Strategic Interchange

Bus or Rail? Finding the right solution for Hamilton's A-Line

Cost-Benefit Analysis

An assessment of rapid transit choices for the proposed A-Line, including projections for ridership and population growth, technology (BRT or LRT), and routing based on a practical cost/benefit analysis of different scenarios for the City of Hamilton's contribution to the project's capital cost. The B-Line is similarly examined, for comparative purposes, with final recommendations for both routes.

Image from Hamilton Rapid Transit, with modification.

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ABSTRACT

The City of Hamilton is currently planning two rapid transit lines, the **A-Line** and the **B-Line** to be completed within the next 10 to 15 years as part of Metrolinx's "The Big Move" Plan. A recommendation on the technology to be used, bus rapid transit (BRT) or light rail (LRT), for the A-Line, between Hamilton Harbour and Hamilton International Airport, has not yet been determined. This paper addresses the question of which technology, LRT or BRT, is the best choice for the A-Line. A cost-benefit analysis of the two systems is conducted, looking at the capital and long-term operating costs, projected population and ridership, funding scenarios, and local tax assessment impacts. It is well documented that BRT has higher operational costs than LRT for high-volume routes. Due to the high existing ridership on the B-Line, Hamilton will gain substantial benefits from building an LRT along this route as soon as possible, with a minimum of 75% of the capital cost funding from Metrolinx. For A-Line, due to the much lower ridership, a phased approach for LRT is more appropriate. The first phase is completion of the core section through Downtown to Mohawk College by 2026, and the remainder of the route phased in between 2031 to 2036. However, to avoid a related property tax increase, the City's maximum capital contribution to a full A-Line LRT project is just 10%. BRT could be used as an interim measure on the A-Line, but the significantly higher operating cost compared to LRT makes BRT more expensive in the long-run. The cost to the City of not building LRT, and instead choosing BRT, is $235,511,403 for A-Line, and $336,444,860 for B-Line, with full capital funding from Metrolinx.

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1. INTRODUCTION

The City of Hamilton is currently planning two rapid transit lines, the **A-Line** and the **B-Line** to be completed within the next 10 to 15 years. Metrolinx has so far assured the City that the project will be fully funded. But does the project still benefit the City if it has to contribute to the substantial upfront cost? Which technology, LRT or BRT, is the best choice for the A-Line? This paper addresses these questions through a cost-benefit analysis of the two systems, looking at the capital, long-term operating costs, and how the upfront capital construction costs could be shared with Metrolinx. These figures will also be compared to the B-Line. Linear regression modelling will be used to estimate population and ridership growth along the transit corridor. Consideration will also be given to the environmental benefits of the energy choice, and whether a BRT solution should use diesel or electricity.

The preferred A-Line route also faces two challenges for LRT: a low-clearance bridge downtown, and a steep incline up "The Mountain", as the Niagara Escarpment is called in Hamilton. The preferred route may therefore only be suitable for BRT without extensive, and expensive, infrastructure modifications. The currently proposed LRT route swings further east, to use an existing expressway up the mountain, which has a shallower incline. A longer distance, and thus travel time, could detract potential riders from travelling via A-Line to Mohawk College, and the proposed James North GO Station, which will have all-day, two-way GO Train service to Toronto in 2015.

To determine the operating and capital costs, project ridership and travel times, information was compiled from some of the city's own reports, reviews of rapid transit projects in other jurisdictions, transit planning and economics guidelines, related articles and literature. The goal of this research is to draw a clear recommendation for which technology, LRT or BRT, has the most benefit to the City of Hamilton, under the right funding scenario. This paper's findings will be presented to Hamilton's Rapid Transit team and transit staff.

The paper begins with a brief history of the Hamilton Street Railway (HSR), which as the name suggests, once operated a network streetcars in the city. Now, Hamilton is coming full circle to renew this technology in modern form. A profile of the current HSR system follows this introduction, along with descriptions and demographic details of the two proposed rapid transit corridors, the A-Line and B-Line.

Current HSR ridership for this study has been derived from the author's analysis of a comprehensive database containing passenger boarding counts for each route and bus stop in the City, which was compiled as part of a 2010 HSR Operational Review. Special thanks to the HSR for making this raw information available for this research. From this accurate data, the base ridership counts for existing bus routes were tabulated for the A-Line and B-Line corridors.

Population and ridership estimates for the corridors were projected using linear regression. The results were then modified to suit targeted population and ridership growth by 2031. Capital and operating costs estimates are based on equivalent numbers available for the B-Line, with adjustment for the different service characteristics of A-Line.

A very comprehensive cost benefit analysis for both routes was then conducted, using these data, and other parameters for inflation, growth, discounting and interest over a 25-year period, starting in 2021. Results were calculated for LRT, BRT and Trolley options, different routes and project phasing. The City of Hamilton is concerned about the impact on local property taxes if the City has to cover any portion of the upfront capital costs. A cost benefit analysis of a debt-financed City contribution is thus considered, to determine this impact, and draw the final conclusions.

2. THE HISTORY OF THE HSR AND RAPID TRANSIT IN HAMILTON

Transit service in Hamilton is provided by the Hamilton Street Railway (HSR). As the name suggests, public transit in Hamilton started with streetcars, operating on rails. The first horse-drawn streetcars came into service in 1874, and the adult fare was 5 cents. (Manson, 2002, pp. 25) The streetcars were electrified in 1890, and Hamilton became known as "The Electric City" (Gilbert, 2006), and continued operation along a network spanning the city and into the surrounding communities, see Figure 1. Inter-city service was discontinued in 1932 (pp. 33), and urban streetcar service ended in 1951, replaced by electric trolley buses. Although the HSR also had a growing fleet of diesel buses, the trolleys operated until 1992. The HSR was first to test pilot a new bus technology in 1985, compressed natural gas (CNG). A fleet of CNG buses soon replaced the electric trolleys, thanks to generous government subsidies at the time (Milner, 2009). Due to higher maintenance costs and lower reliability than diesel buses, and an end to the subsidies, the HSR's CNG fleet is gradually being phased out as the buses reach the end of their service life, and being replaced by hybrid-diesel technology.

Concepts for rapid transit in Hamilton can be traced back from the 1960's through the early 1980's, including monorails, and an "Intermediate Capacity Transit System" or ICTS, on which the Scarborough RT in Toronto and the SkyTrain in Vancouver are based (City of Hamilton, 2009, citing Metro Canada, 1981). Due to an outcry over the project's cost and controversial routing, the plan was shelved.

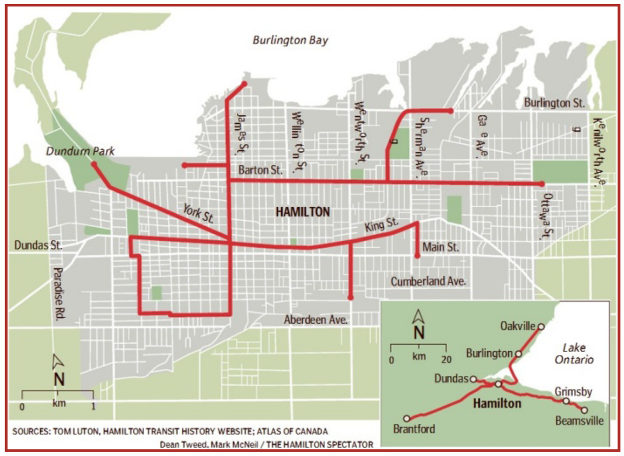

Figure 1 - Hamilton's Original "Light Rail Transit" Network, 1874-1951 (Tweed & McNeil, 2011)

In 2006, the Provincial Government created what was to be an arms-length agency to develop, fund and implement transportation solutions for Greater Toronto. Rebranded as Metrolinx, the agency introduced "The Big Move" in 2008, an ambitions 25-year plan to develop a network of rapid transit routes across the Greater Toronto & Hamilton Area (GTHA). Included in this plan are two urban rapid transit lines in Hamilton, along with commuter GO Train service improvements (Metrolinx, 2008).

The first rapid transit route, the B-Line is based on an already existing rush-hour BRT route in Hamilton called the Beeline, which was introduced in 1989. The new name is likely a result of a desire to adopt a more conventional naming system for Hamilton's BRT routes, as the second of the proposed routes is called the A-Line, not the "Ehline".

Figure 2 - Hamilton Rapid Transit Network conceptual plan (Hamilton Rapid Transit, 2011)

In response, the City of Hamilton created a Rapid Transit Team and entered into an agreement with Metrolinx to begin detailed planning of these transit corridors. A conceptual plan for a network of rapid transit routes across the city was developed, and dubbed the "BLAST" network. See Figure 2.

