LRT PROJECT EVALUATION

AN ECONOMIC ANALYSIS OF LRT PHASE 1

Index of cost evaluation issues:

1. INTRODUCTION

In November 2009[1] and again in December 2012[2] the City Council of Ottawa accepted an *OC Transpo* recommendation to replace the bus transitway with a light rail transit line running from Tunney's Pasture through downtown to Blair Station. The project was set to cost $2.1B[3] and be ready in 2019.

Why look at past decisions on LRT phase 1?

On October 23, 2013, Ottawa announced a $2.5B extension of Ottawa LRT westward to Bayshore, Eastward to Place d'Orleans, and northward to Baseline[4].

The original 2008 plan and the 2013 plan call for light rail included north-south rail extensions to Walkley and Hunt Club, further extensions to the Ottawa Airport and to Riverside South[5]. The cost of these further extensions will be in excess of the $2.5B committed to Phase 2.

With $2B spent and possibly $4B yet to spend, it is relevant to understand what the actual economic cost of *Phase 1* is, in order to to appreciate the full costs and benefits of further phases. This will allow a proper perspective on further phase decisions.

The economic question is always one of *relative* cost of solving a problem. In this case the problem is travel, mostly work-travel, at peak hours, from suburb to downtown and back. How much does travel solution "A" cost relative to travel solution "B" or travel solution "C"? In Ottawa's case there are several possible solutions to the perceived travel problem for which LRT phase 1 was chosen. Likewise there are other travel solutions to LRT phase 2 and phase 3.

By discussing the economic cost of phase 1, Ottawa decision-makers will get a better sense of a number of factors: firstly, the likely demand for LRT trips, secondly, the best way to contract to build future phases, thirdly, the pricing-possibilities of the transit ticket, fourthly, whether a bus-only system is superior to a bus + LRT system, fifthly, whether the LRT generates green benefits, sixthly whether LRT generates intensification benefits. Finally, whether to proceed with phase 2 and phase 3.

As a first step, (a step that has not yet been comprehensively taken on LRT phase 1), is to get a careful appreciation

1 Ref. No. **ACS2009-ICS-TRA-0015**; October 20, 2009 (see appendix to this city document)

2 Ref. No. **ACS2012-ICS-RIO-0004**; December 4, 2012;

3 *Downtown Ottawa Transit Tunnel Project: Business case,* **Metropolitan Knowledge International, Delcan Corporation,** March 26, 2010, p.iii

4 See Transportation Master Plan 2013, p.55;

5 See plan #4: ***Report to the Joint Transportation and Transit Committee*** (April 15, 2008) Ref No: **ACS2008-PTE-PLA-0016**

of the likely *costs per trip*, the likely *subsidy per trip*, the likelihood of increased demand for LRT transit, the likelihood of mode-switch and the likelihood of LRT-generated intensification. All these things have been vaguely talked about without having been definitely considered on LRT phase 1. An attempt is made to do that here so that our approach to phase 2 and phase 3 will be more informed.

What do people think when subsidizing transit is discussed?

When people think about Ottawa LRT they perhaps start with the view that *'public transportation is subsidized in every city'*. The view may be that there is nothing really *wrong* with LRT subsidies since public transportation in general is subsidized[6].

Even though all public transportation is subsidized, we still want to be careful about how much we subsidize. For instance, the city of Buffalo now subsidizes a 10-kilometre LRT ride in the amount of $62 per ride[7]. Certainly, Ottawa would not want to end up in a situation where that amount of subsidy was expected.

6 For any project, basic economics of public-sector cost benefit decision-making stipulates that ridership-revenue is expected to cover operating+capital costs per trip with the full capital repaid over a determined and depreciated life of the project.In large-scale projects such as LRT the life is deemed to be 30 years and fare-revenue is generally expected to cover all costs. This does not happen in practice, but it is important to keep real costs and real benefits in mind even in cases where cities are prepared to heavily subsidize. see: ***Contemporary Engineering Economics, a Canadian Perspective,*** Addison-Westley, Toronto, 1995

7 Buffalo LRT annual operating costs are $280M with $18M debt servicing costs for a city of 260,000. That amounts annually to $1154 per resident for 4,800,000 total work trips provided by the system. The 2012 cost structure of Buffalo LRT produces a per-trip cost of $62. See p.14 of the analysis below.

What is LRT cost per trip in other cities?

Buffalo is a worst-case example, but unfortunately, these type of runaway costs-per-trip are characteristic of many American LRT cities. The fact is that LRT is significantly more expensive than buses (for the same routes that buses used to service before the LRT entered those cities).[8]

LRT is cost-effective in some places. These places tend to be in Asia where density is in the range of 10,000 to 20,000 people per sq. kilometre.[9] Ottawa density is 196 people/km^2.[10]

LRT does not pay for itself in any other North American city because density is too low. More specifically, the reason LRT

8 See Alejandro Tirachini, David A. Hensher ,Sergio R. Jara-Díaz, *Comparing operator and users costs of light rail, heavy rail and bus rapid transit,* **Research in Transportation Economics**, 29 (2010) 231-242;

Allport, R. J. (1981). The costing of bus, light rail transit and metro public transport systems. **Traffic Engineering and Control**, 22, 633-639;

Boyd, J. H., Asher, N. J., &Wetzler, E. S. (1978). *Nontechnological innovation in urban transit: a comparison of some alternatives*. **Journal of Urban Economics**, 5, 20.;

Bruun, E. (2005). *Bus rapid transit and light rail: comparing operating costs with a parametric cost model.* **Transportation Research Record,** 1927, 1-21;

Dewees, D. N. (1976). *Urban express bus and railroad performance: some Toronto simulations*. **Journal of Transport Economic and Policy**, 10, 16-25;

Evans, J. (2005). *Capacity and cost comparisons of rapid transit modes*. In Institute of Transportation Engineers annual meeting, Melbourne, Australia.;

Hensher, D. A. (2007). *Sustainable public transport systems: moving towards a value for money and network-based approach and away from blind commitment.* **Transport Policy,** 14, 98e102.

Meyer, J. R., Kain, J. F., & Wohl, M. (1965). *The urban transportation problem.* Cambridge, Massachusetts: Harvard University Press.

Smith, E. (1973). *An economic comparison of urban railways and express bus services*. **Journal of Transport Economic and Policy**, 7, 20-31.

9 See: Zhi-Chun Li a,b, William H.K. Lam a,□, S.C. Wong c, A. Sumalee a, *Design of a rail transit line for profit maximization in a linear transportation corridor*, **Transportation Research Part E** 48 (2012) 50–70 51

10 Statistcs Canada, metropolitan population and dwelling counts, 2011

is too expensive (compared to buses) for North American cities is that the subsidy that each city has to provide for an LRT trip is substantially greater than the subsidy that each city has to pay to provide the same trip by bus. The infrastructure cost of LRT makes the difference.

Does LRT bring green benefits that outweigh the cost differential?

People in Ottawa are also told LRT is clean energy. It significantly reduces auto-us[11], produces density and therefore produces large environmental gains. None of these results actually occur in North American LRT cities because the natural density is too low to produce high-ridership, the geography of North America cities still induces car use regardless of LRT. There has never been any appreciable mode-switch in any North American LRT city[12]. There has never been any reduction in car-use in any North American LRT city[13]. The green benefits which are dependent upon mode switch do not occur.

Why did Ottawa choose LRT to begin with?

LRT was conceived in Ottawa to address a perceived 'slow-down' because of predicted transitway congestion in 2019[14]. *OC Transpo* demand predictions, upon which this capacity rationale for LRT are based, tend to be overstated.[15] Demand predictions by transit authorities tend to be overstated . This is especially so in North American cities where transit authorities were trying to promote LRT[16]. The simple fact is that there were modest price mechanisms which would have corrected the predicted transitway slowdown where it to occur. These price-mechanisms are already used by *OCTranspo* and are used by other transit authorities and more specifically by public utilities like Ontario Hydro, to re-distribute demand[17]. This was a normal, acceptable, efficient and cost-effective correction to under-capacity issues that *OCTranspo* foresaw for 2019.

What are LRT costs-per-trip estimated to be?

Using OCTranspo data, we can estimate that LRT phase 1 is likely to have a full capital cost per ticket of approximately $8 and an operating cost per trip of approximately $4 making a full cost ticket price in the range of $12 per trip as against bus cost in the range of $5 per trip[18].

Cost of LRT *phase 1* are already essentially spent. This is a sunk cost. The real

11 *Donwtown Ottawa Transit Tunnel Project: Business case*, **Metropolitan Knowledge International, Delcan Corporation**, March 26, 2010, p.49

12 See Bento(2005) below.

13 Ibid.

14 See section 5 below.

15 Don Pickrell, *Urban Rail Transit Projects: Forecast cersus actual ridership and costs*, final report 1990, **US Department of Transportation**, at table S1, p.xi

16 Ibid.

17 See: Karen Herter, Seth Wayland, *Residential response to critical-peak pricing of electricity: California evidence* **Energy** 35 (2010) 1561–1567 at 1561

18 See Part 6 below.

question arising from this analysis looks forward to LRT phase 2, phase 3 and phase 4. Assuming similar cost structures of these phases (where the provincial and federal government carry 60% of the capital cost), the true cost of a trip will be approximately $36 per trip,[19] but the true cost that Ottawa taxpayers will actually face will be in the range of $20 per trip (because they will not have to pay for the provincial and federal share of the cost).

