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Improving Public Transit Access to Large Airports: A Case Study of Pearson Airport in Toronto

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ABSTRACT

Increasing public transit mode-split of airport-bound trips has challenged transportation planners and engineers alike. In North America, the automobile is the most dominant mode of travel for airport-bound trips. An increase in mode-split will reduce congestion as well as reduce green house gas emissions from private automobiles. In the United States, rail-based solutions to improve public transit mode-split have achieved limited success. This paper analyses the spatial distribution of airport-bound trips in Toronto and explains why rail-based alternatives are unlikely to achieve the desired mode-split. It is argued that a rail-link between Pearson airport and Union Station in downtown Toronto will not attract sufficient ridership. On the flip side, if the rail-link becomes successful, it would contribute to the growing congestion in downtown Toronto by attracting additional trips to the Union Station during peak-hour traffic. Results from the spatial analysis of Pearson-based trips calls for a bus service operated from numerous nodes, which are characterised by high concentration of airport-based trips. The proposed bus service will operate on exclusive right-of-way from strategically located bus stations, offering direct service to and from Pearson Airport. These bus stations would serve as extensions of the airport. At the heart of this proposed transit system is an advanced digital communication network, shared by commercial airlines and airport administration, to facilitate remote check-in and seat confirmation, along with real-time monitoring of buses on the street network. Results of this study are transferable to other major cities that depict similar spatial distribution of population.

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INTRODUCTION

Lester B. Pearson International Airport is the largest airport in Canada. In fact, Pearson is the fourth largest entry port into North America after John F Kennedy, Miami, and Los Angeles International airports (1). More than 45 scheduled airlines offer direct service to 145 destinations around the world. Airline passenger forecasts indicate that 40 million passengers annually are expected to use Pearson Airport by the year 2006 (1). Increase in airside activity, from 24.5 million passengers in 1997, will cause a simultaneous increase in groundside activity at Pearson Airport. Expanded airside activity is expected to exert additional pressure on the street network that feeds passengers to the airport.

Increase in airside activity will have a greater impact on the origin-destination (OD) passengers. The number of connecting passengers at Pearson Airport (20% in 1996) is expected to decrease in future because "Better point-to-point transborder service at airports such as Ottawa, Montreal, Winnipeg and Halifax will result in fewer domestic connections to transborder flights through Pearson," (1).

A new terminal at Pearson is being planned to accommodate future air travel demand. The new terminal will replace the existing terminals 1 and 2. Efforts are underway to accommodate the expected increase in airside activity at Pearson Airport. However, little is being done to improve public transit access, which demands a concerted effort from airport administration, regional municipalities, and provincial ministry of transportation.

Following alternatives have been proposed in the past to improve groundside access to Pearson Airport.

1) Providing a high-speed rail link between Union Station in downtown Toronto and the airport;
2) Increasing highway capacity to accommodate the increase in traffic volume; and,
3) Providing bus transit on restricted right-of-way.

Rail-based alternatives cannot achieve the desired mode-split. A rail-based public transit route that could secure a reasonable ridership is not possible due to the spatial distribution of OD trips in the Greater Toronto Area (GTA)[1]. The Toronto Transit Commission (TTC) operates two subway lines, which could serve as a feeder for the suggested airport service. However, most of the Pearson-based trips fall outside of the immediate catchment of Toronto's subway system. Streetcars and buses, operated by TTC, provide transit facilities for areas not served directly by the subway system. However, previous research has shown that an increase in the number of transfers makes public transit an unattractive mode of travel (2).

A recent study by IBI Group concluded that the "Most feasible route to the airport is via the existing CN Weston Subdivision railway line," suggesting option 1 (3). The study however disregarded the actual OD pattern of trips in the GTA. In addition, the study assumed that the proposed rail service could conveniently reach 20% of OD trips. Another major assumption was that 1/3rd of the 20% OD trips would switch to public transit. Even with these optimistic assumptions the study concluded that average load per train would be less than 60 air-passengers.

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[1] In January 1998, Metro Toronto and the surrounding municipalities were amalgamated into one large entity now known as the GTA.

An earlier study that evaluated transit alternatives for groundside access to Pearson airport recommended a similar rail link along with other developments in transit infrastructure (4). A rail-based service between downtown Toronto and Pearson Airport does not account for a large percentage of trips that originate in south-west of the airport. These trips in the south-west, along with the trips in the north-east and south-east of the airport form a large pool of trips that could efficiently be served through a bus transit. However, decision-makers are often inclined towards rail-based alternatives, which are expensive and do not rectify the problem.

In the United States, eight airports are linked directly to the metropolitan subway systems. Washington Transit, the most successful in airport access in the US, reported a public transit mode-split of 15 % for the airport-based trips. The remaining seven airports averaged around 5% for public transit mode-splits. On the other hand, airports in Europe fared better in mode-splits. Zurich airport at 35% has the highest mode-split for rail-based public transit, while Munich airport has the highest public transit (rail and bus combined) mode-split of 40%. Public transit modes in Europe are integrated in such a manner that inter-city trains and metropolitan subways often share rail tracks and stations. Thus, trip-makers, who use rail transit to access airports, often had their trip origins outside the metro boundaries. Many of those trip-makers transfer from regional rail-services to the rail-line running to the airport (2). In addition, the design of buses, subway cars, subway stations, and streetcars in Europe facilitates their use by passengers with luggage. Unlike in Toronto, most subway stations in Munich, Frankfurt, and Berlin have elevators that lead passengers directly to subway/train platforms. Also, buses, streetcars, and subways have sufficient space for luggage. Lessons learnt in the US suggest that a rail-based alternative may not be the most appropriate solution for North American cities, which are characterised by urban sprawl and low population densities.

This paper is divided into two main sections. In the first section, we will present results from spatial analysis of airport-based trips. In the next section, we will explain how a rubber-tired transit system can better achieve the desired public transit mode-split. We wrap the discussion with conclusions and suggestions for further research into the problem.

METHODS

The data analysed in this research was extracted from the Transportation Tomorrow Survey (TTS) conducted in 1996 (5). TTS surveyed 115,193 households or 312,000 persons in the GTA and obtained detailed information about their weekday trip making. No information was collected for weekend trips. We extracted Pearson-based trips (Zone 1209) from TTS 1996 data. To study the spatial trends in the data, trip ends were geocoded to the centroid of traffic zones that they fell under. TTS has divided the GTA into more than 1400 zones. Forty-two hundred factored trips to or from the Pearson Airport were reported in TTS. The data set also included the expansion factors for each reported trip. On average, one surveyed trip represented 20 actual trips. For temporal comparisons, data from previous surveys in 1986 and 1991 has also been included in the analysis.

The data set used for the study has some serious shortcomings. TTS did not cover trips made by non-residents to and from the Pearson Airport. Visitors to the GTA, who choose to stay in a hotel, account for a large number of trips to the airport. TTS does not record these trips and hence valuable information on their mode choice has been lost. Hence, the descriptive, spatial analysis, presented in this paper is based on trips made by residents of the GTA. In addition, explicit information was not available on trip purpose. Thus, trip-makers were not explicitly identified as air passengers, airport employees, or greeters and well wishers. Travel behaviour and mode choice decisions of air passengers can be different from that of airport employees, and greeters and well wishers. In addition, work-based trips to Pearson Airport, such as courier delivery, are different from non-work trips.

A survey conducted in 1990 at the Pearson Airport collected information on trip purpose **(6).** Trip-makers were classified into air passengers, greeters and well wishers, and employees. This survey was also available for analysis. However, the data set lacked precise spatial information on trip origins and destinations. Since the focus of this research is on the spatial distribution of trips in the GTA, hence only TTS data was used for this analysis.

Findings from the study are presented in the following section.

RESULTS

In this section, descriptive analysis of trips recorded under TTS for the years 1996, 1991, and 1986 is presented. Private auto was the most dominant mode of travel for airport-based trips (Figure-1). Almost 90% of the total trips were automobile-based (auto-driver + auto-passenger). Transit trips accounted for less than 4% of the total trips. Figure-1 reveals that mode-split has remained almost the same between 1986 and 1996. Auto-driver was the most preferred mode of travel, accounting for 76% of the trips in 1996. Interestingly, there has been a slight decrease in taxi-based trips to the airport. This is counterintuitive. One would expect taxi-based trips to increase from 1991 levels since the economy has improved over time and has generated more business-related air travel. Further research is needed to explore this anomaly.

A breakdown of trips by occupation is presented in Figure-2. Professionals made almost 40% of all trips to the airport. Figure-2 reveals that professionals have the highest propensity to travel to the airport. Other trip-makers employed in sales and manufacturing sectors constituted the next two most common groups of trip-makers to the airport. Figure-2 does not indicate the propensity to fly since trip-makers, travelling to and from Pearson Airport, may or may not be air-passengers. The unemployed category includes actual unemployed individuals, children, and senior citizens.

