Transportation Safety on Dalhousie Studley Campus

How can traffic calming measures affect the safety of transportation on Dalhousie Studley Campus?

(Image source: http://janicelukes.ca/blog/developing-winnipegs-road-safety-strategy/)

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1.0 EXECUTIVE SUMMARY

The purpose of this study is to determine possible safety measures that could be implemented on the intersection of LeMarchant Street and University Avenue. The research has endeavored to answer how traffic calming measures can be implemented to affect the safety of transportation on Dalhousie Studley Campus.

The scope of this study has been limited to the intersection of LeMarchant Street and University Avenue. This site has been selected due to the high instance of vehicle-pedestrian interaction observed in the field. Using a mixed methods approach counts were conducted of the modes of transport and a survey questionnaire was distributed. Both forms of data collection concluded that the primary mode of transport at this intersection is walking.

Observations at this location revealed a number of logistical features and user behaviours which give rise to vehicle/pedestrian conflict. Observations of note include: a high ratio of pedestrians to vehicles; limited signage and marking of pedestrian crossways; poor adherence to traffic regulations and safety norms; and unintuitive vehicular rights-of-way. Recommendations for traffic calming measures and infrastructure alterations have been presented as a means of mitigating aggravating aspects of this intersection and improving the overall safety and usability.

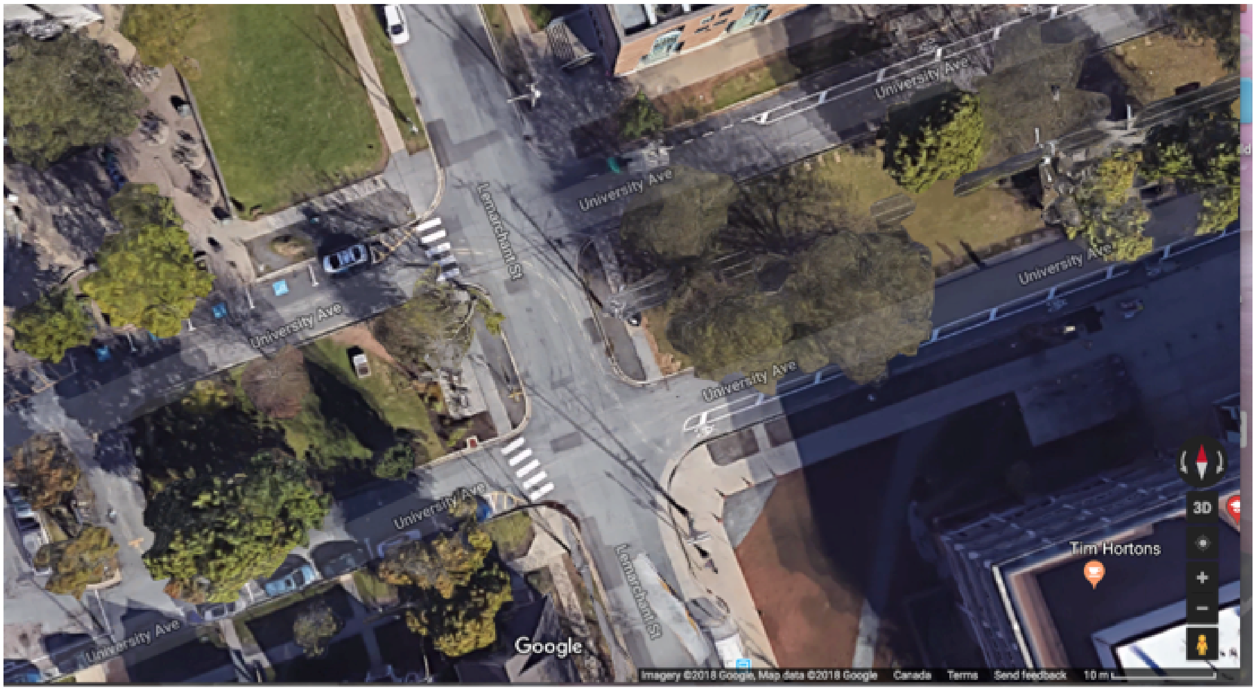
2.0 INTRODUCTION

2.1 Background and Rationale

Transportation on university campuses differs greatly from most other areas in a city and thus requires the provision of alternative transportation modes (Bond & Steiner, 2006). As universities do not have typical peak travel hours since classes are held throughout the day at various times, they present a transportation challenge unique to most communities (Bond & Steiner, 2006). With the increased volume and frequency of vehicle use, public transportation, and active transportation occuring on campuses, additional safety measures must be adopted to protect all stakeholders. The intersection of University Avenue and LeMarchant Street at

Dalhousie University sees a constant, high volume of transportation including public transportation, personal vehicles, delivery services, pedestrians and active transportation modes. As seen in Figure 1, only two of the eight crosswalks in the site are marked. While pedestrians are legally allowed to cross at any intersection where a curb cut is present, many vehicle users and pedestrians do not know or follow this law, resulting in a high rate of pedestrian-vehicle collisions throughout the city (Adams, 2017).

