ENTRA CONSULTANTS

City of Ottawa

2009 Transit Network Planning Project

ENTRA Technical Report

October 2005

Excellence in Transportation Planning

City of Ottawa

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1. Introduction and Summary

ENTRA was retained by the City of Ottawa to provide technical support and oversight to the 2009 Transit Network Planning Project, in the following areas:

- oversight review
  - study design
  - network design concept
  - staff conclusions and recommendations
- technical support
  - calculation of potential to divert passengers to alternative routings not travelling through the Albert/Slater corridor
  - identification and calculation of positive and negative ridership impacts from proposed service changes, including estimation of ridership increases and losses

ENTRA worked cooperatively and interactively with Transit Services staff throughout this process. The following sections outline our principal findings and conclusions in each of these areas.

2. *Review of Staff Study Process and Products*

In addition to providing technical support in the key areas related to elasticity of demand and route diversion elements, ENTRA provided oversight of the major elements of the work completed by Transit Services staff, described in the following sub-sections.

2.1 Study Design

The principal elements pf the Project plan included:

~ design of the conceptual route network

~ ridership forecasting and assignment

~ fleet requirements forecasting

~ impact assessment; and

~ documentation.

In addition to the "business as usual" Network 1, and "hub and spoke" Network 2 alternatives, ENTRA performed an impact analysis on a further refined concept, designated Network 3. Details of these alternatives and their rationale are included in the staff report. In summary:

- Network 1 includes the LRT implementation and the basic service design concept for the bus network in its current configuration. Specifically, this full service includes all the express routes in the east and west that currently exist with expansion into the new growth areas. This network is the basis for comparison for Network 2 and Network 3.
- Network 2 introduces three new rapid transit cross-town bus routes to provide direct connection between key origins and destinations, outside of the downtown area. Local bus services are more direct and all local routes are focussed on connections with rapid transit services, at either Transitway or light rail stations, with passengers transferring to the appropriate service at a rapid transit station. Service levels on existing Transitway routes are improved and new Transitway routes added.
- Network 3 is a hybrid of the Network 1 and Network 2 features. It retains the attractive cross-town rapid transit routes but introduces some frequent direct-to-downtown express routes. It includes two routes moved onto Queen and Wellington.

2.2 Network Design Concept

ENTRA reviewed the development of the network concepts for:

~ adequacy of the network to accommodate growth relative to planned development;

~ consistency of the planned network with the concept objectives;

~ logical and consistent routing;

~ logical and consistent re-assignment of ridership between Network 1, Network 2 and Network 3; and

~ appropriate planning parameters for service level development.

In all respects, the development of the networks was found to be appropriate and consistent. Some minor inconsistencies were identified both by Transit Services staff and the ENTRA review in the course of this review, and satisfactorily corrected throughout the analysis process.

2.3 Transit Services Staff Conclusions and Recommendations

This section reviews each of the conclusions and recommendations made by Transit services staff (detailed in the staff report), in the context of the supporting analysis and research completed by ENTRA Consultants.

2.3.1 Staff Report Conclusions

> *"The continued operation of a large number of express routes from residential areas direct to downtown is not sustainable in the longer term because, with continued ridership growth, the number of buses per hour required and the numbers of passengers crowding at bus stops would exceed the capacity of the space available on Albert and Slater Streets."*

ENTRA did not specifically analyse the operations of the status quo network or their impact on the downtown in the future. However, based on the current operating conditions, and the projected increase in transit operations to support planned growth, this would appear to be a reasonable and sound conclusion.

> *"The adoption of a full hub-and-spoke type of route network, with frequent local routes in residential and commercial areas connecting with frequent rapid transit services, is feasible and would reduce the number of buses per hour on Albert and Slater Streets by the 30 percent level in line with the direction from Council. However, it would lead to a significant ridership loss and would have a high operating cost and a high capital cost for new infrastructure and an expanded bus fleet."*

ENTRA performed an assessment of the ridership impacts of Network 2, assessing the positive effects of reduced travel times, and increased service frequency, and the negative effects of increased transfers and increases in travel times on selected routes and fully support this conclusion. Details of these calculations and the estimates of ridership decline under this concept are explained in Section 5.

> *"The adoption of a hybrid route network, providing a hub-and-spoke type of route network across the City all day long, supplemented by a small number of frequent express routes from residential areas not served by the new light rail line, is operationally feasible and would reduce the number of buses per hour on Albert and Slater Streets by approximately 30 percent, in line with the direction from Council. This network concept would have negligible impact on the overall level of ridership, but would have some capital costs for new infrastructure and would require changes to the plans for bus fleet replacement and growth in the Long Range Financial Plan.*

ENTRA performed an assessment of the ridership impacts Network 3, assessing the positive effects of reduced travel times, and increased service frequency, and the negative effects of increased transfers and increases in travel times on selected routes and fully support this conclusion. Details of these calculations and the estimates of ridership decline under this concept are explained in Section 5. It should be noted that the comparison with Network 1 was made assuming that for Network 1 operations in the central area at the 2009 TMP passenger volumes would be smooth and passenger boarding times similar to those experienced today. This is a best-case scenario for Network 1. It is more likely that as passenger and bus volumes build, operations through the downtown would slow down adding to passenger inconvenience.