Income levels influence mode choice decisions of trip-makers. To capture the effect of income on mode choice, we plotted a composite graph showing mode choice by occupation. We used occupation as a proxy for income with the underlying assumption that professionals are usually high-income earners. Figure-3 reveals that 40% of trip-makers arriving at airport by auto-driver mode were professionals. Trip-makers employed in sales and manufacturing followed professionals in their preference for auto-driver mode. As expected, auto-passenger was the most preferred mode of travel for unemployed, comprising mostly of elderly and children. Professionals for trips to the airport predominantly used taxis. This result was expected since travel time and convenience, and not travel cost, influence the mode choice decisions of high-income earners. Transit trips had a higher percentage of trip-makers employed in sales and manufacturing. Of all trip-makers who took transit to airport, 42% were employed in sales, another 21% in manufacturing, while another 25% were professionals. Due to the small number of transit trips in the data set, these conclusions should be dealt with caution. For trips leaving Pearson Airport, trip-makers falling under unemployed category predominantly used taxis.

Peak periods of activity at Pearson Airport coincide with the AM and PM peak traffic in the GTA. Figure-4 reveals that trips heading toward Pearson reach peak at 8:00 a.m., while the trips leaving Pearson Airport reach peak at 5:00 p.m. Periods of high activity at Pearson Airport are between 7:00 a.m. and 9:00 a.m. in the morning and between 4:00 and 7:00 p.m. in the afternoon. Since the airport-based traffic's peak periods coincide with the AM and PM peak traffic in Toronto, a rail link between downtown and airport would further aggravate traffic problems in downtown Toronto. A direct rail link between Union Station and Airport would increase the incoming traffic into downtown Toronto during AM peak and would also contribute additional trips to the outgoing traffic during PM peak. If the rail link between Union Station and Airport attracts high ridership, AM and PM peak hour traffic in downtown Toronto will experience even more congestion.

One important aspect of airport-bound trips is to determine the percentage of trips originating and/or terminating in a reasonable vicinity of the airport. Euclidean distances were calculated between airport and the origin/destination of the trip. Based on the trip length data, we observed that almost 60% of the trip origins and destinations were concentrated within a 20-km radius of Pearson Airport. Again, 80% of the trips either originated or terminated within a 35-km radius of Pearson Airport (Figure-5). Even more surprising was the fact that 25% of the trips had a trip length of 12-km or less. This suggests that a significant percentage of trips is based in Mississauga and Etobicoke. The actual trip origins and destinations in Mississauga and Etobicoke are significantly higher for the reason that trip-makers who resided in hotels were not interviewed for TTS.

Almost 60% of trip-makers to Pearson Airport cited work as trip purpose. Another 23% trip-makers were auto-passengers, who may or may not be air-passengers, while another 16% were trip facilitators. These figures reveal a small number of trips by actual air passengers and a large number of work trips to the airport. Since the reported number of work trips is unusually large, these results need further exploration.

Trip lengths (Euclidean distances) varied by trip purpose and direction of travel. The average trip length for trips leaving the airport was 24.4-km (Figure-6a) against 30-km for all Pearson-bound trips (Figure-6b). Similarly, average trip length for air passengers heading towards Pearson Airport was 50-km against 32-km for air passengers leaving Pearson Airport. The average home trip leaving Pearson was about 23-km long. Some of the trips in the database were more than 200-km in length, suggesting a positively skewed distribution of trip-length data. All distances reported in this paper are Euclidean distances.

If the trip origin was neither work nor home, such a trip, at an average, was three times (64-km) the length of a trip originating from home or work (23.5-km). Similarly, trips that were not destined for home or work were twice as long (43-km) as the trips destined for either work or home from the airport. Trips that were neither home-based nor work-based accounted for 15% of total trips to and from Pearson Airport. Trip length also varied by dwelling type of trip-maker. Trip-makers living in apartments, at an average, drove for 23.5-km against trip-makers residing in freehold properties, who drove for 42-km for their trips to and from the airport.

DISCUSSION

Private automobile users convert to public transit modes if transit offers savings in travel time, greater flexibility and reliability, and higher level of service than the automobile. If a route is congested during peak hours, a good transit service, which is not affected by traffic congestion, will attract trip-makers away from private auto and taxi. It has been argued that "Public transit running without priority on the congested roads will not be reliable. Hence, in order to be reliable it must be segregated to some extent" (7).

Although buses operating on exclusive right-of-way or HOV lanes have proven to be an equally efficient mode of transit, the public perception of buses has not been favourable. Buses are often considered an unreliable, low-speed, pollution-causing transit system. In instances where new transit services were planned to attract passengers from automobiles, steel-wheeled transit was preferred over bus transit. Mackett and Edwards (7) explained the so-called "bad image" of buses and pointed out following misconceptions about bus transit:

- Buses are hard to finance against rail-based transit;
- Buses are not likely to attract development;
- Buses are not seen as a permanent service;
- Buses contribute to air pollution;
- Buses cannot interact with the heavy rail transit (high-speed transit); and,
- Buses need a loop at terminus.

Although Zurich Airport has the highest percentage of trip-makers arriving by rail-transit, it is the airport in Munich, with a combination of rail- and bus-based service that leads internationally in transit-based access to the airport. Bus transit on its own has been successful in attracting trip-makers, as is the case of airports in Copenhagen, Helsinki and San Francisco (2). The significant role played by rubber-tired transit has not been undermined even in the predominantly rail-based transit systems. The higher public transit modal splits for Munich, Gatwick, and Heathrow airports, where bus transit complements the rail-based systems that include subways and inter-city train services, indicate that rubber-tired transit can improve transit system's performance.

European experience in rail-based transit services is different from the North American experience in numerous aspects. For example, the integrated transit approach in Europe brings together the rail-based transit systems, i.e., subway system, inter-city commuter rails, and regional rails in a fashion that they share rail tracks and subway/train stations. In Frankfurt, for instance, inter-city trains as well as the commuter rails (S-Bahn) make regular stops at the airport. Trip-makers, i.e. air passengers, airport employees or trip facilitators, can take S-Bahn to another subway station to switch to U-Bahn, which in fact is the local subway system. The integrated transit system is partly responsible for higher mode-splits in European cities. Previous studies discovered that majority of riders on the airport rail line were passengers who transferred from the regional trains to the airport spur line (2).

SPATIAL ANALYSIS OF AIRPORT-BASED TRIPS IN THE GTA

In this section results from the spatial analysis of airport-based trips are presented. The actual spatial layout of the airport and other infrastructure is delineated in Figure-7. Union Station in downtown Toronto is marked with a U on the map. The much debated rail route to Pearson Airport is also shown on the map. Current layout of runways at the Pearson Airport along with the major highways in the GTA has also been marked on the map.

The best alternative for increasing mode-split for airport-based trips is the one that recognises the spatial distribution of airport-based trips in the GTA. Figure-8 presents the spatial distribution of the airport-based trips. Municipalities of Mississauga, Etobicoke, City of Toronto, North York, and Brampton have the highest concentration of airport-based trips. Pearson Airport is located in the municipality of Mississauga. From the figure, one can see that Mississauga contributes the maximum number of trips (19%) to the airport. Due to proximity to the airport, hotels in Mississauga and Etobicoke have high airport-based clientele. Though Mississauga and Etobicoke have the highest trip shares, their trip shares are still underrepresented in TTS. As mentioned earlier, TTS does not include trips made by non-residents staying at hotels or with friends and families.

The number of trips from a municipality could be a function of its size. For example, Mississauga, being a large municipality with a large area and population, contributes large number of trips to the airport. Figure-8 could lead to erroneous conclusions since it might over-emphasise the role of large municipalities. Figure-9, however, corrects this problem and offers insights into trip density, i.e., number of trips per square kilometre. It is evident from Figure-9 that municipalities of Etobicoke (71-trips per square km), York (82-trips per square km), and Toronto (102-trips per square km) have the highest trip densities. Brampton, Mississauga, and Oakville, the three major municipalities to the west of the airport, also have high trip densities, along with East York, North York, and Scarborough to the east.

High trip densities or high population densities are a key factor in transit planning. Higher population densities make transit feasible. From Figure-9 it can be seen that the three municipalities to the east of airport, i.e., Etobicoke, York, and Toronto have high trip densities as far as trips per square kilometres are concerned. However, residents of these municipalities do not reflect the same propensity for trips to airport as the residents of Mississauga, Brampton, and Caledon. Figure-10 presents a different trip density map, where trips per 1000 people by municipality are mapped. Residents of Brampton, Caledon, and Mississauga made the highest number of trips per 1000 inhabitants to the airport. It can be argued that residents of the above-mentioned municipalities portray higher propensity to travel to the airport in the GTA. The propensity to travel to the airport does not necessarily mean the propensity for air-travel since these trip-makers may or may not be air passengers. Though inhabitants of Caledon reported the highest number of trips per residents, 39 trips/ 1000 people, the actual trip share for Caledon was one of the lowest (1.6% of total airport-based trips). However, municipalities of Brampton, Etobicoke, and Mississauga reported higher trips per 1000 inhabitants, along with high trip shares and trips per square kilometre. Trip statistics for selected municipalities are presented in the following table.