3. HSR TRANSIT SYSTEM PROFILE

The 2010 Transit Fact Book, published by the Canadian Urban Transit Association, provides some recent statistics for the HSR's operations (see Table 1). HSR annual ridership, revenues and expenses are graphed in Figure 3 (CUTA, 2008, 2010). The HSR had a fare increase in 2010, as shown by the increase in Revenue. Rising oil prices have put increasing upward pressure on operating costs, as indicated by the trend, which shows no sign of reversing. Figures for 2011 are based on HSR's projections of 3.2% ridership growth, reported by HSR staff, and a 1.7% budget increase for 2011 (City of Hamilton, 2010b).

Table 1- HSR Service Summary Statistics (CUTA, 2010, pp. 38)

Annual Ridership	21,226,393 Revenue Passengers
Total Operating Revenues	$34,853,496
Total Operating Expenses	$67,776,313
Cost Recovery	51% ($1.59 revenue / $3.19 expenses per passenger)
Bus Fleet Composition:	217 Buses
	141 Diesel, including 25 Articulated (60') 76 CNG
City of Hamilton Population	504,559 (StatCan, 2006 Census)

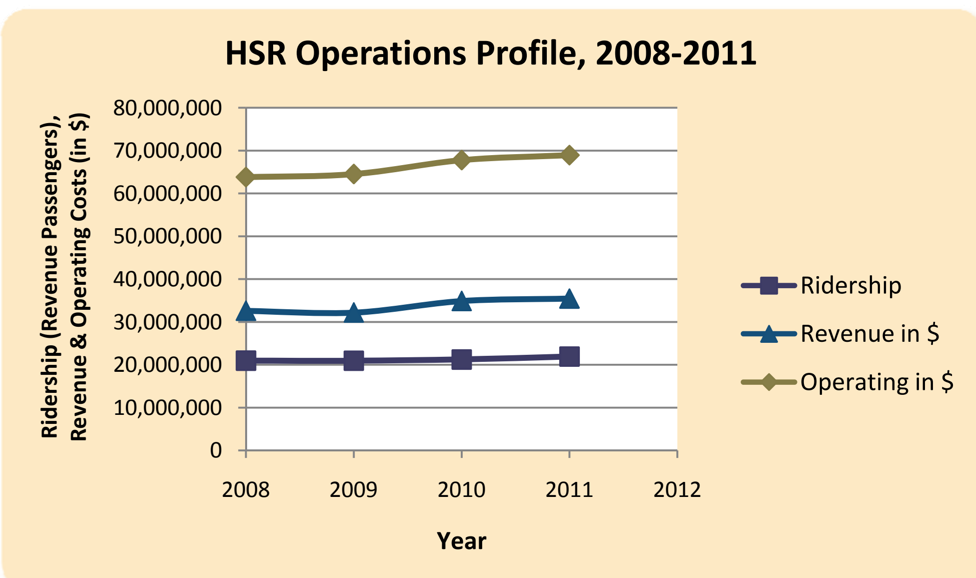

Figure 3 - HSR Ridership, Revenues and Operating Costs
(CUTA, 2008, pp. 84-85; CUTA, 2010, pp. 38-39, Hamilton, 2010b)

4. RAPID TRANSIT CORRIDORS

A-LINE

The A-Line runs from the Hamilton Harbour waterfront in the north, to Hamilton International Airport in the south. The route passes the proposed James Street North GO Train Station, Figure 4, which will be the home of all-day GO Train service to Toronto by 2015, and the Hamilton GO Centre bus terminal, which currently has 4 GO Train trips per day. Statistics Canada (2003) reported that one in ten workers in Hamilton are commuting to work outside of the City, mostly to Toronto, and this proportion is likely now much higher. Therefore, an efficient local transit connection to these GO Stations is important to encourage "smart commuting" with Toronto, in both directions.

Figure 4 - Site of James North GO Station

Figure 5 - TH&B Railway Bridge at Hunter Street

The A-Line line also goes through downtown, and serves Mohawk College once atop the Mountain. The area between the waterfront and the College has a high population density, Figure 6, as with the B-Line, but south of the College, the density is much lower. The route goes through suburban areas and undeveloped rural land along Upper James Street, Figure 7, on its way to the Airport. See Figure 10 for more details.

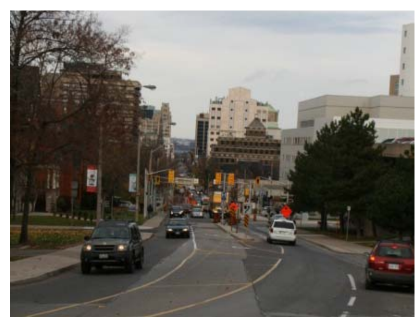

Figure 6 - James Street, looking towards Downtown

Express bus service was introduced on the A-Line in 2010, with a 30-minute frequency during rush hours. This route, along with 3 regular service HSR routes (21, 33, and 35), operate between Downtown and the College, with up to 10-minute frequency during peak periods. Route 27 serves the Upper James section, as far south as the Mountain Transit Garage, with 15-minute frequency during peak periods and 30-minutes off-peak.

Figure 7 - Upper James St.
Welcome to suburbia!

There are two constraints along the A-Line corridor that may impede LRT technology. The first is the low-clearance, narrow bridge on James Street South at Hunter Street, Figure 5. The roadway, on either side of the centre supports, is too narrow for two-way rail. However, replacement of this inadequate structure, built in 1933 (Mason, 2002) could be a warranted capital cost. A 2008 Feasibility Study proposed lowering the road bed below the existing bridge is also feasible (McCormic, 2008)

Figure 8 - At the base of James Mtn. Rd. Location for a tunnel entrance?

The second impediment is the Niagara Escarpment, the Mountain, Figure 8. James Mountain Road, with its 10.7% grade (McCormic, 2008), is too steep for LRT. Iron wheels on iron rails lack the traction to ascend or descend steep grades safely. Ironically, it is this lack of resistance that makes rail a smoother, more energy efficient mode of transport than rubber-tired vehicles. There are 3 possible solutions:

1. Build a tunnel between James St and Mohawk College, a.k.a. subway, at a cost of pproximately $260 million (McCormic, 2008), a solution potentially inflammatory to neighbourhood residents environmentalists.
2. Install a secondary traction technology, such as a cable or cog system along the steep portion of the incline. (Rapid Transit Office, 2009)
3. Re-route the LRT to the Claremont Access, which as a suitable 5% grade but increases the travel distance between Downtown and the College by 60% (see Table 2, and map Figure 10), which shows this alternate A-Line LRT routing. With such an impediment, the LRT may have difficulty competing for riders from the more direct, regular bus routes between Downtown and the College, and for Mountain commuters to the proposed James North GO Station. Due to the longer distance, laying more track, and related infrastructure upgrades, the cost saving is just $100 million, compared to Option 1 (McCormic, 2008). HSR operational costs will also be higher, due to the additional LRT distance, and because conventional bus service along James Street would still have to be maintained.

Table 2 - A-Line LRT Route Options

A-Line Route Options	Downtown to College			Waterfront to Airport		
	Distance	Trip Time	Difference	Distance	Trip Time	Difference
via James Mtn. Road	2.7	8 minutes		16.3	35 minutes	
via Claremont Access	4.5	12 minutes	150%	18.0	39 minutes	111%

Trip times are based on the following methodology for speed and distance:
James Mountain Road: 1km @ 50km/h from base of Mountain to Brantdale, and 1.7km @ 15km/h through Downtown and in the vicinity of Mohawk College, where stopping will be frequent.
Claremont Access: 2km @ 70km/h for Claremont Access and its approaches, and 2.4km @ 15km/h through Downtown and the International Village (King Street East) bottleneck, and in the vicinity of Mohawk College.
An average speed of 30 km/h was used for the rest of the A-Line route from Waterfront to Airport.

B-LINE

Figure 9- King Street at Wentworth (B-Line) A Better Density for LRT?

The B-Line runs from McMaster University in the west, to Eastgate Square in the east, through the heart of Downtown Hamilton. The corridor is the HSR's busiest, and traverses the most densely populated areas of the city. The downtown and McMaster University are the biggest transit ridership draws in the city. The route follows Main Street, to King Street, back to Main Street and Queenston Road. Most of Main and King Streets are one way, so each direction of the current B-Line bus service is split between them. The corridor is also served by Route 1–King and variations of the Route 5/51 Delaware/University, with 6-7 minute frequency most of the day. The proposed B-Line rapid transit route will consolidate these routes, and run in both directions in a dedicated right-of-way along King Street, with a 4 minute peak headway.

Planning for the B-Line is very advanced, compared to the A-Line. As of the end of 2011, the B-Line Environmental Assessment and 30% detail design specification will be completed. This work is proceeding on the basis of LRT being the preferred technology for B-Line. As will be demonstrated in the analyses to follow, LRT is a logical choice with the greatest benefits due to the high population and well-established transit ridership along this corridor. Will LRT similarly be a clear winner for the A-Line?

