Solving the Issue of Streetcars Blocking Traffic at King/Yonge

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1.0 Introduction

Observation revealed that at the intersection of King Street and Yonge Street, streetcars blocked traffic seriously during green lights. To solve the problem, this report provides and evaluates two solutions, namely, streetcar platforms and Transit Signal Priority System. By comparing and analyzing, the superior solution, Transit Signal Priority System, is recommended in this report.

2.0 Problem Statement

This section identifies the current situation, experienced problem at the intersection, and defines the engineering problem and three criteria.

2.1 Current Situation, Experienced Problem and Engineering Problem

The intersection of King Street at Yonge Street is located in the Downtown Toronto core, surrounded by numerous office buildings (Liang, 2016). Both streets are busy thoroughfares in Toronto with 4 lanes (2 lanes for each direction) at the intersection. Streetcar tracks located in the left lanes on both directions of King Street are currently in service (Liang, 2016). King/Yonge station, located at the intersection, connects the busiest subway and streetcar lines in Toronto (i.e. Yonge Subway Line, 504 King, 514 Cherry) (City of Toronto, 2014; Toronto Transit Commission, n.d.). Two of the five subway entrances are located on the northeast and southwest corners of the intersection next to existing streetcar stations (Toronto Transit Commission, n.d.). (See Appendix A for intersection layout.)

A 1.5-hour site visit at 6PM Sept. 16th, 2016 revealed that the streetcars blocked traffic seriously at the intersection while loading passengers when the traffic signals in their heading direction were green (Liang, 2016). Data recorded during the site visit shows that, on average, only 5 cars could pass the intersection during 37 seconds' green lights when the streetcars stopped and loaded. At extreme cases, only 2 cars could pass, while more than 15 cars could pass during green lights when no streetcars were present (Liang, 2016). In front of the intersection, both lanes are blocked because traffic cannot pass the streetcar on the right lane according to *Section 166 of the Highway Traffic Act* (Government of Ontario, 2016) (See Appendix B), while the streetcar is blocking the left lane. Overall, streetcars blocking traffic led to serious traffic congestions on both directions of King Street, also affecting Bay Street and Church Street which intersect with King (Liang, 2016).

The existing traffic flow management system includes only the traffic signals. It manages the vehicle and pedestrian flows at the intersection, while ignoring the status and the position of streetcars (City of Toronto, 2014; Liang, 2016). The current management system causes traffic congestion, which has negative impacts on the surrounding human environment. Therefore, a new traffic flow management method is required to improve traffic flow while maintaining safety of the passengers at this intersection.

2.2 Criteria for Evaluation

This section identifies three critical criteria to evaluate the potential solutions. Criteria are listed in descending order of importance.

2.2.1 Safety

This criterion ensures the safety of streetcar passengers. It examines the potential safety issues caused by the interactions between streetcar passengers and vehicles in new solutions. Any passenger-vehicle interaction should be safer than the current situation, in which the cars on the right lane may not stop when the streetcar is loading passengers (Liang, 2016). Quantitative metrics does not apply for this criterion; a logical comparison of safety issues will be created.

2.2.2 Traffic Flow

This criterion evaluates to what extend the traffic congestion caused by streetcars can be minimized. It is measured by traffic flow rate, the number of cars that could pass the intersection per hour on both streets. The rate should not be less than 2392 cars per hour (Liang, 2016). (See Appendix C.)

2.2.3 Cost

This criterion considers both additional capital cost and operating cost required for implementing the solutions. Existing operating cost, such as track maintenance cost, will not be considered as additional cost. In this project, solution with lower cost is preferred.

3.0 Solutions

This section provides two potential solutions to address the problem.

3.1 Solution 1: Streetcar Platforms

In this solution, two streetcar platforms will be constructed next to the tracks between 2 traffic lanes in each direction; streetcar track path and pedestrian sidewalks will be rearranged according to new platforms. The platforms will function as safety zones so that cars can pass streetcars through the right lane without waiting, according to *the Highway Traffic Act* (Commissioner of Works and Emergency Services, 2002; Government of Ontario, 2016).