Table-1: Trip characteristics of various municipalities in the GTA.

MUNICIPALITY	POPULATION '91	AREA (SQ KM)	TOTAL TRIPS	% OF TOT-TRIPS	TRIPS/1000 POP	TRIPS/ SQ KM
MISSISSAUGA	463388	288.439	16045.85	18.6954	34.6272	55.6394
TORONTO	635395	99.8379	10168.63	11.8477	16.0036	101.859
ETOBICOKE	309993	124.745	8874.5	10.3399	28.6281	71.1383
NORTH YORK	562564	176.198	8369.97	9.75203	14.8783	47.5054
BRAMPTON	234445	268.965	7675.44	8.94282	32.7388	28.5417
SCARBOROUGH	524598	187.464	5194.92	6.05271	9.90267	27.7048
OAKVILLE	114670	138.726	2958.89	3.44746	25.8035	21.3253
BURLINGTON	129575	184.556	1920.82	2.23799	14.824	10.4076
YORK	140525	23.3381	1908.68	2.22384	13.5825	81.7772
CALEDON	34965	694.547	1366.02	1.59158	39.0682	1.9662
EAST YORK	102696	21.2391	1014.38	1.18188	9.8775	47.758

Any isolated rail line or bus service can not capture the majority of spatially distributed trips. Figure-8 reveals trends in spatial concentration of trips. In order to present spatial distribution on a finer scale we generated colour thematic maps for traffic zones in the GTA. These maps classified traffic zones into groups based on the number of trips from that zone. However, zone based maps suffer from two shortcomings. First, numerous traffic zones did not contribute any trip to the airport. Thus, maps were punctuated with white spaces for zones with no trips to airport. Second, these maps did not capture any spatial autocorrelation in trip origins and destinations. For example, zones with fewer or no trips surrounded zones with large number of trips to the airport.

In order to capture the neighbourhood effect, we created a buffer map (Figure-11) with buffers of 2-km radius pivoted at the centroids of traffic zones. Thus each traffic zone reports the total number of trip origins or destinations within a 2-km of radius of the centroid of that particular traffic zone. The result is a colour-thematic map that identifies the spatial trends in airport-based trips and identifies locations for the proposed nodes for bus service. On the map, stars present the proposed node locations. Figure-11 shows that downtown Toronto along with several major intersections on Yonge Street, among others, are strong candidates for node locations. What is evident from Figure-11 is the fact that one rail-line from downtown Toronto to Pearson Airport cannot achieve the desired mode-split, since the trips are disbursed over the entire GTA.

Figure-11 vividly expresses the spatial distribution of trips where areas of high concentration of trips are coded in dark shades. To assume that trip-makers would travel from their trip-origin to downtown Toronto to catch the airport-bound rail service is absurd, especially if one considers the spatially disaggregate trip origins and destinations. Similarly, it is most unlikely that trip-makers exiting from Pearson Airport, instead of heading to their final destination would rather travel to downtown Toronto to transfer to another mode to reach their final destination.

In order to explain the limitations of a single rail-link, we tried to have a rough, first cut at the number of trip-makers that could be attracted by the proposed, dedicated airport line. Three concentric buffers of radius 1.5 km, 3.0-km, and 5.0-km (Euclidean distances measured from the rail line) were created along the CN

Weston rail line. Using a GIS, all trip origins/destinations that fell within those buffers were calculated. This exercise revealed a very rough, yet probable catchment for the dedicated airport line. For comparisons, a simultaneous set of buffers was created for an alternative transit route, which could be a bus route and is shown in Figure-12. Black lines represent the alignment of the two transit alternatives, while buffer lines are in red. Union station is marked with a 'U', while the airport is marked with an 'A'. The same procedure to assess actual trip origins and destinations within buffers was adopted for the alternative route. Results of the analysis are presented in the following table.

Table-2: No of trip origins and destinations falling in the concentric buffers along the transit routes.

	Downtown Link			Alternative Link		
Buffers	**1.5-k**	**3.0-k**	**5.0-k**	**1.5-k**	**3.0-k**	**5.0-k**
Entire Trips	7,319	17,250	26,311	10,831	20,896	30,934
Percentage	8.5%	20.1%	30.7%	12.6%	24.3%	36.0%

TTS data showed 85,827 non-factored airport-based trips. These trips are not classified by trip purpose due to limitations in the database. Hence, trip-makers reported in Table-2 could be air-passengers, trip facilitators or airport employees, who differ in their preferences for trip mode for different reasons. For the downtown rail link, only 8.5% trips fell within a 1.5-km distance of the proposed rail line. The 3.0-km buffer contained 20% of all trips, while the 5.0-km buffer retained 31% of trips. For comparison, one can see that a randomly selected bus route had greater number of trip origins/destinations in its catchment. If reliability of bus transit is improved by offering service on HOV lanes, bus-transit can compete for a larger pool of trip-makers. Similarly, if bus transit to airport were operated on those routes that already have a high airport-based traffic, bus transit would be available as an alternative to a greater number of trip-makers than a fixed rail link.

A mode choice model would perhaps be better to estimate what percentage of riders would switch to transit. In absence of a model, hypothetical mode-splits were calculated to determine the extent of rail service. Reasons for not estimating a model are discussed later. Table-3 presents the results of the mode-split calculations.

Table-3: Hypothetical mode-splits for airport-based trips falling under the two alternatives.

Percentage of Trips	Downtown Link			Alternative Link		
Buffers	**1.5-k**	**3.0-k**	**5.0-k**	**1.5-k**	**3.0-k**	**5.0-k**
05-% of airport-based trips	366	863	1316	542	1045	1547
10-% of airport-based trips	732	1725	2631	1083	2090	3093
15-% of airport-based trips	1098	2588	3947	1625	3134	4640
20-% of airport-based trips	1464	3450	5262	2166	4179	6187
25-% of airport-based trips	1830	4313	6578	2708	5224	7734
30-% of airport-based trips	2196	5175	7893	3249	6269	9280
35-% of airport-based trips	2562	6038	9209	3791	7314	10827
Average Vol. On LRT (25%)	19	45	69	28	54	81
Average Vol. On LRT (35%)	27	63	96	39	76	113

If 5% of all trips that either originated or terminated within a 1.5-km buffer were attracted to transit, only 366 trips/day would be carried on the proposed rail-link. A very optimistic scenario would include 25% of the airport-based passengers in the 5.0-km buffer switching to transit. This would result in 6578 passengers/day taking transit to the airport.

Let us now assume that rail-transit to airport is available from downtown at a 15-minute frequency in each direction. This means that four-trains/ hour would be operated in each direction. For a 12-hour service, 96 trains would operate between airport and Union Station. From the table, if 25% of all airport trips in a 3.0-km buffer were taken on transit, average load per train would be 45 passengers. These figures are, at best, rough estimates of transit ridership. However, it is evident from the figures that even the most optimistic estimate falls short of justifying the expenses related with providing a new rail-ink between downtown Toronto and Pearson Airport. Edwards and Mackett (1996) contend that a Light Rail Transit (LRT) is viable if the projected peak demand exceeds 2000 passengers per direction per hour. In addition, the case becomes even stronger for LRT if the proposed light rail system can use the existing rail lines (7). From the estimates one can see that for a 12-hour service, average number of commuters per hour is approximately 550 (6578 passengers/day), which is not enough to warrant an LRT service.

Table-4 summarizes annual ridership based on hypothetical mode-splits for the two alternatives. If 25% of trips within a 3.0-km buffer were attracted to transit, it would result in 1.2 million riders / year on the proposed rail link. Pessimistic scenarios of transit ridership indicate that annual ridership on airport rail-line would be less than one million passengers.

Table-4: Estimates of annual ridership on transit alternatives.

Annual No. of Trips	Downtown Link			Alternative Link		
Buffers	**1.5-k**	**3.0-k**	**5.0-k**	**1.5-k**	**3.0-k**	**5.0-k**
Annual Trips-15% of airport-based Trips	329,342	776,250	1,183,995	487,395	940,320	1,392,030
Annual Trips-25% of airport-based Trips	548,903	1,293,750	1,973,325	812,325	1,567,200	2,320,050
Annual Trips-30% of airport-based Trips	658,683	1,552,500	2,367,990	974,790	1,880,640	2,784,060
Annual Trips-35% of airport-based Trips	768,464	1,811,250	2,762,655	1,137,255	2,194,080	3,248,070

As stated before numbers reported in tables 2, 3, and 4 are estimates. A mode-choice model would offer better insights in trip-maker's preferences.