Can LRT fare-prices be set to recover more of the true cost per trip?

OCTranspo is unlikely to price these trips at full cost. Instead, the general Ottawa taxpayer is likely to carry more than 80% of the cost ($16) per trip, and the rider will probably pay less than 20% ($4).

We know from *OCTranspo,* that only 1 out of 5 Ottawans take transit[20]. That is to say, 4 out of 5 Ottawa residents who never take LRT, will pay $16 per trip to subsidize the ride to work of 1 out of 5 Ottawa residents who take LRT to work.

19 If we multiply the cost structure for phase 1 by 4 we arrive at a capital cost total of (4 x $8) = $32/trip to which operating costs per trip ($4) are to be added. $32 +$4 = $36

20 Transit generally captures approximately 20% of all work-travellers in Ottawa (see below), which means that, generally, 4 out of 5 work-trips are by auto (see below). Only 1 in 5 travellers use transit but all 5 property-tax payers carry the excessive trasit burden. See: McCormick Rankin, ***TRANS Model Redevelopment***, technical report, (April 2008) table 3-5, p.42. see also: Pierre Filion, et.al. ***Intensification and Sprawl: Residential Density Trajectories in Canada's Largest Metropolitan Regions,*** **Urban Geography,** (2010), 31:4,541-569 at table 4; see also Statistics Canada census data 2006

2. LRT: WHAT IS THE EVIDENCE FROM OTHER LRT CITIES?

intro

Proponents of LRT have been around for the better part of the twentieth century. Only in the last 30 years have they been able to convince municipalities to adopt this century-old technology as an imagined solution to greenhouse gas emissions or, in the case of Ottawa, to fix a non-existent 'under capacity' worry.

There was a period in the early twentieth century when LRT was considered the way of the future for mainstream transit in North American cities. Like many ideas, the moment for LRT passed into history with the advent of mass automobile use after the Second World War[21]. The automobile, road-building and suburban expansion lowered density, created sprawl and destroyed any feasibility of LRT for cities in North America.

Sprawl is a phenomenon that LRT is particularly not equipped to handle. Previous proponents of LRT have made many of the same arguments as Ottawa proponents have made. In particular, proponents have asserted that LRT will reverse the sprawl that makes LRT uneconomic.

In the case of Buffalo for example, the argument was made that LRT investment would re-invigorate a deteriorating inner city. As Hess (2007) demonstrates below, LRT did not slow down urban deterioration in Buffalo.

Before turning to a detailed analysis of the Ottawa LRT case, it is important to point out that this is essentially a pure economic analysis of economic benefits as against economic costs. Economic costs include green costs of automobile use. The essential green take-away from this analysis is that these ancillary benefits will not occur in the Ottawa case because there will be minimal mode-switch and minimal intensification effect from LRT.

There are a few basic points to take away from this part of the analysis. Asian LRT pays for itself through fare-revenue because those cities have high densities. That is to say densities of tens of thousands per square kilometer.[21] North American LRT does not pay for itself through fare-revenue because densities in those cities are too low.

21 Winston(p.777): "By the 1950s, city governments began to take over private, urban bus and rail systems as intense competition from the automobile accelerated the decline in transit ridership.", *On the performance of the U.S. Transportation System: Caution Ahead,* **Journal of Economic Literature,** 2013, 51(3),773-824

Ottawa's density, at 196 people per square kilometer[22], is the lowest density in the world for any major city. It means that LRT will not be reasonably self-sufficient financially in Ottawa. LRT will not pay for itself from fare-revenue. LRT will not generate any significant increase in ridership because of the low city density.

Those are the basic take-always from this part of the analysis.

22 Statistcs Canada, metropolitan population and dwelling counts, 2011

Asia:

In order to show the way that density affects the ability of LRT to break-even financially, Li et.al (2012)[23] examines a number of Asian LRT cases. He considers the normal construction and operating costs of a 30 km LRT line, and he asks the question: how many riders are needed at a fare-price of $1.50 per kilometer, in order for LRT to break even, given the densities of each Asian city in question.[24]

Li (2012) found that Tokyo, with a density of 7100 person per square kilometre, could *not* break even on the capital costs, at a fare-price of $1.50 per kilometer[25]. But shanghai, with a density of 13,400 people/km², could more than break-even.[26] Hong Kong with a density of 34,000 people/km² would make a net profit per hour of operation of $60,000[27] at a fare-price of $1.50 per kilometer. Keep in mind that Hong Kong, commenced a 17 kilometer, 10 station LRT at the same time as Ottawa. Hong Kong LRT will be ready in 2019 as will Ottawa. It will be yet a further proof of this analysis when Hong Kong breaks-even in 2019 and Ottawa does not.

To re-state the main point of this whole analysis, Ottawa, with a density of 196/km², is less than 1/50th of the Tokyo density that is required to *break-even* on LRT at a fare-price of $1.50 per kilometer.

Ottawa's fare-structure will be discussed below, but to summarize the point here, Ottawa density is too low to generate the high demand needed to pay for an LRT system. Even if Ottawa LRT were priced

23 Zhi-Chun Li a,b, William H.K. Lam a,, S.C. Wong c, A. Sumalee a, ***Design of a rail transit line for profit maximization in a linear transportation corridor***, **Transportation Research Part E** 48 (2012) 50–70 51

24 Li(2012) is a simulation analysis pointing to what Asian cities could price their LRT at and what profit could be made. It does not state what those cities ***actually*** price at. The point of the Li(2012) analysis is to demonstrate that density is critical to economic viability of LRT and minimum density for LRT even at high fare-prices of $1.5/km does not allow break-even in Tokyo but allows for significant profit in Hong Kong.

25 Ibid at p.62

26 Ibid.

27 Ibid.

at $1.50, following the Li(2012) analysis, Ottawa would not be able to break-even.

It is illustrative to leave the Asia section of this analysis with a citation from Li et.al. (2012)[28]:

> n principle, the basic parameters to be determined in planning a rail transit line project include the rail line length, number and locations of stations, headway and fare (see, e.g. Vuchic, 2005; and the references shown in Table 1). The design of these parameters depends very much on the population density in the planning area. This is because the urban population density directly influences the level of passenger demand

28 Ibid. p.50.

Europe:

Europe is a half-way house between Asia and North America in terms of density. European cities are significantly more dense than north American cities, but still not dense enough to break-even self-sufficient financing of LRT. London (density 5100 people /km^2) recovers 93% of *operating* costs[29] and no capital costs.

29 Ibid.

North America:

In the promotion of Ottawa LRT, other small cities are put forth as models. *'If they have it why can't we have it?'*

Portland tends to be presented as the model city which has achieved relatively higher transit ridership than all other American cities.[30]

- ***Was Portland LRT a success?***

Portland's East-Side LRT was planned and approved in 1978 for a cost projection of $172M[31]. Its actual cost (1990) was $266M. The more important fact was the demand prediction. In 1978, the ridership forecast was 42,500. The actual ridership (1990) was 19,700. Operating costs were predicted (1978) to be $3.8M. Operating costs ended up being $5.8M.

The US Department of Transportation found that Portland's predicted (1978) total cost per passenger trip was $1.68. The actual (1990) total cost per passenger trip was $5.19.[32]

- ***What were US LRT cost-per-trip?***

Pickrell (1990) found actual costs-per-trip in all American LRT cities to be significantly higher than predicted and significantly higher than could be charged for fares.

The actual total cost per trip of the Washington LRT was $8.75, Atlanta LRT was $5.93, Baltimore LRT was $12.93, Miami LRT was $16.77, Buffalo was $10.57, Pittsburgh was $7.94, Sacramento was $6.53.

American LRT projects tend to be failures in economic terms[33]. The *cost* per unit of trips was far in excess of the *price* that any transit system would charge and far in excess of any benefit the rider would enjoy.[34] LRT transit systems do not charge or recover the total cost of the system or even the annual operating cost of the system. That is the definition of a transit project that should not have been undertaken.

- ***Were all US ridership forecasts over-stated?***

As with Ottawa, the proponents of US LRT asserted that increased ridership would lead to lower costs. This was a

30 We should digress for a moment to explain why european cities are never appropriate comparison-cities to Ottawa. They have extremely high ***pre-existing*** densities. They have essentially fixed auto-contrained ancient inner cities. They had normal population growth in those inner cities before the era of the automobile and therefore have natural density which Ottawa and North American cities in general, do not have. Because most of Europe with a population of more than 300 million can fit into the land mass of Ontario with a population of 12 million, the tendency to sprawl ***due to low land values*** is strictly constrained in europe compared to Ottawa.

31 Don Pickrell, ***Urban Rail Transit Projects: Forecast cersus actual ridership and costs***, final report 1990, **US Department of Transportation**, at table S1, p.xi.

32 Recall that the Ottawa (capital-cost-only) cost per trip (assuming 16 million annual trips) was $3.55 per trip when considering only the $960M that Ottawa taxpayers invested directly. However, when considering the total investment of all monies into the project, the capital cost per trip was $8.03. That is capital cost only. that does not take account of the operating cost.

33 Don Pickrell, ***Urban Rail Transit Projects: Forecast cersus actual ridership and costs***, final report 1990, **US Department of Transportation**, at table S1, p.xi.