It should also be noted that the HSR is currently planning for a new BRT route that will utilize the city's expressway network to connect major hubs on the Mountain to the east and west ends of the City. Currently, the HSR's transit network is focused primarily on the downtown, and the majority of bus routes from the Mountain terminate there. The 2010 HSR Operational Review identified a new Crosstown Express, Route 100, which will connect with the B-Line at McMaster and Eastgate, and the A-Line at Upper James and the Lincoln Alexander Parkway. This route is shown on Figure 10.

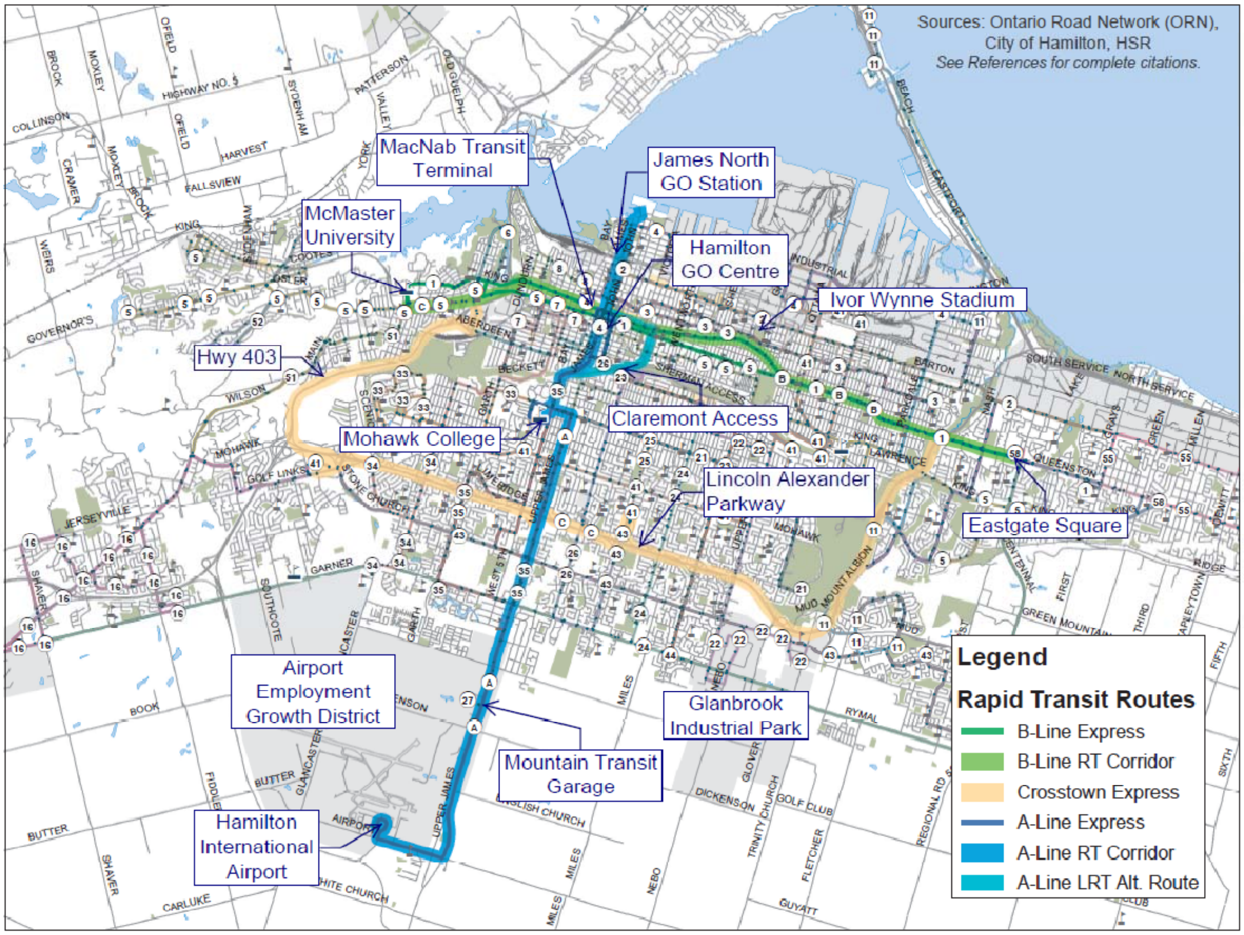

Figure 10 - Rapid Transit Corridor detail map

5. CORRIDOR DEMOGRAPHICS

POPULATION

An analysis of the populations of the Statistics Canada Census Tracts along these corridors reveals that these 2 routes directly serve 35% of Hamilton's population. Table 3 provides a summary of the population and density, along with a comparison of Waterloo's recently approved iXpress LRT corridor between Conestoga and Fairview Park Malls, and the combined A ad B Line corridors. The "A-Line Core" is the section of the route south as far as Mohawk College only. Table 3 shows the very high density of population in this north-end "core" section compared to the route as a whole, see Map, Figure 12.

Table 3 - Population, Census Tract Area and Population Density (StatCan, 2011a)

Corridor	Population	Area (km^2)	Density /sq km
A-Line	81,603	53.97	1,512
B-Line	124,433	31.27	3,979
A & B Lines	177,662	79.90	2,223
A-Line Core	38,681	8.50	4,551
iXpress (KW)	77,140	42.51	1,815

Concern was raised on local talk radio and news media during the summer of 2011 as to whether or not the population density in Hamilton was sufficient to support LRT, referring to a Statistics Canada's 2006 census figure for the city, which includes Hamilton's vast rural area. This statistic was compared to the urban density of the city of Portland, Oregon, where LRT has been a great success. Figure 11 shows the population densities for the 2 rapid transit corridors, as per Table 3, along with densities from 5 other municipalities for comparison, including Portland. The density along the B-Line is comparable to Toronto's urban density. However, population density along the A-Line falls short, outside of the A-Line Core area, which could be of concern in evaluating the cost/benefit LRT and BRT.

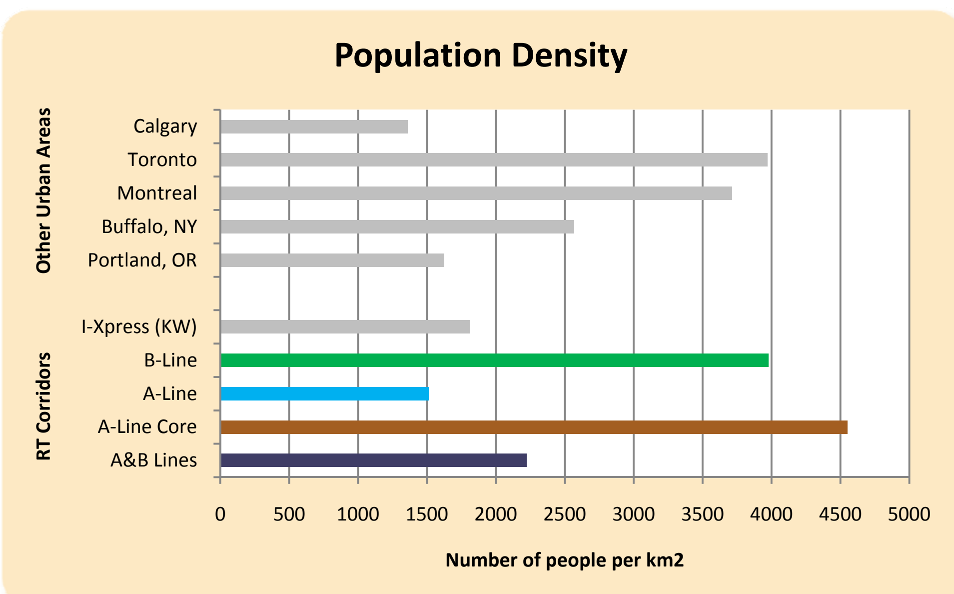

Figure 11 - Population Density Comparison (Statistics Canada, 2011 and City-data.com)

TRANSIT RIDERSHIP

As part of the 2010 HSR Operational Review, a detailed boarding survey was conducted by IBI Group in the Fall of 2008 and Winter of 2009. Each bus route was surveyed over a complete service cycle (Weekday, Saturday and Sunday, from beginning to end of service). GPS coordinates were tracked to cross-reference boardings automatically with standardized bus stop locations. Fare payment categories were also tracked. The result is a very comprehensive database with passenger boardings across the entire system. A special thank-you to HSR staff for making this database available, and for their cooperation on this project. Without this data, the results of this report would not be so meaningful.