> *"The introduction of frequent and convenient new cross-town rapid transit 90-series bus routes between Orléans and Kanata via Baseline and Heron Roads, between Orléans and Kanata via the Queensway and Carling Avenue, and between Orléans and Tunney's Pasture via the Carling and Holland Avenues, would improve service for customers who now travel on bus routes that operate through downtown but who are not themselves travelling to or from points in downtown."*

ENTRA performed an assessment of the potential passenger travel that could be diverted from the downtown area through the provision of more direct convenient routes. ENTRA fully support this conclusion, though the ability to introduce transit priority measures to ensure reduced travel times is an important element of this diversion. Details of the methodology and the estimates of diversion potential are explained in Section 4.

> *"The adoption of a hub-and-spoke type of route network in the areas of the city that would not be served by the north-south light rail line would require infrastructure investment to allow customers to transfer conveniently between local bus services and rapid-transit 90-series bus routes. Specifically, a new transit station would be required at Jeanne d'Arc and Road 174 and an improved transit station would be required at the Eagleson park and ride lot. In addition, terminal facilities would be*

required for buses at Millennium Park in Orléans and at Hawthorne and Hunt Club in Greenboro."

The increase in transfers created by the hub-and-spoke elements of the network alternatives will require increased transfer capacity at key locations. Also, the negative effect of a new transfer can be somewhat mitigated by improving the transfer environment in terms of customer convenience and safety.

"The reduction of the number of bus routes operating on Albert and Slater Streets would greatly reduce waiting times at bus stops and, therefore, reduce the number of passengers waiting at any time."

ENTRA was able to assess the effect of passenger waiting times, based on ridership patterns and planned transit service frequencies. The increase in choice of outbound routes in the afternoon peak period will significantly reduce waiting times, and the number of passengers waiting at any given time.

"The smart card fare system, planned for implementation in 2008 and a real-time bus arrival information system based on the GPS tracking system currently being implemented will speed up boarding times and improve operations on Albert and Slater Streets."

ENTRA did not specifically assess the impacts of future fare technology on boarding times and Albert Street operations. However, this conclusion is consistent with the effects of smartcard implementation, based on industry experience.

"The service changes to make the transition to the recommended network concept should be phased-in over a four-year period starting in 2006 and should be co-ordinated with the major construction work in the central area. Route changes in the area that would be served by the light rail line should be implemented in 2009 along with the opening of the light rail line."

Based on industry experience with major restructurings, this conclusion is crucial to the successful implementation of the recommended network. ENTRA did not assess the short-term ridership declines that are likely to result from the major changes proposed in each of the networks. However, a comprehensive staging strategy, complemented by extensive consultation and communications plan will help minimize these short-term losses.

"The recommended service design results in a dramatic reduction in the number of out-of-service (deadheading) buses on Albert and Slater Streets, from 130 to 160 per day currently to 20-25 per day."

ENTRA did not specifically review the quantitative assessment in this area. However, the basis of the conclusions, in terms of the change in ridership patterns and the operational requirements is sound, and consistent with our understanding of bus operations in each network alternative.

3. Experience from Other Cities

ENTRA conducted a review of other transit systems to determine where restructurings had been planned or implemented that are similar in nature or scope to those being planned in this review. The intent of this review was to identify case study examples where relevant experience might inform the Ottawa project in terms of system and ridership effects, process planning, and general experience.

Several transit systems in North America of similar or larger size as OC Transpo have considered or implemented major network changes. Throughout the review of available documentation and based on industry experience, no directly relevant cases were identified. Denver CO, a smaller city and system, is grappling with a similar issue of impractical combined operating frequencies in the downtown core. Apart from the concerns of merchants and businesses, operations of the high frequency of services are becoming increasingly problematic, as services are becoming unreliable due to delays and congestion.

In this regard Denver is a direct parallel to the Ottawa situation. However, beyond preliminary review of possible route diversions, RTD staff has no major planning initiatives underway.

In all other cases reviewed, service restructuring plans have been designed to improve the overall strategic direction of the service, capitalize on emerging markets, and respond to broad customer demands, or are related to major corridor BRT or LRT implementation. Transit Services staff has addressed these issues in its overall and on-going service development plans, including the LRT project. This restructuring plan is unique in that a major focus is the issue of downtown bus operations. The positive rider experience demonstrated in the case studies indicates the need to take a balanced approach to service restructuring, considering both LRT and direct downtown trips.

The following examples are representative of other major transit network restructuring projects that have been carried out.

3.1.1 Los Angeles County

Los Angeles County, together with LADOT and the MTA, restructured its 2000-bus system, designed to identify unmet transportation needs, develop individually tailored public participation programs and complete a comprehensive analysis and review of the system in 6 major areas.

Service recommendations included the introduction of shuttle services, limited stop and express expansion, on-street bus rapid transit services, and regional and inter-regional integration.

3.1.2 Orange County, CA

Orange County has implemented a major route restructuring over the last few years, primarily in response to low ridership and financial pressures. This study began as a strategic plan to improve services and ridership throughout the County, and over the course of a multi-year project and changing financial pressures, evolved to the point where the objective of the service revisions became an attempt to maintain service coverage within the service area, and maintain service connections, while reducing the overall level of service and financial cost.