Multiple bus routes resulting from these nodes could also be integrated. For example, a bus leaving the node in downtown Toronto can stop at the node in Etobicoke. However, the fewer the stops the more attractive the service would be. In order for the bus service to be attractive, real gains have to be made on level of service (ease with baggage handling, waiting time for buses) and actual travel time.

A mode-split model was not estimated since the available databases lacked in information that was necessary for estimating a Multinomial Logit model. TTS data lacked information on, among other factors, trip purpose, luggage information, financial status of the trip-maker and trip costs. For econometric modelling, new surveys are needed to obtain comprehensive information on airport-based trips. Data from an older survey was available, but was not used for being old and lacking in exact spatial information on trip origins and destinations (6).

BUS-BASED SOLUTIONS FOR PEARSON AIRPORT

In this section, a bus transit system is proposed to improve access to Pearson Airport. An earlier study in 1994 also proposed exclusive bus-based transit link to the airport (8). However, the study did not include any spatial analysis of trips. The findings and recommendations in 1994-study were very similar to an earlier report by Transmode Consultants (4). In addition, Louis Turpen, head of the Greater Toronto Airports Authority (GTAA), also suggested a similar bus-based transit system as proposed in this paper (9). Earlier, a detailed version of this paper was handed over to GTAA in March 1997. In addition, Ontario Motor Coach Association recently proposed to Toronto Board of Trade to operate bus transit between downtown Toronto and Pearson Airport on a dedicated right-of-way along the GO rail line, without disturbing existing rail service.

At the heart of the transit system proposed in this paper is the notion to expand airport-related activities near actual trip origins and destinations. The proposed solution recommends buses operated from strategically located bus stations (nodes) whose locations are sensitive to the OD pattern of the trips made to and from Pearson Airport. These nodes would be different from ordinary bus stations. In fact, they would operate very much like airports and offer remote baggage handling and check-in facilities. Out-sourcing of some of the traditional airport activities can thus restrict the centralised expansion of airports. The important features of the proposed transit system are following:

- Strategically located nodes within a 25-km radius of Pearson Airport,
- Remote baggage handling and check-in facilities at each node,
- Integrated computer network based on Intranet, jointly operated, and controlled by major airlines serving Pearson Airport.
- Specially designed buses equipped with Global Positioning System (GPS),
- Special design features in buses for passengers with luggage,
- Immediate and direct access to terminals, instead of access to a central ground transportation centre,
- Transit Priority/HOV Lanes to operate buses on, thus offering gains in travel time,
- Development of extensive retail facilities at nodes.
- Provision of sufficient parking facilities at nodes for air passengers, and greeters and well-wishers.

Specially designed buses can increase the level of comfort and make transit service more attractive. For example, sufficient on-board space in buses for passengers to store their heavy luggage could be a major attraction. The new buses could have both on-board and restricted luggage spaces. The restricted space should be accessible to the driver only to store the luggage checked in by passengers at nodes. Other facilities could include dissemination of travel-related information through a television screen within buses.

Integrating Airline Communications

The 46-odd scheduled airlines operating at Pearson Airport can have individual or combined offices at each node. Not every airline would like to incur the expenditure of opening new offices. Airlines often share computer information systems for booking and baggage handling. In fact, small airlines depend upon information systems operated by major airlines to keep track of bookings, baggage handling, and for other communication needs. Integrating booking and baggage handing services can further extend the existing co-operation between airlines, which are heading toward four major international alliances. A centralised information system, which shares information with airlines operating at Pearson Airport, can eliminate the need of separate airline offices at each node. Airlines could have the option to come up with a consortium to finance the construction of these nodes and later the same consortium can take over the operation and maintenance of these facilities.

Vital communication errors are a routine in situations where airlines use different booking and baggage handling systems. Often one airline can not decipher messages sent by another airline. An integrated Intranet-based communication system that provides a common platform to the airlines operating at Pearson Airport can become the backbone of the new, efficient groundside access system. There is, however, no guarantee that airlines would like to participate in such an endeavour. In Zurich, however, baggage check-in facilities are available at over 100 train stations.

Using GPS to Locate Bus Movement

Since buses would operate on transit priority lanes, hence they could offer better travel times than automobiles, taxis, and limousine services. Regional municipalities in their future transportation improvement plans have included provision of HOV lanes on freeways that carry airport-bound traffic. The proposed alternative benefits from the already planned improvement to highways in the GTA. Buses should be equipped with GPS to enable authorities at the airport to determine their exact location on the street network. Routes, which are susceptible to congestion, could be monitored by close-circuit television to advise bus drivers for alternative routes.

Buses should head straight to the terminals instead of a central ground transportation centre, as was proposed by the GTAA. By providing direct access to terminals, an additional transfer can be avoided at the airport.

Offering Retail to Air Passengers

The nodes should have tourism-oriented retail space. Gift shops, currency exchange, and restaurants would induce further commercial development in the areas around the nodes. Nodes should also have rooms for small communication centres where passengers can use fax, telephone, email, or Internet. In fact, a device that integrates all these services into one and is half the size of a slot machine is available at airports in Germany. Private meeting rooms for business travellers with small desk-space to plug-in laptop computers could be another attraction at the nodes. Passengers can shop around, if the time permits, or can send email/faxes using the communication facilities.

There is an added advantage of these nodes for both traffic planners and airlines. Since air passengers at nodes would be closer to the trip origin, in case of a delay, passengers might opt to return to their residence or work instead of staying at a hotel.

Greeters and well wishers accompany a significant number of air passengers to the airport. If there is a reliable, conveniently located transit service for airports, greeters and well wishers need not to go all the way to the airport. Instead, they can pick or drop air passengers at these nodes.

CONCLUSIONS

A single rail line linking downtown Toronto with Pearson airport cannot improve groundside access to Pearson Airport. Spatial distribution of trip origins and destinations require a multi-node transit service through strategically located nodes. These nodes would attract air passengers since nodes would be conveniently accessible to a very large number of trip-makers, who are spread all over the GTA. Rubber-tired transit is preferred over steel-wheeled transit because of the greater flexibility and considerably lower capital costs.

To achieve high transit mode-splits for Toronto, several rail transit services from numerous locations to Pearson Airport are needed. This proposition would cost billions of dollars. An alternative solution, offering rubber-tired transit from nodes could do the same job efficiently, but with a considerably smaller price tag. This study has not attempted to calculate costs of the proposed alternatives. A detailed cost-benefit analysis of competing alternatives was beyond the scope of this study. However, such a study would significantly contribute to a better understanding of the issue at hand. In addition, a mode choice model using up-to-date data could significantly contribute to the understanding of groundside activities at Pearson Airport. Further studies are needed to explore the possibility of an integrated communication system, shared by all airlines operating at Pearson Airport.

Certain activities could only be performed at airports. For example, planes can only take off from airports. However, activities, such as confirmation of seats or flight times, getting computerised tags for luggage, and greeting an incoming passenger, could be performed outside of the airport. A node seems to be the right place for such activities.

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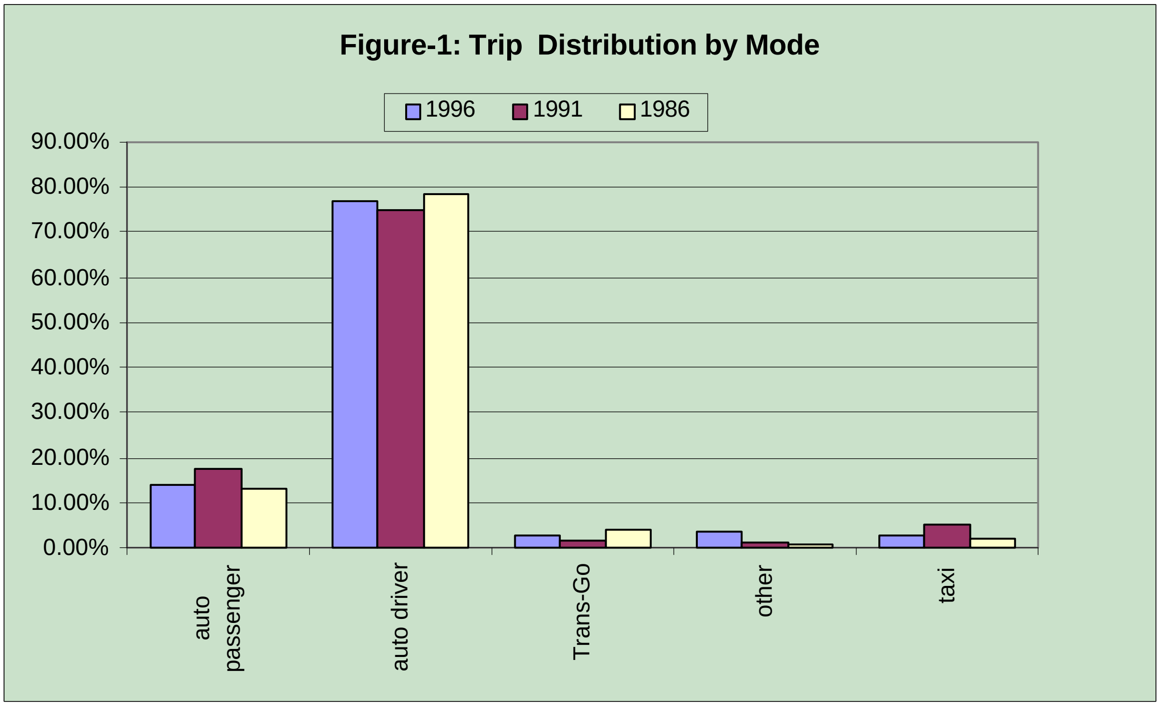


