



TTC Fleet Procurement Strategy and Plan

Date: October 22, 2020
To: TTC Board
From: Chief Vehicles Officer

Summary

This report recommends strategies for the acceleration of transit vehicle procurements, identifies key immediate needs for facilities investment, and highlights promising technologies from the TTC's vehicle innovation pipeline.

The disruption caused by COVID-19 has had significant impact to everyone, including TTC customers, employees, and operations. Ridership declined to as low as 14% of normal levels, and has since risen, however full recovery will take time. There is an urgent need to procure transit vehicles to replace critical assets reaching end-of-life and to ensure that we have the capacity to meet customer demand.

As identified through the TTC's 15-Year Capital Investment Plan (CIP), there is a total need of approximately \$35.23 billion for investment in asset renewal and replacement. In the current 10-year capital planning window, from 2020 to 2029, \$22.26 billion is required for facilities, transit vehicles, and related systems such as eBus charging infrastructure and automatic train control. Of the total need, the current estimate for new vehicles and related systems is approximately \$6.17 billion.

At its meeting on January 27, 2020, the TTC Board approved the TTC's 2020-2029 Capital Budget and Plan recognizing the approved increase in transit funding allocated by Toronto City Council (Council) in the amount of \$4.73 billion. This seminal investment in sustainable funding from the City Building Fund (CBF) was allocated as follows: \$500 million as the City's one-third share towards the \$1.5 billion Bloor-Yonge Station capacity improvement project, \$3.09 billion to fund critical SOGR of subway infrastructure projects (including \$623 million for Automatic Train Control (ATC) on Line 2), and \$1.14 billion in net new funding as the City's share towards the procurement of new vehicles and eBus charging systems

With the approval of the increased funding of \$1.14 billion toward the purchase of new vehicles and related systems and the \$623 million for ATC on Line 2 as well as \$452 million in existing approved funding, TTC's 2020-2029 Capital Budget and Plan provides a total of \$2.24 billion or approximately 36% of funding necessary to address the \$6.17 billion capital need. Having secured more than one-third share of funding from the municipal government, the City and TTC are seeking matching contributions from Provincial and Federal partners in order to fulfill the TTC's vehicle program requirements over the next ten years.

The first priority, and the primary focus of this report, is to advance vehicle procurements. The next priority will be to advance needed investments in facilities and technology to enable effective and efficient storage, maintenance, and operations of those vehicles.

Recommendations

It is recommended that the TTC Board:

Streetcars:

1. Delegate authority to the TTC Chief Executive Officer to issue a contract change with Bombardier Transportation Canada Inc. for the supply of 13 streetcars at an estimated cost of \$140 million, inclusive of all taxes and project delivery costs, based on the following:
 - a. Negotiation of an acceptable agreement that is satisfactory to the TTC Chief Executive Officer and General Counsel;
 - b. Negotiation of acceptable contract pricing for the initial order of 13 streetcars and fixed pricing on options for up to 47 additional streetcars equating to a combined total of 60 streetcars; and
 - c. All streetcars are to be delivered between 2023 and 2025.

City Buses and Wheel-Trans Buses:

2. Delegate authority to the TTC Chief Executive Officer to award up to two contracts for the supply and delivery of approximately 300 hybrid-electric buses for the estimated cost of approximately \$390 million, inclusive of taxes and project delivery costs, based on the following:
 - a. Negotiation of an acceptable agreement, satisfactory to the TTC Chief Executive Officer and General Counsel, with the one or both of the only two qualified suppliers of hybrid-electric buses compliant with Transport Canada's Commercial Motor Vehicle Safety Standards; and
 - b. All buses are to be delivered between 2022 and 2023.
3. Request staff to report back to the TTC Board in Q2 of 2021 with the first year test results of the eBus head-to-head evaluation and the resulting technical requirements for the supply and delivery of approximately 300 all-electric long-range buses commencing in 2023 through 2025.
4. Delegate authority to the TTC Chief Executive Officer to issue a contract change through Metrolinx's Joint Procurement Initiative to Creative Carriage Ltd. for the supply and delivery of approximately 70 Wheel-Trans buses at an estimated cost of \$20 million, inclusive of all project delivery costs, based on the following:

- a. Written approval by the Advisory Committee on Accessible Transit (ACAT) of the 7-metre ProMaster pilot bus that is currently being evaluated;
- b. All buses are to be delivered between 2022 and 2023.

Electric Vehicle Charging Infrastructure:

5. Request staff to continue working with Toronto Hydro Electrical Supply Ltd and Ontario Power Generation and report back to the TTC Board in Q1 of 2021 with a draft agreement(s) for the delivery of the required bus, Wheel-Trans, and non-revenue vehicle charging infrastructure to enable achievement of the TTC's target for a fossil-fuel-free/zero-emissions fleet by 2040.

Subway Trains:

6. Approve expenditure of \$3 million to continue advancing the initial phase of procurement for 80 new subway trains, including employee and customer consultations, development of technical and commercial specifications, and development of concept drawings, through to the end of Q1 of 2021, recognizing that this expenditure will be sunk cost should the additional \$1.61 billion not be committed by that time.

Intergovernmental:

7. Request the Provincial and Federal government to provide funding as outlined below, to leverage municipal funding in order to procure the full program of new vehicles and related systems as follows:
 - a. Streetcar: commitment of \$360 million in net new funding by Q2 of 2021 to fully fund the \$500 million procurement of 60 new streetcars;
 - b. Subway Trains: commitment of \$1.61 billion in net new funding by Q1 of 2021, of which approximately \$1.25 billion is required in 2020-2029 and \$0.36 billion is required from 2030-2034, to fully fund the \$2.24 billion procurement of 80 new subway trains;
 - c. Buses: commitment of \$1.17 billion in net new funding required by Q1 2023 to fully fund the \$1.86 billion procurement of 1,422 buses;
 - d. Wheel-Trans Buses: commitment of \$154 million in net new funding required by Q2 of 2021 to fully fund the \$206 million procurement of 512 new Wheel-Trans buses; and
 - e. Electric Vehicle Charging Infrastructure: commitment of \$442 million in net new funding required by Q2 of 2021 to fully fund the \$550 million deployment of electric vehicle charging infrastructure for buses and Wheel-Trans buses.

Financial Summary

At its meeting on January 27, 2020, the TTC Board amended its approved TTC's 2020-2029 Capital Budget and Plan to reflect additional funding made available through the City Building Fund of \$4.73 billion. This provided the TTC with \$500 million towards the Bloor-Yonge Station Capacity Improvements project and an additional \$4.23 billion in new capital funding to enable the TTC to fund \$3.09 billion for critical subway infrastructure (SOG and service improvements) plus \$1.14 billion towards the replacement of existing vehicles and related systems.

Since January 27, 2020, all cost and schedule estimates for procurement of vehicles have been advanced from a concept screening level (Class 5 cost estimate) to a feasibility level (Class 4 cost estimate). As a result, the January 2020 CIP estimate of \$5.84 billion has been revised to \$6.17 billion, which at a Class 4 estimate reflects a level of confidence sufficient to proceed with procurements as recommended through this report.

The 2020-2029 Capital Budget and Plan now provides for the purchase of new vehicles and related systems in the amount of \$1.14 billion for new vehicles and eBus charging systems, an additional \$623 million for ATC, and \$452 million in approved municipal funding for a total of \$2.24 billion (or 36%) of the \$6.17 billion capital need.

Table 1
Funding Status for Priority Vehicle Procurements

Project Description	Number of New Vehicles ¹	Estimated Total Cost ^{2,3} \$'000s	Funded \$'000s	Funded %	Unfunded \$'000s	Unfunded %	Time Horizon
New Streetcars	60	\$ 500	\$ 140	28%	\$ 360	72%	2020 - 2029
New Buses and Related Systems	1,934	\$ 2,616	\$ 846	32%	\$ 1,770	68%	2020 - 2029
Buses	1,422	\$ 1,860	\$ 686	37%	\$ 1,174	63%	2020 - 2029
Bus Charging Systems	-	\$ 500	\$ 108	22%	\$ 392	78%	2020 - 2029
Wheel-Trans Buses	512	\$ 206	\$ 52	25%	\$ 154	75%	2020 - 2029
Wheel-Trans Charging Systems	-	\$ 50	-	0%	\$ 50	100%	2020 - 2029
New Subway Trains and Related Systems	80	\$ 3,052	\$ 1,259	41%	\$ 1,793	59%	2020 - 2034
Subway Trains	80	\$ 2,240	\$ 624	28%	\$ 1,616	72%	2020 - 2034
Line 2 Automatic Train Control	-	\$ 812	\$ 635	78%	\$ 177	22%	2020 - 2032
Total	2,074	6,168	2,244	36%	3,924	64%	-

1: Number of Vehicles reflects the current fleet plan as described under the Comments section of this report.