The changes in Orange County have been very controversial not only because of the nature of the changes and the service reductions, but because of the overall scope and magnitude of the changes. The process was very complex, with a number of stakeholder groups becoming involved in the planning process. Some of these groups were mandated through the official process, and others were self-appointed in response to a perceived lack of meaningful consultation.

The Orange County example was the only example found of a restructuring project that was not designed to significantly expand the transit system in terms of status quo, or introduce major new technology elements to serve unmet needs. Despite this, in terms of overall ridership growth, the results of the restructuring were quite positive, since the changes redeployed resources where ridership had declined to new growth areas.

3.1.3 Nantes, France

Nantes, a city of about 300,000, restructured its bus network around the stations of a new LRT system. The new LRT service increased the city's public transit ridership by 25 percent. Although the bus lines were strictly intercepted at the LRT stations, they did not experience loss of ridership because of the increased service area and improved level of service.

3.1.4 Lessons Learned

The wide variety of system restructurings naturally have many similarities and differences compared to the specific OC Transpo context. However, most experience points to the success of service restructuring when designed to capitalize on the strengths of new BRT or LRT systems being introduced at the same time – especially faster trip times over long distances. Clearly this may be applicable in Ottawa with respect to the LRT line and its improved access with faster travel times to the CBD. However, there is very little evidence of projects that can be used to compare to the overall restructuring of the system as proposed in the alternative networks.

The success of the restructurings described in the literature relates to the ability of the system to move customers to significantly improved services in terms of level of service and, most important, travel time. The analysis conducted in this review, and described in Section 5, incorporates this positive influence of the new LRT line. This objective was also the rationale behind the further development of Network 3, in an attempt to balance downtown operational objectives with overall ridership growth and customer service.

4. Diversion of Transitway Ridership From Downtown

4.1 Objectives

One of the techniques identified by staff for reducing the number of transit vehicles in the Albert/Slater Corridor is to divert customer-trips that had a potential alternative travel path from the corridor by introducing convenient, attractive alternative services in other corridors. This is the rationale behind the development of the new cross-town rapid transit bus routes.

This analysis worked to identify the number of trips currently using the Transitway through downtown, without an origin or destination in the downtown area, and to identify the proportion of these trips that might be attracted to alternative services.

4.2 Data Sources

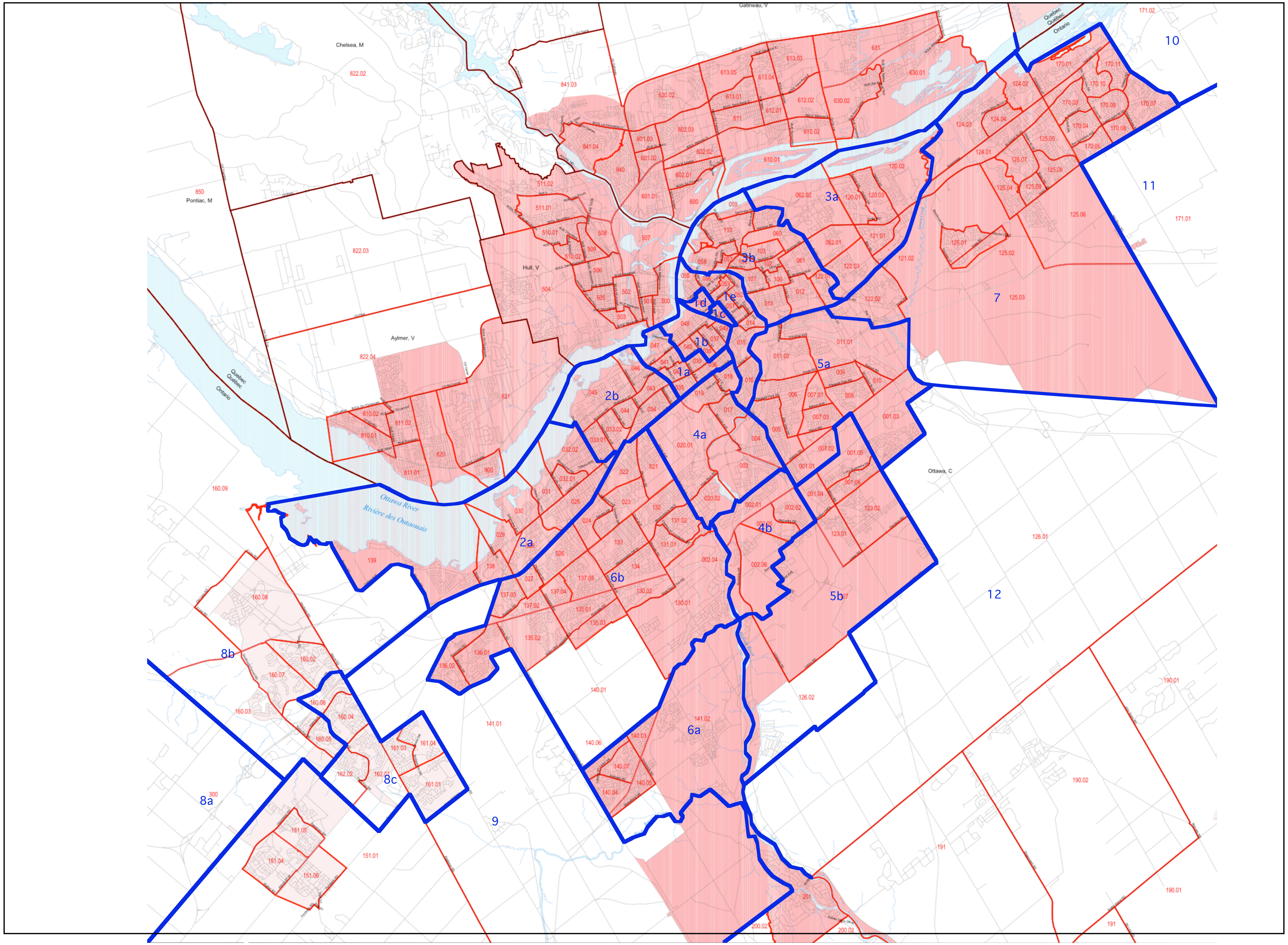
The data used for this analysis were derived from the 2001 Statistics Canada Census Place of Work/Place of Residence database for the Ottawa-Gatineau area. The data represent a 20 percent sample of trips from home to work, and identify the origin zone, the destination zone and the usual mode of travel, including driver, passenger, transit, taxi, bike, walk motorcycle and other. The data are organized by census tract, comprising 173 zones in the Ottawa area and 57 zones in the Gatineau area.

