REVIEW OF METROLINX'S BIG MOVE

Michael Schabas, First Class Partnerships Limited

Neptis Foundation

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To Tony Coombes, 1937-2013, who created better cities with his patient observation, meticulous analysis, and thoughtful perspective.

FOREWORD

This report began as a question asked by Tony Coombes, the founding executive director of the Neptis Foundation, who passed away earlier this year.

It then continued as a conversation between Tony and Michael Schabas, the report's author.

Both Tony and Michael were colleagues during the early days of the Canary Wharf project, when Canada's powerhouse development company, Olympia and York (O&Y), set out to build a new city centre in east London. Tony hired Michael as O&Y's Vice-President of Transport, to conceive, plan, and make the business case for the Jubilee Line Extension that would link London's Underground to the new city, and to upgrade the Docklands Light Railway.

Many years later, Michael and Tony reconnected during one of Michael's visits to Toronto, his hometown. Metrolinx had just released *The Big Move*, the $36 billion regional transit plan. Questions were raised as the two began a series of conversations about the Plan.

- What evidence suggests that the projects in the Big Move will double the number of transit riders and significantly reduce congestion in the region, as promised by Metrolinx?
- Does each project offer good value for money?
- Do all the projects add up to a substantial regional transit network or is the Big Move just an amalgam of projects put forward by diverse sponsors?
- How do the projects in the Big Move relate to the Growth Plan for the Greater Golden Horseshoe, its land use equivalent?

The discussion continued, and when it looked like the Big Move was going to be derailed by political considerations, Tony asked Michael to use his unique skills and experience to provide an evaluation of the *Big Move* and its component projects.

The *Big Move* has a laudable vision and goals, but if it does not deliver on them through its projects, public confidence in transit-building in Toronto region will suffer for many years to come.

Schabas's report attempts to peel back the layers of the Big Move and examine the business case for each project. He uses numbers provided by Metrolinx on their website, and from GO Transit and the TTC or from the original transit agency that conceived each project. The report asks the tough questions and reaches some conclusions that may be difficult to accept six years into the implementation of the Big Move. But the report also identifies opportunities for change and concludes that there is still time to make changes, and build the transit that the Toronto Region needs for today and tomorrow.

The report is therefore not only dedicated to, but a legacy of, Tony Coombes, a man who refused to stop asking the tough questions and always sought out the best regional solutions.

Marcy Burchfield
Director of Research Programming and Communications
The Neptis Foundation

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ABOUT THE AUTHOR

This report was prepared for the Neptis Foundation by Michael Schabas, a partner at FCP, a consultancy based in London, England, which advises governments, operators, passenger groups, contractors, and investors on strategies for technical and commercial development of railways and public transport. Schabas has been involved in planning, funding, and operating bus, LRT, ALRT, subway, and commuter rail in Canada, the USA, Australia, Germany, Nigeria, and Britain. He was born and raised in Toronto and was chairman of the City Cycling Committee from 1977 to 1979. For further details see www.fcpworld.net and www.schabas.net

EXECUTIVE SUMMARY

In its first discussion paper, the Transit Investment Strategy Advisory Panel constituted by Ontario Premier Kathleen Wynne to review the Metrolinx Investment Strategy noted:

> *"The infrastructure investments we make today will determine the quality of our lives for generations. Despite consensus on the seriousness and scope of the problem, we can't seem to agree on how to solve it."*

If decision-makers are to reach agreement on transit investment projects, they must have information that is clear, complete, and consistent to allow for the comparison of the relative merits and drawbacks of proposed projects. At present, this type of information is not readily available, and its absence is impeding public and political debates on how the region can use transit to reduce congestion and improve economic competitiveness.

Given the urgent need to expand transit in the region and to make decisions based on the best possible evidence, the Neptis Foundation commissioned this evaluation of all Metrolinx projects on a consistent basis, the first study of its kind for the Big Move. The report analyses the business case for each project individually and as a package. It also draws on international best practices to offer suggestions for improving certain projects to help Metrolinx realize its goals of doubling transit ridership by 2031, reducing average commute times and highway congestion across the region.

Using data from Metrolinx and TTC and making reasonable assumptions where information is unavailable, this report estimates the total cost of each scheme, including both capital and whole-life operating costs and benefits, the number of new riders that would be attracted to transit, what percentage of the costs could be recovered through passenger revenues, the net financial effect (which, if negative, is known as the "Funding Gap"), and the economic benefits, including time savings to motorists using less congested roads. These calculations generate key indicators, including Net Costs, Net Incremental Revenues, Net Benefits, Benefit:Cost Ratio, and Net Cost per New Transit Rider. As a general rule, if Net Benefits do not exceed Net Costs, and the Benefit:Cost Ratio is therefore less than 1.0, a scheme should not go ahead, at least not without modification.

The result is a high-level analysis that, for the first time, allows comparisons among the proposed projects and should help decision makers and the public better understand which Big Move projects offer the best value for money.

Key Conclusions

The report shows that while some projects represent good value for money, several can be modified to improve cost-effectiveness. A few projects should be reconsidered in their entirety (see Figure E1). The advice to Metrolinx is to consider a "course correction" to ensure that the Big Move reaches its important goals, and makes the best use of its available funds.

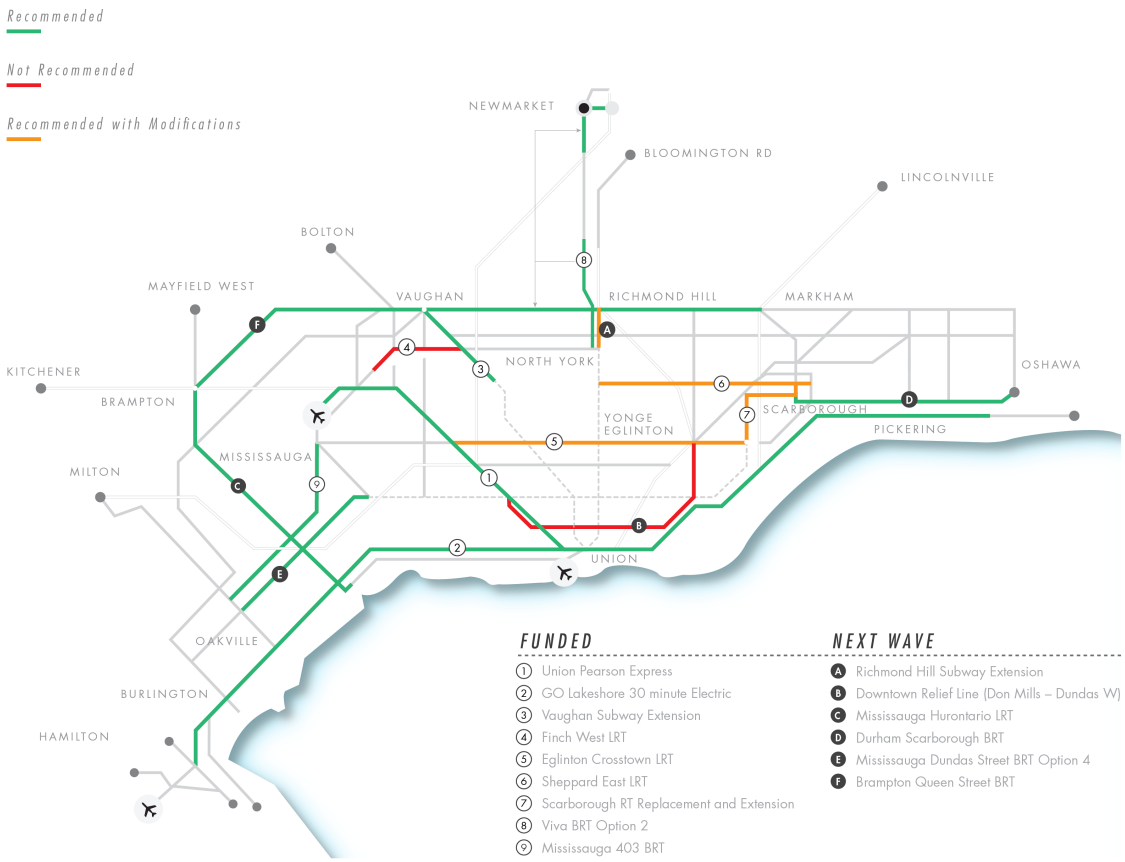

Figure E1: The map summarizes transit projects currently funded or included in Metrolinx's "Next Wave." Green shows projects that represent good value for money. Orange indicates projects that can be modified to deliver better value for money. Red shows projects that are not good value for money, and should not be implemented.

1. Recommended Projects

Union Pearson Express, the **subway to Vaughan** and several "Next Wave" **905 BRT-LRT** schemes generally provide good value. Although the Metrolinx analysis indicates that some of the 905 schemes have low Benefit:Cost Ratios, they are recommended because the Metrolinx analysis ignored the potential of improved transit to alter development or travel patterns and so may have underestimated ridership and benefits.

Metrolinx could push more aggressively to upgrade the GO Rail network into a Regional Express Rail network, through electrification and the operation of faster and more frequent all-day two-way services. GO Rail represents an underdeveloped asset that has more potential to take cars off the regional highways than any other scheme. In the 2008 Big Move plan, upgrading the GO rail network was listed as Metrolinx's "Number One" priority. Now it is on the back burner, with a 15- to 25-year implementation timeframe. Without this "backbone" of the regional transit system, the value of most of the other schemes is reduced.

Metrolinx may have hesitated to proceed with Regional Express Rail because the costs are considerable, without realizing that the benefits are even more so. GO Transit produced a flawed electrification study of

the Lakeshore corridor that overlooked the potential of operating a mixed fleet, using electric locomotives to propel the existing bi-level cars along with smaller Electric Multiple Units (EMUs). The report shows how a mixed-fleet strategy would be more cost-effective, and how an incremental investment of about $1 billion on the Lakeshore line could be offset entirely with additional fare revenues and operational savings. The entire GO system, including branches to Milton, Georgetown, Barrie, Richmond Hill, and Stouffville can be upgraded to a 15-minute-all-day, two-way service with 25% faster journey times for less money than the cost of the Phase 1 of the Downtown Relief Line.

2. Projects recommended with modifications

The report shows that the value for money of some Metrolinx schemes can be substantially improved, with specific modifications. As currently planned, the costs of the **Eglinton Crosstown** line are about twice the expected benefits. However, the Benefit:Cost Ratio can be improved if the construction of stations at Chaplin, Oakwood, Avenue Road, Laird Drive, and Mount Pleasant is postponed – unless major redevelopment is planned for the areas surrounding these stations. Each station costs more than $200 million to build, yet will attract only a few hundred new transit riders per day. The benefits of the line would be increased if the surface sections were elevated, allowing for faster travel times, while eliminating impacts on road traffic. With automated trains, as used on Vancouver's Skytrain, the additional costs could be entirely offset by additional revenues and operational savings.

Similarly the business case for the **subway to Richmond Hill** can be improved by deferring construction of several underground stations, which can be added later with contributions from developers with property interests along the line.

3. Projects for which the business case is weak

Metrolinx itself acknowledges that the business cases for the $2-billion **Finch and Sheppard LRT** projects are weak.

The report finds that surface LRT in the inner suburbs will not attract large numbers of new riders because the distances are too far, the services are too slow, and the vision of "Avenues" along Sheppard and Finch is unrealistic. The Benefits Case Analysis for the Finch and Sheppard Light Rapid Transit (LRT) projects also does not reflect current plans, as it was created for a single continuous line rather than the two separate lines now being proposed.

The report shows how the **Scarborough RT, the** proposed **Sheppard LRT,** and the **Sheppard subway line** can be combined into a single automated light rail system for a similar cost, yet the resulting system would attract many more riders than either TTC's LRT proposal or the subway alternative.

Metrolinx's BCA for the proposed $7.4-billion **Downtown Relief Line** contains no quantitative information about the likely benefits or incremental ridership, and provides no basis for policymakers to decide whether to support the scheme. Making reasonable assumptions, the report suggests that there is little chance that benefits of this scheme will offset even half its cost.

This report suggests relief to subway congestion can be provided more quickly by upgrading GO Transit services and integrating them with the TTC, at a fraction of the cost of a new line. A new link between TTC's Main Street station and GO's Danforth station, with integrated fares and shuttle trains to Union Station, would take thousands of passengers out of the Bloor-Yonge interchange at rush hour.

Similar opportunities exist at Dundas West, Kipling, and Kennedy stations.

4. Overlooked opportunities to improve services and increase value for money

The report identifies several opportunities to optimize transit that Metrolinx has overlooked (see Figure E2):

- **Integration of Services and Fares**: Although TTC has now agreed to implement the PRESTO fare card as an "electronic purse," the benefits of this initiative will be limited unless there is also full integration of the regional fare structure. "Smart pricing" with differential fares for peak and off-peak travel and lower fares for trips involving multiple operators can generate more revenue while attracting more riders onto the system. TTC's view that fare integration will *reduce* revenues is, we think, mistaken. GO could also introduce charges for car parking at stations, perhaps offsetting the impact with a reduction in off-peak fares.
- **Subway Modernization:** The report suggests that a subway modernization package with a 33% increase in capacity and improvements in off-peak frequency, offering transit passengers a faster and more comfortable journey, would result in a 10% increase in ridership and another 15% increase in revenues with "smart pricing."
- **Operating Efficiencies:** The report highlights some outdated operating practices, and estimates the potential financial benefits that could be achieved with automation of the subway and competitive tendering of service delivery, as is now common in many other cities. While the report endorses proposed charges for car usage and parking, which will encourage the shift to transit, it suggests that transit agencies need to demonstrate that they are efficient operators before asking for additional financial support.

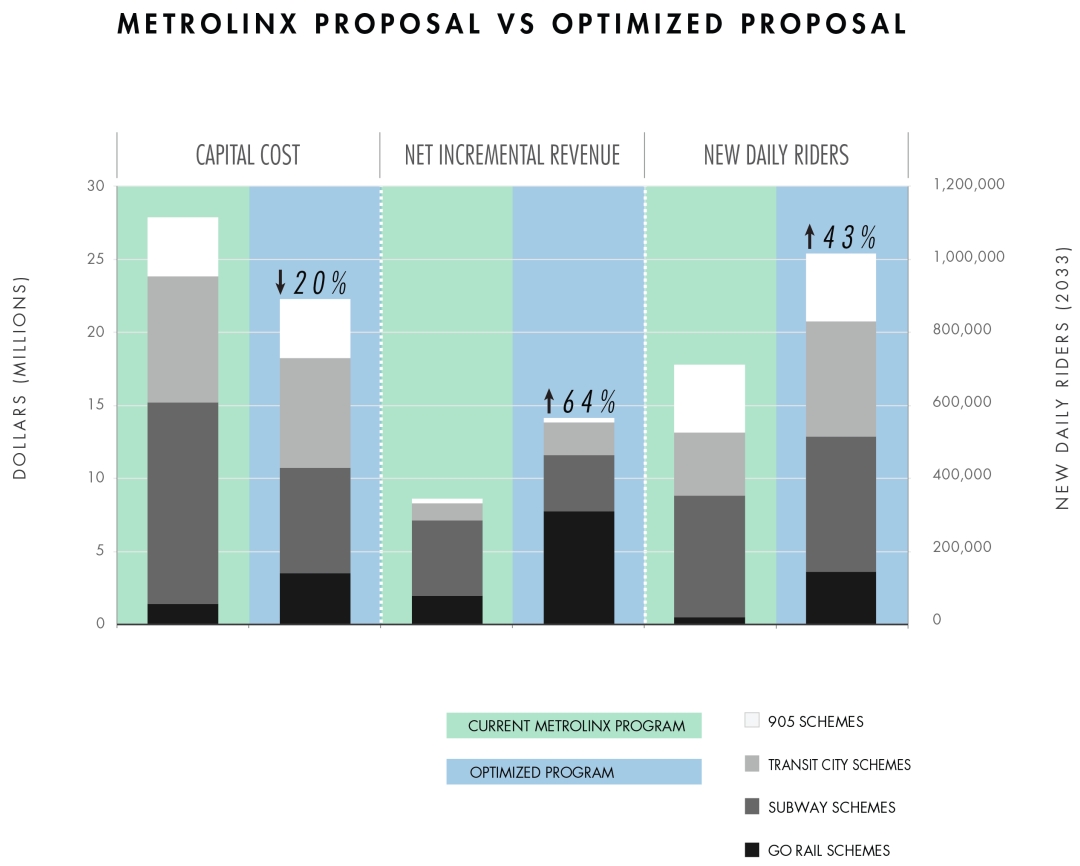

Figure E2: This bar chart shows the differences in capital cost, net incremental revenue, and new ridership for all major Metrolinx projects as currently proposed, and an "optimized" system – that is, projects that incorporate the improvements suggested in this report. The costs and contributions of GO Rail, subways, LRT, and BRT are shown within each bar, all as "Net Present Values." Note the large incremental revenue from the GO Rail schemes in the Optimized Program, far more than the capital cost of the GO Rail schemes.

5. Ridership goals

The report finds that the projects, as proposed, will not achieve the objective of doubling transit ridership. By 2033, the Metrolinx schemes currently under construction or planned will attract only about 700,000 new daily riders. Growth in demand on existing routes will be about 600,000, bringing the total daily ridership up to about 3.4 million, 800,000 short of the Metrolinx target of 4.2 million. With 800,000 more daily trips being made by car, traffic congestion will worsen and average daily commute times will continue to rise. Optimizing the system could, however, improve this situation, attracting about 43% more riders, with 20% less capital expenditure. With higher revenues and greater operating efficiencies, the net Funding Gap would be reduced by more than 50%.

6. Transparency

In 2008, Metrolinx committed to issuing a Benefits Case Analysis (BCA) for every project, and to using these analyses for prioritizing investment in schemes with a "regional focus." In fact, Metrolinx has not

released BCAs for many projects. Where BCAs are available, they do not always provide the consistent, complete, and comprehensive information decision makers need. Specifically:

- The BCAs for the $2.6-billion subway extension to Vaughan and the $456-million Union Pearson Express have never been released, even though both schemes are currently under construction.
- The BCA for the Eglinton Crosstown LRT was not released publicly until the author filed a request under the *Freedom of Information Act,* and after Metrolinx had awarded contracts to construct the tunnels.
- The BCA for the Finch and Sheppard Light Rapid Transit (LRT) projects does not reflect current plans. The BCA was prepared for a single continuous line rather than the two separate, shorter lines now being proposed.
- The BCA for the Downtown Relief Line does not provide any quantitative information about the likely benefits or incremental ridership, and gives no basis for policymakers to evaluate the project.
- No BCA has been issued for the Scarborough subway, which the Province now says it will fund.
- While most BCAs provide estimates of total ridership, they usually do not disclose the proportion that is "new" ridership, attracted to transit specifically because of the scheme. This is a critical measure for comparing cost-effectiveness and the contribution to achieving the Metrolinx goals.

The Transit Investment Strategy Advisory Panel has highlighted the need to take account of operating and maintenance costs and their relationship to fares to understand the larger question of whether a new project will be an ongoing financial burden to the system or a source of additional revenue (if fares exceed operating costs). While some of the BCAs present this information, not all do, and there are some large discrepancies between Metrolinx numbers and TTC numbers.

This report represents the first step towards a re-evaluation of Toronto's regional transit plan. It is not meant to scuttle existing plans, but to improve them. It is based on the limited information made available by Metrolinx and on the author's experience in international transit systems. More analysis is needed to understand the potential and the costs of the Big Move and its individual projects, and to give policy makers and regional residents confidence that Metrolinx is delivering projects that will meet its own principles and achieve its stated goals. In the end, the goal is to develop better transit that meets the region's needs and that demonstrates the power of transit to transform a region and keep it competitive.

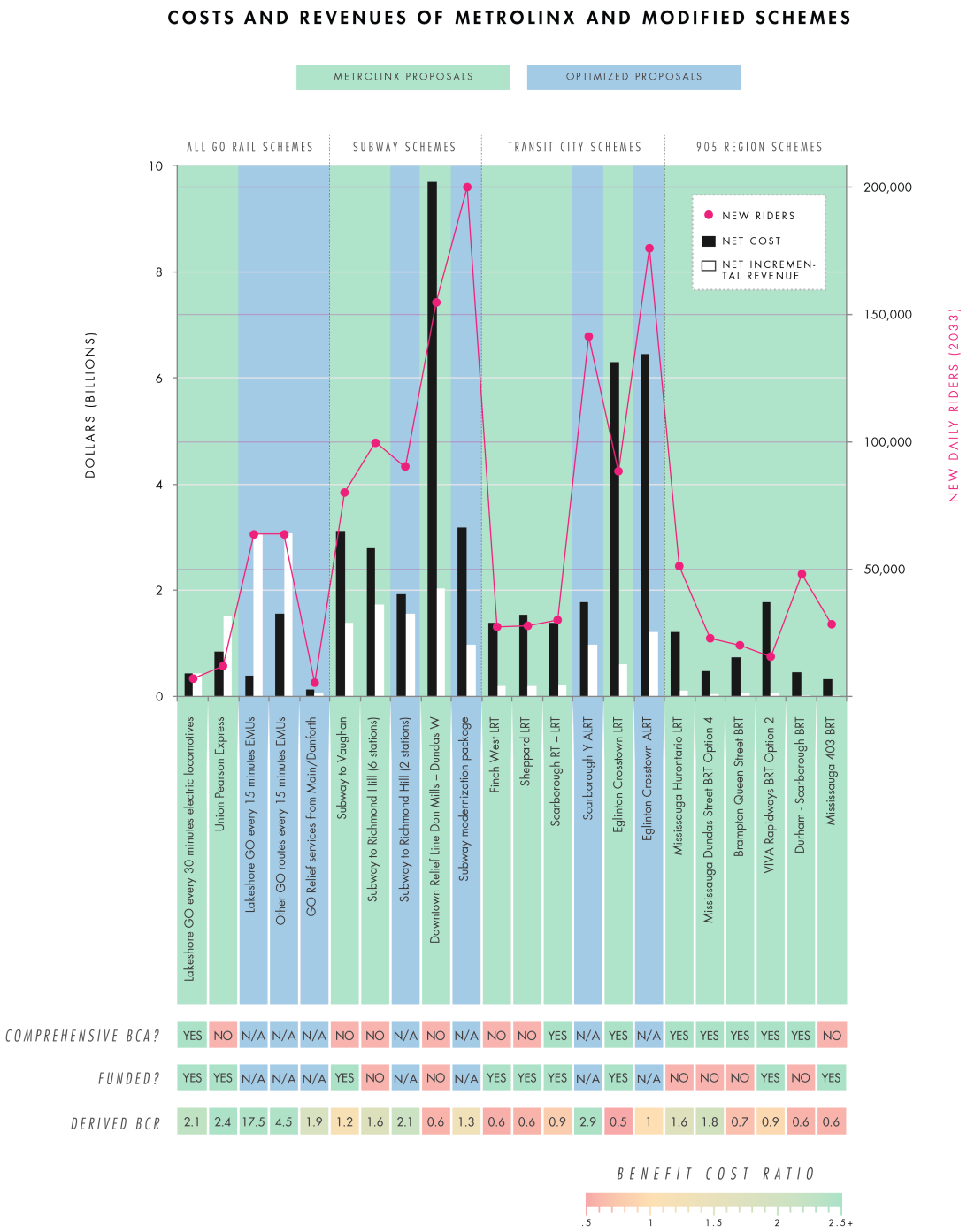

Figure E3: The summary graphic on the following page compares the schemes proposed by Metrolinx and the improvements recommended in this report. The black bars indicate net costs, taking account not only of capital and operating costs, but also savings from services that are replaced. The white bars represent net revenues, and the red line shows new riders for each scheme. Below the graph, the boxes indicates projects for which Metrolinx has issued a comprehensive Benefits Case Analysis, those for which funding has been identified as of late 2013, and the Benefit:Cost ratio for each project. A Benefit:Cost ratio of less than 1.0 indicates that a project does not represent good value for money. Note that incremental revenues exceed total costs for the UP Express and for the GO Rail upgrading schemes.

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INTRODUCTION

1.1 Purpose of this Report

Metrolinx, the transportation authority for the Greater Toronto and Hamilton Area, has embarked on a $36-billion program of capital investment that it calls *The Big Move*. The program includes more than 30 projects, ranging from new surface bus rapid transit lanes to subway construction. According to Metrolinx, *The Big Move* will:

- double the number of transit riders by 2031, from 2.1 to 4.2 million per day (implying an increase in the share of GTHA commuters using transit from 26% to 39%);
- reduce average daily commute times from 82 minutes today to 77 minutes.[1]

Metrolinx claims that without *The Big Move,* transit mode share would continue to fall and average commuting times would increase to 109 minutes per day as traffic congestion worsens.

Metrolinx already has about $11 billion of "committed" funding, and has embarked on several of its "Top 15" schemes. It describes its plans as "aggressive, bold, and doable."[2] It is now consulting on a variety of new regional taxes and charges to raise a further $25 billion to fund the "Next Wave" of projects.

This report is intended to answer the following questions:

- Will the Big Move projects achieve the Metrolinx objective of doubling transit ridership?
- Are these projects consistent with Metrolinx's own "guiding principles"?
- Are they well-designed, consistent with international best practice, and integrated with other transport infrastructure?
- Will they support a shift of inter-regional travel onto transit?
- Are there alternative, more effective schemes that should be considered?
- What changes would help Metrolinx produce better results?

1.2 Transit in the Toronto region since the 1950s

The City of Toronto was once an international leader in public transit. TTC was one of the first operators to integrate buses, streetcars, and a subway across a metropolitan area. From 1954 to around 1980, strict planning controls encouraged high-density development along the subway, and along major arterial routes with good bus services. Despite widespread car ownership, transit ridership was high, even in the suburbs. Development of GO Transit, beginning in the late 1960s, and cancellation of plans for more radial

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[1] Big Move website: http://www.bigmove.ca/what-is-the-big-move/the-regional-plan/a-solution-to-the-problem

[2] Metrolinx presentation "Achieving 5 in 10," May 19, 2010.
http://www.metrolinx.com/en/docs/pdf/board_agenda/20100519/Five_in_Ten_Board_web.pdf

expressways, was a clear statement that central Toronto would remain a city for transit riders and pedestrians.

However, attempts to extend the transit culture to the newer suburbs began to falter in the 1970s. The flat fare was extended to the Toronto (Metro) boundary, bringing a one-off jump in ridership, and suburban bus services were increased. The subway was extended into the outer boroughs. But attempts to extend subway and light rail lines further into the suburbs have been expensive failures. The Scarborough RT and Sheppard Subway did little to spur more efficient, denser development. Planned extensions to these lines were never built and Toronto did not even take steps to protect surface alignments for future rail lines from development.

While GO has continued to extend and improve rail services, and has an extensive bus network, it is still very much a peak-hour commuter operation. Contra-peak and off-peak services are still limited, mostly only operating hourly, and there is little integration with TTC services.

Surrounding regions operate local bus services, and have begun to develop priority bus lanes and BRT routes such as Züm (in Peel Region) and VIVA (in York Region). But cross-boundary service integration is often poor, and the limited regional fare integration means cross-boundary transit trips are discouraged.

While no new radial expressways into downtown Toronto have been constructed, the regional network has doubled, with the construction of Highways 403, 404, 407, 410, and further widening of the 401. Meanwhile, suburban development has continued and even accelerated, and the regional population has doubled. Predictably, the GTHA is suffering from severe traffic congestion, affecting the quality of life for Toronto residents and damaging the city's reputation as a good place to live and work.

There seems to be a recognition, as there was in the 1970s, that road construction can never keep pace with traffic demand. The creation of Metrolinx, a regional body to address a regional problem, reflects a renewed consensus to invest in rapid transit.

1.3 Metrolinx's Guiding Principles

Metrolinx was established in 2006. Within two years, it had produced a Draft Investment Strategy and "The Big Move," essentially a master plan for development of rapid transit across the GTHA.

In its Draft Investment Strategy,[3] Metrolinx set out five "Guiding Principles" (the descriptions below are condensed from the originals):

> ***Principle 1*** *– Regional or "Metropolitan" focus …We need a Regional Transportation Plan and Investment Strategy that reflect the way most of us live our lives and perform business – where we routinely cross local community and municipal boundaries to support a dynamic regional economy, labour market, and institutional and social networks across the GTHA...*
>
> ***Principle 2*** *– Invest where it Matters Most – all Metrolinx investments should be aligned with the RTP and subject to a fair, easy-to-understand and rigorous "Benefits Case" screening process where economic, environmental and social needs and impacts are taken into direct account…*

[3] Metrolinx: Draft Investment Strategy. September 2008.

> ***Principle 3*** *– Prudent Financial Management – We believe that the investments should be affordable and that a financial plan should be in place to show how the investments will be funded…*
>
> ***Principle 4*** *– A System that Works and is Accountable – Metrolinx is a regional authority, and we will be directly accountable to all people in the GTHA. Our pledge is to post regular reports on exactly how we are progressing towards achieving our plans...*
>
> ***Principle 5*** *– Risk Management and Project Implementation Discipline – …We will not make a single investment until we are satisfied that risks will be managed, projects will be delivered on time and on budget, and there will be no "surprises."*

Metrolinx's "guiding principles" make sense. And the prize seems to be well worthwhile, if it can be achieved for the promised price.

In "The Big Move,"[4] Metrolinx set out specific quantified targets, essentially what it hopes to achieve by 2033 (see Figure 1). The Big Move also included a map showing a network of transit lines criss-crossing the GTHA (see Figure 2).

In its effort to produce results quickly, it appears that Metrolinx developed the Big Move by combining all the schemes that were currently being proposed by GO Transit, the TTC, and each local municipality. Metrolinx put them together in a map and a program, with little or no modification. The following year, in its 2009 Regional Transport Plan, Metrolinx seemed to have recognized that not all of the Big Move schemes were compatible with its "guiding principles":

> *To ensure that all transit investments provide the maximum value in return for the investment, Metrolinx will lead an objective and comprehensive Benefits Case Analysis for each transit project. The Benefits Case Analysis will inventory the benefits and costs associated with some projects and will determine the most appropriate routes and technology. The Benefits Case Analysis will also help to identify performance measures that can be applied to transit projects, so that travellers and citizens receive the maximum benefit from transit investments.*[5]

[4] Metrolinx: The Big Move, November 2008.

[5] Metrolinx: Regional Transport Plan 2009

	Today	By 2033	
	Our region	Current trends	With *The Big Move*
Annual transit customers	630 million	800 million	1.3 billion
Rapid transit route network	500 km	525 km	1,725 km
% of people commuting to work by transit, walking or cycling	26%	25.4%	39%
% of people who live within 2 km of rapid transit	42%	47%	81%
Annual greenhouse gas emissions from transportation, per person	2.4 tonnes	2.2 tonnes	1.7 tonnes
Average daily commute time	**82 minutes**	**109 minutes**	**77 minutes**

Figure 1: Targets set out in The Big Move[6]

Figure 2: The Big Move Map[7]

[6] Source: Big Move website: A Solution to the problem

[7] Source: The Big Move, http://www.metrolinx.com/thebigmove/en/interactive/schedule1.pdf

1.4 The Plan

On The Big Move map, the GO Rail system, shown in red, is to be upgraded into a regional metro, a fast network of trains linking all parts of the GTHA. Toronto is fortunate to have a rail network, built originally for freight trains, that can be adapted in this way. Although essentially a radial system, it can also serve many suburb-to-suburb journeys. Subways, light rail transit (LRT) and bus rapid transit (BRT) lines, shown in yellow, are to be extended and linked together into a second-tier '"grid." They are intended to serve shorter trips, connect regional nodes, and carry passengers to the GO lines for longer trips.

London, Paris, Tokyo, Hong Kong, and Singapore have all developed similar "three-tier" transit systems, with a network of radial rail lines for inter-regional trips, slower metro and light rail lines providing local collection and distribution, and bus and surface trams to penetrate local communities.

But maps can be misleading. The actual usefulness of the system will depend on service details such as speeds, journey times and frequencies, the integration of fares, and station layouts. If any one of these does not work, then the competitiveness of transit suffers and many travellers will continue to drive. For example, the 905-region BRT routes, and the TTC's Scarborough-Eglinton-Crosstown LRT route, appear to offer an alternative to Highway 401 for crosstown trips. But in fact, journey times will be too slow – almost two hours from eastern Scarborough to Pearson Airport. Although these schemes appear to be "inter-regional," because together they cross municipal boundaries, most trips will be local unless there are good connections onto a fast inter-regional network.

A key challenge for Metrolinx is to ensure integration, so commuters can travel across the region easily and with few transfers. Motorists driving along local, regional and provincial roads may notice a slight change in signage, but otherwise do not notice much difference between the roads. Transit riders, however, do not have the same kind of experience. Black dots are easy to show on maps, but effective transit interchanges can be much more problematic. Sometimes trains pass but do not stop. Sometimes an interchange requires a long walk between stations, or crossing a busy road. While some interchanges are reasonably well designed, at others even basic signage is lacking. The lack of contra-peak and off-peak services on many GO rail routes means that a trip that looks simple on the map is in fact very slow and difficult to accomplish. It can also be expensive. Currently, people travelling between, say, Oakville and Richmond Hill may need to pay two or three fares. Regular commuters can learn timetables, and purchase a monthly pass. But many people have irregular travel schedules or work shifts. If they need a car for some trips, they will be inclined to use it for all trips.

TTC's agreement to implement the PRESTO farecard will reduce the need for passengers to purchase multiple tickets. But this alone will not achieve the full benefits of smart cards. Currently, each operator sets fares according to its own policies, essentially to recover a target share of costs. Flat fare pricing on the TTC and regional bus services is simple to understand, but does not represent "smart pricing." GO Transit fares vary by distance, but not by time of day. By comparison, London, England, has used smart card technology to increase ridership and revenues, effectively offering discounts for off-peak and inter-regional trips. With carefully designed smart pricing, it is possible to offer lower individual fares while increasing overall revenues by attracting higher ridership.

This report considers each of the Big Move projects. We evaluate them using the criteria suggested by Metrolinx. Are they consistent with the guiding principles? Will they contribute to achieving Metrolinx's

targets for increasing ridership and reducing commuting times at a reasonable cost? And, where it is relevant, we suggest ideas from international best practices that might improve the proposed schemes.

2

STUDY APPROACH

2.1 A Consistent and Transparent Approach to Evaluating Transit Proposals

We looked at Metrolinx's overall strategy, its policies, and how they are being implemented, and at each individual scheme. We used Metrolinx and TTC estimates of cost, ridership and benefits in our analysis, wherever available. We have drawn on international best practices to suggest ways to improve schemes.

For each scheme we considered:

- Capital and operating costs, including offsetting savings to existing transit operations.
- Traffic and fare revenues for 2023, mostly using elasticities applied to existing traffic.
- Road congestion relief benefits: These are assumed to range from $2 to $20 for each new transit rider as indicated in the Metrolinx BCAs for each scheme. We also consider disbenefits to road users, where LRT schemes reduce road capacity.
- Passenger benefits not captured by fares: Metrolinx uses the rate of $13.52 to value passenger time savings per hour for existing riders; half this rate is applied to new riders. The figure of $13.52 is an average and the value of time would be lower or higher for different groups of riders.
- How changes to fares, including use of the full capabilities of PRESTO, could maximize revenues without deterring ridership.

We have sought to explain our methodology, results, and conclusions in a transparent form that can be understood by non-specialists.

2.1 Net Present Value (NPV)

In order to compare schemes, we have converted capital and operating costs and revenues into Net Present Values. This is a normal step in project evaluation: future benefits are worth less to us than benefits received today. Net Present Value (NPV) is a way of representing the current value of future benefits and costs.

We found some discrepancies in the existing analyses that hinder straightforward comparisons and may confuse some readers. For example, the Benefits Case Analyses prepared by Metrolinx provide estimates of NPVs for many costs and benefits, and for many – but not all – of the schemes. In some cases they present annual data as well. By contrast, TTC generally presents estimates of capital costs in current dollars, including allowance for inflation. This means that a scheme estimated to cost, say, $1 billion in current (2013) dollars over several years, might be shown by Metrolinx to have a cost of about $850 million NPV, while TTC might show the scheme as estimated to cost $1.1 billion. The two figures are not necessarily inconsistent; the difference is in the approach. Metrolinx is in effect saying that if you put $850 million in the bank, in an account earning 5% per year interest, plus inflation, you would be able to build the scheme over time, because the money would grow before you spent it. TTC on the other hand is saying that they

would actually spend $1.1 billion on the project, over time, because the costs of the work would increase with inflation.

The best way to estimate NPVs is to build a financial model, with projections of year-by-year cash flows and benefits. Metrolinx seems to have done this, although they have not released the detailed projections, only the final NPVs. We do not have sufficient information to prepare year-by-year cash flow projections. However, we can estimate the NPVs for each scheme from data provided by TTC and Metrolinx, using consistent, somewhat simplified, heuristic methods.

For the GO Rail and TTC schemes, the NPV of revenue, passenger and road traffic benefits, and O&M costs is assumed to be 23 times the 2023 annual figure. Capital costs are converted to NPVs in 2010 (the base year for most Metrolinx analyses) by taking 70% of the estimated cost. The factors of 23 and 70% are broadly consistent with the figures presented in Metrolinx and GO reports, and with Metrolinx's 5% real discount rate.

For the 905 region BRT schemes, we used Metrolinx BCA figures, which are in most cases already presented as NPVs.

2.2 Net Financial Effect – the "Funding Gap"

For each scheme, we estimate the Net Financial Effect to the government, which we also call the "Funding Gap." Usually this is a cost, but not always. Some of the GO Rail schemes, and the Union Pearson Express, show a positive financial return using a 5% public-sector discount rate.

For each scheme, we add up all the capital and operating costs, including any savings to the costs of running existing transit services, as well as the additional revenues that passengers will pay in fares. All of these are converted to a Net Present Value. The Net Financial Effect is the cost to the government over the long run of a new investment, which must be filled, usually with public funds.

While improved transit will benefit the economy, the benefits may be entirely offset if higher taxes make the region a more expensive place to live and work. Fares are a better way to pay for transit, provided they are set at a level that is not a serious deterrent to transit use. "Smarter fares," made possible with smartcards, can maximize revenues while also maximizing ridership.

Overall, fares offset about 80% of operating costs on the TTC and GO networks,[8] but the performance of individual routes can vary widely. Some of the planned schemes will actually generate higher revenues than the net change in operating costs, in effect paying back some of the capital cost. But some will not, and some will even increase the operating subsidy required.

If decision makers choose the schemes that offer relatively good financial performance, Metrolinx's limited resources can be stretched further, and there will be less need to raise additional funds to pay for transit.

2.3 Net Benefits and Benefit:Cost Ratios

Adding up all the costs and benefits of a scheme, converted into NPVs at a single year, allows us to calculate two very important measures.

[8] Metrolinx Annual Report for 2010-2011, http://www.metrolinx.com/en/aboutus/publications/AnnualReport20102011_Final-EN.pdf

1. **Net Benefits** tells us whether a scheme is actually worthwhile as a whole. This number, presented as a Net Present Value, sums up all the benefits, including time savings for passengers and road users, and subtracts the costs. If the number is positive, then the scheme is likely worthwhile.
2. **Benefit:Cost Ratio** shows how confident we need to be of the cost and revenue figures. These figures can only ever be estimates, and estimates can be wrong. However, if the Benefit:Cost Ratio is, say, 3.0, then we can have a high level of confidence that a scheme is worthwhile. The actual costs would have to be three times higher, or revenues or other benefits one-third of what we expect, before the scheme would prove not to be worthwhile. But if the estimated Benefit:Cost Ratio is close to 1.0, then any cost overrun or ridership shortfall could bring it below 1.0, meaning the scheme as proposed is not worthwhile.

2.4 Estimating ridership: fixed and dynamic approaches

The main purpose of the Big Move schemes is to increase transit ridership, to double it, in fact. Therefore it is important to have some confidence that the schemes proposed will encourage people to make the switch from automobile travel to transit.

Metrolinx has estimated ridership for most of the schemes using the Greater Golden Horseshoe Model. This large and complex model is based on years of research and thousands of input assumptions. Models of this type are deployed by regional planning authorities around the world. They are expensive to use, and the results are often difficult to interpret.

The Greater Golden Horseshoe Model (like similar models) also has some important limitations. Specifically, the model takes forecasts of land use as a fixed input, even though the relationship between land use and transportation is dynamic and two-way.

An ideal modelling process would be iterative, allowing for the fact that improved transit attracts new riders and encourages more compact, transit-oriented developed, which in turn supports better transit with greater ridership. However, it is very difficult to devise accurate models that are iterative to this degree. As a consequence, traffic modellers usually look at each scheme as an increment from a "base case" that represents land use and travel patterns for an assumed minimal transit network, and then evaluate each scheme as an added increment to that network.

