

**A Discussion of Road Safety Issues at Airport
Terminal Pick-up and Drop-off Areas**

Jeffrey Lo, Designer EIT, MMM Group Limited

Paper prepared for presentation
at the Active Transportation Safety Session

Of the 2015 Conference of the
Transportation Association of Canada
Charlottetown, PEI

Acknowledgements

The author would like to thank the Calgary Airport Authority (YYC) for their assistance and participation in this study paper and their ongoing commitment to improve and promote safety and operations at the Calgary International Airport and the airport community in general.

Abstract

With a natural resource rich economy, Calgary has experienced unprecedented growth over recent years. The economic growth of the region is reflected in air travel through the Calgary International Airport (YYC) which is estimated to have handled over 15 million passengers in 2014.

The current airport terminal, which handles all scheduled passenger flights, was first opened in 1977. The increased passenger flows have necessitated various expansions and upgrades to the existing terminal building. Furthermore, demand has required the construction of a new international terminal to be opened in 2016, at which time the existing terminal will be reconfigured to handle domestic flights only.

With the growth and expansion of the airport terminals, the Arrivals pick-up and Departures drop-off areas have seen a substantial increase in traffic volumes over the years. Since the new international terminal will be an extension to the current Arrivals and Departures roadways, the pressures on these roads are expected to increase over time. Hence, concerns have been raised regarding the transportation safety of these roadways.

Airport terminal pick-up and drop-off areas are unique in various aspects of road safety. For example, it can be expected that driver familiarity will be very low for many drivers and conversely very high for other drivers, such as commercial operators and taxi drivers. Furthermore, the driver workload is arguably high given the pressure to navigate towards the preferred entrance to the terminal building, finding a place to stop for pick-up or drop-off, vehicles entering and exiting traffic flow from the curb lane, and a heavy volume of pedestrian crossings. Finally these areas can be confusing given the short distances, complex traffic movements, limited sight lines and often large amount of signage; thus resulting in a potentially high safety risk environment.

This paper will review the safety of the aforementioned roadways at the Calgary International Airport using extensive field observations and interviews with key airport staff. The Canadian Guide to In-service Road Safety Reviews, published by the Transportation Association of Canada, will be used as a starting point for the review. However, the primary focus of the paper is to identify any road safety issues at the Calgary International Airport that may also be relevant to many other airports. Suggestions for improvements will be made that may be applicable to YYC and many airports around the world.

1.0 Study Background

The Calgary International Airport is one of Canada's most successful airports. Having served 15.3 million passengers in 2014 the airport has seen a 66% growth in passenger volumes over the past decade (Calgary Airport Authority [YYC], 2015). With year over year growth in passenger traffic, major expansion to the airfield and terminal complex was warranted. A new parallel runway was opened in 2014 to meet this demand, alongside a variety of complimentary projects. A new international terminal is under construction and scheduled to open in 2016, which will add 22 international and transborder aircraft gates (YYC, 2015).

Until the new international terminal is opened, all passengers for domestic and international flights will continue to arrive and depart from the existing terminal, which was first opened in 1977. Numerous improvements and expansions were made over the terminal's 38 year history to improve capacity and operations. Once opened, the existing terminal will be converted to a domestic only facility. Construction is currently underway to provide a direct connections corridor between the existing aircraft gates and the future international terminal. An important note is that access to the new terminal will be via the existing terminal roadways. Therefore when the new international terminal opens, there will likely be an immediate decrease in demand for pick-up and drop-off at the existing terminal. However, the traffic volumes on said roadways are not anticipated to decrease.

2.0 Study Purpose

With the heavy demand on these terminal roadways, and little relief with the future opening of the international terminal, the Calgary Airport Authority (YYC) has become increasingly concerned with the continued safe and efficient operation of both the Departures drop-off and Arrivals pick-up areas. To that effect, YYC has made a number of operational and physical changes over the years to improve the safety and efficiency of their facilities. Further improvements, such as signage replacement, are currently underway for implementation with the opening of the new international terminal in 2016.

In the context of transportation safety, there have been few studies or research undertaken towards the transportation safety of these facilities specifically in an airport context. While these facilities are specialized and not often constructed, they do form a critical part of the transportation network that is utilized by a large proportion of the traveling public, even if on a less frequent basis.

Furthermore, the nature of these facilities constitutes many risk factors that do affect transportation safety. For example, logic suggests that users of these facilities tend to fall into the extremes of driver familiarity. A large proportion of drivers visit these facilities infrequently and are therefore unfamiliar, particularly considering that there are often no similar facilities for a long distance. Conversely another large proportion of drivers are commercial operators, such as taxis and shuttle services, who are highly familiar with the facility. The interactions between the extremes of these groups can be considered a risk to transportation safety.

Another risk factor is the driver workload required due to the nature of the facility. Often signage intensive, drivers have little time to read, interpret and act upon a wealth of navigational information. In the case of picking-up arriving passengers, drivers are often distracted while searching the curbside for a specific person and may even be being distracted by a mobile device. Concurrently, drivers also need to find an appropriate location at the curb side to drop-off or pick-up, all in addition to the task of driving itself.

To further compound the workload, these facilities are often conflict heavy. Virtually every vehicle will need to pull over at the curbside as well as return to the through traffic lanes at least once, thus creating a large density of vehicle merges on top of often complex traffic movements. Finally pedestrian traffic tends to be heavy with a higher crosswalk density than normally found on urban roadways.