34 The cost per trip in Buffalo (2014) is $62. When the rider herself is not willing to pay $62 for a trip, that is the only proof required in economic cost-benefit analysis. When the rider is provided with a cash subsidy and still refuses to pay $62 per trip that is absolute proof that the trip is not worth $62 to anyone and is a pure economic mistake.

particularly important justification of the Ottawa business case.[35]

The reality of US LRT was that ridership predictions were significantly overstated[36]. By at least 54% (Portland), 66% (Pittsburgh). Sacramento, the city citied by Ottawa an important LRT proponent[37] over-estimated ridership by 74%.

The problem for Ottawa, (as identified in the economic analysis: part 2, of Ottawa LRT below), is that the $3.55 per trip and the $8.03 per trip capital costs are estimated based upon Ottawa actual ridership forecast of 10,200 per hour. Ottawa does not need to be wrong about ridership for the project to be uneconomic. It is uneconomic on the existing ridership estimates. If those estimates are overstated, the project will be exponentially more uneconomic.

- ***Were capital costs understated?***

The (1990) US Department of Transportation audit of LRT in Portland[38] showed that the capital cost of the asset was $266M, yet the remaining debt on this capital cost (2013) is $750M. In other words, Portland LRT absorbed massive amounts of capital, well above the original cost[39].

- ***A close look at Portland***

As Buffalo may be the worst-case scenario, Portland is perhaps the best American case scenario. As a city similar to Vancouver, Portland is characterized in part by geographic barriers which intensify its population[40]. The city is only 145 miles^{2}in contrast to Ottawa transit area which is above 466 km^2 served by *OC-Transpo*. Portland population of 600,000 is approximately 66% of the population of Ottawa served by *OCTranspo*.

The characteristic fact about Portland which differentiates it from other US LRT cities is that it has generated a high transit population. Once again this is a direct function of Portland’s tight spaces. It is also a function of very high public dollar-commitment to transit.

Because Portland has succeeded in getting people on transit it has a relatively economic LRT. LRT operating costs are $44 per revenue-mile[41]. This is better than other US LRT cities, but it is still not as good as Portland *bus* service which operates at a cost of $22 per revenue-mile.[42]

35 ***Donwtown Ottawa Transit Tunnel Project: Business case***, Metropolitan Knowledge International, Delcan Corporation, March 26, 2010, p.48-49

36 Don Pickrell, ***Urban Rail Transit Projects: Forecast cersus actual ridership and costs***, final report 1990, **US Department of Transportation**, p.15, table 2.1

37 Nancy Schepers, Deputy City Manager, Transit Committee, 10-year transit tactical plan, transit committee, October 20 2009, p.2.

38 See Pickrell (1990) above.

39 ***Trimet annual report of independent auditors and financial statements,*** June 30, 2013, p.16, statement of net position

40 San Diego is another of the few high-ridership US LRT cities. Like Portland, it is geographically boxed-in by the Pacific Ocean on one side and a mountain range on the other. J.F. Kain Z Liu, ***Secrets of success: assessing the large increases in transit ridership achieved by Houston and San Diego transit providers,*** **Transportation Research Part A** 33 (1999) 601-624

41 ***Tri-Met audited service and ridership information*** (2012): Portland LRT produces 3.93million annual revenue-miles at a total annual operating cost of $174million which is a cost per revenue mile of $174M/3..93M = $44 /rev-mile;

42 ***Tri-Met audited service and ridership information*** (2012): Portland bus produces 19.53 million annual revenue-miles at a total annual operating cost of $423 million which is a cost per revenue mile of $423M/19.57M = $21.6 /rev-mile;

For purpose of comparison, *OCTranspo* operating cost per revenue-kilometre is $0.40[43]. How can it be that Portland bus system operates at $22 cost per passenger mile whereas *OCTranspo* operates at $0.20 cost per passenger-kilometre ($0.32 per passenger-mile)?

Perhaps Portland is the best example of what happens when a city commits everything to getting a small population on transit. Firstly Portland felt committed to build an LRT. Secondly they felt committed to maintain a massive bus infrastructure to serve the LRT. What is the ultimate effect?

Firstly, Portland bus and rail together produce a total of 449 million *passenger miles* from a total cost of $597million[44]. That amounts to an operating cost of $1.32 per passenger-mile. That translates to $0.81 per passenger-kilometre.

We already know that *OCTranspo* with a lower annual operating cost ($397million) than Portland bus ($423million), produces approximately 4 times as many passenger kilometres (990million) than does Portland bus (234million).

OCTranspo produces *twice* as many passenger-kilometres (990M) than the total Portland system of bus + rail (449M passenger-kilometres).

- ***How could this happen in Portland?***

It happens by the public over-commitment to transit infrastructure per capita. Portland adopted LRT and maintained a high intensity bus system as a feeder-system for LRT. The result is that Portland-bus has a 25% *higher* operating cost than *OCTranspo* and a 25% lower occupancy (passenger-kilometres) compared to *OCTranspo*.

- ***What is the message for Ottawa?***

The purpose of this analysis is not to write an exhaustive financial history of all US light rail transit mistakes. The purpose of this section is to highlight a couple of US cases to aid Ottawa in appreciating the cost structure of LRT *for Ottawa*.

The take-away from this section comes from Portland.

Portland committed heavily to LRT, still maintained a massive bus infrasture, more expensive than Ottawa for only 66% the Ottawa population, as a result of which its more expensive bus system provides only 25% of the rides provided by *OCTranspo* at a significantly *higher* cost.

43 *OCTranspo* (2012) total operating cost = $397million; *OCTranspo* total passenger kilometres devlivered (2012) 990million; the cost per kilometre: $397M/990M = $0.40 per passenger kilometre. See: Ottawa city budget document: **03-ACS2012-CMR-FIN-0033**; see also *OCTranspo quick facts*;

44 *Tri-Met audited service and ridership information (2012)*; see also: *Trimet annual report of independent auditors and financial statements*, June 30, 2013, p.16, statement of net position.

The ultimate result is that Portland provides only 75% of the passenger kilometres (718 million passenger kilometres) that are provided by OCTranspo (990million passenger kilometres) for a total system cost ($597M) which is 25% high than OCTranspo ($397M)[45].

If your purpose as a city is to get people from point A to point B, efficiently and cost-effectively, do not introduce LRT and maintain a feeder system, all at highly subsidized rates.***Density:***

45 As a further comparison, consider San Diego, another city with LRT and a bus feeder system. It provides 88M passengers with 15.8M total miles (25M total kilometres) of service for a total cost of $219M. That is a ***cost per kilometre*** of **$8.75**. This is compared to ***OCTranspo*** 100M total system kilometres at $397M for a cost ***per kilometre*** of **$3.97**. All ***San Diego data taken from San Diego Metropolitan Transit System adopted 2014 fiscal year Budget:*** Statistical Summary p.110-115. All ***OCTranspo*** data taken from ***2012 OCTranspo facts and figures***

3. WHAT DOES THE EMPIRICAL EVIDENCE IN THE LITERATURE SAY?

- ***Density:***

The main point brought out in the empirical literature is the same point proven by the facts on the ground in every successful (Asian) and unsuccessful (American) LRT city. Density is the controlling factor that makes LRT work. No American city has the density to make LRT self-financing. No American city can generate sufficient ridership to make LRT fare-revenue sufficient to pay even the *operating* costs of the system. The few US cities which are closest to economic balance, San Diego for example, have density of 3239[46] all along the tightly intensified LRT corridor. San Diego is intensified because of the Pacific Ocean and a mountain range (not because of any municipal policy). Even this density on an ideal corridor was not enough to make San Diego LRT economically self-sufficient.

The centrality of density as the controlling factor in LRT analysis cannot be overstated. The LRT analysis done by the City of Ottawa, to justify its choice of LRT, treated the factor of density incorrectly and incompetently.

Firstly, all the analysis done by Ottawa on the LRT issue spoke as thought this was one factor of many. The Ottawa analysis did not recognize the centrality of this factor in destroying the Ottawa business case.

Secondly, the Ottawa analysis treated density as though it was something that the City of Ottawa *had the power to change*. No city in North America has succeeded in reversing its density deterioration. Ottawa has the lowest density of any North American city. Ottawa density has been falling consistently over thirty years[47]. The Ottawa LRT analysis failed to recognize any of these critical parameters.

Thirdly, the municipal policies that would even begin to reverse density-deterioration, such as taxation by *distance* and severe restriction on *suburban* building permits, and road congestion-charging, are not even within the contemplation of a city council that is oblivious to the density problem. Today, property values and therefore taxes, rise quickly in the center of the city, it becomes more and more expensive to live in the center of the city and relatively cheaper to live in the outskirts therefore *causing* suburban residency choice. To reverse density deteri-

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oration, the city would have to introduce taxation policy which *lowers* center-city taxation and *raises* suburban taxation to change the individual optimization calculation of every resident who chooses to live in the outskirts rather than the urban core. Even a policy such as this would take decades to come to fruition in the density figures.

Taylor's (2009) model of what factors determine transit usage[48] shows that density is a critical factor in terms of determining factors. In other words, the most powerful cause of transit ridership (density) is negative for the City of Ottawa and *not* within the control of the city of Ottawa.[49]

Bento (2005) does a transit analysis of over 100 US cities. Density is the central determining factor for transit success .[50]

- ***Mode-switch?***

Ottawa LRT proponents predicted that building LRT will lead car-drivers to switch to LRT. This is called mode-switch. The literature demonstrates that the mode-switch effect is almost non-existent. When a city doubles its bus-system, the effect is a 2% decrease in auto use. When a city introduces an LRT the effect is less than 1% reduction in car-trips to work[51].