2: Estimated Total Costs includes the following: (1) vendor contract payments for vehicle design, production, delivery and commissioning of vehicles; and (2) delivery

costs including procurement, project management, engineering, quality assurance, and project contingency (see also Cost Estimates in this Report below)

3. Total Estimated Cost has been revised from \$5.84 billion (Class 5) to \$6.17 billion (Class 4). The \$330 million increase is primarily the result of the following: increase in the streetcar estimate by \$81 million based on market engagement; increase in Wheel-Trans Buses of \$92 million based on introduction of a 7-meter-long buses in 2021 and all-electric buses starting in 2025; and an increase to the charging systems estimate by \$157 million due to advancement of fleet electrification designs and addition of scope to electrify the Wheel-Trans fleet.

Of the \$1.50 billion in approved funding for vehicle procurements, this report recommends the commitment of \$553 million to advance vehicle procurements as summarized in Table 2 below.

**Table 2
Summary of Recommended Vehicle Procurements**

Vehicle Type	Number of Vehicles Required ¹ and Estimated Cost	Vehicle Procurements Advanced through Approval of This Report ¹	Funding Approved	Expenditure Approval Through This Report
Streetcars	60 Streetcars estimated at \$500 million	Issue contract change for supply of 13 Streetcars with Delivery Starting in Q1 of 2023	\$140 million	\$140 million
Buses	1,422 Buses estimated at \$1.86 billion	Enter into contract(s) for supply of 300 Hybrid Buses with Delivery Starting in Q1 of 2022 Development of RFP for 300 eBuses with Delivery Starting in Q2 of 2023	\$686 million	\$390 million
Wheel-Trans Buses	512 buses estimated at \$206 million	Enter into contract(s) for supply of 70 Wheel-Trans Buses with Delivery Starting in Q1 of 2022	\$52 million	\$20 million
Subway	80 Subway Trains estimated at \$2.24 billion	Develop RFP for 80 Subway Trains	\$624 million	\$3 million
Total	2,074 new vehicles estimated at 4.81 billion	383 New Vehicles	\$1.50 billion	\$553 million

1: Estimated vehicle procurement quantities are based on Class 4 cost estimates. Given the need exceeds the funding currently available, TTC will seek to maximize the final number of vehicles to be procured through negotiation of contract unit pricing.

Cost Estimates in this Report

Vehicles

All cost and schedule estimates for procurement of vehicles have been advanced over the past six months from a concept screening level (Class 5 cost estimate) to a feasibility level (Class 4 cost estimate) through industry benchmarking, parametric models, and formal market engagements such as Requests for Interest and structured information sessions. With additional funding, estimates for scope (*i.e.*, exact number of vehicles to be procured), schedule, and cost estimates will be matured to project baseline (Class 3 cost estimate) through public procurement, contract negotiations, and contract award process as applicable. The contract baselines for scope, schedule, and cost will be reported to the Board as progress is made against each procurement.

Infrastructure Works

All cost estimates for infrastructure works, including facilities and vehicle related systems such as automatic train control and eBus charging systems, are identified at either a placeholder level or at a concept screening level (Class 5 cost estimate). A placeholder is not an estimated cost, but rather an amount chosen to represent a largely unknown budgetary pressure – it precedes the Class 5 concept screening level estimate. The Class 5 cost estimate, or concept screening level estimate, is derived through parametric scaling, judgment, or analogy of actual costs for similar projects and is referred to as an order of magnitude estimate. Engineering studies will refine the scope, schedule, and cost estimates for infrastructure works and estimates will continue to be matured and presented for stage gate approval through future reporting to the Board, including future capital budget submissions.

Approval of the report's recommended procurements will assist the TTC in meeting its capital need for replacement buses, streetcars and Wheel Trans vehicles by providing 383 new vehicles based on the available \$1.50 billion in approved funding. However, this is 1,691 short of the 2,074 vehicles required and its associated funding.

Consequently, it is recommended, that the TTC Board request the Provincial and Federal governments to provide the remaining funding so that the municipal funding can be leveraged to enable the TTC to procure the full program of new vehicles and related systems.

The Interim Chief Financial Officer has reviewed this report and agrees with the financial impact information.

Equity/Accessibility Matters

Equity

A reliable transit network is critical for equity-seeking groups relying on TTC services to get to work, school, access health services, participate in recreational and cultural services, etc. Studies have shown that people who have less access to public services, including transit, typically have worse economic and health prospects. Access to transit that is equitable, accessible, safe, reliable, and that grows with or ahead of the population will help improve health outcomes, economic prosperity, and equality throughout the City of Toronto, regionally and nationally.

This report recommends procurement of vehicles, identifies needed investment in facilities and related systems, and highlights opportunities to advance the TTC's innovation pipeline, all of which aims to improve health and economic outcomes for all, but with particular benefit to those who rely on public transit as their primary or sole means of transportation.

Accessibility

The TTC has a strong organizational commitment to making Toronto's transit system barrier-free and accessible to all. The TTC believes all customers should enjoy the freedom, independence, and flexibility to travel anywhere on the public transit system, regardless of ability. The TTC's commitment to providing accessible transit is at the forefront of its 2018-2022 Corporate Plan and the 15-Year CIP.

The TTC's 2020-2029 Capital Budget and Plan includes the TTC's Easier Access Program, which is on track to make all subway stations accessible by 2025 with elevators, wide fare-gates, and automatic sliding doors.

The vehicle procurements advanced by TTC staff for approval by the Board in this report will make efficient use of resources to replace vehicles at end of life rather than implement life extension programs, add critically needed capacity to the transit system to meet customer demand, and, through the application of ever improving designs, will help maintain a modern and increasingly inclusive and accessible transit system for all.

Procuring new vehicles provides an opportunity to review and improve designs through the systematic identification and removal of barriers. During new vehicle specification, procurement, design, and validation processes, TTC will continue to ensure new vehicles meet all relevant standards under the Accessibility for Ontarians with Disabilities Act, leverage international best design practices, and work closely with the Advisory Committee on Accessible Transit (ACAT).

Decision History

On January 24, 2019, the TTC Board approved the TTC's first 15-Year CIP. The CIP captured the TTC's estimate of long-term capital needs and formed a baseline against which future Capital Budgets and Plans would be based.

Making Headway: Capital Investments to Keep Transit Moving:

[http://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2019/January 24/Reports/10 TTC Capital Investment Plan Supplementary.pdfh](http://www.ttc.ca/About%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2019/January%2024/Reports/10%20TTC%20Capital%20Investment%20Plan%20Supplementary.pdfh)

On December 12, 2019, the TTC Board adopted the information contained in the 2020 5-Year Service Plan & 10-Year Outlook. The 2020-2029 CIP included the capital investments (unfunded) required to complement the service improvements contained in the Service Plan:

[http://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2019/December 12/Reports/16 5 Year Service Plan and 10 Year Outlook.pdf](http://www.ttc.ca/About%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2019/December%2012/Reports/16%205%20Year%20Service%20Plan%20and%2010%20Year%20Outlook.pdf)

[http://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2019/December 12/Reports/Attachment%201%20TTC 5 year SP web accessible R3.pdf](http://www.ttc.ca/About%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2019/December%2012/Reports/Attachment%201%20TTC%205%20year%20SP%20web%20accessible%20R3.pdf)

On December 16, 2019, TTC Board approved the 2020 TTC and Wheel-Trans Operating Budgets, and the 2020-2029 Capital Budget and Plan:

2020 TTC and Wheel-Trans Operating Budgets:

[http://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2019/December 16/Reports/1 2020 TTC and Wheel Trans Operating Budgets.pdf](http://www.ttc.ca/About%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2019/December%2016/Reports/1%202020%20TTC%20and%20Wheel%20Trans%20Operating%20Budgets.pdf)

2020-2029 Capital Budget & Plan and 15-Year Capital Investment Plan:

[http://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2019/December 16/Reports/2 TTC 15 Year Capital Investment Plan and 2020 2029 Capital .pdf](http://www.ttc.ca/About%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2019/December%2016/Reports/2%20TTC%2015%20Year%20Capital%20Investment%20Plan%20and%202020%202029%20Capital.pdf)

Presentation:

[http://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2019/December 16/Reports/1 TTC Recommended Budgets 2020 Operating Budget 2020-2029 Ca.pdf](http://www.ttc.ca/About%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2019/December%2016/Reports/1%20TTC%20Recommended%20Budgets%202020%20Operating%20Budget%202020-2029%20Ca.pdf)

On December 17, 2019, City Council approved an incremental tax levy dedicated to providing funding for Community Housing and Transit. The incremental City Building Fund included \$4.06 billion dedicated to transit to help alleviate some of the unfunded capital needs identified through TTC's 2020-2029 Capital Budget and Plan and the 15-Year CIP:

<http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2019.EX11.26>

On January 27, 2020, the TTC Board amended its approval of the 2020-2029 Capital Budget and Plan to reflect additional funding made available through the City Building Fund. This provided the TTC with an additional \$4.73 billion in new capital funding to enable the TTC to fund \$500 million towards the Bloor-Yonge Station capacity improvement project, \$3.09 billion for subway infrastructure (SOG and Service Improvements) plus \$1.14 billion towards the replacement of existing vehicles and related systems.