A combination of the extremes of driver familiarity, high driver workload and heavy traffic conflicts can result in an increased risk to transportation safety. Therefore it is important to review and study these situations and take efforts to minimize risks in a contextually sensitive manner.

3.0 Scope of Study and Methodology

With the support and participation of YYC, the scope of this research study was developed to assess the transportation safety of the Arrivals and Departures roadways at the Calgary International Airport with the goal of identifying potential issues or major risk factors. Suggestions will be made for possible improvements to the various facilities at the airport. The study will consist of four primary components as outlined below:

- *Interviews* were conducted with applicable members of YYC who are charged with safety, management of ground transportation facilities and curbside security to discuss known issues;
- *Site observations* were conducted to verify interview findings and observe other issues on site. The Transportation Association of Canada (TAC) guides for In-Service Road Safety Reviews and Road Safety Audits were used as commentary of potential issues for the observation sessions (Transportation Association of Canada [TAC], 2001, 2004). Visits were made during both daytime and nighttime operations including the peak and off-peak periods identified in interviews;
- *Discussions* of the observed issues is included as part of this paper; and
- *Suggestions for improvement* are provided, which may help to alleviate the issues or minimize the safety risk. To present a clear and integrated approach, a suite of suggestions will be made for each level rather than each issue found.

As expansion and construction works are currently underway for the new international terminal, the extents of this study will be limited to the Arrivals and Departures level roadways only fronting on to the existing terminal. Areas under construction are excluded from this study. The bus facility on the Arrivals level is an integral part of the system; therefore the facility itself is included, but limited to potential conflicts between pedestrians and vehicles only as this facility is not accessible to the driving public. Finally, facilities inside the adjoining parkades or terminal itself are not included.

Please note that this study is intended as a research project only and does not contain or constitute the level of detail required in an engineering review or study. Suggestions made will require further study and design prior to implementation.

4.0 Site Conditions

As this study relates to the pick-up and drop-off areas of the terminal, it is important to note the configuration of these roadways. Access to the terminal frontage is split on to two levels, with Departures on an elevated road deck and Arrivals on the lower level immediately below. Figure 4.1 shows an overview of both levels.

The Departures roadway provides three through lanes, plus one continuous curb lane that terminates immediately prior to the end of the study area. Eleven doors provide access to the passenger terminal while four raised and two level crosswalks provide connections to the parkade, rental car and hotel facilities on this level. Three vehicle bridges also provide access to the parkade for reserved staff parking and car rental returns. Security personnel are stationed throughout the area to enforce parking restrictions. The study area on the Departures level is approximately 492 m in length, measured along the outside of the outermost through lane.

The Arrivals roadway is constructed below the elevated Departures roadway. It consists of two travel lanes, plus one curb lane. Seven raised crosswalks include curb bumps, making the curb lane non-

continuous, whilst providing access to the bus facility, hotel, parkade and rental car facilities. Nine doorways provide access to the passenger terminal. The bus facility comprises of one driveway to access twenty-six bus bays, some of which are a pull through design, and crossed by seven level crosswalks from the parkade. The study area on the Arrivals level is approximately 422 m in length, measured along the outside of the outermost through lane. However, the initial part of the curbside is

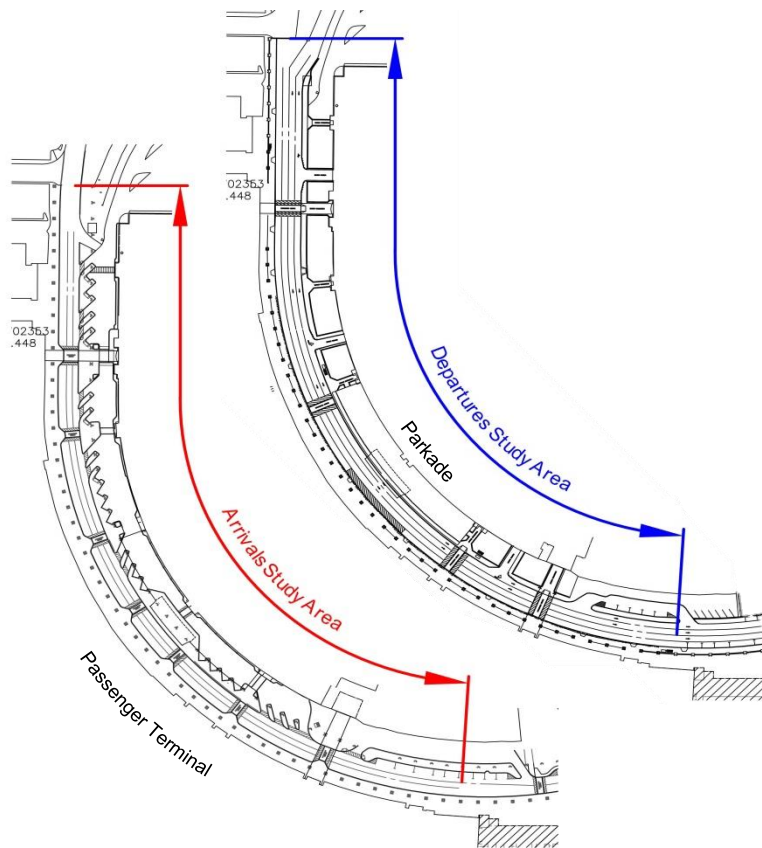


Figure 4.1 - Site Overview

some distance from the terminal and the curb lane is interrupted by crosswalks with curb bumps; therefore the effective frontage of the terminal for pick-up usage is considerably less. For the purposes of the study, this is estimated to be 304 m measured along the outside of the outer through lane provided that the adjacent curb lane is a minimum 3.70 m width (due to curb bump outs), and the location is within 30 m of a publically accessible doorway to the terminal.