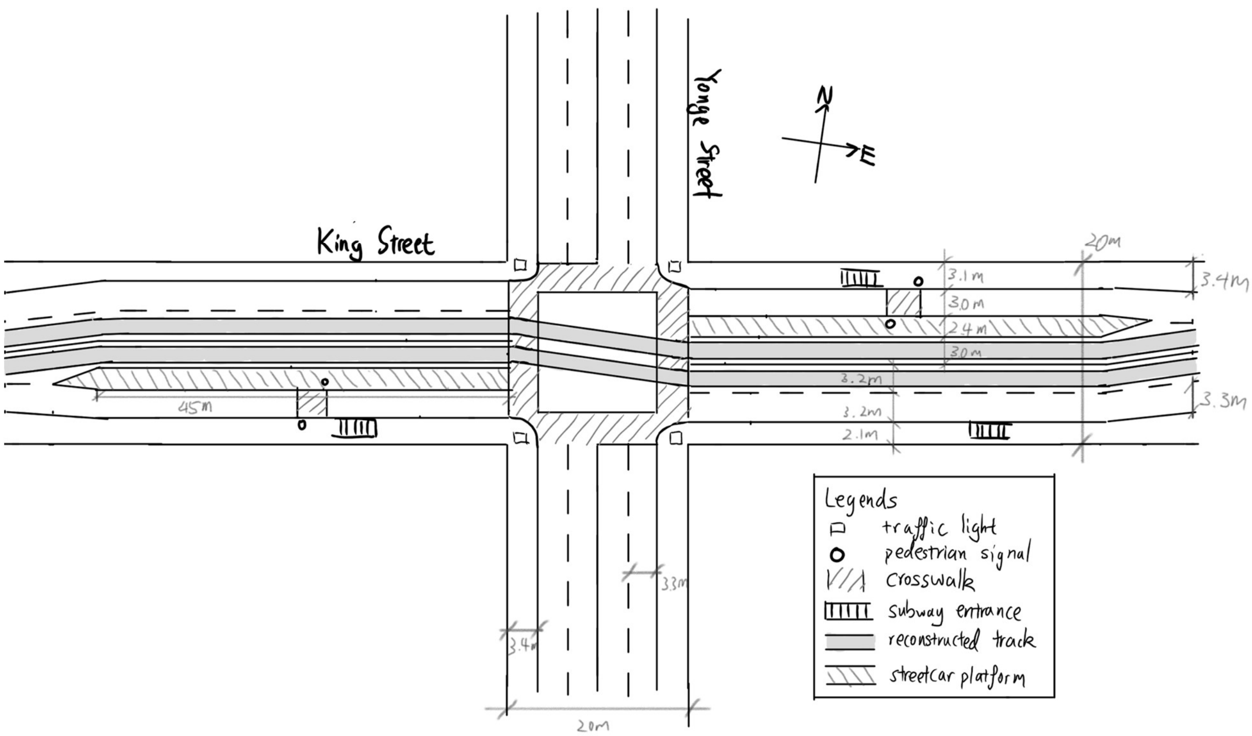

Figure 1. Intersection Layout by Implementing Solution 1

As shown in Figure 1, each platform will be 45m by 2.4m to accommodate TTC's new Flexity Outlook streetcars (City of Toronto, 2013). Platforms will be constructed separately to the opposite sides of Yonge Street. Traffic lanes and pedestrian sidewalks will be narrowed on King Street to provide spaces for the platforms. Widths of the lanes and sidewalks are shown in Figure 1, which complies with design guidelines (Lea, Schutrumpf, & Smahel, 2012).