Figure-1: Trip Distribution by Mode
1996
1991
1986
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
auto passenger
auto driver
Trans-Go
other
taxi

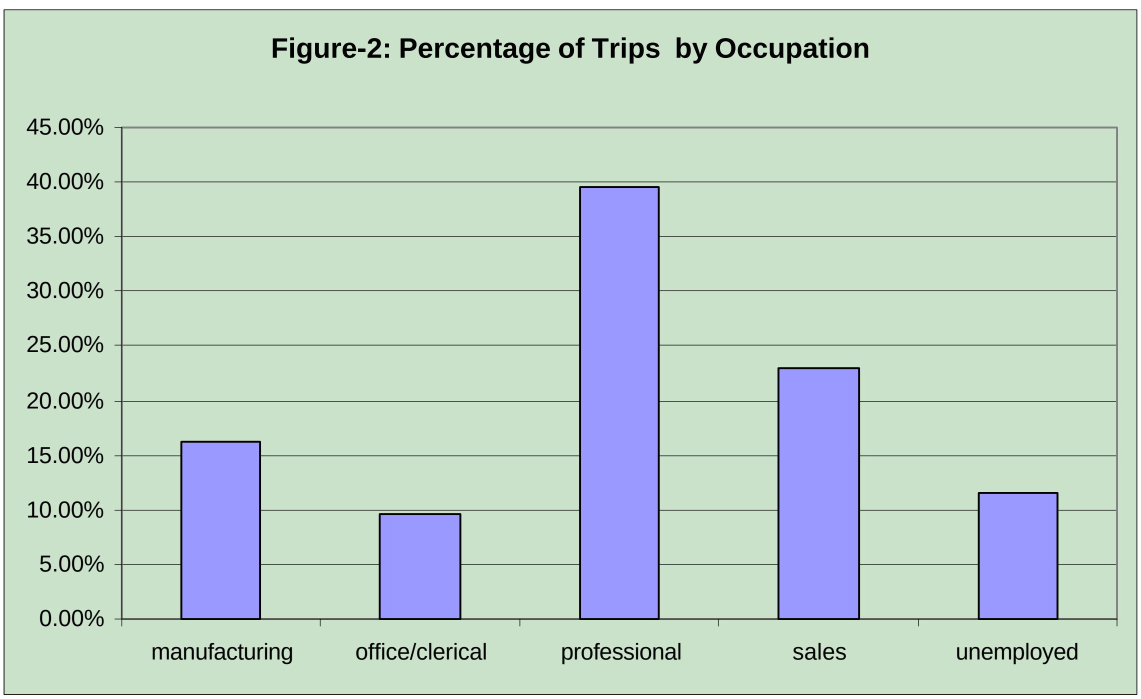


Figure-2: Percentage of Trips by Occupation
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
manufacturing
office/clerical
professional
sales
unemployed

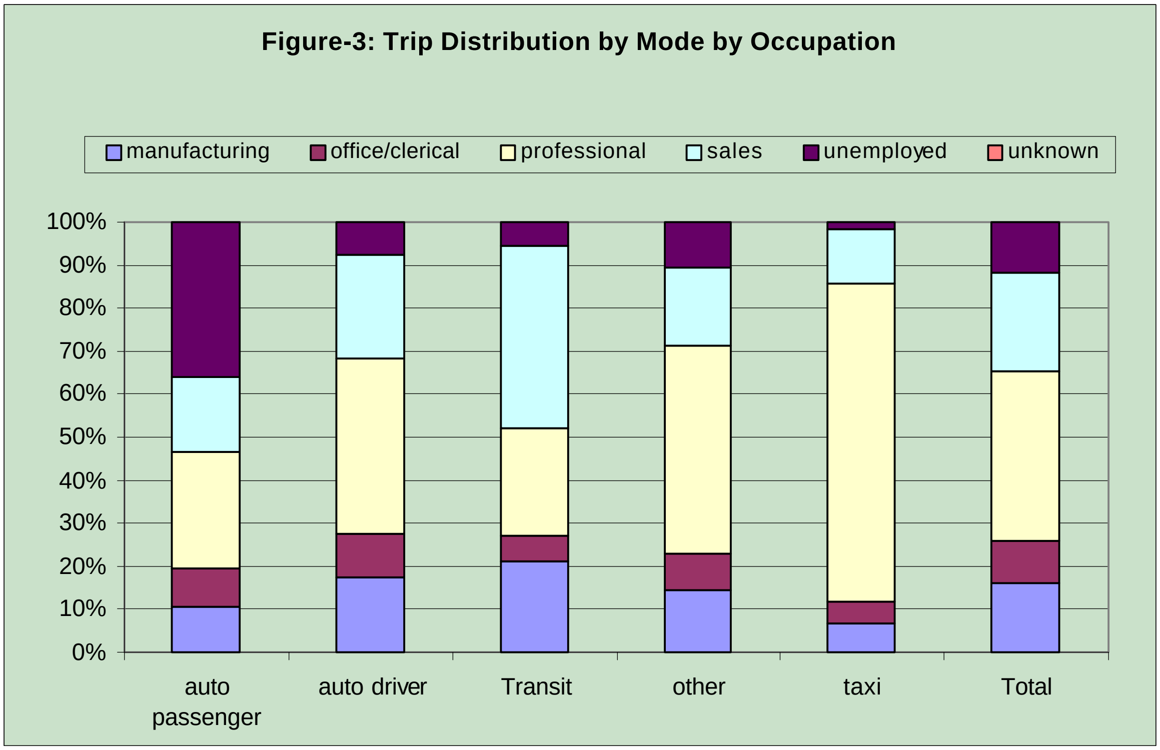


Figure-3: Trip Distribution by Mode by Occupation
manufacturing
office/clerical
professional
sales
unemployed
unknown
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
auto passenger
auto driver
Transit
other
taxi
Total

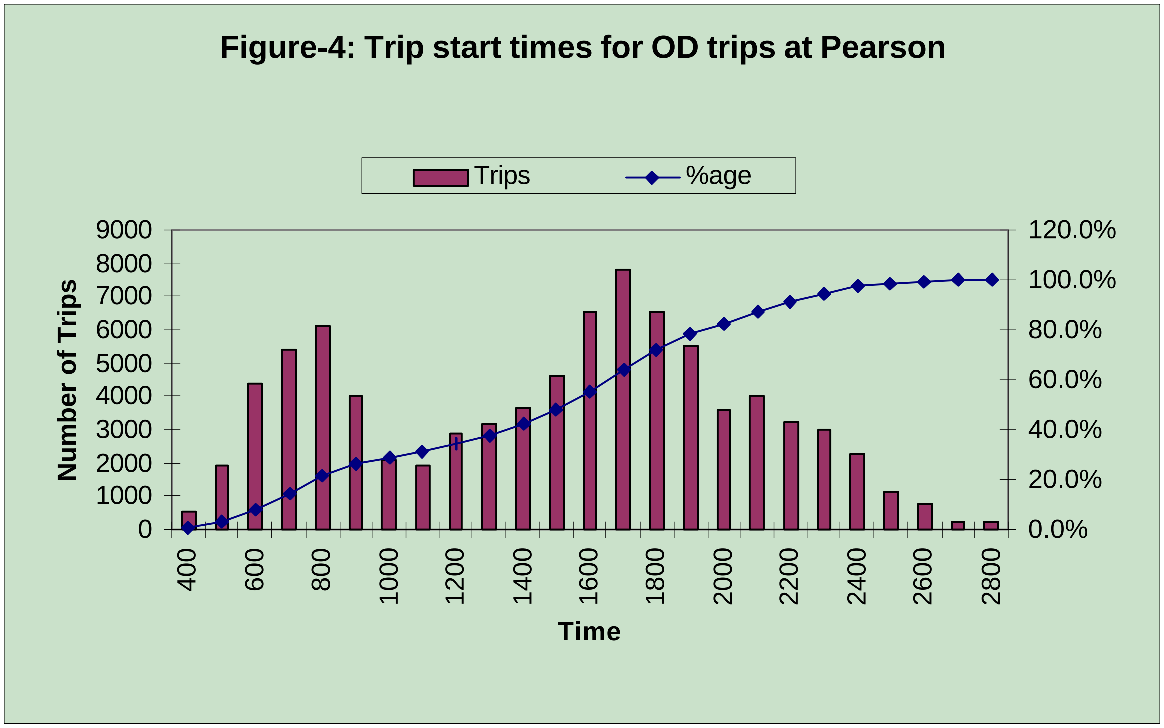


Figure-4: Trip start times for OD trips at Pearson
Trips
%age
Number of Trips
Time
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800