Report:

[https://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2020/January 27/Reports/10 TTCs 2020 2029 Key Capital Investment Priorities Subway I.pdf](https://www.ttc.ca/About%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2020/January%2027/Reports/10%20TTCs%202020%202029%20Key%20Capital%20Investment%20Priorities%20Subway%20I.pdf)

Decision:

[https://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2020/January 27/Reports/Decisions/10 TTCs 2020 2029 Key Capital Investment Priorities Subway I.pdf](https://www.ttc.ca/About%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2020/January%2027/Reports/Decisions/10%20TTCs%202020%202029%20Key%20Capital%20Investment%20Priorities%20Subway%20I.pdf)

On February 25, 2020, the TTC Board received the TTC Green Bus Program Update report for information and further adopted motions requesting staff to:

1. report back on potential partnership opportunities that could advance design, procurement, construction, and enable co-investment, co-ownership, and co-maintenance of TTC's electric vehicle charging infrastructure; and
2. direct the TTC CEO to submit to the September 2020 TTC Board meeting a business case analysis for action on an expedited procurement plan for the 614 funded buses included in the revised 2020-2029 Capital Budget and Plan.

Report:

[https://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2020/February 25/Reports/7 TTC Green Bus Program Update.pdf](https://www.ttc.ca/About%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2020/February%2025/Reports/7%20TTC%20Green%20Bus%20Program%20Update.pdf)

Decision:

[https://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2020/February 25/Reports/Decisions/7 TTC Green Bus Program Update Decision.pdf](https://www.ttc.ca/About%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2020/February%2025/Reports/Decisions/7%20TTC%20Green%20Bus%20Program%20Update%20Decision.pdf)

On February 25, 2020, the TTC Board approved the purchase of 111 Wheel-Trans vehicles, 90 of which were conditional on ACAT approval.

Report:

[https://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2020/February 25/Reports/8 Procurement Authorization Purchase of Wheel-Trans Buses.pdf](https://www.ttc.ca/About%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2020/February%2025/Reports/8%20Procurement%20Authorization%20Purchase%20of%20Wheel-Trans%20Buses.pdf)

Decision:

[https://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2020/February 25/Reports/Decisions/8 Procurement Authorization Purchase of Wheel Trans Buses De.pdf](https://www.ttc.ca/About%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2020/February%2025/Reports/Decisions/8%20Procurement%20Authorization%20Purchase%20of%20Wheel%20Trans%20Buses%20De.pdf)

Issue Background

On January 27, 2020, the TTC Board amended its approval of TTC's 2020-2029 Capital Budget and Plan to incorporate additional funding made available by Toronto City Council through the City Building Fund. This provided the TTC with an additional \$4.73 billion in new capital funding to enable the TTC to fund \$500 million as the City's one third share of the Bloor-Yonge Capacity Improvement priority project; an additional \$3.09 billion for critical subway infrastructure (SOGR and Service Improvements) plus \$1.14 billion towards the overhaul and replacement of existing vehicles.

When evaluating options for where best to apply this significant contribution towards the TTC's unfunded capital needs, the TTC applied the following criteria to allocate the net new funding:

1. **Safety/Legislative:** Projects that ensure our infrastructure are in a state-of-good repair for safety and legislative compliance.
2. **Critical State of Good Repair:** Projects that maximize capital assets' capability to operate at full performance levels.
3. **Service Improvements:** Projects that address the current and projected requirement for service demand..

The \$3.09 billion provided funding for subway infrastructure safety and SOGR projects within the 2020 and 2029 timeframe for the following:

1. \$1.49 billion toward the Line 1 Capacity Enhancement program.
2. \$817 million toward the Line 2 Capacity Enhancement program.
3. \$623 million toward implementation of Line 2 ATC re-signalling project.
4. \$158 million toward other subway infrastructure SOGR projects.

The \$1.14 billion, when added to the \$474 million in existing funds (formerly allocated to the T1 Life Extension Overhaul), resulted in a total of \$1.61 billion and was applied toward the overhaul of existing vehicles, procurement of new vehicles, and delivery of related systems as follows:

1. **New Subway Trains**

\$623 million toward procurement of 80 subway trains, including replacement of the 62 legacy T1 trains on Line 2 and 18 trains to match capacity to customer demand.

2. **T1 Subway Train Maintenance and Overhaul**

\$74 million allocated for the SOGR of T1 vehicles to ensure they remain safe and reliable until 2030 when they will be fully replaced at end-of-life by the 62 new trains.

3. Buses and eBus Charging Systems

- \$686 million for procurement of buses.
- \$64 million toward eBus charging system infrastructure.

4. Wheel-Trans Buses

\$22 million toward procurement of Wheel-Trans buses

5. New Streetcars

\$140 million toward procurement of 60 additional streetcars

Subsequent to the January report, all cost and schedule estimates for procurement of vehicles were advanced through industry benchmarking, parametric models, and formal market engagements.

With more than the typical one-third municipal share for such investments, the original intent was to engage in procurements after securing full funding from other level of governments. Due to COVID-19 related delays, it is now critical to initiate this work with the funding available and secure on-time delivery of new vehicles that will ensure the SOGR of the transit system and match capacity to customer demand.

With funding currently available, the TTC can advance procurements as recommended through this report.

Comments

The TTC's Multi-Modal Fleet and Facility Plan (Plan) pulls together and integrates data, assumptions, and constraints from across the organization to inform strategy and planning for key vehicle and infrastructure investments.

For each mode, the Plan reflects projected service demands, associated fleet sizes projected over the next 15-years, the current capacity of maintenance and storage facilities and trigger points for needed increases, milestones for commissioning of new subway and light rail lines, timeline for introduction of new technology, constraints, and interdependencies between modes.

When reviewing these factors, it is clear that the interdependency posing the greatest risk is the ongoing need for buses to supplement service on streetcar routes. The 50 buses allocated for this purpose are an attempt to match capacity to customer demand. However, the effectiveness of this mitigation is only partial given that one streetcar has the capacity of two and a half buses. Further, the mitigation itself introduces a secondary issue, as there are fewer buses available to improve service and match capacity to customer demand.

Following this example through, this issue is solved for both modes through the procurement of 60 additional streetcars as recommended through the CIP. However,

until those new streetcars arrive, customers on both modes will experience overcrowding.

Due to the high impact of streetcar service demands on the bus fleet, this section describes strategies for accelerated procurements in the following order: streetcars, buses, Wheel-Trans buses, and subway trains. The latter is the only priority need that cannot yet be committed to given the current level of funding. This order is not reflective of corporate priority, as described in the January Board Report “TTC’s 2020-2029 Key Capital Investment Priorities”, but the logical order of precedents given constraints imposed by interdependencies and the current state of funding.

Streetcar Fleet and Facilities

The TTC’s CIP identified the need for 60 additional streetcars. These vehicles were initially required to address latent service demand, projected increases in travel time due to traffic congestion, and to enable growth within the practical constraints of storage and maintenance capacity.

First delivery of new streetcars can be expected as early as Q1 of 2023 or as late as 2025, depending on the procurement approach taken. The time required for streetcar service demand to recover fully from the disruption caused by COVID-19 is uncertain; however, TTC must work to increase capacity through additional streetcars before demand returns to pre-COVID levels.

Additionally, these additional streetcars offer the dual benefit of: 1) addressing immediate streetcar fleet requirements; and 2) allowing for the reallocation of 50 buses, that are currently supplementing streetcar service, to return to operate on bus routes.

In January 2020, the TTC Board approved allocation of funding committed by Toronto City Council through the City Building Fund in the amount of \$140 million toward the procurement of 60 streetcars. The TTC and City are seeking matching funding contributions from intergovernmental partners to fulfill the full streetcar requirement.

Streetcar Procurement Strategy and Plan

In February 2020, the TTC engaged a consultant to perform an independent risk-based assessment of procurement options. The TTC also issued an RFI in order to ensure input to the assessment reflected current market sounding data as it related to the vendors’ interest and ability to deliver new streetcars that meet the following:

1. The technical requirements to operate in TTC’s network.
2. Delivery starting in early 2023 to match capacity with customer demand.
3. Ensure value-for-money and fair market cost.
4. Minimize risk to schedule and cost.

The five respondents to the RFI were as follows (in alphabetical order): Bombardier, CRRC Qingdao-Sifang, CRRC Tangshan, Hyundai Rotem, and Siemens.

Procurement Quantity

All vendors have non-recurring costs to amortize across the production quantity and the supply chain would demand higher unit prices for lower part quantities. Bombardier will have non-recurring costs to remobilize their production line, and all other vendors will need to invest in design, testing, changes to the supply chain to achieve 25% Canadian content, as well as production mobilization. These costs must be amortized over the initial procurement quantity resulting in a higher unit cost at 10 streetcars than at 60 streetcars.