This use of a "fixed trip matrix" and incremental analysis of schemes against a base case, means that the GGH model usually underestimates the effects of schemes that will have large impacts on land use or on regional trip patterns, or both. These are important limitations.

We also understand that Metrolinx modelled schemes against a base case that did not include the effects of policies such as higher gas taxes, road tolls, or parking charges. If these were to be implemented, then the Benefits Cases and the Benefit:Cost ratios for many schemes would probably be higher than those indicated in the Metrolinx BCAs.

Wherever Metrolinx has provided traffic and revenue forecasts, we use these, recognizing the limitations stated above. However, for many of the Big Move schemes, including the Vaughan Subway extension, the Downtown Relief Line, and the Sheppard and Finch LRT lines, Metrolinx has not provided traffic and revenue forecasts (Metrolinx has provided forecasts for a combined Sheppard-Finch LRT, but the scheme it analysed is substantially different from the two schemes now being proposed).

We have therefore developed our own estimates for ridership. As we do not have the resources to use the GGH model, we have used sketch planning methods. Primarily, we use demand elasticities, based on research and experience of operators around the world.

We separately estimate the ridership that could be generated by each scheme by 2033, taking account of network synergies, development, and the impact of higher fuel taxes and parking levies. We acknowledge that ridership depends on the quality of the transit system: speed, frequency, fares, crowding, comfort. But it also depends on urban development and other factors such as fuel prices, parking charges, and traffic congestion.

Ridership also depends on synergies with other schemes. Specifically, light rail and BRT schemes will have much greater benefits if they connect to a higher-order inter-regional network, but Metrolinx has not made clear in its BCAs whether high-frequency all-day GO regional express rail service is assumed to be in place or not.

This is, to the best of our knowledge, the first time anyone has attempted to estimate the costs and benefits of all the Big Move schemes on a standardized basis. Notwithstanding its limitations, we think this type of analysis is essential, if policymakers are to make intelligent choices as to how to spend scarce public funds.

Metrolinx, TTC, and transit providers in other municipalities should use their own financial and economic models to develop more detailed estimates. We look forward to seeing them. We think they are likely to arrive at similar conclusions.

2.5 Other Limitations

We acknowledge that transit accounting and project evaluation is complicated and subject to many limitations:

- Capital investments are very large, with implementation over many years, during which time cost rates may change in ways that cannot always be predicted accurately.
- Capital investments may interact with the renewal of existing assets. Unless project accounts are "ring fenced" (that is, paid into a separate corporate entity with a single purpose), it is difficult to track planned against actual expenditure. Certain costs may be attributed either to the new project, or to maintenance and renewal of the existing system.
- Fares are set by government policies and not necessarily in response to market demand.
- Returns on investment can accrue through increased revenues, operational savings, or broader economic benefits. All can be difficult to estimate with confidence. Estimates of revenues depend on assumptions about fare policy and urban development, and on other transport policies.
- Labour is a high proportion of operating costs, and the industry is highly unionized. Estimates of operating costs depend on assumptions about wage rates, but also on pension liabilities that fluctuate depending upon the stock market.
- New services may increase or decrease traffic and revenues on other services or other operators. They may also increase or decrease crowding, affecting other investment and cost requirements. Individual investments need to be evaluated both on a stand-alone basis and as an increment to the entire system.
- Project evaluation requires estimates of the cost of capital, so that figures for costs, revenues, and benefits can be converted into Net Present Values. The choice of interest rate can be decisive in deciding whether an investment is worthwhile. While governments may be able to borrow at relatively

low interest rates, without reliable new sources of funding, large borrowings may affect the province's credit rating and the cost of all debt.

We have attempted to consider these points in our analysis.

We have not considered social benefits (such as safety or equity) or environmental benefits (such as reduced air pollution or increased energy conservation), which often go unpriced in transportation forecasts. While these are important considerations, they are seldom the deciding factors in scheme selection.

We have tried to use numbers from Metrolinx, TTC, and other public sources, so schemes can be evaluated on a consistent basis. However, there are some inconsistencies and weaknesses in the available figures and studies.

Metrolinx and the TTC have not updated the Benefit Case Analyses (BCAs) as schemes have changed. For example, there is no published BCA for the Sheppard LRT, as it is currently envisaged, or for any of the current GO Rail schemes. There is no BCA for the Scarborough subway proposals. Metrolinx has issued a "Preliminary BCA" for the Downtown Relief Line, but it includes no estimates of ridership or benefits.

As noted above, the GGH model uses a fixed trip matrix, which Metrolinx rightly acknowledges has significant limitations. It is particularly likely to underestimate the benefits of the 905-region schemes, and its use is discussed further in the section on those schemes.

TTC and Metrolinx often present ridership forecasts as an *annual* figure, and do not break the figures down to show how many of these riders have been diverted from existing transit lines and how many are new riders who previously used automobiles to make a particular trip. We prefer where possible to give figures for *daily* riders, which are easier to understand and more meaningful. TTC forecasts also usually compare future ridership (after an improvement has been implemented) to existing ridership. This approach is potentially misleading, as some or even most of the ridership growth might have occurred even without the improvement. We try to distinguish "underlying" ridership growth from new ridership growth that can be attributed to a particular scheme or investment.

Metrolinx BCAs provide estimates of both incremental fares and auto cost savings. One or the other should be included in calculating the Benefit:Cost ratio, but not both, because they are two sides of the same coin. New transit riders pay fares, but pay less to drive their cars. One would expect the figures to be roughly similar. For the Eglinton Crosstown scheme, auto operating cost savings are said to range from 1.4 to 2.5 times incremental fare revenues,[9] but for Durham Scarborough Bus Rapid Transit, they are 10 times higher. For Transit City schemes, the Benefit:Cost ratios seem to have been calculated using auto cost savings, while for most of the 905 region BRT schemes, Metrolinx seems to have used incremental fares. We think that the calculation of auto cost savings is misleading, and recommend consideration only of incremental fares. This measure reflects the net value to passengers, taking account of the convenience and comfort factors that are traded off when they switch to transit.

Metrolinx BCAs usually do not disclose the number of trips that will be diverted from car to transit, so they provide no basis for verifying the claim that the Big Move schemes will, together, reduce road congestion from current levels.

[9] See Eglinton Crosstown BCA, tables 4.5 and 4.6.

Most of the BCAs refer in general terms to reliability benefits of rapid transit, but only the Eglinton Crosstown BCA includes calculations of its possible value.[10] We do think there may be a case for including reliability benefits, which to some degree may also be a proxy for passenger comfort. However, we think this reliability benefit should probably be counted only for existing passengers; new passengers are making a trade-off between their existing mode and transit, and any benefit should already be reflected in the fare revenue. Metrolinx appears to be claiming the reliability benefit for all passengers, which would overstate its value by a large margin.

2.6 Understanding mode choice

Policymakers need to understand the costs and benefits of regional express rail, subway, light rail transit, bus rapid transit and regular buses in a way that allows for a full appreciation of trade-offs and a comparison of their potential uses. See the Appendix, Section A13, for a fuller discussion of this issue.

[10] The GO Electrification study also includes some estimates of reliability benefits.

3

GO RAIL AND A REGIONAL EXPRESS RAIL NETWORK

Metrolinx's ability to deliver on its first guiding principle, "Regional Focus," depends on its use and management of the GO Transit system. This is the backbone of any future regional network. Understandably, in the 2008 Big Move, Priority Action Number 1 was upgrading the GO rail system into a "fast, frequent and expanded regional rapid transit network."[11]

Our analysis confirms the original conclusions of The Big Move: there are massive benefits to be gained from upgrading the GO Rail system into a two-way system offering fast and frequent all-day services. Indeed, the financial benefits of reduced operating costs and higher fare revenues could offset most or all of the costs. Compared with the subway extension and LRT schemes, the capital costs are actually fairly modest. Taking account of the time savings and other benefits to transit riders and road users indicates very high benefit:cost ratios. Unfortunately, GO does not seem to have recognized this opportunity.

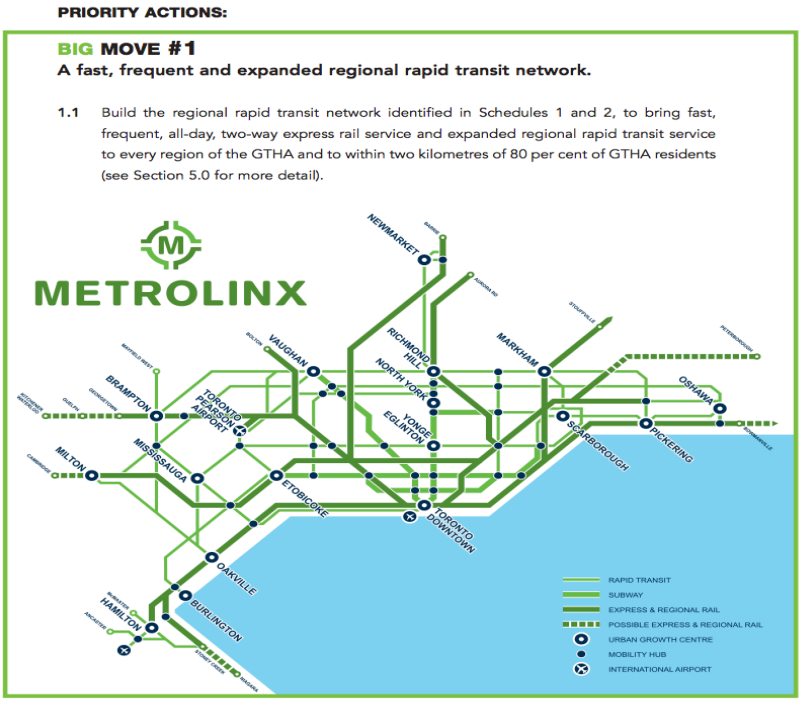

Figure 3: Upgrading GO into a true Regional Express Rail system: Priority Project 1 in the Big Move.[12]

[11] Source: The Big Move, http://www.metrolinx.com/thebigmove/en/strategies/strategy1.aspx

[12] Source: http://www.metrolinx.com/thebigmove/en/strategies/strategy1.aspx

GO management has a record of successfully delivering incremental service upgrades over the past half century. Typically, it has had a capital budget of $50 million or $100 million per year, while consistently recovering 80% or more of operating costs through the farebox.

In 2009, Metrolinx completed a "Benefits Case Analysis" for GO Transit Lakeshore Express Rail, indicating that phased electrification and service upgrading (costing, initially, about $2.5 billion) would bring benefits, mostly time savings to passengers and reduced traffic delays to motorists, of about $5.8 billion.[13]

GO then proceeded with an electrification study,[14] published in December 2010. This longer, more detailed study concluded, essentially, that electrification *might* be worthwhile, taking account of operating savings and passenger benefits. But the Benefit:Cost ratio was not much greater than 1.0, and depended on certain assumptions about capital costs and future energy costs that were subject to change.

Figure 4: GO rail upgrading hardly figures in Metrolinx's "9 Top Priority Projects" in 2011.[15]

GO management and provincial decision makers hesitated to take on a massive investment that the study seemed to show to be barely worthwhile in economic terms and which would, apparently, need to be funded mostly by public investment.

In 2011, Metrolinx reviewed its investment priorities.[16] "Express Rail" had dropped off the agenda. Now the only "Big Five" project relating to GO Rail is the rebuilding of Union Station.

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13 http://www.metrolinx.com/en/regionalplanning/projectevaluation/benefitscases/Benefits_Case_GO_Lakeshore_Final.pdf

14 http://www.gotransit.com/electrification/en/current_study/docs/ElectricificationStudy_FinalReport.pdf

15 Source: Metrolinx, May 2010, http://www.metrolinx.com/en/docs/pdf/presentations/rob_prichard_presentation_tbot170510.pdf

16 http://www.metrolinx.com/en/aboutus/publications/Strategic_Plan_Final.pdf

GO has since purchased diesel multiple units for the Union-Pearson Express service,[17] and low-emission Tier-4 diesel locomotives to propel bi-level trains. This suggests at least a medium-term commitment to diesel power.

GO is now adding tracks and grade separations, increasing all-day services on the Lakeshore route to half-hourly, and seems committed to extending services to Bowmanville. It is also exploring ways to introduce two-way all-day services on other routes, using diesel-powered bi-levels at half hourly frequencies. Metrolinx is also proceeding with preparation of an Environmental Assessment for electrification of the Union Pearson Express line. This could be a first to step to gradual upgrading of the system. However, no master plan for the system as a whole has been released.

The initial enthusiasm for upgrading the GO Rail system, which was "Priority Action #1" in the Big Move, dissipated quickly. Money that could be spent to turn the GO Rail system into a true regional metro, with frequent all-day services, has been diverted to LRT projects, mostly in the City of Toronto, at least for the "First Wave" of projects. What happened?

It matters, because until the GO Rail system is upgraded, there is little chance of delivering the Metrolinx objectives. The regional rail system is the "backbone" of the GTHA public transit system. LRT and BRT services have a local and feeder role, but are too slow to compete with the road system for longer-distance trips within Toronto and throughout the region.

3.1 Existing service on GO Rail

Currently, GO's operating strategy is to carry large numbers of peak commuters on very large bi-level trains, propelled by diesel locomotives. The trains do not move very quickly, and acceleration is relatively slow, but when you are competing with a crowded highway such as the 401 or the Queen Elizabeth Way, in peak hours, this does not matter much. GO has high cost recovery, with revenues more than 80% of operating costs.[18]

An all-day service operates along the Lakeshore route, which in April 2013 was upgraded to run half-hourly.

On other routes, off-peak services are mostly provided by buses, which can actually be faster than the train services for journeys to or from downtown but do not provide service between intermediate stations (and do not provide the same level of comfort as a train).

GO's current service pattern serves peak commuters travelling into downtown quite well. However, it does not support the development of suburban activity nodes, which would require services that are faster and more reliable than the roads, with a service at least every 15 minutes, in both directions, throughout the day.

[17] http://www.upexpress.com/en/project/vehicles.aspx The DMUs are self-propelled rail cars with diesel motors in each car. They operate in "consists" of two or three cars. The DMUs may also adhere to the same Tier 4 emissions standards as new locomotives. Metrolinx has said the DMUs could be converted to electric power in future, if the GO network is electrified. While this is technically possible, more likely the diesel cars would be shifted onto another route or sold to another operator, and new all-electric EMUs purchased.

[18] http://www.gotransit.com/public/en/docs/publications/Strategic_Plan_GO_2020_lowres.pdf (p. 17).

3.2 The GO Electrification Study

GO tested four technologies, and the six network options, against a single "Reference Case" operating plan. Essentially this was an evolution of the existing plan, which has been optimized for diesel locomotives. Peak services would be increased as required to carry expected growth in demand. The off-peak service would be half-hourly, as it is today, and continue to run with trains of the same length as today.

The final electrification study shortlisted four options:

1. Continued operation as today, with diesel locomotives and 10-car bi-level trains
2. Use of electric locomotives to replace the diesels, with 10-car bi-level trains
3. Use of hybrid (dual-mode) locomotives to replace the diesels, capable of electric traction where there are wires and otherwise propelled by diesel traction, with 10-car bi-level trains
4. Electric-multiple unit (EMU) trains, also 10 cars long and bi-level

For all four technologies, GO assumed that peak service provides sufficient capacity to carry commuter demand. The non-peak services would operate every 30 minutes, as they do today on the Lakeshore route.

Overall, the GO study concluded that the economic and financial benefits of electrifying the Lakeshore route only would just offset the incremental costs, with a Benefit:Cost ratio of about 1.11 (Figure 5 shows Table 12 from the GO Electrification Summary Report). In theory, this would be worth doing, provided one had high confidence in the forecasts. However, in financial terms, the project is not very attractive. GO would need to invest about a billion dollars ($855 million NPV in 2010) in infrastructure and rolling stock, but would get only about half of it back in operating cost savings and additional revenues. GO has a record of getting a much better return on its investments.

Accepting the findings of its study, GO Transit has decided to proceed slowly with electrification, perhaps converting the Union Pearson Express service to use it.

The study did acknowledge some benefit from the (slightly) faster acceleration possible with electric locomotives, and noted that this feature would attract more passengers and allow fewer trains to carry the same peak capacity. But they made no other changes to take advantage of the opportunities electric traction opens up. EMUs were rejected before the final screening of options, because GO found that they cost about 40% more than locomotives combined with un-powered bi-level cars and could not see any offsetting benefits.

We agree that if GO intends to continue to operate 10-car trains during both peak and off-peak hours, then it may well be cheapest to use locomotives and coaches.

GO has recognized the potential to use multiple units, initially diesel-powered, configured as two-car trains, on the Union Pearson Express route, which will be a high-frequency all-day service. But the study seems not to have considered the business case for similar higher-frequency services along the Lakeshore, or indeed on any other route.

Table 12: Detailed 30 Year Life-Cycle Transportation Appraisal of Electric Locomotive Trains (All Figures in $m Discounted at 5% p.a. to 2010 Present Values)

Electric Locomotives: Transportation Appraisal Impacts (All figures in $m and Discounted at 5% p.a. to 2010 Present Values)	**Option 1**	**Option 2**	**Option 3**	**Option 11**	**Option 15**	**Option 18**
	Georgetown + ARL	**Lakeshore:** Hamilton James to Bowmanville	**Option 1+2**	**Option 3 plus Milton**	**Option 11 plus Barrie**	**Full Network**
Infrastructure Capital Costs	521	764	1,089	1,251	1,584	2,369
Rolling Stock Capital Costs	62	91	139	212	310	543
Operations & Maintenance Costs	-88	-337	-424	-506	-595	-697
Incremental Revenues	-23	-50	-73	-86	-96	-109
TOTAL PRESENT VALUE COSTS	**473**	**467**	**731**	**871**	**1,204**	**2,106**
Journey Time Saving Benefits	145	409	554	657	752	845
Reliability Benefits	1	3	4	5	6	7
Auto Cost Savings	24	105	129	154	181	206
TOTAL PRESENT VALUE BENEFITS	**169**	**518**	**687**	**816**	**939**	**1,058**
Net Present Value (NPV)	**-303**	**50**	**-44**	**-55**	**-265**	**-1,048**
BENEFIT COST RATIO (BCR)	**0.36**	**1.11**	**0.94**	**0.94**	**0.78**	**0.50**

Figure 5: Summary of options from the GO Electrification Final Report.[19] GO considered electric locomotives with 10-car bi-level trains, similar to the current operation. This was easy to evaluate, but did not reveal any very attractive schemes.

3.3 The Flaw in the Electrification Study Methodology

The GO electrification study team, in its own words, set out to be "objective, comprehensive, inclusive, and evidence-based."[20] We have no reason to suggest they were not objective, and the work they present is "evidence-based." However, the study was far from comprehensive, and did not test some of the most promising electrification scenarios.

The flaw in the methodology was the failure to recognize that new technology does not simply replace older technology; it can have more far-reaching effects. It usually makes little sense to buy a new technology, with new features, and then use it more or less exactly the same way as the old technology. GO did recognize that electric trains have faster acceleration, but the study ignored the potential to operate smaller, more frequent trains in the off-peak. It assumed that GO would run only one type of train on all routes. It also assumed that the existing fleet would be replaced all at once, and did not consider staged migration strategies that would require less capital investment up front.

[19] Source: GO Electrification Study, December 2010, http://www.gotransit.com/electrification/en/current_study/docs/ElectricificationStudy_FinalReport.pdf (p. 56).

[20] See http://www.gotransit.com/electrification/en/current_study/default.aspx

Of course, it is impossible to be completely "comprehensive." It is not possible to test and evaluate thousands of scenarios for this type of project, even with computers. The accepted way to do this type of study is to identify promising technologies or combinations, usually based on the experience of other operators, and test them against operating scenarios that are optimized for each technology. Usually this is an iterative process. Rather than try to test thousands of scenarios, or even 24 as GO did, the study team could have defined a smaller number of potentially promising options, and then tried to make them as good as possible.

There are many suitable examples to draw on for such a study. Most commuter rail lines in Western Europe, Asia, and Australia have been electrified over the past half century. In most cases, the railway company can show a good business case, with the capital cost of electrification offset by increased passenger revenues and reduced operating costs. However, simply electrifying an existing route, without any other changes to the operating plan (train configurations, service frequencies, and fares), rarely appears worthwhile.

Normally, electrification is justified because it allows faster and more frequent services, often using smaller trains for at least some services, at a cost that is offset by incremental revenues. Initial rolling stock capital costs are often kept down by using a mix of electric multiple units and electric locomotives, so existing cars can be retained to provide peak capacity. Sometimes, reductions in peak journey times are matched by fare increases.

The GO study ignored this experience. It could, more accurately, be described as a comprehensive study of the benefits of using electric locomotives to replace diesel locomotives.

The study therefore did not consider the following combination:

- partial conversion to EMUs, with continued use of bi-level trains, with electric locomotives, as the "heavy lifters" for the morning and evening peaks;
- operation of shorter trains at higher frequencies in off-peak hours, which is possible with EMUs at much lower cost than with the existing GO trains.

These changes would allow GO to take advantage of the capabilities of EMUs to operate a faster and more frequent service for non-peak passengers, where demand is more time-sensitive, while avoiding the capital cost of replacing the large fleet required to carry peak passengers.

GO's Rolling Stock Technology review does note, "It is believed that a 25 kV, European-derived multi-level EMU may be a feasible and commercially viable alternative for Metrolinx's consideration."[21] It seems some members of the study team recognized there might be some promising scenarios that had not been considered. But this idea was never pursued.

Multiple Units are trains formed of two or more cars, each with its own motor. They can be single- or double-deck, and either electric (EMUs) or diesel (DMUs). They are about 25% to 40% more expensive to purchase than ordinary locomotives plus unpowered rail cars, but they have many advantages for intensive urban rail services.

[21] GO Electrification Study, Appendix 4, Rolling Stock Technology Assessment, p. 16.

- With power distributed to all the cars and all the wheels, EMUs and DMUs can accelerate and brake faster than unpowered cars pulled (or pushed) by a locomotive. On a typical GO route with 10 station stops, the total time saving can be 5 minutes or more. This may not sound like much, but a saving of 5 minutes, each way, or 10 minutes per day, can attract commuters to choose rail over driving.
- With faster acceleration, fewer trains and fewer train crews are required to provide the same capacity. Faster trains are more productive, reducing unit operating costs.
- Because power is distributed to each car, train lengths can be varied to match demand. GO's existing service with 10-car trains propelled by diesel locomotives is efficient only if there are at least 1,000 passengers to fill each train. In rush hour, this is easy, but during the middle of the day, loads are typically 500 passengers per hour or fewer. With shorter EMUs, GO can operate more frequent trains for the same cost, attracting more passengers.

GO's current business model of running high-capacity trains into Toronto in the morning peak, and home in the evening, is attractive for people who work normal, regular hours. But many people now work more flexible hours, coming in early or working late, or making trips during the middle of the day between offices or to visit clients. For these trips, GO's service is slow and infrequent, and many workers choose to drive instead.

In Europe and in Australia, EMUs[22] are routinely used on suburban rail routes (see Figures 6 and 7). Most operators vary train lengths between the peak and off-peak, to maintain a high frequency while avoiding the high costs of running empty trains. Trains have only one driver, who usually also controls the doors. Most European commuter rail operators use EMUs because, taking all these factors into account, they are cheaper than diesel locomotive-hauled trains. Many also still operate some push-pull trains, propelled by locomotives, to provide higher peak capacity.

[22] Toronto's subway cars are actually EMUs, although TTC does not vary the train length during the day. One reason is the high crew cost; TTC has a policy of operating with a two-person crew on every train; one drives, while the other closes the doors.

Figure 6: The regional rail "S-Bahn" system in Zurich, Switzerland, operates a mix of single- and double-decked EMUs, as well as single- and double-decked cars propelled by electric locomotives. Configured as 4-car trains, they can be coupled into 8-car sets at peak times.[23]

Figure 7: The rail system serving the greater Sydney region in Australia uses double-decked EMUs configured as 4- and 8-car sets, which can operate singly or coupled together.[24]

3.4 Making Electrification Work

3.4.1 Electrification with Electric Locomotives and EMUs

We have used GO's own numbers from the technical appendices to the electrification study and its Summary Report to replicate GO's estimates for electric locomotives on the Lakeshore route (Option 3) and to estimate the potential case for a different scenario: electrification with electric locomotives hauling bi-level coaches in the peaks, with shorter EMUs operating every 15 minutes, all day. We considered the Lakeshore route, and "all other routes." Our findings are summarized in the Appendix (Table A1). Our approach to estimating ridership, revenues, and benefits is explained below.

3.4.2 Boosting Ridership and Revenues

Carrying passengers is, of course, GO's primary purpose and increasing ridership should be the main objective of any investment scheme. For some reason, the GO Electrification Study Summary Report does not give an explicit figure for the additional ridership that might be attracted by electrification, with faster and more frequent trains. This would seem to be the most important criterion, alongside cost, in evaluating any scheme.

Table 17, in the back of the Final Report, does indicate a capital cost per new 2031 transit rider of $260,000, on the Lakeshore route, with electric locomotives. Note that this is *not* the "Net Cost per New Rider," as

[23] Photo source: http://en.wikipedia.org/wiki/File:RABe_514_bei_Felben-Wellhausen.jpg

[24] Photo source: http://en.wikipedia.org/wiki/File:Cityrail-millennium-M32-ext.jpg

much or all of the capital cost might be paid back from increased revenues, and operational savings. It does, however, give us a way to estimate the new ridership that GO is expecting. Dividing this number into the capital cost of $1.16 billion from the same table suggests a figure of 4,461 new daily riders, roughly a 4% increase from current ridership, and perhaps a 2.5% increase relative to the base case 2031 ridership.

GO's technical appendix 8A states that estimated demand uplift from electrification is calculated using a journey time elasticity of -0.6. Although the actual equations are a bit more complicated, essentially this means that a 10% reduction in journey time will bring a 6% increase in traffic, all other things being equal. Electric locomotive-hauled trains have faster acceleration, and GO calculates they will shorten the average commute by 2.4 to 2.8 minutes. But elasticity applies to the *total* trip (which includes the time required to drive to the station, park, wait for the train, take the train, then walk or use the subway to get to the office). Altogether, a typical GO trip takes about an hour, door-to-door. So a 2.4-minute time saving might be about 4% of the total trip (2.4/60 minutes). Applying the elasticity of -0.6 explains why GO says total demand is expected to increase only 2.4%, with electric locomotives.

U.K. railway operators have many decades of experience improving and electrifying rail routes. The general experience, presented in the Passenger Demand Forecasting Handbook (PDFH),[25] is that demand for non-peak (including both off-peak and contra-peak) travel is more time-sensitive, with more journey time elasticity. A 10% reduction in non-peak journey time will, generally, bring a 10% increase in traffic, sometimes even more. Peak traffic is less sensitive to time savings, because the peak market is mostly "captive." GO rail is already much faster than driving, and much cheaper than driving and parking, so a 10% time saving might indeed attract only 1.2% more peak riders. The -0.6 elasticity GO used in the electrification study is, in effect, the all-day average. This did not matter in GO's analysis, because it did not consider strategies using more than one kind of train for serving the different peak and non-peak markets.

To evaluate the case for using electric locomotive in the peaks, and EMUs all day (including some peak services), the peak and non-peak markets need to be analyzed separately. We can estimate the current split of peak and non-peak trips on GO as follows. GO says its total ridership is 55 million per year, of which 80% or 44 million is by rail.[26] GO Rail Lakeshore ridership is about 26 million passengers per year. GO operates about 25 trains arriving at Union Station between 7 a.m. and 9 a.m.,[27] most of them full (because GO adds peak trains only when it needs to), carrying about 1,200 passengers per train or about 30,000 passengers total. The same passengers mostly depart between 4 p.m. and 6:30 p.m., about 250 workdays per year, so the total peak ridership is about 15 million per year. The remainder, about 11 million per year or one-third of ridership, generating revenues of about $66 million per year, is non-peak.[28] Assuming ridership on Saturdays and Sundays is the same as weekday non-peak ridership, the figure of 11 million a year implies about 30,000 passengers a day.

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[25] This handbook was developed by the Association of Train Operating Companies (ATOC) in the U.K. http://www.atoc.org/about-atoc/commercial-activities/passenger-demand-forecasting-council/the-passenger-demand-forecasting-handbook/

[26] http://www.gotransit.com/public/en/docs/publications/Strategic_Plan_GO_2020_lowres.pdf (p. 9).

[27] For 2010 GO ridership on each rail route, see http://urbantoronto.ca/forum/showthread.php/17355-2009-and-2010-GO-Ridership-Figures.

[28] Note this includes weekday off-peak and contra-peak, and weekend all-day ridership, all of which is more sensitive to journey time and wait times than peak ridership. While road congestion is worst at peak times, the GTHA also suffers severe congestion in the contra-peak direction and even on weekends. While our forecasting method works from the off-peak and contra-peak, changing travel patterns will mean the benefits of improved GO rail services will accrue to all travellers.

U.K. Rail operators also have experience with the impact of service frequency improvements. According to the Passenger Demand Forecasting Handbook, going from a 60-minute frequency to a 30-minute frequency is equivalent to about a 10-minute reduction in journey time, on a typical 60-minute journey. On the GO Lakeshore route, this is about the same as a 16% reduction to the average journey. So introduction of half-hourly all-day services should bring a 16% increase in non-peak riders.

GO has introduced a half-hourly all-day service, with about 10 more trips each way on weekdays and about 20 more on weekends. The labour cost for each one-way trip is estimated at $400.[29] Energy, rolling stock maintenance, and track costs would triple this to about $1,200 per trip. For the extra 9,360 one-way trips per year, the incremental cost would be about $11 million. Initial counts indicate the service is indeed attracting about 15% more non-peak passengers, about 150 new passengers per additional train, or about 5,000 per day or 1.8 million per year.[30] With an average fare of about $6, incremental revenues will be about $11 million per year, offsetting the incremental labour costs, although not fuel or rolling stock maintenance. The overall growth rate confirms that growth is in line with U.K. experience, and that there is strong demand for increased non-peak rail services.

With development over the next decade expected to double underlying demand, GO's half-hourly lakeshore service will be good for the GTHA and should even be a financial success.

With EMUs, journey times are reduced a further 8%, because of the faster acceleration and braking. Going from half-hourly to quarter-hourly service brings an even larger benefit, equivalent to a 15-minute saving or about 25%. With a service of four trains per hour, passengers have a "turn up and go" service – they do not need to adjust their schedules to match the train. And they can cut their arrival time at the station finer, because if they do miss the train they were planning to catch, another one will come along soon.

So the overall revenue increase on the Lakeshore, compared with diesel trains, would rise almost $3 billion NPV with a mix of electric locomotives and EMUs. The increase is due to more frequent and faster all-day services. Weekday ridership could rise about 57,000 by 2023 compared with diesel locomotives, to 249,200 per weekday.

Assuming complementary policies, including fuel taxes, parking levies, land use controls, integrated fares, and an improved network of feeder public transport services, non-peak traffic could grow at 5% to 7% per year. This is the rate achieved in Greater London with similar policies. We assume, conservatively, that both peak and non-peak ridership increases a further 50% from 2023 to 2033, to 372,000 passengers each weekday.

Note that we are not assuming any increase in peak ridership, over and above GO's base case assumptions, as the journey time improvement from electrification would be small. In fact, many passengers travel one way in the peak and one way outside the peak. There are also peak-hour commuters who travel in the reverse direction, who are therefore by our definition "non-peak" passengers.

[29] Each one-way trip, from Burlington to Oshawa, takes about 2 hours. GO rail labour cost per train hour is about $180, as estimated in the Appendix, Section A1. Allowing for driver rest time, labour cost would be about $400 per trip.

[30] Information provided by a senior GO Transit official to the author, 26 July 2013.

We are, however, forecasting that by 2023, non-peak ridership, including contra-peak, off-peak, and weekend ridership, would *exceed* peak ridership. This pattern is consistent with experience in Europe, on lines where frequent all-day services are offered.

Some may question whether GO can ever attract sufficient two-way all-day traffic volumes to justify a more intensive service. Outside downtown Toronto, most GO stations are surrounded by large parking lots, often in industrial areas with few jobs or other destinations within walking distance. Many stations do not even offer frequent regular bus connections to local destinations. We see this as a chicken-and-egg problem. At the current level of service, this situation is likely to persist. But with improved service and more people using it, change begins to make economic sense. Station car parks can be redeveloped at higher densities. Feeder bus services can be improved. Already, GO has attracted impressive all-day traffic onto the Lakeshore line. With coordinated planning policies, and a proactive operating strategy, GO can do the same on the rest of the network

The ridership and revenue uplift from frequent and faster all-day service with EMUs should be similar on the rest of the GO rail network. Existing non-peak ridership is very low, as on most routes, trains serve only peak trips. We assume that with electrification, the other GO rail lines can generate as many passengers as the Lakeshore route, with similar benefits. Essentially, we are saying that if they are given the same sort of rail services, then development and traffic will grow along these routes in more or less the same way.

Altogether, the total ridership increase from GO electrification with EMUs to 2033 might be about 125,000 daily passengers. Even this number might be conservative. As the entire network is upgraded, there will be "network effects." For example, it will be possible to go from Richmond Hill to Oakville in about one hour, with a train every 15 minutes, a trip that currently takes about 2 hours by public transport and sometimes that long by road. Many of these trips would have been made otherwise by car on the regional expressways. Rail will become the preferred mode of travel for trips not just to downtown, but also between many other destinations on the GO Rail network.

Further benefits to increasing ridership on the GO system would include reduced congestion on the roads, and the option to increase peak fares for faster trips, while lowering fares for non-peak trips to encourage greater use of the system. Land use intensification around more frequently used stations may also occur.

This is a very rough analysis, but it suggests there is a very good case for electrification of the Lakeshore line, immediately, with electric locomotives used in the peak and with 3-car EMUs operating a frequent all-day service. The up-front investment of about $1 billion NPV can be paid back entirely from addition fare revenues, and reduced operating costs to GO Transit.

After reviewing an earlier draft of this report, Metrolinx staff told us that they now recognize that different rolling stock strategies might generate better business cases, but at first chose to test only a standard operating plan in the electrification study. They are now studying further strategies, and are looking specifically at electrifying the Georgetown corridor and possible use of EMUs for the Union Pearson Express service.

3.4.3 Electrification of other GO routes

Further detailed analysis is required to determine whether only some or all of the "all other routes" should be electrified. While the case for electrifying all other routes is not as strong as for the Lakeshore route, this is probably only because it has been treated as a single project. There could be a very strong case for

electrifying some of the more heavily used "other routes," while diesel haulage or dual-power trains will be appropriate for some of the longer, less heavily used services, and outer sections of the network such as Oshawa-Bowmanville. But completing this analysis should not delay electrification of the Lakeshore, which is long overdue.

Electrification of the GO network with a fast and frequent all-day service could be transformational.

4

UNION PEARSON (UP) EXPRESS

A high-quality, fast, reliable link to Pearson Airport, not vulnerable to road congestion, is considered important to maintaining Toronto's position as Canada's leading business centre. The Union Pearson Express is now under construction and will be completed in time for the 2015 Pan-Am Games. Our analysis indicates that the scheme is very good value for money, and most if not all capital costs will be repaid from operating surpluses.

Metrolinx seems not to have prepared a Benefits Case Analysis for the UP Express scheme, even though construction is well under way. Metrolinx has released only limited information in Project Fact Sheets. Nevertheless, the limited information makes it possible to estimate the benefits of the scheme.

According to Metrolinx, traffic volumes on the UP Express will be fairly small, perhaps 3 million per year or about 8,000 per day, when it opens. Perhaps half of the passengers would otherwise have used the existing express bus, which provides service direct to several downtown hotels. However, some passengers would otherwise drive, either by taxi or by limousine. Taking even a few hundred peak-hour trips off the Gardiner Expressway, Queen Elizabeth Way, and Highway 427 will have a real benefit.

Metrolinx has not yet disclosed its fare strategy for the new service. The current express bus from the airport to the Royal York charges about $27, with cheaper fares if tickets are pre-purchased or purchased in bulk. Metrolinx expects the Union Pearson Express will take 1.2 million cars off the road in 2015,[31] suggesting a total ridership of perhaps 3 million, including passengers diverted off the existing express bus service.

Ridership will depend on the fares that are charged, but also on convenient arrangements for onward travel. Currently, the express bus runs directly to several downtown hotels. UP Express passengers will need to walk or take taxis from Union Station. Some passengers, especially those with considerable luggage, will continue to use a taxi for the entire journey, because they will not want the inconvenience and delay of transferring at Union Station.

Our analysis uses the Metrolinx ridership figure of 3 million annual passengers in 2015. We assume an average fare of $15. About half of these passengers might be new to transit, and the rest would be diverted from the express bus. The average load per train would be 57 passengers, although numbers would vary widely by time of day and some trains would reach the full capacity of 180 passengers on a two-car DMU. Using these figures, revenues should be sufficient to recover all incremental costs, so there is no net cost per new passenger. We also believe that ridership will grow quickly, perhaps 50% by 2023, and doubling again by 2033.

[31] http://www.upexpress.com/en/information/information.aspx.

Passenger benefits would mostly be captured with fares. Road user benefits could be substantial, in the order of $10 for each trip diverted or about $504 million NPV.

Table A3 in the Appendix contains our estimates of costs and benefits for the Union Pearson Express.

Overall, the UP Express scheme seems to be worthwhile, with all costs recovered from fares over time.[32] Metrolinx should consider how to make the service more attractive to airport workers and travellers who need to connect to the subway, GO, or VIA to complete their journey. PRESTO makes it possible to apply various market-segmentation techniques. For example:

- A large discount could be offered to frequent users. The fare could be $15 for the first 4 trips each month, and then drop to $2 for subsequent trips. Airport workers would then only pay an average of $4.60 per trip, assuming they use it 20 days per month.
- Discounts can be offered to passengers using connecting subway or GO rail services. Most likely, the connecting trip should be "free," as passengers who need to ride the subway or GO to get to Union Station from their home or workplace probably have alternative ways to get to the airport more directly.
- UP Express should also consider offering "family" fares, for groups of two or more travelling together.
- UP Express could operate a connecting bus from Union Station to downtown hotels. This would either be free to UP Express passengers, or have a small incremental fare. This would be similar to the van service that currently links downtown hotels to the Airport express bus.

These types of initiatives could double or triple the ridership on the UP Express, and mitigate criticism that the service is aimed only at affluent business travellers, and not "ordinary travellers."

[32] Metrolinx had hoped that the line could be developed as a P3 concession with private investors taking traffic and revenue risk, but it seems private investors demanded too high a risk premium. While revenues seem likely to outweigh costs when discounted at a "public-sector" rate of 5%, private investors would insist on a much higher rate, typically 15% on equity. Private investors are also likely to insist on guarantees from Metrolinx such as long-term rights to train paths, which might make it difficult to develop new commuter services over the Georgetown Line, and even restrictions on competing airport bus services.

5

USING THE GO SYSTEM TO RELIEVE THE SUBWAY

Metrolinx has recently appointed consultants for a "Relief Line Study." The scope of the study apparently includes looking at ways to use the GO rail corridors to complement, or as alternatives to, TTC's Downtown Relief Line (DRL), which is included in the Big Move program. While the GO electrification program described above would greatly increase capacity for longer trips across the rail network, it would take several years to implement. We look here at how new services could be introduced over the GO Rail system, quickly and at low cost, to relieve the subway.

There seems a very good case for using the GO system to relieve congestion on the subway into downtown Toronto from Scarborough, as several transit commentators have already pointed out. Currently there are 41,000 transit trips in the a.m. peak, by subway, from east and northeast Toronto into the downtown core.[33] Mostly these passengers use the Danforth subway and change onto the Yonge line at Bloor-Yonge station. The Bloor-Yonge station does not have the capacity to handle the passengers comfortably, and adding new platforms would cost hundreds of millions of dollars and cause massive disruption. In any case, the Yonge subway is approaching capacity. Although capacity can be increased with new signalling and longer trains, lengthening the line, including a planned extension to Richmond Hill, will also add substantially to demand.

GO has, until now, concentrated mostly on moving large numbers of commuters, at premium fares, from the outer suburbs into downtown Toronto. Although GO Trains serve stations within the inner suburbs, GO has done little to encourage traffic from these areas, or to encourage transfers from the TTC subway at Kipling, Kennedy, Bloor/Dundas West, and Danforth/Main to nearby GO routes. There is limited fare integration, and signage is poor or non-existent. Station names are not coordinated and most GO and TTC passengers are probably not even aware of the proximity of the other line.

Our analysis indicates that, at least at Main and Danforth, improving the interchange and providing additional shuttle services to Union Station would be very beneficial, relieving congestion at Bloor-Yonge at a tiny fraction of the cost of a DRL. Similar GO-TTC interchanges at Dundas West/Bloor, Kennedy, and Kipling may have potential but the case is less clear.