4.3 Methodology

4.3.1 Zone Aggregation

To simplify the analysis, the data for the original 230 zones were aggregated into a super-zone system, comprising 23 zones with zone aggregations defined with consideration for the geographical patterns and need for travel detail. For example, since information on specific destinations in Gatineau would not affect the analysis, all Gatineau zones were aggregated to one superzone. On the other hand, since more detail was required on the destination of downtown-oriented trips, less aggregation was used in this area. Aggregate zones were sensitive to the configuration of the Transitway and its access, as well as physical barriers.

Figure 1 shows the original census tracts and the aggregated zone system used for the analysis. This zone aggregation reduced the number of zone pairs from about 53,000 to 576.



Not to Scale

Figure 1
Original Concensus Tracts
OC Transpo 2009 Transit Network Planning Project

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4.3.2 Travel Pattern Identification

After isolating transit trips only in the data, the next step in the analysis was to identify those zone pairs where connecting trips would not logically use the Transitway through downtown. For instance, all trips internal to each zone (with the exception of the downtown core), were eliminated from the analysis, as were trips between adjacent zones remote from the downtown area. This step eliminated 268 possible zone pairs.

The second step in the travel pattern identification was to identify those trips that would logically use the Transitway via Albert/Slater in any likely service scenario, either because the destination was in or immediately adjacent to the Albert/Slater corridor. Referring to Figure 1, all trips destined to Zone 1B were deemed to either to divert to the new LRT service or continue to use Transitway bus service to reach their destination in the future. For zones immediately adjacent to Zone 1B (the remaining Zone 1 subzones), trips were assumed to remain on Transitway bus routes, or use the LRT, if their origin location required them to pass *through* Zone 1B. This step eliminated a further 80 zone pairs from consideration.

All trips between the remaining 228 zone pairs were considered in the next step of the analysis.

4.3.3 Transitway Trip Identification

In this step of the analysis, each zone pair that had been identified in the previous step as comprising travel through downtown that might be diverted, was examined to identify the proportion of the trips that are currently using the Transitway, versus those using other services.

This step was accomplished through the professional judgment of Transit Services staff planning staff, with consideration for available routing patterns, levels of service on the alternative routes and knowledge of the travel patterns on existing services. For each zone pair, a percentage of Transitway versus non-Transitway trips was estimated. ENTRA staff assisted in this compilation and monitored the assumptions developed by staff to ensure their consistent application between zone pairs.

The result of this step was an estimate of the number of Transitway trips that could potentially be diverted from the downtown core through attraction to other services.

4.3.4 Potential Diversion Estimates

The final step in the analysis was to estimate the proportion of remaining trips that would be diverted by increasing the attractiveness of alternative services. This step assumed that the passengers making the trips identified in the previous step were attracted by the frequency and speed of the Transitway trip compared to the slower but more direct trip offered by existing alternatives. In Networks 2 and 3, several improvements are introduced to improve the frequency and travel time of additional services to make them competitive to the Transitway. These new cross-town rapid transit routes were examined relative to the travel patterns of the remaining trips. Transit Services planning staff applied professional judgment to determine the likelihood of trips in each zone pair diverting to the alternative services on a three-point scale (high-medium-low). ENTRA staff assisted in this compilation and monitored the assumptions developed by staff to ensure their consistent application between zone pairs.

Each class of the 3-point scale was then applied a percentage value, to determine the quantity of trips diverted from the downtown Transitway. These values were varied to determine the sensitivity of the estimates to a range of percentages. Based on this analysis, the High value was set at 70 percent diversion, the Medium at 50 percent and the Low at 33 percent.

