time-Dependent External Routing 2
- Option 8: Distance Based Routing
- Option 9: Time-Dependent Sub-population Feedback Eco-Assignment (ECO-SFA
- Option 10: Time-Dependent Individual Feedback Eco-Assignment (ECO-IFA)

Of these, Options 1 and 5 use macroscopic link travel time estimation to find the user equilibrium condition, which is similar to those used in regular travel demand models. These are "static" traffic assignment methods that do not allow travelers to update their travel decisions once they start the trip. The difference between those two options is the heuristics used to find the user equilibrium. Option 1 was used to simulate the Baseline and Existing scenarios as it reflects the situation in which route choice decisions are made prior to the travel without information on gate closures. Option 2, with a different setting for each scenario, were used to simulate the remaining scenarios. In INTEGRATION user can set the frequency of traffic condition updates to be used for simulations. For Scenarios 3 and 4, 30 minutes and 10 minutes were used, respectively. For Scenario 5, it was set to 2 minutes. INTEGRATION also allows the setting on the frequency of route choice updating by the travelers to be changed. For Scenarios 3 and 4, the route choices were locked at the time of departure from the trip origin, which means that travelers must use the most recent travel time information at the time of departure for choosing the routes. For Scenario 5, it was unlocked, allowing route choices to be updated at any time before or after the departure based on the traffic conditions that are disseminated every 2 minutes.

Analysis time periods

INTEGRATION requires that the trip origins and destinations data must be provided in hourly volumes. Since the data prepared by the process described in page 11 resulted in volumes divided into eight CMAP time periods, they had to be translated into hourly volumes. Traffic counts collected by the study team were used for this purpose. The following table shows the factors used for this process.

Period	Times	Duration (hrs)	Priod factor	Hourly factor
1	8 PM - 6 AM	10	0.196	0.0196
2	6 AM -7 AM	1	0.036	0.0357
3	7 AM 9 AM	2	0.120	0.0600
4	9 AM – 10AM	1	0.051	0.0514
5	10 AM – 2 PM	4	0.208	0.0521
6	2 PM – 4 PM	2	0.142	0.0711
7	4 PM – 6 PM	2	0.124	0.0620
8	6 PM – 8 PM	2	0.122	0.0611

Table 6. Hourly factors

For each of the scenarios, simulations were carried out for Period 3 (7 AM – 9 AM), Period 6 (2 PM – 4 PM), and Period 8 (6 PM – 8 PM). Varying frequencies and durations of gate-down evens were recorded for each of these periods. Such variation is important for obtaining insights into the impacts of rail crossings and the efficacy of the mitigation strategies under a variety of conditions. In order to ensure that all the simulated trips can complete the journey even when substantial standing queues form, simulations were run with one extra hour added to the study time period. For example, the simulation for Period 1 was set to run for three hours (7 AM – 10 AM).

Gate-down events in simulations

Gate-down events were coded as incidents on INTEGRATION. In the simulation, they are treated as a 100% reduction in saturation flow during the duration of the gate-down events.

For simulations, only the gate-down events that exceeded 10 minutes in duration were included. The main reason for this is the limitation by INTEGORATION in the number of incidents that can be included in a simulation. This certainly would result in an underestimation of the total delay associated with the rail crossings in the study area and will need to be addressed in future studies. However, the evaluation of mitigation measures should produce reasonably accurate results as it is unlikely that dissemination of travel information help alleviate impacts of short gate-down events. This is because 1) short events, especially those below two minutes in duration, are over before information about them are conveyed to travelers, and 2) the effects on travel time are not sufficient to induce route changes in most cases.

The following table shows the gate-down events that occurred during the study time periods and lasted over 10minutes. While all other gate-down durations are between 11 and 17 minutes, the gate closures that occurred at 6:32:55 PM at the Cottage Grove Ave. crossing and the Park Ave. and Lincoln Ave. crossing - two adjacent crossings on the IBH tracks - exceeded 42 minutes. They are the only gate-down events that occur during the simulations for the 6 PM – 8 PM time period.