5.1 Improving the GO-TTC Interchange at Main / Danforth

The clearest opportunity is at Main and Danforth, where the subway and GO station are only 250 metres apart, or about the length of a GO Train (see Figure 8). We think GO is missing an opportunity to earn revenue. And Metrolinx is missing an opportunity to relieve congestion through the crowded Bloor-Yonge interchange.

[33] See DRTES Final Report Exhibit 1-8.

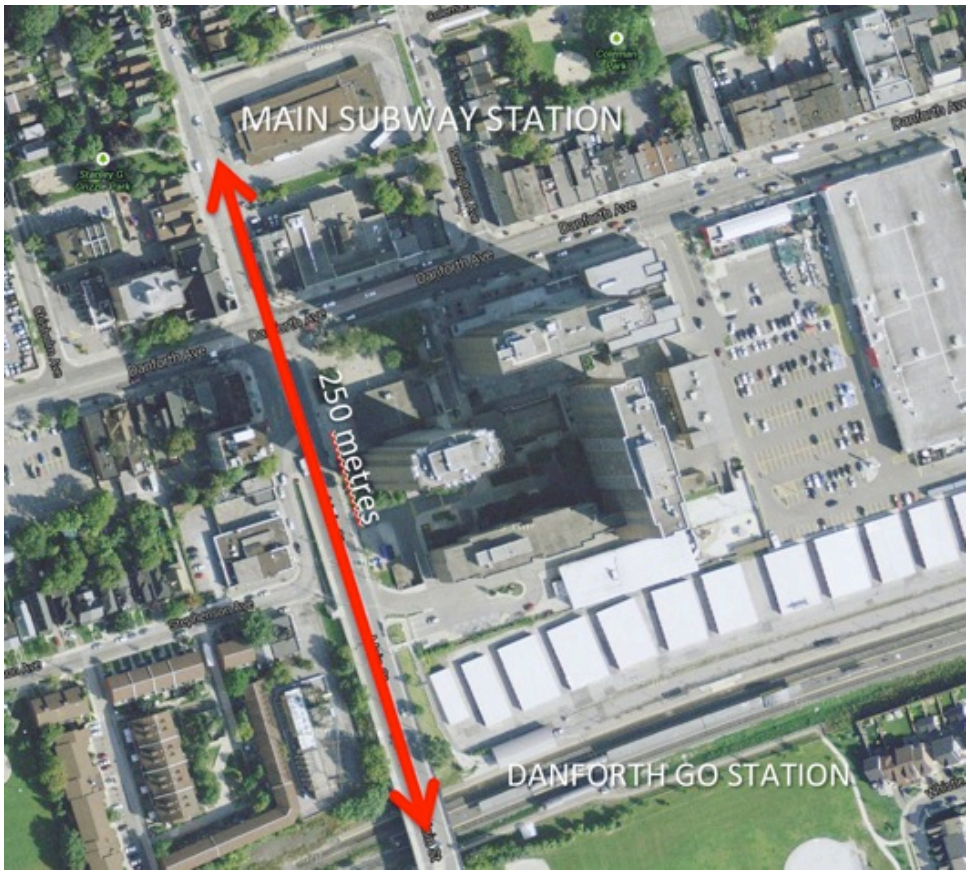

Figure 8: TTC's Main Station is only 250 metres from GO's Danforth Station, less than the length of a GO train.

GO already operates five trains in the morning peak hour through Danforth from Lakeshore East, and two more from Stouffville. But these trains are largely full when they get to Danforth Station, and only two are scheduled to stop. GO could provide more capacity and a more frequent service by running some morning peak-hour trains from the north and west (Georgetown, Milton, Barrie) through Union Station to Danforth, and then returning to Union Station before retiring to the yard for the day. With spare capacity at Danforth, passengers on the Danforth subway at Main Station could be encouraged to switch to GO trains for travel to downtown Toronto.

With a train every 5 to 10 minutes, and a journey time of 10 minutes to Union Station, travel times would be competitive with staying on the subway and changing at Yonge, at least to places within walking distance of Union Station or further south. Perhaps 5,000 to 10,000 passengers each way or 10,000 to 20,000 passengers each weekday would find it attractive to switch, if there was no fare penalty. This assumes about 200 passengers boarding each GO train at Main, or 20 on each car. Diverting 5,000 peak passengers off the subway at Main would materially relieve congestion at Bloor-Yonge station. It would take 100 people off every southbound Yonge subway train.

Figure 9: GO's system map identifies "TTC Connections" but does not show whether they are bus or subway. Riders are left to figure out for themselves that Bloor and Danforth stations are actually adjacent to TTC's Dundas West and Main stations.[34]

The cost to operate 12 additional trips on the 10-km line between Union and Main Street every morning and evening peak would be about $1.4 million per year. Assuming, very conservatively, that only 5,000 people switch from TTC onto GO (or one-quarter of those expected to use the Downtown Relief Line), the cost would be $0.14 per passenger.

Costs are low because it would not be necessary to buy or run any new trains. In the morning, the services would use trains from Georgetown and other routes from the west, which have already made a long trip into Toronto and would otherwise go straight to the yard for the day. It would, however, be necessary to make some changes to trackwork, signalling, and platforms at Danforth Station, which might cost some tens of millions of dollars. It would also make sense to build a pedestrian tunnel under Danforth Avenue, linking the two stations, similar to the existing link at Spadina/Bloor between the two stations. Indeed it seems provision was made for such a link when Main subway station was built in the mid-1960s (the station has an oversized mezzanine level between the tracks and the street). Total capital cost for the track changes and the pedestrian tunnel might be $100 million NPV.

[34] Source: Timetable, Go Transit: http://www.gotransit.com/timetables/en/schedules/maps.aspx#

Even at $100 million, the capital cost for improved Danforth-Union services would be a tiny fraction of the cost of a Downtown Relief Line. Developing the connection at Main Station would achieve substantial congestion relief benefits, and attract new riders onto transit at a reasonable cost.

Paying for these services requires some rethinking of how TTC and GO charge fares. Few passengers will use the interchange if they are required, as they are at present, to buy another ticket and pay $5 to ride the GO train, in addition to their subway fare.

For the Danforth/Main service, TTC could simply pay GO $1.5 million per year, to carry passengers transferring from the subway from Danforth to Union. This would free up space for more passengers to join the subway westbound from Main, and southbound from Bloor-Yonge, who do not currently use it because it is overcrowded. If TTC fills even a fraction of the space freed up by passengers switching onto GO at Danforth/Main, at the current average fare of about $2.50, it will recover what it has to pay GO. In fact, TTC already has "customers" for the space that would be released on the Yonge Subway: riders using the proposed extension to Richmond Hill. At present, the extension has not been scheduled, presumably because of the capacity problems south of Bloor.

The transfer of $1.5 million a year from TTC would more than offset GO's additional Operating and Maintenance costs, so both GO and TTC should be financially better off. GO may be concerned about lost revenue from the passengers, admittedly few, who currently board at Danforth and pay $5 to travel to Union Station. With PRESTO (see section 10.4), GO could allow free transfer for passengers connecting from the subway, boarding at stations further east, while still charging $5 for passengers boarding directly onto GO at Danforth who have not come from the subway.

The time savings and congestion relief benefits will be substantial, both to those who transfer and to existing subway passengers, including passengers who stay on the subway, or board further west, because they will have a less crowded trip. These benefits could be worth at least $2 per diverted rider, or about $115 million NPV. Auto user benefits would probably be fairly modest, relating mostly to new passengers joining the subway further west.

Our sketch model, shown in Table A4 in the Appendix, suggests that the economic Benefit:Cost ratio is a very attractive 1.9, even with only 5,000 passengers transferring in each direction. Cost per new daily rider is about $12,000, less than one-third of the average of Metrolinx Big Move schemes.

5.2 Improving Interchanges at Bloor/Dundas West, Kipling and Kennedy

For a similar service from Bloor/Dundas, the ridership, both diverted and incremental, seems likely to be lower, perhaps half as much, because trains on the University line are not as close to capacity as those on the Yonge line, and the interchange at St George is less crowded. Congestion relief benefits will be less, but time savings benefits to those who transfer will be greater, as the interchange walk distance is shorter. Metrolinx is already upgrading the interchange as part of the Union Pearson Express service, so capital costs would be lower. The distance to Union Station is also less, so there may be slightly lower O&M costs. The scheme seems to be just worthwhile, but there would be no incremental revenue to TTC or to GO.

Incremental O&M costs from Kipling and Kennedy subway stations are significantly higher, as the distance is further, but the time saving is also much greater, about 20 minutes, worth $3 to $5 to the typical passenger, and auto user benefits are also likely to be higher. However, incremental ridership is probably much lower because many passengers are already using GO, even given the $5 fare.

One solution would be to use PRESTO to levy a $2 surcharge to TTC passengers transferring onto GO, capturing half of the benefit. In effect the TTC feeder service, most likely a bus, would be "free." Passengers who drive to the station would continue to pay $5, and might also be charged for parking. Some passengers currently paying a $3 TTC fare and a $5 GO fare would benefit from a price cut, although these numbers may be fairly small. TTC would also benefit from additional revenue from people filling empty space on trains on the Bloor line. On this basis, the additional service from Kennedy-Eglinton seems worth exploring as a possibility, but probably not the Kipling-Bloor service.

Metrolinx has now apparently appointed consultants to examine this type of solution, but the Danforth-Main linkage, despite its obvious advantages, has not yet been analysed.

6

SUBWAY SCHEMES

The subway is the biggest "heavy lifter" in Toronto's public transit system. There are about 1.3 million rides each day on the three subway lines,[35] although many riders use two (and some all three) lines, so there are probably only about 1 million riders in total.

The main subway lines were completed between 1954 and 1978, with a short extension to Downsview (3km) and the Sheppard Line (5km) added more recently. Toronto led the world in improvements and innovations in its early years:

- When the Yonge subway opened in 1954, it offered free transfers to surface streetcar and bus routes at 6 stations. This was probably the first subway system in the world where passengers did not even need to show a paper transfer to connect onto buses or streetcars.
- In 1963, the TTC introduced the first 75-foot long (23-metre) cars. With lightweight aluminum bodies, these were probably the largest subway cars in the world at that time. They had faster acceleration, allowing fewer trains to operate the service on the Bloor-Danforth subway, despite the large number of stops.
- On the Bloor-Danforth line, opened in 1966, TTC opened the first "automatic" entrances, with entrance turnstiles operated by tokens and closed-circuit TV supervision.
- The H-5 subway cars, introduced in 1977, were the first to be fully air-conditioned. They were also the first in North America, and perhaps the world, to have fully-regenerative braking using solid-state motor controls.

However, TTC's innovation slowed down after the 1970s. Today, parts of the system are overcrowded and the infrastructure is aging. This section will look at two proposed extensions and a connector line, as well as options for modernizing the system.

6.1 Subway extensions to Vaughan and Richmond Hill

6.1.1 Spadina Line to Vaughan

TTC is now completing the extension of the subway from Downsview via York University to Vaughan Metropolitan Centre. Metrolinx has not issued a Benefits Case Analysis for this extension. Evaluating this line means piecing together figures from various sources. Overall, our analysis suggests that the economic case for this scheme is fairly weak, with benefits just slightly in excess of costs. Benefits could be increased if the line succeeds in stimulating intensive development. Cost to the taxpayer can be reduced if TTC makes use of the PRESTO Farecard to introduce "smart pricing," as discussed in Chapter 10. Doing so could capture some of the $1.4 billion NPV time savings that would benefit riders, but would be paid for with public funds.

[35] Figures from 2011-2012 for Yonge-University-Spadina, Bloor-Danforth, and Sheppard lines only: http://www.ttc.ca/PDF/Transit_Planning/Subway%20ridership%202011-2012.pdf

In 2005, TTC forecast weekday ridership at about 100,000 for a line ending at Steeles.[36] Of course, the line is actually being built further, to Highway 7, so ridership should be higher. But no estimates seem to have been provided, nor is there any information available as to how many of these riders will be new to transit.

Information on capital costs is a bit better. Metrolinx has provided data on infrastructure capital costs for the line to Vaughan, but not data on rolling stock costs, operating costs, or ridership. TTC will need 6 to 10 more trains to operate the extended line, costing about $120 million. We estimate that incremental operating costs will be about $25 million per year or $575 million NPV. See Table A5 in the Appendix.

The extension from Steeles to Highway 7 (Vaughan Metropolitan Centre) will allow a direct interchange to the VIVA bus rapid transit system of York Region. We estimate that it might attract 20% more riders than the scheme studied by TTC, which was to end at Steeles, so weekday ridership on the line to Vaughan might be 120,000, or 3.6 million per year. Of this, two-thirds might be diverted from existing TTC services, with one-third or 40,000 per day being new riders. New ridership might double to 80,000 per day by 2033, with complementary planning policies.

TTC will need to use the capabilities of PRESTO to offer reasonable integrated fares for passengers travelling from York and Peel regions by bus, who are travelling only as far as York University. But it could also use PRESTO to charge more than $3, perhaps something like the $5 fare GO charges, for passengers travelling from Vaughan all the way to downtown. TTC could also charge $5 for integrated fares from VIVA and Züm to downtown, and $4 for passengers transferring onto the subway from TTC buses within the city boundary. In our evaluation we assume an average incremental "yield" of $1 per diverted passenger, although in fact many will pay less and some will pay more. The additional income of about $1 per diverted passenger would generate extra revenue of about $552 million NPV. Road user benefits could be in the order of $5 per new rider.

6.1.2 Yonge Line to Richmond Hill

The Yonge Subway is Toronto's most intensively used transit line, carrying more than 700,000 passengers per day. While it is now operating near to capacity south of Bloor, the diversion of passengers from east and west on to GO services, as we have already suggested, would release capacity for more passengers to travel into the downtown on the Yonge Subway. This will allow further extension of the line. Our analysis indicates that the scheme is worthwhile with benefits well in excess of costs. Net benefits can be increased further and costs to the taxpayer reduced by deferring construction of most of the intermediate stations, unless developers make substantial contributions to costs. As with the Vaughan extension, revenues and ridership can be increased by using smart pricing.

There is now continuous development beyond Richmond Hill. There are also intensive bus and BRT routes on intersecting east-west streets, with many routes turning south to connect with the subway at Finch. Extension of the subway 6.8 km to Richmond Hill Centre seems an obvious next step.

Metrolinx has prepared a Benefits Case Analysis for this extension, and it contains most of the information we need to evaluate the scheme. TTC has also provided some relevant data. TTC has estimated costs of $2.4

[36] TTC: Spadina Subway Extension Environmental Assessment, Appendix M, August 2005. http://www.vivanext.com/files/EnvironmentalAssessments/SpadinaExtension/M_TravelDemandForecastReport.PDF

billion (in 2008 dollars), including six new stations and the renovation of the Finch station.[37] Incremental rolling stock and operating and maintenance costs would be about 80% as much as for the Vaughan extension, which is 8.6 km. It would significantly reduce travel times, and support transit-oriented development in the corridor.

We believe that costs can be reduced about $800 million by deferring construction of stations at Cummer, Clark, Royal Orchard, and Langstaff/Longbridge. At about $200 million each, the cost of these stations will far exceed the incremental riders and benefits, perhaps 90% of which would be captured with an extension to a single terminal at Richmond Hill Centre, perhaps with one intermediate station at Steeles Avenue. The other stations should be added over time in partnership with developers: Vancouver and London have shown how local developers can be persuaded to pay for intermediate stations.[38] Deferring stations will also reduce incremental rolling stock and O&M costs

Ridership might be 25% higher than on the Vaughan extension, reflecting the higher density of development. TTC suggests ridership at Finch might grow by 8,400 in the peak hour or perhaps 80,000 per day by 2031.[39] Obviously much of this growth would happen even if the subway is not extended. We assume a daily incremental ridership of 150,000 with six stations, of which 50,000 are new riders. Ridership would be reduced 10% if there are only two new stations. Incremental ridership could increase about 50% to 2033 with complementary policies, somewhat less than on the Vaughan extension because the traffic will be starting at a higher base.

Incremental revenues are about three times O&M costs. There could also be substantial benefits to TTC of having a yard at the north end of the line. Currently, TTC must run about 10 trains empty each morning and evening from Wilson to Finch, a distance of 30 km. These trains are apparently crewed with two employees, even though there are no passengers and no need to open or close the doors. The yard could be located under the hydro lines, immediately south and west of the Yonge-407 interchange. TTC could store trains there overnight, and some drivers could be assigned to sign on for work there.

Time savings to existing passengers will be similar to the Vaughan extension. Again, much of this benefit could be captured with smart pricing, reducing the net cost to the taxpayer. As on the Vaughan extension, fares might be $5 for travel from north of Steeles to downtown, $4 for passengers boarding at Steeles, but with a lower fare of perhaps $3 for passengers travelling from Richmond Hill, but all the way not to downtown Toronto (perhaps to York Mills). Smart pricing is possible with the PRESTO smartcard.

Road user benefits are likely to be similar to those for the Vaughan extension, about $5 per new rider, because trips will be relatively long and originating in the suburbs.

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[37] http://www.ttc.ca/PDF/About_the_TTC/yonge_subway_extension_recommended_concept_project_issues_de.pdf

[38] Vancouver and London have successfully extracted large contributions from developers, in return for provision and sometimes modification of transit stations. In Vancouver, developers at Main Street and Metrotown stations on the initial Skytrain line made up-front capital payments as well as ongoing payments per square metre of space developed on their sites. In return, Translink agreed to shift the station locations, and to feed passengers through the sites for access to bus interchanges. In London, the Canary Wharf developer entered into a similar arrangement for construction of an extension to the Jubilee Line, and also for the Crossrail scheme now under construction. At Cutty Sark (Greenwich Waterfront), North Greenwich, and Woolwich Arsenal, developers also made substantial contributions. In each case, the Government could make a credible threat that it would not build the station, or would even run the line on a different route, unless the contribution was made.

[39] http://www.ttc.ca/PDF/About_the_TTC/yonge_subway_extension_recommended_concept_project_issues_de.pdf

6.2 Downtown Relief Line

Advocates of the Downtown Relief Line like to recall that the idea of a rail connection between Danforth Avenue and Union Station can be dated back to 1910, even before the TTC was created.[40] The decision in the late 1950s to build an east-west line along Bloor-Danforth instead of Queen took away much of the original function. In the 1970s a second east-west line was proposed as "downtown distributor" for longer lines to northeast and northwest Toronto.

FIGURE 1: DRTES OPTIONS CORRIDOR AND GO CURRENT RAIL NETWORK

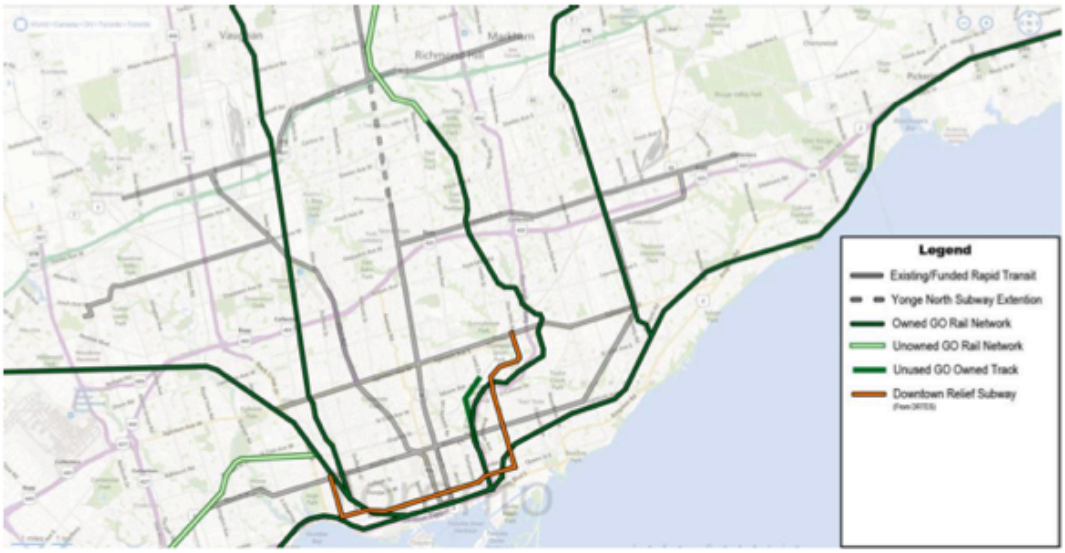

Figure 10: Plan showing proposed DRL and existing GO Rail and TTC subway lines. Source: Metrolinx Relief Line Preliminary BCA, November 2012.[41]

It is only in recent years that the word "relief" has been used, with the implication that the primary purpose of the line is to provide additional capacity into downtown from east and west, providing network resilience and relieving congestion at Bloor/Yonge and on the southern part of the Yonge subway. There will also be improved access to areas east and west of downtown, including the "Kings," Riverdale, and the eastern Harbour, where there is significant development potential. The eastern extension might encourage more intensive development of Don Mills. But these objectives seem to be secondary to congestion relief.

According to the TTC, an "initial phase" DRL from Pape/Danforth to St Andrew would cost about $3.2 billion to build. Costs for the full line, from Don Mills/Eglinton all the way to Dundas West, would be $8.3 billion, plus perhaps $320 million for rolling stock. The initial phase would carry about 11,700 passengers in the peak hour, generating a 4% increase in total rapid transit (subway) ridership. The full line would carry

[40] http://levyrapidtransit.ca/1-3-the-jacobs-davies-report-prescient-but-premature/#.UiYVFJXJA5Q

[41] Source: Metrolinx Relief Line Preliminary BCA, November 2012. http://www.metrolinx.com/en/regionalplanning/projectevaluation/benefitscases/Preliminary_Benefits_Case-Relief_Line.pdf

14,900 in the peak hour, with an 11% increase in overall rapid transit ridership.[42] TTC is not explicit about the year when this level of traffic would be reached, but the suggestion is that it might be in 15 years or about 2028.

With fewer stations than the parallel Yonge or Bloor-Danforth lines, some passengers would have slightly faster trip times, but the actual time saving depends on exactly where they are going in the downtown.

As currently planned, the DRL would not connect directly with GO Rail in the downtown. This shortcoming would limit its "inter-regional" use. TTC has looked at a scheme terminating at Exhibition, to function as a distributor for the Barrie and Georgetown-Kitchener lines.[43] An interchange station with the Richmond Hill line also seems possible at River Street, although there is no mention of this option in any of the DRL reports.

Like the Spadina subway, which was also built as a "relief" line, the DRL would do relatively little to increase all-day transit use or encourage higher-density, transit-oriented development. While some passengers would have faster or less crowded journeys, crowding is only a serious problem in the peaks. So ridership growth seems likely to be small unless the line stimulates more intensive development along its length and not just in the downtown area. This seems unlikely.

Daily subway ridership today is about 1,340,000,[44] so TTC's estimate of a 4% increase implies 53,600 new riders on the Pape-St Andrew Line. This is four times as many new riders as we are assuming would be generated by a GO Relief service from Main and Danforth to Union Station. Some of the new riders would use the Bloor-Danforth and Yonge lines, which would be less crowded than they are today. Some would be generated by new development around stations on the line.

The estimated 11% increase for the longer line implies 147,400 new riders. This line is intended primarily to relieve an existing line. Although there is some development potential, most passengers would have used transit in any case and would not be new riders. Incremental traffic might increase a further 5% to 2033, assuming complementary policies.

These estimates assume the GO relief services are not developed. If they are developed (as described in Chapter 5), with integrated fares from Danforth/Main and Dundas West/Bloor, ridership on the DRL would be substantially less. If GO services to Markham and Richmond Hill are upgraded to offer a "regional Metro" service, and if fares are integrated, then ridership on the DRL will be reduced further.

To estimate the benefits of the DRL, we need to make various assumptions about total ridership, fares, and time savings. See Table A7 in the Appendix for additional details.

Metrolinx says that by 2031, ridership could be 107 million on the entire 13-km line, or about 350,000 per day.[45] Metrolinx has not disclosed whether this estimate assumes upgrading of parallel and competing GO

[42] See "TTC: Downtown Rapid Transit Expansion Study" October 2012, p. 2. http://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2012/October_24/Reports/Downtown_Rapid_Trans.pdf

[43] As described in the Relief Line Preliminary BCA.

[44] See http://www.ttc.ca/About_the_TTC/Operating_Statistics/2011.jsp.

[45] Metrolinx Next Wave Project Quick Facts Downtown Relief Line at http://www.bigmove.ca/wp-content/uploads/2013/01/NxWave_DRL.pdf . We assume daily ridership is 1/300 annual ridership, and that 2023 ridership is 20% less than 2023 ridership.

Rail services. Current ridership on the Bloor Danforth subway is about 519,000; this line goes east and west and is longer. Ridership on the much shorter initial DRL from Pape to St Andrew should be less than half this amount, perhaps 160,000 per day in 2023.

As with the GO relief schemes, which serve fairly short trips, we assume revenue of about $2 and auto benefits of $1 for each new transit rider. We also assume passenger benefits of $1 for all riders, not just those diverted.

Notwithstanding some fairly optimistic assumptions, our analysis indicates that benefits are only about two-thirds of the costs, even for the shortest scheme. Put simply, the scheme in its current form is not worthwhile, costing more than it delivers. However, incremental revenues appear to cover incremental operating costs. This fact could explain why TTC supports the scheme; if the capital cost can be covered, TTC will make a profit on the operations.

The case for the scheme would be further eroded if GO is upgraded. As we have shown, GO relief and express rail services, with interchanges at Danforth/Main, Kennedy, Kipling, and Bloor/Dundas West, can provide similar relief to the subway at a fraction of the cost. Although TTC seems not to have pursued the potential of GO relief services, in the 2012 Downtown Rapid Transit Expansion study[46] TTC did consider the alternative of a "Lakeshore RT" service along the GO rail line, with a station at Danforth, but apparently with no interchange to the subway, and with average speeds reduced to 40 km/h,[47] about the same as the subway. Perhaps not surprisingly, TTC concluded that this scheme would not relieve demand on the Yonge subway south of Bloor.

The DRL seems to us to be a scheme whose time has not yet come, if indeed it ever will. Upgrading of the GO rail system would do much more to make the entire GTHA a "transit metropolis," at a fraction of the cost.

Metrolinx seems to be thinking on similar lines. Although the DRL was included in the $36-million Big Move program, Metrolinx has never issued a detailed Benefits Case Analysis. A "Relief Line Preliminary Benefits Case Analysis," dated November 2012 was finally released September 2013. The document provides few hard numbers, with no indication as to gross or net benefits.

6.3 Scarborough Subway

As this report was being written, Toronto City Council voted to extend the Bloor-Danforth subway to Scarborough Centre, instead of converting the RT to LRT technology as part of the Transit City scheme. The subway would be extended along Eglinton and McCowan Avenue, at a cost of about $1.9 billion to Scarborough City Centre.[48]

[46] http://www.ttc.ca/PDF/About_the_TTC/DRTES_Final_Report_-_September_2012.pdf

[47] See Table 2-5 of the DRTES Final Report, p. 40.

[48] See TTC Report Scarborough Subway Options, September 25, 2013.

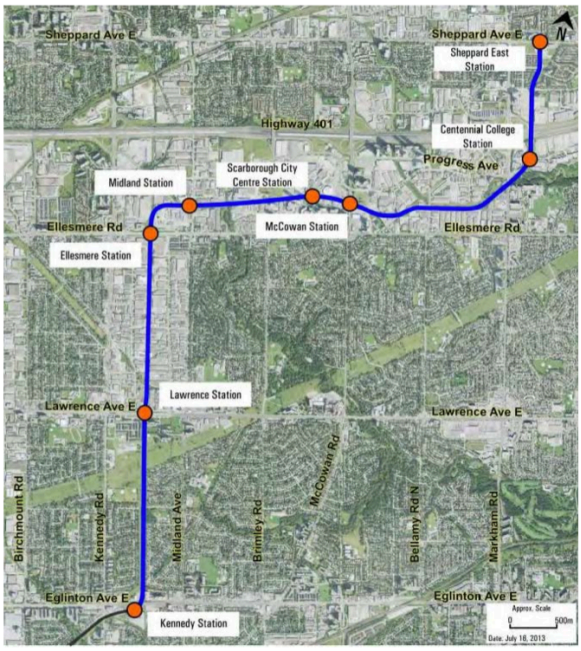

Figure 1: LRT Option

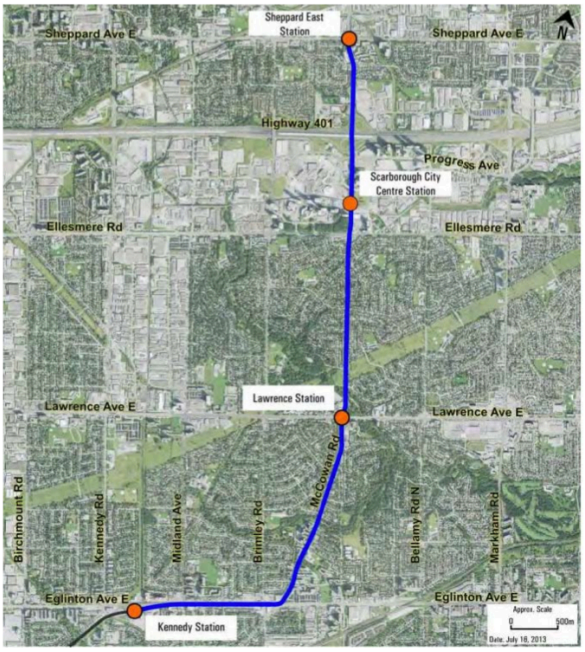

Figure 2: Subway Option (McCowan Corridor)

Figure 11: Metrolinx and TTC are now proposing to extend the subway to Scarborough City Centre, and eventually to Sheppard Avenue, but on different alignments. Although the routes are very different, most passengers would arrive using feeder buses, so the two schemes would serve similar markets albeit in somewhat different ways. Source: TTC Report Scarborough Subway Options, September 25, 2013.[49]

The Province then announced support for a subway scheme, but along the route of the existing Scarborough RT. The cost would be similar to Scarborough Centre. Either scheme could be extended to Sheppard, but on different routes.

TTC argued that the route via McCowan could be built with less disruption to transit riders, and could offer faster journeys because it has fewer sharp curves and fewer stations. Metrolinx seemed to prefer the RT alignment because it would require less tunnelling, and had more stations to serve "Priority Neighbourhoods."

No Benefits Case Analysis has been made public for either scheme, although Metrolinx has produced a Benefits Case Analysis for the plan to convert the Scarborough RT to LRT technology.

Operating the line as a subway, with 6-car trains, would certainly cost more than the existing RT that it would replace. Neither scheme would attract many new passengers. Journey times on the TTC route may be slightly less, but mostly because the new line will have fewer stations. This result could be achieved at far lower cost simply by closing some of the stations on the existing line. Speeds will be similar on the subway extension: Toronto subway cars have a top speed of only about 80 km/h, the same as RT and LRT cars.

[49] Source: TTC Report Scarborough Subway Options, September 25, 2013. http://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2013/September_25/Supplementary_Reports/Scarborough_Subway_O.pdf

Passengers would be able to travel through Kennedy station without having to change trains. This would save about five minutes per trip for the typical passenger. However, journey times to downtown, about an hour from Scarborough Centre, would still be too long to be attractive, at least in comparison with the GO service or with driving.

We conclude that the expenditure of almost $2 billion will bring little benefit to existing transit riders or to the region. Much greater benefits, at lower cost, could be achieved by modernizing the Scarborough RT, and integrating it with the GO Rail system, which can offer the required capacity and much faster journey times, not just to downtown Toronto but across the GTHA.

6.4 Modernization to make better use of the existing system

Although the subway system continues to operate reliably, carrying more passengers than ever, many aspects of the operation are now archaic or obsolete. Modernization of the control system and train crewing practices has the potential to substantially reduce losses and the need for subsidies, and enable higher capacity, improved reliability, and more frequent off-peak services. Changes to the fare structure, now possible with PRESTO, could generate new ridership and revenues, even though some fares would be reduced.

6.4.1 New Train Control System and Unattended Train Operation

TTC subway trains are operated with two-person crews, as they have been since the system opened in 1954.

TTC is already planning to install a new, modern system to replace the existing electro-mechanical signalling system, which uses 1950s technology. The new control system will cost about $1 billion.[50] TTC says this expenditure is required because the equipment "has reached the end of its useful life and needs to be replaced," and because it will allow TTC to operate about 35% more trains, because trains can run closer together. TTC also says it will allow safer and more reliable operations. However, TTC has now said that re-signalling of the Bloor Danforth line can be deferred, probably for several years, so perhaps that system is not in such urgent need of replacement.

One potential benefit of re-signalling is that it would allow driverless train operation. TTC is buying additional trains, so it should have the capability to make use of this feature of the new signalling system. But TTC has given no hint that it is thinking on these lines.

Most western European transit systems have adopted one-person operation, with the driver controlling the doors. Newly constructed lines in Paris, Vancouver, Dubai, New York, Copenhagen, Taipei, and other cities are completely driverless (called "Unattended Train Operation" or UTO), but with "roving attendants," who assist passengers, check tickets, and help with crowd management. Some but not all UTO lines have "platform screen doors" (PSDs) that provide another level of safety and reduce delays from trespass and suicides.[51]

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[50] TTC has quoted various figures. According to the TTC 2012-2016 Capital Program and 10 Year forecast, June 8 2011, Automatic Train Control and Re-Signalling Yonge-University-Spadina will cost $568 million while the cost for the Bloor Danforth line will be $431 million. However, in a later paper of September 16 2011 it suggested that, with construction of the Eglinton Line taking some traffic off the Bloor Danforth, that line may not need to be resignalled at this time.

[51] TTC recently indicated that it was considering installing platform screen doors, with an estimated cost of up to $10 million per station. See "TTC plans suicide barriers on Yonge Line," in the *Star*, October 12, 2013. According to the *Star*, TTC had 18 suicide attempts on the subway in 2012.

Now driverless operation is being introduced on existing, older lines.[52] Paris has recently upgraded its Line 1, which runs under the Louvre and Arc de Triomphe, for UTO. Platform Screen Doors were retrofitted, at night, over several years, and a new control system was installed. This is Paris's busiest and oldest Metro line. Conversion to UTO, with PSDs, allowed an increase in capacity of about 30%, while reducing operating costs. The Paris Metro is heavily unionized; nevertheless, the transition to UTO operation has been achieved without strikes. Paris has now decided to convert another line, Line 4, to UTO.[53]

Automated systems are also more reliable, and offer a better passenger service. Without the cost of a driver (or on TTC, two!), it makes sense to operate more frequently, even in off-peak hours.

Converting the TTC subway to UTO could save about $200 million per year, or $2 billion NPV. Installation of PSDs might cost another $300 million to $500 million.

The new control system and UTO will not, in themselves, attract many new riders, although there should be some small reliability and safety benefits, and fewer service disruptions due to trespass and suicides. These improvements do, however, bring large cost savings, which can be spent instead on other service improvements, and enable higher capacity on the subway. UTO also allows more operating flexibility, with the potential to short-turn trains and inject additional trains from sidings into the service, to meet peak traffic demands. With closed-circuit TV, platform screen doors, and other safety systems, UTO is extremely safe.

[52] The author recalls when elevators in office buildings were automated. Some of the last manual-operated elevators were in government buildings, remaining well into the 1970s.

[53] See: http://www.railwaygazette.com/news/single-view/view/ratp-cleared-to-automate-paris-metro-line-4.html

RATP cleared to automate Paris metro Line 4

12 Jul 2013

Conversion of Line 1 to driverless operation was completed in 2012.

FRANCE: The board of Ile de France transport authority STIF voted on July 10 to approve the conversion of Paris metro Line 4 to fully automated operation, endorsing proposals submitted by operator RATP on June 28. Carrying 740 000 passengers/day, the north-south Line 4 is the second-busiest metro line in Paris after east-west Line 1, where the conversion to unattended operation was completed in December 2012. The 12·1 km rubber-tired line links Porte de Clignancourt with Mairie de Montrouge, serving 27 stations including the main line termini at Nord, Est and Montparnasse. It is the only line that interchanges with all other metro and RER routes in the city. A 1·7 km southern extension from Montrouge to Bagneux is currently under construction. Work on Line 4 is expected to begin next year for completion in 2019. This will include the installation of half-height platform screen gates at all stations, as well as the ATO equipment. Total cost of the conversion is put at €256m, of which €100m will be provided by STIF. Under RATP's proposal, Line 4 will be operated by the existing fleet of driverless trainsets now used on the Météor automated Line 14, which are due to be replaced by new trains when that route is extended from Saint-Lazare to Mairie de Saint-Ouen. Line 14 currently has a mix of MP89CA trainsets supplied by Alstom for the opening of the line, augmented by a handful of MP05 sets of the type introduced on Line 1 during the automation of that route. Transferring these sets to Line 4 would in turn enable RATP to cascade the manually driven MP89 sets which Line 4 inherited from Line 1 to replace older stock on other rubber-tired routes. Citing its experience on Line 1, RATP said the conversion of Line 4 to UTO would allow it to increase capacity, improve punctuality and the quality of service, as well as enhancing its ability to react to changing demand patterns. It would also improve safety, thanks to the introduction of the platform screen doors.

Source: Metro Report 12 July 2013

6.4.2 Adding Capacity

Adding capacity through the day will require more trains. With the Vaughan extension, TTC will need about 750 cars to operate the current service. Based on recent orders, TTC can purchase additional subway cars at about $3 million each. We allow a cost of $750 million to purchase 250 additional cars. This includes some allowance for additional train sidings that could be built at Wilson where there is vacant land.

Adding capacity will also require further capacity improvements at key stations, which could notionally cost a further $500 million, in addition to works that are required in any case to carry ordinary traffic growth.

6.4.3 Putting it all together

Our estimates of the costs and benefits of a "modernization package" are found in Table A8 in the Appendix and include smart pricing, discussed in detail in Chapter 10. Ridership is assumed to grow 10% due to smart pricing, and a further 5% due to the higher frequency of service, with reduced wait times and reduced crowding, for a total uplift of 150,000 passengers per day or about 45 million per year. With an average fare of about $2.00, the revenue increase would be $90 million per year or about $2.1 billion NPV. The net incremental capital and O&M costs for modernization and resignalling are about $3.2 billion, but the net cost, after taking account of incremental revenues, is about $1.1 billion or $5,540 for each incremental daily transit rider.

We think our estimates are conservative and the additional revenues might well offset all incremental costs.

As with the GO schemes, traffic on the subway will grow faster with more frequent off-peak services. However, the effect will be less, as the subway already operates a fairly frequent service. We assume a further 33% growth, to 200,000 additional riders due to the "Modernization Package." The 35% capacity increase will enable the subway to carry underlying growth in demand, but less-crowded off-peak trains will also make the system more attractive to new riders.

7

"TRANSIT CITY" LRT SCHEMES

The four "Transit City LRT" projects together account for almost $8 billion of Metrolinx's initial $11 billion in capital funding. Work has started on some projects. Metrolinx has already signed a contract with Bombardier for the supply of low-floor light rail vehicles. Tunnelling has begun from Laird Drive on the Eglinton Crosstown line.

During preparation of this report, the debate continued about whether the Scarborough RT should be converted to LRT, as envisaged in Transit City, or should be built as a subway. As of November 2013, the Province seems to have agreed that the City of Toronto can build this route in the form of a subway, but there are many unanswered questions about the route, the cost, and the benefits. This analysis will focus on the LRT proposals. Our estimates of costs and benefits are summarized in Table A9 in the Appendix.

7.1 Background: Extending transit to Toronto's suburbs

Transit City is the latest attempt to extend higher-order urban transit to Toronto's post-1945 suburbs.

In the 1970s, it was recognized that traffic volumes would be too low to justify extending the subway beyond the terminals at Kennedy in the east and Kipling in the west. A less expensive, but equally high-quality technology was required. GO was already beginning to develop a rail system that would serve radial peak commuters, but planners saw the need, notably in the 1975 Metropolitan Toronto Transportation Plan Review, for a network that would link suburban nodes, providing a faster service than buses travelling in mixed traffic on arterial streets. MTTPR envisaged light rail transit (LRT) lines, essentially streetcars running mostly on exclusive rights of way. Toronto already had the largest streetcar system in North America, and some sections of the Long Branch (route 501) line had LRT characteristics.

Around 1980, TTC began construction of an LRT line from the subway terminal at Kennedy Station, running north and east to the new shopping mall at Scarborough Centre. A further extension to Malvern was planned.