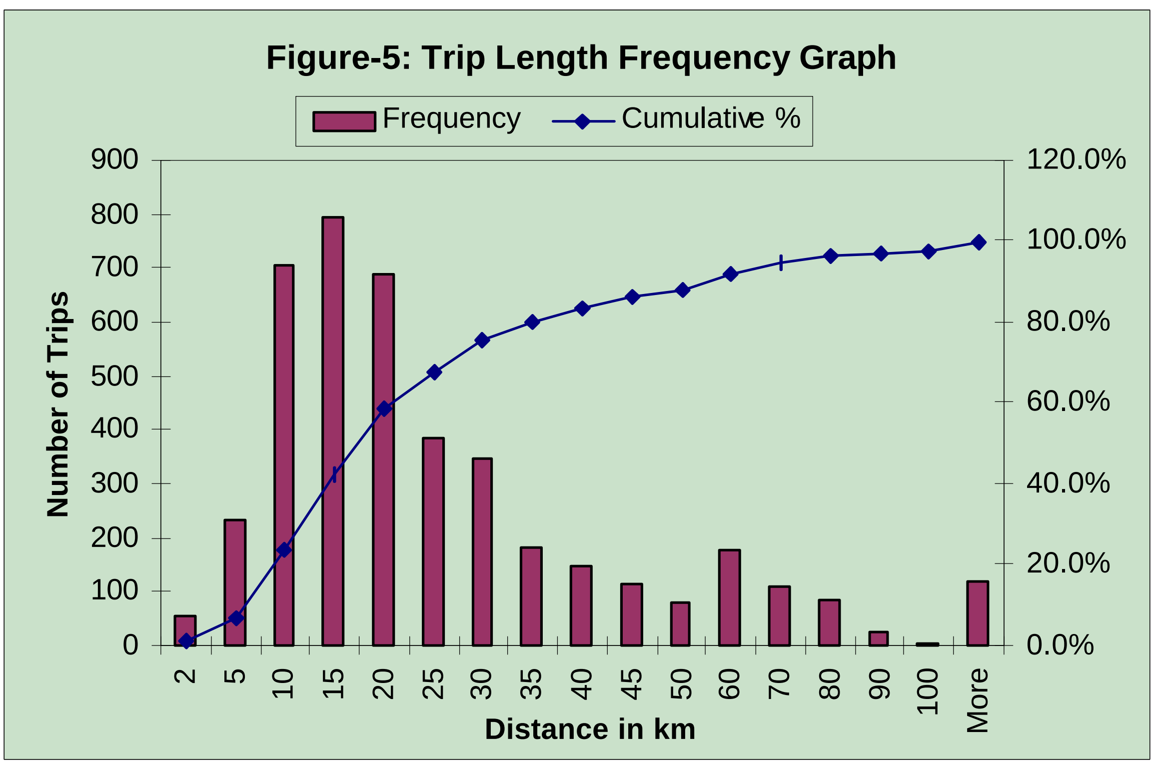


Figure-5: Trip Length Frequency Graph
Frequency
Cumulative %
Number of Trips
Distance in km
900
800
700
600
500
400
300
200
100
0
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
2
5
10
15
20
25
30
35
40
45
50
60
70
80
90
100
More

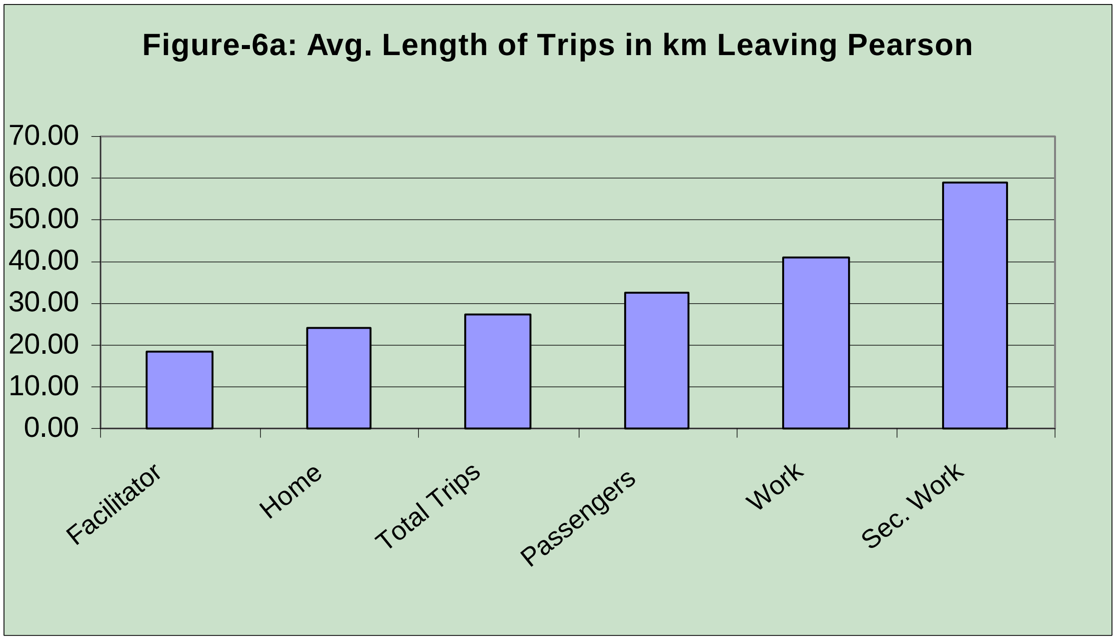


Figure-6a: Avg. Length of Trips in km Leaving Pearson
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Facilitator
Home
Total Trips
Passengers
Work
Sec. Work