The total daily boardings derived from this database, and by further extrapolation to yearly boarding figures, are in Table 4. The Boarding data included all of the different fare types and noted special characteristics of the rider, such as whether they loaded a bicycle, or were in a wheelchair. Those types of boardings were double-counted, so the totals were adjusted by factoring in fare versus non-fare boardings. Transfers were also tracked, so the total boardings were adjusted by the transfer rate applicable to ticket and cash fares, in order to arrive at a revenue-passenger number. Through a further analysis of the proportions of fare categories by boarding, an average revenue per boarding of $1.40 was determined, based on an adult cash fare of $2.55, ticket fare of $2.00, a range of $1 to $2 for the various types of passes, and zero for “Free” boarding categories and transfers.

The reported HSR revenue-passenger ridership in 2008 was 20,952,826, (CUTA, 2008) and the total adjusted boardings from the database is 21,252,451 revenue-passengers, a discrepancy of only 1.4%. Considering that the database represents a sampling of just 3/365 days for each route, this data is very reliable!

Table 4 - HSR Daily and Yearly Boardings and Revenue Passengers

Day	Boarding	Days/Yr	Total
Weekday	110,210	260	28,654,600
Saturday	50,979	52.5	2,676,397
Sunday	32,200	52.5	1,690,500
Annual Total			33,021,497
Adjustment for Transfers	35.64% of boardings		21,252,451 Revenue Passengers

CURRENT A-LINE & B-LINE RIDERSHIP

The tabulation of ridership for the A-Line and B-Line for this report began by identifying all of the bus stops along the corridors, and cross-referencing to the different routes currently servicing them. A series of queries were then executed to find the total ridership for each corridor. Care was taken to ensure the most relevant data was captured for routes such as Delaware/ University, which have a number of routing variations and also service areas beyond the B-Line corridor. Another example is James Street North, where only Route 2 in-bound data was used, because out-bound riders are unlikely have the A-Line corridor as their destination, and transfers would be captured at the Downtown terminal stops. The results by route, service level and the total for each corridor are shown in Table 5.

Table 5 - A-Line and B-Line Corridor Total bus stop Boarding

Current A-Line Route-Specific Passenger Boardings		
Route Captured	Weekday Boarding	Weekday, Sat. & Sun. Boarding
Route 27 (Upper James)	3,118	6,571
Downtown to College (20, 21, 33, 35)	7,122	11,524
James North (2, 4)	826	1,483
Total	11,066	19,578

Current B-Line Route-Specific Passenger Boardings		
Route Captured	Weekday Boarding	Weekday, Sat. & Sun. Boarding
Route 1 (King)	15,461	32,198
Route 10 (B-Line Express)	7,023	7,023
Route 5/51 (Delaware/University)	13,518	25,886
Total	36,002	65,107

A new passenger boarding survey was conducted by the HSR at Mohawk College in March, 2011, which showed that ridership to/from the college had increased by between 68% and 84% due to increased enrollment at the College. For the purposes of the boarding data used for this research, the Downtown to College weekday boarding total in Table 5 was increased by 1,100, a rounded median value to account for the increase at the College.

Total annual boarding was calculated by multiplying the Weekday value by 260, the number of weekdays in a typical year, and the Saturday & Sunday value by 105, the number of weekend days in a year. The result is shown in Table 6. The "A-Line Core" is the passenger boarding volume for the north section of the A-Line between the Waterfront and Mohawk College only, see Figure 12.

Table 6 - Annual A-Line and B-Line Boarding Volume

Total Annual Passenger Boardings		% of Total HSR
A-Line	3,319,784	10%
A-Line Core	2,329,548	7%
B-Line	10,873,980	33%

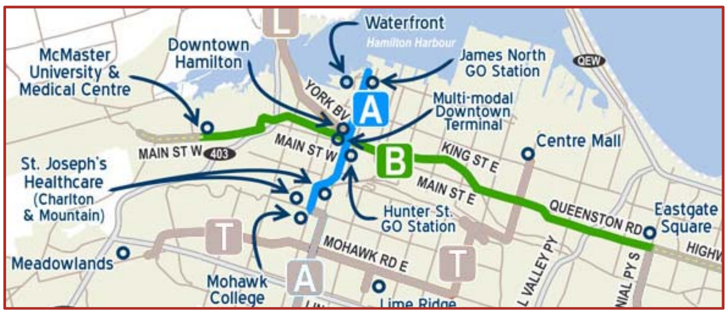

Figure 12 - A-Line Core (Phased) Option
(Hamilton Rapid Transit, 2011, With Modification)

6. TECHNOLOGY CHOICES

The two rapid transit technology choices for Hamilton are Light Rail Transit (LRT) and Bus Rapid Transit (BRT). LRT, Figure 13, has a high initial capital cost, due to the installation of tracks and overhead wires, compared to BRT, which can operate on normal roadways. The inverse is true for operational costs. LRT is less expensive to operate, because each train has a higher passenger capacity than an articulated (high-capacity) bus, therefore the labour cost for the vehicle operator is cheaper on a per-passenger basis. The life cycle of an LRT train is typically 25 to 30 years, but only 17 years for a bus (City of Vancouver, 2006, pp. 2). An October 13, 2011 city staff report to Hamilton City Council posits that operating LRT on the B-Line will result in 18 buses being removed from the HSR network, resulting in annual savings of $5.7 million (Hamilton, 2011).

Figure 13 - LRT Operating in Portland, OR. Photo: Ian Dunlop

The HSR currently operates an express bus service along the B-Line with hybrid-diesel articulated buses; see Figure 14. The difference between the current level of service and a full BRT system, is the latter provides more efficiency and passenger amenities such as dedicated lanes, station-style bus stops, traffic signal priority, and real-time information systems.

Figure 14 - Current HSR BRT Service Along the B-Line. Photo: Cindy Slinn, HSR

LRT takes the efficiencies and amenities of BRT system further, by operating in a dedicated right-of-way, offering a smoother, quieter, more comfortable ride and thereby a better overall passenger experience. Much of the literature also touts the psychological factors that play a role in the popularity and increases in ridership associated LRT. The curb lane of city streets, the one buses use most, tend to be the roughest and most pot-holed, and are sloped for water drainage, resulting in a bumpy, rattled ride for bus passengers. People want "a feeling that transit is an important part of exciting urban living." (Vuchic, 2005, pp. 553)

Another possible choice, which does not yet appear to have been explored in detail during the current planning process, is a return to electric trolley buses. Translink in Vancouver operates a fleet of 228 trolleys, which is about the same size as Hamilton's entire bus fleet of 217 (CUTA 2008, 2010).

Figure 15 - Translink Articulated Trolley, Mfr. by New Flyer Industries. Photo: Steve Morgan

Although trolleys cannot claim the same, smooth ride as LRT trains, they are very quiet compared to diesel buses. Trolleys are also a smoother ride than diesel buses because they do not require a transmission, which causes the bus to lurch as it changes gears. Trolleys have obvious flexibility advantages to LRT because they can change lanes, and maneuver around disabled vehicles, whereas an LRT does not have such capability when the track is blocked. Translink recently purchased a new fleet of articulated trolleys from New Flyer industries, which have proved to be very popular with riders.

The new, articulated trolleys were purchased in 2005 at a cost of approximately $1.2 million each, while articulated diesel-hybrid buses cost is $1 million each. LRT trains are $3 to $5 million each (Metrolinx, 2008). Trolleys last longer, and the energy costs are 56% lower, compared to diesel buses. (Gilbert & Perl, 2010, citing Anderson, P.G.)

ENVIRONMENTAL BENEFITS

Energy choice also favours electric propulsion. Oil prices have fluctuated wildly since 2008, resulting in high diesel fuel costs. As noted earlier in this paper, there are no longer incentives for the HSR to continue operation of their natural gas fleet after the current CNG fleet is fully retired.

However, the LRT's electric power can claim zero-emissions at source, due to Hamilton's proximity to Niagara Falls. Therefore, not only does LRT offer operational cost savings through its inherently low resistance and electric-powered efficiency, it also offers significant environmental benefits. Table 7 shows the possible reduction in CO_2 emissions for electric LRT/Trolley compared with diesel BRT on the A-Line and B-Line. Diesel fuel consumption is based on the HSR's reported fleet fuel consumption (CUTA 2010, pp. 38), with a 25% reduction to account for the *claimed* fuel economy benefits of hybrid-diesel buses.

Based on these figures, the HSR's fleet CO_2 emissions are currently 17,450 tonnes/yr, or 1.87 kg/km, which could be reduced by 4,985 tonnes/yr, down to 1.47 kg/km with the use of electric vehicles on the A-Line and B-Line. By comparison, Translink's current fleet emissions are 1.36 kg/km (based on CUTA 2008, pp. 28). Interestingly, a car with a fuel economy of 6L/100km would produce 0.14 kg/km. These emissions are based on 2.73 kg/L of diesel fuel and 2.36 kg/L of gasoline and 1.9kg/cubic metre of CNG (Gilbert & Perl, 2010, pp. 175).