The platforms will be connected to the existing pedestrian crosswalk allowing passengers to cross the street. Additional crosswalk will connect the platforms to subway entrances/exits for the ease of transfer. For safety reasons, pedestrian signals will be installed on the crosswalk; adjacent traffic lane will also be separated by the railings installed at the side of the platforms (City of Toronto, 2010).

3.2 Solution 2: Transit Signal Priority System

This solution functions by letting streetcars load while waiting during red lights. It involves installing the Transit Signal Priority (TSP) Controller onto the existing traffic signals at the intersection. The TSP Controller would be able to communicate with the existing TSP System equipped onboard all TTC streetcars, receiving the information of streetcar's status and position (City of Toronto, 2014).

When a streetcar is approaching the intersection, the TSP Controller will function in the following 5 steps:

1. Requesting for an extension of green light on King Street in order to clear the traffic in front of the streetcar, allowing it to approach the station (City of Toronto, 2014).
2. Terminate the green light on King Street once the streetcar doors are open, letting the streetcar load while facing a red signal (City of Toronto, 2014).
3. Switching the traffic signal on Yonge Street into green, the duration of green light should be no less than 35.5 seconds (Liang, 2016).
4. Terminate the green light on Yonge Street after 35.5 seconds or the streetcar finishing loading if loading time exceeds 35.5 seconds.
5. Switching the signal into green on King Street and release the traffic.

By installing the TSP Controller as a method of traffic flow management, streetcars will load only when the signal is red.

4.0 Evaluation

This section analyzes and evaluates the solution against each criterion.

4.1.1 Streetcar Platforms and Safety

According to the City of Toronto, streetcar platforms with safety measures (crosswalk, pedestrian signal, railing) have satisfying safety records (Commissioner of Works and Emergency Services, 2002). However, concerns about passengers may cross the traffic to catch streetcars were risen by the Toronto Pedestrian Committee (Commissioner of Works and Emergency Services, 2002).

4.1.2 Transit Signal Priority System and Safety

Streetcars will load passengers only when the signal is red while the traffic on the right lane are stopped, which prevent the situation that traffic on the right lane may not stop when the streetcar is loading.

4.2.1 Streetcar Platforms and Traffic Flow

Based on estimation, traffic flow rate is 2662 cars/hour (Liang, 2016) (See Appendix C).

4.2.2 Transit Signal Priority System and Traffic Flow

Based on estimation, traffic flow rate is 2933 cars/hour (Liang, 2016) (See Appendix C).

4.3.1 Streetcar Platforms and Cost

The cost of each construction/maintenance step in Solution 1 is listed as below:

Capital Cost:

1. Removing parts of the existing sidewalks: $1872 (Ainley Group, 2016)
2. Road paving: $15934 (Ainley Group, 2016)
3. Reconstruction of streetcar tracks: $1.2-2.4M (Metrolinx, 2008)
4. Construction of platforms: $54000 (City of Toronto, 1998) (See Appendix D.)

Operating Cost:

Platform maintenance: $30000/year (City of Toronto, 1998)

4.3.2 Transit Signal Priority System and Cost

The cost of parts in Solution 2 is listed as below:

Capital Cost:

Transit Signal Priority Controller: $8000-10000 (U.S. Department of Transportation, 2013)

Operating Cost:

Emitter Replacement: $333/year (Calgary Transit, 2004; U.S. Department of Transportation, 2013) (See Appendix D.)

5.0 Recommendation

This section compares both solutions and provides a recommendation based on the comparison.

Table 1: Comparison of Solutions and Current Situation Based on Each Criterion

	Safety	Traffic Flow	Cost
Current Situation	Cars may not stop when the streetcar is loading	2392 cars/hour	N/A
Streetcar Platform	Good safety records with minor concerns	2662 cars/hour	Capital Cost: $1.27-2.47M Operating Cost: $30000/year
TSP System	Safety is guaranteed	2933 cars/hour	Capital Cost: $8000-10000 Operating Cost: $333/year

By comparing the two solutions to current situation, both solutions solve the existing problem by allowing more traffic flow over a certain period of time while maintaining safety at the intersection.