5.0 Observed Issues

As part of the scope identified above, formal interviews were conducted with key managers whose responsibilities include the Arrivals and Departures level roadways. Their insight, along with the review prompts recommended by the aforementioned TAC publications provided the initial key observations to be made. During the course of the study, three site visits were made on March 19 during daylight/dusk hours, March 22 during nighttime hours and March 24, 2015, during daylight hours to make said observations as well as to take note of other issues. The visits were made via curbside observations and using drive-through video recordings. Issues that were observed are discussed in the subsequent sections 0 and 5.2.

5.1 Departures Level

During the course of the study, a variety of issues were noted along the Departures level study area. Sections 5.1.1 through 5.1.6 discuss these issues in detail including possible causes in some cases.

5.1.1 Signage Difficult to Read

While many of the signs appeared to be easily readable during daylight hours, the situation changes considerably at night. It was observed that much of the signage used was not reflective; this includes signage restricting waiting or stopping and some of the car rental directional signage. Figure 5.1 shows the difference between day and night conditions from the perspective of the driver. While the facility is equipped with lighting, the lighting is generally aimed vertically downwards or mounted below the signage level and are unable to adequately illuminate the signage. That being said, standard roadway signage for crosswalks, traffic control and overhead gantry indicating lane use were reflective and readable at night, though modification panels affixed to the gantry are not reflective.



Figure 5.1 – Night and Day Comparison of Signage Readability (Driver's Perspective)

In addition, issues were noted with the signage for the car rental returns. Upon entry to the Departures level, two relatively small (and unreflective) signs direct drivers to either one of two entrances, which are identified as 1 and 2. While it was not possible to measure the signage and text sizes to verify the sizes, they did appear to be too small for the speeds at which vehicles tend to be traveling at immediately after reaching the top of the entrance ramp. The following signage at the entrances are also difficult to read as the logo images showing the rental companies are at the far left of the sign and relatively small given the distance from the travel lane. Furthermore, the signage at the entrances themselves do not refer to the entrance numbers shown on the initial set of signage, which can contribute to driver confusion. Photographs of the aforementioned signage is shown in figure 5.2.

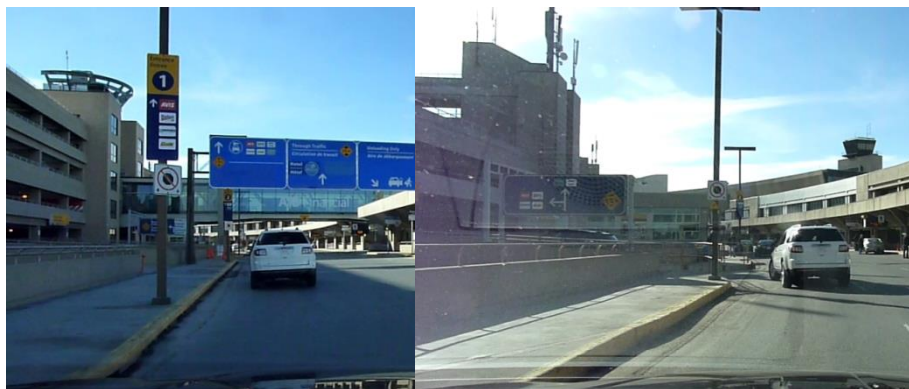


Figure 5.2 – Examples of Car Rental Return Signage (Driver's Perspective)

5.1.2 *Significant Speed Differences*

Observations found that there appeared to be significant speed differences between vehicles. Whilst measurement of vehicle speeds was not possible in the study, qualitatively the differences were notable, particularly with commercial operators such as taxis and shuttle busses appearing to have the greatest speeds. Some drivers came to a near stop in order to read the signage presented, whilst conversely others would travel more quickly and often accelerated rapidly after passing a raised crosswalk. Increased speeds and the significant differences in speed are often considered safety risks.

Logically, these differences are not unexpected. An informal count of 207 vehicles over the visits found that approximately 68% of vehicles were private vehicles versus 32% commercial vehicles. As it is reasonable to assume commercial operators will be more familiar with the airport versus private vehicles, it is not surprising that many slow and many fast moving vehicles were observed.

5.1.3 *Crowding at Curbside*

Another noted issue was the crowding of vehicles at the curbside near the terminal entrances. Typically, there was often ample space before or after the location but drivers appear to prefer stopping only at one specific location. A potential reason may be related to the variable message signs (VMS) that display the airline check in area over each doorway. It appeared that many vehicles will pull over immediately upon seeing a particular airline appear on the VMS sign and were unwilling or unaware that they could drive further ahead for more space and another location for the particular airline.

Subsequent to the crowding, double parking was common on the Departures level, though usually short lived as double parking events tended to clear within one or two minutes. It was also observed that the commercial operators, such as taxis and shuttles often would double park. Once initiated, it appeared private vehicles would follow their example and do the same.