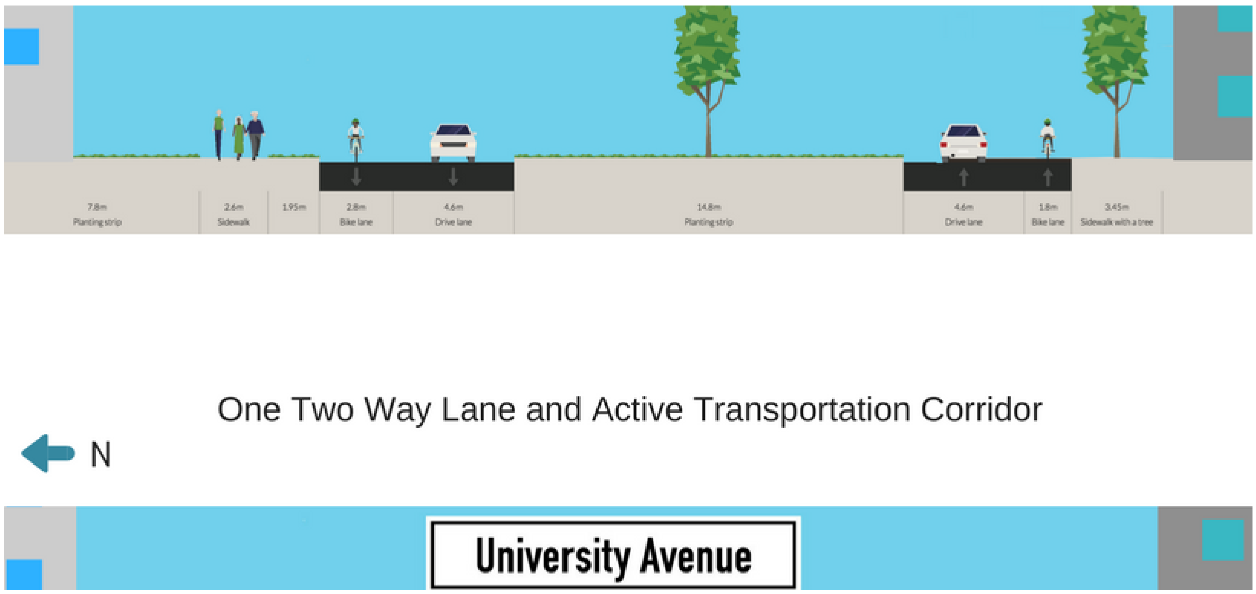
University Avenue has been specified as a key road on the Halifax Peninsula as it is a destination point for many of the city's residents (Dalhousie, 2010). Past initiatives to improve transportation along University Avenue include the 2010 Dalhousie Campus Master Plan. Among the various goals of the master plan is the enhancement of the Student Union Building (Dalhousie, 2010). Located on the corner of University Avenue and LeMarchant Street, the Student Union Building was slated to become an improved gathering and socializing space for Dalhousie students (Dalhousie, 2010). While the master plan aimed to improved access to bus routes (Dalhousie, 2010), few attempts were made to improve pedestrian safety, as is evident with the lack of clearly marked crosswalks at the intersection. The 2010 Master Plan does however, intend to apply easily identifiable pavement treatments along active transportation routes where pedestrians and or cyclists cross vehicle roadways, though this is yet to be accomplished (Dalhousie, 2010).



(*Figure 1*. Marked crosswalks at University Avenue and LeMarchant Street. Photo source: Google Maps, 2018).

The Dalhousie Master Plan (2010), states that the western terminus of the University Avenue boulevard where it meets LeMarchant Street requires special attention in terms of transportation design. One conceptual design of the 2010 master plan is to create a two way vehicle lane on the southern lane of University Avenue and convert the northern lane of University Avenue into an active transportation route (Dalhousie, 2010), figure 2 illustrates how this may look. While the creation of a car-free lane could enhance on-campus experience for users, pedestrians will still be crossing seven intersections where cars will also travel through, therefore this design does little to protect pedestrians and cyclists from vehicles and proves the need for alternative options.

Pedestrian and cyclist safety should be of concern in this site due to the high volume of pedestrian, cyclist, bus and personal vehicle traffic occurring in this area on a daily basis. The current speed limit in the site is 50 kilometres per hour. Studies have estimated that accidents involving a vehicle and pedestrian will result in fatality for 55% of occurrences when traveling at 50 kilometres an hour, this statistic increases to 90% when the speed increases by only ten kilometres more (Strathacona County, 2018). While 50 kilometres an hour is the average speed limit for residential areas in Nova Scotia, speeding has been an increasing problem throughout the province, thus it is critical to consider traffic calming measures in the site (McEachern,



(*Figure 2*: Conversion of the southern lane to two way traffic with an active transportation corridor on the northern lane. Source: L Slade, 2018).

2017). In addition, speed limit reduction has proven an ineffective safety measure. Furthermore, a study on pedestrian and vehicle collisions in Toronto states that 43% of collisions occur at crossings where pavement markings or light signals are absent, with pedestrians crossing mid-block being the greatest risk for incidence, and crossings at intersections being the second greatest risk (Biro, 2017). As the site being considered for this report is an intersection with the majority of crossings unmarked, and mid-block crossing was frequently noted during observations, this intersection poses a great threat to those traveling through it.

In a 2001 inventory and evaluation of 850 unmarked crosswalks in Seattle, Washington, researchers found that pedestrian and vehicle collisions were more likely to occur in areas with a higher volume of pedestrians, higher average daily traffic and the presence of more vehicle road lanes (Hefferan & Lagerwey, 2004). By implementing various appropriate streetscaping elements, such as curb ramps, revisions and bulbs, road diets, traffic signals, and other traffic calming measures, pedestrian and vehicle collisions were less likely to occur (Hefferan &

Lagerwey, 2004). While there is a considerable selection of streetscaping measures that can be used to improve safety at the LeMarchant Street and University Avenue intersection, it remains an unsafe intersection that puts all of those who travel through it at risk of collision.