Based on the analysis, TSP System is recommended in this report due to 3 reasons:

1. It guarantees the safety of passengers at the intersection without concerns.
2. It allows more traffic flow to go through the intersection over a certain period of time comparing to solution 1.
3. Implementation cost for TSP System is much less than new platforms.

While TSP System is promising, more studies need to be conducted before implementation regarding to how it will affect the traffic flow on both streets and the interaction between streetcar passengers and traffic.

6.0 Reference list

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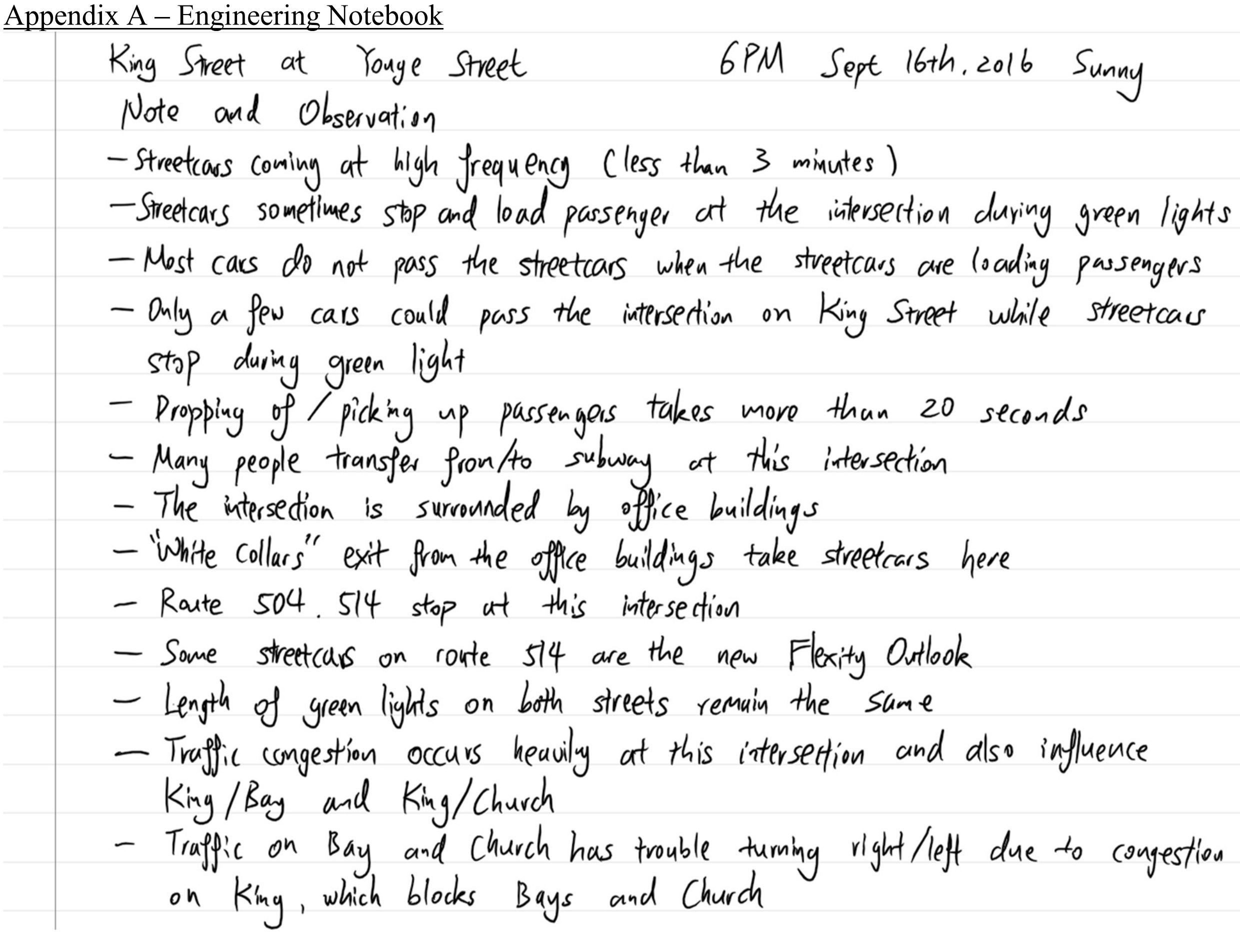
7.0 Appendices