Based on our assessment of vendor responses to the RFI, the funding available will allow for procurement of between 10 and 15 streetcars.

Procurement Options: New Procurement Vs Contract Change

The recommended procurement option must deliver new streetcars on-time to meet projected customer demand and minimize risk of both cost and schedule overruns. A summary of the risk-based assessment is as follows:

1. Ability to Meet Technical Requirements

New Procurement Option: All existing vehicle platforms proposed by the respondents required varying levels of modifications to the vehicle design; however, all vendors are believed to be capable of developing a technically compliant vehicle given time to design, prototype, and validate modifications to their standard vehicle platforms.

Contract Change with Bombardier: Bombardier proposed their Flexity Outlook vehicle platform for the additional streetcar order; the same streetcar supplied to the TTC under the existing base contract. This platform has been service proven to operate in TTC infrastructure and has met the contractual reliability targets.

The technical risks associated with vehicle design, integration, and reliability are lowest for the contract change option.

2. Ability to Deliver Starting in early 2023

New Procurement Option: All vendors would require approximately three years for design, prototype manufacturing, testing, and to begin delivery of their standard platform vehicle without any of the required customizations to run on the TTC's infrastructure.

While schedule submissions varied widely, vendors who appeared to have the best understanding of TTC's technical requirements estimated delivery of mass production vehicles to start in 2025, assuming contract award in Q1 of 2021 and minimal schedule contingency. This timeline is consistent with the fact that no vendor has a record of delivering a customized vehicle in North America in under four years.

Contract Change with Bombardier: Bombardier's submitted timeline included remobilization of their production line and delivery commencing in 2022.

Considering both the technology risk described previously and the fact that only Bombardier submitted a response that reflects a vehicle design that meets TTC's requirements, the schedule risk is lowest for the contract change option. With schedule contingency, it is TTC's assessment that deliveries would start in early 2023.

3. Ability to Deliver within Budget

New Procurement Option: Industry responses on the Rough Order of Magnitude (ROM) pricing for 60 streetcars ranged from \$200 million to \$500 million with Bombardier's response in middle of the range.

All vendors, other than Bombardier, acknowledged that their standard platform would require "major design modifications" and that additional investment would be needed should Canadian Content be required. Non-recurring costs for a new procurement of this complexity is estimated at approximately \$100 million. As such, pricing that reflects the TTC's minimum technical requirements are expected to be significantly higher than ROM pricing provided through the RFI.

Other significant cost factors and budget risks associated with any new procurement include:

- **Project Delivery:** The cost of delivering a program with significantly higher technical complexity and longer duration is expected to be approximately \$10 million higher for a new procurement compared to a contract change.
- **Mixed Fleet:** When operating a mixed fleet there is an incremental increase in operating and maintenance costs over the vehicles' lifetime for parts management, training, etc., estimated at 10% to 15% of the capital cost or \$40 million to \$60 million.

With a new procurement, the cost variance could be advanced from the current Class 4 level of confidence to Class 3 (within -20% to +30%) upon contract award with a new vendor.

Contract Change with Bombardier:

Given the base order from Bombardier was completed so recently, their non-recurring costs would be relatively low at approximately \$50 million.

This amount would be spread over the procurement quantity, resulting in unit costs that descend significantly as the quantity increases (see Chart 1).



While the first 20 streetcars, for example, would cost approximately \$9.2 million each, the remaining 40 streetcars would cost approximately \$6.4 million each, bringing the average cost down to \$7.3 million each when ordering 60 streetcars.

As mentioned previously, all vendors other than Bombardier state they would have to undertake major modifications to their standard platform. Streetcars supplied by Bombardier are likely to be lower in cost due to the lower non-recurring costs and the relatively low production quantities.

Should additional sources of funding be identified by Q2 of 2021, contract options can be exercised to increase the quantity without incurring any additional non-recurring cost.

Subject to successful negotiation with Bombardier for final pricing, the expected cost variance could be advanced from the current Class 4 confidence level to Class 2 - within -15% to +20%.

The financial risk is lowest for the contract change option.

Based on market responses and the independent risk-based procurement options assessment, a contract change with Bombardier is the only option that is likely to ensure delivery of additional streetcars on-time and that offers the lowest overall risk when considering technical scope requirements, schedule, and budget.

With the same terms as the existing contract with Bombardier, a contract change would result in an initial procurement quantity of 12 streetcars. By altering the contract terms, such as waiving liquidated damages and advancing cash flow through a larger upfront milestone payment, the procurement quantity rises from 12 to 13 streetcars. Through

contract negotiations, TTC would ensure sufficient leverage through remaining cash flows and mitigation of risk through a performance bond.

Should additional sources of funding be identified by Q2 of 2021, options for up to a combined total of 60 streetcars could be secured within the current Class 4 estimate of \$500 million, inclusive of all delivery costs.

Streetcar Facility Plan

The TTC's three existing streetcar facilities can accommodate a total of approximately 239 streetcars, beyond which safety and reliability of operations would demand additional storage and maintenance capacity at TTC's Hillcrest facility. A \$100 million investment in the Hillcrest facility would accommodate approximately 25 of the 60 additional streetcars, allowing for a total fleet size of 264 vehicles and improving service resiliency through the addition of a fourth facility located adjacent to St. Clair Avenue right-of-way, a major streetcar route.

This report recommends the immediate procurement of 13 additional streetcars with the funding currently available. Existing facilities can accommodate 13 streetcars; however, should additional sources of funding be identified to ensure supply of all 60 streetcars to meet fleet requirements, an investment in the Hillcrest facility will be required by Q1 of 2021 to ensure capacity is available in advance of approximately Q1 of 2024 when the total fleet size exceeds the maximum capacity currently available.

Immediate Next Steps:

Of the \$500 million estimated total cost for 60 additional streetcars approximately \$140 million (or 23%) is funded. When combined with the additional \$100 million for the associated facility modifications required to TTC's Hillcrest facility, there is an incremental funding need of \$460 million. Given this, the next immediate steps are outlined below:

Fleet: With existing funding, secure a base order for accelerated delivery of 13 streetcars between Q1 of 2023 and Q1 of 2025. To ensure the earliest possible delivery of additional streetcars with the lowest technical, schedule, and cost risk, a contract change with Bombardier is recommended.

This initial order would ensure capacity matches customer demand on both streetcars and bus routes as it allows for the reallocation of buses currently allocated to supplement service on streetcar routes. The order would also allow for an increase in procurement quantity to a combined total of 60 additional streetcars through contract options should sources of additional funding be identified prior to the end of Q1 of 2021.

Facilities: Advance study of necessary modifications to Hillcrest (currently funded to \$2.5 million) to enable storage, maintenance, and delivery of service for up to 25 streetcars.

Secure funding commitment for remaining \$97.5 million (placeholder) by Q4 of 2020 (along with remaining funding required for all 60 additional

streetcars) to ensure delivery of required facilities infrastructure in time for delivery of the last 25 of 60 streetcars.

Note: The study to be performed at Hillcrest to accommodate additional streetcars is one component consideration in the overall scope of work to determine the highest and best use of the entire Hillcrest complex. Progress against this study is to be reported through a TTC Real Estate Investment Plan.

Bus Fleet and Facilities

The TTC's CIP identified the need for 1,575 buses from 2020 to 2029. This included 1,347 buses for SOGR and 228 buses for service reliability, network improvements and to address pre-COVID projections for ridership growth.

Investments in higher order transit, including Light Rapid Transit (LRT), Bus Rapid Transit (BRT), and the additional 60 streetcars, allow for buses from the existing fleet to be reinvested to address the need for future growth as follows:

- 50 buses reallocated from streetcar routes
- 50 buses reallocated with opening of Eglinton LRT
- 25 buses reallocated with opening of Finch LRT
- 18 standard 12m (40 foot) long buses reallocated with commissioning of 68 new 18m (60 foot) long articulated buses
- 10 buses reallocated with opening of 5 Bus Rapid Transit ways

Assuming continued support for these projects, it is estimated that approximately 150 buses could be reinvested to deliver added capacity over the next five years. As a result, the number of buses required between 2020 and 2029 is revised from 1,575 buses to 1,422.

The TTC 2020-2029 Capital Budget and Plan includes approximately \$794 million in funding, with \$686 million for buses and \$108 million for charging systems, for the TTC's Green Bus Plan. With a 10-year estimated cost of \$1,860 billion for new buses and \$500 million for eBus charging systems, this amount represents approximately 34% of the \$2.36 billion total cost, and will be sufficient for the procurement of approximately 600 buses.

Bus Procurement Strategy and Plan

The TTC Green Bus Technology Plan, originally approved by the TTC Board in November 2017, recommended the purchase of hybrid-electric buses as a transition technology toward zero-emissions buses and an initial procurement of 60 eBuses from the only manufacturers of long-range battery electric buses: BYD, New Flyer Industries, and Proterra. These procurements were to be followed by at least one year of eBus head-to-head testing before the next procurement.