2.2 Traffic Calming

Traffic calming is the application of pavement treatments and streetscaping measures that create safer roads (Halifax Regional Municipality, 2017). By decreasing the speed at which vehicles travel, including cars, trucks and motorcycles, traffic calming can influence the speed drivers travel at and enhance the amount of attention they pay to their speed and the surrounding areas (Halifax Regional Municipality, 2017). Traffic calming requires more than reducing the maximum speed limits, as this has proven an ineffective safety measure (Halifax Regional Municipality, 2017). While the site currently includes boulevards, which can improve pedestrian safety as they provide a refuge for those crossing the street, additional measures need to be taken to improve the behaviour of drivers in the site as many drivers neglected to stop at the stop signs in the site during field observations.

2.3 Goal of Research

The goal of this report is to identify a number of traffic calming measures suitable to the intersection of LeMarchant Street and University Avenue that will enhance safety for all modes of transportation. Through analyzing the current conditions and acknowledging where improvements can be made, we seek to present to the Dalhousie College of Sustainability a solution to transportation safety in the site. While Dalhousie University strives to develop sustainable transportation on campus, consideration of safety should be at the forefront of any further decisions.

3.0 METHODS

3.1 Description of Study Design

To determine effective traffic calming measures, we employed a mixed methods approach of sampling to factor in intersection use and safety. The mixed methods approach consisted of physical counts of the varying modes of transport and surveys administered at two locations near the intersection.

The quantitative portion of the study consisted of counts collected at the intersections of LeMarchant Street and University Avenue. The counts were collected using counters at both sides of the intersection (Killam Library and McCain, SUB and LeMarchant) as to include all modes of transport such as public transit, private vehicles, pedestrians and cyclists. They were collected over a three-day period, at three half hour time intervals during the rush hour period on campus, between the hours of 8:00 to 8:30 AM, 1:00 to 1:30 PM, and 4:30 to 5:00 PM. The time periods were chosen in order to compare frequency use between the different scheduled days and its effect on rush hour period.

As for the qualitative portion, we employed a pencil-and-paper survey that was administered at two locations, the Killam Library and the Student Union Building. Since it is not possible to survey drivers and cyclists while they are using the intersection, the best option was to survey respondents in buildings near the intersection. A total of five survey questions were created to obtain a general view into pedestrian interaction at the intersection. The survey consisted of predominantly Likert-type scale questions and categorical-response questions used to determine mode of transport, vehicle-pedestrian conflicts and pedestrian safety. Surveys were administered using a non-probabilistic sampling method covering a sampling size of one hundred respondents. Survey answers were collected over a three-day period at the two locations for a one-hour interval from 12 to 1.

3.2 Justification of Design

Since a considerable quantity of surveys had to be answered, a pencil-and-paper method was the optimal survey method. Questions were worded concisely and kept to a minimum number possible to ensure filled out survey responses. Likert-type and categorical-type were used as we were interested in whether respondents agreed or disagreed with the issue presented by the research team (Palys & Atchison 2014). Furthermore, the two categories eliminate respondent reluctance, insure exact answers and reduce the possibility of missing data compared to single-response or open-ended questions (Palys & Atchison 2014). Surveys were distributed to a sample of one hundred respondents, which represents a fraction of the number of pedestrians that used the intersection. The sample size was determined according to the average number of pedestrians as it is difficult to determine the number of people in private or public transport.

3.3 Reliability and Validity Concerns

Surveys were conducted at the Killam Library and the Student Union Building on Studley Campus. They were not conducted at the intersection due to the apparent safety issues that could occur by surveying drivers or cyclists while in motion. Also, as the two buildings are nearest to the intersection, most users were already headed in that direction. Although the selection of respondents was based on random selection, it reduced the likelihood of having a predominant transport group answer (drivers, pedestrians, cyclists, and public transit users). However, the reliability is tested as there is a greater likelihood of having pedestrians at the survey locations over the other users. As the surveys were anonymous, it could not be determined whether the respondents were either drivers, pedestrians, public transit users or cyclists.

As for the statistical analysis, a chi-square test was used instead of a t-test or ANOVA because it is an effective statistical test for category based questions such as the survey questions. The test was carried out using statistical software such as Minitab to reduce human based calculation error. The remaining calculations such as averages were carried out using excel, which also aids in reducing the likelihood of human error impacting the results.

3.4 Limitations and Delimitations

A limitation that was faced during the study was the time span allocated for count collection and survey responses. By having a short time period for data collection, we reduced the number or variation of respondents that may have answered the surveys. Another limitation of the surveys is that the respondents are primarily Dalhousie students or faculty which does not factor in all the people who could possibly use the intersection such as bus drivers, residents of the neighborhood etc.

Other limitations were the time in which the counts were collected. Since counts were conducted in March, during the winter season, it is not completely representative of the users all year round. The weather severely influences the type of users at the intersection as the likelihood of cyclists and pedestrians decreases during the colder months. Also, counts were primarily collected during days of clear weather, i.e. no rain or snow, which is not informative on how road impedances could affect intersection use or the effect of road impedances on safety measures at the intersection.