Table 7 - Carbon Footprint of BRT vs LRT, related to current HSR Fleet

Route	Vehicles	Route Length (km)	Trips/Day	Roundtrip Travel (km)	L/100km	Diesel Bus Consumption (L)	kg/day CO_2 Emissions	Tonnes CO_2/yr	LRT/Trolley
A-Line	21.00	16.30	136.00	4,433.60	60.19	2,668.50	7,151.59	2,231.30	0.00
B-Line	36.00	14.10	194.00	5,470.80	60.19	3,292.78	8,824.64	2,753.29	0.00
Total	57.00	30.40	330.00	9,904.40	60.19	5,961.28	15,976.23	**4,984.58**	**0.00**
				System km/yr		**System Fuel Use**	**kg/yr CO_2**	**Tonnes/yr**	**Reduction**
System	217.00	Buses		12,454,662.00	Diesel	6,494,436.00L	17,405,088.48	17,405.09	
	141.00	Diesel			Nat Gas	3,103,648.00CM	5,896,931.20	5,896.93	
	76	CNG			Total		23,302,019.68	23,302.02	**-21.39%**

Gilbert (2006), in a report prepared for Hamilton City Council, posits that by 2018, natural gas and oil production will peak, if not earlier. This phenomenon known as "Peak Oil" is expected to cause dramatic rises in the cost of all carbon-based energy, which will also have a significant impact on the HSR's operational costs if there are no actions being taken by then to adopt alternatives.

7. POPULATION & RIDERSHIP PROJECTIONS

Population and ridership growth have been projected to 2041 using a linear regression technique. As was revealed through a lecture presentation, linear regression analyses the available statistical data to calculate a trend, or a "line of best fit". Although a simplistic approach, because no extraneous factors are considered, linear regression is a useful tool in predicting future behaviour if the historical trend continues. As demonstrated below, the trend from one result can be transposed to another, to develop different "what if" scenarios.

POPULATION

The population counts for the census tracts used in Table 3 were compiled back to 1986, giving us a 20-year population profile up to the last Census in 2006. Unfortunately, the 2011 census population data will not be released by Statistics Canada until February, 2012. The regression projections for the A-Line and B-Line corridors are shown in Figure 16 & Figure 17.

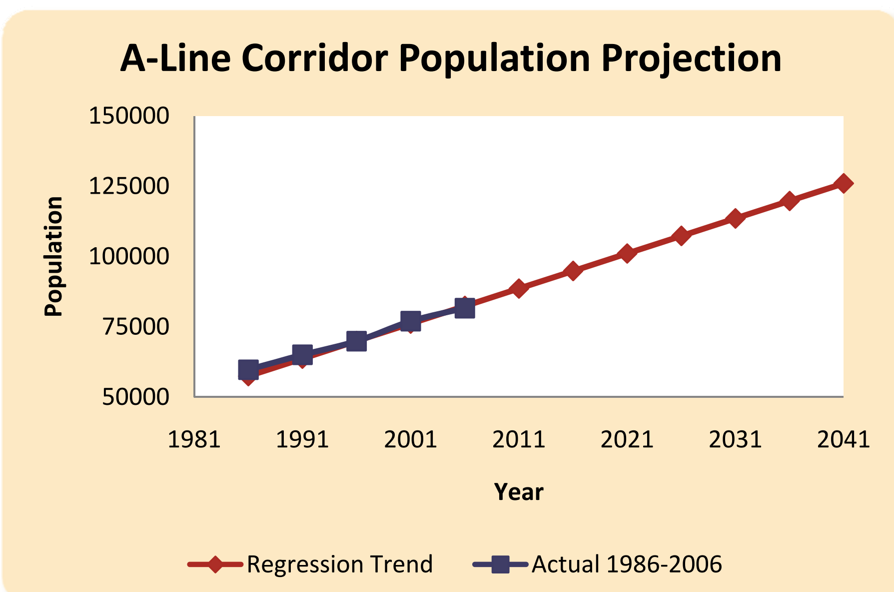

Figure 16 - Linear Regression Projection for A-Line Population
(Actual based on Statistics Canada Census data, compiled by tract, 1986-2006)

The trend for the A-Line is for the population to continue increasing at a steady pace, as the city continues to expand its urban area southwards, particularly in the area between the Lincoln Alexander Parkway and the Airport Employment Growth District. Some of the tracts in the A-Line Core area experienced a decline over the same period. As a whole, the growth rate for the corridor is approximately 1.1% per year.

The current growth trend for B-Line is not as progressive. The gradual population decline noted for the A-Line Core tracts is present in many of the tracts along the B-Line corridor. For many years, the population decline has mirrored a socio-economic decline in the "Lower City". However, there is great optimism for the rebirth of these areas, as can be seen in several up-and-coming neighbourhoods like Locke Street, James Street North and Ottawa Street. The introduction of all-day GO Train service to the new James North station is expected to spark further rejuvenation. Many, including the author, believe that LRT along the B-Line is also an essential catalyst to ensure the long term vitality of the area, with spin-off benefits for the entire City.

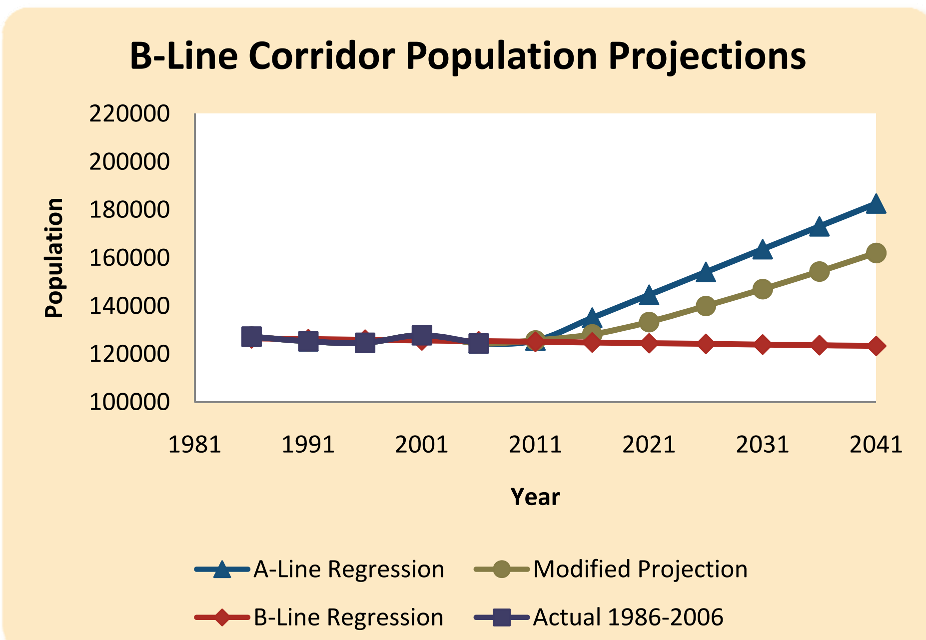

Figure 17 - Linear Regression Projection and Modified Projections for B-Line Population (Actual based on Statistics Canada Census data, compiled by tract 1986-2006)

Although the regression trend for the B-Line corridor population calls for decline, the Ontario Places to Grow Act (Ministry of Public Infrastructure Renewal, 2006) calls for a 30% population increase across the GTHA by 2031, and at least 40% of this new growth must be through intensification of existing urban areas. The B-Line corridor has great potential for intensification, with low real estate prices and new zoning on the way to foster redevelopment.

The regression trend for the A-Line is very close to the 30% population increase by 2031 target. This trend has been transposed to the B-Line, and is represented by the green trend line in Figure 17. With this trend, population will increase from 125,600 today to 182,609 by 2041. The sudden shift to this growth trend will not happen overnight, so the modified projection line, shown in purple, plots a more gradual curve towards this ultimate trend.

RIDERSHIP PROJECTIONS

Overall ridership growth on the HSR has been modest for the past few years. Between 2007 and 2008, there was a decline of 0.5% (CUTA, 2008), which was attributed to a fare increase. Although there was another fare increase in 2010, ridership actually grew by 1.4%. According to HSR staff, ridership is up 3.2% in 2011, and shows no signs of slowing down.

The overall growth regression trend for the HSR, excluding the 2007 data, is shown in Figure 18, next page. At this rate, indicated by the blue line, HSR ridership growth will not keep pace with the projected 30% population growth. If ridership grows in lock-step with the 30% population growth trend, the result will be the green line on the graph, topping out at 28 million revenue passengers year in 2041, compared with 21.5 million today. With the urban intensification imposed by Places to Grow (Ministry of Public Infrastructure Renewal, 2006), and the more ambitious overarching goals of Metrolinx (2008) to increase transit use in the GTHA, a 100% increase by 2031 is also graphed by the purple line. Under this scenario, overall revenue passenger ridership will climb to 43 million passengers in 2031. This ridership growth is equivalent to 3.527% per year, slightly higher than the growth rate reported for 2011. This rate will be used in the cost/benefit analysis which follows. The resulting projected boarding volumes for the corridors are shown in Table 8.