The head-to-head evaluation was to begin in Q1 2019 and include 2019/2020 winter testing of both eBus and charging systems. However, due to a 10+ month delay in production and delivery of BYD buses and COVID-19 related delays in commissioning, head-to-head testing began in August 2020, over one year late.

As results of winter testing are required before finalizing the design of the next production of eBuses, delivery is delayed by one year, from 2022 to 2023. In an effort to maintain progress toward fleet electrification, the 80 eBuses originally targeted for 2022 will not be eliminated, but rather added to those previously planned for 2023 and 2024.

This slip in the schedule for head-to-head testing, while unfortunate, will provide schedule contingency for the eBus charging systems infrastructure program, ensuring chargers are in place ahead of bus deliveries in 2023.

The result is the revised procurement plan in Table 3, with procurement of only zero-emissions buses starting a year earlier than previously planned.

**Table 3
Revised Bus Procurement Plan**

Bus Technology	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	Total
Hybrid-Electric	0	0	298	39	n/a	n/a	n/a	n/a	n/a	n/a	337
All-Electric	0	0	0	100	133	167	170	170	170	175	1,085
Total	0	0	298	139	133	167	170	170	170	175	1,422

To ensure SOGR of the bus fleet and to maximize the economies of scale, it is recommended to engage the market for procurement of approximately 600 replacement buses. Along with the reallocation of buses displaced by higher orders of transit, the 600 buses will address fleet requirements in 2022, 2023, 2024 and through Q1 of 2025.

To mitigate against the risk of higher than expected customer demand or a requirement for greater physical distancing leading to the need for additional buses, all procurement contracts will include contract options for buses beyond the base scope.

Hybrid-Electric Buses

As reported to the TTC Board in February through the TTC Green Bus Program Update, between 2018 and 2019 the TTC procured a total of 255 of the latest generation hybrid-electric buses under the Government of Canada’s Public Transit Infrastructure Program.

When compared to the conventional diesel buses they replaced, these new hybrid-electric buses lower greenhouse gas emissions by 47%, they are saving the TTC \$6.5 million annually, and their reliability has consistently exceeded the TTC’s target metric for mean distance between failures.

Furthermore, the hybrid bus plays a critical role in the TTC's transition towards a zero-emissions fleet as the technology provides maintenance staff, operators, and our customers the experience of an all-battery electric bus.

The procurement plan identifies the need for 337 hybrid-electric buses between 2022 and 2023, including 269 12m (40 foot) long buses and 68 18m (60 foot) long articulated buses. Due to the proven maturity of both the hybrid-electric propulsion technology and the TTC's hybrid bus technical specification, this procurement will be advanced quickly following Board approval of this report.

Subject to confirmation by the Fairness Monitor, General Counsel and the TTC Chief Executive Officer, the contract(s) will be awarded and progress will be reported to the Board on a quarterly basis.

All-Electric Long-Range Buses

Procurement of eBuses can commence immediately following completion of winter testing and staff's report of results to the TTC Board in Q2 of 2021.

With an RFP process that takes three to six months and a design and production lead-time for all-electric buses of 18 months, deliveries would begin in 2023.

Due to the transformational nature of the eBus program, the RFP is being structured using an innovative approach that engages all major stakeholders throughout the procurement process.

The procurement process will include the following:

1. Retention of a Procurement Consultant Firm with experience in innovative procurements.
2. Retention of a Fairness Monitor.
3. Engagement of internal stakeholders and customer focus groups (including ACAT) to solicit input to the RFP.
4. All vendors will be invited to participate, including BYD Canada, New Flyer Industries, Nova Bus, and Proterra.
5. Vendors will be qualified based on their ability to supply a product that meets the TTC's 'must haves' list reflecting lessons learned to-date.
6. Submission of an initial proposal package by qualified vendors.
7. The TTC will host information sessions for each qualified vendor with key stakeholders including the following:
 - i. Customer Focus Group, including members of the Advisory Committee on Accessible Transit.
 - ii. Transportation Employees (incl. operators and management).

- iii. Bus Maintenance Employees (incl. maintainers and management) and Toronto's Emergency Services.
8. Updates to the technical specifications reflecting input from key stakeholders and re-issuance to qualified vendors.
9. Submission of final proposal package by qualified vendors.
10. Evaluation of final submissions and determination of weighted scores for each qualified vendor based on final technical proposals.
11. Selection of up to 2 vendors based on value-for-money ranking of commercial and technical proposals.

Bus Facility Plan

Need for a 9th TTC Bus Garage

The eight existing bus garages have a design total capacity of approximately 2100 buses. With growth over the next five years accommodated through reallocation of buses from streetcar routes, LRTs and BRTs, etc., and with capacity for an additional 20 buses at each of the existing garages, the need for a 9th maintenance and storage facility is revised to the mid-2030s.

To prepare for growth beyond the mid-2030s, TTC has undertaken an initial scan of all eight existing garages and identified the potential to increase storage and maintenance capacity within the limits of the existing properties and/or by procuring adjacent land. An engineering study is required as the next step, after which the business case, including benefits and estimated timing and costs, will be developed.

Progress of this study will be reported through the TTC Real Estate Investment Plan.

eBus Charging Systems Infrastructure

Working closely with Toronto Hydro over the past three years, the TTC has successfully delivered and commissioned charging system infrastructure for its first 60 battery-electric buses. This work is recognized across the transit industry as the most critical and challenging aspect of fleet electrification.

As the TTC looks towards full electrification of its bus, Wheel-Trans, and non-revenue vehicle fleets, it is clear that the TTC needs to continue to build on its work with Toronto Hydro and expand strategic partnerships with its utilities. With this in mind, and in preparation for a report back to the TTC Board on its direction to explore potential partnership opportunities for delivery of eBus infrastructure, staff have been working with both Toronto Hydro and Ontario Power Generation (OPG) on what has the potential to result in Canada's first tri-party agreement between a transit agency and utilities to jointly implement full-fleet electrification.

This agreement would serve as a declaration of mutual intent and outline roles and responsibilities for this innovative delivery model between public agencies and

corporations. Toronto Hydro would deliver increased electrical service capacity to each of the TTC bus garages (as well as on-route charging sites if required in the future) ahead of the electrification schedule. In turn, OPG would undertake the design, build, operations, and maintenance of all on-site charging infrastructure under a definitive agreement reflecting a co-investment/co-ownership model.

A draft agreement is tentatively targeted for consideration by the TTC Board in Q1 of 2021. In the meantime, TTC, Toronto Hydro, and OPG are working proactively on feasibility studies, preliminary design, detailed scheduling, and procurement strategies to keep pace with future eBus deliveries and full fleet electrification.

Immediate Next Steps:

Of the \$2.36 billion estimated for the procurement of 1,422 buses and related charging systems from 2020 through 2029, approximately \$794 million (34%) is funded.

Fleet: With existing funding, secure orders for accelerated delivery of approximately 600 buses starting in early 2022.

Of the 1,347 required for replacing buses at end-of-life, current procurement plans include 337 hybrid-electric buses and 1,010 all-electric buses starting in 2022 through 2029. Applying the funding available toward SOGR only ensures delivery of the 600 buses required in 2022, 2023, 2024, and through Q1 of 2025.

Based on the one-and-a-half-year long lead-time for procurement of all-electric buses, secure commitments by Q2 of 2021 for additional sources of funding in the amount of \$1.17 billion for the remaining 822 all-electric buses needed in 2025 through 2029.

Facility: With existing funding, advance design, procurement, and construction of charging systems in 2021 and 2022 in advance of eBus deliveries.

Advance discussions with Toronto Hydro Electrical Supply Ltd and Ontario Power Generation to establish agreement(s) for delivery of infrastructure for full fleet electrification and to ensure ongoing resiliency and performance of that infrastructure to support TTC operations.

Secure \$442 million in additional funding for 2023 through 2029 to ensure changing systems infrastructure advances ahead of procurements.

Wheel-Trans Fleet and Facilities

The TTC's CIP identifies the need for 525 new Wheel-Trans buses from 2020 through 2029 for state-of-good-repair (SOGR) and to address projected growth. Of the 525 buses, 512 are required for SOGR (including accelerated retirement of the legacy fleet by 2022).

There has been no growth in Wheel-Trans ridership over the past five years and while the impact of Family of Services on ridership has yet to be determined, the focus of investment will be on maintaining SOGR of the existing fleet. The total need has been revised from 525 to 512 Wheel-Trans buses from 2020 through 2029.

As part of the 2020 Budget process, \$22 million in new funding from the City of Toronto's City Building Fund was allocated towards the procurement of new Wheel-Trans buses. Combined with pre-existing funding, the total approved funding is \$52 million which will be sufficient for the procurement of approximately 180 new Wheel-Trans buses.