Some of the delimitations were related to the time frame and sample size. We decided to collect one hundred surveys based off the average number of pedestrians as it is difficult to determine total number of users in cars or public transport. The time frame was selected to cover a range of periods likely to have high user volume in order to attain the most accurate counts possible. In addition, it ensured a higher number of possible respondents for surveys as students and faculty congregate in the Killam Library or Student Union Building during lunch (rush hour).

4.0 RESULTS

4.1 Quantitative Analysis

Table 1: Average counts of the Killam Library and Marion McCain intersection located on Dalhousie University campus, in Halifax, Nova Scotia, Canada. Completed on March 7th, 13th and 15th 2018 at three peak times of intersection frequency:

	Pedestrians	Cars	Bicycles	Buses
8:00-8:30 a.m.	337	128	4	1
1:00-1:30 a.m.	759	124	5	0
4:30-5:00 p.m.	365	114	7	1

Table 2: Average counts of the intersection outside of the Student Union Building (SUB) located on Dalhousie University campus, in Halifax, Nova Scotia, Canada. Completed on March 7th, 13th and 15th 2018 at three peak times of intersection frequency:

	Pedestrians	Cars	Bicycles	Buses
8:00-8:30 a.m.	346	123	2	8
1:00-1:30 a.m.	557	87	2	6
4:30-5:00 p.m.	403	114	5	1

Table 1 displays the averaged frequency of the four most common modes of transportation though the Killam Library and Marion McCain side of the intersection while table 2 displays the results for the SUB side. For both the intersections we saw that the pedestrians and cars highly outnumbered the frequency of bicyclists and buses. The SUB intersection experienced a higher rate of buses than the Killam Library and Marion McCain intersection (table 2).

4.2 Qualitative Analysis

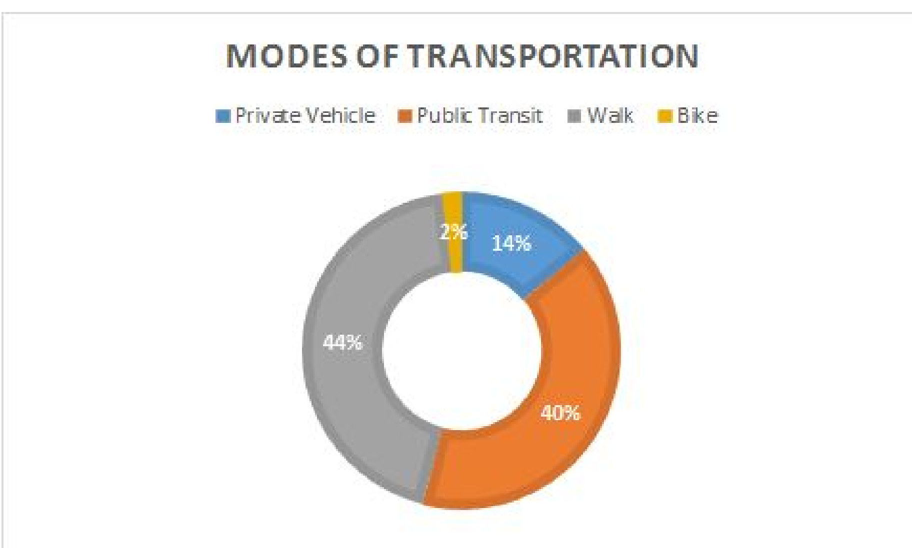


Figure 3: Results of survey question on participants primary mode of transportation taken on Dalhousie University campus individuals in Halifax, Nova Scotia, in the last week of March, 2018.

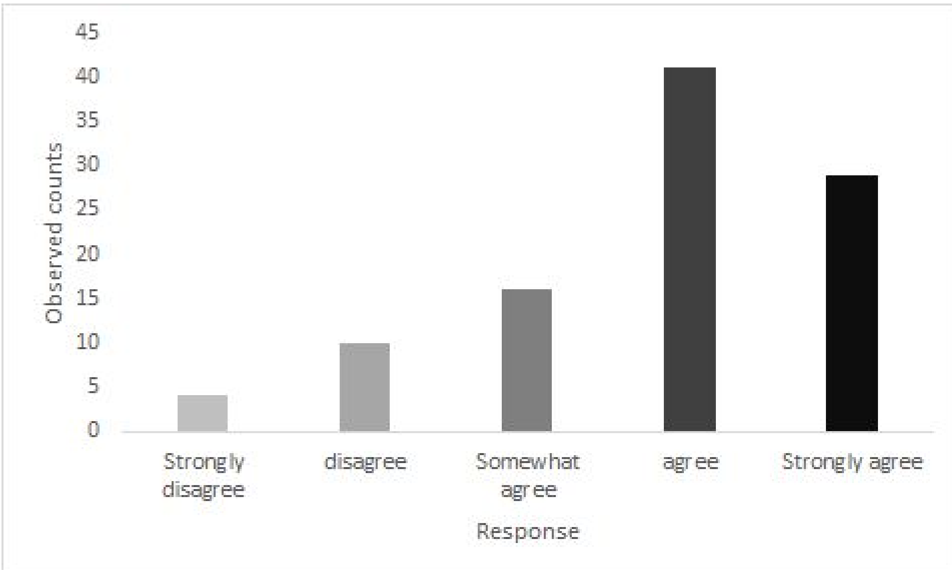


Figure 4: Results of survey question on the perception of safety if painted crosswalks were implemented at both of the intersections at the intersections of LeMarchant Street and University Avenue in Halifax, Nova Scotia. Data collected in the last week of March, 2018.