4.3.5 Screenline Analysis

As a final step, the results of the diversion estimates were converted to screenline estimates by examining the number of transit trips identified as diverted that cross selected screenlines as a proportion of the total transit travel across those screenlines. (Screenline locations are shown in Figure 1. This estimate was then used by Transit Services staff to identify the actual number of trips, based on current transit ridership data, that could be diverted from the downtown area and the resulting implications for bus operations through the downtown.

4.4 Diversion Calculation Results

4.4.1 Trip Identification Steps

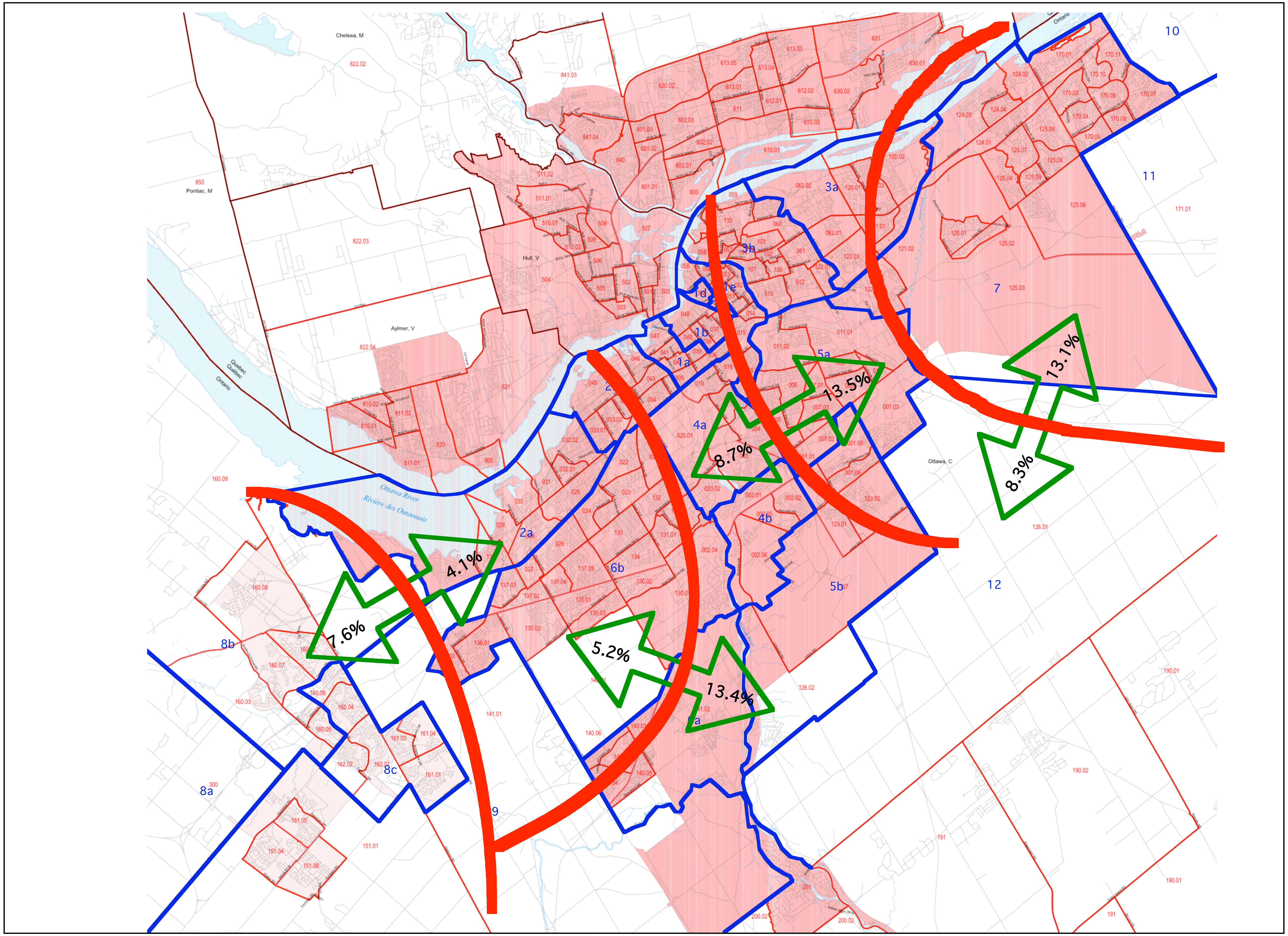
Table 1 shows the results of each step in the diversion calculation. After each subsequent step, the percentage of total transit trips in the system with the potential to be diverted was reduced, as described in the methodology. As shown in Table 1 the final result of the various steps was value of 4.8 percent. This means that the diverted trips are about 4.8 percent of the system total.

Table 1
Diversion Calculation Results

	Percentage of trips eliminated from analysis	Remaining percentage of trips with potential to be diverted
Travel Pattern Identification Step		
Trips not travelling through downtown	43.6	
		56.4
Trips continuing to travel downtown	41.3	
		15.1
Transitway Trip Identification Step		
Trips Not using Transitway	6.0	
		9.1
Trip Diversion Estimates		
Trips not diverted	4.3	
		4.8

4.4.2 Screenline Analysis Step

The 4.8 percent value identified in the trip identification steps represents the proportion of total system-wide ridership that can potentially be diverted. To determine the impact on downtown bus operations, it was necessary to calculate this value as a percentage of downtown-based trips. Since current actual transit ridership at the screenlines is known, the percentages were applied to these known values. The result is potential diversions ranging from 4.1 percent to 13.4 percent, with an average of approximately 8 percent of downtown-based trips. Percentages of trips diverted from each screenline are shown in Figure 2.