At the February 2020 TTC Board meeting, staff recommended the procurement of a slightly larger vehicle than the 6-metre ProMaster. This larger vehicle, a 7-metre ProMaster, will allow the TTC to accomplish the following:

1. Carry customers with larger mobility devices or with medically supported restrictions, which represents approximately 2% of the trips (17,000 trips annually). Neither the 6-metre ProMaster or contracted services are able to accommodate this.
2. Accommodate ridership growth, which is approaching the target of three Passengers Per Hour (PPH).
3. Continue operating the Community Bus Program following retirement of the last 'Friendly' buses.

The TTC Board approved the immediate procurement of 20 new 6-metre ProMasters vehicles and one prototype of the newer 7-metre long vehicle. The TTC Board also granted approval to procure an additional 90 7-metre ProMasters subject to ACAT's approval of the prototype.

With conditional approval by the TTC Board in January 2020 for supply of 111 new Wheel-Trans buses, there remains funding for an additional 70 of the 94 buses required in 2022 and 2023.

Wheel-Trans Procurement Plan

To ensure SOGR of the bus fleet and to maximize the economies of scale, it is recommended through this report to further engage Metrolinx on procurement of approximately 70 additional Wheel-Trans buses. This additional procurement quantity, which is still pending ACAT approval of the pilot 7-metre ProMaster bus, will ensure the SOGR of the Wheel-Trans bus fleet through 2022 and begin to address SOGR requirements in 2023.

Wheel-Trans Green Bus Plan

As part of the TTC's efforts to green all of its revenue and non-revenue fleets, staff is investigating options for zero emission buses for the Wheel-Trans fleet. Currently, there are no known available options on the market for all-electric buses that are in the size range

required (6-metre to 7-metre) for Wheel-Trans operations and that comply with the Government of Canada's Commercial Motor Vehicle Safety Standards.

A Request for Information (RFI) was released in August 2020 to formally survey the market's availability to supply suitable 6 to 7-metre-long all-electric buses. Accordingly, the TTC will develop a Green Fleet Plan for Wheel-Trans buses and report back to the TTC Board as options become available.

In the interim, the TTC is participating in Metrolinx's TPI program for the purchase of Wheel-Trans vehicles.

Wheel-Trans Facility Plan

While battery electric vehicles that meet Wheel-Trans requirements are not yet available, it is expected that the market will respond to this need in the next three to five years.

An investment to design, procure, and construct charging systems infrastructure at the TTC's Lakeshore Garage will be required to enable Wheel-Trans fleet electrification by 2040 in line with the TTC's target for the conventional bus system and TransformTO.

Immediate Next Steps:

Of the \$206 million estimated cost for the procurement of 512 Wheel-Trans buses and \$50 million for related charging systems from 2020 through 2029, approximately \$52 million (20%) is funded.

Fleet: The TTC issued a purchase order for the 7-metre pilot vehicle to Creative Carriage Ltd. in March 2020. Since that time, the project team has been meeting with the vendor to review the design based on feedback received from stakeholders, including ACAT. Updates on the progress of this project continue to be communicated to all internal and external stakeholders regularly.

7-metre Pilot ProMaster

The pilot vehicle was delivered on September 15, 2020 and is currently undergoing commissioning activities and engineering tests to evaluate ride quality, noise, and lighting levels. Once the vehicle is commissioned, it will be presented to ACAT members

and internal stakeholders for in-person review and to experience the ride quality of the vehicle. The TTC will then place the 7-metre pilot vehicle into service to gather additional feedback from a wider audience. Upon successful completion of these activities, and with formal endorsement of ACAT through meeting



minutes, the remaining 90 production units will be ordered for delivery in 2021 and 2022.

With existing funding, secure orders for accelerated delivery of approximately 70 additional buses starting in 2022.

Based on the one-and-a-half-year long lead-time for procurement of Wheel-Trans buses, secure commitments by Q2 of 2021 for additional sources of funding in the amount of \$154 million to fully fund the 512 Wheel-Trans buses needed in 2023 through 2029.

Secure additional funding for SOGR and moderate growth from 2023 to 2029.

Subway Fleet, Signalling, and Facilities

The TTC's CIP identifies the need for 80 new subway trains, including 62 to replace the T1 fleet on Line 2 and 18 for growth on Line 1, all of which are required to be delivered in 2026 through 2030. The CIP also identified the need to replace the aging signalling system on Line 2 with ATC. The total need for these highly interdependent programs is approximately \$3.05 billion.

The 2020-2029 Capital Budget and Plan includes \$624 million for procurement of new subway trains and \$635 million for the Line 2 ATC re-signalling program. The funded amount of \$1.26 billion represents the City's 41% contribution toward the total estimated cost.

Of the remaining \$1.79 billion required to fully fund new subway trains and ATC on Line 2, a commitment of \$1.61 billion is required by Q1 2021 for new subway trains and the remaining \$177 million is required for Line 2 ATC post-2029. These investments would complete the modernization of TTC's subway trains and train controls systems, and provide options to Metrolinx to procure trains for subway expansion projects.

Line 1 – Ridership Growth Requirement

On Line 1, ATC will be fully commissioned in 2022. With a temporary reduction in the subway fleet maintenance spare ratio, ATC will enable more frequent train service to accommodate ridership demand to approximately 2026. Anticipating a full return of ridership by that time, an additional 18 trains will be required for delivery in 2026 and 2027 to restore the spare ratio and match service capacity with customer demand. This increase in capacity, along with improvements made through the Line 1 Capacity Enhancement Program and relief provided by the Ontario Line in the late 2020s, will meet projected demand within the existing system until the early 2040s.

Additional trains required to operate the Yonge North Subway Extension are to be funded by Metrolinx. Contract options in the TTC's procurement would present Metrolinx the opportunity to secure additional trains from the same production line and offer economies of scale.

Line 2 – State-of-Good-Repair Requirement

The first priority for capital investment is to ensure safety and SOGR including the on-time replacement of critical assets. On Line 2, the TTC operates T1 subway trains, which are currently 21 to 25 years old. With a design life of 30 years, the fleet will reach the end-of-life starting in 2026. Upon completion of the Line 1 and Line 2 Capacity Enhancement Studies, the TTC's Multi-Modal Fleet and Facility Plan will be reviewed accordingly to confirm (or revise) the number of trains required for long-term growth.

Subway Train Procurement Strategy and Plan

The January Board Report "TTC's 2020-2029 Key Capital Investment Priorities", identified subway procurement as TTC's first corporate priority given its potential to provide additional capacity (on both Line 1 and Line 2) and thereby mitigate station overcrowding and associated safety risks. However, the procurement of subway trains is the only priority need that cannot yet be committed to given the current level of funding. There are two options to satisfy the subway fleet requirement:

1. Option A (recommended): Secure full funding to procure 80 trains and implement ATC on Line 1 as follows:
 - 62 trains to replace the T1 fleet on Line 2 at end-of-life with state-of-the-art technology and greater interior capacity starting in 2026; and
 - Replace the signalling system on Line 2 with ATC in sequence with completion of the T1 replacement by 2032 to ensure SOGR, improve service reliability, and enable future growth; and
 - 18 additional trains for growth on Line 1 utilizing the same contract as for the 62 replacement trains for economies of scale; and

This option requires a commitment of \$1.61 billion in net new funding by Q1 of 2021, of which approximately \$1.25 billion is required in 2020-2029 and \$0.36 billion is required from 2030-2034, to fully fund the \$2.24 billion procurement of 80 new subway trains.

Along with other infrastructure improvements through the Line 2 Capacity Enhancement Program, this option would result in new subway trains and train controls systems meeting projected demand on Line 2 until the late 2030s. Lastly, this option would also allow for Metrolinx to procure the trains it needs for subway expansion projects; procurement(s) that would otherwise likely cost the Province more due to the relatively low procurement quantity.

2. Option B: Extend the life of the T1 fleet through a Life Extension Overhaul (LEO) and invest in the ongoing state-of-good-repair of the existing Line 2 signaling system.

This option would require that all of the \$1.26 billion in existing funding commitments currently allocated to Option A be reallocated to sustain (not improve) current asset performance through to 2036. In 2036, the trains and signalling system would have to be replaced at an escalated cost of approximately \$5.25 billion.

With approval of partial funding for the next subway train procurement (Option A above), the TTC initiated development of the technical specifications, conducted a Request for Information to gauge market interest and ability to satisfy 'must have' requirements, and engaged a procurement specialists firm to assist with the development of the commercial terms and the tendering process through to contract award.

This pre-RFP work for the procurement of new trains will continue through to the end of Q1 of 2021, by which time a commitment is required to close the \$1.61 billion funding gap.

The target train delivery timeline to meet fleet requirements is as follows:

**Table 4
New Subway Train Delivery Timeline**

Train Allocation	2024	2025	2026	2027	2028	2029	2030	2031	Total
Line 1 Growth	1		9	8					18
Line 2 Replacement	1		12	13	12	12	12		62
Metrolinx Options					Trains for Subway Expansion Quantities and timeline TBD				
Total	2		21	21	12	12	12		80

This timeline includes delivery of all 80 trains required for replacement of T1 trains on Line 2 and growth on Line 1. Deliveries are staged with a prototype train to be delivered in 2024 for testing on each Line, followed by mass production deliveries starting in 2026.