Results for question one of our survey are displayed in figure 3. The most frequent modes of transportations according to our survey results are walking and driving of personal vehicles. The most common mode of transportation, walking, accounted for 44% of the total responses.

The fifth question on the survey asked the participants whether painted crosswalks in the site would increase their feelings of safety (figure 4). A majority, approximately 70%, of respondents stated that they would agree or strongly agree that implementing painted crosswalks in the site would increase their perception of safety.

Results that are not displayed in this report asked the participants about their current perception of safety when crossing through the intersection. About 60% felt they were somewhat safe to not safe at all, whereas the other 40% agreed or strongly agreed that they felt safe when crossing the intersection. The remaining survey questions are located in Appendix A.

4.3 Statistical Analyses

This research project included two statistical test to analyze the significance of our data. These statistical tests were conducted on questions one and five of our survey results. The statistical tests were completed for these two questions as they were found to be closely related and the responses to these questions played a crucial role for informing future decisions regarding safety in the intersections.

The statistical test which was used to test the significance of the data was the chi-square test. This test was used as our assumptions included that there was an equal probability between the selection of five options per questions (strongly disagree, disagree, somewhat agree, agree, or strongly agree). We also used the chi-square to compare our results against a significantly different random distribution.

These statistical tests were tested with an alpha level of 0.05, or with a 95% confidence. Question one had statistically significant results (df: 4, p-value: 6.32E-07), as well as question five (df: 4, p-value: 4.60E-09); therefore, we reject the null hypothesis for both questions in which assumed there was no difference between the the five various categories for selection.

For the quantitative counts, classic central tendencies were used to analyse the data (appendix B). The average pedestrians crossing at any time, (three peak times of number of pedestrians divided by three) gives us a value of 487 and 437 for the Killiam/McCain and SUB/LeMarchant intersection respectively. When a ratio between cars and pedestrians was calculated, both were seen to show an approximate four to one ratio for people to cars.

5.0 DISCUSSION

5.1 Purpose of Research

Our research question is ‘How can traffic calming measures affect the safety of transportation on Dalhousie Studley Campus?’. This research question was selected in order to present to the Dalhousie Office of Sustainability a suitable method for increasing the safety for all modes of transportation in the intersection of LeMarchant Street and University Avenue.

5.2 Significant Findings

The quantitative counts which were completed include the bulk of our data and observations. Over the course of the three day sampling period, we found pedestrians to be the highest observed frequency, with cars, bicyclists and buses following. The data we collected is highly variable and can greatly change depending on the time and date of data collection. For example, this data was sampled in the winter; therefore, it is logical to assume there would be a lower number of bicyclists than if sampling was completed in the fall. In addition, given that the majority of university courses are held during the fall and winter months, it is expected that late spring and summer would have different results as fewer people would be on campus.

During these 30 minute sample periods, behaviours of the various modes of transportation were observed in conjunction with the counts. During our observations, we noted that pedestrians tended to be fairly careless in terms of crosswalk safety. Frequently, pedestrians were observed to be using their handheld devices while walking, and crossing the intersection at mid-block points rather than at the formal crosswalks. These behaviours put pedestrians in danger and are related to the root cause of many pedestrian/vehicle related incidents (Mwakalonge, 2015). This cognitive dissonance in terms of basic crosswalk safety could be attributed to the very fact that pedestrians on campus are university students; a demographic which tends to be bound by time constraints, and timeliness is one of the leading reasons for unsafe crossing (Forsythe & Berger, 1973). It was also noted that people tended to carry out conversation at the sidewalks of the intersections before or after crossing. This could potentially confuse drivers, and delay their safe transport through the intersection.

Similarly, vehicles also displayed frequent disregard for basic intersection safety. It was noted that many vehicles were not coming to a full stop (rolling stop) or were texting and driving when pulling up to the intersection. Both of these scenarios, especially when combined, can breed disastrous and fatal outcomes. These vehicle behaviours could also be applied to bicyclists, who were also observed flouting laws for stop signs. Lastly, busses tend to obstruct the view of the intersection when idling at the bus stops on LeMarchant Street. This is a potential risk for pedestrians or drivers, who may not be able to see if a vehicle is approaching from behind the buses.

In addition to the prevalence of mid-block crossing, which puts pedestrians at odds with vehicles which would otherwise have the right of way, vehicle/pedestrian conflict at this intersection is aggravated by a complex arrangement of rights-of-way. Asymmetrical traffic flows (both vehicular and otherwise) incentivize vehicles to jockey for available openings in traffic and rights-of-way often go unnoticed or unheeded as drivers look for possible opportunities to cross the intersection.

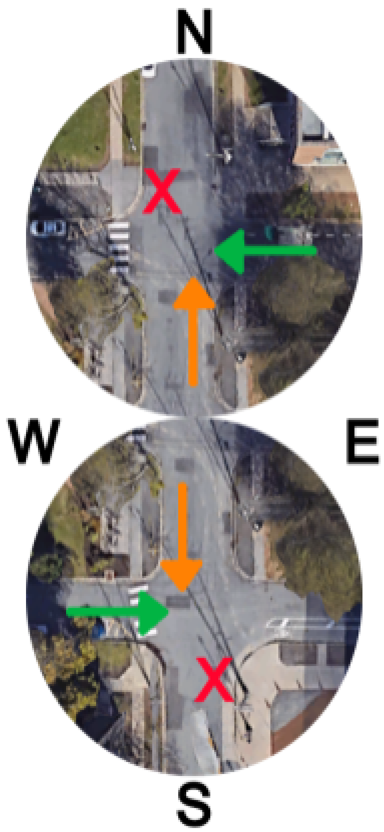


Figure 5. Rights-of-way at the intersection of University Ave and LeMarchant Street.