Location	Start time	End time	Duration
138th St. and Indiana Ave.	7:41:37 AM	7:58:33 AM	0:16:56
Cottage Grove Ave.	8:36:47 AM	8:47:53 AM	0:11:06
Park Ave. and Lincoln Ave.	8:36:47 AM	8:47:53 AM	0:11:06
Cottage Grove Ave.	2:29:02 PM	2:41:16 PM	0:12:14
Park Ave. and Lincoln Ave,	2:29:02 PM	2:41:16 PM	0:12:14
138th St. and Indiana Ave.	2:36:17 PM	2:50:20 PM	0:14:03
Cottage Grove Ave.	2:44:11 PM	2:58:52 PM	0:14:41
Park Ave. and Lincoln Ave,	2:44:11 PM	2:58:52 PM	0:14:41
Lincoln Ave.	6:15:18 PM	6:26:25 PM	0:11:07
Cottage Grove Ave.	6:32:55 PM	7:15:07 PM	0:42:12
Park Ave. and Lincoln Ave.	6:32:55 PM	7:15:07 PM	0:42:12

Table 7. Gate-down events included in simulations

4. Analysis Results

The results from each of the 15 simulations are summarized in Table 8. Comparing the total travel times for Scenarios 1 and 2 reveals that the rail crossings are the major contributors to traffic congestion in the study area. Additional travel time experienced by the travelers for Scenario 2 in comparison to Scenario 1 range from 82 hours for the 7 AM – 9 AM period to 611 hours for the 6 PM – 8 PM period. It should be noted that the latter is attributed to a single gate-down event that blocked the two rail crossing on the IHB track fro more than 40 minutes. A screen capture of the simulation, shown in Figure 10, depicts the substantial queues (shown in red) that formed during the abovementioned gate closure.

On a per trip basis, at a minimum, the rail crossings doubled the average delay experienced by the travelers. At worst, the rail crossings multiplied the average delay by more than twelvefold. During the 6 PM – 8 PM time period, the extremely long gate-down events at two locations added over 4 minutes of delay to every traveler in the study area. It should be noted that the calculation of average delay includes travelers who were on other routes or completed the trip before the event. Thus, for the travelers who were in the vicinity of the crossings and/or were traveling during and after the gate-down event experienced far greater average delay. Across the all three simulated time periods, as a whole, the 11 gate-down events shown in Table 7 increased the aggregate travel time by 954 hours (Table 9).