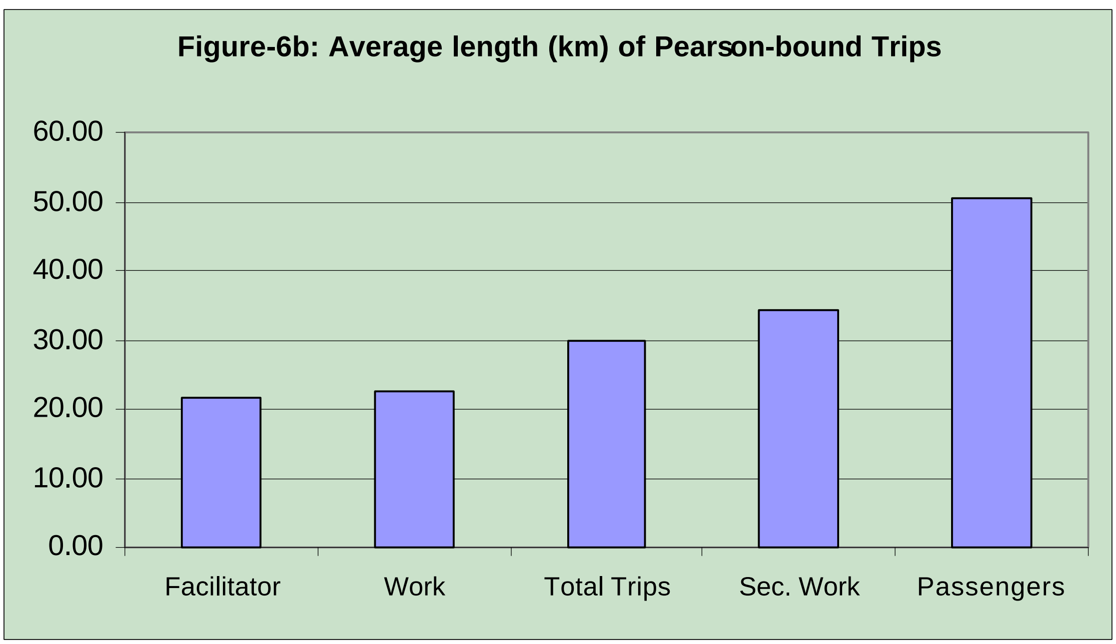
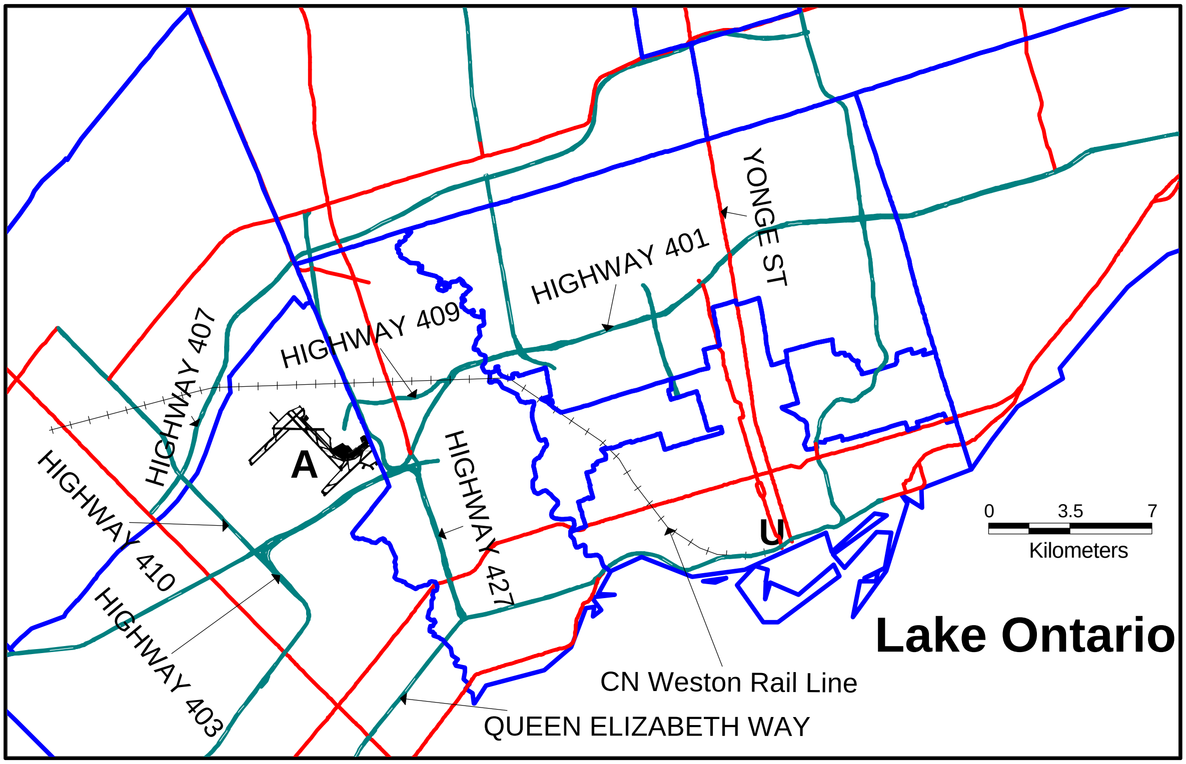


Figure-6b: Average length (km) of Pearson-bound Trips
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Facilitator
Work
Total Trips
Sec. Work
Passengers



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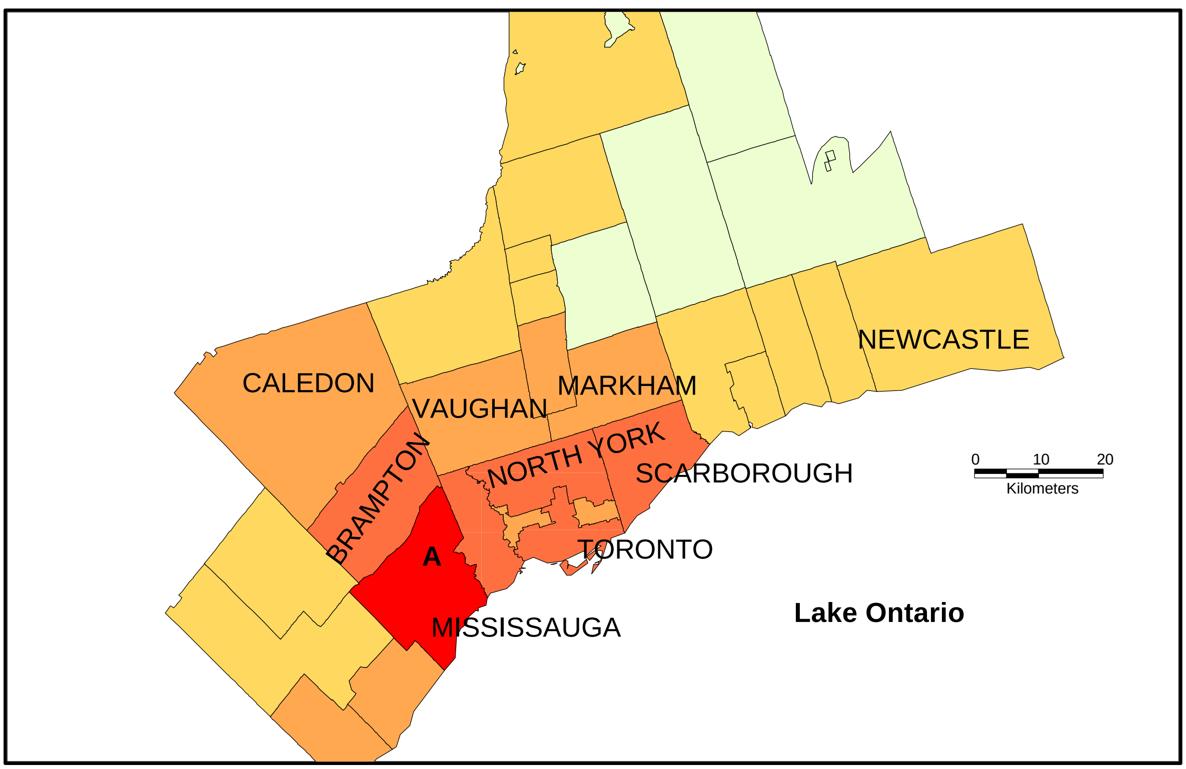

Figure-8: Spatial distribution of airport-based trips in the GTA (%age of trips by municipality).

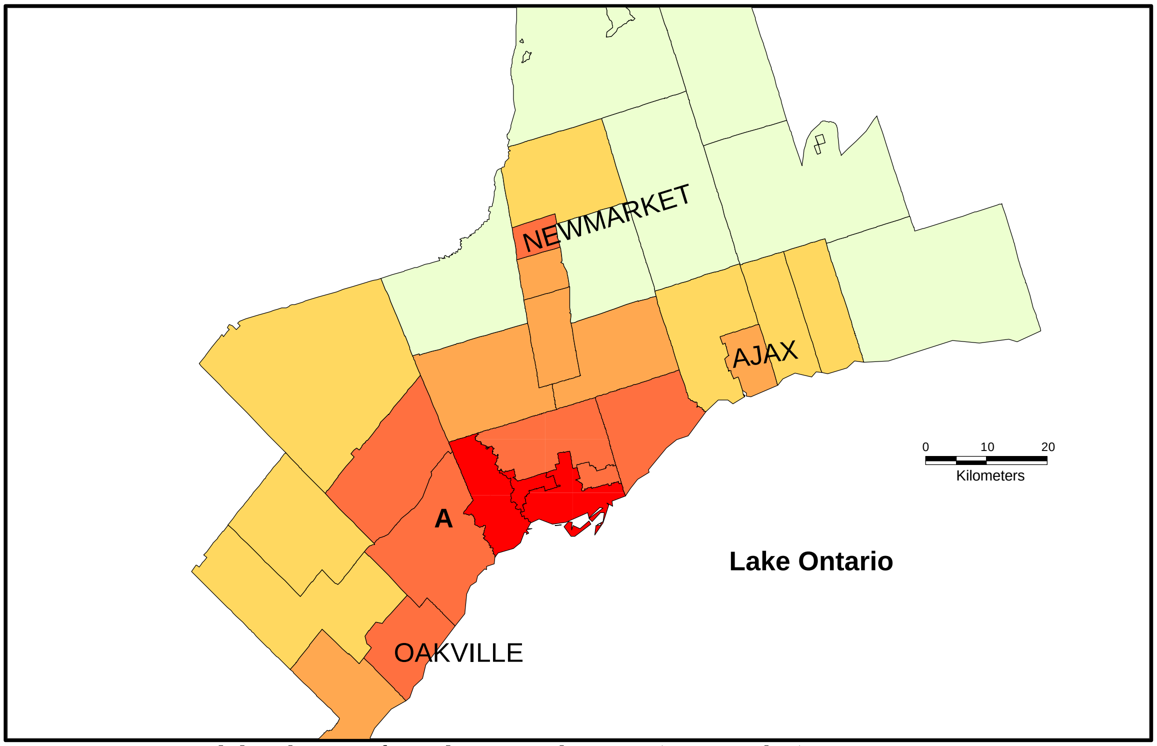

Figure-9: Spatial distribution of trip density in the GTA (trips/ sq. km).