Each sub-intersection has a total of three vehicular traffic inflows and four pedestrian crossings (figure 5). Not considering pedestrians, vehicular traffic on University Ave has unfettered right of way and does not have to stop or yield to other traffic flows. Vehicles traveling northbound on LeMarchant Street are required to stop when intersecting the eastbound boulevard of University Avenue, and yield when intersecting the westbound boulevard. For vehicles traveling southbound on LeMarchant Street the opposite is true; these vehicles must stop when intersecting the westbound boulevard of University Avenue, and yield when intersecting the eastbound boulevard.

This arrangement of rights-of-way is replicated wherever a perpendicular street intersects with University Avenue, with the notable exceptions of the intersections at Robie Street and South Park Street. Though each intersection on University Avenue has distinct features, these intersections in particular stand out as being especially differentiated. These two intersections are characterized by the streets which comprise them. Both Robie Street and South Park Street feature multiple lanes in either direction, serve a high volume of vehicular traffic, and provide thoroughfare routes for long-haul traffic. Due to their unique qualities, the intersections at Robie Street and South Park Street are both fully equipped with a range of infrastructure specifically designed to manage traffic at these locations.

Our findings suggest that the intersection at LeMarchant Street is also sufficiently differentiated such that the implementation of unique measures is justified. Situated squarely within the heart of the Dalhousie University Studley campus, this intersection caps the westernmost point of University Avenue and is surrounded by multiple buildings which feature a high volume of foot-traffic. As the terminus of University Avenue, a turning-point ultimately funnels westbound traffic back into the eastbound intersection. Additionally, the presence of adjacent green space, a bus terminal, and high volumes of pedestrians all contribute to the distinct character of the intersection.

For the qualitative analysis our research group created five questions for which we asked 100 random individuals on the Dalhousie University Studley campus about the two intersections on LeMarchant Street and University Avenue on Dalhousie campus (appendix A). The results for question one of our survey asked the participants what their primary mode of transportation was (figure 4.2), we found these results to mirror the results from the quantitative analysis (appendix B). This excludes the results for public transportation as we did not count how many people were on the bus, but by per bus.

5.3 Implications

The primary focus of this report was to look at improving the relationship among the four most common modes of transportation. It brings forth empirical data which was collected with intentions to provide the Dalhousie Sustainability office with empirical counts on the intersections of University Avenue and LeMarchant Street. It also provides them with possible solutions to the many dangers that were found at the intersections, and observations that were witnessed to give rise to these concerns.

In the future, if this experiment were to be carried out again, it would be completed on a much grander scale to get a better idea of the true relationship of the four common modes of transportation. It would also be completed on a more yearly temporal interval as to account for the varying seasons. It should focus on collecting data with the same weather and same season in order to compare the difference between the data. Other people could use the data and information that we collected to focus on other studies, such as how traffic condition affect pedestrians' willingness to walk across the intersection; does the university need to broaden the intersection's street to increase the safety of the pedestrians and provide unimpeded traffic flow.

5.4 Sources of Error

While collecting the counts some errors may have occurred. Large vehicles passing through the intersection may have resulted in visual disruptions which could lead to missed counts of pedestrians or vehicles. Some of the counts were collected during rainy or windy weather which may have resulted in reduced pedestrian traffic as pedestrians may select an alternative mode of transport. Some pedestrians and cars also passed through both intersections which led to double-counting. During peak travel time there was a large number of pedestrians crossing the intersection which may have caused an under or over estimation of the counts due to counting error. These mistakes will make our data slightly inaccurate and could affect our conclusions.

6.0 CONCLUSIONS

After consideration of our collected data (quantitative and qualitative) and observations, we have compiled a selection of recommended traffic calming measures and infrastructure alterations. These recommendations should ultimately address one or more of the major issues impacting this intersection.

6.1 Painted Crosswalks

Of the eight legal pedestrian crossings at this intersection only two are marked, however, simply marking these crossings may not be sufficient to improve safety. Previous research has indicated that painted crosswalks alone do not decrease the incidence of vehicle/pedestrian conflict, but when found in conjunction with other measures, they improved the overall level of safety (Zegeer et.al, August 2005). Additionally, the presence of crosswalks has been identified as improving pedestrian adherence to crossing location, making them beneficial for the reduction of midblock crossing (Sisiopiku & Akin, 2003). As such it is recommended that painted crosswalks be implemented as a complementary measure in each of the following alteration scenarios.

6.2 Conventional Traffic Calming Measures

Several low cost traffic calming measures could be implemented at this intersection to reduce conflict between vehicles and pedestrians. Speed humps have been shown to reduce top speeds, with 7cm speed humps decreasing the 85th percentile of recorded speed by as much as 22km/h (Vaitkus et al., 2017). This reduction in speed could be crucial for preventing pedestrian collisions from becoming fatal. Speed humps could be particularly effective if installed on the midblock portion of LeMarchant Street - between the eastbound and westbound lanes of University Avenue - to ensure that vehicles on LeMarchant Street do not quickly accelerate through the second intersection.