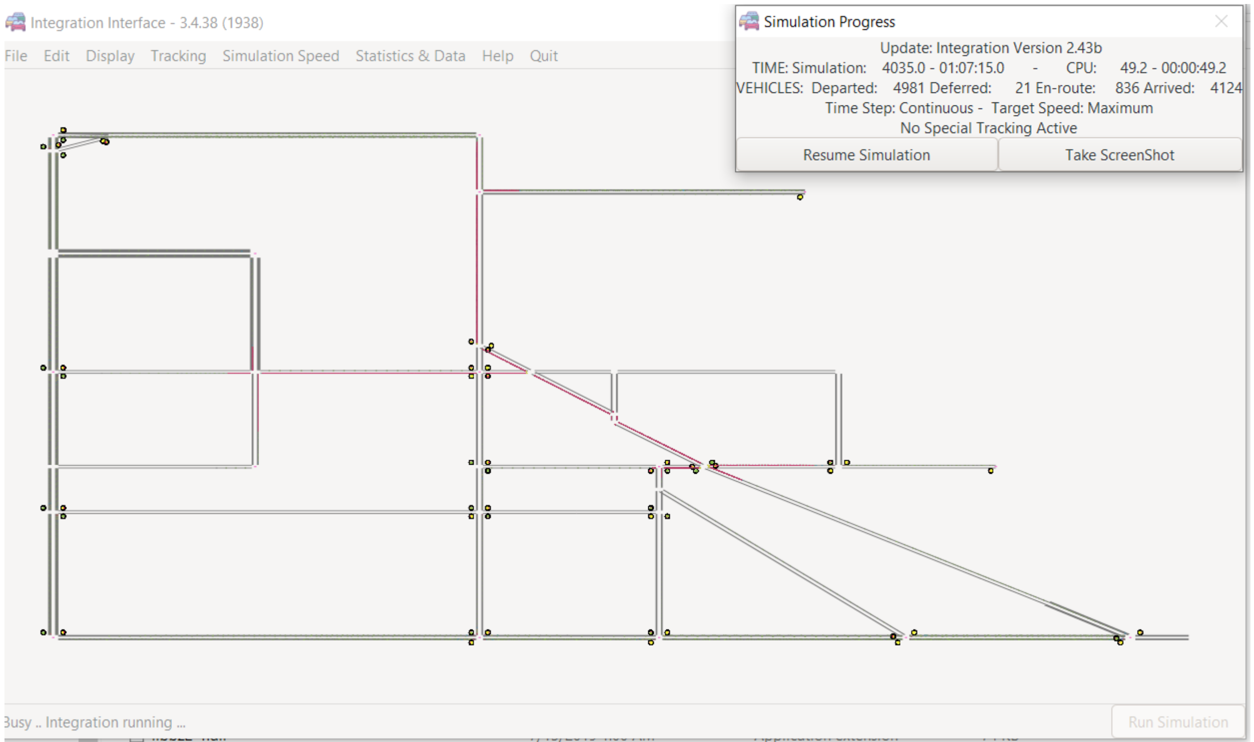

Figure 10. Screen capture of standing queues at 7:07 PM

Meanwhile, the mitigation measures showed that providing up-to-date traffic information to the travelers is effective, albeit at varying levels, for reducing the negative impacts of gate-down events. It is clear from Figure 11, Figure 12, and Figure 13 that using mobile devices to disseminate near real-time information frequently, simulated in Scenario 5, is the most effective measure. While it cannot completely eliminate the delay associated with rail crossings, in some cases, as seen for the 6 PM – 8 PM simulation, the improvement can be substantial.

The second most effective measure is Scenario 4 which entails disseminating information every 10 minutes through TV or other devices that cannot be accessed once the trip commences. Although the travelers are not able to deviate from the route planned before the departure, the availability of relatively recent traffic information can reduce delay to the level that are comparable to Scenario 5. Interestingly, when the frequency of updating the traffic information was set at every 30 minutes (Scenario 3), the effectiveness is dramatically reduced, especially for the 7 AM – 9 AM time period (Figure 11). This is probably due to the fact that traffic information was updated and disseminated at a 30 minute interval starting from the beginning of the simulation (e.g. 7 AM, 7:30 AM, 8 AM, 8:30 am, etc. for the 7 AM – 9 AM time period), and the delay caused by the gate-down events occurred in between the updates. The gate-down event at 8:36:47 AM is such an example. It occurred soon after the traffic information was updated at 8:30 AM and when the next update took place at 9 AM, the delay had already dissipated to some degree. As the level of congestion increase, the delays tend to persist longer, and even infrequently updated traffic information can benefit the travelers, as seen in Figure 13.

Table 9 shows the sums of travel times across all three simulation time periods for each scenario. It also shows the magnitudes of reduction in travel time in relation to Scenario 2 for each of the mitigation measures. As these numbers indicate, frequently providing traffic information to the travelers to facilitate efficient routing choices can bring substantial benefit in terms of travel time savings. It also suggests the importance of frequent updating of traffic information.

5. Conclusion

This study examined the impacts of rail crossings in the communities of Dolton and Riverdale. The analysis used a tool that carries out dynamic traffic assignment (DTA) to simulate how travelers can utilize real-time information on traffic conditions to avoid lengthy delays that are caused by gate-down events that exceed 10 minutes. The results of the simulations illustrate the severity of the impacts associated with the rail crossings in Dolton and Riverdale. Long gate closures in particular can result in massive delays experienced by the travelers.