5.1.4 *Distracted or Overwhelmed Drivers*

During the observation process, the behaviour of many drivers displayed behaviours indicative of distraction or were overwhelmed by the situation. Characteristics of these drivers included fixation on signage, driving slowly, unsafe lane changes and even near misses with pedestrians or vehicles were observed.

One possible reason may be related to the amount of signage. Over the length (492 m) of the Departures level, a total of 65 signs were counted ranging from directional, regulatory, parking restrictions and VMS's. This translates to a sign every 7.7 m on average, or 0.9 s of travel time between signage at the 30 km/h speed limit. The amount of signage is well in excess of the 30 m sign spacing recommended by the British Columbia Ministry of Transportation ([BC MOT], 2000). Other research and recommendations suggest that at minimum it takes drivers 0.5 s to read each word on signage or 1.0 s for symbols (Smiley, Houghton, & Philip, 2004)(Alberta Infrastructure and Transportation [AB I&T, 2006]). The Manual of Uniform Traffic Control Devices (MUTCD) recommends a minimum of 3.5 s to read simple signage (TAC, 2014). From this it is clear that there is more signage posted than what a driver can be reasonably expected to fully read and interpret. However, given the nature of the facility it may be difficult, if not impossible, to reduce signage to the amounts suggested by the aforementioned sources.

Another contributing factor may be the VMS's used to identify which airlines check in near each door. These signs often command more attention than static signage, but they may be showing more information than is actually necessary for the drivers. For example, some VMS signs were observed to cycle through up to seven messages, some of which included non-airline messages such as the

current date/time, “No Unattended Vehicles”, “Drop off and go only”, the sectors served such as “US Destinations” or directions such as “For WestJet USA go to Door 5 ahead”.

The number of signs and VMS messages, and the length of some messages, are likely contributing to drivers being overwhelmed with information. Recall that drivers are also tasked with interpreting signage, navigating to the correct location as well as the task of driving itself and other distractions within their vehicle. While this study cannot prove that drivers are being overwhelmed or are distracted, it can be reasonably assumed there the probability is high, thus constituting a risk to transportation safety.

5.1.5 Drivers Failing to Yield to Pedestrians

It was also observed that drivers were failing to yield to pedestrians, particularly at the level crosswalks. This may be due to the design of the crosswalks themselves. While four crosswalks were raised, it is important to note that two were not. The previous raised crosswalks can form a driver expectation that all crosswalks are raised, thereby making the level crosswalks easily missed.

The signage of crosswalks is also of possible concern. There were varying types of signage used to show crosswalks, such as standard white crosswalk signs mounted on sign poles of varying height, some were mounted to the canopy structure and one crosswalk had fluorescent yellow signage on poles with fluorescent strips (refer to figure 5.3). The differences in signage are also against driver expectation and can cause drivers to be unaware of the signage, particularly given the workload situation. The mounting of the white crosswalk sign to the canopy structure can be confusing as the canopy has other signage mounted to it at a similar height with a similar background colour.



Figure 5.3 – Examples of Crosswalk Signage

5.1.6 Jaywalking

In addition to issues with vehicle, substantial jaywalking was observed. In nearly all instances, jaywalking was to and from smoking areas on the opposite side from the terminal. In general, where a crosswalk was immediately at the smoking area, adherence was considerably higher.

5.2 Arrivals Level

During the course of the study, a variety of issues were noted on the Arrivals level. Many of these issues were common to the Departures level as well and will not be discussed in detail in this section. However, there were a variety of other issues that are specific to Arrivals. Sections 5.2.1 through 5.2.9 discuss these issues in detail, as well as identifying issues that were common to the Departures level.

5.2.1 Lighting

From the site observations, it was evident that the Arrivals level may suffer from significant lighting issues. Contrary to expectations, the issue is during the daytime conditions rather than nighttime. As

the Arrivals level is fully covered, it tends to be a dark area. Supplementary lighting is provided even during daylight hours, however there is no transition period for one's eyes to adjust when entering on road as seen in figure 5.4. This can result in drivers missing signage and/or hazards while their eyes adjust to the darker conditions.



Figure 5.4 – Light Level Difference Upon Entry (Driver's Perspective)

In addition, to the lighting adjustment at the entrance, the lighting levels appeared inconsistent. As the majority of the roadway is open on both sides between the road deck and the terminal as well as the road deck and the parkade, sunlight does filter down from the upper level. However, the amount of sunlight changes due to the curvature of the roadway and surrounding buildings. Furthermore, near the Rental Car Centre, both sides are infilled with structures, resulting in a dark area where no sunlight filters down. This lighting level change greatly affects both the Arrivals roadway and even more so the bus facility as evidenced in figure 5.5. This area is of greater concern than the initial transition as these areas are busier with pick-up traffic and crosswalks whereas the former area had fewer conflicts.



Figure 5.5 – Dark Area near Rental Car Centre (Bus Facility left, Roadway right)

5.2.2 Difficult to Read Signage

Similar to the Departures level, much of the directional signage on Arrivals is not reflective, again with the exception of regulatory signage. This is particularly important on Arrivals as the curb space is split between Taxis, Sedans, Cell Phone Pick-up and general pick-up areas therefore drivers need to read much more of the signage. An example is shown in figure 5.6.