Other cities with LRT systems, and relevant literature, report a significant increase in ridership after the LRT is operational. Phoenix, AZ, for example, experienced ridership increases 25% higher than forecast during weekdays, and 60% higher on Saturdays shortly after their system opened (Holstege, 2009). Vuchic (2005, pp. 547) cites the example of an LRT line in Philadelphia and a BRT in Washington, DC, both opened at the same time, with similar alignments and demographic profiles. The ridership on the LRT is 24% higher than the BRT line.

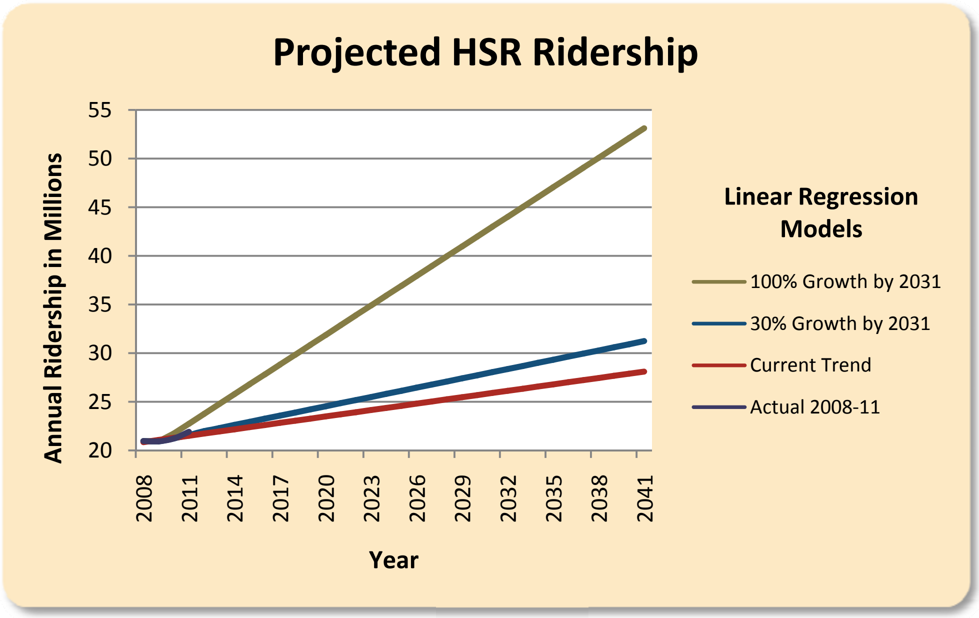

Figure 18 - Linear Regression Projections for HSR Ridership

Table 8 - Projected Passenger Boardings

Year	2011	2021	2031
A-Line	3,319,784	4,694,887	6,639,578
A-Line Core	2,329,548	3,294,481	4,659,103
B-Line	10,873,980	15,378,141	21,747,992

No similar jump in ridership has been added to the estimates for the Hamilton LRT option cost/benefit analysis. In the models used above, ridership will have increased by over 40% by 2021, on its way to doubling by 2031. This growth seems sufficient and realistic for the models which follow, and levels the playing field between the LRT and BRT options.

8. COST/BENEFIT OF LRT VS. BRT

A Cost/Benefit analysis is a useful undertaking for large capital projects. We need to see how the long-term benefits of the project, especially those with a high upfront cost, could pay off later in the project's life. The benefits that may come at some point in the future have to be adjusted to their present-day value in order to make the comparison meaningful. Inflation or other market conditions affect the value of future-dated costs benefits over time. These factors become more important if money has to be borrowed to pay for the project.

The effect of inflation means that a dollar we receive today is not worth the same as a dollar we receive 20 years from now. It will likely be worth less, in terms of its purchasing power (i.e. its net benefit) while a dollar we received 20 years ago would have been worth more at the time. Therefore, along with increasing future costs and benefits for factors like inflation, they must also be discounted to state them in their present value. Discount rates can be based on factors such as bank or investment interest rates.

A summary of the Capital Costs, Operating Costs and other Cost/Benefit model parameters is included in Table 9, and are explained in detail below.

CAPITAL COSTS

The LRT capital costs (construction, vehicles) of $875 million for B-Line (City of Hamilton, 2011) will also be used for the A-Line model. The rationale for using the same figure is based on the additional construction costs related to the Mountain crossing and the longer length of the route, balanced with the lower construction costs for the suburban and rural sections of the line. These assumptions appear to be appropriate in comparison to the A-Line sectional costs estimated in McCormic (2008).

The BRT capital costs for B-Line are estimated at $264.7 million (City of Hamilton, 2011). The A-Line figure was reduced by 30% to $185.29 million, as the escarpment crossing will use the existing James Mountain Road access, and again, the suburban areas of the route will require less infrastructure than the urban B-Line. For the Trolley option, this cost was doubled, to allow for the 20-30% additional trolley bus purchase price (Metrolinx, 2008), and cost of installing the electrical wiring and infrastructure. Gilbert & Perl (2010, pg 160) posit that trolley construction is only $1 million more per km than diesel BRT, but this seems optimistically low. Further research is needed to ensure the trolley estimate is accurate.

For the A-Line Core LRT, 60% of the full-route cost, or $525.3 million, has been assumed. Although this section it is only about one-third of the full A-Line route length, construction and infrastructure costs will be high through the downtown and building the mountain access tunnel. A second option for A-Line Core LRT via Claremont Access is estimated at $100 million less, as per McCormic (2008). For BRT, the estimated cost of $105.88 million is based on 40% of the full A-Line BRT cost, as the Core section should require proportionally less new infrastructure than LRT.

OPERATING COSTS

Lower passenger boarding costs for LRT, and electric transit vehicles in general have been well documented in the available literature on the topic. In St Louis, MO, for example, the per passenger operating costs are $2.49 for bus and $1.32 for LRT (Condon, 2010, p.p. 17, citing Lyndon, 2007). By comparison, the HSR's current system-wide operating cost per passenger is $3.19 (CUTA, 2010). To provide a benchmark for the estimated operating costs of the proposed LRT and BRT options, this cost/benefit analysis will reference the same City of Hamilton (2011) report used for determining the capital costs. The annual B-Line LRT operating cost is $7.8 million and BRT operating cost is $16.1 million. For the A-Line, these numbers have been reduced by 30% to $5.46 million and $11.27 million respectively, to account for the A-Line's lower frequency of service, and likewise the fewer vehicles required. A service level of every 7.5 minutes peak and every 10 minutes off-peak is assumed appropriate for initial A-Line service, compared to 4 minutes peak and 7.5 to 10 minutes off-peak for B-Line.

Operating costs used for A-Line Core are 50% of B-Line, accounting for the shortened route but a service level similar to the B-Line being warranted by the volume of passengers. For the A-Line Core via Claremont Access option, the disadvantages of the longer route have been factored through an increase in the A-Line Core operating cost of 50%, to account for the longer distance and travel time. The Claremont option will also require one more LRT vehicle operating in each direction, and continuing to maintain bus service on James Mountain Road. A one-third penalty in passenger boarding is also estimated, due to the less convenient routing compared to the more direct bus service.

COST/BENEFIT MODEL PARAMETERS

All of these numbers have been used as the initial values in the Cost/Benefit analysis model. An operational date of 2021 is assumed. Initial costs have not been adjusted for inflation to that date, because our benchmark for analysis is in "today's dollars", in 2011. If the future-dated 2021 value of the capital cost of $875.5 million were used, it would actually be $1.13 billion at the current inflation rate of 2.9% (Bank of Canada Annualized Inflation Rate, Oct. 2011, from www.bankofcanada.ca), and then discounted back to this year. As the intent of this research is to provide a comparable cost/benefit analysis across the different options, introducing this step would only add unnecessary complexity and be a distraction from the actual results.

Each Cost/Benefit table spans a 25-year period, from 2021 to 2045, which is the average lifespan of an LRT vehicle (City of Vancouver, 2006). For revenues, the previously calculated revenue per boarding of $1.40 is applied, and increases at an annual inflation rate of 2.9%. No additional capital cost inputs for reconstruction, expansion or new vehicle purchases are included during this time-span. All regular maintenance and repair costs are assumed to be covered by the Operating Costs, which increase by the rate of inflation and be further compounded by ridership growth over time. It is understood that costs ramp up over time as equipment and infrastructure ages. In the beginning, "everything is new, there is a holiday from wear and tear costs." (Newkirk, 2002, pp. 176) Thus, the operating costs will become higher in proportion to the revenues over the 25-year time span with this model.

Ridership begins with the 2021 estimate, growing by 3.527% per year, in keeping with the target to increase ridership by 100% by 2031. As noted earlier, no special consideration has been given to any difference in ridership levels between the different technologies. To determine the present-day, 2011 value of future-dated costs and revenues, an annual discount rate of 2.63% is applied (Bank of Canada Long Term Bond Rate, from www.bankofcanada.ca).