But even then, labour costs were recognized as a serious impediment to reliable, frequent, and affordable service. The Province decided that the solution was Automated Light Rapid Transit (ALRT), and invested about $100 million developing this technology at the UTDC research centre in Kingston. The plan was to build it for Ontario cities, but also to export it around the world.[54] In 1982, TTC agreed to use ALRT for the Scarborough RT.[55]

[54] The author was employed by UTDC 1981-1986, first on the Vancouver Skytrain project and then in business development.

[55] The province also gave its backing to extending the line into a regional network, with "GO-ALRT" lines into downtown as envisaged by MTTPR, and a line along the power line corridor north of Finch to link Scarborough with North York and Pearson Airport. The lines would use faster cars, capable of 120 km/h running, to offer journey times competitive with driving on Highway 401. However in 1985, after preparatory work, the government changed and the incoming Liberal government decided instead to concentrate on extending the GO rail system using conventional bi-level equipment.

TTC opened the Scarborough RT in 1985. Although it uses the same technology as the driverless Vancouver system, TTC insisted on crewing trains with a driver, although in normal operation the driver's only function is to operate the doors at stations. With much higher operating costs, TTC operates the line with 5-minute headways, whereas Vancouver operates more frequent trains as little as 100 seconds apart. TTC managers say that Toronto passengers would not have "accepted" driverless operation,[56] although this seems not to have been a problem in Vancouver, and is not a problem in London, Dubai, Singapore, New York, or Paris, all of which have automated driverless metros on at least part of their networks.

Traffic on the Scarborough has grown gradually and the line now carries about 40,000 passengers on a typical weekday.[57] Plans to extend the line to Malvern were never implemented. The line is now showing signs of deferred maintenance. Trains are very noisy, much noisier than cars of similar design and age running in Vancouver, and service disruptions are common. TTC officials insist that safety is not being compromised.[58]

In 1993, the NDP provincial government decided to build two new east-west subway lines, and construction began on both Eglinton and Sheppard. Underground alignments were adopted on both routes, and TTC decided to build them for operation with conventional subway trains. The Eglinton scheme was cancelled in 1995 by the Conservative government. The Sheppard scheme survived in a shortened form: only the stage from Yonge to Don Mills Road was built. It opened in 2002, with five stations on the 5.5-km route. Weekday ridership is about 50,000.[59] The capital cost was just under $1 billion, or $200 million per km.[60] Trains are operated conventionally, as on the rest of the subway, with two employees on every train.

In 2007, the City of Toronto and TTC issued the "Transit City" plan. This envisaged a network of no fewer than seven LRT lines, mostly on the surface running in semi-exclusive street medians.[61] This followed TTC's experience with developing new LRT routes on Spadina Avenue and Queen's Quay, and upgrading the St Clair West route. Having failed to find the funds to finish either the Scarborough RT or Sheppard subways, TTC was now reverting to a cheaper technology. It seems the idea was to spread rail more cheaply, and more widely, so it would get support from all parts of Toronto.

[56] From discussion with a senior TTC manager.

[57] http://www.ttc.ca/PDF/Transit_Planning/Subway%20ridership%202011-2012.pdf

[58] Email correspondence with a senior TTC manager, after a very noisy ride on the RT.

[59] http://www.ttc.ca/PDF/Transit_Planning/Subway%20ridership%202011-2012.pdf

[60] According to Edward J. Levy, "When the time came to build Phase One [of the Sheppard subway] during the late 1990s…the decision was made to reduce the length of the project from Victoria Park Avenue to Don Mills Road, likely because the original proposal would have incurred a total capital cost in excess of the $1 billion estimated and agreed to by all parties. This expenditure would have been "politically awkward," to say the least, considering that the provincial administration favoured austerity in so many other realms." *Rapid Transit in Toronto: A Century of Plans, Progress, Politics and Paralysis*, http://levyrapidtransit.ca/12-4-the-sheppardfinch-rapid-transit-corridor-study-1985/#.UoTsARbO9hM

[61] http://transit.toronto.on.ca/archives/maps/Transit_City_Map_Nov_2009.pdf

Transit City was also associated from the start with the City's "Avenues" program, a vision of transforming suburban arterials into more "urban" environments, lined with medium-rise buildings and shopping, and more conducive to use by pedestrians and cyclists.

Figure 12: This illustration from the TTC's original Transit City report of March 21, 2007, shows a rather idealized (European-style) outcome in a historic setting that emphasizes urban design rather than transit efficiency.[62]

Although the schemes together will cost billions of dollars, and contracts are already being signed, there seems to have been very little evaluation of the economic or financial impacts. TTC staff produced an 18-page report, really just a memorandum,[63] called "Evaluation and Comparison of Routes," which simply lists the proposed schemes, giving their length, capital cost, and annual ridership. There is no mention of alternative routes or modes. There is no estimate of economic benefits. There is no information about operating costs or revenues. While the report breaks riders down into "Existing" and "New – Projected 2021" it is not clear whether these number represent riders that are new because of the scheme, or merely underlying growth; probably they include a bit of both. Background tables list potential populations and specific traffic generators that will be served, but no information was published on whether the impact would be worth the costs.

Metrolinx subsequently completed a Benefits Case Analysis for the Eglinton-Crosstown scheme, but did not release it until we requested it under the *Freedom of Information Act*. TTC planners have not provided any further information, stating that Eglinton-Crosstown is now a Metrolinx project.

Metrolinx also prepared a Benefits Case Analysis in 2009 for the Sheppard-Finch projects, considering different configurations for linking them into a single line across Toronto. Option 1 was a single scheme: two separate lines, one from Yonge along Finch to Humber college, and a second from Don Mills station to

[62] Source: http://www.toronto.ca/legdocs/mmis/2007/pg/bgrd/backgroundfile-3311.pdf

[63] See TTC Report of November 14, 2007, Transit City Light Rail Plan – Evaluation and Comparison of Routes.

Meadowvale Road. Both lines are now to be substantially shorter; however, Metrolinx has not published an updated Benefits Case Analysis. Logically, the two lines would be evaluated separately, as they are now independent projects.

Metrolinx prepared a Benefits Case Analysis for Scarborough Rapid Transit in 2009[64] (although it was not released until later), but the original proposal has now been superseded by more recent plans for Scarborough transit.

The Transit City schemes attracted political support very quickly, and Metrolinx included them in The Big Move. Four of Metrolinx's "Big 5" schemes are in fact Transit City schemes.[65] Transit City materials are liberally illustrated with photographs of trams running on tree-lined avenues. But they are short on hard facts and figures about cost, ridership and benefits.

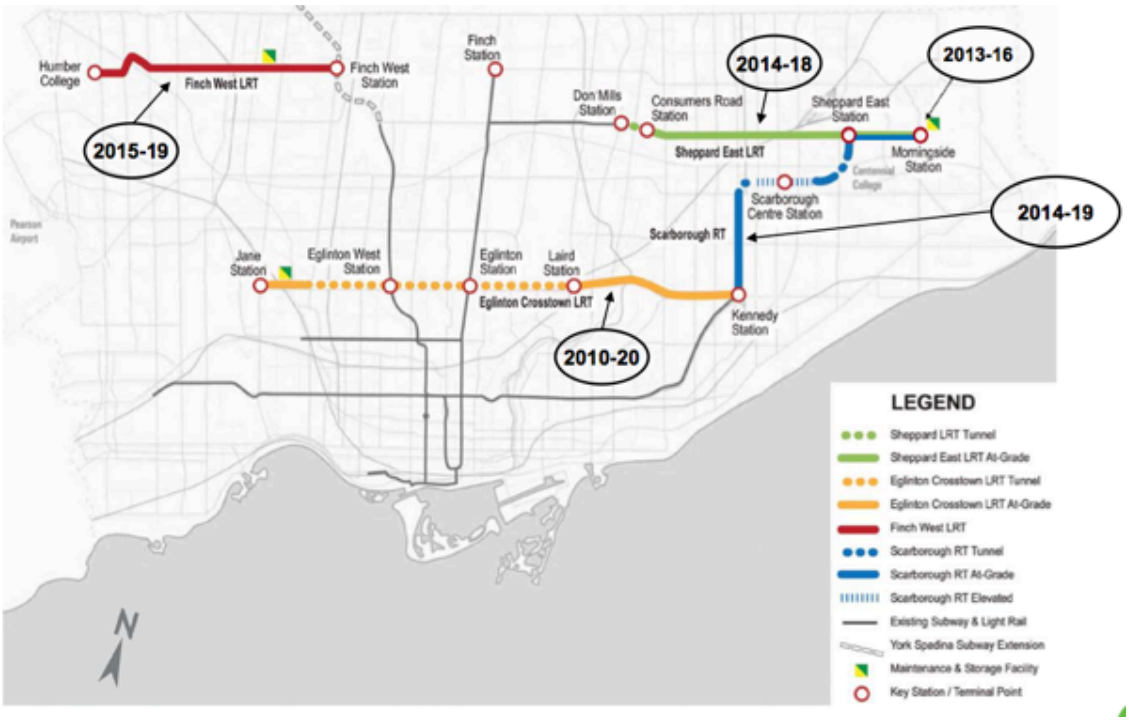

Figure 13: The four "Transit City" LRT schemes included in Metrolinx's "Big 5"[66]

Figure 14 presents data from Metrolinx's BCAs for the Eglinton Crosstown scheme, and the combined Sheppard-Finch schemes. Note that while the Eglinton Crosstown BCA gives estimates of ridership and benefits from the GGH model, the Sheppard-Finch BCA gives estimates only of total benefits and does not

[64] http://www.metrolinx.com/en/regionalplanning/projectevaluation/benefitscases/Benefits_Case-SRT.pdf

[65] http://www.metrolinx.com/en/docs/pdf/board_agenda/20100519/Five_in_Ten_Board_web.pdf

[66] Source: Toronto Transit Plan, April 2012, http://www.metrolinx.com/en/docs/pdf/board_agenda/20120425/torontotransitplan_boardpresentation_25april2012.pdf

disclose the total or incremental daily or annual ridership. This important information would have been helpful in evaluating the scheme.

	Sheppard Finch Option 1	Eglinton Crosstown Weston Rd - Kennedy
Infrastructure Capital Cost $m NPV	$ -1,807	$ -3,345
Operating Costs (incremental) $m NPV	$ -93	$ 417
TOTAL COSTS $m NPV	$ -1,900	$ -2,928
Total daily riders 2023	?	350,000
New riders 2021		50%
New daily riders 2023	?	175,000
Incremental revenues $m NPV	$ 60	$ 101
NET FUNDING GAP $m NPV	$ -1,840	$ -2,827
Road user benefits $m NPV		$ 103
Passenger Benefits $m NPV		$ 810
Passenger and road user time savings $m NPV	$ 570	$ 913
TOTAL BENEFITS $m NPV	$ 630	$ 1,014
NET BENEFITS $m NPV	**$ -1,270**	**$ -1,914**
BENEFIT:COST RATIO	0.33	0.35

Figure 14: Transit City LRT Schemes (Metrolinx BCA data)

The Eglinton BCA shows the scheme has a Benefit:Cost ratio of 0.35. In other words, government will be paying about $5 billion to get benefits for transit riders and road users worth about $2 billion (including bus operating cost savings).

There are some inconsistencies in the data presented in the Eglinton Crosstown BCA. Ridership seems to be very high: about 350,000 per day and more than double the TTC forecast and three times existing bus ridership. Yet incremental revenues are very small, implying less than 10,000 new riders per day. Operating costs seem optimistic; the figures suggest that savings from operating fewer bus-km would not only entirely offset all costs of operating the LRT, but also provide a substantial surplus.

In the next sections, we will review the assumptions underlying Transit City and evaluate the Metrolinx figures.

7.2 Costs

Although LRT is often proposed as a way to offer the service speed of a subway, at the cost of a streetcar, the infrastructure costs are still substantial and in some cases not much less than for a full subway.

7.2.1 Infrastructure

7.2.1.1 Sheppard East LRT

The Sheppard East LRT will run 13.6 km, almost entirely in the centre of Sheppard Avenue, from Don Mills Road to Morningside Avenue. TTC is planning a short underground section at Don Mills Road, for interchange with the subway.

Sheppard is currently 7 lanes wide from Don Mills to Pharmacy Road, then 5 lanes to Markham Street, then 4 lanes. Provision of LRT in the median will mean reconstructing the road, and in most cases eliminating the left-turn lane. Metrolinx quotes a price of $1 billion or about $75 million per km.[67]

7.2.1.2 Scarborough LRT

Metrolinx issued a Benefits Case Analysis for the Scarborough RT replacement and extension project, dated January 2009. It examined four scenarios, including upgrading the line with existing technology for operation of four-car trains, and conversion to LRT technology with extension to Malvern. Unfortunately, none of the four scenarios that are evaluated matches the scheme actually included in Metrolinx's plans.

The BCA gives an estimated capital cost of $1.4 billion to rebuild the line with LRT technology, and to extend it on an exclusive right of way to Malvern Centre. For slightly less, $1.2 billion, the line could be extended to Malvern but with surface right of way beyond McCowan. TTC has more recently said it would cost $1.8 billion to rebuild and extend the line only as far as Sheppard and Markham Road.

At $1.8 billion for 10 km, the Scarborough LRT line would be considerably more expensive than the Sheppard Line,[68] or about $180 million per km. About half the cost is for conversion of the existing 6.5-km RT to accommodate low-floor LRT cars, with overhead power collection. This involves substantial reconstruction of six intermediate stations, and complete reconstruction of Kennedy Station to provide a larger underground loop, and track connection with the Eglinton LRT so TTC can exchange cars for maintenance purposes (but not for through-running with passengers). The balance is for construction of 4 km of new line, mostly elevated, from McCowan to Sheppard Avenue.

Note that at $180 million per km, the cost per km for the Scarborough RT is about 30% higher than the cost of the Evergreen Line, a fully grade-separated ALRT line in Vancouver,[69] even though the Scarborough line uses mostly existing infrastructure, and otherwise operates through a broadly similar corridor.

In the Scarborough LRT BCA, Metrolinx accepts TTC's position that expenditure of $452 million is "required" in the base case, simply to replace aging rolling stock and increase capacity to meet projected demand. This expenditure has the effect of reducing the incremental costs of other options, including conversion to LRT. The logic is sound, but we question whether the upgrading needs to be so expensive, especially if alternatives such as upgrading the GO Rail System can take passengers who would otherwise ride the Scarborough RT.

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[67] Data for Transit City Light Rail schemes is mostly from Metrolinx project fact sheets, http://www.bigmove.ca/what-were-building/projects-underway-completed, and from the TTC Commission presentation "Transit City Update" of September 30, 2010. According to TTC, the Metrolinx funding for the Sheppard line is $1.13 billion including escalation. Metrolinx figures are in 2010 dollars, while the TTC prefers to use the expected "outturn" cost, including inflation during the construction period.

[68] This is the Metrolinx figure for a 10-km line ending at Sheppard. The TTC figure is $2.465 billion for a 12-km line extending to Malvern Centre, and also appears to include inflation.

[69] According to the project website, http://www.evergreenline.gov.bc.ca/faq.htm capital cost for the 11-km line is $1.4 billion. Rolling stock is a further $90 million (see http://www.railway-technology.com/news/newsbombardier-supply-skytrain-cars-evergreen-line-canada), bringing the total cost to about $1.5 billion or $136 million per km.

We question some of the assumptions in the Scarborough LRT BCA:

- It is stated that as the ALRT Mark 1 vehicles "are no longer manufactured," the line must be rebuilt to accommodate the larger Mark 2 vehicles. This is not correct. Transit cars are all "built to order," and while there can be cost synergies in combining with another order, trains are not build on continuous assembly lines like cars or planes. Toronto's replacement streetcars are a special design, to match the geometry of Toronto's tracks. Certainly, TTC could procure replacement cars of the size and performance of the Mark 1 cars, if it wished to avoid the cost of rebuilding stations and curves. The cost per car would probably be higher, but total project cost might well be less. There is no evidence TTC or Metrolinx has considered this option, or enquired with Bombardier whether they would be prepared to build additional cars to the Mark 1 dimensions. The BCA notes that the line would need to be closed for at least 8 months for rebuilding. While it may make sense to upgrade the line for the larger Mark 2 cars, for other reasons, replacement with new cars built to the Mark 1 size could avoid any need to close the line down.
- It is stated in the summary that the existing line has a capacity of 4,500 passengers per hour per direction (PPHPD), and that this would be increased in the Base Case to 7,000 PPHPD. In Part B of the BCA, it states that 3-car trains operating at 2-minute headways would provide the "capacity requirement of 5,400 [PPHPD] by 2031." Actually, Mark 2 cars have a capacity of 130 passengers; so 3-car trains at 2-minute headways represents a capacity of about 11,700 PPHPD. Elsewhere, the BCA refers to expected demand of 10,000 PPHPD, about double current levels but easily carried with the existing technology, with additional cars but without rebuilding. Vancouver actually operates the Expo Line at 1.8-minute headways in the peak, with capacity of about 16,000 PPHPD.
- It is stated that the interchange at Eglinton requires passengers to "travel three levels between platforms." While it is correct, the distance is not far and is partly served by escalators. It is already a very good transfer. We question whether it is necessary to rebuild the station, in the way proposed by TTC, or whether it might be sufficient to add another escalator or two (which could also be much cheaper).
- TTC seems to be requiring a fairly elaborate and expensive yard. The BCA (which was prepared by consultants) notes, "The cost of a Vancouver facility with comparable capacity was roughly $200m lower, although the yard alignment and maintenance practices differ from the TTC's." If Metrolinx thinks there may be the opportunity to save $200 million, surely it should give this more attention than a short footnote?

In our evaluation, we do not "net out" the $452 million "base case" costs, because we do not accept the need to rebuild the line as the "base case." TTC might need to spend $200 million replacing the train fleet and making other expenditures to restore the line to a "state of good repair," bringing the incremental capital cost of the TTC scheme (converting to LRT and extending to Sheppard) to $1.6 billion, or $1.4 billion excluding rolling stock. Taking 70% of this gives an NPV of $980 million. We use this figure in our evaluation (it has the effect of substantially reducing the Benefit:Cost ratio, actually below 1.0).

7.2.1.3 Eglinton Crosstown LRT

The Eglinton Line is far more expensive, with capital costs of $4.9 billion, according to Metrolinx.[70]

The less expensive sections are from Laird Drive to Kennedy in the east and from Keele to Jane in the west, on the surface in the median of Eglinton Avenue for about 11 km altogether. Eglinton Avenue will need to

[70] The TTC quotes a figure of $6.065 billion for the 10-km line from Jane to Kennedy, including inflation. The figure in the Table shown here is lower, because it is a Present Value.

be rebuilt, similar to Sheppard, so the cost of this might be $75 million per km or $825 million, similar to Sheppard West.

The expensive parts are the tunnels, 11.25 km in deep bore from Laird to Weston Road, and for 12 or 13 underground stations. The tunnels will cost about $1 billion, or $100 million per km. The stations add a further $150 to $200 million each, or about $2.4 billion. The power system, a maintenance yard at Mount Dennis, design and project management fees, and contingency for overruns make up the remaining $700 million.

7.2.1.4 Finch West LRT

Metrolinx estimates the cost of this line at about $1 billion, or $100 million per km,[71] the same total as the Sheppard West LRT. It is not clear why the costs are the same, as the Finch line is only 11 km long, and Sheppard line is 13.6 km long.

7.2.2 Rolling stock

When it proposed Transit City, TTC was already procuring new low-floor streetcars, to operate on its existing surface routes. An $851-million contract was awarded in 2009 to Bombardier for 204 "Flexity Outlook" cars, or about $4.17 million per car.[72]

In 2010, Metrolinx signed an order for a further 182 cars to operate the Transit City routes. The price was $770 million or $4.23 million per car.[73] While the initial order is for single-ended units that are designed to operate on Toronto's non-standard track, the additional "Flexity Freedom" cars will be larger, double-ended, 2.65 metres wide, and operate on standard 1435mm gauge track. It seems that, by making the Transit City order an "add-on," Metrolinx could avoid an international competition, as required by World Trade Organization rules, ensuring political support for the procurement because it will create local jobs.

Although it is difficult to make direct comparisons, Bombardier's price seems high for such a large order. For example, Siemens recently won a $153-million contract to supply 41 low-floor LRT cars to Minneapolis,[74] at an estimated price of $3.73 million per car.

7.2.3 Operating costs

Metrolinx has provided estimates of incremental transit operating costs for the Eglinton Crosstown line, the Scarborough LRT schemes, and for the combined Sheppard-Finch scheme, in its BCAs. The Metrolinx forecasts are much less than ours, with the Eglinton Crosstown scheme actually costing $417 million NPV *less* to operate than the bus services it would replace. Without further detailed information from TTC, it is not possible to verify whether this estimate is reasonable.

Our estimates for the Scarborough LRT scheme are very similar to Metrolinx's; we estimate incremental operating costs of $12.5 million per year, offset by bus costs savings of $1.5 million per year for a net

[71] The TTC Transit City Update gives a figure of $1.28 billion, again including inflation.

[72] See http://www.railwaygazette.com/news/single-view/view/bombardier-signs-largest-ever-tram-order.html?sword_list%5B%5D=toronto&sword_list%5B%5D=flexity&no_cache=1. The "headline" price was $851 million, but the total contract price was estimated at around $1.2 billion including taxes, spares, and maintenance.

[73] http://www.thestar.com/business/2010/06/14/toronto_buying_182_more_bombardier_streetcars.html

[74] http://www.railwaygazette.com/news/urban/single-view/view/light-rail-contracts-awarded-in-minneapolis.html

additional annual O&M cost of $11 million per year or about $250 million NPV. Metrolinx costs are slightly higher: $14 million per year O&M costs additional to the Base Case, offset by $1.8 million bus cost savings.

7.3 Passenger benefits

7.3.1 Journey times

Transit City, TTC, and Metrolinx documents make little mention of journey times or speeds.

Surface LRT can be ideal for relatively short trips: the Spadina line is only 3 km long; the St Clair line is 6 km long, but the typical trip is less than 3 km. Although the average speed is fairly slow, only 15 to 20 km/h, journeys still take only 10 or 15 minutes. These lines are close to downtown, and passengers can complete their trips on the subway in another 10 or 20 minutes.

Typical journeys on the Transit City LRT lines will be very different. With an average speed of about 25 km/h, a trip from the east end of the 13-km Sheppard Line to Don Mills station would take about 30 minutes. Total journey time from Malvern to downtown Toronto using the subway would be about 1 hour and 15 minutes, with two changes. This is not much faster than driving in rush-hour traffic and slower than the existing GO rail service, which takes 26 minutes from Agincourt Station to Union Station. The Transit City schemes will certainly improve local mobility, but will do little to further Metrolinx's *regional* transport objectives.

Where LRT runs on the surface, it will be a bit faster and more reliable than the current buses, because vehicles will not have to share a lane with cars and may have priority at intersections. Because LRT cars carry about three times as many passengers as a bus, and cost more to operate, passengers are also likely to face longer wait times, as TTC will likely operate fewer vehicles at longer intervals. Because LRT will run along main streets like Sheppard and Finch, many passengers in neighbourhoods like Malvern will need to change to a local bus or walk some distance to complete their trip home.

Along Eglinton between Laird and Keele, the LRT will run in a deep tunnel, and will be unaffected by traffic. However, it will still run at only 30 km/h on average. This is because TTC is building 13 stations, with an average spacing of about 700 metres. While older parts of the Toronto subway have stations spaced as little as 500 metres apart, normal practice is for metro stations to be at least 1 km apart even in city centres, and 2 km to 5 km apart in lower-density suburban areas. TTC's plans make sense only if Eglinton Avenue is substantially redeveloped, at much higher densities, a prospect that is at best, distant.

7.3.2 Ridership and Revenues

TTC has prepared forecasts of the ridership on each LRT, although it is not clear how these were developed.[75] TTC breaks the ridership down into "existing," on the current route, "diverted," currently using a different route, and "new" ridership to 2021. The forecasts do not, however, distinguish new ridership that would be generated by population growth and development, even if the LRT line is not built.

[75] Estimates for "existing" and "new" ridership expected to be attracted onto the Transit City LRT routes are presented in TTC memorandum to the Commission "Transit City Proposed LRT Extensions September 30, 2010." TTC's "Transit City Full Report" of March 21, 2007 gives annual ridership for each line in 2023, and "existing corridor ridership."

TTC's figures are usually for the full schemes (for example, for the 30-km Eglinton Crosstown line extended to Pearson Airport), and not necessarily for the somewhat shorter lines now envisaged. Generally, LRT lines serve local and feeder trips, so ridership is roughly proportional to route length. Some passengers may travel from Eglinton and Yonge to the airport, but with the slow speeds and long journey times, the service may not be attractive to many riders. Passengers making longer journeys might use GO Rail or GO Bus services, but more likely, they will drive.

Metrolinx provides some total ridership figures for the "Big 5" schemes in a series of project fact sheets, but has not specified the proportion expected to be new riders.[76] The Eglinton Crosstown BCA gives a figure of 105 million boardings in 2021,[77] which works out to 350,000 riders per day with an annualization factor of 300.[78] This is double TTC's forecast of 176,000 per day, and about three times as much as current bus ridership on the route. It is also two-thirds of the current traffic on the Bloor Danforth subway. We question the validity of this figure.

The Metrolinx BCA provides a figure of $5.6 million per year or $101 million NPV for incremental revenues on the Eglinton LRT. This figure implies new ridership of less than 10,000 per day. We do not understand how this figure can be consistent with Metrolinx's forecast of 105 million boardings on the line in the same year. Again, we find the figure questionable.

Figures in the Metrolinx BCA for the Scarborough LRT states are even less plausible: base-case ridership is forecast to be 112.7 million trips in 2031, or about 373,000 per day. This is almost 10 times current ridership, and three times the ridership implied elsewhere in the report. The figure is actually similar to ridership on the Danforth subway, and several times beyond the capacity that the BCA is assuming would be provided.

Bizarrely, the Metrolinx BCA then states that additional ridership with extension of the line to Malvern will be only 600,000 to 800,000 passengers *per year*, or about 2,000 per day. These cannot be simple typographic errors: the figures are repeated several places in tables and text. While most riders on the extended line would otherwise ride the bus a bit further before boarding the RT, we would be very surprised if extending the Scarborough line to Sheppard does not attract at least 15,000 new riders per day, beyond the underlying growth that is expected.

We use TTC's forecasts, adjusted pro-rata for route length, for the new LRT lines. To estimate the benefits, we need to know what share of projected ridership is new ridership, that is, riders who have switched from another mode of travel to transit specifically because of the scheme. Neither TTC nor Metrolinx has disclosed this figure. We think new ridership might realistically be about 25% of the projected total.

With complementary policies, the incremental ridership on the Transit City LRT routes could double to 2033. However, this will happen only with strong land-use planning policies. Higher-density development has been slow to materialize around the Spadina and Sheppard subways and the Scarborough RT, even though these are fully grade-separated lines with relatively fast average speeds. The Transit City schemes are relatively slow, local transit lines. Although they improve local accessibility, longer-distance trips are still overwhelmingly made by car.

[76] From discussions and informal email communications with senior Metrolinx managers.

[77] Eglinton Crosstown BCA, Table 3.2.

[78] This rounded figure of 300 assumes that traffic on the weekends is half that of weekdays.

7.3.3 Other passenger benefits

Surface LRT lines are typically 10% to 20% faster than surface buses in mixed traffic, so a typical 25-minute bus journey would become a 20-minute LRT trip. The 5-minute saving is worth about $1.12 to a typical passenger, at the rate of $13.52 per hour that Metrolinx has used in its calculations. The benefits may be reduced, however, if passengers using the LRT need to make an additional transfer to a local bus. We ignore this possibility, but in some circumstances, it will cancel out much or all of the benefit of LRT. We assume passenger benefits, not captured by fares, of $1.50 per existing rider for the Sheppard, Finch, and Eglinton lines, and $0.75 for new riders.

For the Scarborough line, Metrolinx estimates travel time benefits to transit users and motorists together worth about $1.3 billion NPV. While it does not split these, time savings to motorists must be very small, as with so few new riders, there cannot be many avoided car trips. According to the BCA, time savings are valued at $13 per hour. This implies time savings of about 14,000 hours per day, or about 60,000 daily riders each saving 10 minutes compared with riding the bus to the existing terminus at Scarborough Centre. We assume a benefit of $2.00 per trips for existing riders, and $1.00 per trip for new riders.

Metrolinx's BCA reveals that the Eglinton Crosstown scheme has a Benefit:Cost ratio of less than 0.4. In this case, Metrolinx has added in "reliability benefits," something that is not included in any of the other Benefits Case Analyses.

The value of the reliability benefit appears to be about $0.50 per passenger, which is credible, given the vulnerability of buses on Eglinton to traffic congestion. Metrolinx provides no empirical evidence to support this estimate, but we accept that existing transit riders will benefit and that this improvement may not be reflected fully in calculations of time savings.

FIGURE 4.1 BENEFIT COST RATIOS WITH RELIABILITY BENEFITS INCLUDED

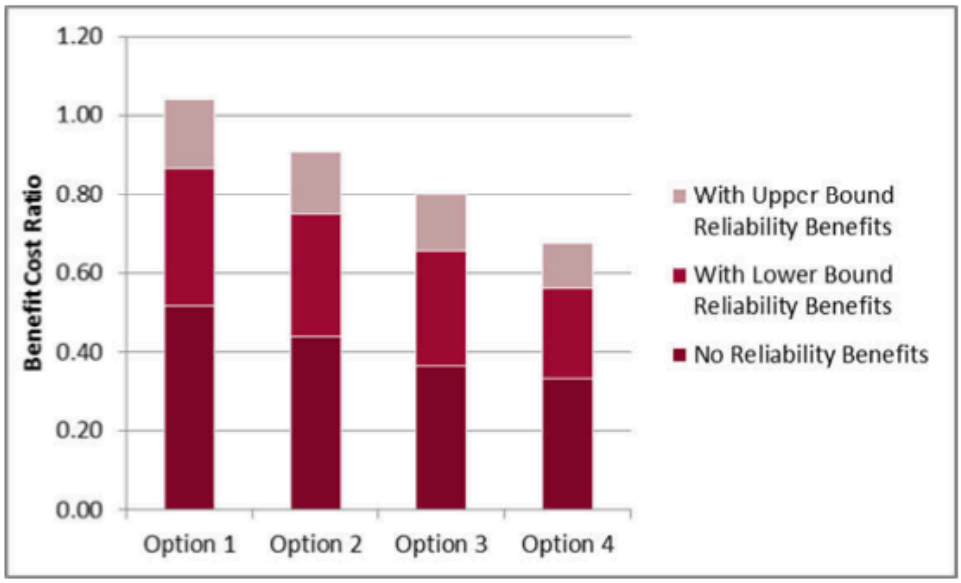

Figure 15: This figure from the Eglinton Crosstown BCA includes "Reliability Benefits" in the Benefit:Cost ratio for the Eglinton Crosstown. Even so, benefits are substantially less than costs for Option 3, the scheme currently under construction. Benefits might exceed costs for Option 1, which would be entirely underground. The increased capital costs would be offset by greater benefits because there would be faster trips, with fewer stations between Laird Drive and Kennedy.[79]

However, Metrolinx has also forecast massive growth in transit ridership on the corridor, and seems to be applying the benefit to all riders, not just existing riders. This seems very optimistic. While existing riders will benefit from improved reliability at no cost, new riders consider reliability in their decision to switch to transit from automobiles.

7.3.4 Road traffic impacts

There will be some reduction in car traffic from new riders attracted onto the LRT lines. However, the LRTs do not seem likely to attract many new inter-regional trips, because of the slow journey times and relatively poor connections to commuter rail. Car trips diverted onto transit will mostly be fairly short, so this benefit might therefore be worth about $2.50 per trip, on average.

Because Toronto's streets are generally narrow, providing an exclusive median for LRT means that some sections of Eglinton, Sheppard, and Finch may be reduced from three lanes to two lanes. Even where it is possible to maintain the number of through traffic lanes, left-turn lanes will disappear except at intersections, and access to driveways and parking on either side may require a time-consuming U-turn, as it often does now on St. Clair West and Spadina Avenue. There will therefore be road user disbenefits. We

[79] Eglinton Crosstown BCA, June 2012, http://www.metrolinx.com/en/regionalplanning/projectevaluation/benefitscases/Benefits_Case-Eglinton_Crosstown.pdf

Note: Figures 2.1 – 2.3 in the Metrolinx BCA show each option, however they have been labeled incorrectly. From the BCA text and Table 2.4, it is clear that Option 3 is the adopted scheme.

estimate these at $1,000 per day for each kilometre of road affected. This rate assumes 10,000 motorists per day are each delayed (that is, they face longer trip times) by 27 seconds on average, because of the loss of a road lane.[80] Actual road user disbenefits will depend on details of road design that have not yet been disclosed.

The Metrolinx BCA for the Scarborough LRT scheme estimates that the scheme will take 60 million car-km off the roads. We find this puzzling. This implies that each of the 800,000 new riders would otherwise drive 75 km per trip, or 150 km per day. We don't think the extended Scarborough RT is likely to attract many new riders who would otherwise drive to Hamilton. In the same section of the BCA, Metrolinx estimates automobile operating cost savings to be worth $60m in 2031, which it says are calculated at $0.60 per km. Applying long division, this implies only 1 million car-km taken off the road in 2031. This is probably a gross underestimate, but is at least consistent with the estimate of 800,000 new riders per year.

7.4 What is wrong with the schemes?

7.4.1 Few benefits for the costs

According to Metrolinx's own Benefit Case Analyses, these schemes are not worthwhile, at least as transport investments. The Benefit:Cost ratios are all less than 1.0 and some are less than 0.5, indicating that costs are more than double the estimated benefits. Cost per new transit rider is high: $40,000 or more. At this rate, Metrolinx would need $50 billion to achieve its 2033 ridership objectives, not the $36 billion it is currently trying to raise.

The Transit City schemes seem to have been developed more to achieve an urban design vision than to improve transportation in Toronto. The TTC's original "Transit City" report of 2007 describes the scheme as supporting "city-building," and includes pictures of LRT systems in attractive, mostly European environments. At about the same time, the city was developing its "Avenues" program, attempting to create a more pedestrian- and bicycle-friendly environment along urban and suburban arterials.

The TTC's Transit City report includes estimates of annual 2023 ridership for each line. Existing ridership is also given for each corridor, but (as with the TTC's background report) it is not clear how much of this is new ridership due to the scheme, and how much is due to underlying growth in existing ridership. While the text says explicitly that it describes the "benefits and costs" of each scheme, there is no other quantitative information in the report, such as operating costs, revenues, or time savings. The Transit City schemes might have a purpose as urban design initiatives, but it is hard to imagine how the costs could be justified in this way alone. Certainly they are not an effective use of Metrolinx's limited funds. Nevertheless, work is proceeding on many of these initiatives.

[80] By way of comparison, Transport for London now charges utility companies £2,500 ($4,166) per day, about four times as much, to occupy traffic lanes in congested areas.

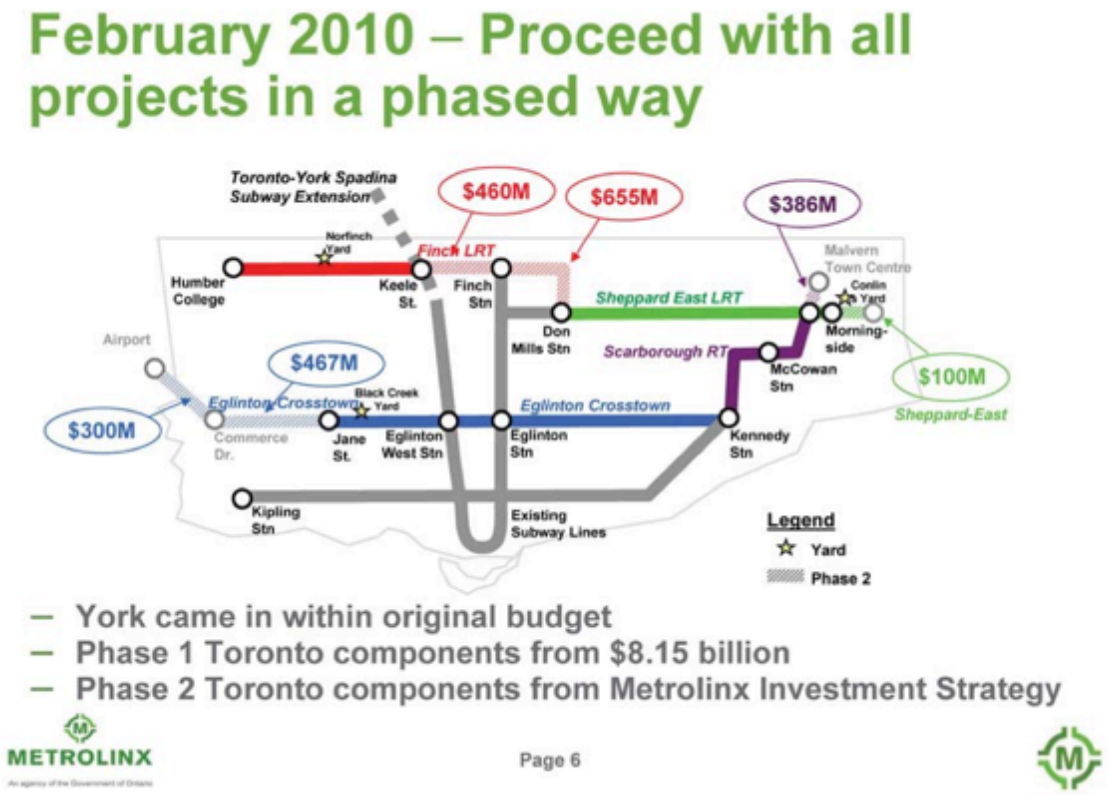

Figure 16: Metrolinx's cost estimates and proposed completion times for Transit City schemes.[81]

7.4.2 Choice of technology

There has been an unproductive debate about whether Sheppard and Scarborough lines should be built using "subway" or LRT technology. Torontonians think they understand the key features of a subway – fairly fast trains, running mostly in tunnels, not interfering with traffic. LRT is thought of as being a superior form of streetcar, as operated on Spadina, Harbourfront, and St. Clair; slower than a subway, not much faster than a bus, but cheaper to build and operate. At least, that is the advertisement. Reality may be somewhat different.

The Sheppard and Finch lines are, indeed, fairly cheap, although they still cost about $1 billion each. They also deliver a slight improvement over the existing bus service. It remains to be seen whether a relatively slow surface transit line will transform the suburban streets into pedestrian-friendly urban "avenues."

Passengers on the Sheppard Line who want to go downtown will need to transfer at Don Mills onto the Sheppard Subway, then onto the Yonge line. On the "Big Move" map, there is the suggestion of a continuous LRT line across the north of Toronto, but in fact, passengers would need to change at least three

[81] Source: Metrolinx, May 2010, http://www.metrolinx.com/en/docs/pdf/presentations/Rob_Prichard_Presentation_TBOT170510.pdf

times to travel from Malvern to York University.

FIGURE 2.2 OPTION 3: FUTUREPROOFING EGLINTON SCARBOROUGH CROSSTOWN

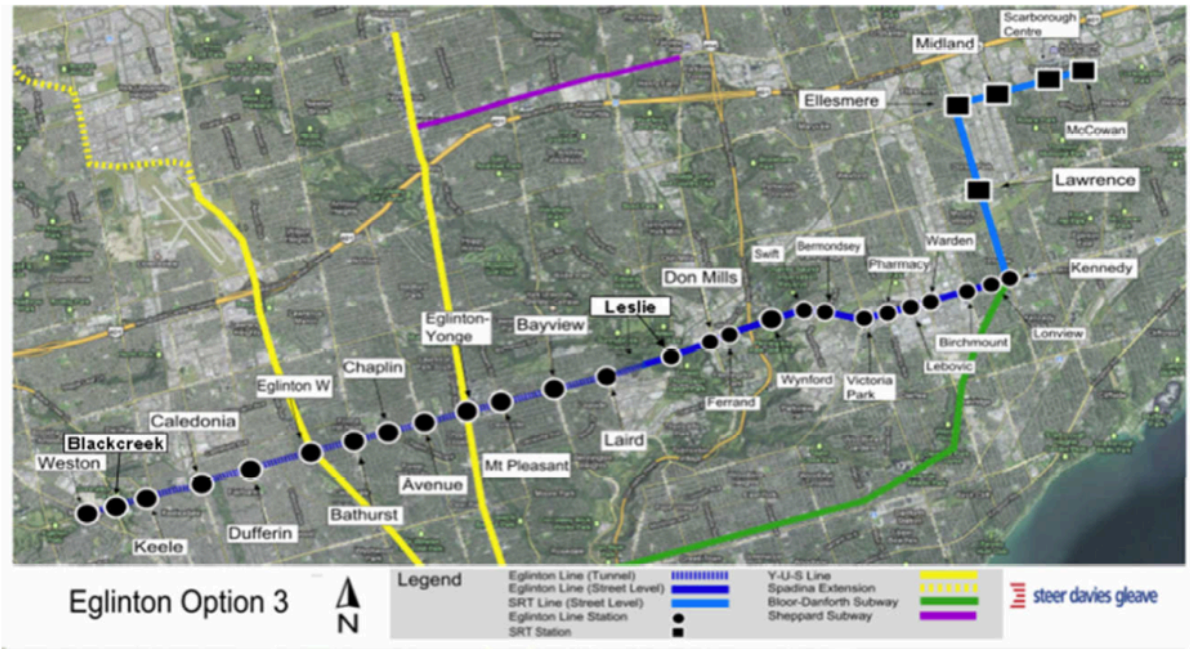

Figure 17: Scarborough RT and planned Eglinton Crosstown[82]

TTC looked at converting the Sheppard Subway to LRT technology, but the cost to rebuild the stations for low-floor cars would have been about $600 million. Metrolinx also considered a plan to turn the Sheppard line north up Don Mills Road, then west to connect with the Finch West line, but the case for this addition is weak, and Metrolinx has not announced any firm plans to build the line.[83]

[82] Source: From Metrolinx Eglinton Crosstown BCA, June 2012, http://www.metrolinx.com/en/regionalplanning/projectevaluation/benefitscases/Benefits_Case-Eglinton_Crosstown.pdf

Note: That the label is incorrect; the map shows Option 3, which is the scheme now being implemented, but it is not the "futureproof" scheme, which is Metrolinx's Option 2.