The most ironic fact that Ottawa LRT proponents failed to notice was that an increase in *bus-intensity* reduces car-use hundreds of times more effectively than an LRT system. Bus is more important for reducing car-use. But in any case, the mode-switch effect is small.

Getting people out of cars was a big selling point for Ottawa LRT. The empirical literature says LRT will have negligible effect[52]. But the literature tells us that a 1% increase in *densification* decreases car-use by 1.5%.[53] That is a variable with 150% power. The most powerful of all variables in the literature. Sadly for Ottawa, although there is no end to *intensification-speak* from the Ottawa city council, the empirical evidence demonstrates that Ottawa is losing density year over year and it is not reversing[54]. In other words, the one variable that would change the dynamic (densification) is not a variable that Ottawa really takes seriously, though it *talks* incessantly about it.

It has been demonstrated that the presence of rail has essentially a zero elasticity of demand effect upon owning a car[55]. The effect of a *bus* system upon the

48 Brian D. Taylor, Nature and/or nurture? *Analyzing the determinants of transit ridership across US urbanized areas*, **Transportation Research Part A** 43 (2009) 60–77, (set out in his table 7, p.71)

49 Taylor states (p.72):

Collectively, the six external and two internal variables in the final total urbanized area ridership model (Table 7) explained 91% ($R2 = 0.9125$) of the variation in overall transit boarding's in our sample. The six external control variables in this model appear to account for most of the observed variation in ridership, though the two internal, policy variables have small, albeit non-trivial effects on ridership

50 Antonio M. Bento, et.al., *The Effects of Urban Spatial Structure on Travel Demand in the United States,* **The Review of Economics and Statistics**, August 2005, 87(3): 466–478 at 475.

51 Ibid, at 471, see also table 3 at 472;

52 Ibid

53 Ibid at p.475.

54 See Ottawa density section below;

55 Ibid, table 4, p. 474

tendency *not* to own a car is 100 times greater than the *rail* incentive to not own a car.[56] In other words, buses have a 100 times more powerful disincentive effect upon car ownership. But both effects are still very small. To give an example, a doubling of the bus system would reduce car ownership by only 2%. The rail effect is 100 times less even than this.[57]

The point of this discussion is to put the Ottawa LRT into the context of Ottawa's position as the least dense million person-city in the world. To assess Ottawa's density in the context of the Bento (2005) analysis, of the 114 cities assessed in his study, the smallest city in his study[58] had a density of 446 people/km^2. Ottawa has a density of 196 people/km^2, less than half the density of the smallest US city in the Bento(2005) analysis. The point is that all the empirical regularities regarding increased transit-use will tend toward zero as density falls.

The next fundamental fact that needs to be kept in mind throughout the analysis is that Ottawa's own data establishes that at least 70% of all trips in Ottawa are done by car.[59] Closely related to the Ottawa car-use statistic, is the Ottawa car ownership statistic[60]. Ottawa's own numbers show, for example, that in Ottawa:

> the number of cars available to the household is strongly correlated with the number of workers in the household: for example, households with 2 workers are most likely to have two cars, a little less likely to have one car, and much less likely to have 3 cars or no car at all [61]

This is important to remember because the empirical regularities in the literature show that public transit-use is *negatively*-correlated to the percentage of car ownership[62]. This is obviously a factor that relates back to density. Because Ottawa is so sprawling, most people must own cars. The ownership of the car then reduces the tendency to use transit. This fact is not going to change in any appreciable way with LRT phase 1. The presence of rail does not reduce the likelihood of a household owning a car.[63]

LRT advocates dismiss data like this with suggestions that 'policy can be made to change all of these factors'. But that's the very point that is missed. Policy cannot change these facts. These are foundational facts based upon geography, income and population-size. Policy cannot change any of these factors to affect LRT.

- ***Intensification?***

Finally, Bento(2005) shows that intensification does not tend to occur as a result

56 Ibid

57 Ibid

58 Ibid table 6 p.477

59 McCormick Rankin, ***TRANS Model Redevelopment***, technical report, (April 2008) table 3-5, p.42. see also: Pierre Filion, et.al. ***Intensification and Sprawl: Residential Density Trajectories in Canada's Largest Metropolitan Regions***, **Urban Geography**, (2010), 31:4,541-569 at table 4; see also Statistics Canada census data 2006

60 Jon Willing, Ottawa Sun, July 21, 2014: "in 2013, there were 514,855 vehicles registered in Ottawa according to the Ontario Ministy of Transportation." That is a ratio of 0.58 vehicles per person in Ottawa.

61 Ibid table 5-1, p.77.

62 Bento (2005), table 4 p.474 (see: supply of bus transit effect excluding New York City)

63 Ibid

of LRT. Intensification around stations is the causation-analysis promoted by LRT proponents. There is some evidence on this question of intensification and it is mixed.

Hess (2007) [60] showed that Buffalo LRT was sold in the 1980's on the principle of its ability to intensify and re-vitalize the city-core. After twenty years, Hess found *"the effect in Buffalo is weak"* (p.1061). More problematic for Ottawa, the effect at three of the Buffalo stations was a dramatic decline in property values (p.1062).

The Hess (2007) analysis of Buffalo LRT is instructive for Ottawa. After a concerted political effort in the 1980's to launch Buffalo LRT *phase 1*, there was taxpayer backlash which stalled follow-up extensions. Secondly, LRT ridership is lower in absolute terms in 2014 than it was in 1985. Most importantly, LRT had no influence on regional travel behavior because riders had to re-board buses to reach suburbs, because of Buffalo's inherent suburban density structure (p. 1062).

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Hess (2007) found that there was a small positive effect upon property values in wealthy neighbourhoods and a negative effect everywhere very close to stations, precisely because of the congestion that the city presumes to be a good thing.

Ottawa LRT proponents will be quick to claim that Ottawa is different from Buffalo. There are certainly differences, Ottawa's population of 890,000 is significantly larger than Buffalo (260,000) and that is an important factor.

But there are similarities which make Buffalo hard to ignore. Buffalo has a per capita income ($42,788) identical to Ottawa ($42,715). Buffalo had a higher density (6000/mile^2) significantly denser than Ottawa but still not dense enough to support LRT. Ottawa has a larger population but a larger footprint. Ottawa's inner core has, like Buffalo lost significant density over the last three decades[65]. Finally, the need to re-board buses to reach suburbs

64 Daniel Hess, Tangerine Almeida, ***Impact of Proximity to Light rail Transit on station-area property values in Buffalo, New York***, **Urban Studies**, vol 44, no 5,6, 1041-1068, May 2007

65 Pierre Filion, et.al. ***Intensification and Sprawl: Residential Density Trajectories in Canada's Largest Metropolitan Regions***, **Urban Geography**, (2010), 31:4,541-569 at 554

was fatal to Buffalo LRT. This is precisely the way OC Transpo sells LRT, as a trunk, feed by buses-to-stations rather than bus-straight-downtown.

LRT has been recognized to have been a mistake in Buffalo, it is a significant burden on the city budget. LRT annual operating costs are $280M with $18M debt servicing costs for a city of 260,000[66]. That amounts annually to $1154 per resident for 4,800,000[67] total work trips provided by the system. The 2012 cost structure of Buffalo LRT produces a per-trip cost of $62.

- ***Ottawa's traditional position?***

The most incredible thing to keep in mind when considering LRT is to remember that the City of Ottawa already knew that LRT was a bad idea when LRT went through one of its intermittent resurrections in the late 1980's. Consider the words of Colin Leach, head of *OC Transpo long*-range planning (June 23, 1992):

> One of the major advantages of a busway compared to an LRT system is that it gives the benefits of a fixed infrastructure without the drawbacks of a fixed guideway…the lack of a fixed guideway allows incredible flexibility of operations[68].

Consider further the approach of the 1988 Ottawa official plan:

> The official plan accepts that most residents prefer to live in low-density residential settings and does not attempt to alter those preferences. The transportation "means" to support this land use end was the introduction of a highly flexible bus transit network.[69]

Any fair reading of this official rationale, from the era when the new transitway was the official position, as LRT is today, indicates that Ottawa has reversed its position on all essential facts. Suddenly busing does not make sense. Suddenly, it now makes sense to 'alter preferences'. Ottawa no lower accepts that people want to live in 'low-density residential setting.'

The problem with Ottawa reversing its 1988 position is that low-density is truly a fact of life that Ottawa is not really prepared to alter. So now we will have the worst of all worlds, low-density *att* an under-used LRT *and* a less-efficient bus system all of which will carry a much higher cost-per-trip than in the pre-LRT status-quo, all paid for by property-taxes of people, 4 out of 5 of whom do not take LRT.

66 2012 Buffalo Light Rail annual report;

67 Hess (2007) p.1050

68 Robert Cervero, The Transit Metropolis, p.259

69 Ibid.

4. HOW DID OTTAWA APPOACH THE ANALYSIS OF WHETHER TO ADOPT LRT?

Having looked at the experience in North American and Asian cities, having seen that a cursory analysis shows that LRT fails the most basic cost-benefit assessment, how did Ottawa city council, a board of directors controlling billions in revenues and expenditures, approach the decision to adopt LRT.