One substantial difference however is that pedestrian crosswalk signs are mounted overhead, are oversized, inverted coloured and backlit (refer to figure 5.7). Interviews with staff and observations suggest that these signs are very visible and readable.



Figure 5.6 – Examples of Pick-up Signage



Figure 5.7 – Backlit Overhead Pedestrian Sign

5.2.3 Significant Speed Differences

Similar to the Departures level, there were significant speed differences qualitatively observed. Furthermore, vehicles tended to maintain a high rate of speed until the first raised crosswalk and often accelerated significantly immediately after a crosswalk. The estimated proportions of familiar commercial operations versus unfamiliar private vehicle drivers were similar as well with 38% and 62% respectively for 334 observed vehicles.

On Arrivals there is also a change in speed limit that may not be warranted. The speed limit is reduced to 30 km/h just prior to entering the level and continues majority of the way. However near the end, there is an approximately 50 m stretch where the speed limit is further reduced to 20 km/h before resuming 30 km/h as it enters the construction area. This speed limit change may not be warranted and due to the high driver workload, the signage could be easily missed.

5.2.4 Double Parking at Pick-Up Areas

Similar to the Departures level, double parking was also a notable area of concern. Despite the effort of security staff who are often very active in directing drivers, the problem appears to be significantly higher. A likely cause is the longer dwell times as some drivers need to wait for or find their passengers, as well as the pressure to stop where their passengers happen to be waiting, in addition to the time taken to load baggage on to vehicles and return the baggage cart. Another important note is that there is considerably less effective frontage (304 m) due to walking distance to doorways and the space occupied by the curb bump outs at crosswalks, which are also more common on the Arrivals level.

The double parking issues may also be related to the supply of unreserved curb space. Unlike the Departures level, a substantial portion of the curb space is reserved for taxi and sedan operators (bus operators have a facility across the roadway and do not use the primary curb). There is a concern that the allocation of space may not be optimal. Estimation based on site observations found that

55% of the effective frontage is dedicated to taxi and sedan services, with the remaining 45% general pick-up or cell phone pick-up areas. The informal traffic count conducted observed 303 vehicles needing curb access of which 69% were private vehicles and only 31% were taxis or sedans (busses are in a separate facility and not included in these counts or proportions).

5.2.5 *Driver's Making Unsafe Lane Changes*

The site observation sessions also observed a number of vehicles making potentially unsafe lane changes that may result in collisions. It is likely that distracted or overwhelmed drivers are a contributing factor, which will be further discussed in section 5.2.6. However, it was also noted that many of these incidents involved the taxi, sedan or commercial operators in some manner.

It was observed on more than one occasion that taxi dispatchers would direct taxis to merge out and proceed to another taxi area. However, this direction was given without regard to whether it was safe for the taxi to merge out into the travel lanes. This creates a false sense of safety for taxi drivers and substantial collision risk.

Furthermore, the manner in which the taxis are called forward to each taxi area may be a cause for concern as well. While unconfirmed with the taxi operator at this time, it was evident that when the second taxi area needs taxis, they would be called from the first taxi area. At the start of the Arrivals roadway, there is an intermediate taxi staging area from which taxis are called forward to replenish the first taxi area. This results in taxis needing to merge into the traffic lanes at minimum twice, once from the intermediate staging area and once after picking up a passenger. A taxi that picks-up a passenger at the second area will likely merged into the traffic lanes three times, once from the staging area, once from the first taxi area, and one final time after picking up a passenger. These extra merges into traffic lanes are additional potential conflicts and may be contributing to the already busy and workload heavy conditions on the Arrivals level.

5.2.6 *Distracted or Overwhelmed Drivers*

Similar to the Departures Level, the behaviour of many drivers appear to indicate they were distracted or overwhelmed by the situation. The volume or density of signage is likely a contributing factor. Over the length of the effective frontage (304 m), a total of 47 signs were counted as intended for drivers. This translates into an average of 0.8 seconds of travel time between each sign, which is less than the recommendations discussed in the Departures Level discussions (refer to section 5.1.4).

Potentially adding to the driver workload are the greater number of conflict points on Arrivals. Over the course of the effective frontage, there are also 13 access points from the bus facility and 7 crosswalks demanding attention. Each crosswalk is also equipped with automatic flashing lights which are automatically actuated (refer to figure 5.8), however the actuation appears unreliable. This translates into 14 flashing lights over the effective frontage, which start and stop regularly and adds to the level of distraction in addition to a larger volume of vehicles merging both to and from the curbside as well as from the bus facility on the left.



Figure 5.8 – Crosswalk with Flashing Warning Signal

5.2.7 Drivers Failing to Yield to Pedestrians

On the Arrivals Level, some drivers were observed to not stop for pedestrians, despite the highly visible signage. A possible reason would be that drivers are overwhelmed and/or distracted and fail to notice the pedestrians at the crosswalks. However there may also be an issue with driver frustration as it is not uncommon to stop at many of the seven crosswalks whilst driving through this level. The number of crosswalks may also be a concern as some are very closely spaced and often have a consistent “trickle” of pedestrians. The average spacing of the crosswalks is 39 m with the two closest being 27 m apart from centerline to centerline, which translates to 5 s and 3 s of driving time between crosswalks respectively at the 30 km/h speed limit. As drivers lose patience, they are more likely to take unsafe risks.