Screenline 1
Inbound 8.3%
Outbound 13.1%

Screenline 2
Inbound 8.7%
Outbound 13.5%

Screenline 3
Inbound 5.2%
Outbound 13.4%

Screenline 4
Inbound 4.1%
Outbound 7.6%

Not to Scale

Figure 2
Screenlines and Diversion Values
OC Transpo 2009 Transit Network Planning Project

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5. Ridership Elasticity with Respect to Service Changes

5.1 Standard Practice and Research Results

Considerable research has been completed within the transit industry on the impacts of various changes on ridership, or the elasticity of transit ridership with respect to the specific change. The most robust research relates to the elasticity of ridership with respect to fares, as it relates more directly to economic analysis and theory. However, considerable research has also been completed to identify the effects of changes in service levels and characteristics on ridership.

The proposed changes as part of the development of the 2009 alternative networks involve several factors that could have an influence on the ridership compared to Network 1.

5.1.1 Elasticity with Respect to Service

Generally, ridership can be expected to increase as service levels increase, and decrease as service is reduced. Considerable research has been conducted in this area, and levels of service in this research is usually expressed in terms of vehicle-hours of service, since this is a simple surrogate for both levels of service and span of service.

Research with respect to service level changes is difficult to undertake, since it is very difficult to control the variables in the analysis. This is another reason that the independent variable often used is total vehicle-hours or vehicle-miles, since as a coarser measure, it is less sensitive to external influences.

The other factor often examined in service factors is the effect of a transfer on ridership behaviour.

Results of some of the typical research examined in the literature is summarized in Table 2 (Evans, 9-9).

Table 2
Ridership Elasticity with Respect to Serve – Research Results

Location	Year	Headway Change	Service measure	Elasticity
Vancouver WA	1980	Mixed: 19-23 to 10-15 in peak	Peak buses	+0.33
Charlottesville VA	1980-1981	60 minutes to 30 minutes in peaks	Vehicle Miles	+0.33
Mt. Pleasant Bus, TTC	1987	10 to 15 in peaks and 15 to 30 in evening	Headway	-0.47 pk, -0.29 off-peak
Tasta, Norway	1990	30 to 15 minutes	Headway	-0.26
Santa Clarita	1992-1997	60 to 30 minutes	Vehicle hours	+1.14
Los Angeles, CA	1996	Various	Vehicle hours	+1.03
Snohomish, WA	1996	60 to 30 minutes	Service Hours	+1.0
Santa Monica. CA	1998	Various	Vehicle hours	+0.82
Lincoln Blvd, Santa Monica	1998	20 to 10 minutes	Vehicle hours	+0.97

Source: TCRP Report 95, p. 9-9

The results shown in Table 2 are consistent with respect to direction (the mix of negative and positive values reflect the fact that improved service results in *reduced* headways, but results in *increased* vehicle-hours or vehicle-miles). However, the values vary considerably, and reflect different responses to other factors, Response to service changes appear to be highest when the original service level was low, where ridership components were largely choice riders, and where trip distances are short, and so the reduced waiting time and increased frequency is a larger component of the trip. The application of these considerations is not completely consistent with the OC Transpo context, since the proposed changes in the alternative networks likely involve a large proportion of choice riders (a considerable component of the peak ridership compared to off-peak), but also involve longer trip distances, and a wide range of headways.

For this reason, the effect of service changes was incorporated into an overall time value model in terms of reduced wait time, as described in the next section.

5.1.2 Elasticity with Respect to Fares

Elasticity with respect to fare changes is probably one of the most extensively researched areas of transit ridership elasticity, partly because these changes are quite common, and it is necessary to understand the overall revenue implications of a fare change, and the effects are more easily isolated than changes in service levels.

Traditionally, many transit systems operate on historical research that suggests the fare elasticity of demand is –0.33, meaning that a 10 percent increase in fares will result in a 3.3 percent reduction in ridership. This factor supports fare increases to increase revenue, since the revenue loss from reduced ridership is more than offset by the increased fare revenue overall. Other and more recent research indicates that a simple application of a single elasticity figure to fare changes is not appropriate, since the effects will vary by trip purpose, by income level and other factors.

What is clear from a variety of research is that there is no one elasticity factor for changes in fare. Price elasticities are typically higher for choice rides compared to 'captive' riders, higher for discretionary trips, typically taken in the off-peak, than for peak-period commuter trips, and variable within these groups as well (Litman, 13).

5.1.3 Components of Travel Time

A variety of recent research indicates that transit travellers perceive the elapsed time, and therefore the attractiveness, of particular components of a trip differently. Generally, the actual time spent travelling on the bus (in-vehicle travel time, or IVTT) is the base measure of perceived time, and afforded a weight of 1.0. Research has been conducted to determine the relative values of travellers' perceptions of other components of the trip, including the initial wait, a required transfer, and the transfer wait. Table 3 shows the results of a variety of studies from the last few decades (Booz, 6).