Tactical Plan for Transit Operation and Finance: November 2009

The preliminary assessment of LRT came to the council in the form of a *2009 10-Year Tactical Plan: City of Ottawa Transit Services 2009 Tactical Plan for Transit Operations and Finances*[70]. This was an update of a November *2008 Transportation Master Plan.*

It was this document which deemed the presently-existing bus-system to have reached 'capacity' by 2019. According to this document, reaching capacity will mean that speed will be reduced on Albert and Slater, followed by uncertainty by riders and a consequent loss of demand because

of the deemed congested transitway.[71]

This November 2009 analysis contains inherent contradictions that any competent reader on the council should have identified and critiqued. None of this was done. The report essentially endorsed a wholesale change to the existing bus system in favour of a more expensive LRT + bus system. This report promised that Ottawa would save $106M per year in costs by adopting LRT.

- ***Contradiction #1:***

A large part of the 'need' for LRT comes from the idea that a slow-down of transitway speed will lose riders. If a mere slow-down of the speed of the system premised upon 5pm congestion on the transitway is sufficient to cause a significant loss of ridership, this suggests that riders can easily substitute away from transit. If riders can substitute away from transit as easily as predicted by this report, the correction of the 'congestion' is in the substitution away from the congested system. The substitution away from the congestion system implies a return to an equilibrium level of acceptable 'congestion' where the presently-existing structure can fully accommodate the riders who desire to take the system at the *subsidized price*.

In other words, the correction to rider-congestion is a *self-determined* loss of ridership, as each unsatisfied rider substitutes away, down to an equilibrium level. This is a self-correcting mechanism. It is fair, it is economic, it is sensible.

It is not rational for OC Transpo to say " we must provide *immediate* and *fast* and *unlimited* supply of rides, at *precisely* peak-period to every rider who wants to ride, at 75% subsidized fares". That is the fundamental theme of the November 2009 report.

It is understandable that OC Transpo didn't want to lose riders. But the cost of maintaining all riders at exactly the peak period is prohibitive, unnecessary and an unfair allocation of public wealth to 1 out of every 5 Ottawa residents.

- ***Contradiction #2:***

The quick and immediate loss of ridership (substitutability) that *OCTranspo* predicts from its 5pm 'congestion', implies that there is significant elasticity of demand in peak ridership. In other words, there is capability of the system to provide the transit on *extended* peak times.

The policy of guaranteeing unlimited *peak time*, *heavily-subsidized* transit availability at the 5pm time slot, is the fact that drives the entire rationale for LRT. The system is virtually empty at all times other than a short peak period at the end of day. Without the policy of immediate cheap peak-time transit availability there would be no rationale for LRT.

The natural way to solve this situation is *differential-pricing*[72] where the absolute peak-period (5pm) ride would cost significantly *more* than non-peak rides. A graduated schedule of peak pricing would immediate *redistribute* the existing peak-moment demand over an extended period by the voluntary *choice* of riders without any change in the transit structure or new infrastructure. The extension of demand redistributed over a slightly longer time horizon[73] would easily manage the transit capacity. The only inconvenience to riders, (who make up one 1 in 5 citizens), is that their 75% subsidized ride is now perhaps only 50% subsidized during peak periods.

- ***Contradiction #3:***

The idea that riders so easily substitute away from *OC Transpo*, due merely to a predicted slow-down in time-of-trip im-

72 Differential peak-period pricing was the solution adopted by the utilities-providers in North America to solve the identical 5pm peak period demand on the electricity grid. The actual result of the 2003 California peak-price pilot project:

residential participants of the CPP rate shifted load out of the peak period everyday, shed significant load during critical events across a broad range of temperatures and generally liked the new tariff better than the old tariff.

The California differential price experiment involved a modest increase in price at the critical 3pm-8pm period. The result was a 5% cut in demand during this period. The cut came from all residences and involved dropping air conditioning in the hottest climate zones Ontario today uses smart metering. See: Karen Herter, Seth Wayland, ***Residential response to critical-peak pricing of electricity: California evidence*** **Energy** 35 (2010) 1561–1567 at 1561

73 By way of example: this means that a rider who is not prepared to pay $5 for the 4pm peak-ride would have to wait until 5:30pm for a $3 ride, or wait until 6pm for a $2 ride.

plies that those same riders would be unlikely to tolerate a generally higher fare-price. This implies many things. Firstly, it implies that they have alternatives.[74] So the usual response that transit riders are economically-constrained to take transit is a claim contradicted by ridership loss data. Secondly, it implies that the city would not be able to charge higher LRT fares.

Yet, it should have been obvious that a $2.1B expenditure on new infrastructure while *maintaining the existing bus system* [75] implied a higher cost per trip. This constitutes a significant re-direction of public wealth to a small part of the Ottawa population, that is , the 1 in 5 Ottawans who take transit.

- ***Contradiction #4:***

The 2009 '*Tactical Plan*' speaks about the dramatic change from trunk-and-branch to a trunk-and-feeder system. Cutting through the *bureaucrat-speak*, this means that people who previously got on a bus in Orleans or Kanata got to Slater Street directly, without changing modes of transit. This is a large part of the desirability of the Ottawa transit system today.

The post-2019 LRT 'feeder' system means that the Orleans rider will get on a bus to be taken to the Blair station (not to Slater) in order to 'feed' the LRT, likewise for Kanata. The same OC Transpo which is, sensitive to the loss of riders caused by an imagined peak slow-down at Slater, see no damage at all to ridership caused by the substantial increase in inconvenience and time caused by mode switch created by the new feeder system.

- ***Inadequate demand analysis***

The 2009 *Tactical Plan* does a 'demand analysis' regarding LRT. The *Plan* mentions the TRANS demand forecasting model built by Ottawa. There is essentially no demand analysis done. What demand analysis that is done points away from LRT.

For example, OC Transpo acknowledges that its ridership is highly sensitive to distance. A small *increase* in distance from a stop, for example, causes a 50% drop in ridership demand[76]. This being said, the LRT +feeder system will dramatically *increase* the total distance travelled by riders. Yet there is no appreciation that this will dramatically *diminish* rider-demand.

The *Plan* logically suggests that all riders now using transit on the transitway will switch to the LRT in 2019. This is a reasonable starting assumption. But that is the end of the *Plan*'s demand analysis. The missing analysis is set out below, using the numbers provided by the Ottawa documents.

74 Ottawa planners often cite Sacramento as a model. Price elasticity of demand, for increasing of fares in Sacramento, show that a 100% increase in fare would reduce ridership by 16%. In Seattle, a 100% increase in fare would reduce ridership by 26%.Analysis of peak-pricing elasticity shows that there is a 20% fall in riders for ever 100% increase in peak fares. (*Effects of fare changes on bus ridership*, american public transit association, may 1991, table 1, p.7.)

Taylor(2009) shows that, in general, transit price elasticity is between 40% and 50%. That is to say, a 100% increase in fare leads to a 40% reduction in ridership in the medium term. The Taylor study included over 200 metropolitan areas in the United States. It is unlikely that Ottawa's fare-price elasticity of demand is lower than 50%. Many of the Taylor cities had very low vehicle-registration rates whereas the Ottawa vehicle-registration rate is extremely high at 0.60 vehicles per person. In other words, Ottawa has high substitutability away from LRT. (Brian D. Taylor, ***Nature and/or nurture? Analyzing the determinants of transit ridership across US urbanized areas,*** **Transportation Research Part A** 43 (2009) 60–77, at 73 footnote 8

75 Table 5 t

76 Page 15, table 5.

In order to understand whether the *Ottawa Business Case* prediction of 51M annual LRT trips is reasonably accurate, consider OCTranspo's long-term annual-trip data-history. Extrapolating the OCTranspo historical 15 year growth rate forward to 2030 produces at a 13% increase in trip-demand.[77] This is significantly below the 30% increase in demand predicted by the *Business Case*. This looks like the demand-over-estimates that we have seen in many other American cases

- ***Contradiction #5: OC Transpo's own transitway data***

In support of its claim that the transitway will provide inadequate capacity by 2019, OC Transpo included their own route-by-route occupancy data. This is figure 17 in the 2009 *Tactical Plan*. It is an excellent tool for understanding the way OC Transpo operates. I have reproduced figure 17 in the appendix to this report.

Occupancy rate is critical to understanding the reality of OC Transpo's claim of capacity-limits in 2019. OC Transpo transit buses now operate at 63% of full capacity. OC Transpo occupancy rates have been level or falling for many years. In other words, a 63% of full capacity. OC Transpo occupancy rates have been level or falling for many years. In other words, a 63% occupancy rate does not support a claim of capacity-limit. The claim that somehow there will be a capacity-limit in 2019 should have been critically-examined by council, not accepted at face value as it was. If the 13% estimated increase in *OCTranspo* trip demand is accurate, the 63% capacity had sufficient room to expand to allow the new trips.

- ***Contradiction #5.1: What was the transitway occupancy rate in 2009?***

OC Transpo provided data on its 4 important route categories[78]. The most important route is the transitway (including express routes). All of the buses that run on those routes are contained in figure 17. OC Transpo's own data tells us that there is an approximate 63% occupancy rate on transitway and express routes[79]. OC Transpo tells us that these are the routes that will be over-capacity in 2019. But OC Transpo occupancy numbers are falling. They have been level or falling for many years. It is highly unreasonable to assert that there will be a significant change in this basic relationship by 2019.

77 This 13% increase in ***OCTranspo*** trip demand was calculated by ***OCTranspo*** historical ridership data provided by OCTranspo on their website. The data shows: trips (2001) = 85M, trips (2013) = 97M. that is a 1% per year growth rate; extrapolated forward, produces a total trip demand in 2029 of 113M trips.