That being said, the security personnel controlling busy crosswalks is working well as they ensure pedestrians can cross and group pedestrians into larger platoons to ensure vehicles are given the opportunity to drive as well.

5.2.8 Poorly Located Crosswalks

In addition, there was a potentially hazardous situation observed. Behind the Rental Car Centre, there is a crosswalk exiting the parkade at a 90° angle. However, approximately 7 m further, there is a second crosswalk that is unlikely to be expected by drivers (refer to figure 5.9). Furthermore this crosswalk is at a 60° angle where pedestrians exiting the parkade face away from traffic and are obscured from view by the fire stair structure. Pedestrians walking towards the parkade are obscured from view by the Rental Car Centre building until they enter the crosswalk area. This crosswalk has been a concern to YYC for a period of time and a stop sign has been installed for the bus as a mitigation measure. However, from interviews and observations driver compliance with the Stop sign was poor.



Figure 5.9– Example Poor Crosswalk Placement

There are five crosswalks originating from the parkade that are of concern. Due to the fire stair structure, there is no opportunity for the pedestrian or busses in the bus facility to see each other prior to the pedestrian stepping foot onto the driveway itself (refer to figure 5.10). YYC has taken steps to mitigate the issue by playing an automatically actuated audible warning message upon leaving the parkade and an amber rotating beacon activates on the driveway side to help reduce the risk. However, due to the limited space, it is likely impossible to further improve on these aforementioned measures.



Figure 5.10 – Parkade Exiting Directly to Driveway

5.2.9 Poorly Located Smoking Areas

Finally, the location of some smoking areas on this level is a cause for concern. Figure 5.11 shows an example of several smoking areas are located alongside the parkade on the edge of the driveway of the bus facility and are only accessible by walking on the bus facility's driveway near the stair structures. While these locations benefit from the crosswalks at the stairwells, they are sometimes located on the driveway resulting in smokers being obscured from view by the stairway structure.

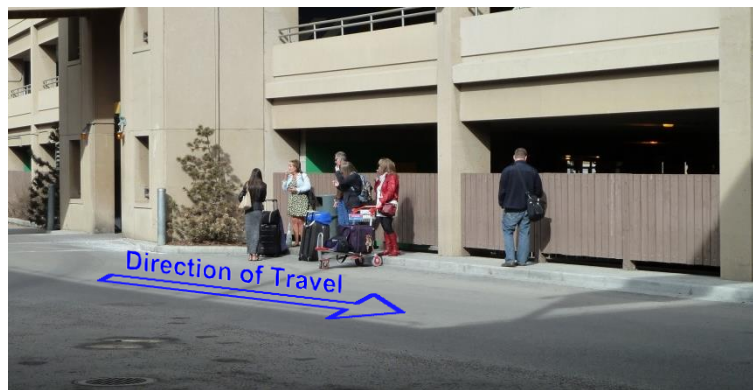


Figure 5.11 – Smoking Area on Driveway

6.0 Suggestions for Improvement

Based on the observed issues, a series of suggestions for improvement can be made. While the scope of this research study is insufficient to be considered an engineering study, these suggestions are potential solutions or at minimum improvements; however, further analysis would be necessary prior to implementation.

6.1 Departures

Based on the observed issues, sections 6.1.1 through 6.1.7 provide some suggestions that may assist YYC, and potentially other airports as well, in addressing their transportation safety issues and concerns related to the Departures level.

6.1.1 Improve Signage

Signage improvements should be considered throughout, which is currently underway with a full replacement program to coincide with the opening of the international terminal in 2016. An important first step would be to upgrade all signage to either backlight signage or to reflective signage. This can

help to reduce driver confusion imposed by the signage by allowing drivers to easily read and recognize signage from a further distance. TAC recommends reflective signage and provide guidelines as part of the MUTCD (TAC, 2014).

Consider reducing the amount of text on signage, by eliminating information not necessary for drivers. It is considered ideal for directional signage to consist of 3 or 4 units of information as comprehension reliability decreases with additional information, while non-urgent signage should include no more than 7 units (National Cooperative Highway Research Program [NCHRP], 2012). Utilizing standard and recognized pictographic symbols also allows for easier interpretation and is often recommended for locations where language barriers may be common (NCHRP, 2012).

Crosswalk signage should be made consistent throughout the Departures level. Consideration can be given towards mounting signage away from the other similar signage on the canopy structure. While alternative colours are not normally recommended, the fluorescent green used at one of the crosswalks does provide a clear visual distinction from other signage that may be beneficial in this case.

Finally, consider modifications to the directional signage to the car rental return facility. The signage can be replaced such that directional information is made larger and moved closer to the roadway. The existing signage that refers to entrance numbers should be removed, or have the entrance numbers incorporated into the signage at each entrance.

6.1.2 Advance Destination Signage

Many airports around the world choose to provide directional information to passengers well in advance of arrival at the terminal. Often these take the form of road side signage approaching the airport and group drivers into following simpler instructions, such as proceeding to a certain entrance, zone or terminal. Figure 6.1 shows examples of such an implementation approaching Toronto Pearson International Airport where drivers are directed to different terminals, and Tampa International Airport direction drivers to different drop-off and pick-up zones.