Appendix A – Engineering Notebook


King Street at Yonge Street 6PM Sept 16th, 2016 Sunny

Note and Observation

- Streetcars coming at high frequency (less than 3 minutes)
- Streetcars sometimes stop and load passenger at the intersection during green lights
- Most cars do not pass the streetcars when the streetcars are loading passengers
- Only a few cars could pass the intersection on King Street while streetcars stop during green light
- Dropping of / picking up passengers takes more than 20 seconds
- Many people transfer from/to subway at this intersection
- The intersection is surrounded by office buildings
- "White Collars" exit from the office buildings take streetcars here
- Route 504. 514 stop at this intersection
- Some streetcars on route 514 are the new Flexity Outlook
- Length of green lights on both streets remain the same
- Traffic congestion occurs heavily at this intersection and also influence King/Bay and King/Church
- Traffic on Bay and Church has trouble turning right/left due to congestion on King, which blocks Bays and Church

Figure 2. Note and Observation in Engineering Notebook (Liang, 2016)

Data Recording

Table 1. The number of cars that pass the intersection on King Street during green light when streetcar does not stop (west to east direction)

No. of green light	No. of cars	length of green light
1	17	37s
2	16	36s
3	15	38s
4	16	37s
5	15	36s
6	17	38s
average	16	37s

Figure 3. Data Recording in Engineering Notebook (Part 1) (Liang, 2016)

Table 2. The number of cars that pass the intersection on King Street during green light when streetcar stops and loads passengers (west to east direction)

No. of green light	No. of cars	No. of streetcar	Length of green light
1	2	1	36s
2	4	1	36s
3	2	2	37s
4	8	1	38s
5	6	1	38s
6	9	1	37s
average	5.17	/	37s

Table 3. The number of cars that pass the intersection on Yonge Street during green light (south to north direction)

No. of green light	No. of cars	length of green light
1	10	35s
2	16	36s
3	11	35s
4	15	35s
5	13	35s
6	15	37s
average	13.33	35.5s

Figure 4. Data Recording in Engineering Notebook (Part 2) (Liang, 2016)

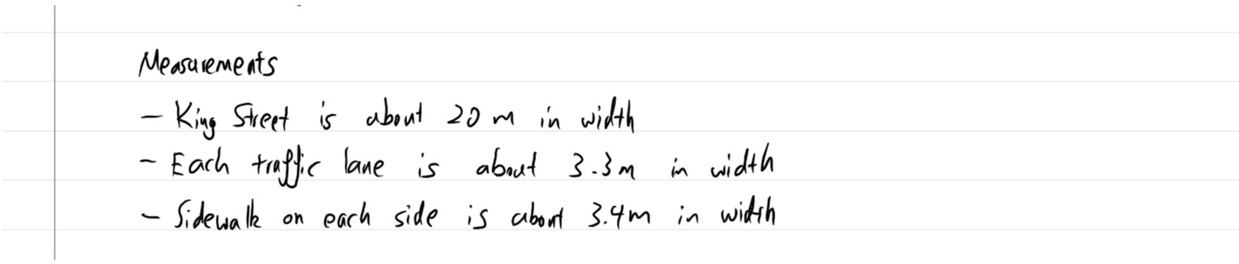


Figure 5. Measurements in Engineering Notebook (Liang, 2016)