[83] This is Option 3 in the Benefits Case Analysis for Sheppard Finch. http://www.metrolinx.com/en/regionalplanning/projectevaluation/benefitscases/Benefits_Case-Sheppard-Finch.pdf

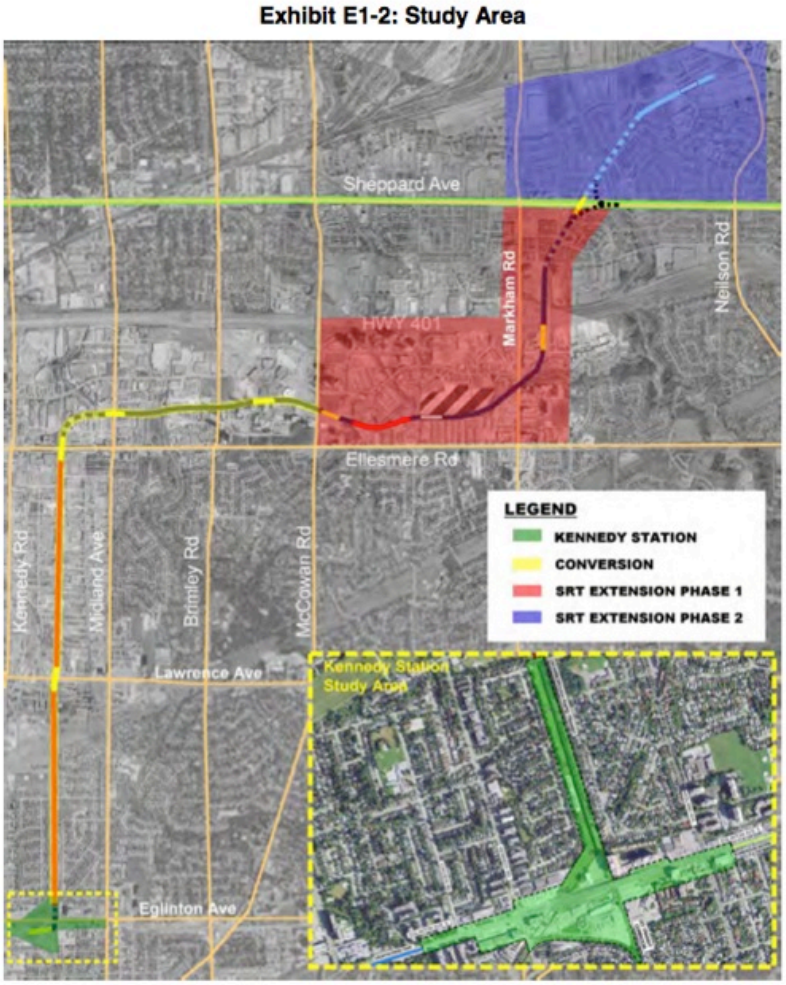

Figure 18: Map showing existing and proposed extensions of Scarborough RT. The existing line has sharp curves at the Kennedy terminus and where the line turns to cross under the GO rail line north of Ellesmere Road.[84]

The Scarborough RT "replacement" and extension is not cheap, almost $2 billion when rolling stock costs are included. This buys 3.5 km of additional line, from the current terminus at McCowan to Markham Road. About $1 billion of this is being spent converting the existing RT to LRT standards, so TTC can operate it with the same LRT cars as the Sheppard and Eglinton lines.

TTC does need to increase capacity on the line, and it is true that the 10m-long "Mark 1" cars are "no longer in production." The newer "Mark 2" cars, which are 16m long, cannot go around the curves at Eglinton and north of Ellesmere. But curves can be rebuilt, and all transit cars are built to order. It is not clear why the TTC believes the line needs to be rebuilt at all, when Vancouver is operating and even extending a line of similar age and technology, carrying many more passengers, without serious problems.

[84] Source: Scarborough Rapid Transit Environmental Project Report, http://www.toronto.ca/involved/projects/scarborough_rapid_transit/epr/a5_a6_exec_summary.pdf

One alternative would be for TTC to get Bombardier, or another manufacturer, to supply 40 replacement cars, for a price of about $4 million each or $160 million. For perhaps $100 million, TTC could remove the curve at Kennedy, and build a new station on a north-south alignment alongside the GO platform. If GO is eventually upgraded into a regional metro, most Scarborough RT passengers will want to transfer onto GO anyway, because it offers a much faster service to downtown. We suggest that TTC is trying to improve the wrong interchange.

7.4.3 Too Many Stations

Although the Eglinton line has the cost of a subway (which it is across the central 11 km from Jane to Laird Drive), it will deliver a service more like that of a streetcar. Like the Bloor-Danforth subway, there are many stations, so trains will have a very low average speed. And some of the stations will have very low ridership. According to TTC's forecasts, the station at Chaplin Crescent will be used by only 850 passengers in the a.m. peak hour, or maybe 5,000 per day.[85] Most of the 850 passengers are probably assumed to be transferring off the Glencairn and Forest Hill buses, which together carry only 2,200 passengers per day. Probably fewer than 1,000 of the daily boardings at this station would be new transit riders.

Underground LRT stations, of the kind planned for Eglinton, cost $150 million to $300 million each to build, including property design, project management, and contingency costs.[86] In addition, there is a cost of about $20 million NPV for operations and maintenance, as well as fleet operations and maintenance costs to serve it. Each station adds about a minute to the trip time, and thus reduces ridership by a few percent.

For most of the route between Weston Road and Laird Drive, Eglinton is surrounded by stable neighbourhoods containing single-family homes, densely developed on relatively small lots. Based on experience on the Bloor-Danforth and Spadina subway lines, more intensive development will occur slowly, if at all. At an incremental cost of at least $100,000 per new transit rider, there seems no reasonable case for building the station at Chaplin. Stations at Avenue Road, Oakwood, Laird Drive, and Mount Pleasant should also be subject to further study. The case for these stations depends upon whether the surrounding areas are likely to be redeveloped at higher densities. Given current policies, this prospect seems unlikely.[87]

[85] TTC: Eglinton Crosstown LRT Demand Forecasting Report, p. 25, http://www.toronto.ca/involved/projects/eglinton_crosstown_lrt/epr/appendixn-travel-demand-forecasting-report.pdf

[86] Metrolinx staff and consultants have verbally confirmed that costs of Eglinton LRT stations are in this range.

[87] By comparison, redevelopment is being encouraged along Cambie Street, a broadly similar corridor in Vancouver served by a new underground line. See http://vancouver.ca/home-property-development/cambie-corridor-plan.aspx

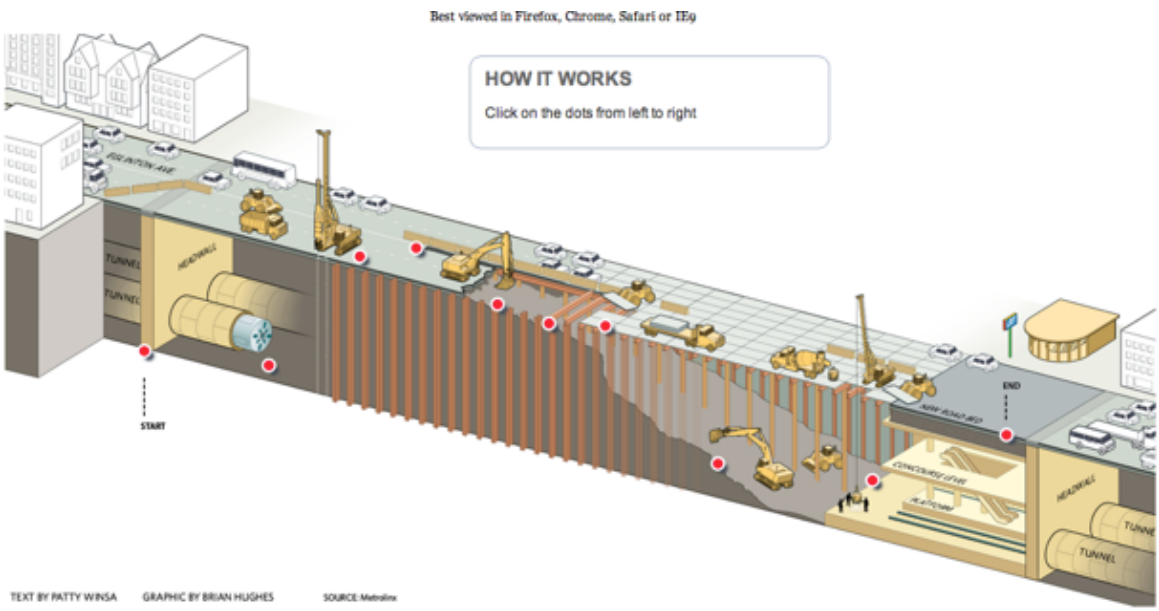

Figure 19: This drawing from Metrolinx shows how the underground stations along Eglinton will be built. For the full interactive version, see the Metrolinx website.[88]

7.5 How could the Toronto LRT Schemes be improved?

7.5.1 Consider using ALRT or similar technology

Neither Metrolinx nor TTC seems to have given serious consideration to development of Scarborough and Eglinton Crosstown lines using ALRT or similar "light metro" technology. This technology has been applied very successfully in more than 20 cities around the world.[89] Some architects and urban designers prefer surface LRT, because it is less visually intrusive, and can run in mixed traffic and pedestrian environments, albeit at much lower speeds. But faster services on exclusive rights-of-way are far more effective, and efficient, at getting motorists to switch to transit.

The Toronto LRT schemes could be greatly improved by building them with fully exclusive rights of way, perhaps automated ALRT or similarly technology. Ridership would be much higher, as would the benefits to the region. And the costs could actually be less.

Metrolinx could begin by negotiating with Bombardier to supply ALRT cars, as are being built for Vancouver, in place of the 182 Flexity Freedom low-floor LRT cars. To the best of our knowledge, Bombardier has not actually started building these cars.[90] Currently it is building the Flexity Outlook cars for Toronto's streetcar lines. The first Flexity Freedom is not due to be delivered for at least three years.

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[88] Source: Toronto Star, http://www.thestar.com/news/gta/crosstown/crosstown-graphic.html

[89] Completely driverless metro or light rail systems now operate in Barcelona, Brescia, Copenhagen, Dubai, Hiroshima, Kuala Lumpur, Las Vegas, Lausanne, Lille, London, Lyon, Manila, Milan, New York, Nuremberg, Osaka, Paris, Rennes, Sao Paulo, Singapore, Tokyo, Toulouse, and Turin. There are also driverless systems at many airports. See Wikipedia http://en.wikipedia.org/wiki/List_of_driverless_trains

[90] Confidential discussion with Bombardier senior manager, May 2013.

ALRT cars are smaller than Flexity cars, but also cheaper. Metrolinx should be able to order at least 182 ALRT cars from Bombardier, for the same price. Toronto is a key customer of Bombardier and, although the negotiation may not be easy, Metrolinx should be able to get a reasonable deal.

ALRT Mark 3 cars have a top speed of 100km/h, compared with 80km/h for the Flexity LRT.[91] With the short, 0.7-km average station spacing currently planned along Eglinton, there is little point in being able to run faster, but with wider station spacing, the time saving is significant. On a line like Eglinton, which will eventually have about 20 stations, the total saving would be about 5 minutes, for an end-to-end trip. While power costs are higher to run faster, passenger numbers and revenues would also be higher. Also, with faster trips, fewer trains are required to provide the same capacity; with 2-minute headways, saving 5 minutes from the one-way trip time means 10 fewer trains will be required to operate the service. As the line is extended eventually to the Airport and into Mississauga, faster running speeds would bring a substantial benefit.

If Bombardier refuses to negotiate a change to ALRT technology at a reasonable price, Metrolinx should be prepared to cancel the contract and invite new competitive bids, even if it means paying substantial cancellation penalties. There is no point burdening Toronto for the next century with the wrong system.

Operating costs for ALRT would be substantially higher, perhaps twice as high as the existing line or the Transit City LRT, because TTC will be operating 6-car trains in place of 2-car RT or LRT cars. Unless frequent service is maintained, ridership would actually fall from current levels.

7.5.2 Ways to improve the Eglinton Crosstown scheme

There are five main ways to make the Eglinton Crosstown scheme better, reducing costs while increasing ridership, revenues, and benefits:

1. Reduce the number of intermediate stations, to reduce capital and operating costs, offer faster journey times that will attract more new riders, and reduce disruption in surrounding communities. There should be a maximum of 10 stations on the 11-km underground section. The Avenue Road, Chaplin, and Oakwood stations could be omitted. Laird Drive station can be deferred, and built if and when a developer makes a substantial capital contribution to the station. Capital cost savings would be about $600 million, with a further savings of $1 million per year O&M costs per station.
2. Use high-floor cars with a top speed of 100km/h, such as the ALRT Mark 3 being supplied to Vancouver, instead of the 80 km/h low-floor cars TTC has specified. Besides saving staff costs, the higher speeds and faster journey will attract additional riders. Note that, as on the subway and existing RT, high-floor ALRT cars stop at high platform stations and will therefore be fully accessible.[92]
3. Grade-separate the entire line, so trains will not affect road traffic and will offer faster journeys for transit riders. East of Laird Drive and west of Weston Road, Eglinton is a wide street with plenty of space to build an elevated line without harming the environment. This would add about $800 million to project costs, or perhaps $100 million per km, compared with the surface line that is currently planned. Road traffic disruption will be greatly reduced and there will be little or no permanent loss of road space.

[91] This is an evolution of the original RT cars supplied to Toronto and Vancouver, and the Mark 2 version currently operating in Vancouver, Kuala Lumpur, New York (JFK), Beijing, and Yongin.

[92] For example, Calgary, San Diego, Manchester, and other cities combine high-floor cars with high platforms on surface routes, thereby ensuring accessibility for those with wheelchairs, walkers, or strollers.

4. Automate the trains. With an entirely grade-separated line, trains can be automated, with large operating cost savings and the ability to offer more frequent off-peak services.
5. Build shorter platforms to reduce station costs. Current plans show 150-metre platforms, similar to the subway. Savings of about $10 million per underground station, or about $100 million could be captured by building 60-metre platforms, sufficient for all foreseeable traffic.

Overall, average trips times (including wait times) would be reduced about 25%, and we would therefore expect ridership to be about 25% higher with these improvements. Trips will be faster, both because trains run faster and stop less frequently, and are not delayed in traffic. They will also run more frequently, with shorter waiting times, especially at off-peak hours.

We estimate passenger benefits of $2.50 per trip, as the time savings for many passengers will be about 5 minutes more than with the surface LRT scheme. Road user benefits should also be higher, perhaps $5.00 per new rider, as faster service should attract more inter-regional trips that would otherwise be made by car.

Altogether, these changes would bring the Benefit:Cost ratio to 0.94. Construction of the tunnels is, of course, already under way. This analysis suggests that, with the changes we suggest, the line might just about be worth the costs.

Our estimates for these improvements are summarized in Table A10 in the Appendix.

7.5.3 Consider BRT for Finch West

At present, there appears to be no reasonable economic case for building the Sheppard East or Finch West LRTs. In Section 11 we suggest an alternative way to serve the Sheppard East corridor.

For the Finch West corridor, we think it would be worth considering whether an extension of the existing 3-km BRT line from Dufferin to York University, in the hydro corridor, might give similar benefits at a far lower capital cost. If either the TTC or Metrolinx has evaluated this alternative, neither has made the results public.

In the Environmental Project Report,[93] there is a brief consideration of BRT. The report states LRT is chosen because although "the capital costs of…BRT are lower than for LRT, roughly $10 million per km in contrast to approximately $40 million per km for LRT … ongoing maintenance costs … for LRT is anticipated to be cheaper than BRT." There is no consideration of whether the maintenance cost difference can offset the large capital cost. By comparison, Mississauga also considered an LRT for the Dundas route, but decided that BRT offered better value for money.

Even if LRT turns out to be preferable to BRT on a stand-alone basis, we think there is a good argument for deferring the Finch West scheme until a decision has been made about whether and how to integrate the Sheppard Subway and any extension east to Scarborough. If this could be done with ALRT technology, then it might be sensible to anticipate construction of the "missing link" from Yonge/Sheppard to connect with the Finch Line at the Finch/Spadina station. Before building another line that might end up as an "orphan," it would be worth investigating whether a coherent integrated plan can be implemented.

[93] http://lrt.daxack.ca/blog/presentations/FinchWestReport/chapter_2.pdf, p. 2-2.

7.6 The Scarborough Wye

We have identified a way to extend the Scarborough RT and connect it into the Sheppard Subway. Further details are explained in in Section 11.

7.7 Is it too late to change course?

After reviewing this report, Metrolinx staff told us that they had been reluctant to challenge the Transit City schemes because these projects already had strong political support when the organization was created in 2007. They argued against re-opening design issues relating to the Eglinton Crosstown, for which some contracts have been awarded, fearing the result might be complete cancellation of the project. We disagree. Over the past half-century, Toronto has built three expensive rail lines (Spadina, Scarborough, Sheppard) that have attracted few new riders and had little impact on road congestion. After each scheme was completed, Toronto lost its appetite for new rail investment for a decade. If $5 billion is spent building an Eglinton LRT that is slow and attracts few new riders, the same thing could happen again. Metrolinx's own BCA for the Eglinton Crosstown, which has finally been released, shows that a fully grade-separated line is likely to give a far better return on investment. Metrolinx needs to adhere to its own guiding principles, and insist that money is spent "where it matters most."

Metrolinx managers were also cautious about considering the "Scarborough Wye" proposal (see Chapter 11 in this report), fearing that yet another proposal could "cloud the debate" over subway and LRT options. If the debate is "cloudy," it is because policy makers have not been presented with coherent and consistent information, or attractive choices. We think the "Scarborough Wye" is worthy of investigation, with the potential to give greater benefits at lower costs than either the subway or LRT schemes. Metrolinx needs to consider all promising solutions to the need to extend transit into Scarborough.

8

905 REGION BRT AND LRT SCHEMES

Our evaluation of the 905 region BRT and LRT schemes is based mostly on the Metrolinx Benefits Case Analyses. These are generally concise and credible, although as with the Transit City schemes, most do not explicitly state the new daily ridership that will be generated. We use Metrolinx's estimates for costs, revenues, and benefits, and our own estimates of new riders, to calculate the net financial cost per new rider. Our estimates are summarized in Table A11 in the Appendix.

8.1 Mississauga Hurontario/Main LRT and Dundas BRT Schemes

The Mississauga Hurontario/Main Street LRT and Mississauga Dundas Street BRT schemes both appear to offer good value for money, with Benefit:Cost ratios above 1.5, and a cost per new transit rider of about $20,000. Together, they cost about one-quarter as much as the Eglinton Crosstown LRT, yet they seem likely to attract almost as many new transit riders.

The Hurontario/Main Street LRT will link the centres of Mississauga, Brampton, and Port Credit, and connect with three GO stations. This scheme has the potential to encourage development of transit-related land uses along the corridor. Apparently for funding reasons, the line will be built in phases and the link south to the Lakeshore completed sometime after 2020.

Four options are presented in the Metrolinx BCA for the Mississauga Dundas Street BRT. Two show the same, attractive 1.7 Benefit:Cost ratio. Option 4, the more ambitious scheme, delivers about twice the absolute level of Net Benefits and appears to be the scheme that should be implemented. Given the relatively small costs compared with the Toronto schemes, we wonder if it might be possible to build these Mississauga BRT and LRT schemes sooner, to encourage transit-oriented development along the corridors.

8.2 Brampton, VIVA, 403, and Durham BRT Schemes

The cases for the Brampton Queen Street, VIVA Rapidways, 403, and Durham Scarborough schemes are not quite so strong, with Benefit:Cost ratios in the range of 0.7 to 1.1. However, as Metrolinx notes in its BCAs, these schemes are evaluated on the basis of a "fixed matrix," and assume no changes in land use patterns due to transport policies or investment.[94] With appropriate policies, the benefits of these schemes would likely outweigh the costs. Metrolinx should also be asked to re-evaluate the schemes using a "dynamic" model, assuming substantial but plausible changes to employment patterns due to the schemes.

It also seems some of the schemes were evaluated assuming the existing, fragmented fares system.[95] Schemes should be evaluated assuming integrated fares made possible by the implementation of PRESTO smart cards.

[94] This is noted on page 17 of the Metrolinx BCA for the VIVA Next scheme.

[95] See Durham-Scarborough BCA page 34, for example.

Benefits will be further increased if the GO rail system is upgraded into a regional metro with faster and more frequent services all day. It is not clear what improvements to GO services were assumed in the preparation of the Metrolinx BCAs.

Correcting for these factors is important, not only because the current BCAs probably substantially understate the benefits of schemes relative to alternative uses for Metrolinx's money, but also because it can affect the ranking of schemes from alternatives. For example, the Metrolinx BCA for the VIVA Next scheme suggests the Benefit:Cost ratio can be raised from 0.7 to 0.9 by deferring some of the expenditure. But if the benefits have been underestimated, deferral might reduce the net benefits. The case for Brampton Queen Street is similar. While the Benefit:Cost ratio of Option 1A is only 0.8, according to Metrolinx analyses, it has the potential to increase employment around transit stations by 126,700, compared with only 87,300 in Option 1B, which includes less investment and which Metrolinx seems to be favouring. Use of a dynamic model could easily push the Benefit:Cost ratio for Option 1A above 1.0. It also is important that policymakers understand that the objective should be to maximize Net Benefits, not the Benefit:Cost ratio.

9

THE IMPORTANCE OF INTEGRATION

One of the major objectives of establishing Metrolinx was to improve transit service coordination and integration across the GTHA. Compared with construction of new rail lines, integration of existing services can be done relatively quickly and at relatively low costs. Yet in the six years since it was established, Metrolinx has not yet succeeded in integrating the many transportation systems in the region.

An effective public transport system is a "network," and there are strong network synergies. Passenger numbers and benefits will be maximized if services are planned and coordinated so passengers can travel easily across jurisdictional boundaries. Services may be procured or delivered by different organizations, operating at national, provincial, regional or local levels, but there are large benefits if routes, timetables, fares, and information are coordinated.

In the 1950s, TTC was a world leader in this area, one of the first to offer an integrated fare (free transfer) between bus, streetcar, and subway modes. Since the 1970s, services across the region have developed in an uncoordinated way.

9.1 Why not have a single operator for the entire system?

Bigger is not always better. The GTHA transit system comprises hundreds of routes with thousands of staff, providing a wide range of services. While a single operator might achieve some economies of scale, experience with large organizations in the public sector suggests that smaller delivery organizations can be more accountable and more efficient.

Local bus services act as feeders for longer-distance trips, but many passengers will always be making local trips, to schools, shopping, and recreation. It makes sense for local government agencies, appointed by elected officials, to determine routes, stops, and service standards. Logically, each local municipality also provides operating subsidies, although a portion of these can be offset by a dedicated share of the provincial gas tax. Each operator seeks to serve the local residents who fund it, and will naturally be less interested in providing services to the wider region.

GO was created because no individual municipality had the incentives or the resources to operate inter-regional services. GO is a provincial agency that is currently managed by a board appointed directly by the provincial government. In the past, GO has been governed by a board representing the constituent local municipalities.

VIA Rail Canada and Greyhound mostly serve longer distance passengers but also carry small numbers of trips within the GTHA, for example, to and from Oshawa and Burlington. Various smaller companies also operate specialist public transit services within the GTHA, for example, the express bus linking Pearson Airport and downtown Toronto. These services are generally considered to be "commercial," with fares covering costs and even generating profits. VIA receives a subsidy from the federal government, but this is mostly required to support transcontinental and "remote" services.

The Province (through Metrolinx) and the federal government provide about half of capital subsidies for municipal transit services, and all funding for GO. Special funding was allocated for development of the Spadina subway extension to Vaughan.

Metrolinx was created in recognition that the fragmented structure was not working. For transit to attract more riders across the region, it requires greater funding, and better integration than the individual municipal operators would deliver. There is nothing wrong in principle with Toronto's two-tier structure, with Metrolinx concerned with regional issues and with each municipality operating local services. But Metrolinx has failed to use its powers to ensure that the local operations are coordinated to deliver regional benefits.

9.2 Integrating Routes and Services

All of the municipal operators provide some cross-boundary services. Several TTC bus routes extend into surrounding regions, while Brampton, Durham, Mississauga, and York operate services to TTC subway terminals and to major nearby destinations (mostly university campuses, hospitals and shopping centres).

Brampton and York regions have established their own special "brands" for their express services, Züm and VIVA. TTC has also introduced several express routes, some requiring payment of an extra fare. GO also provides express bus services on a network of routes.

There are many streets on which services overlap, and where passengers may be confused by the number of different operators, with different fares and timetables. In many cases, operating costs and passenger wait and journey times could be reduced if some routes were combined, or operated jointly by two operators. Metrolinx should be making this happen.

9.3 Integrating Information and Fares

There is no comprehensive, integrated information or on-line "journey planner" for the entire GTHA. There is also no comprehensive integrated fare system. If people cannot easily get information about how to make a multi-modal cross-boundary journey, and how much it will cost, they are likely to drive instead, if that option is available to them.

Timetables for most services can be found using Google Maps or other websites; however, they do not provide any fare information and do not always work effectively where there is a walk or interchange required. Some municipal operators have developed their own journey planners, offering more information; however, they do not include regional trips involving other operators.

Each of the regional systems operates its own fare system, usually with a flat fare allowing free or discounted transfer between buses or trains, but passengers using two or more systems usually need to purchase two or more fares. There are many integrated fares available, but the rules are complicated and are mostly useful for regular commuters. For example, the $55 weekly "GTA Pass" is valid on TTC, York, Brampton, and Mississauga transit, but not on GO or other regional systems. It can be purchased in person only, at a limited number of locations.

Metrolinx is introducing PRESTO, an electronic smartcard payment system. This will mean passengers do not need to stand in line to purchase tickets. It will also make it easier to offer multi-operator fares.

For example, a person who wants to travel from Square One in Mississauga to the Toronto Zoo can use Google Maps to determine that the trip can be made by various combinations of Mississauga Transit (MiWay), GO buses and trains, and TTC buses and subway. Journey time can range from 2 hours 5 minutes to almost 3 hours. The fare can range from about $10 to $20, but to determine this, the traveller would need to study the websites of all three operators, and would probably give up in confusion. Passengers travelling from, say, Scarborough Centre to Mimico must purchase separate fares if they want to use the faster GO train as well as the TTC, although TTC has now introduced a "TTC Times Two" policy which allows use of TTC, then GO, then TTC without requiring payment of a second TTC fare.

Features of an integrated fares system include:

- A single fare for a journey, even if it involves travel over two or more operators;
- Fares set at a level that are competitive with alternatives for most passengers, and which thereby maximize ridership and revenues, within public subsidy constraints, usually achieved with a zone fare system;
- Premium fares for higher quality and faster services (and, conversely, lower fares for passengers, who use only slower surface routes);
- Fares which help to manage demand, for example with lower fares for off-peak and non-radial trips;
- Easy payment, now usually achieved with a smartcard that can be "topped up" either at a machine or by direct bank or credit card payment;
- Regular fare adjustments in line with average incomes, to support continued system investment, renewals, and service improvement without increased subsidies and without the "shock" of large, less frequent fare increases.

For comparison, see the London regional journey planner at http://journeyplanner.tfl.gov.uk. This online service offers various public transport route choices at any time of the day between any two points across southeastern England. Origin and destination can be specified by street address, postcode, station, or other identified place. Information is current, reflecting any special service changes or suspensions, and is available on the web and on smartphones. Users can also specify whether they are seeking the fastest overall journey, fewest changes, or routes that do not require using stairs or escalators. They can even specify their own walking speed; on some complex routes, it is faster to walk rather than transfer to a bus or train for a part of the trip, and sometimes a very different route is then suggested.

The Transport for London (TfL) Journey Planner does not give fare information for each journey, but the website does provide comprehensive information which makes it fairly simple to calculate the fare for any journey. This is because TfL has implemented an integrated fares system. Passengers can use the Oyster smartcard for almost any journey across the network, changing between modes and operators without paying a separate fare. The fare is set for the total journey based on an easily understood zone system.[96] Short feeder bus trips to rail are, in effect, free to the user. Revenues are shared between bus, underground (subway), light rail and commuter rail operators, according to actual usage. While passengers can purchase daily, weekly, monthly, and annual passes for specific zones, the Oyster system automatically "caps" payments each day.

[96] The main exception is Heathrow Express, which charges a special (and much higher) fare. The Riverbus, Emiriates Skyride (cable car), and Kent High Speed trains can be used with Oyster but there are surcharges on top of the normal zonal fares.

Oyster users don't need to know the fare before they travel, because the system automatically gives them the benefit of the cheapest applicable fare, for each trip, up to the value of the day pass. TfL has used the capping system to manage crowding, and also to address social needs. Higher daily caps apply if the Oyster Card is used before 9:30 a.m., or in the central zone, or on rail services (including the Underground). By giving passengers a financial incentive to avoid travelling in the morning peak on the busiest parts of the network, TfL can reduce crowding and avoid spending money on additional trains that will be required only for one trip each day.

TTC seems to believe that fare integration inevitably means a loss of revenue.[97] We think this view is mistaken. While simply providing free transfer onto TTC from GO might result in a loss of revenue to TTC, international experience shows that a carefully designed integrated fare structure can increase overall system ridership and total revenues at the same time.

9.4 Integrating Land Use Planning and Transportation Planning

The effectiveness of the regional transit system depends critically on integration with regional development. In the 1960s and 1970s, Toronto had a successful policy of directing new office construction to locations served by the subway, while residential development, even in the suburbs, was configured to support reasonably efficient bus services. However, in the 1980s this policy was relaxed, and other policies (including zoning and taxes) encouraged office development to occur outside the city of Toronto, mostly in "industrial" areas with little or no transit service. Residential development has been allowed to sprawl across the countryside. Although the region now has a Greenbelt, it is quite far beyond the development frontier. While Toronto still has, generally, a reputation as a good place to live and work, Toronto's transportation crisis has been exacerbated by some misguided planning and fiscal policies.[98]

Many cities around the world integrate transportation planning and land use planning. In London, new office development has generally been directed into locations served by the regional rail system and parking provision is strictly controlled. In Vancouver, the Skytrain and commuter rail system have been developed explicitly to link together suburban employment nodes with each other and with downtown Vancouver. Suburban developments are planned for service by feeder buses. Copenhagen, Stockholm, Frankfurt, and Hong Kong are just a few of the other cities with policies that direct employment development to nodes on the regional rail system. The Toronto region can learn from these examples of integrating transportation and land use planning. At present, the two functions are carried out by different groups and there is little evidence of coordination.

[97] See "Integration of TTC and GO Fares – Update", TTC, November 18, 2013. http://ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2013/November_18/Reports/Integration_of_TTC_a.pdf

[98] See http://www.canurb.com/cui-publications/the-new-geography-of-office-location-and-the-consequences-of-business-as-usual-in-the-gta.html

10

FUNDING CONSIDERATIONS

It is a widely held view that all transit systems lose money, and that they all need public subsidies. This is not the case.

Many individual bus services are profitable, recovering their full capital and operating costs from fares. Most bus routes in Britain outside London are operated on a purely commercial basis, by private operators. There are also many routes in Germany developed and delivered by private operators under "route licenses." Germany's "market initiative" allows private operators to launch new routes, even within urban areas, if they see an opportunity to serve a market that is being neglected by municipal operators. Private operators even have the right to participate in integrated fares schemes, so passengers view them as a part of the wider public transport network.

Many suburban rail services in Britain and Japan recover their full operating costs, even paying for amortization and renewal of capital assets, including tracks and trains, and some even generate a profit for shareholders. Often, however, fares are held down by government policy, so that subsidy is required. Public transit operators are usually highly regulated, and profitable routes are used to cross-subsidize other routes and services. Even wholly private operators may be required to operate late-evening and weekend services where incremental revenues may not offset all incremental costs.

There is little doubt that with smarter fare policies, and more efficient operating practices (including changes to work and overtime rules for operating staff), the TTC and GO systems could recover all operating costs for existing services from fares and even generate a surplus that could go towards service improvements. Current operating subsidies may be supporting inefficient operating practices, rather than expanding services for passengers.

Nevertheless, it is true that very few subways (metros) can generate sufficient revenue to pay the massive costs of construction, maintenance, and renewal, especially of expensive tunnels and stations in urban areas. Almost inevitably, these systems require capital subsidies.

In 2005, Metrolinx received "committed" funding totalling $9.5 billion, mostly from the provincial and federal governments. Metrolinx now says it has projects under way costing $16 billion in total. It is seeking ways to raise another $2 billion per year, to sustain the current rate of capital expenditure of about $3.5 billion per year, and fund the $34 billion "Next Wave" schemes.[99]

Metrolinx has examined a wide range of "investment tools." It presented a proposed Investment Strategy on May 27, 2013.[100] In its proposals, it pointed to the experience of other cities in North America and Europe.

[99] The $34 billion cost is given in part 6.4.2 of the Metrolinx Investment Strategy.

[100] See http://www.metrolinx.com/en/regionalplanning/funding/investment_strategy.aspx

A full review of Metrolinx's Investment Strategy is beyond the scope of this review; however some points have particular relevance to the schemes in the Big Move.

"After thorough and exhaustive study and consultation," Metrolinx has recommended four options:

- A one percentage point increase to the Harmonized Sales Tax, which would raise an estimated $1.3 billion annually;
- A five-cent-per-litre increase on a GTHA basis to the Fuel and Gasoline Tax, which would raise an estimated $330 million annually;
- A Business Parking Levy on off-street, non-residential parking spaces based on relative market value, which would raise an estimated $350 million annually (apparently the charge would be about $0.25 per day);
- A share of the revenue raised from updated and amended development changes levied in the GTHA, which would raise an estimated $100 million annually.

Proposals to raise the gas tax, and to introduce a non-residential parking levy, will also help to encourage greater transit use. However the levels currently being discussed can be considered "introductory levels."

10.1 Gas taxes

The proposed gas tax increase will add about 4% to the price of gas. With a typical commuter vehicle requiring about 6 to 10 litres per 100 km,[101] this will add about $0.30 to the cost of a typical 30-km commute into downtown Toronto. The actual amount might be higher, for a longer commute in heavy traffic, or lower, with a hybrid car. The increased tax will have a small, although not trivial, impact. To the extent that most GO rail commuters can choose, at least in theory, between driving and taking the train, the $0.30 increase in gas tax is equivalent to $0.30 or about a 5% reduction in GO fares, and could generate a small increase in GO rail ridership.[102]

Gas taxes are much higher in some other jurisdictions. In Britain, regular gasoline (petrol) retails for about £1.40 per litre, equivalent to $2.20. Pre-tax costs are similar; the difference, about a dollar per litre compared with Ontario prices, is almost entirely extra taxes. Beginning in 1993, the U.K. Government pursued a policy of raising fuel taxes 3%, and then 5% per year in real terms. Although the "escalator" was formally abandoned in 2000, after protests from truckers, real increases have continued and prices have risen a further 17% in real terms.[103] While nobody likes taxes, the fuel tax is seen as an effective way of discouraging use of gas-guzzling cars, and encouraging the use of public transport.

Since, 1993, the population of Greater London has grown by 21%[104] and per capita incomes are now the highest in Europe,[105] yet car usage has declined by about 10%, from almost 26 billion to about 23 billion

[101] These are "city" figures from http://oee.nrcan.gc.ca/transportation/tools/fuelratings/FCG2013_e.pdf

[102] The Metrolinx model apparently assumes a 2% per year real increase in auto operating costs, from $0.50 per km in 2007 to $0.65 in 2021, and $0.79 in 2031. This is stated in the BCAs, usually in Appendix A, with other input variables and assumptions.

[103] See analysis by the Institute for Fiscal Studies http://www.ifs.org.uk/publications/5503

[104] UK Office of National Statistics data at http://data.london.gov.uk/datafiles/demographics/ons-mye-population-totals.xls

[105] According to Eurostat; see http://epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/1-21032013-AP/EN/1-21032013-AP-EN.PDF

vehicle-kilometres per year.[106] While London still suffers traffic congestion, it has actually become less severe in recent years, despite continued population growth and prosperity. The three graphs below tell the story.