Figure 6.1 – Example of Advance Signage (Google Maps, 2015, 2015)

YYC can consider such infrastructure as well given that many vehicles approach from Airport Trail NE which has a long stretch with little signage or distractions. Drivers can be advised ahead of which area to proceed to, which can be made consistent with the concourse and gate lettering system used within the terminal. Therefore as drivers approach they already have an idea of their destination and can follow a simple letter or colour coding rather than reading airline information at the curb. In order to implement this option, consistent and highly visible lettering will need to be shown at the curbside as well. Finally, this suggestion may also assist in the door crowding issue as some drivers will be encouraged to stop at any door for their area letter, rather than depending on and stopping at one location.

6.1.3 *Modify VMS Signage Messages*

In another effort to reduce the driver workload, YYC can consider modifying the VMS signage to reduce the amount of information wherever possible. Some messages that may not be needed by drivers as part of the driving and navigation process may be removed, such as the current date and time. Regulatory information such as parking restrictions are already shown on permanent signage as well as enforced by security staff. Check in sector, such as “Domestic-International” can be moved to the permanent backlit portion of the signage above the VMS as it already is for some signage. Furthermore, consider showing only the airlines operating at that time of day on the VMS signage to further reduce unnecessary information.

The VMS signage can also help to reduce the crowding at doorways. Where this is a problem, it may be helpful to have the next or previous VMS to show that airline name as well, therefore helping to spread drivers out along the curbside and potentially reduce double parking.

6.1.4 *Modify Crosswalks*

YYC can consider upgrading the two remaining basic crosswalks to raised crosswalks in order to provide awareness and congruency to driver’s expectations. Another alternative would be to close the crosswalks and eliminate the curb ramps; however it will be necessary to ensure that pedestrians have another reasonably convenient route otherwise jaywalking is likely to ensue.

6.1.5 *Relocate Smoking Areas*

As regular jaywalking was observed to and from smoking areas, YYC can consider relocating smoking areas to locations where crosswalks are provided. Physical barriers to jay walking may be helpful as well, but require careful consideration as they can cause pedestrians to perform even more unsafe acts.

6.1.6 *Rumble Strips*

Rumble strips are often utilized to warn drivers of approaching hazards and to encourage drivers to slow down. Whilst typically found on highways, they may be an effective and unobtrusive reminder to drivers to slow down as they enter the Departures level, as well as serve as speed reminders in other areas where speed is of a concern.

6.1.7 *Other Suggestions*

Many sources refer to engineering, education and enforcement as being three important pillars for transportation safety. Whilst this research study has focuses primarily on the engineering aspect, it is important to note that the education and enforcement aspects are critical as well. YYC can consider educational efforts, in particular with their commercial operators who are role models for other drivers, to help encourage better behaviours, whilst security staff provides the enforcement aspects of safety.

Finally, in order to maintain safe operations, it is suggested that YYC ensure maintenance procedures are in place to regularly check the proper function of safety systems, including lighting, and that signage and pavement markings are clean and undamaged.

6.2 *Arrivals Level*

Similar to the discussion for the Departures level, a series of potential solutions are outlines in sections 6.2.1 through 6.2.10. Some suggestions are common to both Arrivals and Departures and will not be discussed again in detail here.

6.2.1 Lighting Improvements

In the site observations, the lighting issue was the most visually apparent. As drivers enter the Arrivals level which is underneath the Departures level road deck, the lighting condition can change drastically within seconds from bright sunlight to a covered roadway. A suggested improvement will be to provide transition lighting, not dissimilar to systems in tunnels, to allow the driver's eyes time to adjust to the reduced light levels. Figure 6.2 shows an example of such a system, where intense lighting is provided near the entrance that transitions over a distance to lower levels provided in the remainder of the tunnel.



Figure 6.2 – Example of Transition Lighting (Google Maps, 2015)

Furthermore, it is suggested that YYC review and take steps to improve the lighting uniformity on the Arrivals level. YYC can consider installing a supplementary lighting system that provides additional infill illumination to areas where natural sunlight is obstructed and unable to reach the roadway or bus facility. Such a system may benefit from automatic photosensitive control to adjust the supplementary lighting to only what is necessary to provide and maintain lighting uniformity and prevent over lighting such as during night time or on overcast days.

6.2.2 Signage Improvements

As mentioned previously, YYC will undergo a signage replacement program coinciding with the opening of the international terminal in 2016. It is suggested that YYC consider upgrading signage to be backlit or reflective in addition to removing signage or simplifying messages wherever possible similar to the discussion for Departures in section 6.1.1. As curbside signage on Arrivals is more complex due to the reserved portions of the curb, it may be beneficial to utilize different colours on portions of the signage to help drivers who only have a moment to glance at the signage.

6.2.3 Advance Destination Signage

The suggested Advance Designation Signage (refer to section 6.1.2) can also be implemented on the Arrivals level. In some manner, these letters are already partially in use on the Arrivals level with major signs indicating YYC's Meeting Places A and C, which are aligned to the concourse and gate lettering system.

6.2.4 Simplify Pick-Up Areas

As discussed in section 5.2.6, drivers are tasked with finding the passengers to be picked-up, whilst performing the tasks of driving, navigating and finding curb space. As it would be beneficial to help reduce the driver work load, a revamped system of simpler loading zones may be beneficial.

A potential solution to simplify said zone will be to eliminate the current distinction between cell phone loading zones and general loading zones. As the restrictions are identical and enforced by security staff, there may not be a need to distinguish between the two types.