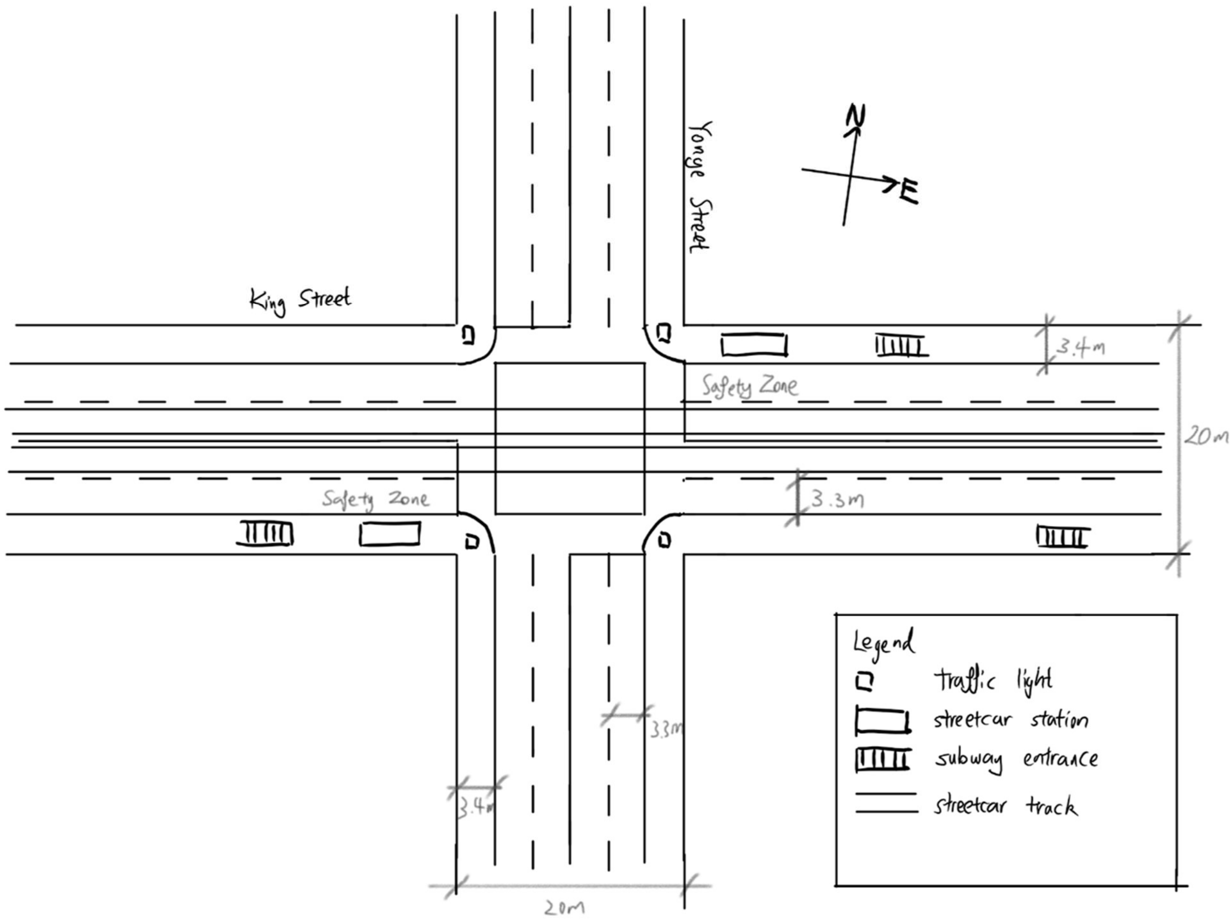


Figure 6. Layout of the Current Intersection (Liang, 2016; Toronto Official Plan, 2010)

<u>Appendix B – *Section 166 of the Highway Traffic Act* (Government of Ontario, 2016)</u>

"Passing street cars

Standing street car, etc.