78 Figure 17 is a description of the relationship between how many kilometers OC Transpo buses travel and how many passengers are on the bus when the bus is travelling. In other words, if one bus does a 10 kilometer circuit 10 times per day that is 100 kilometers travelled that day. If that bus has 100 seats then the bus could have provided 100 kilometes of ride to 100 riders or (100 x 100 =) 10,000 total seat-kilometers on that day. That is how OC Transpo constructed the horizontal axis. In other words, the horizontal axis measures capacity, the very thing that OC Transpo is saying will disappear in 2019.

The vertical axis measures the acutal kilometers when the seat on the bus is actually filled. In other words, the vertical axis measures the demand, the very thing that OC Transpo says will be too-high in 2019 for buses to handle.

79 OC Transpo has done its own analysis of the average-occupancy by intersecting its red-lines at approximately 7,000 on the vertical axis and 11,000 on the horizontal axis. This gives a slope of 7,000/11,000 = 63% occupancy rate.

- ***Contradiction #5.2: What are the occupancy rates on non-transit-way buses?***

The transitway occupancy at 63% is the most efficient route that OC Transpo operates. Their other routes are as low as 10% occupancy. This is the reason for OC Transpo insolvency (in other words, OC Transpo cannot pay its expenses with its fare-revenues). The city must (annually) pay more than $100M to OC Transpo to run buses that have 1 passenger for every 10 seats.

- ***Contradiction #5.3: how should OCTranspo have fixed its occupancy/capacity issues?***

There are two rational answers to this: increase fares and reduce the number of routes and times. Consider what the effect would be if OC Transpo were forced to offer fewer buses. There would be two effects. There would be some loss of ridership as riders substituted away. However, the more important effect would be that each *remaining* bus would *increase* its average number of passenger-kilometers. In graphical terms, the presently-existing occupancy-curve would pivot upward toward the 45 degree line[80] which is a good thing for OC Transpo efficiency.

None of the low efficiency routes should be offered. The rationale put forward for a system to provide a 50-seat bus to transport, on average, 5 passengers, at a ticket price which covers only 50% of operating costs and none of the capital cost, is to vacuum up every possible passenger who might otherwise decide not to take a main route because peripheral routes are not part of the system.

While there is certainly some truth is this statement, the ultimate economic perversity of expending resources at dramatically falling ridership rates is the more important fact. At some point, even the Ottawa City Council should be able to veto entirely empty buses. It is only a matter of degree to veto 10% buses.

A large part of OC Transpo insolvency comes from the manner of operational-thinking which insists on chasing every potential passenger down every country road and offering her an empty bus to ride in. The 10% filled buses on three of the four transport graphs shows that this criticism is only slightly exaggerated.

A corrected management approach to OC Transpo would eliminate the perceived 2019 'congestion' problem. Increasing fare-prices, time-differential fare prices, distance-fare prices and reduced routing would correct all of OC Transpo's perceived 2019 infrastructure needs.

80 The 45 degree line implies a 1 to 1 perfect equilibrium bettwen seats offered and seats filled. This would imply that the bus is operating at 100% efficiency. In other words, if OC Transpo's sotry of 2019 capacity-limit were accurate, the present red-line intersection point would have to pivot upward from a slope of 0.63 to a slope of 1.0. in other words, there has to be significant new transit use in the next 5 years for this unlikely event to take place.

Conclusion:

In this section, we have examined the essential city documents which supported the decision to spend $2.1B on a light rail transit system. We have shown that the impetus was a perceived transitway capacity shortage that was predicted for 2019. We have shown that a proper and sustained analysis of the OC Transpo arguments showed the following:

1. There was no evident consideration given to the self-correcting element of people substituting away from congested OC Transpo thereby automatically relieving the system;
2. There was no evident consideration given to the idea of increasing fares to relieve perceived congestion;
3. There was no evident consideration given to a differential fare structure to distribute demand away from the 4pm departure peak time onto less demanded times.
4. There was no evident consideration given to the fact that OC Transpo was at only 63% capacity on the transitway in 2009.
5. There was no evident consideration given to the fact that OCTranspo occupancy numbers have risen at only a 1% rate for many years and therefore not likely to increase by 30% by 2019.
6. There was no evident consideration given to the fact that the LRT trunk and feeder system significantly increased travel time and distance and therefore would lead to ridership loss.
7. There was no evident consideration given to the fact that a $2.1B LRT system added to an existing bus system was likely to increase the cost-per trip.
8. There was no evident critique of the assumed 51 million LRT trips forecasted in the *Ottawa Business Case*.

5. ECONOMIC ANALYSIS:

QUESTION #1: WHAT IS THE COST PER TRIP?

The data available in the *Design Build Finance Report* [81] allows for an immediate consideration of actual capital cost per seat-kilometre.[82]

We start the calculation of cost-per-trip with the fact that there will be 10,700 individual riders per hour for three hours inbound and the same for outbound. This represents 32,100 passenger-trips inbound and 32,100 passenger outbound in each direction each day. This represents 64, 200 daily-trips multiplied over 250 weekdays or 16,050,000 annual peak-passenger trips, over which the capital cost + operating cost of the rail must be distributed.

This estimate of 16M trips per year on LRT is an important part of the cost structure. More trips mean more tickets over which to divide the total cost. The *Ottawa Business Case* assumes 51M. the *Business Case* arrives at 51M trips (which is more than 300% higher than the basic number in this analysis), by assuming a 30% population increase and a ridership increase of 78%.[83] We will discuss the consequences of this forecast below.

We have determined (in part 2 below) that the annual debt service imposed upon the Ottawa city budget will be in the range of $57M per year. This capital cost should, optimally, be divided over the 16 million annual trips (that we have estimated)and paid for by the riders through the fare structure.

In order to make the analysis simple and clear, we will abstract from operating cost for the moment[84], reflecting only upon capital costs of $57M per year[85] divided over 16 million trips, averages **$3.55** per trip in capital carrying cost. If the *Ottawa Business Case* is accurate, and there is in fact 51 million LRT trips taken, the capital cost per trip falls to **$1.11**.

Note that this amount reflects only the distorted *Ottawa-portion-only* perspective on costs. Ottawa citizens perceive only the 40% that they have to pay for. But even this 40% of capital costs rep-

81 Ref. No. **ACS2012-ICS-RIO-0004**; December 4, 2012

82 This report provides the underlying system data from which the economic analysis in this paper is derived. The ***Design Report*** indicates that peak operating capacity per hour will be 10,700. There will be a two-car configuration (p.23) with each car having a maximum capacity of 300 people (p.27). That is a capacity of 600 per linked-car.
Therefore, to move 10,700 persons per hour[82] A.M. inbound from Tunney's and 10,700 per hour A.M. inbound from Blair, will therefore require 16.6 dual-cars trips inbound within the peak hour. (p.31: car-purchase budget is $344M which is equal to 68 cars at $5M per car)
Therefore, at 24 minutes round-trip, this implies 4 dual-car trains inbound from Tunney's and 4 dual-car trains inbound from Blair each hour. This indicates a dual-car departing from inbound from Tunney's every 15 minutes and a dual-car departing inbound from Blair every fifteen minutes. In the language of economics, this is an estimate of the structure of production. We have thus derived the **seat-unit** output over which the **total cost** must be properly ***allocated***.

83 *Downtown Ottawa Transit Tunnel Project: Business case*, **Metropolitan Knowledge International, Delcan Corporation**, March 26, 2010, p.23

84 We can assume that operating costs will be similar to other cities and therefore add $4-$8 cost per trip above the capital cost per trip.

85 Calculated below in economic analysis: part 2

resents **$3.55** per peak week-day trip, where the vast bulk of the carrying costs must be allocated. This $3.55 per trip cost is completely uneconomic. It represents only the capital costs. It does not factor in operating costs which will add substantially to that figure. If other cities are any measure, the costs will be a minimum of $4 per ticket.

In any event, given the price elasticity of demand for transit, such an *increase* in fare, to represent the true cost of this LRT, would produce a dramatic collapse of ridership. Ottawa city council will therefore force the general tax-payer to absorb almost all of the true cost per trip. The 'fare', whenever it's determined, will not even cover operating costs (as is the case with *OC Transpo* today).

Houston: an example of low fares resulting from low demand

Houston is an instructive example of the fare-pricing problem that Ottawa will likely face after LRT. Houston built an LRT where there was insignificant demand for LRT. Because there was insufficient demand to financially sustain LRT, Houston had to *drop fare prices* to an average of $0.95 per trip[86]. That is, less than a dollar per trip. The actual operating cost per passenger-trip (2013) is $6.49.[87]

86 *Dallas Area Rapid Transit, Comprehensive Annual Financial Report, September* 30, 2013, P.52

87 Ibid: P.60

Houston LRT is in unfortunate, though perfectly predictable, economic predicament of providing $5.50 per-passenger-trip in subsidy. The Houston transit system delivers only 107million passenger kilometres[88] for a total cost of $701 million for a cost-per-kilometre of $6.55 operating cost. *OCTranspo* delivers 990million passenger kilometres for a total operating cost of $397 million or $0.40 per kilometre operating cost. That is, forty cents per kilometre as opposed $6.55 per kilometre.