Furthermore, as many drivers are in contact with their passengers utilizing cellular phones, the task of finding a passenger can be simplified by numbering all loading zones. The zone numbering can be kept consistent and be numbered in a manner compatible with the signage improvements discussed above. For example, a possible numbering system may designate loading zone B2 as serving Concourse B Arrivals and it is the second zone in the B area of Arrivals.

6.2.5 Modify Taxi and Sedan Operations and Increase Pick-Up Areas

YYC can consider making changes to their taxi and sedan curb reservations in order to create more space for pick up areas on Arrivals. A comprehensive review of the curb requirements will be necessary to determine the optimal proportions of each area.

Furthermore, YYC can consider making modifications to taxi operations such that taxis are not being called from one taxi zone to the next, which can reduce the number of unnecessary merges to and from the curb lanes. Dispatchers can be instructed ensure the through lane is available prior to waving taxis into them.

Finally, YYC can consider consolidating some of the operations. For example it may not necessary to have two taxi areas and three sedan zones along the effective frontage. As many users have already decided on their transportation mode prior to leaving the terminal, it may be beneficial to consolidate some of these areas to provide smoother operations and allow more space for passenger pick-up.

6.2.6 Improve Pedestrian Flashing Lights

During the course of the site observations, it was noted that the current system of flashing pedestrian warning lights affixed to the crosswalk signage may be a distraction, particularly as the actuation system is unreliable resulting in false positive and negatives. YYC can consider making improvements to the system to improve the accuracy. Other alternative options can also be considered to draw attention to the crosswalks more passively in lieu of flashing lights. Possible alternatives may include supplementary lighting to highlight the crosswalk, installing coloured lighting strips on the ceiling structure above the crosswalk and/or embed coloured lighting into the pavement.

The existing backlit signage appears to be clear and well-functioning. Security staff appeared to be adept at controlling traffic and regulating pedestrian crossings. It is suggested that these facilities and staff efforts be maintained with ongoing monitoring.

6.2.7 Review and Modify Crosswalks

A study of the existing crosswalks can be undertaken to determine if there are design deficiencies or improvements that can be made. For example, the angled crosswalk behind the Rental Car Centre, (refer to in section 5.2.8) may benefit from relocation to the opposite side of the stair structure to cross in the opposite direction as shown in figure 6.3. This may help to improve sight lines for vehicle operators as they would then be afforded a view of pedestrians approaching from the terminal and parkades, as well as forcing pedestrians coming from the parkade to face oncoming traffic.

YYC may wish to review existing crosswalks to determine whether all of them are warranted. Due to the close spacing of some crosswalks, it may be beneficial to close and reduce the number of crosswalks. A study into whether the crosswalks require positive control may be beneficial as well. These efforts can help to reduce driver frustration due to the volume of crosswalks and pedestrians, create additional curb space and reduce the number of crosswalks needing patrolling or control by security staff.

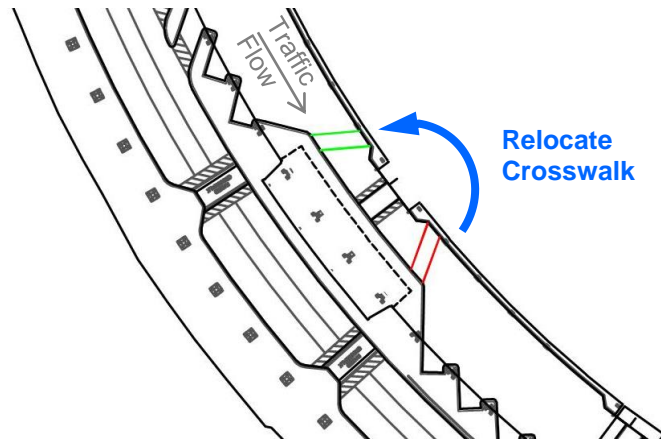


Figure 6.3 – Diagram of Possible Crosswalk Reconfiguration

6.2.8 Relocate Smoking Areas

Consideration can be given to relocating some smoking areas that are currently on the driveway of the bus facility to non-vehicle surfaces where practical. Where not practical, it may be beneficial to move these smoking areas such that their view from bus traffic is not obstructed by the parkade stairwell structures and ensure adequate lighting is provided.

6.2.9 Rumble Strips

As discussed in section 6.1.6, rumble strips are a potential solution to encourage drivers to slow down as they approach the Arrivals level roadway and as a reminder where speeding issues are noted.

6.2.10 Other Suggestions

As discussed in section 6.1.7, education, enforcement and good maintenance will also be essential to the continued safe operation of these facilities.

7.0 Conclusion and Recommendations

Based on the site observations it was found that the study facilities appear to have functioned well. However, even a well-designed system can still have opportunities for improvement. This paper observed and discussed issues relating to signage, driver workload, VMS messages, drivers failing to stop for pedestrians, unsafe lane changes, double parking, lighting and jaywalking among others. Suggestions for potential improvements were made including improvements to signage, crosswalks, VMS messages, navigational information, and commercial vehicle operations among others.

Based on the observations, it is evident that the airport terminal environment can be very different than typical urban and rural roadway environments. Therefore it is clear that further study into transportation safety at airports, at both site specific and research levels, can provide major improvements and contributions to transportation safety, as this is often an overlooked part of the transportation network.

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