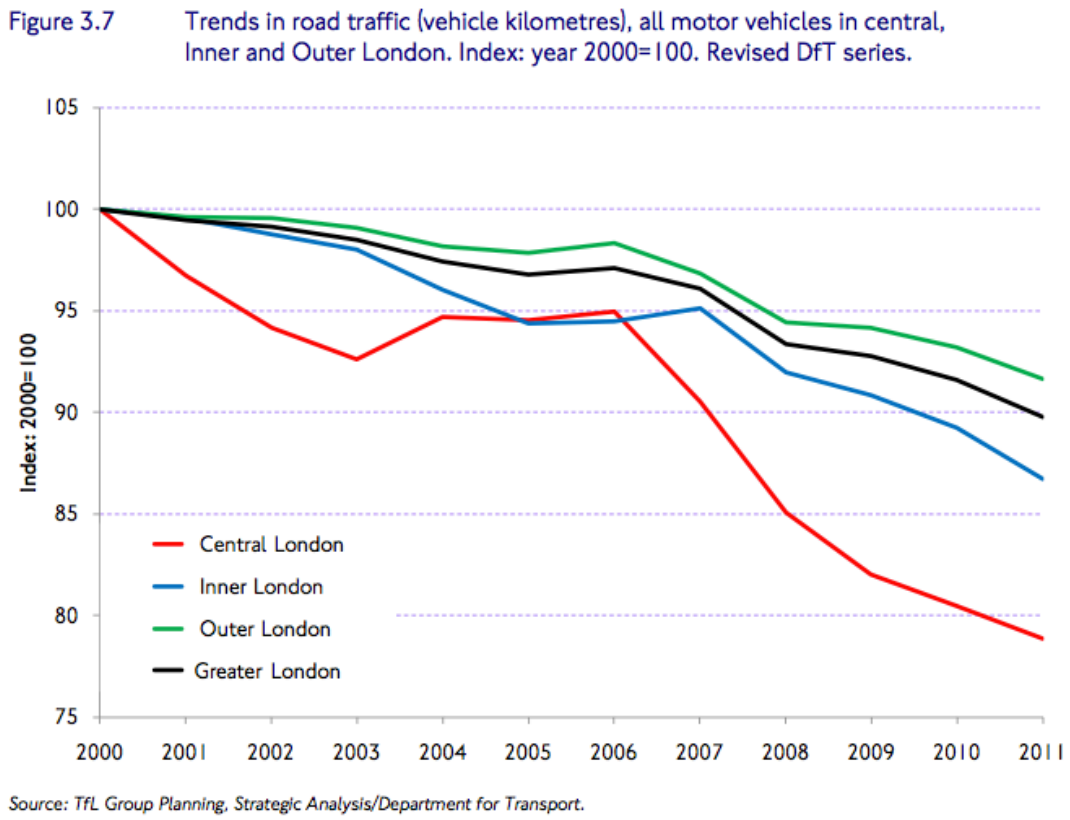

Figure 20: London's "congestion charge" attracts the most media attention. But the £10 ($15) charge applies only to a 5-km-square area in the city centre – in Toronto, this would be from St Clair to the Gardiner, between Bathurst and the DVP. Traffic in Central London has fallen about 20% since it was introduced. But traffic has fallen about 10% even in outer London, which is not affected by the charge, and despite the London population growing about 10% in the same period. The "carrot" is improved public transit, but the "stick," higher gasoline prices, seems to have been just as important.[107]

[106] For data on car mileage in Greater London see https://www.gov.uk/government/statistical-data-sets/tra89-traffic-by-local-authority

[107] Source: Transport for London Group Planning (p. 55). http://www.tfl.gov.uk/assets/downloads/corporate/travel-in-london-report-5.pdf

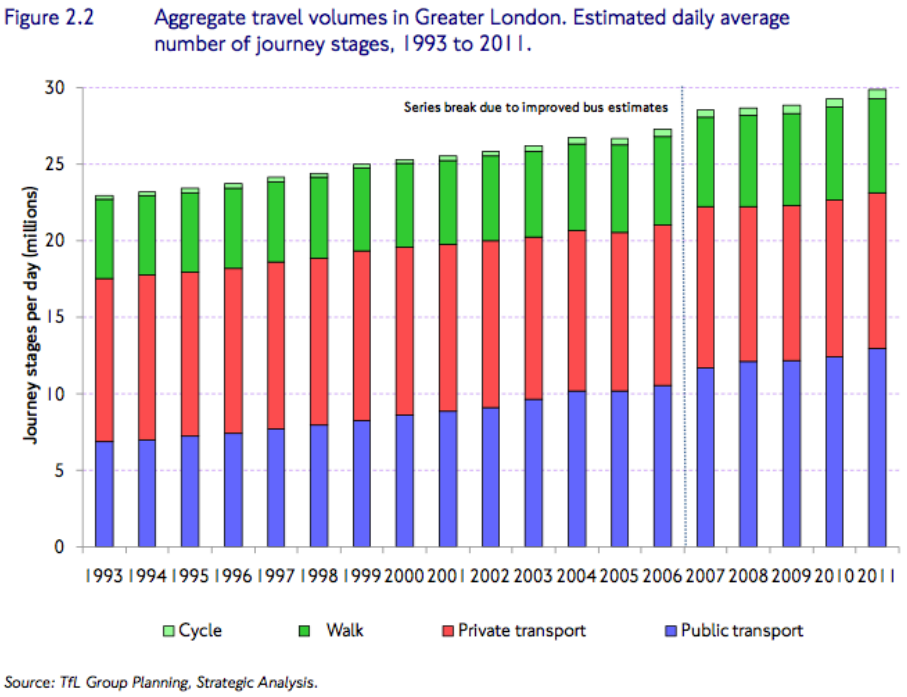

Figure 21: Total travel in London has increased about 25% since 1993, along with the population and prosperity. Public transport use has doubled, while private transport (mostly car) use has actually fallen. Regular increases in motor fuel taxes have been accompanied with improvements to public transport. Public transport fares have also been increased in real terms.[108]

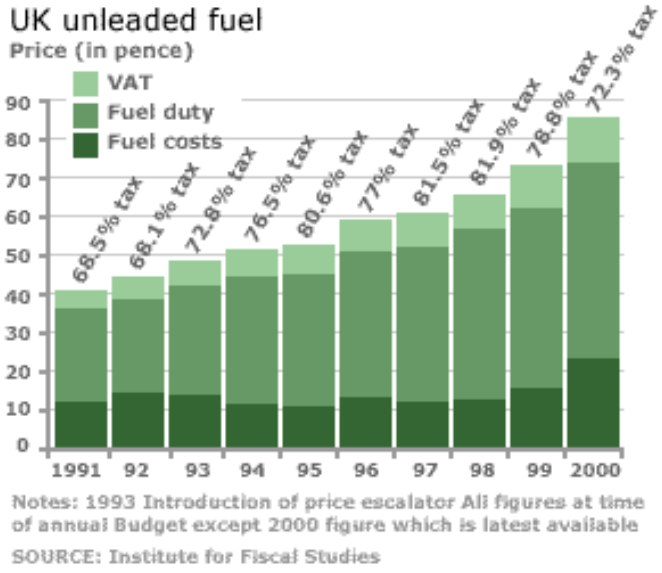

Figure 22: Since 1991, the UK has had a policy of raising fuel taxes each year.[109]

[108] Source: London Travel Report, Transport for London 2012 (p.41). http://www.tfl.gov.uk/assets/downloads/corporate/travel_in_london_report_2.pdf

[109] Source: BBC News, http://news.bbc.co.uk/1/hi/in_depth/uk/2000/pre_budget_report/988650.stm

The most expensive place in the world for gasoline is Norway, where the price is almost $3 per litre. The country is a rich oil-exporting nation, but has accepted that gasoline should be heavily taxed, for environmental reasons. Car ownership is high, but so is public transit use.

Before expending too much political capital raising the gas tax, however, consideration should be given to the alternative of mileage-based charging, as is now being tested in Oregon. A gas tax is simple to administer, but may become ineffective if hybrid and electric-powered vehicles become widespread. A per-mile charge, using smartphone technology, can also be varied depending by location and time of day. For example, driving after 10 p.m., or on local roads in areas without good transit, might be free of charge, while charges would be highest on downtown streets and expressways during peak hours.

10.2 Parking levies

Metrolinx has proposed a parking levy of about $0.25 per space per day. Details are not entirely clear, but it seems this would be across the GTHA and would be levied on property owners. This also should create a small but significant incentive towards using public transport. Even if employers and merchants do not immediately pass the cost on to staff or customers, it will certainly discourage provision of parking spaces.

Some European and Asian cities have introduced strict controls on parking provision. London has strictly controlled the provision of non-residential parking in the central area since about 1963. While suburban retailers usually provide free parking to customers, it is tightly controlled and usually time-limited. More recently, the London Government has also restricted the provision of residential parking, sometimes allowing less than one parking space per apartment.

10.3 Other "investment tools"

The increase in Harmonized Sales Tax, as proposed by Metrolinx, will raise the lion's share of the money. Unlike the gas tax and parking levy, it will do nothing to encourage transit use or discourage driving. Indeed, it will have a small but significant adverse impact on GTHA retailers, and will encourage more purchases to be made in ways that avoid the tax. U.S. retailers are already advertising their lower sales taxes on Toronto radio stations.

The increase in the HST is likely to be controversial. Before going ahead with such a move, Metrolinx needs to be able to demonstrate that transit operators are already making good use of the money they are spending now, and that transit users are making a reasonable contribution to the cost of the services. This is not the case.

Although there is brief mention of service and fare integration,[110] there is no recognition of the potential of using smarter fares to raise higher revenues while encouraging additional ridership. There is also no discussion of operational efficiency. GO and TTC lose money in part because of inefficient operating practices. These issues are discussed below.

[110] See Metrolinx Investment Strategy, part 6.32.

10.4 Revenues: Smart Pricing and Charging for Parking

The purpose of fares is to help pay the cost of providing the best possible transit system, recognizing that there will always be limits to government funding. Current fare policies do not always achieve this objective.

TTC and most regional operators have flat-fare systems that have changed little over the years. Historically, they were set at a level that recovered costs. This approach worked fairly well when ridership was "captive," but as transit began to face competition from the car, governments began to pay subsidies, assuming that reduced fares would attract more riders and thereby reduce road congestion. Some cities even experimented with free transit.

However, simply subsidizing fares, especially with a flat-fare system, is a relatively ineffective way to encourage increased ridership. The main beneficiary of fare subsidies seems to be existing transit riders. New riders are attracted to transit by better *services*, not lower fares. Motorists will not get out of their cars even if transit is free unless the service is also comfortable, fast, and convenient to use.

Toronto began subsidizing TTC operations in the early 1970s, shortly after the decision not to build more radial expressways. At the same time, the zone-fare system was abolished. The effect was a one-off increase in ridership. However, financial pressures eventually precluded service expansion.

The introduction of operating subsidies coincided with the last period of subway expansion. TTC subsidies cost the government $450 million in 2011.[111] Even in the 1970s, TTC argued that low fares might not be a good policy. Higher fares might deter a few riders, but if they funded better services, they might attract even more new riders.

More complex fare structures can attract more riders, while raising more money to fund further service improvements. Many cities operate zone fare systems, as Toronto did until 1971. Zone fares more closely match transit prices to the cost of alternative modes. While fares for longer trips may be higher, fares for shorter trips can be lower. Some cities, including London, England, and Washington, D.C., offer lower off-peak fares, an approach that encourages travel outside peak hours.

With a zone fare system and some differential for peak and off-peak prices, TTC might be able to recover all its operating costs from fares, while attracting more riders. The current operating subsidy of about $450 million could instead fund service improvements and further capital investments.

10.4.1 Using PRESTO to boost TTC revenues

Currently TTC charges $3 adult cash fare per ride (less for those who buy several tokens or tickets at a time), with free transfers between bus, streetcar, and rail on a single journey. GO charges $5 to $7 for rail trips within Toronto. There is no variation by time of day or direction, and no daily cap on the amount that riders can pay. A commuter from Scarborough to the University of Toronto could pay $20 per day using TTC and GO, even if the trip is taken at midday. The trip could also be made for $3 each way entirely on TTC, but might take 2 hours or more. No wonder so many people drive, especially for off-peak and short trips.

[111] TTC Annual Report 2011.

Backgrounder: Smart Pricing on London's Transit System

Over the past 30 years, Transport for London has gradually introduced a fares system that attracts more riders, while also generating higher revenues. This reduces dependence on subsidy, or (alternatively) raises more funds for service improvements. TfL's system includes the following features:

- Single-trip fares are high and are paid mostly by occasional riders. Currently this is £4.50 on the underground (subway) if paid in cash, but varies from £2.10 to £3.00 ($3.30 to $4.80) with the Oyster smartcard depending on whether one, two, or three zones are crossed.
- The single bus fare is lower, £2.40 cash but reduced to £1.40 ($2.30) using the Oyster card.
- There is no free transfer with a single fare. Instead, the daily fare is "capped," with unlimited free travel after a certain number of trips each day. For travellers who use buses only, the cap is at £4.40 ($7.30) and similar to the price of two TTC tickets. So single bus fares are actually lower than in Toronto, and after the third bus trip, further bus trips are free.

For users of the rail system, the cap depends upon when they travel, and how many zones they cross. The daily cap for a passenger travelling in the peak, across 3 zones, is £11.00 ($18). This is more than the TTC day pass, currently $10.75, but less than a TTC day pass plus a return trip on GO from one of the stations within Toronto. Again, once the Oyster card hits the £11 cap, additional bus and rail trips are free, so regular commuters don't need to pay a full extra fare for a bus to and from their local station. And if they need to take a bus or streetcar at the other end to finish their trip, it is effectively free.

People who can avoid travelling before 9:30 a.m. have a lower cap of £8 ($13.30). And passengers who travel within only one or two zones, and do not travel before 930 a.m., have an even lower cap of £7.30 ($12).

Regular commuters can also buy a monthly or annual Travelcard, which brings the cost per weekday down to about £5 ($8), similar to two trips on the TTC, but in London this includes travel on the commuter rail system as well.

TfL also has a policy of raising fares each year 1% to 3% above the rate of inflation. The rationale is that passenger incomes rise above inflation, as do labour costs. Above-inflation increases give TfL the money to continue improving services, just as the quality of other goods and services rise.

TfL management believe their pricing strategies raise 10% to 20% more income, while also attracting 10% to 20% more riders.

TTC buses that cross the city boundary into York or Peel region charge a small fare supplement. TTC also sells one-day and monthly passes, but about 99% of riders pay the same amount, whether they are travelling 1 km on a half-empty streetcar, in the middle of the day, or commuting 50 km across the city in rush hour, squeezing onto crowded buses and subway trains.

Since 1970, TTC has been expected to recover about 70% of its operating costs from fares. Capital costs are funded separately, usually by grants from the City, Province, and occasionally the federal government. TTC's flat-fare system allows it to recover about 70% of annual costs. For many passengers, the flat fare is a

bargain. They pay $3 for a trip that they would willingly pay $5 or more to make. But many other passengers drive, because for short trips with free parking, the car is cheaper. And some trips are not made at all, because the $3 fare is too high, even though it may be far above the incremental cost to carry a passenger. Ideally, fares should be set to maximize system ridership, within the limits of public funding support.

TTC is joining the PRESTO Smartcard system, which will simplify travel that involves multiple operators, and reduce cash-handling costs.[112] However, until TTC implements a more sophisticated pricing structure, fares will still be too high for some trips, so potential riders will drive, and still too low for others, denying TTC of revenue it could use to improve services.

Revising the TTC fare structure is long overdue. Change may be unavoidable as the subway is extended across the city boundary into Vaughan. Many students who travel from places like Woodbridge and Brampton to York University, using the VIVA or Züm express buses, will instead be expected to transfer to the subway at the Vaughan Corporate centre and use the subway to finish their journey. This may save them a few minutes, and it will allow Züm and VIVA to save a substantial amount of money. However it will be deeply unpopular with travellers if it means they must pay a $3 extra fare each way. TTC's problem is that it has no way of distinguishing whether passengers boarding at Vaughan are travelling just to York University, or all the way into downtown Toronto.

A more intelligent fare system for Toronto might copy that of London, which has a system of radial zones, with a premium for use of faster modes (commuter rail and subway) (but not a full additional fare), and with reductions for off-peak travel.

To introduce "smart pricing," TTC would need to introduce "touch out" points at station exits, just as GO now does at rail stations. We do not know the details of the PRESTO contract, but extending the features used on GO to the TTC system should be a priority, and the payback would be relatively rapid. Assuming, very conservatively, that TTC generates 5% more revenues, the additional income would be about $50 million per year or $1.15 billion NPV. It should also generate at least 5% more riders, or about 50,000 more per day, bringing the same again for total revenue uplift to $2.3 billion NPV.

For example, Züm passengers boarding the subway at Vaughan would have $3 in their card PRESTO put into "escrow"; most or all of this would be returned when they "touch out" at York University. Züm would share some of its revenue with TTC for these trips. Similarly, passengers boarding at York would have $3 put into "escrow"; most of this amount would go Züm if the passengers travel into Bramalea.

There will also be significant road user benefits. Many TTC passengers would use PRESTO to make fairly short trips (because those are the trips for which the current fares are, at present, too high). If 50% of the 100,000 new daily riders are attracted off the road system, and assuming a benefit to other road users of $1 per car (1/20th of the rate used for the GO Electrification Study for new GO rail trips), the benefit is $15 million per year or about $345 million NPV.

Smart pricing should be a very effective way to achieve the Metrolinx objectives. Many passengers will pay lower fares, in total. And it will actually raise more money.

[112] It will also end the annual "token famine" when passengers hoard tokens in anticipation of a fare increase.

10.4.2 Peak pricing on the GO system

GO Transit operates a distance-based fare system, achieving more than 80% recovery of operating costs. However, it has no peak/off-peak fare differential and limited integration with TTC fares. A slightly higher peak fare, and an offsetting reduction in the off-peak fare would encourage some people to change their travel patterns.

GO's biggest capital cost is rolling stock, which must be purchased to carry peak demand. Peak fares can "flatten" the peak, saving millions of dollars. Peak riders are mostly "captive": driving is not an attractive option, usually because of traffic congestion and the high cost of parking in downtown. Off-peak passengers are more price-sensitive. Lower off-peak fares can attract more new riders than the higher peak fares would deter.

10.4.3 Charging for parking at GO stations

GO currently provides free, all-day parking at most stations.[113] Most GO rail passengers drive to their station, and free parking is part of the GO transit "offer." If GO were to charge for parking, it would be equivalent to a fare increase for most riders. However, some passengers do not drive: they use feeder buses, they are driven (or share a car), and some even walk. They do not benefit from the free parking. Parking is now fully used at many stations, and GO is building multi-storey car parks at several stations, at considerable expense. At some stations, parking may be scarce or unavailable during the day, deterring casual or off-peak use of the system.

By comparison, TTC charges for parking. Prices vary depending on the location and the time of day. For example, at Kennedy the price is $5 a day, reduced to $2 from 3 p.m. onwards. The all-day price at the east lot, further from the subway (but actually closer to the GO platform) is $4. These charges seem to make sense.

GO has more than 60,000 parking spaces. It would seem that GO could increase both transit ridership and revenues, by:

- Reducing peak fares (arriving in downtown before 9:30 a.m.) by $0.50 (about 10%) and off-peak fares by $1 (about 20%);
- Charging $3 per day for car parking, reduced to about $2 after 3 p.m.

Existing riders who drive alone would pay $2 more per day, net, about a 17% increase on a typical $12 return fare. Assuming there are 50,000 riders in this group, GO would increase its revenues $25 million per year.

Peak riders who use transit, walk, or car-share to go to the station would pay $1 less per day. Riders who can shift their trips outside peak hours would save even more. Total ridership and revenues would both increase. GO would have more money to improve services. GO also might not need to buy so many additional trains to carry the peak-hour passengers.

[113] GO does offer reserved parking at many stations, for $80 per month. At some stations within the City of Toronto, GO does not provide parking. Parking may be offered by TTC, for example at Kennedy and Kipling.

10.5 Savings through service efficiency

Public transit is a big industry. Annual operating costs for the TTC are more than $1.5 billion per year, while GO's costs are about $500 million. Together with operators in the surrounding regions, total turnover probably approaches $3 billion per year. About two-thirds of this amount is recovered from fares, with the balance (about $1 billion) paid by local and provincial governments. The TTC's operating deficit is about $200 per year for every Toronto resident.

Capital spending has been erratic, less than $0.5 billion through decade to 2003, but rising sharply since then to almost $3.5 billion per year at present,[114] all of it provided by federal and provincial governments.

Clearly, if Metrolinx is to continue to spend money on such a scale, it needs to be able to demonstrate that it is getting the best value for it.

10.5.1 Operational efficiency

Many GO and TTC operating practices seem inefficient, at least in comparison with international best practices. Labour costs are high, comprising about two-thirds of operating costs. For example:

- TTC subway trains operate with two drivers, whereas normal practice in Western Europe since the 1980s has been single-person operation. Paris is gradually converting certain of its heavily used Metro (subway) lines to driverless operation. Vancouver's system is entirely driverless.
- GO Transit operates all trains with a three-person crew, including an engineer (driver), conductor (guard) and ticket inspector. In Europe it is common to operate commuter trains with a single driver, and with occasional inspection of tickets on trains and at stations.
- GO Transit achieves very low fleet utilization, with most trains making only a single trip morning and evening. GO has been slow to develop off-peak and contra-peak services that could increase fleet utilization.
- GO has one of the largest and most intensive diesel-operated commuter rail networks in the world, while other operators have discovered that, at this intensity of service, electrification makes financial sense. Electrification is probably 10 years overdue.
- While the TTC basic wage rate of about $30 per hour for a driver does not seem excessive for a stressful job requiring unsocial hours,[115] many operating staff earn considerably more from premiums for working evenings, weekends, and overtime. According to TTC records, more than 1,300 employees earned more than $100,000 per year,[116] including 196 operators (drivers) and 21 station collectors.[117] These figures include taxable benefits, but exclude the cost of pension benefits (which are substantial). Private sector transport operators, such as Megabus and Porter Airlines, pay staff a fixed hourly rate, with shift patterns set to match traffic requirements and without premiums for overtime, weekend or evening shifts.

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[114] According to the table on page 45 of the Metrolinx Investment Strategy.

[115] Salary and wage rates are from www.glassdoor.com and other sources on the web. See http://www.torontosun.com/2013/03/28/ttc-staff-making-100gs-hits-1395

[116] See http://www.citynews.ca/2011/03/31/over-1000-ttc-employees-made-more-than-100000-in-2010/. Under the Public Sector Salary Disclosure Act of 1996, TTC is required to disclose details of all employees with total taxable benefits exceeding $100,000 per year.

[117] In comparison, pilots on Porter, and Westjet are paid about $90,000 to $100,000, including overtime. Greyhound and Coach Canada bus drivers are paid much less, in the range of $40,000.

- Although TTC subway cars can operate as 2-car units, TTC runs 4-car trains all day on the Sheppard Subway, far in excess of required capacity.

Operating trains and buses may look simple and straightforward, but efficient operators find many ways to reduce costs, improve efficiency, and maximize output.

10.5.2 Commercial opportunities

GO and TTC also do not fully exploit commercial opportunities. They are constantly under pressure to add services, while keeping fares down. Expanding peak capacity is seldom profitable and requires increased capital expenditure. However, there are opportunities to add services or make capital investments to serve off-peak traffic, in ways that can actually make money.

The recent increase in off-peak services on the Lakeshore is one example. Another is service along Highway 401, from Pearson Airport to Yorkdale. Currently this service operates as part of an hourly route from Brampton to Scarborough. Looking at other cities with similar airport traffic, one would expect a more frequent service at least between Pearson and Yorkdale Subway Station to be worthwhile. In Montréal, the 747 bus now operates every 10 minutes from Dorval to Atwater. The minimum fare is $7, which includes a day pass, so it maximizes revenue from airport travellers while being affordable for airport workers.

10.6 Learning from other transit systems

10.6.1 Benchmarking

TTC and GO achieve high direct cost recovery in comparison with other North American operators,[118] but this comparison is misleading for several reasons. First, GO and TTC are relatively new operations, and do not have the legacy of 19th and early 20th century infrastructure that increases the costs of subway and commuter rail systems in New York, Philadelphia, and Boston.

Second, TTC and GO also benefit from a relatively favourable market environment, with a large and concentrated central business district, surrounded by relatively high-density residential neighbourhoods. In the United States, only New York, San Francisco, Chicago, Philadelphia, and Boston have comparable densities. Toronto has an efficient arterial road grid, good for bus services, but very limited radial expressway capacity and so very little competition for commuters into the city centre.[119] Toronto also has never suffered the problems of crime and racial segregation, which have certainly deterred transit use in most U.S. cities.

TTC does participate in "benchmarking" with metro operators in other countries, including London and European metros, but does not usually publish the findings. Many commuter rail and metro operators in those regions recover 100% of operating costs, and even pay part of capital renewal costs from fares. Of course, cost recovery also depends on fare revenue, and many cities have explicit policies of subsidizing fares.

[118] See Metrolinx Annual Report 2010, which states "Metrolinx cost recovery ratio compares favourably with those of other public transit authorities in Canada and the United States." Few US operators recover more than 50% of operating costs from fares.

[119] The Gardiner and Don Valley expressways together provide only six expressway lanes into downtown. In comparison, Boston has five radial expressways with about 20 lanes, and San Francisco has four expressways with 14 lanes into the city centre.

The City of Toronto does release some benchmarking comparisons of TTC and other Canadian municipal operators, as part of a wider municipal benchmarking program.[120] Toronto is at or near the top in many measures, including trips per person, but (as the report acknowledges), "population density can have a large impact on ridership," and with the largest population, and some of the highest densities, TTC should be able to do better than other cities.

Certainly TTC and GO management can point to efficiency improvements they have introduced over the years. They also have to operate within constraints imposed by political decision-makers, the physical environment, and Canadian law. The question is whether they could do better. The benchmarking shows that cost per vehicle hour is high, in comparison with other cities, but (as is pointed out) this is because TTC operates streetcars and subway trains, which are more expensive to operate than buses. So the comparison is fairly meaningless. The data might be useful if TTC could split out bus operations from other modes, but it does not do this.

The benchmarking does show that TTC unit costs have risen faster than inflation, and also faster than in other cities.

10.6.2 Outsourcing and Competitive Tendering

GO has outsourced the operation and maintenance of trains to Bombardier, but overall service features are still set by GO. By comparison, in Hong Kong, Stockholm, Shenzhen, and several French cities, companies compete to operate subway, light rail, and bus lines to which they bring commercial innovation as well as operating efficiency.

London began competitive tendering of bus services in 1988, experimenting with both gross cost and net cost contact models. Unit costs were reduced 15% to 25%, although the savings have subsequently been used to fund service improvements. Ridership has grown more than 50% since 1999.

In Western Europe, it is now accepted that only competitive tendering can establish that value for money is being achieved in delivery of public services. Competitive tendering imposes transparency, as well as relentless pressure for efficiency. A recent study for the U.K. Department for Transport concluded that competitive tendering of regional (commuter) rail services in Germany had brought cost savings of up to 40%.[121]

[120] See http://www.toronto.ca/legdocs/mmis/2013/ex/bgrd/backgroundfile-57525.pdf#page=348

[121] See Realising the Potential of GB Rail – Final Independent Report of the Rail Value for Money Study, https://www.gov.uk/government/publications/realising-the-potential-of-gb-rail

11

A SOLUTION TO THE SCARBOROUGH IMPASSE: THE SCARBOROUGH WYE

Although the main purpose of this report is to review the work done by Metrolinx, and point out some overlooked opportunities to improve net benefits for the proposed schemes, we would like to present one new idea to the ongoing debate of how best to provide improved transit to Scarborough.

We believe that the Scarborough RT and Sheppard Subway could be linked together into a single system using ALRT technology. With automated operation, this line could offer faster and more frequent services at a substantially lower cost and attract more new transit riders. With an entirely grade-separated right of way, ALRT will not compete for road space with cars. In effect, the Sheppard Subway would be extended to Scarborough Centre and Markham Road, with service also to Kennedy/Eglinton. The "Scarborough Wye" would feed directly into both the Yonge and Danforth subways, but also into a GO Regional Express Rail system at Kennedy and perhaps at a new station near Ellesmere and Midland.

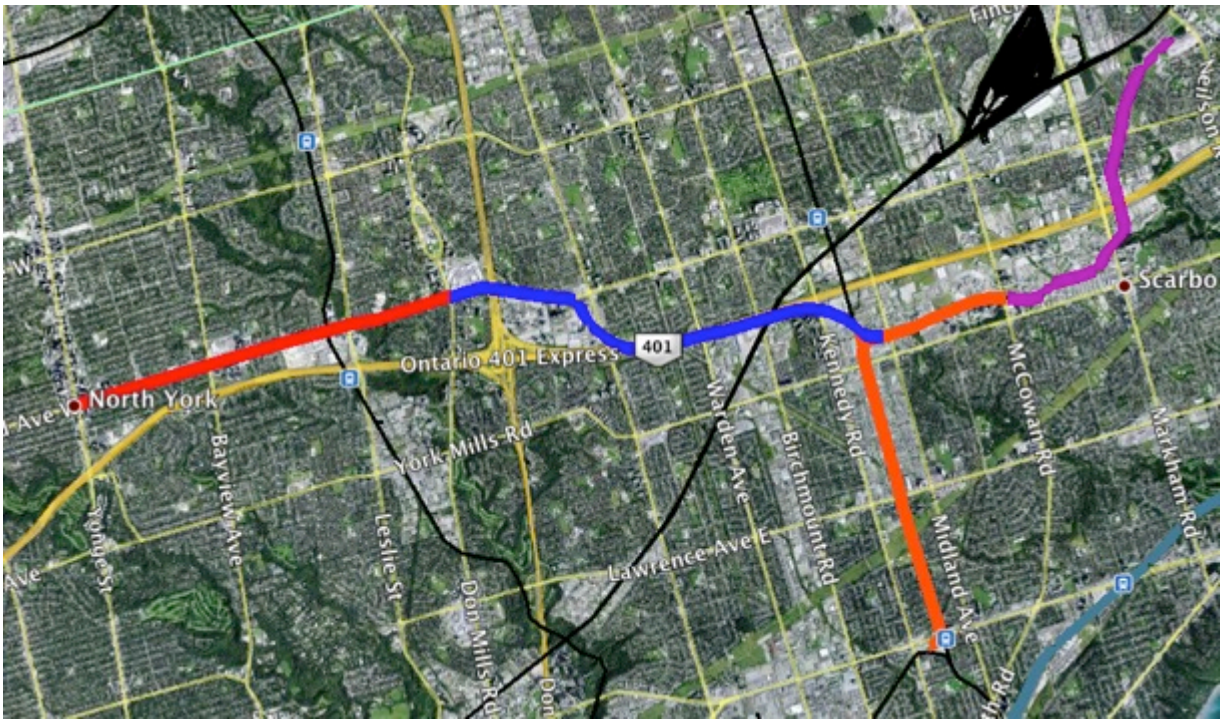

Figure 23: Proposed Scarborough "Y." Red is existing Sheppard Subway; Orange is existing Scarborough RT; Blue is proposed elevated link. Magenta is planned extension to Malvern Centre. Automated trains could run every few minutes between all three terminals.

11.1 The Route

The existing Sheppard Subway would be converted to ALRT technology. A new section of line 6.5 km long could be built linking it and the Scarborough RT, which can be upgraded and extended to Sheppard Avenue. The new line can be elevated, running mostly above Highway 401. There cannot be too many objections to the visual impacts of an elevated ALRT line built above a 14-lane freeway. This would be much less expensive than proposals to extend either the Bloor or Sheppard subways, while actually offering much greater benefits.

Three new stations would be built. One, at Victoria Park Avenue, would serve the Consumers Road area, which has major development potential. The second might be at Warden Avenue. A third would be at Kennedy Road where there is also development potential.

A junction could be built with the Scarborough RT between Midland and Kennedy, so that trains could run from Sheppard/Yonge to both Kennedy/Eglinton and to Malvern via Scarborough Centre. With automated, driverless trains, a high-frequency service can operate on all three routes over what we call a "Scarborough Wye."

Figure 24: Most of the Vancouver Skytrain network is elevated. This does not seem to have damaged Vancouver's reputation as one of the world's most beautiful cities. Transit passengers enjoy the view. The system has been extended several times, and now includes three lines, with 47 stations and a total length of 69 km. Ridership is almost 400,000 per day. It forms the backbone of Vancouver's public transit network. The Evergreen Line, an extension to the original Expo Line, is now under

construction. The construction cost of the 11-km line, mostly elevated with six stations, is $1.4 billion or about $127 million per km. Bombardier is supplying 28 "Mark 2" ALRT cars for $91 million or $3.25 million per car.[122]

Figure 25: The Airtrain to New York's JFK Airport, which uses the same Ontario-designed technology, runs high above the 6-lane Van Wyck expressway. The proposed link between the Sheppard Subway and Scarborough RT would run above 401, which is more than twice as wide.[123]

11.2 Costs

ALRT technology can be retrofitted into the Sheppard Subway much more cheaply than low-floor LRT. ALRT cars are high-floor, like subway cars, but with smaller wheels, so ALRT can be fitted inside the existing tunnels without major modifications. Costs should be in the order of $20 million per km, or $50 million to convert the line. We allow $100 million, including construction of a portal (ramp) exit east of Don Mills Road.[124]

This new line would be about half as long, and have fewer than half as many stations, as Vancouver's Evergreen Line. On this basis, it should be deliverable for about $700 million. We allow a further $200 million to refurbish the existing Scarborough RT for use by larger ALRT cars, including reconstruction of

[122] Photo Source: http://upload.wikimedia.org/wikipedia/commons/9/97/Canada_Line_Skytrain_Cars-2008-04-22.JPG

[123] Photo Source: http://static.panoramio.com/photos/large/882438.jpg

[124] Estimate based on survey of comparable projects.

the Kennedy terminal to provide better interchange with GO Rail as well as with the subway and Eglinton line.

Extending the line 3.5 km from McCowan to Sheppard is equivalent in scale to about one-third of Vancouver's Evergreen Line, and so should cost about $500 million.

Development of the Scarborough Wye would displace about 20 subway cars currently operating on the Sheppard Subway Line. These may have a use elsewhere on the system; however we assume, pessimistically, that they are scrapped. We also assume replacement of the entire Scarborough RT fleet.

Total cost to integrate the existing Sheppard and Scarborough lines and extend them through to Sheppard east of Markham would be about $1.8 billion NPV, or $2.3 billion NPV including incremental operating costs, about 15% more than it will cost just to convert the Scarborough RT to LRT technology and almost certainly less than the cost to extend the Bloor Danforth subway.

Our estimates of costs are summarized in Table A12 in the Appendix.

11.3 Ridership, Revenues, and Benefits

Without a network model, it is difficult to predict the ridership with great confidence. However, we can look at four distinct origin-destination pairs.

- Scarborough Centre – Sheppard Centre: TTC already attracts 10,000 daily riders onto the Scarborough Centre Rocket, which runs every 5 minutes weekdays, but is scheduled to take 29 minutes for the trip. Most passengers then change onto the Sheppard subway, taking about 45-50 minutes for the entire trip, including one transfer. ALRT would offer a single-ride trip, taking about 22 minutes with no transfer. With journey time halved, we would expect traffic to double, at least, with 10,000 new riders.
- Malvern/Sheppard East towards Yonge: TTC has estimated 55,000 daily riders on the Sheppard LRT, with 25,600 "new riders." Sheppard Avenue is mostly developed with uses that will not generate much walk-on ridership, so we assume most of this is transferring from north-south bus routes that can also feed the Malvern-Sheppard/Yonge ALRT route. Some passengers will have a slightly longer feeder bus trip, but the additional time should be offset entirely by a faster trip, and no transfer at Don Mills onto the subway.
- Extending the Scarborough RT to Sheppard/Morningside should attract the same 20,000 additional riders with ALRT, as forecast by TTC.
- Offering a direct service from Sheppard/Yonge to Kennedy/Eglinton, with a trip time of about 25 minutes, should generate new traffic. Currently this requires a 46-minute subway journey, via Bloor/Yonge. From Don Mills Station (Fairview Mall) to Kennedy takes even longer, about 50 minutes using the Scarborough Rocket bus and then the RT. We estimate that this might attract 15,000 new daily riders.

In total, therefore, we anticipate the Scarborough Wye would attract 70,600 new riders. Note that because the new ridership results from an integrated scheme, it cannot be specifically allocated to any of the four segments. Total ridership on the entire Wye might be 200,000 per day, with 80,000 on the Kennedy-Scarborough and 80,000 on the Sheppard/Yonge-Scarborough routes, and 40,000 on the Sheppard/Yonge-Kennedy route.

We assume that incremental ridership might double by 2033, as with the LRT schemes. We think this is probably conservative, given the faster service and wider range of journey opportunities that the ALRT network will offer.

Time savings will be substantial:

- The 10,000 passengers diverted off the Scarborough Centre Rocket will save 20 minutes, and have a more comfortable ride with no need to change. At $13 per hour, the benefit is $299 million NPV. Total benefits, including those to the 10,000 new riders attracted onto the serve from Scarborough Centre to Sheppard/Yonge, and the 15,000 new riders attracted onto the Sheppard/Yonge – Kennedy Service will be worth half as much, for a total of $675 million.
- About 70,000 or so existing and new riders will have faster and more comfortable trips, although the net benefit will vary and might be on average about 5 minutes. This implies a benefit of $1,047 million.

Total passenger benefits not captured through fares might total about $1.7 billion.

We assume the same road user benefit rate, $5 per new transit rider, about twice the rate for the Transit City LRT schemes. With higher speeds and much better connections to inter-regional services, many more of the new trips attracted by the scheme would otherwise be made by car on the regional road system. There will be no road user disbenefits, because the scheme will not take any existing road space.

11.4 Net benefits

The Benefit:Cost ratio of 2.90 (see the Appendix, Table A12) indicates a very good scheme, and the cost per new transit rider is only about $5,600. Moreover, the scheme can be implemented with less disruption than any of the current schemes. The Sheppard subway would need to be closed for a few months to modify track and signalling, but no major changes would be required to stations. There would be no need for an extended closure of the Scarborough RT, as the replacement terminal at Kennedy would be built on a different site. There would be much less disruption to traffic on Sheppard Avenue. The elevated line along 401 could be constructed mostly at night, so some overnight lane closures would be required as they are now when repaving work is under way.

This scheme could be described as a subway extension, as it would indeed be an extension of the Sheppard line and would offer the quality of service that is associated with a subway. Of course, if the Markham GO line is upgraded to offer a "metro" service, there may be no need to rebuild the Scarborough line south of Ellesmere. The Scarborough line could simply be joined into the Sheppard Subway, offering a direct "subway" from Sheppard-Yonge to Malvern via Scarborough Centre, with interchange to the Markham GO line at a new station east of Kennedy and north of Ellesmere Road. With travel times of about 30 minutes to Union Station, GO would offer much faster connections to downtown, and indeed through to emerging employment centres elsewhere in the GTHA, and at much lower cost than extending the subway.

12

CONCLUSIONS

We have analysed the projects that constitute *The Big Move* and reached the following conclusions.

First, the projects *as proposed* will not achieve the objective of doubling transit ridership. As currently defined, we estimate that by 2033 the Metrolinx schemes will attract only about 700,000 new daily riders. Growth in demand on existing routes will be about 600,000, bringing the total daily ridership up to about 3.4 million, 800,000 short of the Metrolinx target of 4.2 million. With 800,000 more daily trips being made by car, traffic congestion will worsen and average daily commute times will continue to rise.

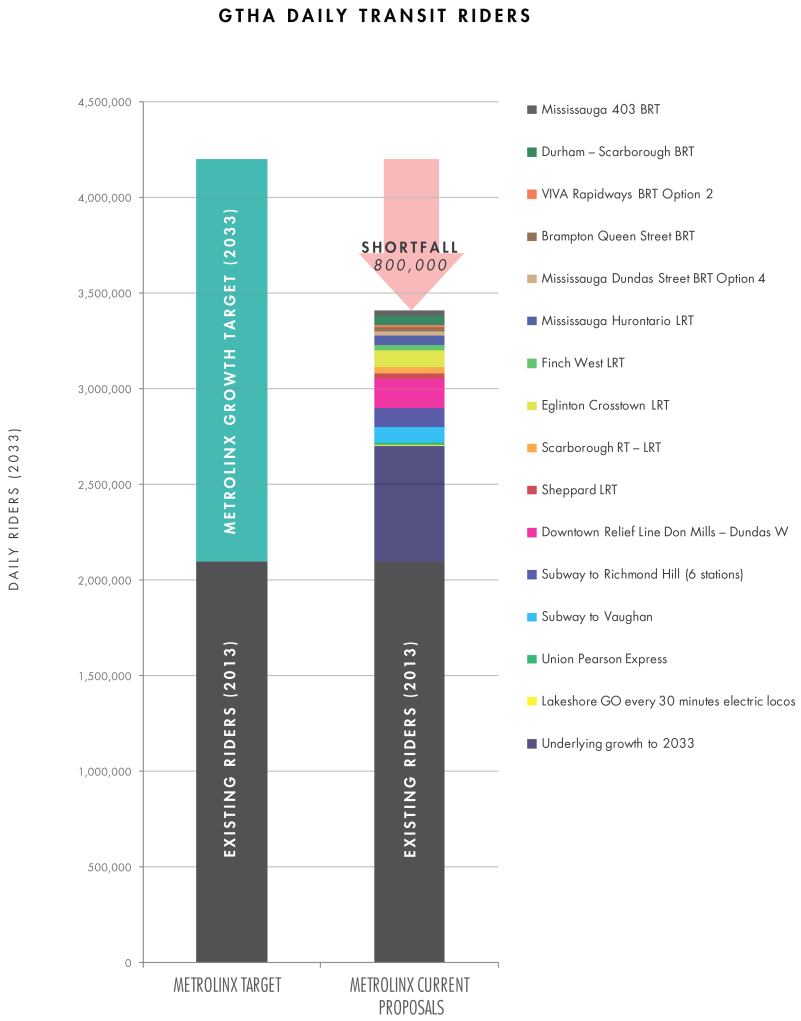

Figure 26: The current Metrolinx schemes will not deliver the target of doubling transit ridership.

Second, Metrolinx is not adhering to its own guiding principles. It is not investing "where it matters most." Most of its funds are going towards schemes with little or no regional focus, with costs in excess of benefits, which will deliver poor value for money. The schemes reflect the priorities of individual municipalities, but do not add up to an integrated plan to serve the region.

Metrolinx is not aggressively pursuing the most important scheme, the upgrading of GO Rail into a regional express rail network. Instead, it is focusing largely on secondary schemes that have strong local champions, but that will bring much less benefit without the regional rail backbone.

Nor is the organization living up to the principle of accountability. Metrolinx has not published a detailed financial plan, showing what it plans to build, how it will be paid for, and what this will deliver. "Benefit Case Analyses" have not been issued for some schemes. The BCAs that have been issued omit key information. The BCAs for the two most expensive schemes, the Eglinton Crosstown line and the Downtown Relief Line (DRL), were not made public until we obtained them for this report through a Freedom of Information request. In any case, Metrolinx seems to be ignoring their conclusions. The BCAs for the Transit City LRT schemes, including the Eglinton LRT, shows a very low Benefit:Cost ratio, yet Metrolinx is proceeding with the $5 billion Eglinton scheme, in contravention of its own principles of prudent financial management and accountability.

Third, despite these negative findings, there are many opportunities for Metrolinx to improve its schemes and spend its money effectively in a way that will benefit the residents of the region.