Of great importance to Hamilton's decision makers is how much of the upfront capital costs will be funded by Metrolinx. Other transit projects currently underway across the GTHA are funded 100% by Metrolinx, and this position was reiterated by senior Metrolinx staff at a City Council meeting on October 13, 2011. With the recent provincial election, economic pressures, and the funding arrangements recently announced for the Waterloo LRT project, there is concern that Metrolinx will not be able to follow-through with its promise, and the City of Hamilton will have to make up for the shortfall.

The Costs/Benefits have been modelled based on the City funding 0% (full Metrolinx funding), 10%, 25%, 33%, 50% and 100%. In any event, the City will cover the full operating costs of the chosen system. Even if the funding arrangement is for Metrolinx to cover "100%", it would be shortsighted to assume there would not be some related incidental capital and related costs to be covered by the City, perhaps in the order of 5 to 10%. The following tables summarize the cost/benefit analysis input values described above.

Table 9 - Summary of Cost/Benefit Model Input Parameters

Input Parameters	LRT Capital Cost	LRT Operating Cost	BRT Capital Cost	BRT Operating Cost
A-Line	$875.5 million	$5.5 million/yr	$185.3 million	$11.27 million/yr
A-Line Core	$525.3 million	$2.7 million/yr	$105.9 million	$10.59 million/yr
B-Line	$875.5 million	$7.8 million/yr	$264.7 million	$16.1 million/yr

Input Parameters for Alternative Options	Capital Cost	Operating Cost	Ridership
A-Line Trolley BRT	$370.6 million	$8.45 million/yr	Same as A-Line
A-Line Core LRT via Claremont Access	$425.3 million	$4.1 million/yr	33% Less

Other Input Parameters	
Time-span	25 Years
City's Contribution to Upfront Capital Costs	0% (Metrolinx will fully fund)
	10%, 25%, 33%, 50% and100% funded by the City
Operating Costs	to be covered by City
Initial Boarding Revenue/Passenger	$1.40
Inflation Rate	2.9% (October, 2011 Annualized Inflation Rate)
Growth Rate	3.527% (100% Ridership Growth by 2031)
Discount Rate	2.63% (Gov't Can Long Term Bond Rate)

RESULTS

Summaries of the Benefit-Cost Ratios (BCR) and Net Present Values (NPV) are included below, in Table 10 for A-Line, Table 11 for B-Line, Table 12 for A-Line Core, and graphed in Figure 19. The Cost/Benefit table for the A-Line LRT scenario is attached in Appendix A, to provide an example of the detailed calculations used to determine these results.

For comparison, the current HSR system-wide BCR is 0.51 (CUTA, 2010). This BCR may make any of these models seem feasible, but it is important to consider that the A-Line and B-Line corridors are the HSR's highest volume bus routes, and therefore have a much higher BCR than other routes in the system. A reduction in current the BCR on these routes will be detrimental system-wide, because the lower volume routes could no longer be subsidized by them, and service may have to be reduced to avoid a tax increase. The current A-Line and B-Line BCR (i.e. for HSR routes 1, 5, 10, 20, 27, 35, etc.) could be calculated with further research, but since the B-Line currently accounts for about one-third of all HSR passenger volume, it is almost assured that its BCR is greater than 1.

Table 10 - A-Line LRT, BRT & Trolley Results

City's % of Capital Cost	A-Line LRT		A-Line BRT		A-Line Trolley BRT	
	NPV	BCR	NPV	BCR	NPV	BCR
0%	45,109,628	1.20	-190,401,775	0.58	-76,192,932	0.78
10%	-42,440,372	0.86	-208,930,775	0.56	-113,250,932	0.70
25%	-173,765,372	0.61	-236,724,275	0.53	-168,837,932	0.61
33%	-243,805,372	0.52	-251,547,475	0.51	-198,484,332	0.57
50%	-392,640,372	0.40	-283,046,775	0.48	-261,482,932	0.50
100%	-830,390,372	0.24	-375,691,775	0.41	-446,772,932	0.37

Table 11 - B-Line LRT & BRT Results

City's % of Capital Cost	B-Line LRT		B-Line BRT	
	NPV	BCR	NPV	BCR
0%	556,528,354	2.76	220,083,494	1.34
10%	468,978,354	2.16	193,613,494	1.29
25%	337,653,354	1.63	153,908,494	1.21
33%	267,613,354	1.44	132,732,494	1.18
50%	118,778,354	1.16	87,733,494	1.11
100%	-318,971,646	0.73	-44,616,506	0.95

Table 12 - A-Line Core LRT Routing Option Results

City's % of Capital Cost	A-Line Core LRT via James		A-Line Core LRT via Claremont	
	NPV	BCR	NPV	BCR
0%	76,298,930	1.69	-29,662,966	0.81
10%	23,768,930	1.15	-82,192,966	0.60
25%	-55,026,070	0.77	-160,987,966	0.44
33%	-97,050,070	0.66	-203,011,966	0.38
50%	-186,351,070	0.50	-292,312,966	0.30
100%	-449,001,070	0.29	-554,962,966	0.18

Note: HSR's Current System-Wide BCR is 0.51 (CUTA, 2010)

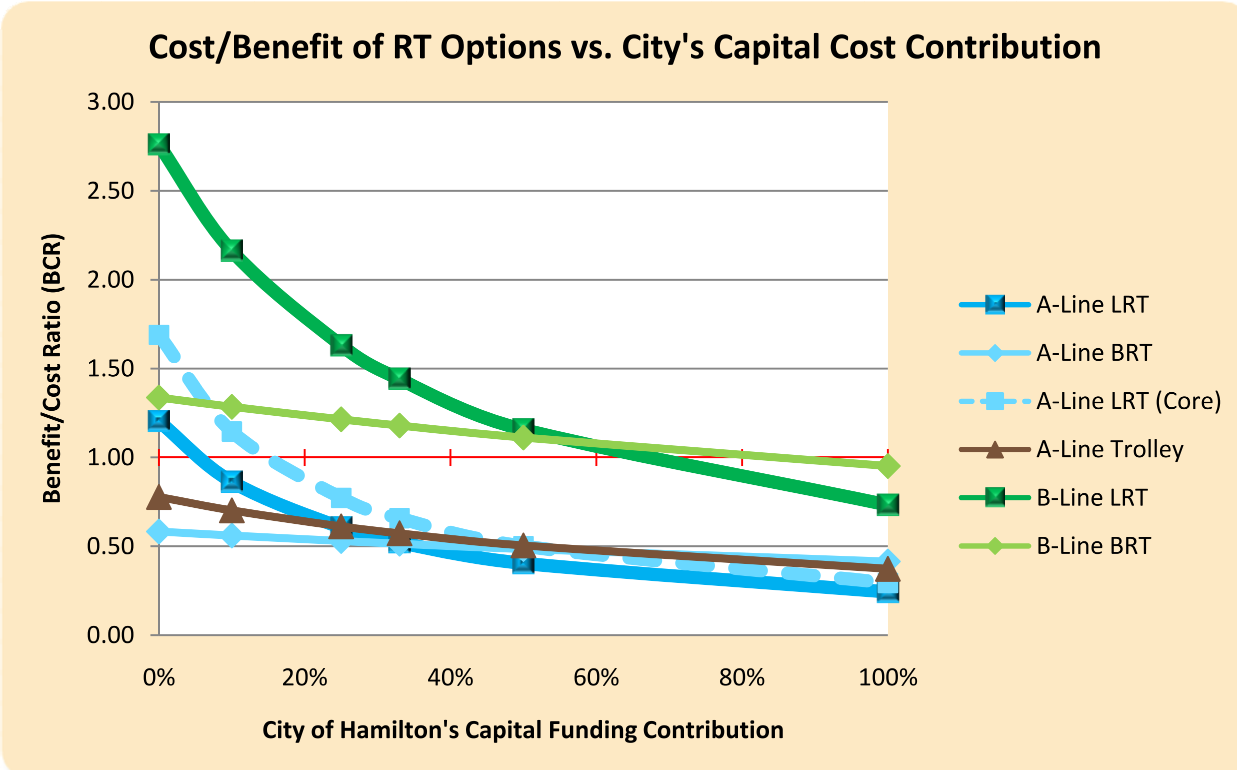

Figure 19 - Comparison of BCR for A-Line & B-Line LRT/BRT Options

From the results in Tables 10 to 15, the Opportunity Cost, which in this case is the difference in Net Present Value of LRT versus BRT, can be calculated. The Opportunity Cost reveals what the City of Hamilton will pass-up over 25-year period by choosing BRT over LRT. With 100% funding from Metrolinx, the cost to the City of not building LRT is $235,511,403 for A-Line, and $336,444,860 for B-Line.