With all trains delivered by 2030, and with completion of required infrastructure upgrades on Line 1, there would be an option (not included in existing estimated costs) to procure individual subway cars that could be inserted into the 18 new growth trains on Line 1 to provide additional capacity during peak service.

Chart 2 depicts the high-level program schedule required to achieve the delivery timeline.

**Chart 2
New Subway Train Program Schedule**

Deliverable	2020				2021				2022				2023	2024	2025	2026	2027	2028	2029	2030
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4								
Technical Specifications Development & Review		■	■	■																
RFI			■	■																
Public & Internal Consultation			■	■																
PM & Eng. RFP			■	■																
Commercial Terms Development			■	■	■															
Procurement RFP					■	■														
Contract Award						■	■	■	■											
Design Reviews & Mock Up										■	■	■	■							
Prototype Delivery & Evaluation													■	■	■					
Vehicle Delivery															■	■	■	■	■	■

Subway Facility & Signalling System Plan

The Line 1 and Line 2 Capacity Enhancement Programs will define requirements for subway facilities and infrastructure modifications to enable growth of the existing system and to ensure effective coordination with Metrolinx for the efficient and effective deployment of subway system expansion programs.

The two programs are currently estimated at \$8.3 billion of which the 10-years from 2020-2029 are fully funded through the approved Capital Budget and Plan for \$2.3 billion.

While the detailed scope of these programs is being developed, immediate priorities include the following:

Line 1 Facilities:

- Completion of Line 1 Automatic Train Control
- Renewal and Upgrade of Davisville Carhouse in 2020-2029 period to provide additional capacity
- New Maintenance and Storage Facility (MSF) to store and maintain trains for servicing the YNSE and to accommodate future growth. Preliminary work to commence in mid-2020s in order to have the facility operational by the early to mid-2030s

Line 2 Facilities:

- Line 2 ATC to replace the existing signalling system
- Renewal and Upgrade of Greenwood Shop and Carhouse to enable maintenance of new trains with roof mounted equipment

Progress will be reported back to the TTC Board through a future Line 1 and Line 2 Capacity Enhancement Program update.

Lastly, the CIP identified the need to replace the existing fixed block signalling system on Line 4 with ATC in order to enable deployment of 6-car consists, matching capacity long-term ridership demand - this program is currently unfunded.

Immediate Next Steps:

Of the \$3.05 billion estimated need for 80 new subway trains and ATC on Line 2, approximately 41% is funded. Should the remaining \$1.61 billion be committed for the new subway train procurement by Q1 of 2021, the public procurement process will begin in Q1/Q2 of 2021.

Fleet: Continue market sounding, employee and customer consultations, and finalize development of technical I specifications and commercial terms for public procurement.

Secure additional funding of \$1.61 billion by Q1 2021

Re-signalling: Maintain focus on completing delivery of ATC on Line 1 and commence with Line 2 ATC program in preparation for replacement of the existing signalling system on Line 2 with ATC – program fully funded from 2020–2029 with TTC Board commitment for remaining funds post 2029.

Facilities: Advance study and construction of facilities repair and upgrades required for maintenance and storage of new trains at TTC’s Greenwood Yard, Carhouse, and Shop.

Secure additional funding of \$177 million for ATC on Line 2 post-2029

New Technology and Innovation

In 2018, the TTC established a New Technology and Innovation (NTI) team to evaluate emerging vehicle technologies with a focus on enhancing safety and operational efficiencies. This section highlights some of the more promising opportunities from the innovation pipeline, rough timelines, and rough order of magnitude costs for each.

Streetcar Operator Safety Assist Systems

Over the past 4 months, the NTI team has received information on new streetcar operator safety assist systems (OSAS), which aim to improve operational safety through the use of a suite of different technologies that detect and flag hazardous events.

Data is drawn from an onboard GPS system, accelerometers that measure changes in vehicle movement, and smart cameras that capture and analyze video in real-time. These systems detect vehicle location, speed, direction, operator commands for braking and acceleration, but they also predict the movement of surrounding vehicles,

pedestrians, and cyclists and warn the operator of external hazards that might otherwise go unnoticed.

The data acquired can also be used to identify systemic issues that otherwise go unreported such as the identification and geographical heat mapping of high-risk areas throughout the network where events are routine and network design mitigations may be appropriate, such as relocating stops to avoid high pedestrian traffic, addressing areas of low track adhesion, and clearing obstructions to operator sightlines.

In practice, transit authorities utilizing this technology on streetcars and buses report that the system helps to identify top-performing operators and assist in the reconstruction of incidents, the latter of which more often than not serves to exonerate the transit authority, both operators and management. Transit authorities also report a reduction in at-risk driving behavior, reduction in preventable collisions, and reduction in associated legal claims – all of which they directly linked to the introduction of this technology.

This technology is very promising and will eventually lead to automatic emergency braking of streetcars with reaction times significantly faster than what is possible from a human operator. Today, however, the technology is not yet proven in broad application and only two manufactures are now offering the technology as an option for future procurements.

In the coming months, the TTC will be initiating a Request for Interest to seek partnership on a limited trial of this technology on dedicated rights-of-way in Toronto such as on St. Clair Avenue West and Spadina Avenue.

Progress will be reported back to the Board through the CEO's Report.

Bus and Wheel-Trans Emerging Technologies

The emergence of advance technologies for conventional buses and Wheel-Trans buses typically lag the automotive industry, but the emergence of new technology for the personal automobile has been advancing quickly as consumer demand grows for driver safety assist systems, ever lower greenhouse gas emissions, and improved connectivity between vehicles and between people. As a result, the majority of opportunities being pursued by the New Technology and Innovation team are those that have the potential to improve safety and operational efficiency with bus and Wheel-Trans buses.

Driver Safety Assist System

In the five-year period from 2014 to 2019, there were 15,722 bus collisions resulting in 1,133 injuries and 11 fatalities. Over this same period, the TTC settled \$17.7 million in claims on average each year.

In 2015, the TTC developed a Safe Service Action Plan to strengthen the recruitment, training, supervision, and recertification cycle for bus operator and supervisory staff, and to actively promote safe behaviour and awareness among the public. While this effort

was successful in reducing the number of incidents in 2015 and remains effective mitigation, the risk exposure has been increasing as new operators are recruited to deliver an ever increasing demand for bus service.

Review of incident data found that there is a strong correlation between bus operator experience and the number of collisions, confirming that defensive driving behaviour is a strong mitigating factor against the risk of collision (even when most collisions are found to be the result of at-risk behaviour by pedestrians and cyclists). However, process based risk mitigations such as training, signage, and discipline have limited the potential to reduce the frequency of bus collisions. Engineering based risk controls, such as the driver safety assist system, have the potential to provide automatic feedback to operators and to capture data on close calls that is otherwise not possible.

Driver safety assist systems that use smart cameras with AI, accelerometers, and GPS to flag events that can be used to warn, coach and train operators have matured over the past several years and will help realize the City's Vision Zero objectives. This technology is already in use at various other transit authorities including LA Metro, NJ Transit, and WMATA (Washington DC).

Time Horizon: Technology is commercially available

Implementation

Costs: \$5 million for full fleet
\$0.75 million for one (1) garage pilot program
+ \$4.25 million for remaining fleet, subject to successful pilot

Operational Cost: \$1.5 million annual savings
\$2.5 million in license and subscription fees for full fleet
+ \$0.5 million for enhanced training and supervisory costs
- \$4.5 million in claims avoidance, assuming 25% effectiveness

Payback Period: ~ 4 years

Progress will be reported back to the TTC Board through the CEO's Report.

Enhanced Turn Warning System

To assist in mitigating the 27% of collisions that occur while turning or changing lanes, the TTC is currently prototyping an Enhanced Turn Warning System comprised of floodlights directed at the road, a white noise generator, and additional lights that are activated by the operator's turn signal.



While the prototype will require evaluation by the ACAT and others, it is believed that this relatively simple solution will be at least somewhat effective at mitigating the risk of collisions with pedestrians and cyclists who unknowingly travel in the bus blind spots. Progress will be reported back to the Board through the CEO Report.

Time Horizon: Prototype is targeted for completion and evaluation Q4 2020
Full fleet implementation by Q4 2021, pending approval of
prototype by Q1 2021

Implementation

Costs: \$1.5 million for full fleet implementation

Ongoing

Operational Cost: Negligible Impact

Progress will be reported back to the TTC Board through the CEO's Report.

Connected Autonomous Vehicle

The City sponsored program entitled "Minding the Gap: Advancing Toronto's Transit System through Automation", is a collaboration between the City, TTC, and Metrolinx to deploy an automated shuttle service for a six to 12-month period on public roads in Toronto.