Table 3

Relative Value of Time – Various Results

Location	IVTT	Walk Time	Initial Wait	Transfer Wait
New Orleans	1.0	2.2	5.13	2.13
Chicago	1.0	4.13	0.84	4.13
Seattle	1.0	1.10	0.75	1.10
Dallas	1.0	1.86	1.85	1.99
Minneapolis	1.0	4.36	4.36	4.36
Boston	1.0	.79	1.31	2.38
Portland	1.0	1.87	1.25	2.46

Source: TCRP Chapter 10, p 10-36

An extensive study undertaken in Australia determined the value of wait time to be approximately 2.4 times that of in-vehicle travel time.

5.2 Elasticity Implications

Much of the research into the various elasticity factors deals with the ridership implications of a single factor, and whereas the analysis in this assignment involves the combination of several positive and negative factors. In addition to this complication, many of the elasticity research conclusions present varying conclusions, or ranges of conclusions of how a change in a service factor might affect ridership. There is complete consistency, however, with respect to the overall direction of the effect. For example, there is consistent evidence that decreased waiting time at the stop (which can be created by increased service frequency) will have a positive effect on ridership levels and that additional transfers (in the absence of other changes) will have a negative effect on ridership levels.

Effective analysis of the variety of factors involved in the network assessment suggested that a range of elasticity values should be tested for each factor. Since several effects are involved in this analysis, this would have created an unwieldy number of combinations of effects and elasticity ranges.

For this reason, ENTRA decided on a generalized cost elasticity approach, which effectively combines all positive and negative effects into one calculation, then permits a range of elasticity factors to be applied to this single calculation. This method is described more fully in the next section.

5.3 Generalized Cost Elasticity

5.3.1 Description and Rationale

Generalized cost elasticity is a way of bringing together a variety of changes such as those involved in the development of the alternative networks, including fare reductions, in-vehicle travel time changes, wait time reductions, new transfers and transfer wait times. This technique is converts each of the various positive and negative effects of the service changes under each Network alternative to an overall assessment of travel time, then applies a single elasticity factor to that time calculation.

Section 5.3.2 describes the general factors considered in this model, and Section 5.3.3 describes the specific application of the generalized cost model.

5.3.2 Factors Considered In the 2009 Networks

The 2009 Alternative Networks each involve several of the factors dealt with in the research. Factors include reduced wait time from increased service frequencies, particularly on boarding routes in the downtown in the afternoon peak, elimination or reduction of the express routes as well as their associated premium fares, truncation of the local routes at the various transit hubs, and introduction of new express or rapid transit routes. The following section describes some of the considerations associated with these factors and the positive and negative influence on the overall value of time.

Table 4
Positive Time Factors (Time Reductions)

Factor	Description	Effect	Analysis Assumptions
Increased service frequency	Passenger boarding downtown can take advantage of any Transitway bus departing downtown.	Reduced waiting time downtown will increase ridership	Passengers will board any trip leaving downtown to shorten their initial wait, at the expense of potentially longer transfer wait. Wait time is valued more highly than in-vehicle travel time (Booz, 23)
Decreased Travel Times on Assigned Route	Shorter trip time on new Transitway routes or on LRT, due to more direct route and improved travel speeds	Reduced travel time will increase ridership	Changes in travel time are estimated on a route-by-route basis, using the characteristics of each network
Reduced Fare	Express passengers currently pay $0.34 per trip premium	Reduced fare will increase ridership	Express users purchase pass, ride 44 trips/month; $15 pass premium, with 44 trips = $0.34

Table 5
Negative Time Factors (Time Reductions)

Factor	Description	Effect	Analysis Assumptions
Transfers to Transitway routes for local and express riders on Transitway	Transfer created at transit hub	Act of transferring creates passenger perception of time delay (booz,24) (, 18) Individual route-by-route impacts, depending on network alternative	Transfer is perceived as 5 minutes delay (booz,23) (balcombe,25) (evans, 9-8) Additional actual wait time at hub for local service connection, depending on service level Actual wait time is calculated based on one-half the headway, since passenger arrival at transfer hub is largely random
Increased Travel Times on Assigned Route	Longer trip time on some routes, since Transitway buses stop at all stations with longer dwell times, and other assigned routes may have less direct travel	Increased travel time will decrease ridership	Changes in travel time are estimated on a route-by-route basis in the analysis
Increased passenger crowding on Some Routes	More crowded vehicles on Transitway portion	Increased crowding can decrease ridership; (Balcombe, 80)	This factor has not been applied in the analysis because of the conflicting evidence in the documented research and because of a basic assumption by staff that the established service capacity standards would continue to be met under all network concepts

5.3.3 Generalized Cost Methodology

In this analysis, each of the various effects of the proposed changes in the alternative network proposals were converted to relative time values, then a single generalized cost elasticity factor calculated from the overall calculated trip time, compared to the Network 1 calculation. This elasticity factor was then applied to the assigned ridership to determine the effect on overall ridership.

Time values and weights for the various components of the transit trip were calculated in ranges to determine a low and high scenario. The following is the list of factors, and their low and high values.