Unlike the Metrolinx BCAs, our analysis also considers ways to improve operating efficiencies, and to increase farebox revenues (while still maximizing ridership) rather than relying primarily on increased government funding. Well-designed schemes can repay more than 50% of capital costs, and in some cases, all capital costs, as well as incremental operating costs from fares, while maximizing transit ridership.

Although further work is required to confirm our estimates, our approach provides a sound basis to determine whether, under plausible assumptions, the schemes are likely to be worthwhile in economic terms, affordable, and otherwise consistent with the Metrolinx Guiding Principles. This is not the "last word" – much further study is required to confirm costs and benefits before any of the schemes can be funded and built. However, we have shown a way to start.

Key measures for the schemes as currently planned are presented the Appendix and in the table below. Costs are shown in red italics; savings, revenues, and benefits are show in blue roman. Schemes understood to be in the current Metrolinx program are shown in green. The same information is provided for a modified program.

We also present figures for a possible modified program, with inclusion of GO upgrading into Regional Express Rail, changes to the design of the Richmond Hill Subway and Eglinton Crosstown LRT, and replacement of the Scarborough LRT/Subway and Sheppard LRT schemes with the "Scarborough Wye." The 905-region LRT and BRT schemes are retained, but the Finch West BRT and DRL have been eliminated. Our analysis indicates capital costs can be reduced by about 20%, and the total funding requirement (net of revenues and operational savings) by about 62%, while generating about 43% more new transit riders than the current Metrolinx program.

After reviewing our report, Metrolinx staff noted that this analysis includes only current and "Next Wave" projects, and that further schemes are included in their "25 year Plan," appended as Schedules 1 and 2 to the 2008 *Big Move Regional Transportation Plan*. Metrolinx has, however, provided little information on these schemes, usually no more than the name of the scheme, an indication of the proposed mode, and a line on a large-scale map. Estimates of costs or ridership are not available, and do not seem to be included within Metrolinx's proposed $36-billion program. Therefore, we have not included them in this analysis.

Summary Data for Big Move Schemes (all figures are $ millions Net Present Value)

	Capital Cost $m NPV	O&M costs or savings $m NPV	Incremental revenues $m NPV	Funding Gap $m NPV	New Daily Riders 2033	Net Cost per new 2033 Rider	Net Benefits	Benefit: Cost Ratio
GO RAIL SCHEMES								
Lakeshore GO every 30 minutes electric locomotives	$-855	$418	$440	$2	6,925	nil	$482	2.10
Union Pearson Express	$-531	$-306	$1,511	$674	12,000	nil	$1,178	2.41
SUBWAY SCHEMES								
Subway to Vaughan	$-2,720	$-395	$1,380	$-1,735	80,000	$-21,688	$473	1.15
Subway to Richmond Hill (6 stations)	$-2,500	$-280	$1,725	$-1,055	100,000	$-10,550	$1,705	1.61
Downtown Relief Line Don Mills-Dundas W	$-8,620	$-1,075	$2,034	$-7,661	154,770	$-49,498	$-3,695	0.62
TRANSIT CITY SCHEMES								
Sheppard LRT	$-1,147	$-391	$190	$-1,348	27,500	$-49,027	$-696	0.55
Scarborough RT – LRT	$-1,127	$-253	$207	$-173	30,000	$-39,083	$-189	0.86
Eglinton Crosstown LRT	$-5,236	$-1,052	$607	$-5,680	88,000	$-64,549	$-3,383	0.46
Finch West LRT	$-1,084	$-304	$189	$-1,199	27,350	$-43,850	$-537	0.61
905 REGION BRT/LRT SCHEMES								
Mississauga Hurontario LRT Option 1	$-1,022	$-185	$105	$-1,102	51,120	$-21,557	$1,141	1.56
Mississauga Dundas Street BRT Option 4	$-369	$-97	$47	$-419	22,680	$-18,479	$656	1.76
Brampton Queen Street BRT Option 1A	$-523	$-221	$69	$-675	19,800	$-34,076	$-191	0.69
VIVA Rapidways BRT Option 2	$-1,509	$-263	$65	$-1,707	15,333	$-111,326	$-190	0.90
Durham - Scarborough BRT Option 1	$-366	$-78	$25	$-419	48,000	$-8,723	$54	0.57
Mississauga 403 BRT	$-259	$-55	$18	$-296	28,306	$-10,468		0.57
TOTAL Metrolinx current program	**$-27,868**	**$-4,537**	**$8,612**	**$-23,793**	**711,784**	**$-33,427**	**$-3,192**	

Summary Data for possible Modified Program (all figures are $ millions Net Present Value)

	Capital Cost $m NPV	O&M costs or savings $m NPV	Incre-mental revenues $m NPV	Funding Gap $m NPV	New Daily Riders 2033	Net Cost per new 2033 Rider	Net Benefits	Benefit: Cost Ratio
GO RAIL SCHEMES								
Lakeshore GO every 15 minutes EMUs	$-897	$502	$3,070	$2,675	63,755	nil	$6,502	17.47
Other GO routes every 15 minutes EMUs	$-2,015	$467	$3,070	$1,521	63,755	nil	$5,349	4.46
GO Relief services from Main/Danforth	$-100	$-32	$72	$-61	5,000	$-12,111	$114	1.86
Union Pearson Express	$-531	$-306	$1,511	$674	12,000	nil	$1,178	2.41
SUBWAY SCHEMES								
Subway modernization package	$-2,800	$-378	$962	$-1,108	200,000	$-5,540	$962	1.30
Subway to Vaughan	$-2,720	$-395	$1,380	$-1,735	80,000	$-21,688	$473	1.15
Subway to Richmond Hill (2 stations)	$-1,690	$-236	$1,553	$-374	90,000	$-4,150	$2,111	2.10
TRANSIT CITY SCHEMES								
Scarborough Y ALRT	$-1,920	$150	$974	$-796	141,200	$-5,639	$3,361	2.90
Eglinton Crosstown ALRT	$-5,588	$-856	$1,214	$-5,230	176,000	$-29,714	$-372	0.94
905 REGION BRT/LRT SCHEMES								
Mississauga Hurontario LRT Option 1	$-1,022	$-185	$105	$-1,102	51,120	$-21,557	$1,141	1.56
Mississauga Dundas Street BRT Option 4	$-369	$-97	$47	$-419	22,680	$-18,479	$656	1.76
Brampton Queen Street BRT Option 1A	$-523	$-221	$69	$-675	19,800	$-34,076	$-191	0.69
VIVA Rapidways BRT Option 2	$-1,509	$-263	$65	$-1,707	15,333	$-111,326	$-190	0.90
Durham-Scarborough BRT Option 1	$-366	$-78	$25	$-419	48,000	$-8,723	$54	0.57
Mississauga 403 BRT	$-259	$-55	$18	$-296	28,306	$-10,468		0.57
TOTAL modified program	$-22,309	$-1,984	$14,135	$-9,050	1,016,949	$-8,900	$21,147	
TOTAL MX Metrolinx current program	$-27,868	$-4,537	$8,612	$-23,793	711,784	$-33,427	$-3,192	
Improvement over Metrolinx program	20%	56%	64%	62%	43%			

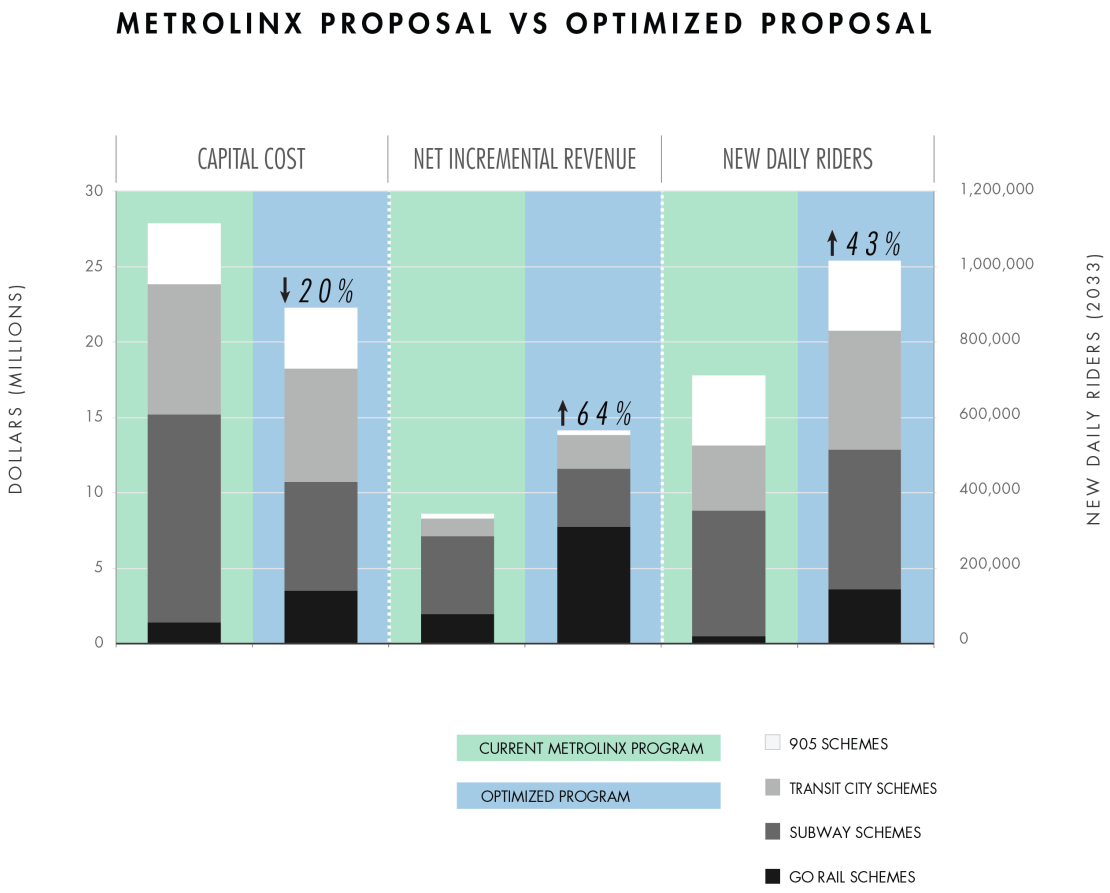

Figure 27: Optimizing the Program

12.1 GO Rail Schemes

Metrolinx's main priority should be upgrading the GO Rail system into a "regional metro," with frequent, fast, all-day services that would attract suburb-to-suburb, contra-peak and off-peak trips and support the development of higher-density development nodes throughout the region. This is to be the "backbone" of the regional transit system. It is the only scheme that can make a major impact on inter-regional traffic. Without it, the effectiveness of all other investments will be greatly reduced.

The Big Move in its original evaluation endorsed this vision, but Metrolinx has since failed to follow up, after a lukewarm evaluation by GO in the 2010 electrification study. GO's lack of enthusiasm seems due to a flawed study methodology and a misunderstanding of the financial implications of electrification. GO does not seem to understand how efficient electrified commuter rail services are operated, and how much revenue they can generate. Essentially, GO looked at operating the system much as it does today, but with electric locomotives replacing diesels. GO did not consider how to optimize its operations around the technology. Lacking an enthusiastic sponsor, this vital scheme was pushed aside for LRT schemes with much weaker business cases and which, without the GO Rail "backbone," will do little to transform travel in the GTHA.

Our analysis indicates that, using electric locomotives in the peaks, and smaller, self-propelled Electric Multiple Units (EMUs) to offer a frequent all-day service, the incremental investment of about $1 billion to electrify the Lakeshore line could be offset entirely with additional fare revenues and operational cost savings, in effect paying a commercial return as well as alleviating road congestion. This sort of "hybrid" operating strategy, with two different types of train operating on the same network, is common in Europe. Indeed, Metrolinx is already purchasing Diesel Multiple Units (DMUs) to operate the Union Pearson Express, interworking with push-pull GO trains. While a mixed fleet is more challenging for GO management to operate, the financial benefits will make it worthwhile. Electrification of the rest of the network will cost more, but promises similar benefits.

The Union Pearson Express scheme offers reasonable value for money and will help deliver the Metrolinx objectives. Indeed, UP Express will use the smaller "Multiple Unit" trains that GO did not consider for the rest of the network, and should recover most or all costs (including capital costs) from revenues. Although the financial return was not, apparently, strong enough to attract risk-averse private capital, it should be a good investment for Metrolinx.

Development of additional peak-hour GO services from Danforth/Main, Dundas West/Bloor, Kipling, and Kennedy could relieve the subway quickly and effectively, and at a small fraction of the cost of the proposed Downtown Relief Line. Services from Danforth/Main seem especially promising, and could be started even in advance of full GO electrification. The Downtown Relief Line should be deferred, and may prove not to be needed at all.

12.2 Toronto/TTC schemes

The Vaughan and Richmond Hill subway extension schemes give reasonable value for money. The costs of the Richmond Hill extension can be reduced, and the benefits increased, by building intermediate stations only if developers make major financial contributions.

The Toronto "Transit City" LRT schemes, as currently configured, give poor value for money and do not serve regional needs. They will swallow about two-thirds of Metrolinx's initial $11 billion, but will not attract many new riders onto transit or reduce average daily commute times at a reasonable cost. While advocates like to claim that LRT offers "the service of a subway for the price of a streetcar," the Eglinton Crosstown and Scarborough schemes will offer the service quality and speed of a streetcar, at costs that are not much less than for a full subway. Nor will they stimulate substantial higher-density development. Implementing them is not consistent with Metrolinx's principles of "regional focus" or "investing where it matters most."

Extending the Bloor-Danforth subway to Scarborough Centre, as currently supported by Toronto City Council, is also not an effective way to attract new inter-regional riders. The capital cost will be high, while journey times to downtown Toronto via the subway will still not be attractive. Commuters from northern and eastern Scarborough will still prefer to use GO rail for trips downtown, or will drive to jobs elsewhere in the GTHA (as most of them already do).

The Transit City schemes could be improved. We show, in concept, how Automated Light Rapid Transit (ALRT, or "Skytrain") technology, as pioneered in Vancouver and now operating in more than 20 other cities worldwide, could be used to integrate the Scarborough, Sheppard, and Eglinton schemes into a true Scarborough-Crosstown scheme that would act as an effective regional distributor, connecting directly into the Yonge Subway and the GO regional system. Although LRT cars have been ordered and the tunnels are

being dug, it is not too late to make changes. With faster trains and fewer stations, the case for the Eglinton Crosstown scheme can be substantially improved, although the Benefit:Cost ratio may still be less than 1.

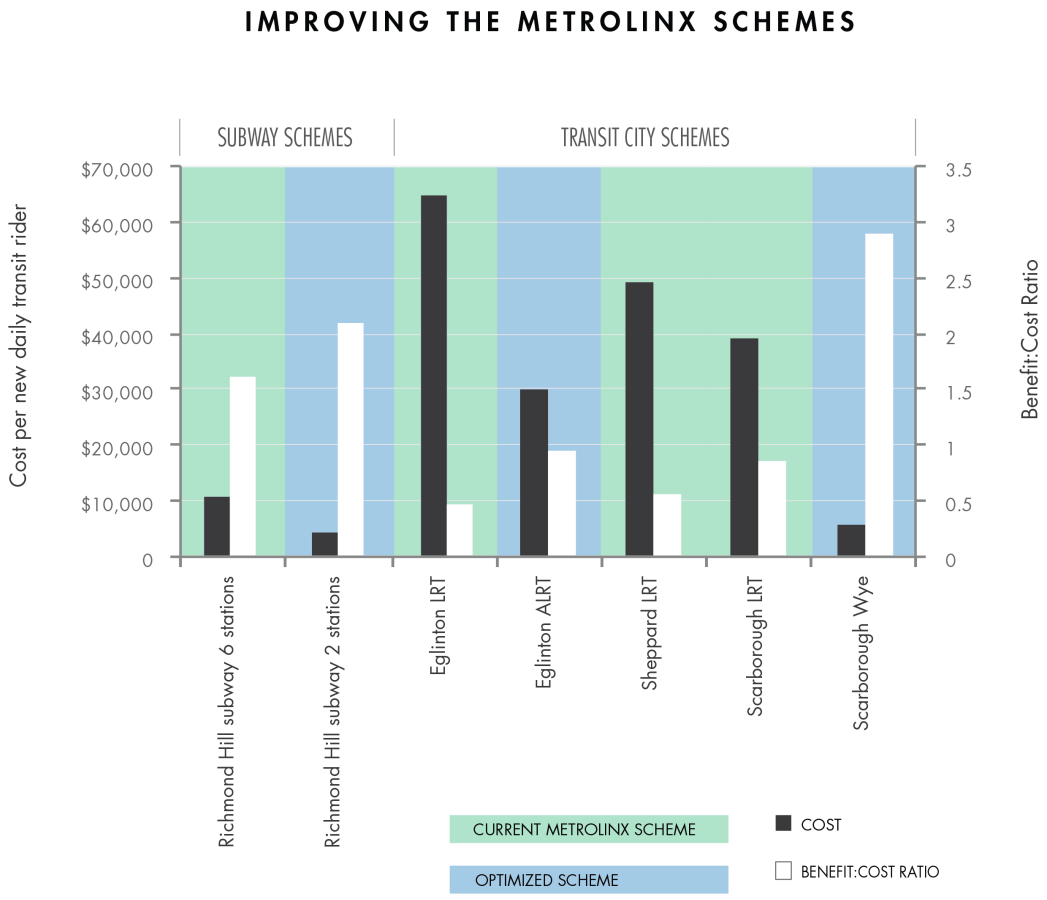

Figure 28 Performance of the Richmond Hill Subway, Eglinton-Crosstown, and Scarborough schemes can be improved with suggested modifications

12.3 Suburban ("905") schemes

Plans for expansion and upgrading of BRT services in the "905" regions, and for an LRT scheme in Mississauga, seem generally to offer reasonable value for money. In comparison with the Toronto LRT schemes, they are cheap. However, the schemes do not always seem to have been designed to address regional as well as local trips, feeding passengers onto the GO Rail system. It is also unclear why the Hurontario LRT and Dundas Street BRT schemes, which have Benefit:Cost ratios far superior to any of the TTC schemes, cannot proceed more quickly.

12.4 Making the System Work Better

The effectiveness of the "carrot" of improved transit can be multiplied if it is linked with a "stick." Metrolinx proposes to introduce parking levies and raise gas taxes to help to fund transit investment and deter car use. These are "win-win" fundraising tools; they encourage use of transit and help fund it at the same time. And those who remain on the roads will suffer less severe congestion. However, to be effective in reducing road congestion, the proposed levies and taxes need to be raised to levels several times higher than those Metrolinx is currently contemplating. London, England, is one of the few megacities that have actually reduced traffic congestion while sustaining economic growth and prosperity. While the central London charge attracts most media attention, it affects only a tiny proportion of journeys. Gas taxes and parking restrictions, combined with integrated fares and improved inter-regional transit, have reduced traffic throughout Greater London. The GTHA could achieve similar results with similar policies.

Raising taxes is never popular. It will require skill and commitment from policymakers to persuade voters that the proposed taxes are fair and necessary. Before asking for a regional sales tax, Metrolinx should make all transit operators demonstrate that they are as efficient as possible, consistent with international best practice. Currently they are not. Notably, TTC's practice of two-person train crews on subway trains and GO's practice of three-person train crews represent a considerable expense to the system and a deterrent to service improvement. Competitive tendering of bus and rail services, now standard practice across much of Western Europe, should be used to improve value for money. The government should be supporting improved transit services, not propping up inefficient operating practices.

Metrolinx should also look at fares as a tool to manage demand and attract off-peak and contra-peak riders. "Smart pricing," making full use of the capabilities of the PRESTO Smartcard system, could pay a significant share of the costs of schemes, while generating new ridership and raising revenues. GO should charge market rates for parking at stations, and raise peak-hour single-trip fares, but offer more discounts for journeys combining bus and rail. Simply using PRESTO as an electronic "purse" to charge discrete fixed fares does not make use of its full potential.

Benefit Case Analyses need to take account of operating costs and revenues and the potential for operating efficiencies. Metrolinx should set out key figures, such as the number of new daily riders each scheme is expected to attract, the average time savings for existing and new passengers using it, and whether incremental fare revenues will pay all incremental operating costs. Currently these figures are not disclosed or are unclear. For example, they quote only peak-hour ridership figures or only annual ridership figures. Commuting is a daily phenomenon, and ridership figures should be presented by the day, not the year.

Finally, transit and land use should be planned together. Regional decision-makers need to insist that new traffic-generating development is built where commuters can use higher-order transit. It is not enough to increase the zoning at designated development nodes. Major development should be permitted only within walking distance of a rail station or where the developer can show that a high proportion of trips will be made by transit. Parking provision should be strictly controlled, because each new parking space usually means another car will be on the roads. The Province needs to guide development in ways that are consistent with the broader regional agenda, and a sustainable transport strategy is a key element of it.

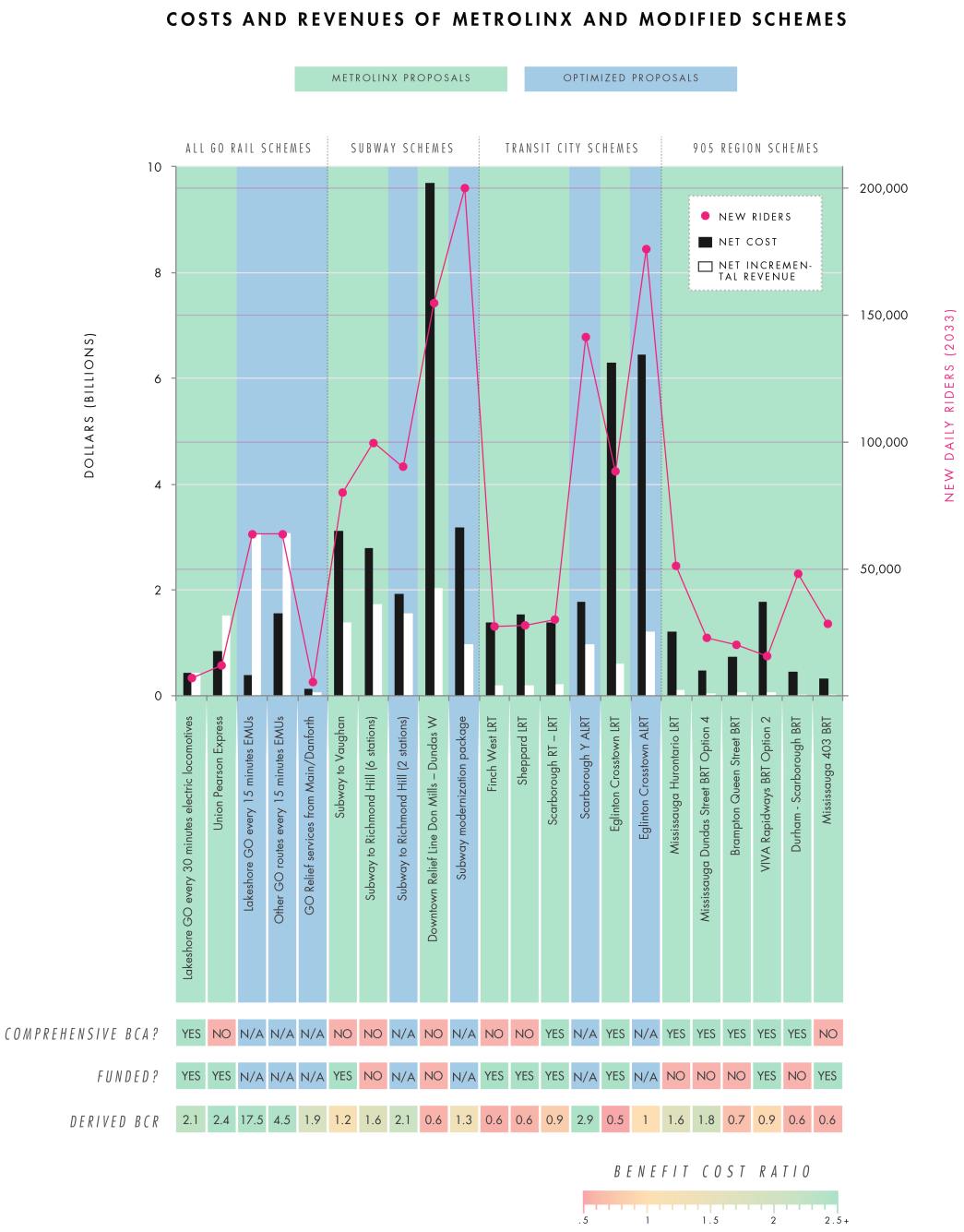

Figure 29: The summary graphic compares the schemes proposed by Metrolinx and the improvements recommended in this report. The black bars indicate net costs, the white bars represent net revenues, and the red line shows new riders for each scheme. Below the graph, the boxes indicates projects for which a comprehensive Benefits Case is available, those for which funding has been identified as of late 2013, and the Benefit:Cost ratio for each project. A Benefit:Cost ratio of less than 1.0 indicates that a project does not represent good value for money.

APPENDIX:

DETAILED ESTIMATES OF COSTS AND BENEFITS

The following tables contain estimates based on information from Metrolinx, GO Transit, and the TTC, as well as additional assumptions (provided with each table) about fares and benefits. The intention is to offer comparable analyses for all schemes considered in this review and highlight where Metrolinx may have under- or overestimated costs, revenues, or net benefits.

A1. GO Electrification

Table A1: GO Electrification Options

	Lakeshore (as studied by GO)	Lakeshore (Proposed)	All other routes (Proposed)
Peak Service	Electric Locos and 10 car trains to match demand	Electric Locos and 10 car trains plus EMUs to match demand	Electric Locos and 10 car trains plus EMUs to match demand
Non Peak Service	Electric locos and 10 car trains every 30 minutes	3 car EMUs every 15 minutes	2 car EMUs every 15 minutes
Infrastructure Capital Cost $m NPV	$ -764	$ -764	$ -1,605
Rolling stock Capital Cost $m NPV	$ -91	$ -133	$ -410
Energy savings $m NPV	$ 312	$ 411	$ 376
Train Maintenance savings $m NPV	$ 99	$ 131	$ 131
Labour costs $m NPV	$ 7	$ -40	$ -40
TOTAL COSTS $m NPV	$ -437	$ -395	$ -1,548
New daily riders 2023	4,617	52,213	52,213
Total daily non-peak riders 2023	76,945	129,159	129,159
Total daily peak riders 2023	120,000	120,000	120,000
Incremental Revenues (non-peak) $m NPV	$ 233	$ 2,863	$ 2,863
Incremental Revenues (peak fare increase) $m NPV	$ 207	$ 207	$ 207
FUNDING GAP (SURPLUS) $m NPV	$ 2	$ 2,675	$ 1,521
New Daily Riders 2033	6,925	63,755	63,755
Net cost per new 2033 daily rider	$ 312	nil	nil
Peak passenger benefits (net of fare increase) $m NPV	$ 259	$ 259	$ 259
Non-peak passenger benefits $m NPV	$ 26	$ 1,183	$ 1,183
Road user benefits $m NPV	$ 194	$ 2,385	$ 2,385
TOTAL BENEFITS $m NPV	$ 919	$ 6,897	$ 6,897
NET BENEFITS $m NPV	$ 482	$ 6,502	$ 5,349
Benefit:Cost Ratio	**2.1**	**17.5**	**4.5**
Annualization factor	300		
Average GO fare	$ 6.00		

NPV factor	23	
Value of time per hour	$13.52	
Road benefit for new GO Rider	$5.00	
Peak fare increase	5%	

We have estimated the incremental costs to operate with a mix of EMUs and electric push-pull trains. Except where otherwise noted, figures are derived from data provided in the GO Electrification Study Final Report[125] and technical appendices.

Infrastructure Capital Costs

These should be about the same as for GO's electric push-pull option. It might be necessary to provide some additional sidings to split and join the EMUs, but we have not included these costs.

In its Appendix 8B, GO presents a capital cost estimate of $1,019,000 to $1,170,000 for electrifying the Lakeshore.[126] This is shown in the Summary Report, Table 12, reproduced above, as $764 million NPV, about 69% of the actual total. This is because GO discounts figures to a common start year, 2010, and the money is actually spent over several years. Infrastructure capital expenditure to electrify the rest of the network is about twice as much, $1,605 million NPV, presumably because although the ridership is similar, it has about twice as many route km.[127]

We have not examined GO's infrastructure capital cost estimates in detail, and take them as given. Given the issues we have found in the rest of the study, a detailed review is warranted, but was beyond the scope of this study.

Rolling stock capital costs

The GO Electrification Study Appendix 8B contains some very conservative assumptions that we think are biased against EMUs. The consultants who prepared the estimates may have had limited experience with EMUs, which are still quite rare in North America. Moreover, although some commuter rail systems are operated by private contractors, as is GO, almost all of the North American electrified systems are operated by public-sector organizations and are encumbered by inefficient work rules and procedures.

Specifically, GO assumes a minimum spares ratio of 20% for EMUs, higher than the 16% spares ratio allowed for diesel locomotives. While the 20% may be "standard" among U.S. operators, U.K. train operators work successfully with spares ratios as low as 5% for EMU fleets. If the operator is, occasionally, short an EMU, it can substitute a short locomotive-hauled train to provide the service with similar performance. And with a high-frequency service, every 15 minutes, a train service might be missed only every month or so. We assume a minimum of 10% spares and at least two spare units, allowing one for heavy maintenance.

GO estimates the rolling stock cost to convert the Lakeshore route to electric locomotives as $91 million NPV, which does not seem unreasonable. Existing diesel locomotives would be cascaded to meet growing

[125] http://www.gotransit.com/electrification/en/current_study/docs/ElectricificationStudy_FinalReport.pdf

[126] http://www.gotransit.com/electrification/en/current_study/Appendix%20Files/Appendix%208B.pdf, p. 15.

[127] "The rest of the network" is GO's Option 18 minus Option 2.

traffic on other routes. Electric locomotive do generally cost a few million dollars more, each, than diesels, and GO will also need to spend money to modify its maintenance facilities.

Rolling stock capital costs would be higher with EMUs. Although EMUs would be bought in place of some electric locomotives and bi-levels, GO is correct that that EMU cars are more expensive to buy than electric locomotives and unpowered cars, when configured as 10-car trains. However, even using the figures in GO's own reports, the premium is more like 25%, and not the 40% GO claims.

GO assumes a base cost of $2.6 million and an "extended cost" including engineering support, spares, etc. of $4.6 million for each single-deck EMU car. We think this figure is probably too high, especially for a new large fleet that can be procured with competition. In 2009, Paris purchased a fleet of 300 double-deck EMU cars (actually 60 five-car trains) from Alstom and Bombardier for €917 million ($1,175 million), or about $3.9 million per car; this seems to have been closer to an "extended cost," including spares, support, etc.[128] Sydney, Australia, has recently purchased new "Waratah" double-decked EMUs built in China, apparently offering high quality at an even lower price.[129] These are built in Changchun Railway Vehicles Company, which produces subway cars in joint venture with Bombardier.

We assume an "extended cost" of $5 million for powered bi-level EMU cars, 60% more than LTK's $3.1-million cost for an unpowered bi-level cab car and 25% above the price supplied to Paris. We think this figure is probably still too high.

GO's "extended cost" for unpowered bi-level cars is $2.75 million, or $3.1 million with a driving cab. GO's cost for an electric locomotive is $11.2 million, versus $7.8 million for a diesel. A 10-car bi-level push-pull train with an electric locomotive and with one of the bi-levels having a cab, costs about $40 million.

An all-day service every 15 minutes between Hamilton and Bowmanville would require 16 EMU sets, plus two spare sets. We assume these are actually 3-car sets, each with two powered EMUs and one unpowered bi-level.[130] The 18 sets, or 54 cars, would substitute for 5 electric locomotives and bi-level trains. GO might also incur costs of, say, $20 million to provide maintenance facilities for this new type of train. The net additional capital cost should be about $133 million NPV.

GO estimates the rolling stock cost to convert "all other routes" to electric locomotives as $452 million NPV,[131] more than 5 times as much as for the Lakeshore route. This figure seems to reflect the loss on disposal of 52 diesel locomotives, which the consultants assume would be sold for $1 million each and replaced with new electric locomotives costing $11.2 million. We question this assumption. Our understanding is that there is a reasonably liquid market for good, slightly used locomotives. GO has replaced all its old locomotives and now operates entirely with MPXpress locomotives that are used on 12 other existing systems across North America. These also seem to be the locomotive of choice for new operators, which start up every few years in cities across the United States. GO should be able to get $3

[128] As reported in Railway Gazette International, March 2011.

[129] See http://en.wikipedia.org/wiki/Sydney_Trains_A_set

[130] Travel time from Bowmanville to Hamilton will be about 160 minutes with diesel-hauled trains. GO acknowledges that, with the higher acceleration of electric locomotives, journey times would be reduced at least 10%. With EMUs, the saving would be even greater, reducing the Hamilton-Bowmanville trip by about 25% (40 minutes) to 120 minutes. So 16 sets are required to operate a 15 minute two-way service.

[131] "All other routes" is GO's Scenario 18 minus Scenario 2.

million for each used MPXpress locomotive, perhaps more. GO currently has 65 locomotives, and will certainly have continued use for several of these as it extends services to places like Kitchener, St Catharines, and perhaps Peterborough. And GO has several years to find the right buyer. The rolling stock cost for conversion to electric locomotives, for all other routes, should be reduced $2 million for each of 52 locomotives, or $102 million NPV, to $252 million NPV.

On "all other routes," traffic will be lighter and 32 two-car, bi-level EMU sets should be sufficient for likely traffic with a 15-minute all-day service. There is an issue whether to power both cars, to achieve higher performance and reliability, or have one powered car and one trailer. Both options can work. We assume, conservatively, that both cars are powered EMUs with cabs. The 32 two-car, bi-level EMU sets displace 6 locomotive-hauled trains, so the net cost increment would be $411 million NPV, compared with diesel operation, or $554 million for the entire GO rail system.

Operations and maintenance costs

GO's electrification study Appendix 8C[132] Table 1 indicates a net O&M saving of about $14.6 million per year with electric locomotives on the Lakeshore. The corresponding NPV figure in the Summary Report is $337 million or 23.6 times the annual figure. According to Table 1 in Appendix 8C, the annual figure appears to be made up of $18 million reduced energy costs, and $1.1 million rolling stock maintenance savings, offset by $4.5 million costs to maintain the wayside electrical system. GO also uses an NPV figure of $337 million, 23 times the annual figure. For all other routes, the saving is slightly less, $10.3 million per year in Appendix 8C, although in the summary report GO's NPV figure is $360 million, somewhat higher, and 35 times the annual figure.

To estimate the O&M savings from operation of smaller EMUs but at a higher frequency, we need to look in more detail at the energy, maintenance, and labour costs.

Energy

Appendix 8C of the GO electrification study indicates that electricity consumption is assumed to be about $0.00756 per ton-mile.[133] A GO bi-level car weighs about 55 tons, with 100 passengers. Locomotives weigh about 135 tonnes, so the weight of 10-car train is about 685 tonnes or 68 tonnes per car. EMU cars, fully loaded, weigh about 60 tonnes, so slightly less.

The energy cost for 3-car EMUs operating every 15 minutes, or 12 cars per hour per direction, non-peak, will be about $4.3 million per year less than for 10-car electric locomotive-hauled trains every 30 minutes. Capacity is also 40% lower, but the capacity is not needed anyway in the off-peak. The actual saving will depend on driving, and one benefit of EMUs is that they have faster acceleration, but this also uses more power. On the other routes, the energy saving from operating two 2-car EMUs every 15 minutes instead of a single 10-car locomotive-hauled train should be even larger, about $5.5 million per year.

Rolling Stock Maintenance

According to Appendix 8C of the GO Electrification report, the maintenance cost savings with electric locomotives will be almost negligible, about $1.1 million per year. We think this is a serious underestimate.

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[132] http://www.gotransit.com/electrification/en/current_study/Appendix%20Files/Appendix%208C.pdf

[133] The North American rail industry uses Imperial measures such as tons and not metric tonnes.

While the maintenance costs for an electric locomotive may only be about $40,000 per year less than for an diesel locomotive (which explains the $1.1 million per year saving with 34 locomotives on the lakeshore), electric trains have faster acceleration, so about 10% fewer trains are required to provide the same service. GO acknowledges this difference in its fleet capital cost analysis, but seems to have overlooked it when estimating O&M costs. Maintenance cost for a diesel locomotive and 10 coaches is about $1.7 million per year. Assuming, very conservatively, that 5% fewer trains are required (locomotives and coaches), the saving will be about $4.3 million per year or $99 million NPV.

Rolling stock maintenance calculations are complicated, because costs depend both on time and usage. The consultants who prepared GO's Electrification study, Appendix 8C, are not very clear about how they derived their estimates of maintenance costs for electric and diesel locomotives and EMUs. Firm estimates are difficult to obtain, because maintenance costs depend on how equipment is used and most operators have experience with only a few types of equipment. While the estimates presented in Appendix 8C of the GO study, Table 3, are given to the last dollar, implying great precision, it is not clear how they relate to actual costs either of GO or of any other operator. They can best be described as educated guesswork, with a lot of underlying calculations for support.

The study also provides estimates of EMU maintenance costs, also in Table 3 of Appendix 8C. At $254,811 per year, they are about 50% higher than for unpowered bi-level cab cars and almost double the rate for bi-level coaches. The problem here is giving prices per year, without regard for usage. Some maintenance costs do depend on time, but at least half relate to usage (mileage). We use GO's figures, but assume half are mileage-related, and convert them to a mileage rate assuming they reflect average use of 80,000 miles per year.

With 3-car EMU sets operating non-peak services on the lakeshore, savings would be about $5.65 million per year or $130 million NPV. Savings on all other routes are similar; although there will be more EMU cars required, 2-car sets will replace 10-car bi-level in the off-peak services.

Labour Costs

GO's analysis assumes no change in operations, and so there is no change in labour costs with electric locomotives. In fact, this is not correct. Electric locomotives have faster acceleration, so crew hours per trip will be reduced by about 10%. With EMUs, the time savings will be even greater, about 20%, but the savings will be wholly offset if a higher service frequency is operated.

Crewing policies are an issue. In the U.K., train driver costs are about $60 per train hour, and most EMU commuter trains are operated by a single driver. GO pay levels are similar, but working practices require a crew of three staff on each train, an engineer (driver), conductor (guard), and ticket inspector. Apparently the cost is about $70 per hour each for the engineer and conductor, and $40 per hour for the ticket inspector. Altogether, the labour cost is about $180 per train hour.

Going from half-hourly to quarter-hourly service will require about 40% more train hours. This would be a good time to negotiate more efficient labour practices: in return for 40% more train hours, crew per train will be reduced to $110 per hour with single-driver operation, but still with a conductor/ticket inspector on every train. With much smaller trains, there should be no reasonable case to oppose this arrangement.

Single-person operation, with occasional on-board inspectors paid closer to a true market price, is normal practice in most western European countries where EMUs are in service, and would reduce the incremental

cost roughly by half. Certainly the labour arrangements should be agreed with the unions before the final decision is made to acquire the EMUs. An agreement should be possible, because although there will be fewer crew members per train, there will be more crew overall and the jobs will be more sustainable.

Track costs

GO's analysis assumes no change in operations, so there is no change in labour costs with electric locomotives. GO now owns most of its track, and maintenance costs are therefore internalized and not separately calculated. Generally, track costs relate to the speed and weight of trains running over the track. Replacing 10 car bi-levels and electric locomotives with two three-car EMUs should reduce track wear and tear. However, GO has provided no data, so we have not included this in our estimate.

A2. Analysis of Potential Lakeshore GO Rail Ridership Growth

Table A2: Potential Lakeshore GO Rail Ridership Growth

		Peak Riders per year thousands	Non-Peak Riders per year thousands	Total Riders	Total Non-peak trip time (minutes)	Non-peak riders Growth	New daily non-peak riders thousands	Non-peak Riders per day thousands	Weekday Riders (thousands	Revenue Increment per year at $6 fare (millions)	Revenue Increment NPV	Average load per Non-peak train	Non-peak trains per weekday
2010	Hourly	15,000	11,000	26,000	60			30.1	90.1			75.3	40
2013	Half Hourly		13,200	28,200	50	20%	6.0	36.2	96.2	$ 13.2		60.3	60
2023	Underlying Growth	30,000	26,400	56,400	50	100%	36.2	72.3	192.3	$ 79.2		120.5	60
2023	Electric Locos	30,000	28,085	58,085	47	6.4%	4.6	76.9	196.9	$ 10.1	$ 233	128.2	60
2033	Electric Locos	45,000					6.9	115.4	295.4				
2023	EMUs		30,698		43	9%	7.2	84.1		$ 15.7	$ 361	140.2	60
2023	Quarter Hourly EMUs		47,143		28	54%	45.1	129.2		$ 98.7	$ 2,269	107.6	120
	Cumulative 2023		47,143				**63.8**	129.2	249.2	$ 124	**$ 2,863**		
2033	Quarter Hourly EMUs	45,000	70,413			100%	63.8	192.9	372.9			160.8	120
		Incremental riders 2013 to 2033						**162.8**					

Note: Assumed underlying growth is 2.0 to 2023, and 1.5 for 2023 to 2033.