166. (1) Where a person in charge of a vehicle or on a bicycle or on horseback or leading a horse on a highway overtakes a street car or a car of an electric railway, operated in or near the centre of the roadway, which is stationary for the purpose of taking on or discharging passengers, he or she shall not pass the car or approach nearer than 2 metres measured back from the rear or front entrance or exit, as the case may be, of the car on the side on which passengers are getting on or off until the passengers have got on or got safely to the side of the street, as the case may be, but this subsection does not apply where a safety zone has been set aside and designated by a by-law passed under section 9, 10 or 11 of the Municipal Act, 2001 or under section 7 or 8 of the City of Toronto Act, 2006, as the case may be. 2006, c. 32, Sched. C, s. 24 (6).

Prohibition as to passing street cars on left-hand side

(2) No person in charge of a vehicle or on a bicycle or on horseback or leading a horse, overtaking a street car or the car of an electric railway, operated in or near the centre of the roadway, which is stationary or in motion, shall pass on the left side of the car, having reference to the direction in which the car is travelling, but this subsection does not apply to a fire department vehicle while proceeding to a fire or answering a fire alarm call or where the street car or car of an electric railway is being operated on a highway designated for the use of one-way traffic. R.S.O. 1990, c. H.8, s. 166 (2); 2009, c. 5, s. 50."

Appendix C – Estimation of Current Traffic Flow and Effects by the Solutions

Based on the data recorded in Engineering Notebook, the average length of green light on King Street and Yonge Street are 37s and 35.5s respectively (Liang, 2016).

60*60/(37s+35.5s)=49.655=50

For every one-hour period, green lights emerge on both streets for 50 times.

Assuming streetcars appear on King Street every two green lights.

The current number of cars that could go through the intersection over one-hour period can be estimated as: 2(25*16+25*5.17+50*13.33)=2391.5=2392 (5.17 and 13.33 are the average number of car passing the intersection on both street under different conditions refer to Appendix A.)

By applying Solution 1, the traffic flow can be estimated as: 2(25*(16+5.17)/2+25*16+50*13.33)=2662.25=2662 (5.17, 16, and 13.33 are the average number of car passing the intersection on both street under different conditions refer to Appendix A.)

By applying Solution 2, the traffic flow can be estimated as: 2(100*(16+13.33)/2)=2933

Appendix D – Calculation and Estimation of the Additional Cost for Solution 1 and 2

For solution 1:

The cost of removing existing sidewalk is \$11.7/m^2 (Ainley Group, 2016). The cost of removing sidewalk can be estimated as: (2*(3.4m-3.1m)*50m+2*(3.4m-2.1m)*50m)*\$11.7/m^2=\$1872

The cost of repaving street per m^2 is \$8.41(HL 3 Asphalt)+\$17.00(HL 4 or HL 8 Hot Mix or Recycled)+\$0.29(Tack Coat)=\$25.7 (Ainley Group, 2016). The cost of repaving the street can be estimated as: (3.0m+3.2m)*50m*2*\$25.7/m^2=\$15934

The cost of construction of streetcar track per kilometer is approximately \$5-10M (Metrolinx, 2008); assuming the length of track that need to be reconstructed is 120m (>45*2+20=110m), on both directions, the cost can be estimated as: 2*(\$5M/1000*120m)=\$1.2M to 2*(\$10M/1000m*120m)=\$2.4M

The cost of construction 7 streetcar platforms was \$190000 (City of Toronto, 1998). The cost of installing 2 streetcar platforms at the intersection can be estimated as: \$190000/7*2=\$54285=\$54000

For solution 2:

The emitter of the transit signal priority controller need to be replaced every 3 years (Calgary Transit, 2004). The cost of each emitter is \$1000 (U.S. Department of Transportation, 2013). Therefore, the maintenance cost of the TSP System is \$1000/3years=\$333/year.