The analysis also showed that the negative impacts of rail crossings can be mitigated to a degree by collecting and disseminating up-to-date information on travel time on each link. In the analysis, information that are infrequently updated (every 30 minutes) produced inconsistent improvements while more frequent updates, every 10 minutes or 2 minutes, generated much greater reductions in travel delays.

Period	Assignment method	Scenario	Vehicle trips	Vehicle kilometers	Total travel time (hours)	Total delay (hours)	Avg. delay (Sec)/trip
7 AM -9 AM	MSA (no on-route decision)	1	8,945	35,944	652	53	21.4
7 AM -9 AM	MSA (no on-route decision)	2	8,945	35,943	734	135	54.2
7 AM -9 AM	SFA (pre-trip decision) 30min updates	3	8,945	36,818	748	134	54.0
7 AM -9 AM	SFA (pre-trip decision) 10min updates	4	8,945	36,721	713	101	40.6
7 AM -9 AM	SFA (on-route decision) 2min updates	5	8,945	36,681	696	85	34.1
2 PM -4 PM	MSA (no on-route decision)	1	10,585	42,517	788	80	27.2
2 PM -4 PM	MSA (no on-route decision)	2	10,585	42,517	1,036	327	111.3
2 PM -4 PM	SFA (pre-trip decision) 30min updates	3	10,585	43,988	957	224	76.1
2 PM -4 PM	SFA (pre-trip decision) 10min updates	4	10,585	43,942	913	181	61.6
2 PM -4 PM	SFA (on-route decision) 2min updates	5	10,585	43,865	897	166	56.5
6 PM -8 PM	MSA (no on-route decision)	1	9,108	36,590	665	55	21.9
6 PM -8 PM	MSA (no on-route decision)	2	8,926[5]	35,730	1,290	666	268.6
6 PM -8 PM	SFA (pre-trip decision) 30min updates	3	9,108	38,846	1,019	367	145.1
6 PM -8 PM	SFA (pre-trip decision) 10min updates	4	9,108	37,119	758	139	55.0
6 PM -8 PM	SFA (on-route decision) 2min updates	5	9,108	37,078	719	101	39.8

Table 8. Simulation results

[5] In this simulation, the extreme level of congestion resulted in some of the vehicle not able to complete the trip.

Scenario	Total travel time (hours)	Reduction from Scenario 2 (hours)
1	2,105	
2	3,059	
3	2,723	336
4	2,384	675
5	2,311	748

Table 9. Total travel time for three simulation time periods

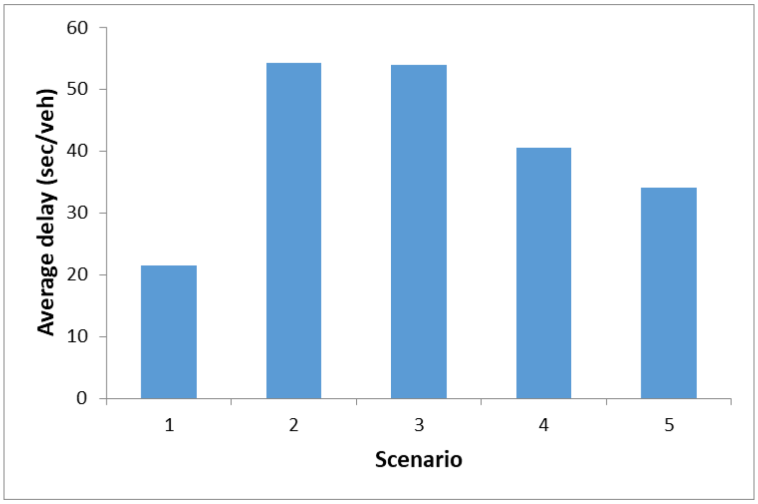

Figure 11. Average delay per vehicle (7 AM – 9 AM)