~ Initial wait time was calculated based on the headway of the assigned route, using the square root (reflecting non-random arrival) for longer headway routes and one-half the headway (reflecting random arrival) for shorter headway routes

~ Initial wait time was weighted at 2.5 (constant for low and high scenario)

~ In-vehicle travel time was calculated on estimates of actual travel times, or expected changes from existing travel times, and weighted at 1.0 (constant for low and high scenario)

~ Transfers were assessed an initial perceived delay of 5 minutes (low) and 8 minutes (high)

~ Transfer wait times were calculated in the same way as initial wait, and weighted at 2.0 (low) and 2.5 (high).

~ Fare reductions were calculated as time savings, based on the value of time, assuming a per trip savings of $0.34 and a value of time set at $12.00 (low/high?) and $9.00 (low/high?)

~ Total travel time (including all penalties and weights) were calculated for travel projected on all routes in Network 1 and the alternative networks and the differences observed.

~ An overall elasticity factor was applied to the total calculated time difference, with an interim calculation used to determine the impacts of the services changes and transfer changes separately.

Research in England (Halcrow Fox, 12) shows generalized cost elasticities for bus travel ranging from –0.40 to –0.80 with the elasticity effect increasing as income increases. Elasticity effects among middle-income earners ranges from –0.50 to –0.70 for the home based work trip, and increases for more discretionary travel. In similar Australian research, generalized cost elasticities range from –0.87 for peak period travel to –1.18 for off-peak travel, with an average of approximately –1.02 (Booz, 40)

The generalized Cost Elasticity factors were applied in a range of –0.5 to –0.7.

5.4 Resulls of the Analysis

5.4.1 Ridership Results

Using the various ranges of factors, a number of scenarios were developed with combinations of high, medium and low values of each factor.

The Low scenario was developed by using the lowest value of each factor, while the high scenario was developed using the highest value of each factor. Based on ENTRA's analysis of the research and OC Transpo context, the most likely scenario is deemed to be the LOW scenario, and the HIGH scenario should be considered as a worst case.

Table 6
Ridership Change (Thousands of customer-trips per year)

		Network 2		Network 3	
		Likely	Worst Case	Likely	Worst Case
Change in ridership from service level changes	AM	112	233	17	110
	PM	168	345	87	304
	Total	280	578	104	414
Change in ridership from route structure (transfers, including service level changes on transfer routes)	AM	-835	-1235	-110	-428
	PM	-797	-1392	-517	-1097
	Total	-1632	-2647	-627	-1525
Total from all changes	AM	-722	-1002	-93	-318
	PM	-629	-1046	-430	-793
	Total	-1352	-2049	-523	-1111

Table 6 shows the low (likely) and high (worst case) estimates for each of Network 2 and Network 3, compared to Network 1. Table 6 indicates that both Networks are expected to create some decline in ridership compared to Network 1, with a combination of positive effects from service level increases and negative effects from route structure changes.

Note that the values in Table 6 for change in ridership for route structure also include some service level change effect. The model calculation combines the impact of a transfer and a lower service frequency on the transfer route. This is the reason that Network 3 exhibits a greater decline in this value, even though the transfer effect is expected to be lower.

The decline in ridership expected from the implementation of Network 3 ranges from 523,000 annual rides in the Likely scenario to just over 1.1 million in the Worst Case scenario. This is about 40 percent of the impact expected from the implementation of Network 2, with ridership declines ranging from about 1.3 million (Likely) to approximately 2.1 million (Worst Case).

It should be noted that these comparisons were made assuming smooth operations through the central area for Network 1. Were there any deterioration in the waiting times, travel times or boarding times in the central area, as would likely be the case as ridership grows to the levels projected in the Transportation Master Plan, the ridership loss relative to Network 1 would diminish.

5.4.2 Sensitivity Analysis

The various input factors, including the estimated travel times on future routes determined by Transit Services staff were assessed to determine the sensitivity of the overall ridership impacts to changes in each of the factors. Since the overall result of the changes is a ridership change, factors were assessed in terms of their effect on the ridership change, and are expressed in that manner.

The least sensitivity results from changes in in-vehicle travel time, as expected by the unit weight of this component of travel time. This also means that, despite the consistent application of assumptions by staff to the estimates of new travel times, any estimate errors or unexpected changes in these estimates will not have any significant effect on the results.

The highest degree of sensitivity is found in changes to the generalized cost elasticity, followed by the wait time factors.

Sensitivity of results to changes in the relative weights of the initial and transfer wait time is in the opposite direction. Increases in the weight of the initial wait time tends to reduce the overall ridership loss, since the alternative networks, especially Network 2, have a number of instances where initial wait in the PM peak is substantially reduced by the improved service levels of the current and new Transitway routes. Doubling the value of the weight of this factor reduces the overall ridership loss by approximately 15 percent.

On the other hand, changes in the relative value of transfer wait has a significant effect on the overall result in the same direction. Increases in the transfer wait value increases the ridership decline. Doubling the value of the weight of this factor increases the ridership decline by 50 percent to 75 percent.

Ridership declines are slightly less sensitive to changes in the perceived transfer delay. A doubling of the transfer delay increases the ridership decline by approximately 50 percent in most ranges.

The highest level of sensitivity results from changes in the generalized cost elasticity, which is to be expected since the factor is applied to the overall time calculation. The relationship between this factor and the ridership change is close to unitary.

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