Because Houston over-invested in too *much* transit, acquiring *both* bus and LRT, for a sprawling city of only 1.2 million, a number of things resulted. Firstly, the ticket price had to be set so low as to cover less than 15% of the true operating cost. Secondly, Dallas and all surrounding cities had to pledge their total annual sales tax revenue to repayment of the capital cost of LRT ($3B). Like Ottawa is in the process of doing, these monies could have been devoted to more important truly-desired city priorities. Thirdly, even at a trip-price of $0.95, *few people want to take the transit system*. Although the total population of the cities surrounding Houston make up 2.4 million, Houston delivers less than 11% of the passenger kilometres (107M) delivered by *OCTranspo* (990M) to a city 50% the size of greater-Houston.

88 Ibid: Page 60: Houston LRT revenue miles (9.1m) x passengers per revenue mile (3.23) = 29.39M passenger-miles x 1.6 = 47m passenger kilometres; Houston bus revenue miles (27.2m) x passengers per revenue mile (1.39) = 37.8m passenger-miles x 1.6 = 60.5m passenger miles for a grand system total of 107million passenger kilometres.

On this basis the LRT is an overwhelming financial mistake for Houston. All signs point to the same result for Ottawa.

Ottawa trip demand

The reason it is likely a financial mistake for Ottawa is that the capacity of 10,700 per hour, for three hours inbound in each direction and 3 hours outbound in each direction, is not a sufficient flow-rate to carry the debt-service charge per trip. The debt carrying charge per trip is when there are only 16 million annual trips on the Tunney's-Blair line.

We are already assuming full capacity for each hour of peak operation, morning and evening. The only way to generate more trips is to assume those trips take place in the off-peak hours. However, this is a ridiculous assumption. If the peak hours are 10,700 per hour, it is impossible that the off-peak hours are equal to or more than this amount. It is impossible to generate a scenario where the quantum of trips rises appreciably above 16 million per year on the Tunney-Blair line.

Adding more trains does not answer the issue. the City themselves state that the system capacity is 10,700 per hour. This is not a function of more of less trains. It is the overall system capacity. And that capacity requires a fare-price of at least $3.55 to cover only capital carrying charges and not operating costs.

Remember, this is only the carrying charge on the city's 40% portion of the project. If the full project cost were allocated to the fare price as it would be in any rational economic project decision[89], the fare price would be **$7.50** per over the 16M annual trips. If the Ottawa Business Case is accurate, and there is in fact, 51 million annual LRT trips, rather than 16 million, the full capital cost per trip falls to **$2.67.**

Quite a lot depends upon the accuracy of the 51 million LRT trips that the *Ottawa Business Case* predicts. *OC Transpo's* own 2019 numbers are approximately 16M, so quite a lot depends upon the theoretical drawing power of LRT, which the empirical evidence suggests will not occur.

How reasonable is the Ottawa Business Case estimate of 51 million trips?

As a rough test of the likelihood of accuracy between my estimate of approximate 16M annual trips, and The *Ottawa Business Case* estimate of 51M annual trips, consider the case of all US cities[90].

The following cities are *below* 20M annual trips: Salt Lake City, St. Louis, Sacramento, Phoenix, Jersey City, Houston, San Jose, Seattle, Minneapolis, Pittsburgh, Baltimore, Newark, Buffalo, Port-

89 See for example the cost assessment of San Deigo LRT and Houston Metro: J.F. Kain Z Liu, ***Secrets of success: assessing the large increases in transit ridership achieved by Houston and San Diego transit providers***, **Transportation Research Part A** 33 (1999) 601-624 at 609:

Operating costs are only part of the cost-effectiveness story. A complete assessment of benefits and costs must include the full costs of providing transit services, which in addition to operating costs include depreciation on transit capital and the opportunity, or ownership, costs of the transit capital owned by each system

90 List of United States light rail systems by ridership: wikpedia

land, Charlotte, Cleveland, Norfolk, Memphis,

The following cities are between 20M and 30M: Denver and Dallas.

The following cities are between 30M and 40M: Portland and San Diego.

Only three cities are above 40M annual trips: Boston (72M), San Francisco (51M) and Los Angeles (63M). All three cities are geographically constrained therefore favouring high trip-numbers. Boston and Los Angeles have dramatically higher populations therefore favouring higher trip numbers. Boston's density goes back to the pre-vehicle area. In short, there are particular reasons for high ridership on these 3 lines. Ottawa's geographic characteristics, low density, and low population all point away from an annual ridership demand of 51M.

In fact, 19 of the 26 LRT cities have very close to 16 million annual trips. As such, the estimate made in this analysis is somewhat supported by the real-world evidence. The *Business Case* is not.

QUESTION# 2: WHAT IS THE ANNUAL DEBT-SERVICE CHARGE?

We know the basic project costs and the amount that Ottawa will have to pay.[91]

The first assessment will be the cost of the project considered only from the perspective of Ottawa payers; since, the provincial and federal amounts are not perceived by the Ottawa taxpayer those amounts will be left out of the preliminary analysis. Essentially the city of Ottawa is receiving an LRT for a price tag of $930M. Are the annual benefits at lease equal to the annual cost of $930M?

We know that 300M is financed at 6.32% (30yrs)

With these critical points put aside, it is now necessary to determine the PV and the annual payments required for capital-retirement of $2553M (2017) in a payoff period of 2017-2067 (50 years) at 6.32% interest.[92]

How do we calculate the capital costs of LRT?

We know that the City of Ottawa only committed $930M to this project. $1.2B is being committed by other levels of government and will therefore be perceived as 'free', from the Ottawa point of view, of paying for the project. In other words, the project looks to Ottawa taxpayers as though it costs $930M to them. As such, the direct issue for Ottawa taxpayers, (considering the issue only from their own financial welfare) is whether the

91 COST STRUTURE OF LRT:
600M federal
600M provincial
930M city
•Of which 300M at 6.32% (30 years)
•630M at 3.82% (30yrs)

92 6.32% interest rate required to be paid by Ottawa to the builder because the builder agreed to use some of his own funds to build the LRT rather than require Ottawa to deliver all funding.

benefits amount to more than $930B of present-valued dollars.

First we will determine the treatment of the first $300M of Ottawa monies toward the project which the city borrowed at 6.32%. Then we turn to the assessment of the remaining $630M which the city borrowed at the preferred federal guarantee rate (3.82%). Are the project benefits worth the cost?

The way to answer this question must start with how much people are prepared to pay to take a train-ride. That is the fundamental starting fact in every cost-benefit analysis. There are always other alleged benefits mentioned in these projects, alleged green benefits and alleged congestion benefits. They will be considered in turn, but if the true cost of a single-trip is so prohibitive that no one would pay it, there is no way that other 'benefits' could be weighed in to offset this deficiency.

When we factor in the total capital costs of the project and allocate those capital costs over all the expected trips to be taken over the next 30 years, the average ticket cost amounts to $3.55 just for the capital costs. Approximate operating costs[93] add another $4 to that $3.55 capital cost per trip, giving a true fare price of about $8 per person per trip.

There are few riders who would pay this price in today's Ottawa environment, even though it costs in excess of $20 to park a car and $3-$6 to drive a car, per trip to downtown Ottawa per day. It should be an easy sell to get $8 per trip. But the fact is clear from OC Transpo, *the trip value to customers is much less than $8 per trip*. This is a novel statement to citizens who have been listening to *Transpo-speak*, telling you how highly OC Transpo is considered. This analysis is aimed at laying out the real costs that will be hidden in the general property taxes of residents, 4 out of 5 of whom will never take the LRT.

- ***Step 1: calculate the full amount paid to builder for using builder-money for 3 years***

In the contract to build LRT, Ottawa wanted the builder 'committed' to the project in the sense of having some 'personal risk' involved so that the builder would have the proper incentive to finish the project on time and on budget.

While this is a good idea, the way that the City of Ottawa secured this committed builder was to pay him $167M[94] as a kind of signing bonus. The way that this was inserted into the contract was by Ottawa agreement to pay the builder an interest rate of 6.32% on the first $300M of monies injected into the project. In other words, Ottawa borrowed the first $300M from the builder, immediately gave the

93 We do not know the Ottawa LRT operating costs as the system is not yet operating. We can ***proxy*** Ottawa LRT operating costs by looking at Portland LRT annual operating costs per passenger-trip. Total Portland operating cost: $174M / total Portland passenger trips 34M = $5.11 Portland operating cost per passenger trip.

94 $5.58M per year over 30 years totalling $167M;

$300M back to the builder and agreed to give back 6.32% for the privilege of borrowing that money from the builder.

The reason that this 6.32% borrowing was mistake for Ottawa to do was because Ottawa was able to borrow the $300M elsewhere, at a lower rate of interest (3.82%). Because the builder somehow convinced Ottawa that this 'commitment' was a big win for Ottawa, Ottawa decided to pay this grossed-up interest rate to the builder.

So what is the true cost of this grossed up interest rate to Ottawa taxpayers?

Firstly, using the conventional methodology[95] to determine the annual payback amount on the ($300M) principal borrowed, we determine what we have to pay annually to the builder (over 30 years) to repay the $300M notionally borrowed from the builder. This amount is $22.5M annually[96].

Secondly, we determine the amount we would have had to payback if we borrowed this $300M from the best lender rather than from the builder. That best rate (3.82%), (which is the guaranteed federal government-backed rate) produces an annual payback of $16.9M. [97]

The difference between what we *did* do and what we *should have* done is ($22.5 -$16.9M) $5.6M per year. We have to pay this differential to the builder for the builder's apparent 'commitment'. This amount, considered separate and apart from all other monies in the project, amounts to $167M in total or $99M paid today[98].