The temporary service would be delivered using a small state-of-the-art electric shuttle running a route set through residential streets not currently served by conventional transit. The shuttle would be an automated vehicle (AV) that is mostly self-driving with an on-board human attendant at all times.

The aim is to demonstrate the future opportunity for a safe, green, accessible, and convenient transit technology to support local travel needs. This type of "first and last mile" service would be offered as an alternative choice for residents to get to the nearest transit station, which could reduce future local traffic congestion and parking lot demand.

The project partners want to understand the value of an automated shuttle service in the transit and transportation system so that they can make decisions about the use of this and similar technologies in the future. The project partners also want to understand how users and community members respond to this type of service, and provide an opportunity for the public to learn more about AVs.

There is currently no intention to make this service permanent. However, the project provides an opportunity for the TTC to investigate technologies used in AVs for possible application in driver safety assist systems as previously described (e.g., LiDAR, radar, machine vision, connected vehicle-to-vehicle communications, vehicle based cybersecurity, etc.) and what impacts these technologies have on nearby systems such as traffic control devices.

The collaboration, through which TTC staff provide service planning and engineering support, has undertaken broad technical and community consultation, engaged with the vendor market through a Request for Interest and has undertaken the Request for Proposal process. Contract award is expected in Q4 of 2020

Time Horizon: With COVID-19 related delays, the vendor selection and contract award for the supply and operational support of the shuttle is postponed from the fall 2020 to early 2021.

Implementation

Costs: The trial is funded by Transport Canada through the Program to Advance Connectivity and Automation in the Transportation System (ACATS), the City and in-kind contributions from the TTC and Metrolinx.

Ongoing

Operational Cost: None

Progress will be reported back to the Board through the CEO's Report.

Bus Platooning

Bus platooning is the linking of two or more buses in a tightly grouped convoy. The bus at the head of the platoon would act as the leader and would be operated by a human driver. The buses behind, connected through a virtual coupler comprising of sensors, cameras, and wireless tethering, would react in real-time to the leader's commands to steer, accelerate, or brake.

The technology has yet to be matured and made commercially available for surface transit, including conventional buses or Wheel-Trans buses, however, platooning is proven in the transport industry with trucks on public roadways and through platooning of subway trains (i.e., Automatic Train Control).

Platooning requires a lower level of automation than a fully autonomous vehicle. The latter is not expected on transit buses for another five to 10 years, but platooning has many of the potential benefits, including enhanced safety, lower emissions, improved operational flexibility, and significantly lower capital and operating costs when compared to light rail transit.

Time Horizon:

In 2021, TTC plans to engage the market to seek partnership with a bus manufacturer in a demonstration trial that would advance this transformational technology and signal the TTC's interest in pursuing its development and commercialization.

Hydrogen Fuel Injection System for Diesel Engines

Responding to an unsolicited proposal from dynaCERT Inc., the New Technology and Innovation team is evaluating a system that generates hydrogen from water through a small electrolyzer and subsequently injects the hydrogen into the engine's air intake. The premise is that the addition of hydrogen to the engine results in a more complete combustion process, leading to reduced fuel consumption and greenhouse gases emissions.

The vendor is undertaking a dynamometer test at its expense and has provided test units for evaluation on buses scheduled for decommissioning. Should this technology prove effective and practical to implement, the potential fuel savings will likely offset the

cost of the investment and the reduction in emissions would advance progress toward the City's goals under the TransformTO Climate Action Plan.

With successful demonstration of the technology, the TTC would undertake a public procurement to broaden the pilot and adoption of this system on all clean diesel and hybrid-electric buses with sufficient life remaining to warrant the investment.

Time Horizon: Prototype evaluation targeted for completion by Q4 2020
Full fleet implementation by Q4 2021, pending approval of
prototype by Q1 2021

Implementation

Costs: \$7,500 per bus; or
\$11.3 million for 1,500 diesel and hybrid-electric buses

Ongoing

Operational Cost: \$2,000 net savings per bus per year, assuming 5% fuel savings; or
\$3 million per year for 1,500 buses

Payback Period: ~ 4 years

Progress will be reported back to the TTC Board through a future Green Bus Program update

Hybrid Bus Electric Vehicle Mode

The TTC's latest generation hybrid-electric buses are propelled by electric motors fed by regenerative braking and an onboard generator. This propulsion system has been shown to result in a 45% reduction in fuel consumption and a 47% reduction in greenhouse gas emission.

To fully realize the benefits of this technology, the New Technology and Innovation team is working with the hybrid bus manufacturer, Nova Bus, and propulsion system supplier BAE Systems, to pilot a global positioning system (GPS) controlled electric vehicle (EV) only mode.

The system will detect when the bus enters a designated geo-fenced area, such as a TTC garage or TTC subway station bus platform where idle times are normally greatest, and where it is a confined area, and/or there is a large concentration of people. The system will turn off the diesel engine for the duration of its travels through the designated area, running purely in EV mode. After leaving the designated area the diesel generator resumes normal operations, recharging the on-board batteries.

While this function will not further reduce the average daily fuel consumption or greenhouse gas emissions, it will reduce local noise emissions by approximately 80% and eliminate emissions of diesel exhaust from the engine in areas where people would benefit most from a reduction in air pollution and improvement in air quality.

Should the system prove successful, additional areas will be geo-fenced with a focus on residential streets during night bus service when the benefits of lower noise emission would be most impactful.

Time Horizon: Prototype evaluation targeted for completion by Q2 2020

Implementation

Costs: TBD

Ongoing

Operational Cost: TBD

Progress will be reported back to the TTC Board through a future Green Bus Program update

Free Wi-Fi Internet Service

Since 2018, TTC customers have had access to free wireless internet service at subway stations. In July 2020, the TTC Board requested a study into the possibility of launching a pilot project on surface routes that serve post-secondary institutions and designated neighborhood improvement areas.

Responding to an unsolicited proposal from Cradlepoint Inc. to equip 25 to 30 buses at their expense to demonstrate viability of the system, the TTC is planning an initial pilot deployment to verify installation requirements, ongoing maintenance requirements, and to ensure the system does not interfere with wireless communications between the buses and Transit Control.

With successful demonstration of this pilot, which will also include an open evaluation of systems supplied by Clever Devices (supplier of TTC's Vision system), and others who are qualified and offer to participate, TTC would undertake a public procurement to broaden the pilot and adopt the system on all buses.

Time Horizon: Timeline is under development

Implementation

Costs: TBD

Progress will be reported back to the Board through future CEO Reports.

Optimization of Bus Propulsion Performance

With 315 hybrid-electric and all-electric buses in the TTC's fleet today, there is an opportunity to optimize and standardize acceleration and deceleration performance of 15% of the TTC's fleet to, (1) maximize regenerative braking; and (2) minimize the effect of instantaneous changes in acceleration.

The TTC is currently modeling the optimum settings for propulsion performance to achieve these benefits. A trial is expected by the end of Q1 2021 and the standard

is to be deployed across all 315 of the TTC's newest buses, including buses from BYD, New Flyer, Nova Bus, and Proterra, by Q2 of 2021.

Through upcoming procurements advanced through approval of this report, this new propulsion performance standard will be applied across approximately 50% of the TTC bus fleet and will result in further reduction in emissions and a smoother and more consistent ride for our customers and operators.

Time Horizon: Q2 2021

Implementation
Costs: Negligible

Ongoing
Operational Cost: TBD

Progress will be reported back to the TTC Board through a future Green Bus Program update.

Design Mitigations for COVID-19 and Other Pathogens

All project management and engineering staff engaged on upcoming procurements for new streetcars, subway trains, buses, Wheel-Trans buses as well as new non-revenue vehicles are actively pursuing potential design mitigations to reduce the risks of viral transmission.

Staff have consulted and remain engaged with health officials, peer agencies, original equipment manufacturers (OEMs), sub-suppliers, technical consultant firms, and industry partners such as the American Public Transportation Association, C40 Cities, the Canadian Urban Transit Association, the Canadian Urban Transit Research and Innovation Consortium, the Ontario Public Transit Association, and others.

As an organization, the TTC is working diligently to stop the spread of COVID-19. Transit agencies internationally are working to design and deliver the next generation of vehicles that mitigate the risk of the next virus.

Some of the design mitigations under consideration include:

- Enhanced air ventilation, filtration, and disinfection to minimize airborne transmission;
- Elimination of fabric seating and introduction of antiviral / antimicrobial surfaces;
- Introduction of enclosed cabs for operators;
- Reduction of touch points;
- Redesign of seating layouts to mitigate transmission;

While some of these mitigations are known to be effective and are easy and cost effective to implement, others are under development and their effectiveness has yet to be proven. There is also a need to ensure that secondary risks to people and equipment introduced through these design changes are considered and managed. That said, it is the TTC's intention to be aggressive in the pursuit of potential mitigations that are available through the OEMs.

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