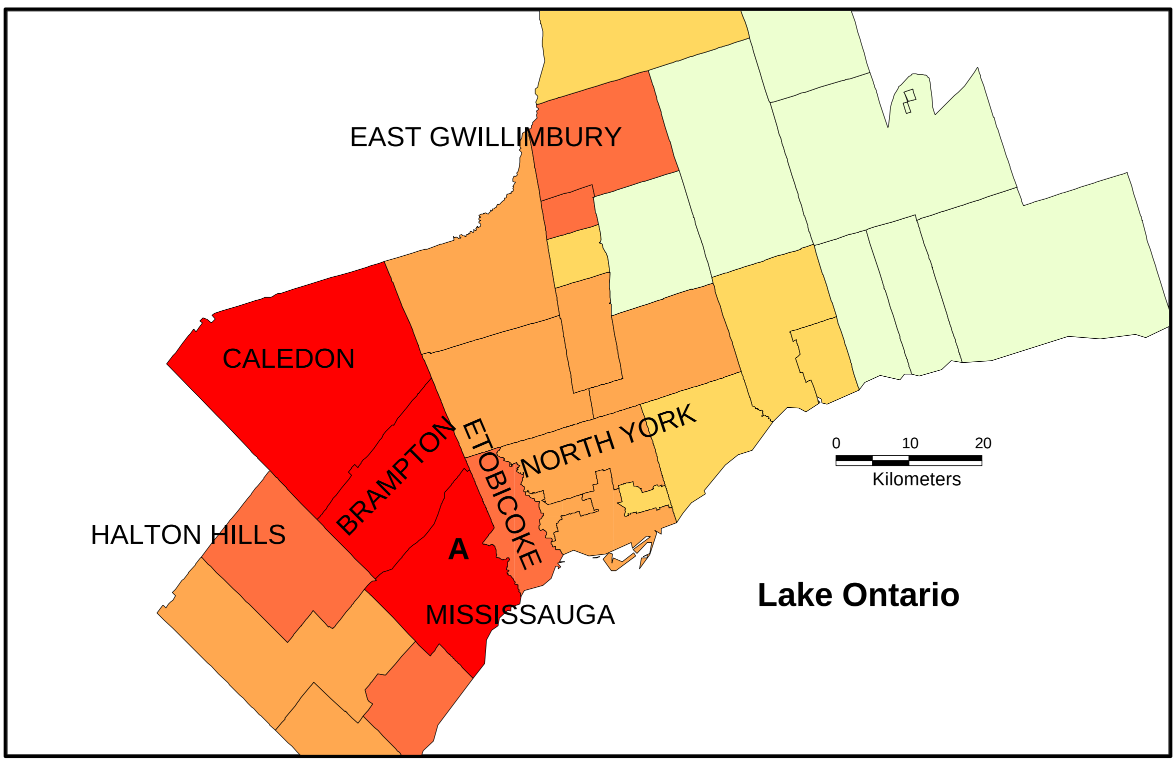

Figure-10: Spatial distribution of trip density in the GTA (trips/ 1000 residents).

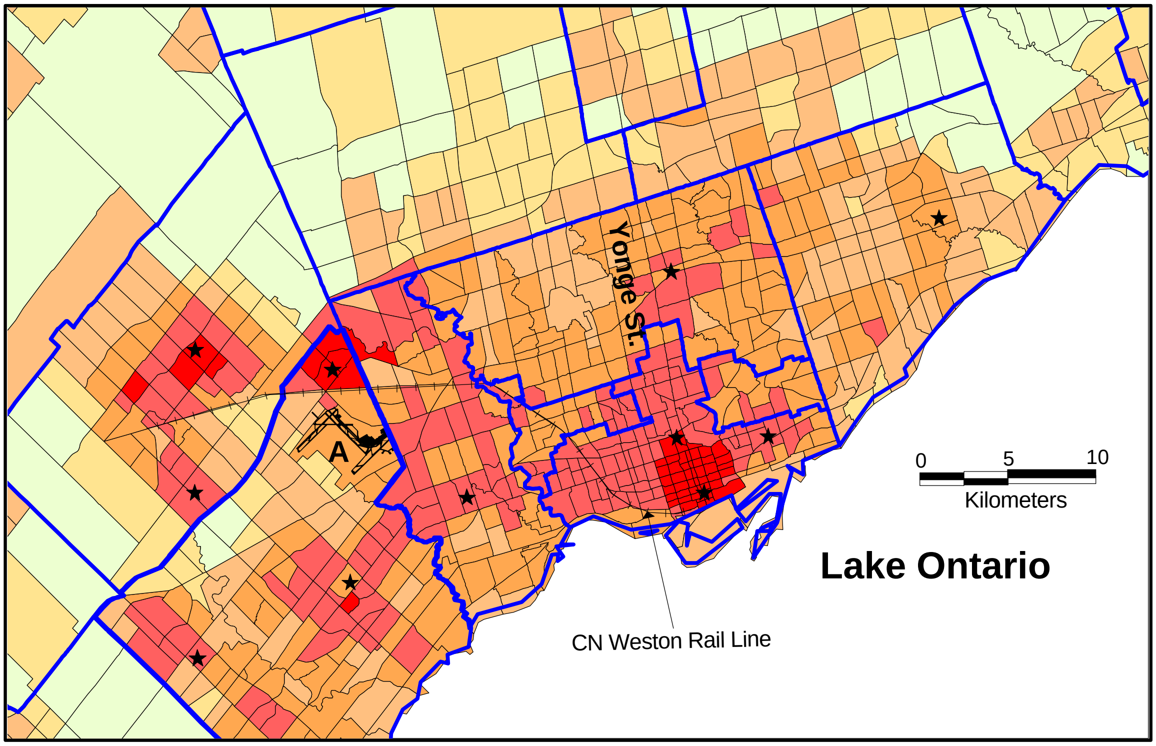

Figure-11: Colour-thematic map identifying spatial trends in airport-based trips.

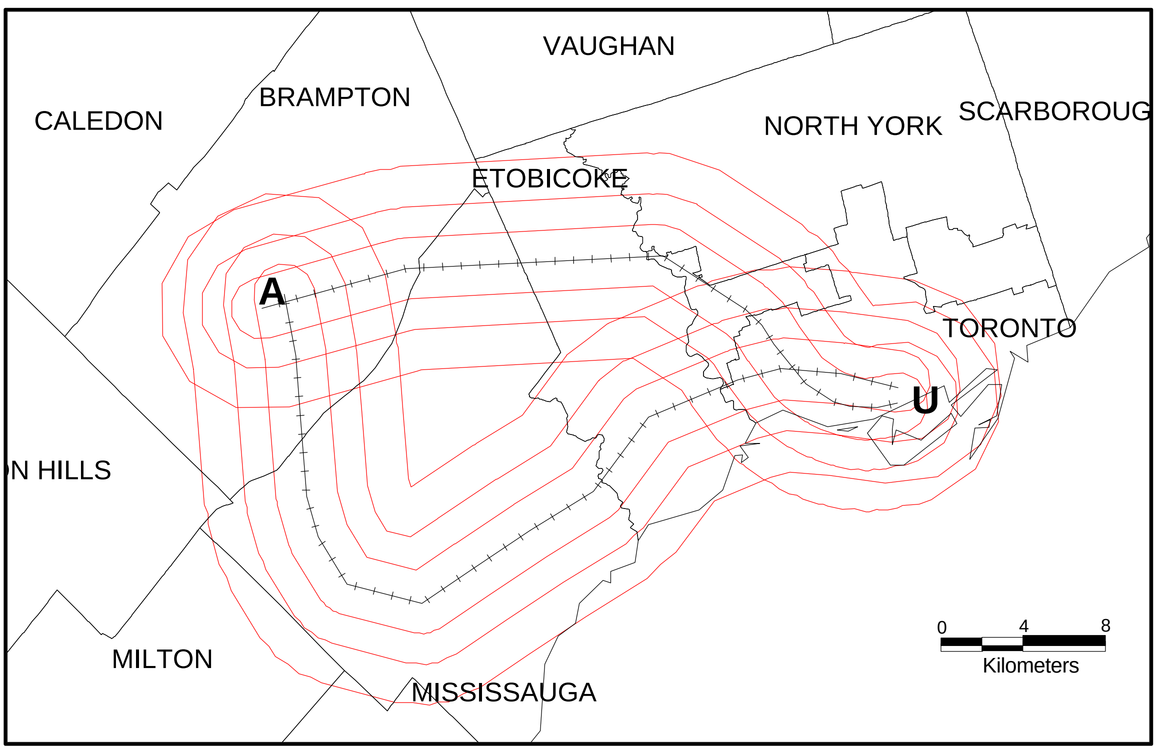

Figure-12: Concentric buffers showing catchment for two alternative transit routes.