Vehicle adherence to pedestrian crossings can be increased with the installation of pedestrian safety cones and/or overhead crossing signage. Both of these measures have independently increased the instance of motorists yielding to pedestrians in crosswalks (U.S. Department of Transportation, 2000). Pedestrian safety cones are simple plastic cones (approximately 1m tall) which feature messages reminding motorists to yield to pedestrians. These cones are placed in the centre of the street between lanes of traffic and are therefore not suitable for a boulevard, but could be implemented on LeMarchant Street. Overhead crossing signage is illuminated signage which identifies a pedestrian crossing, and is suitable to be implemented at all eight pedestrian crossings at this intersection.

6.3 Traffic Restrictions

This alteration scenario pertains to the elimination of through-traffic on University Avenue, West of Robie Street. This stretch of road, which traverses the bulk of Studley campus would be closed to vehicular traffic during peak hours, with some exceptions.

It is posited based on our observations that such a measure could be implemented without affecting inordinate pressure on the surrounding traffic systems. Unlike nearby South Street and

Coburg Road, University Avenue does not connect the major traffic arteries of Robie Street and Oxford Street, so long haul thoroughfare traffic is unlikely to be impacted. Similarly, because this section of University Avenue already features no on-street parking, the majority of traffic is comprised of vehicles bound for the surrounding blocks, or dropping off passengers. Perpendicular streets subdivide this stretch into blocks of 100m or less, allowing for continued ease of navigation around the neighborhood, and relatively convenient drop off locations.

6.4 Roundabout

Alternatively, the intersection of University Avenue and LeMarchant Street could be converted to a roundabout. This scenario involves the most substantial alteration to existing infrastructure, however it has been shown that proper urban design can reduce barriers to walking without sacrificing safety or convenience (Handy, 1996) therefore it is worthwhile to consider all options. This conversion would have multiple benefits for vehicles and pedestrians alike, and would address many of the issues impacting the intersection such as speeding, inadequate rights-of-way, and unsafe pedestrian crossings.

Converting to a roundabout would simplify traffic flows for all vehicle modes. Rather than two sub-intersections with three vehicular inflows each, the roundabout would be consolidated into one intersection with just four vehicular inflows. A raised central island would eliminate diagonal midblock crossing and reduce the number of legal pedestrian crossings from eight to six. Stop signs at each inflow would improve pedestrian safety, and simplify the right-of-way for vehicles. As directness of route is cited by pedestrians as the primary reason for unsafe crossing, rounded corners would create more direct and intuitive pedestrian routes thereby reducing unsafe crossing (Carsten, 1999). Similar conversions have been made at intersections throughout the HRM, as roundabouts have been shown to reduce the severity of incidents, hasten travel times, and reduce idling (Halifax Regional Municipality, 2018).

REFERENCES

Adams, J. T. (2017). A crash course on crosswalks. *Halifax Magazine*. Retrieved from halifaxmag.com/editors-message/a-crash-course-on-crosswalks/

Biro, V. (2017, November 12). Fatal crossings. *The Globe and Mail.* Retrieved from https://www.theglobeandmail.com/news/toronto/more-than-160-pedestrians-killed-by-vehicles-since-2011/article30391640/

Bond, A., Steiner, R. (2006). Sustainable campus transportation through transit partnership and transportation demand management: A case study from the university of Florida. *The Berkeley Planning Journal*. Retrieved from https://escholarship.org/uc/item/04b7c73h

Carsten, O. M. J. (1994). Pedestrian behavior and pedestrian signal design. In Proceedings of the sixth ICTCT workshop, Pedestrian problems, pp. 115–118

Dalhousie University. (2010). Dalhousie University campus master plan framework plan. *Dalhousie University*. Retrieved from work%20Planhttps://cdn.dal.ca/content/dam/dalhousie/pdf/plan/Dal%20Campus%20Master%20Plan%20Frame.pdf

Forsythe, M. J., & Berger, W. G. (1973). Urban pedestrian accident countermeasures experimental evaluation. Vol. 1, Appendix C: Behavioral Evaluation Summary Data, Biotechnology, Inc. Falls Church, VA; *US Department of Transportation*, Washington, DC

Halifax Regional Municipality (2017). Traffic calming for safer streets. *Halifax Regional Municipality.* Retrieved from https://www.halifax.ca/transportation/streets-sidewalks/traffic-calming-safer-streets

Halifax Regional Municipality (2018). Roundabouts. *Halifax Regional Municipality.* Retrieved from https://www.halifax.ca/transportation/streets-sidewalks/roundabouts

Handy, S. (1996). Urban form and pedestrian choices: Study of Austin neighborhoods. *Transportation Research Record: Journal of the Transportation Research Board,* 1552, 135-144. 10.3141/1552-19 Retrieved from https://trrjournalonline.trb.org/doi/abs/10.3141/1552-19

Hefferan, R. J., Lagerwey, P. (2004). The city of Seattle, WA, US, crosswalk inventory and improvement plan. *Institute of Transportation Engineers*. Retrieved from https://search-proquestcom.ezproxy.library.dal.ca/docview/224904283/fulltextPDF/C89F96D503604D55PQ/1?accountid=10406

McEachern, C. (2017, August 9). RCMP: Speeding in Nova Scotia more common than ever. *Truro Daily News.* Retrieved from www.trurodaily.com/news/local/rcmp-speeding-in-nova-scotia-more-common-than-ever-824/

Mwakalonge, J., Siuhi, S., & White, J. (2015). Distracted walking: Examining the extent to pedestrian safety problems. *Journal of Traffic and Transportation Engineering (English Edition)*, 2(5), 327-337. 10.1016/j.jtte.2015.08.004 Retrieved from http://www.sciencedirect.com/science/article/pii/S2095756415000689

Palys, A., Atchison, C. (2014). *Research Decisions: Quantitative, qualitative, and mixed methods approaches*, 5th ed. Toronto: Nelson Education.