Any Ottawa resident who has ever searched for a mortgage and compared mortgage rates between conventional banks and B-lenders knows the difference between borrowing at 3.8% and borrowing at 6.3%. No Ottawa resident who has been forced to borrow from a B-lender at 6.3% has ever called it a *'big negotiating win*' when 3.8% was available to them. Only Ottawa would say something like this.

- ***Step 2: calculate the full cost of the remaining $630M that Ottawa spent on LRT construction***

Next we turn to the remaining $630M which we will deem to be borrowed at 3.82% also for 30 years.[99] We follow the same method as in the treatment of the $300M. We use the standard annual equivalent amount calculation from con-

95 ***Contemporary Engineering Economics, a Canadian Perspective***, Addison-Westley, Toronto, 1995 p.268

96 Annual equivalent worth[96](i) = -P(A/P, i, N)
AE (6.32%) = -300M (0.0750, 6.32%, 30)
AE (6.32%) = $22,500,000

97 ual equivalent worth (i) = -P(A/P, i, N)
AE (3.82%) = -300M (0.0564, 3.82%, 30)
AE (3.82%) = $16,920,000

98 Present value (i) = (P/A, i, N)
PV (3.82%) = (22.5M – 16.92M)(17.4, 3.82%, 30)
PV(3.82%) = 5.58M(17.4, 3.82%, 30)
PV = $98.97M

99 The apparent fact that this $630M will be financed from gas tax and other current income does not change the analysis of the requirement to treat these monies as though they were borrowed. The simplest proof of this is that if the monies were not spent on this project they could at least be saved at 3.82% if not spent on a higher valued alternative.

ventional engineering economics project evaluation.[100] We see that at an interest rate of 3.82%, we must pay an annual repayment of $35.5M on the $630M we borrowed.[101]

So, the amount that the city must directly and immediately finance is equivalent to $35.5M per year. As of 2019, the city will have to add the $22.5M that is payable on the builder's financing ($300M) bringing the annual total to approximately $57M per year in financing on the approximately $900M that the city sees as its financing cost.

So far, the LRT is an annual cost project of $57M from the restricted perspective of Ottawa citizens, who only have to pay for less than half of the actual project costs. The carrying-charges to retire the Ottawa-portion of the debt in 30 years is $57M (annually).

- ***Step 3: how many trips will be taken annually on the LRT***

We will need to know the total number of trips that will be taken annually on the LRT in order to know the total number of units over which the total costs must be distributed

The City tells us what peak-demand will be. The City states:

> The initial vehicle purchase has been sized to meet the expected demand between today's peak demand of approximately 9,300 pphpd and the anticipated opening day peak demand of 10,700 pphpd. Because such projections are long-term in nature and based on City growth scenarios that are difficult to accurately predict into the future, the RIO built into the procurement process, vehicle options that allow the City to purchase additional vehicles to right size the fleet and provide for growth beyond what is currently anticipated. [102]

What is clear from this citation is that the City projects demand to be 10,700 riders per hour per in each direction in 2019.

From the 10,700 riders per hour in each direction, we can estimate the total number of trips annually to be approximately 16,050,000 peak-passenger trips, over which the capital cost + operating cost of the rail must be distributed. [103]

Distributing the $57M over 16M peak-period trips requires a fare at least set at $3.55 per trip. This will cover the capital cost. If operating cost is $4 that makes a fare-price of approximately **$8**.

100 ***Contemporary Engineering Economics, a Canadian Perspective***, Addison-Westley, Toronto, 1995 p.268

101 Annual equivalent worth (i) = -P(A/P, i, N)
AE (3.82%) = -630M (0.0564, 3.82%, 30)
AE (3.82%) = $35,532,000

102 Report to Council: ***Design Build Finance and Maintenance of Ottawa's Light Rail Transi***t (OLRT) Project, Ref. No. **ACS2012-ICS-RIO-0004**; December 4, 2012, p.23;

103 The total number of trips per year: the way this should be thought about is 10,700 per hour for three hours inbound and the same for outbound. This represents 32,100 passenger-trips inbound and 32,100 passenger outbound in each direction each day. This represents 64, 200 daily-trips multiplied over 250 weekdays or 16,050,000 annual peak-passenger trips, over which the capital cost + operating cost of the rail must be distributed. Off-peak trips are assumed to be negligible.

- ***Step 4: calculate the full cost of the total project as though Ottawa paid all costs***

Project analysis requires that all costs be accounted for. Even though Ottawa is in the enviable position of only paying 40% of the costs, assessing the true value of the project means looking at all the costs and all the benefits, (where the benefits are defined as the annual number of trips provided by the LRT).

When we factor in the *full* cost of the whole project we arrive at an annual re-payment requirement of $120M.[104]

When we factor this total annual repayment over the 16M trips, we arrive at a fare-price of **$7.50** per trip for capital costs. If we add $4 for operating costs, we arrive at an approximate true fare price of **$12** per trip.

This is the way economic theory arrives at the cost-benefit assessment. Even though no passenger will ever be faced with a $12 fare ticket, it is important to keep the truth in perspective so that we do not stray too far from reality when we undertake financially inappropriate decisions as cities and countries.

104 Annual equivalent worth (i) = -P(A/P, i, N)
AE (3.82%) = -2130M (0.0564, 3.82%, 30)
AE (3.82%) = $120,132,000

6. CONCLUSION:

Ottawa LRT phase 1 was not justified when a reasonable cost-benefit analysis is applied.

The break-even price to cover all costs of 16M annual trips is approximately $12 per ticket.

The break-even price of a ticket to cover only-Ottawa costs of 16M annual trips is approximately $8 per ticket.

Riders are unlikely to pay that much and *OCTranspo* is unlikely to charge that much.

The true ticket price falls to approximate $4 if there are in fact the 51million LRT trips predicted by the *Ottawa Business Case*. This is unlikely to be an accurate forecast.

The claims of ancillary ‘non-economic’ benefits, is not supported by the economic evidence from more than a hundred other transit cities. There will not be any significant mode switch away from vehicles. There will not be any significant ‘intensification’ caused by LRT. This means that the alleged green benefits from removing vehicles from the road will not take place.

Density is the key to economic success of LRT. Ottawa has the lowest density of any million-person city in the world. Ottawa’s density is less than half the lowest density evaluated in the literature. Ottawa has 1/50th the density of Tokyo LRT which cannot break even at $1.50 per kilometer ticket price.

7. POSTSCRIPT ON TRANSIT POLICY GOING FORWARD

Ottawa did not really consider all the available policy instruments for dealing with a perceived 2019 slow-down on the transitway. Light Rail Transit was an attractive idea to address predicted transitway slowdown. LRT was conceived as a measure to do more things than simply address a transitway slowdown. As with other cities that took on LRT, Ottawa LRT provided a multitude of solutions to everything from transitway slowdown to green benefits, to combatting sprawl to getting people out of vehicles.

Unfortunately these hopes never seemed to be achieved in other North American cities. The ultimate reason for this is that LRT cannot reverse sprawl.

In the 1980's when the transitway was built, the reasoning process in those early Ottawa master plans was realistic. The 1988 Ottawa Plan proposed:

> The official plan accepts that most residents prefer to live in low-density residential settings and does not attempt to alter those preferences. The transportation "means" to support this land use end was the introduction of a highly flexible bus transit network.[105]

105 Ibid.

Recent Ottawa planning (specifically the LRT) built around the theory of intensification is problematic because the basic causes of low-density are high-income, low land-prices, open geography and excellent roads. Intensification *by policy* is a very difficult result to achieve after 50 years of sprawl.

Confronted with the undesirable aspects of sprawl, Ottawa's recent actions tend toward more sprawl, not less. Heavily subsidized LRT induces *more* suburban living. *More* buses are estimated in the Transit plan, which means more sprawl. *More* development in Kanata, Orleans and Barrhaven implies sprawl.

Sprawl is not bad in itself, if the choice of suburban residential living includes all the costs to the city of that choice. This is the point. Almost every action Ottawa takes tends to *lower*, not *raise*, the perceived cost to the individual of suburban living.

Intensification is thus an Ottawa policy-objective pursued, in part, for narrow program-specific reasons. That is , a desire is to have shorter more dense bus-routes, shorter denser waste-management routes, denser emergency servicing etc.

Strong policy moves to force intensification are not necessary or desirable and policies such as easing downtown high-rise building permit issuance will do little to increase density.

The policy moves that should be pursued *start from* a respect for the private choices of individual residents who seek suburban space. But with this as the foundation, services to these residents *should not* be heavily-subsidized. They are moving there in large part *because of* the subsidized services.

There is nothing inherently wrong with an intensive and expensive OC Transpo or even an LRT, *as long as it is fully-priced to the user and still demanded at that full price*. The simple fact is that Ottawa is not populous or dense enough to provide the rider-population to financially sustain an LRT.

Public services like transit should be fully priced, wherever possible, so we are sure the quantity of that service is actually desired and the service is managed properly. Proper pricing actually makes management of the service easier.

Transit policy, like 'intensification' policy should start with a careful consideration of what the rider wants. This is not properly determined by surveys (people will always want a free good). Abstracting from income issues, desire for a transit-ride is measured in the price people want to pay for it. Ottawans will not want to pay anything close to the real cost per trip of LRT. This should be a strong signal to the city about whether to build LRT phase 2 and 3.

Appendix:

Figure 17 – Transit Occupancy of Existing Routes (2008)