A3. Union Pearson Express

Table A3: Union Pearson Express

Infrastructure Capital Cost $m NPV	$ -456
Rolling Stock Capital Cost $m NPV	$ -75
O&M (cost) $m NPV	$ -306
TOTAL COSTS $m NPV	$ -837
New daily riders 2023	6,000
Diverted daily riders 2023 (from bus)	6,000
Revenues $m NPV	$ 1,511
FUNDING GAP $m NPV	$ 674
Road user benefits $m NPV	$ 504
TOTAL BENEFITS $m NPV	$ 2,015
NET BENEFITS $m NPV	$ 1,178
Benefit:Cost Ratio	**2.41**
2033 incremental daily ridership	12,000
Net cost per new 2033 daily rider	Nil
Annualization factor	365
NPV factor	23
Road benefit per diverted rider	$10.00
Average TTC fare	$ 2
Average UP Express Fare	$15.00

The route is approximately 25km in length, with a trip time of 25 minutes. It will be operated using two-car DMUs running every 15 minutes. Expected daily ridership is 4,000 passengers. Metrolinx expects the line to divert 1.2 million car trips in 2015 onto rail, or about 4,000 per day.

Capital Costs

Infrastructure capital costs are stated on the Metrolinx website[134] as $456 million in 2010 dollars. As the line is currently under construction, there is no reason to reduce it to derive an NPV.

The service could be operated with 4 units, with 5-minute layovers at the terminals. Given that these units will operate 18 hours a day, every day, it would be prudent to have three spare units, one for maintenance, one as a "standby" unit, and one for long-term maintenance. So the requirement is for 7 units. According to the Metrolinx website, it has purchased "18 diesel multiple units" but this presumably means nine 2-car

[134] UP Express factsheet at www.metroinx.com/en/projectsandprograms/upexpress/upexpress.aspx

DMUs with 18 cars in total. Other news stories refer to a contract for 6 units, costing $75 million, including spare parts etc.

It seems likely that Metrolinx plans to operate with 5 or even 6 units in service, allowing for longer layovers. This would explain the purchase of 9 units.

It is not entirely clear whether or not the Metrolinx figure of $456 million includes rolling stock capital costs. There may also be some discretion in allocating infrastructure costs to UP Express, or to the Georgetown South project, which operates over the same line.

Operating Costs

We assume Metrolinx plans to operate with two-man crews, costing $110 per hour, although one-person operation should be perfectly possible. With 6 units in service, 18 hours per day, and staff costs of $110 per train hour, driver costs would total $4.3 million per year or about $100 million NPV.

According to the GO Electrification Study, maintenance costs per DMU car are about $260,000 per year, so costs to maintain the 18-car fleet will be about $4.6 million per year or $108 million NPV.

Table 8C-2-D in GO's Technical Appendix 8C gives a cost of $918,398 per year for electric power for the Airport Rail Link, or about $23 million NPV. Diesel costs might be 25% higher, so $1.25 million per year or about $29 million NPV.

In addition, there will be costs to operate station facilities at Union, Bloor, and Pearson, and to maintain the track infrastructure. We understand UP Express is planning to have its own lounge facility at Union Station, which we find unusual, given the high train frequency. We estimate that these, together with UP Express management overheads, insurance, and other miscellaneous costs will add a further $3 million per year or $69 million NPV.

Total O&M costs would therefore be $13.15 million per year or $306 million NPV.

A4. GO Relief Services

Table A4: GO Relief Services

	Danforth/ Main	Bloor/ Dundas W	Kipling/ Bloor	Kennedy/ Eglinton
Capital Cost $m NPV	$ -100	$ -10	$ -10	$ -50
O&M Cost $m NPV	$ -32	$ -25	$ -50	$ -52
TOTAL COSTS $m NPV	$ -132	$ -35	$ -60	$ -102
Riders diverted to GO per day	10,000	5,000	2,500	2,500
GO O&M cost per rider diverted	$-0.14	$-0.22	$-0.87	$-0.91
New TTC riders per diverted rider	0.50	0.10	0.10	0.50
New daily TTC Riders	5,000	500	250	1,250
Incremental GO revenue per diverted rider	$-	$-	$2.00	$2.00
Incremental TTC revenue per new rider	$2.50	$2.50	$2.50	$2.50
Incremental TTC + GO revenue $m NPV	$ 72	$ 7	$ 32	$ 47
NET FUNDING GAP $m NPV	$ -61	$ -28	$ -28	$ -56
Net cost per new daily rider	-$12,111	-$55,581	-$110,081	-$44,503
Time savings and decongestion benefit per diverted rider (net of fares)	$2.00	$1.00	$1.00	$3.00
Time savings and decongestion benefits $m NPV	$ 115	$ 29	$ 14	$ 43
Road user benefits per new TTC rider	$2.00	$1.00	$1.00	$3.00
Auto user benefits $m NPV	$ 58	$ 3	$ 1	$ 22
TOTAL BENEFITS $m NPV	$ 246	$ 40	$ 49	$ 114
NET BENEFITS $m NPV	$ 114	$ 5	$ -11	$ 12
Benefit:Cost Ratio	**1.86**	**1.14**	**0.82**	**1.12**
Annualization factor	250			
NPV factor	23			
Road benefit per diverted rider	$5.00			
Average TTC fare	$ 2			

We estimate costs to operate "relief services" as follows. The "reference case" as set out in Appendix 5 of the GO Electrification Study[135] is an expanded 333-mile (532-km) rail system with 489 train starts per day. This seems to be the expanded network, with half-hourly all-day service using 10-car push-pull trains. Unfortunately, GO does not provide the total train-km in any of their documents. However, we calculate that it implies 19,022 train-km each weekday on the Lakeshore lines (east and west) (from GO Technical Appendix 5 Table 2), or 4.8 million train-km per year. From GO Technical Appendix 8C, Table 8C-2-D, weekend, holiday and non-revenue train-km are estimated at 35% of the weekday, so the grand total for the

[135] http://www.gotransit.com/electrification/en/current_study/Appendix%20Files/Appendix%205.pdf

Lakeshore routes is 6.4 million train-km. Electricity cost for the Lakeshore routes is estimated in the same table as costing $12.5 million per year, or just under $2 per train-km.

Annual maintenance costs are estimated in Table 8C-1-B at $1.7 million per train per year. GO Technical Appendix 5 Table 3 indicates 37 trains are required to operate the Lakeshore, so each train would operate about 130,000 km per year. Assuming half of maintenance costs are mileage-related, the cost per increment train-km would be $6.53.

GO train crew costs are understood to be about $180 per train hour, although we think this can be reduced to $110, potentially less, with more efficient labour practices.

A5. Subway extension to Vaughan

Table A5: Subway to Vaughan

	With existing fares	With "smart pricing"
Stations	6	6
Infrastructure Capital Cost $m NPV	$ -2,600	$ -2,600
Rolling Stock Capital Cost $m NPV	$ -120	$ -120
Operating Costs $m NPV	$ -575	$ -575
Bus cost savings $m NPV	$ 180	$ 180
TOTAL COSTS $m NPV	$ -3,115	$ -3,115
Diverted daily riders 2023	80,000	80,000
New daily riders 2023	40,000	40,000
Incremental revenues from diverted riders $m NPV	$ -	$ 552
Revenues from new riders $m NPV	$ 828	$ 828
NET FINANCIAL EFFECT $m NPV	$ -2,287	$ -1,735
Passenger benefits not captured by fares $m NPV	$ 1,380	$ 828
Road user benefits $m NPV	$ 1,380	$ 1,380
TOTAL BENEFITS $m NPV	$ 3,588	$ 3,588
NET BENEFITS $m NPV	$ 473	$ 473
Benefit:Cost Ratio	**1.15**	**1.15**
New daily riders 2033	80,000	80,000
Net cost per new daily rider 2033	$ -28,588	$ -21,688
Revenue from new passengers	$3.00	$3.00
Incremental yield from diverted passengers	$-	$1.00
Time saving benefits to diverted passengers (net of fares)	$2.00	$1.00
Time saving benefits to new passengers (net of fares)	$1.00	$1.00
Road user benefits per new rider	$5.00	$5.00

Estimating the Costs of TTC Schemes

TTC provides a data sheet "Ridership and cost statistics for bus and streetcar routes, 2011."[136] This gives the number of passengers, vehicles, hours of service and bus-km, and the "Cost per day Mon-Fri." This table can be used to estimate the bus costs that will be saved, by partially or wholly replacing bus routes with new LRT or subway services.

Unfortunately, TTC provides no comparable data for the subway. This is further complicated because subways have high fixed costs to maintain and operate tunnels and stations, which do not vary in proportion to traffic volumes.

We can estimate total costs to operate the entire subway system by subtracting the costs of surface routes from TTC's total operating budget, as disclosed in its annual report. We can then calculate a cost per kilometre, recognizing that costs will be higher for the downtown sections with more stations and more trains, and less for outer sections with fewer stations or trains.

[136] http://www.ttc.ca/PDF/Transit_Planning/Ridership_and_cost_statistics_for_bus_and_streetca_routes_20.pdf

The sum of costs for all surface routes is $3,521,900 per weekday. Applying an annualization factor of 300, which assumes expenditure on weekends and holidays is at half the weekday rate, gives a figure of $1,056,600,000. Of this, $186 million is for streetcar routes, and $871 million for bus routes.

We estimate incremental O&M cost for the subway extensions based on total costs to operate the existing subway system, per route km.

According to the 2011 Annual Report,[137] Note 14, TTC's total expenditures excluding Wheel Trans, depreciation (assets funded by capital subsidy), and pension fund society income totalled $1,529,054,000. Applying 2% inflation to get the 2012 figure, and subtracting the surface route costs implies costs to operate the subway and RT are about $503 million per year or about $6.8 million per route km.

We can check this against the Eglinton Crosstown BCA, which gives annual cost of $68 million for a 19-km LRT from Weston Road to Kennedy, or $3.6 million per km. About two-thirds of this line is in subway, with closely spaced stations, however it would be operated with much smaller LRT trains and we would expect operating cost to be about half as large.[138]

The subway extension to Vaughan will increase the length of system by about 8.6km. Applying the rate of $6.8 million per route km would give incremental O&M costs of $55 million per year. We assume a lower figure of $25 million per year (about $3 million per km) or $575 million NPV because:

- the $6.8 million per km figure probably includes substantial fixed costs, including transit control, and various engineering functions that should not grow proportional to subway mileage;
- the line will probably be served at a lower peak headway;
- stations are relatively widely spaced.

O&M costs on the Richmond Hill extension should be less, as the new line is only 6.8km in length. We assume the cost is $20 million per year or $460 million NPV.

We estimate costs to operate more intensive services based on current average cost per subway train km.

According to TTC operating data for 2011, TTC operated 76m subway car-km and 3.3m Scarborough RT car-km. Subway trains have 6 cars and two drivers while RT trains have 4 cars and one driver. Treating each RT train as half a train, TTC operated 13.5m train-km.

This implies an average cost of about $26 per train-km. The incremental (marginal) cost for increased services would be lower, as the subway has substantial fixed costs relating to stations, track, and control centres. The cost per incremental train-km might be $20.

Assuming an incremental cost of $20 per train km, the cost to operate 35% more subway train at all times would be about $86 million per year or $1,978 million NPV.

Incremental O&M costs for buses should be similar to average costs, as buses do not have large fixed costs.

[137] http://ttc.ca/PDF/About_the_TTC/TTC_Annual_Report_2011.pdf

[138] Eglinton Crosstown BCA, Table 4.4.

TTC has not provided any data on expected O&M costs for the new LRT schemes. We assume they will be similar to streetcar lines, about $2.5 million per km, but with additional costs for stations and tunnels. As the new lines will not connect with the rest of the streetcar system, and will use incompatible technology, there will be few synergies.

For LRT lines running underground, we add $1 million for each km of tunnel and $1 million for each underground station, per year. For elevated stations, or stations which are likely to require escalators or elevators, we add $0.5 million per year. These are fairly crude estimates; they reflect the total cost to operate the subway of about $6.8 million per route km, of which perhaps half relates to stations and tunnels and half to trains. While LRT stations are somewhat smaller than subway stations, tunnel costs for LRT and the subway will be similar.

Subway extensions and LRT lines will usually replace one or more bus routes. The offsetting saving will depend on how TTC chooses to modify the bus network. The Vaughan and Richmond Hill subway extensions will each replace about 6km of frequent bus services. Using the same rate of $30 million NPV per km, we assume savings on each of $180 million NPV.

A6. Subway extension to Richmond Hill

Table A6: Subway to Richmond Hill

	Current plan	With fewer stations
Stations	6	2
Infrastructure Capital Cost $m NPV	$ -2,400	$ -1,600
Rolling Stock Capital Cost $m NPV	$ -100	$ -90
Operating Costs $m NPV	$ -460	$ -416
Bus cost savings $m NPV	$ 180	$ 180
TOTAL COSTS $m NPV	$ -2,780	$ -1,926
Diverted daily riders 2023	100,000	90,000
New daily riders 2023	50,000	45,000
Incremental revenues from diverted riders $m NPV	$ 690	$ 621
Revenues from new riders $m NPV	$ 1,035	$ 932
NET FINANCIAL EFFECT $m NPV	$ -1,055	$ -374
Passenger benefits not captured by fares $m NPV	$ 1,035	$ 932
Road user benefits $m NPV	$ 1,725	$ 1,553
TOTAL BENEFITS $m NPV	$ 4,485	$ 4,037
NET BENEFITS $m NPV	$ 1,705	$ 2,111
Benefit:Cost Ratio	**1.61**	**2.10**
New daily riders 2033	100,000	90,000
Net cost per new daily rider 2033	$ -10,550	$ -4,150
Revenue from new passengers	$3.00	$3.00
Incremental yield from diverted passengers	$1.00	$1.00
Time saving benefits to diverted passengers (net of fares)	$1.00	$1.00
Time saving benefits to new passengers (net of fares)	$1.00	$1.00
Road user benefits per new rider	$5.00	$5.00

Our general approach to estimating TTC subway schemes is described in the preceding section.

A7. Downtown Relief Lines

Table A7: Downtown Relief Lines

	Pape - St Andrew	Don Mills/Eglinton - Dundas W/Bloor
Length km	6	18
Stations	7	16
Infrastructure Capital Cost $m NPV	*$ -3,200*	*$ -8,300*
Rolling Stock Capital Cost $m NPV	*$ -120*	*$ -320*
Operating Costs $m NPV	*$ -600*	*$ -1,300*
Bus cost savings $m NPV	$ -	$ 225
TOTAL COSTS $m NPV	*$ -3,920*	*$ -9,695*
Total Riders 2023	160,000	280,000
Diverted daily riders 2023	106,400	132,600
New daily riders (assuming no GO Relief services) 2023	53,600	147,400
Incremental revenues from diverted riders $m NPV	$ -	$ -
Revenues from new riders $m NPV	$ 740	$ 2,034
NET FINANCIAL EFFECT $m NPV	*$ -3,180*	*$ -7,661*
Passenger benefits not captured by fares $m NPV	$ 1,104	$ 1,932
Road user benefits $m NPV	$ 740	$ 2,034
TOTAL BENEFITS $m NPV	$ 2,583	$ 6,000
NET BENEFITS $m NPV	$ -1,337	$ -3,695
Benefit:Cost Ratio	**0.66**	**0.62**
New daily riders 2033	56,280	154,770
Net cost per new daily rider 2033	*$ -56,509*	*$ -49,498*
Revenue from new passengers	$2.00	$2.00
Incremental yield from diverted passengers	$-	$-
Time saving benefits to diverted passengers (net of fares)	$1.00	$1.00
Time saving benefits to new passengers (net of fares)	$1.00	$1.00
Road user benefits per new rider	$2.00	$2.00

Our general approach to estimating TTC subway schemes is described in section A5.

A8. Subway Modernization

Table A8: Subway Modernization Package

New Control System PSDs and Driverless operation $m NPV	$ -1,500
Operational cost savings of driverless trains etc. $m NPV	$ 1,600
Capital costs of fare collection upgrade $m NPV	$ -50
250 additional subway cars for 35% capacity increase $m NPV	$ -750
Additional station capacity works $m NPV	$ -500
Additional operating and maintenance cost $m NPV	$ -1,978
TOTAL COST $m NPV	$ -3,178
New daily riders 2023	150,000
Additional Fare Revenues $m NPV	$ 2,070
NET FUNDING GAP $m NPV	$ -1,108
Time savings and road user benefits at $2 per new rider NPV	$ 2,070
TOTAL BENEFITS $m NPV	$ 4,140
NET BENEFITS $m NPV	$ 962
Benefit:Cost Ratio	**1.30**
New daily riders 2033	200,000
Net cost per new daily rider	$ -5,540
Average TTC Fare	$2.00
Additional train-km millions	4.455
Cost per train-km	$-29.81
NPV factor	23
Annualization factor	300
Time savings and road user benefits to passengers per new daily rider	$2.00

A9. Transit City LRT Schemes

Table A9: Transit City LRT Schemes

	Sheppard East -Don Mills - Morningside	Scarborough Kennedy - Sheppard	Eglinton Jane-Kennedy	Finch West – Spadina Subway – Humber College
Route km	13	10	19	10
New route km	13	3	19	10
Underground km	1	1	11	0
Underground stations	1	0	12	0
Surface or elevated stations (4)	0	8	0	0
Road lane km lost	12	0	8	10
LRT Cars (1)	35	35	80	20
Infrastructure Capital Cost $m NPV	*$ -1,000*	*$ -980*	*$ -4,900*	*$ -1,000*
Rolling Stock Capital cost $m NPV	*$ -147*	*$ -147*	*$ -336*	*$ -84*
Operating Costs (incremental) $m NPV (2)	*$ -794*	*$ -288*	*$ -1,622*	*$ -575*
Bus costs reduced $m	$ 403	$ 35	$ 570	$ 271
TOTAL COSTS NPV	*$ -1,538*	*$ -1,380*	*$ -6,288*	*$ -1,388*
Total daily riders 2023 (3)	55,000	60,000	176,000	54,700
New riders 2023	25%	25%	25%	25%
New daily riders 2023	13,750	15,000	44,000	13,675
Incremental revenues $m NPV	$ 190	$ 207	$ 607	$ 189
NET FUNDING GAP $m NPV	*$ -1,348*	*$ -1,173*	*$ -5,680*	*$ -1,199*
Road user benefits $m NPV	$ 237	$ 259	$ 759	$ 236
Road user disbenefits $m NPV	*$ -83*	*$ -*	*$ -55*	*$ -69*
Passenger benefits per existing rider	$1.50	$2.00	$1.50	$1.50
Passenger benefits per new rider	$0.75	$1.00	$0.75	$0.75
Passenger Benefits $m NPV	$ 498	$ 725	$ 1,594	$ 495
TOTAL BENEFITS $m NPV	$ 842	$ 1,190	$ 2,905	$ 851
NET BENEFITS $m NPV	***$ -696***	***$ -189***	***$ -3,383***	***$ -537***
BENEFIT COST RATIO	0.55	0.86	0.46	0.61
Growth to 2033 with complementary policies	2.00	2.00	2.00	2.00
New daily riders 2033	27,500	30,000	88,000	27,350
Net cost per new daily rider 2033	*$ -49,027*	*$ -39,083*	*$ -64,549*	*$ -43,850*

(1) Fleet requirements are derived from TTC's estimates as set out in the report of November 14, 2007, with the numbers reduced pro-rata to reflect shorter line lengths.

(2) For Scarborough RT, Incremental O&M cost for the 3.5-km extension from McCowan to Sheppard.

(3) Ridership figures are from TTC's November 14, 2007 report.

(4) Excludes simple unstaffed surface stations, without elevators, escalators, or station buildings.

Cost and benefit assumptions	
Cost per LRT car $m	$-4.20
O&M cost per km - surface LRT $m/yr	$-2.50
O&M cost per km - underground LRT $m/yr	$-1.00
O&M cost per underground station $m/yr	$-1.00
O&M cost per surface or elevated station $m/yr	$-0.50
Average fare per new daily rider	$2.00
Road user benefit per new daily rider	$2.50
Road disbenefit per lane km per day $	$ -1,000
Annualization factor	300
NPV factor	23

Subway extensions and LRT lines will usually replace one or more bus routes. The offsetting saving will depend on how TTC chooses to modify the bus network:

- The Sheppard LRT will replace about 70% of the mileage of the Sheppard East bus and the Scarborough Centre Rocket. According to TTC's data, these routes cost about $25 million per year to operate, so if they are 70% replaced, then the savings will be about $403 million NPV or about $31 million NPV per LRT route-km.
- The Scarborough RT extension will not replace any specific route, however, it should displace peak-hour buses on several routes. We assume a saving of $10 million NPV per incremental route-km or $35 million NPV.
- The Eglinton LRT will replace about 60% of the Eglinton West and Eglinton East routes, for savings of $570 million NPV or $30 million NPV per LRT route-km. With stations spaced 600 to 800m apart, TTC will probably need to continue operating a bus service on the route, although at reduced frequency. The Metrolinx BCA gives a much higher figure, suggesting the scheme will reduce bus operating costs by $109.7 million per year.
- The Finch LRT will replace about half of the Finch West bus, saving $271 million NPV or about $27 million NPV per LRT route-km.

A10. Improving the Eglinton Crosstown Line

Table A10: Improving the Eglinton Crosstown Line

	Eglinton Crosstown Transit City	Eglinton Crosstown Modified
Route km	19	19
New route km	19	19
Underground km	11	11
Underground stations	12	9
Surface or elevated stations	0	8
Road lane km lost	8	0
LRT or ALRT Cars	80	140
Infrastructure Capital Cost $m NPV	*$ -4,900*	*$ -5,000*
Rolling Stock Capital cost $m NPV	*$ -336*	*$ -588*
Operating Costs (incremental) $m NPV	*$ -1,622*	*$ -1,426*
Bus costs reduced $m	$ 570	$ 570
TOTAL COSTS NPV	*$ -6,288*	*$ -6,444*
Ridership uplift with faster trips		25%
Total daily riders 2023	176,000	220,000
New daily riders 2023	44,000	88,000
Incremental revenues $m NPV	$ 607	$ 1,214
NET FUNDING GAP $m NPV	*$ -5,680*	*$ -5,230*
Road user benefits $m NPV	$ 1,518	$ 3,036
Road user disbenefits $m NPV	*$ -55*	*$ -*
Passenger benefits per existing rider	$1.50	$2.50
Passenger benefits per new rider	$0.75	$1.25
Passenger Benefits $m NPV	$ 1,594	$ 1,822
TOTAL BENEFITS $m NPV	$ 3,664	$ 6,072
NET BENEFITS $m NPV	*$ -2,624*	$ -372
BENEFIT COST RATIO	0.58	0.94
Growth to 2033 with complementary policies	2.00	2.00
New daily riders 2033	88,000	176,000
Net cost per new daily rider 2033	*$ -64,549*	*$ -29,714*
Cost per ALRT car $m	$-4.20	
O&M cost per km - ALRT $m/yr	$-2.00	
O&M cost per km - underground LRT $m/yr	$-1.00	
O&M cost per underground station $m/yr	$-1.00	
O&M saving subway to ALRT $m/yr per km	$2.00	
O&M cost per surface or elevated station $m/yr	$-0.50	
Average fare per new daily rider	$2.00	
Road user benefit per new daily rider	$5.00	
Road disbenefit per lane km per day $	$-1,000.00	
Annualization factor	300	
NPV factor	23	

A11. 905 Region Schemes

Table A11: 905 Region BRT and LRT Schemes

	Mississ-auga Huron-tario LRT Option 1	Mississ-auga Dundas Street Option 4	Bramp-ton Queen St. Option 1A	VIVA Rapid-ways Option 2	Durham Scar-borough Option 1	Mississ-auga 403
Route-km	20.8	40	23.7		36	
Infrastructure Capital Cost $m NPV	*$ -1,022*	*$ -369*	*$ -523*	*$ -1,509*	*$ -366*	*$ -259*
Operating Costs (incremental) $m NPV	*$ -185*	*$ -97*	*$ -221*	*$ -263*	*$ -78*	*$ -55*
TOTAL COSTS NPV	*$ -1,207*	*$ -466*	*$ -744*	*$ -1,772*	*$ -444*	*$ -314*
Total daily riders 2021	63,900	37,800	24,000	101,000	40,000	28,306
of which new riders	40%	30%	28%	8%	30%	50%
New daily riders 2021	25,560	11,340	6,600	7,667	12,000	14,153
Average fare per new daily rider	0.94	0.95	2.42	1.95	0.48	
Incremental revenues $m NPV	$ 105	$ 47	$ 69	$ 65	$ 25	$ 18
NET FINANCIAL EFFECT $m NPV	*$ -1,102*	*$ -419*	*$ -675*	*$ -1,707*	*$ -419*	*$ -296*
Auto operating cost savings	$ 569	$ 350	$ 110	$ 52	$ 269	$ 190
Road user benefit per new transit rider	$ 5.62	$ 7.83		$ 2.07		
Road user benefits $m NPV	$ 625	$ 386		$ 69		
Passenger time saving (mins)	$19.16	$10.83		$15.35		
Total travel time benefits $m NPV	$ 1,779	$ 772	$ 443	$ 1,530	$ 229	$ 162
Passenger Benefits $m NPV	$ 1,154	$ 386		$ 1,461		
TOTAL BENEFITS $m NPV (fares)	$ 1,884	$ 819	$ 512	$ 1,595	$ 254	$ 180
NET BENEFITS $m NPV (fares)	**$ 677**	**$ 353**	***$ -232***	***$ -177***	***$ -190***	***$ -134***
BENEFIT COST RATIO (fares)	1.56	1.76	0.69	0.90	0.57	0.57
TOTAL BENEFITS $m NPV (auto costs)	$ 2,348	$ 1,122	$ 553	$ 1,582	$ 498	
NET BENEFITS $m NPV (auto costs)	**$ 1,141**	**$ 656**	***$ -191***	***$ -190***	***$ 54***	
BENEFIT COST RATIO (auto cost)	1.95	2.41	0.74	0.89	1.12	
Growth to 2033 with complementary policies	2.00	2.00	3.00	2.00	4.00	
New daily riders 2033	51,120	22,680	19,800	15,333	48,000	28,306
Net cost per new daily rider 2033	*$ -21,557*	*$-18,479*	*$-34,076*	*$-111,326*	*$-8,723*	*$-10,468*

Capital and operating costs, and road user and passenger benefits are from the Metrolinx BCAs. Passenger time savings, road user benefits, and average fare per new rider are derived from these. We have had to make some estimates because most of the BCAs do not explicitly report the incremental and total daily ridership that is forecast.

Mississauga Dundas: Peak-hour ridership figures are given for four alternative schemes but not for the Base Case. The Metrolinx Next Wave Fact Sheet says ridership will be 13 million in 2031; assuming annual traffic is 300 times the daily, then daily traffic is about 9 times peak hour traffic at the peak point. At least 30% must be incremental, because this is the difference between Option 4 and the worst option. This gives a plausible figure of $5.62 road user benefits per new transit rider. The implied time saving of 19 minutes per passenger seems high, but plausible: according to the data in the BCA, end-to-end trip times will be about 38 minutes versus just over one hour today by bus. Most passengers, however, will not be travelling the full length of the route. Some will benefit from higher frequencies but some will need to make an additional transfer, from a feeder bus. The fare of $1.95 for per incremental passenger seems reasonable.

Hurontario Main: As with Mississauga Dundas Street, we have had to derive daily and incremental ridership, which appears to be at least 40% of the total as this is the increment over the least ambitious scheme.

Brampton Queen Street: peak point hourly and total daily boardings are given for the base case and each option.

VIVA: The daily figures are given for the VIVA schemes, as is the base case (do nothing) ridership so we can work out that incremental ridership is about 8%.

Durham Scarborough: The Metrolinx Fact Sheet predicts 2031 annual ridership of 18 million. Allowing 50% growth from 2021, and annualization of 300,this implies 40,000 passengers per day. The more detailed BCA does give a daily or annual figure, but indicates an a.m. peak-hour load of 2,500 (both directions), suggesting a multiple of 16, much higher than for the other schemes.

Mississauga 403: Metrolinx has not published a BCA, only a fact sheet quoting the capital costs. We assume the scheme has similar costs.

A12. A Proposal for a Scarborough ALRT Line

Table A12: Scarborough ALRT "Wye"

	Sheppard/ Yonge – Sheppard/Don Mills Subway Conversion	Don Mills/ Sheppard to Scarborough RT Link	Scarborough RT refurbishment	Scarborough RT extension McCowan – Sheppard (Malvern)	Complete Scarborough Wye Scheme
Route km	5.5	6.5	6.5	3.5	22
New route km	0	6.5	0	3.5	10
Underground km	0	0	0	0	0
Underground stations	0	0	0	0	0
Surface or elevated stations	0	3	0	2	5
Road lane km lost	0	0	0	0	0
ALRT Cars	30	30	30	10	100
Infrastructure Capital Cost $m NPV	$ -100	$ -700	$ -200	$ -500	$ -1,500
Rolling Stock Capital cost $m NPV	$ -126	$ -126	$ -126	$ -42	$ -420
Operating Costs (incremental) $m NPV	$ 253	$ -334	$ -	$ -184	$ -265
Bus costs reduced $m	$ -	$ 207	$ -	$ 207	$ 414
TOTAL COSTS NPV	$ 27	$ -953	$ -326	$ -519	$ -1,771
Total daily riders 2023	50,000	80,000	40,000	20,000	190,000
New daily riders 2023					70,600
Incremental revenues $m NPV					$ 974
NET FINANCIAL EFFECT $m NPV					$ -796
Road user benefits $m NPV					$ 2,436
Road user disbenefits $m NPV					$ -
Passenger Benefits $m NPV					$ 1,722
TOTAL BENEFITS $m NPV					$ 5,132
NET BENEFITS $m NPV					$ 3,361
BENEFIT COST RATIO					2.90
Growth to 2033 with complementary policies					2.00
New daily riders 2033					141,200
Net cost per new daily rider 2033					$ -5,639

Cost per ALRT car $m	$-4.20	(includes assumed $1 million per-car penalty for contract change)
O&M cost per km - ALRT $m/yr	$-2.00	
O&M cost per km - underground LRT $m/yr	$-1.00	
O&M cost per underground station $m/yr	$-1.00	
O&M saving subway to ALRT $m/yr per km	$2.00	
O&M cost per surface or elevated station $m/yr	$-0.50	
Average fare per new daily rider	$2.00	
Road user benefit per new daily rider	$5.00	
Road disbenefit per lane km per day $	$-1,000.00	

A13. Comparing Transit Modes

If the Big Move program is to deliver what it promises, then project evaluation must be based on rigorous analysis, with investment targeted "where it matters most," an approach that represents international best practice and that was endorsed by Metrolinx in 2008 in its own "guiding principles."

In an attempt to inform the debate on the Scarborough RT replacement, Metrolinx provided the *Transit Investment Strategy Advisory Panel* with a graph showing the comparative whole-life costs of different transit modes. This graph is shown in Figure 30.[139] Unfortunately, the graph is potentially misleading, and could lead to ill-informed decisions.

First, the graph includes all costs, including financing costs, but as spent at the time rather than discounted to Net Present Values. This approach downplays the value of capital-intensive schemes, even where they can bring offsetting savings and benefits.

Second, the graphic shows costs, but not benefits, not even financial benefits such as savings in costs of operating bus routes that may be replaced by the transit investment, and the incremental revenues generated by the improved transit service.

Third, the graphic omits Regional Express Rail, a mode that the Big Move identified as the backbone of the regional transit plan. Regional Express Rail can be built mostly over existing GO Rail corridors, and in many cases even over existing track, so capital costs are low. With relatively large trains, Regional Express Rail can be very efficient, and with higher operating speeds and higher yields, it has the potential to pay its way, recovering all operating costs and even paying back a large portion of capital costs from fares.

Fourth, each transit corridor is unique, with unique capital costs, and operating costs (and revenues) depending on traffic. Looking at the operating costs for each mode in the Metrolinx graph, it seems to compare a heavy bus route, which could be replaced with:

- BRT, with modest capital costs but apparently no reduction in operating costs, even though the productivity of drivers and buses on a BRT are normally higher
- At-grade LRT, with higher capital costs, but lower operating costs, presumably because the service is operated with larger, but less frequent, vehicles
- Elevated LRT and subway, with much higher capital costs but similar operating costs

[139] See *Hard Truths*, at http://transitpanel.ca/news/the-hard-truths-about-transit?p=1

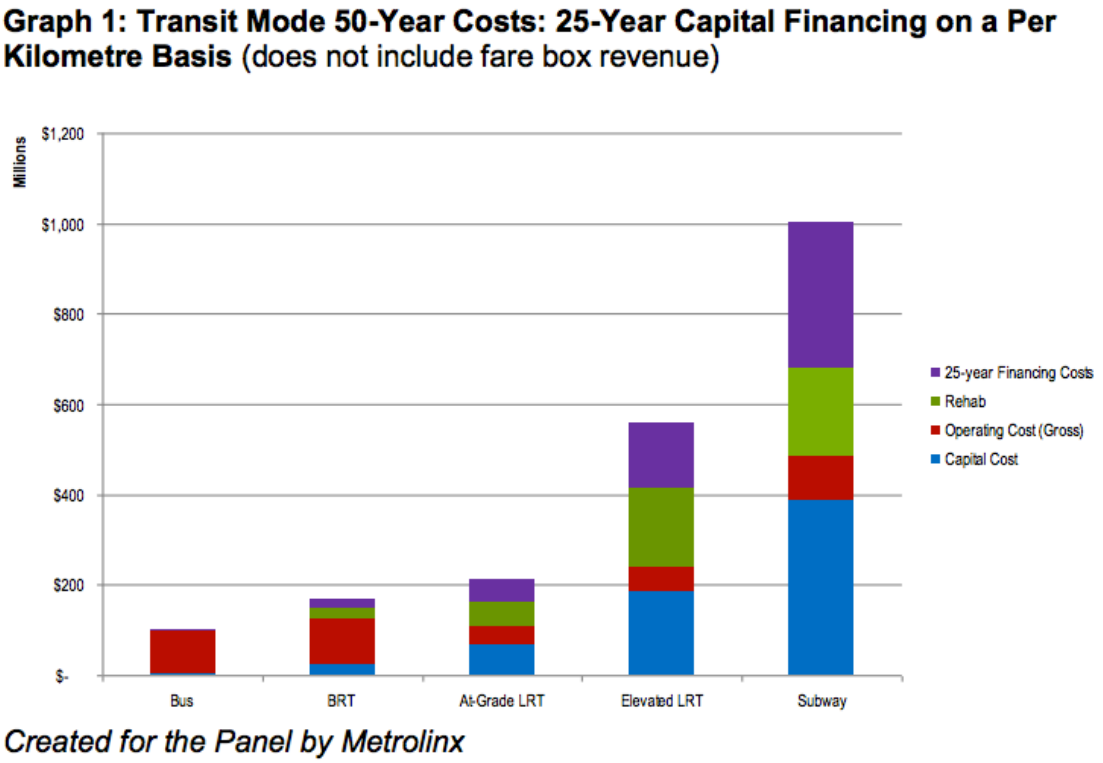

Figure 30: Graph prepared by Metrolinx to inform the debate on choice of modes

We think projects costing billions of dollars deserve a more sophisticated analysis. We also think the public and policymakers can appreciate the complex trade-offs that have to be made when selecting the appropriate transit mode for each corridor.

Clearly, subways make sense on very heavily used corridors, while elevated LRT (or more precisely grade-separated LRT, with an exclusive right of way) offers an attractive mix of cost and speed for many suburban corridors. At-grade LRT works in the older parts of Toronto, for short routes, while BRT is often a cost-effective way of improving transit in low-density suburbs. This graphic does not help policymakers understand these distinctions.

Figure 31 shows our comparison of different traffic modes, correcting for key deficiencies in the Metrolinx graphic, and based on data for specific Metrolinx schemes. Subway remains the most expensive mode, but at least on the Vaughan and Richmond Hill extensions, the savings to bus operating costs and the incremental revenues from new rider offset a significant part of the costs. The net cost (or "Funding Gap") is only about $300 million per route-km, one-third of the $1 billion figure suggested by Metrolinx.

Indeed, the funding gap on the Eglinton Crosstown LRT is similar, because although capital costs are slightly lower per kilometre, bus costs savings and incremental revenues are also lower. Surface LRT and BRT schemes cost less, but again, relatively little of the cost is offset by incremental revenues, at least for the schemes that are shown.

Regional Express Rail has very low costs, because it uses mostly existing surface corridors, trains are relatively large and fast, and revenues per passenger are high. Indeed, the net cost barely shows on the graph, per kilometre, while incremental revenues are as high as for the subway extensions.

Figure 31 shows the incremental costs and revenues of each Metrolinx scheme, and the "Funding Gap" per route kilometre, and for some suggested modified schemes. Note that most of the GO Rail schemes have revenues far in excess of incremental costs. By comparison, the LRT schemes generate very little incremental revenue in proportion to their costs. Further details, including the underlying analysis, are discussed in the following sections.

Note that elevated (and automated) LRT, as used successfully in Vancouver, Dubai, London, and other cities, is not shown, because no Metrolinx projects use this technology.

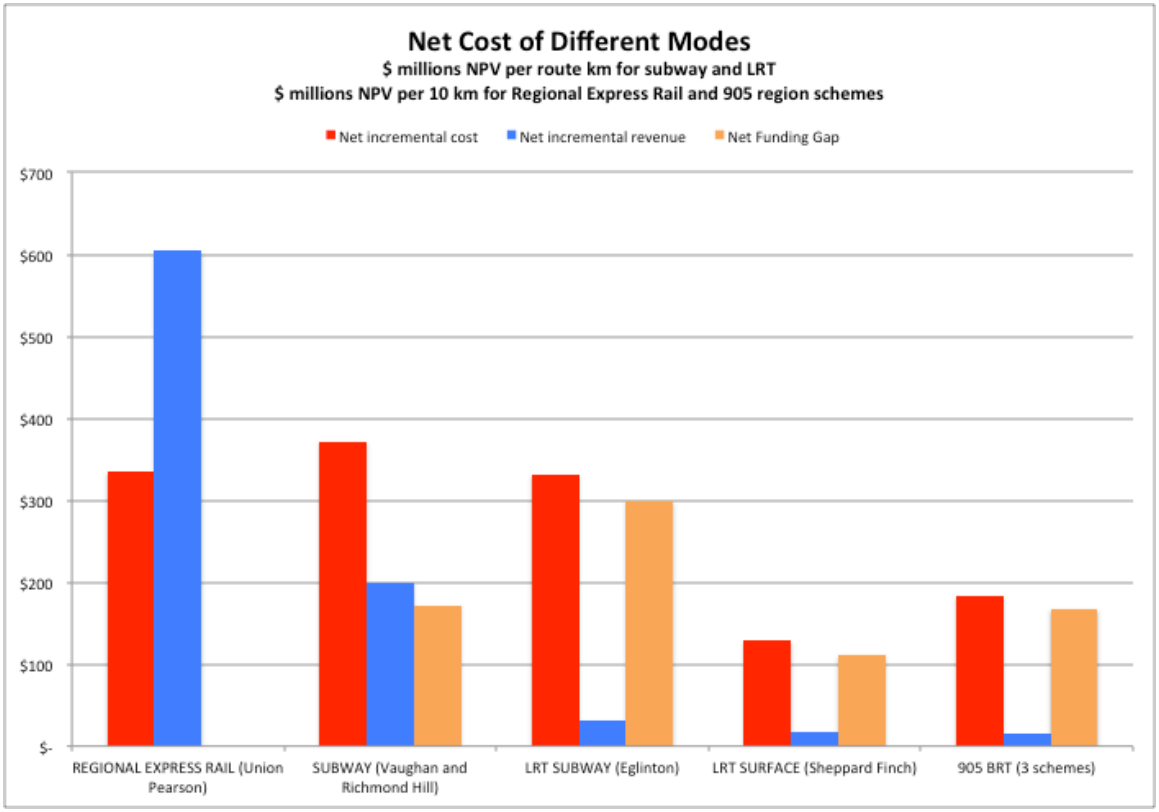

Figure 31: Comparative Costs and Revenues of Different Modes

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