Sisiopiku, V. P., & Akin, D. (2003). Pedestrian behaviors at and perceptions towards various pedestrian facilities: An examination based on observation and survey data. *Transportation Research Part F: Traffic Psychology and Behaviour*, 6(4), 249-274. 10.1016/j.trf.2003.06.001 Retrieved from https://www-sciencedirect-com.ezproxy.library.dal.ca/science/article/pii/S136984780300041X

Strathacona County. (2018). Pedestrian safety. *Strathacona County.* Retrieved from https://www.strathcona.ca/transportation-roads/traffic/traffic-safety/help-keep-pedestrians-safe/

U.S. Department of Transportation. (2000). The effects of innovative pedestrian signs at unsignalized locations: A tale of three treatments. *U.S. Department of Transportation.* Retrieved from https://www.fhwa.dot.gov/publications/research/safety/00098/00098.pdf

U.S. Department of Transportation. (2005). Safety effects of marked versus unmarked crosswalks at uncontrolled locations final report and recommended guidelines. *U.S. Department of Transportation.* Retrieved from www.fhwa.dot.gov/publications/research/safety/04100/04.cfm

Vaitkus, et al. (2017). Traffic calming measures: An evaluation of the effect on driving speed. *Promet (Zagreb)*, 29(3), 275-285. 10.7307/ptt.v29i3.2265 Retrieved from https://doaj.org/article/872dc5a17cef42f48739972a98ceb7cc

APPENDICES

Appendix A. Survey

Survey on Transportation and Safety

I give consent to my responses being used in aggregated form in a project on transportation safety through the course SUST3502. I understand my responses will be kept confidential and only used for research purposes.

For any questions please contact Lindsay at LN497073@dal.ca
Or instructor, Amy Mui at Amy.mui@dal.ca

1. What is your primary mode of transportation that you use to travel to University Avenue?
   Private Vehicle   Public Transportation   Walk   Bicycle

2. How frequently do you travel through the intersection of University Avenue and LeMarchant Street?

   Daily []
   Several Times Per Week []
   Several Times Per Month []
   Once Per Month []
   Less Than Once Per Month []

3. I perceive vehicle/pedestrian conflicts to be a safety issue at the intersection of University Avenue and LeMarchant Street.

   1 Strongly disagree []
   2 Disagree []
   3 Somewhat agree []
   4 Agree []
   5 Strongly Agree []

4. On a scale of from 1 to 5, with 1 being very unsafe and 5 being very safe, how safe do you feel crossing the intersection of University Avenue and LeMarchant Street?

   1 [Not Safe]   2 [Somewhat Safe]   3 [Mildly Safe]   4 [Safe]   5 [Very Safe]

5. Painted crosswalks would improve your feeling of safety when crossing the intersection of University Avenue and LeMarchant Street.

   1 Strongly disagree []

2 Disagree []
3 Somewhat agree []
4 Agree []
5 Strongly Agree []

Appendix B. Intersection Counts

Killam/McCain Intersection

Date	Name of observer # 1	Weather	# of Pedestrians	# of Bicycles	# of Cars	# of Buses
Wednesday, March 7th						
8:00 - 8:30 AM	Calum		328	5	123	1
1:00 - 1:30 PM	Calum		717	2	113	0
4:30 - 5:00 PM	Lama		338	11	125	1
Thursday, March 15th						
8:00 - 8:30 AM	Duncan	cold, windy, clear	314	5	121	0
1:00 - 1:30 PM	Lindsay	cold, windy, clear	796	5	110	0
4:30 - 5:00 PM	Duncan		302	5	101	0
Tuesday, March 13th						
8:00 - 8:30 AM	Lindsay	cold, clear roads but storm later	367	2	138	1
1:00 - 1:30 PM	Lindsay (March 20th)		764	6	149	0

4:30 - 5:00 PM	Calum	Cool, sunny	453	3	115	1

SUB/LeMarchant Intersection

Date	Name of observer # 2	Weather	# of Pedestrians	# of Bicycles	# of Cars	# of Buses
Wednesday, March 7th						
8:00 - 8:30 AM	Huiyang		410	4	155	8
1:00 - 1:30 PM	Huiyang		701	3	95	4
4:30 - 5:00 PM	Huiyang		437	4	114	4
Thursday, March 15th						
8:00 - 8:30 AM	Calum	Clear, sunny	295	0	98	5
1:00 - 1:30 PM	Huiyang		509	1	74	5
4:30 - 5:00 PM	Lama	Cloudy, windy	368	4	94	7
Tuesday, March 13th						
8:00 - 8:30 AM	Lama	Cold - Clear Roads	331	1	114	10
1:00 - 1:30 PM	Lama	Cold - Clear Roads	460	2	92	7

4:30 - 5:00 PM	Lindsay	Cool, sunny	402	6	98	6