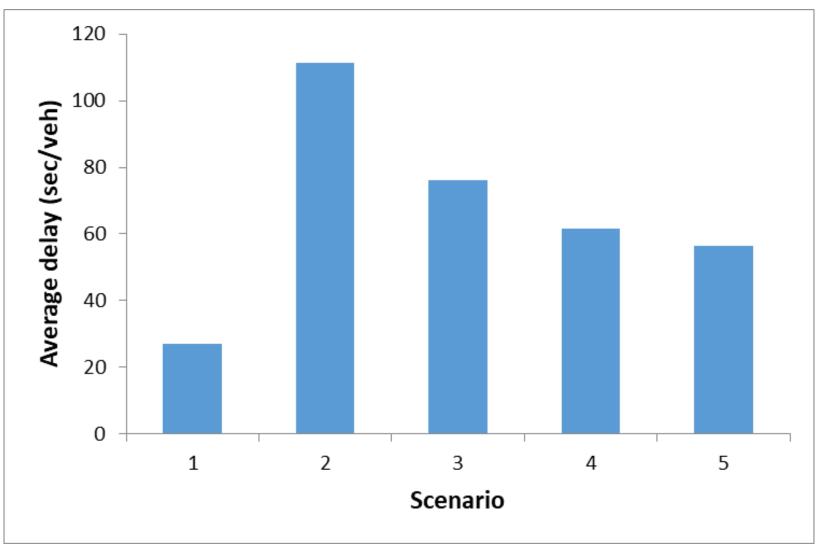

Figure 12. Average delay per vehicle (2 PM – 4 PM)

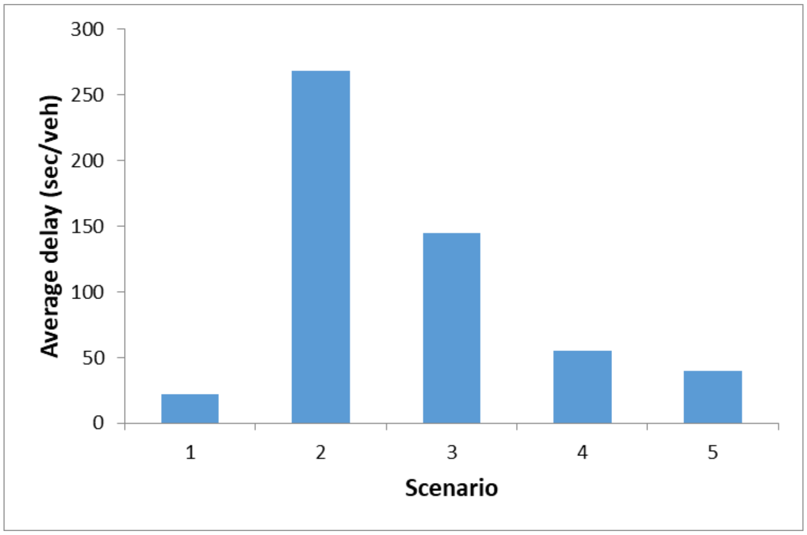

Figure 13. Average delay per vehicle (6 PM – 8 PM)

The simulations estimate that providing near real-time information on traffic conditions can reduce travel time over the simulation time periods (total of six hours) by nearly 750 hours. The data collected from the filed show that gate closures occur throughout the day and our analysis did not include the peak hours (e.g. 5 PM – 6 PM). As such, total reduction in travel time over a 24-hour period is likely to be substantially greater than 750 hours. Given such potential, at a minimum, economical ways to collect up-to date traffic information at several key locations in the road network and disseminate through either mobile or non-mobile channels is worth investigating.

It is not clear if these findings translate to other areas or even another day and time in the study area since the data on gate-down events were collected just for one day at each of the crossings. Traffic pattern and the configuration of the street network are other factors that can affect both the severity of the impacts and the effectiveness of the mitigation measures invested in this study.