PROJECT TIMING

Ridership being a key issue on the A-Line, another cost/benefit model was tabulated, based on opening the LRT 10 years later, in 2031, see Table 13. The BCR is much better in this model, because the ridership would have increased by 100%, compared with 2011 levels.

Table 13 - BCR of Delaying A-Line LRT by 10 Years

City's % of Capital Cost	A-Line LRT Opening in 2021		A-Line LRT Opening in 2031	
	NPV	BCR	NPV	BCR
0%	45,109,628	1.20	155,470,327	1.70

10%	-42,440,372	0.86	67,920,327	1.22
25%	-173,765,372	0.61	-63,404,673	0.86
33%	-243,805,372	0.52	-133,444,673	0.74
50%	-392,640,372	0.40	-282,279,673	0.57
100%	-830,390,372	0.24	-720,029,673	0.34

DEBT FINANCING AND PROPERTY TAX IMPACT

The Cost/Benefit analysis shows that the City of Hamilton could contribute, in the case of the B-Line, a substantial portion of the capital cost, and still come out ahead. But, where would this money come from? Unfortunately, there is no pool of millions of dollars set aside somewhere, which the City could tap into to pay for its portion. Such a large capital investment cannot be paid through an increase to the property tax assessment alone, without being done so over a number of years. The current political climate in Hamilton is not favourable anything that would increase property taxes, so for this reason the cost/benefit model does not consider any non-market indicators, such or environmental and social benefits.

The necessity is debt financing, to borrowing the money to pay for the upfront capital cost investment, and paying it off over a number of years. However, the interest paid on such a loan could be substantial, so will there still be a net benefit to the City, and at what thresholds?

The parameters in Table 14 will be used for the debt-financed model. The model will assume equal payments to be made each year over the financing term, like a mortgage.

Table 14 - Cost/Benefit Input Parameters for City Debt-Financed LRT

Input Parameter	Value
Term of Financing	20 Years
Interest Rate	5.5%
Discount Rate	5.0% based on City's long-term debt discount rate (Hamilton, 2010b)
Opening Dates	2021 B-Line
	2026 A-Line Core (Phase 1) 2031 A-Line (Phase 2 to Airport)

The BCR results are shown in Table 15, below, along with whether or not a property tax increase would likely be necessary to finance the project.

Table 15 - BCR Results for City Debt-Financed LRT, With Assessment Impacts

% Capital Cost	B-Line LRT 2021	Tax Impact (+ up, - down)	A-Line LRT 2026-2031	Tax Impact (+ up, - down)
0%	2.76	– –	1.74	–
10%	1.61	–	0.85	Neutral
25%	0.99	Neutral	0.48	+
33%	0.82	+	0.39	+ +

From this analysis, if Metrolinx fully funds the project, the cost of operating the HSR to the taxpayers of Hamilton will actually go down. At the 10% level, the excess benefits from B-Line could be used to accelerate debt repayment and offset the city's capital contribution towards a phased A-Line. With a 25% city-financed project, the B-Line still comes out strong, with no net tax impacts. However, proceeding with the A-Line LRT financing at the 25% level would increase the assessment rate, based on these parameters. But as we saw in Table 10, an A-Line BRT could have a similar tax impact due to its high ongoing operating costs, even though it is not debt-financed. To think that choosing neither solution is an option is also short-sighted, because future bus service will have to be provided in response to growing demand, which will continue to increase the HSR's operating costs.

As noted before, the HSR's current system wide BCR is 0.51, but the reason why the B-Line's 0.82 BCR at 33% could result in a tax increase is because the B-Line corridor currently brings in substantial revenue for the HSR, and thereby subsidizes the lower-performing routes. The loss of revenue from the B-Line could hurt HSR service elsewhere, or raise its share of assessment. Another consideration is that the high cost of debt in the first few years of operation could result in additional interest costs if repayment must be deferred, or a short-term tax increase. The actual current BCR of the B-Line bus routes should be calculated for more certainty on this matter, as part of further research.

FURTHER RESEARCH

In addition to determining the current BCR on the A-Line and B-Line corridor bus routes, there are several other cost and benefit variables that can be introduced to this mode. These variables could provide a broader picture of the long-term benefits of the project. For example, the reduction of nearly 5,000 tonnes of CO_2 per year has benefits which can be quantified through market methods, such as applying the European Union's $35/tonne trading price. Non-market benefits like improving air quality and reducing pollution-related healthcare costs can also be introduced. This more detailed analysis may improve the argument to consider electric trolley technology for an A-Line BRT over diesel-hybrid buses.

Costs can be further offset by considering the employment and economic benefits generated by the construction and operation of the rapid transit system. A B-Line benefits case published by Metrolinx (2010) outlines some of these figures, including $201 million in salaries, $487.5 million in local GDP for B-Line LRT construction. B-Line development and property value assessment uplift are be examined in a separate Strategic Interchange report. Further research can be conducted to consider these additional benefits for A-Line, which only strengthens the argument for the LRT option under the right capital cost sharing formula. An estimate of the actual property tax impacts could also be calculated, as could the cost of not building LRT at all.

9. CONCLUSIONS

LRT for the B-Line is the clear winner in this BCR contest, but this is virtually a foregone conclusion to everyone involved in its planning. There are clear benefits to the City, even if required to contribute a portion of the project's capital cost. LRT's lower operating cost and great capacity to handle the high-volume of B-Line passengers provides significant ongoing benefits to the City, by reducing overall transit operating costs, subsidizing the HSR's conventional bus service to outlying areas, or some combination of the these. If the City passes up the opportunity to build LRT on the B-Line, it is also passing up the opportunity for significant financial benefits.

The benefits case for LRT on the A-Line is not as strong. The BCR quickly drops to below zero even with a modest capital contribution by the City. However, with the higher operating cost of BRT, the LRT does warrant some consideration up to the point of a 25% capital outlay. The BRT option appears to be hindered by the low ridership on the route, making it difficult to justify operating buses at a very high headway frequency when the ridership demand is not demonstrated. Depending on what the current BCR of the A-Line conventional bus service is, a case could be made in favour of Trolley technology. Trolleys offer some LRT characteristics, such as quiet, clean operation and significant environmental benefits compared to diesel buses, but with a lower capital cost than LRT.

Ridership on the A-Line Core section is much higher than on the rest of the suburban route. Therefore, a phased approach for LRT should be considered. After the A-Line Core is built, the line will be gradually extended from Mohawk College to the Airport. Expansion should be in response to development in the Airport Employment Growth District, and increased air-passenger volumes at Hamilton International Airport, see map, Figure 10. These destinations will increase ridership and service demand in the suburban areas. But the City should avoid a "build it and they will come" approach by extending the line too soon.

However, one more consideration is for the route of the LRT. As shown in Table 12, any alternative routing with the potential to increase operating cost and reduce ridership has a detrimental effect on the BCR. Although the Claremont LRT route will be less expensive to build, and perhaps less controversial, it is clearly not as desirable as the direct route up James. Effort should therefore be spent on convincing the skeptics of the environmental benefits of boring a tunnel through the Escarpment to service the College, Downtown and the two GO Stations in the most direct and efficient manner possible, with a sustainable, zero-emissions technology.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

1. **Build B-Line LRT**
   - Ideal funding commitment for City, without an assessment increase, is 10% to 25% of B-Line capital cost.
   - B-Line LRT will generate substantial revenue for the HSR.
   - Lower operating costs than the existing bus service.
   - Work must be started as soon as possible so it is in operation by 2021, if not sooner.
2. **Build A-Line LRT in Phases**
   - A-Line Core section LRT as Phase I, by 2026.
   - Route must be direct, requiring a tunnel.
   - College to Airport section by 2031-2035, or as influenced by population, employment and airport growth.
   - Ideal funding commitment for City, without an assessment increase, is up to 10% capital cost.
   - A-Line BRT service could be expanded and enhanced as an interim measure, as Brampton, Mississauga and YRT are doing.

The upfront capital costs associated with LRT are daunting, and this project can only be made feasible with the bulk of funding coming from upper levels of government, through Metrolinx. Capital works projects of this magnitude are traditionally funded in large part by upper levels of government, as the municipal property tax system is not well suited for financial burdens beyond ongoing municipal operations, maintenance and growth related expansion of existing infrastructure. Hamilton City Councillors are rightly concerned about placing such burdens on the property tax base, and the citizens of the city. But as this report has shown, ongoing operational costs will be lower than bus service. If Metrolinx fully funds, or comes close to full capital funding for the project, the opportunity cost to the

City of not building LRT, and instead choosing BRT, is $235,511,403 for A-Line, and $336,444,860 for B-Line over 25 years. This potential benefit to Hamilton, totaling over half a billion dollars, without even considering other spin-off benefits for the City, should not be passed up.

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