

Traction Power Upgrade Program & Four-Car Train Service

1. Executive Summary

Traction power upgrades are required to run four-car trains along the 201-Red line and the 202-Blue Line. Requirements for traction power have evolved over the past 5 years as LRV funding and LRV design specifications have become available. Outside of the four-car train service, traction power upgrades are required for the lifecycle and reliability of the system.

The purpose of this document is to provide additional explanation and background information for the Traction Power Upgrade program including the introduction of four-car train service. Included are the scope and associated cost and budget changes since inception in 2009, as well as explanation of the benefit of continuing the program with an additional \$30 million of capital funding in the 2015-2018 budget cycle.

2. Background

2.1 The Traction Power System

The original traction power system was constructed in 1980 and by 2009, was beginning to experience higher levels of unavailability and lower reliability due to component failures, based on an expected 30-year lifespan. Limitations in the ability to provide sufficient power for future four-car train deployment were also a concern, given the desire to eventually provide enhanced CTrain service using longer trains.

The traction power system provides electrical power from the local utility grid to the LRT system, where it is used to power up to fifty (50) trains (150 Light Rail Vehicle cars) during the peak periods. The bulk electricity supplied by the grid must first be stepped down in voltage, and then converted to direct current (DC). This produces nominal 720 DC no-load voltage at the exit point from the traction power substation (TPSS). This direct current is then distributed via overhead wires, where it is picked up by the rooftop pantographs of the LRV and flows through the on-board electrical system. The majority of the electrical energy is used by the four 193hp traction motors which propel each vehicle; the remaining power is used for lighting, heating/cooling and control functions. The LRV allows the return current to exit via the steel wheels into the track system, where it makes its way back to the TPSS of origin via the negative return system.)

2.2 The Traction Power Upgrade Program - History

In May 2009, Capital Program 655-07W was initiated to “Upgrade electrical substations, overhead wiring and associated facilities, to conduct lifecycle maintenance and accommodate 4 car trains.”

Enmax Power Service Corporation (EPSC) was contracted to perform a functional engineering study on the existing traction power system. The study concluded that on the 201-Red Line, 13 new traction power substations would be required (6 installed as upgrades at existing substations locations, 5 new substations locations, and 2 spare/portable units) to accommodate four-car trains. In addition to the identified work at the traction power substation sites, the copper plant (messenger wire, feeder cable, rail bond cables and impedance bonds) needed to be upgraded along older sections of the overhead contact system (OCS) and approximately 20km of 201-Red Line LRT track. As the 202-Blue Line was not anticipated to provide four-car service in the 10 year planning horizon, identified upgrades for the 202-Blue Line were limited to copper plant analysis only.

In order to employ one-third matching Government of Canada Infrastructure Stimulus Fund (ISF) funding available at the time, spending of the funds was required to be complete by March 2011. As such, it was decided to use pre-fabricated substations, instead of the traditional built-in-place substations and purchase all materials early on in the project. In the absence of more refined engineering evaluations, available cost estimates were high level and reflected the emphasis on the early purchase of materials in order to maximize eligible spending under the ISF program.

Due to the lack of funding for new LRV purchases at the time (2009), it was anticipated that four-car train service would be limited to alternating several three and four-car trains at peak hours only. The additional cars would draw down on the spare portion of the overall LRV fleet kept on hand to allow for maintenance activities. At the time, full four-car service was not anticipated to be feasible until at least 2020.

In May 2011 (LPT 2011-44), Calgary Transit made the recommendation to use Provincial Green Trip funds for the acquisition of additional LRVs in order to improve reliability, begin the retirement of the original U2 LRV fleet and enable four-car service. The application for GreenTRIP funding was submitted to the Province in December 2011, approved in February 2012 and the funding agreement was signed in December 2012. An RFP for the LRVs was released in March 2013 and in September 2013, the successful proponent was announced. The lower costs of the bulk (50) LRV purchase, and a competitive bidding process containing an extension clause, allowed The City to acquire an additional ten (10) cars with the existing funding for the 2014-2017 LRV purchase. This increased the total number of new LRVs to be acquired to sixty (60), to be divided between replacement and service growth. This certainty about the quantity and timing of additional LRV acquisition has allowed us to establish the four-car service implementation plan as follows:

- First four-car train to come into service in December 2015, approximately two months after receiving the first of the new LRVs.
- Through 2016, increase the number of four-car trains by approximately two to three per month until all trains on the 201 Red Line are four-car trains (approximately thirty (30) trains in total). Exact timeline will vary, as deployment of new cars being received needs to be balanced between new four-car service and the replacement of old U2s.

- Beginning in 2017, six four-car trains are planned to be introduced on the 202-Blue Line, using the last LRVs of the sixty (60) car order.

3. Four-Car Trains – Service Delivery Considerations

The level of LRT service provided is continuously monitored to ensure a balance between costs, CTrain use and customer satisfaction. The following factors were considered when deciding on what level of four-car service to provide.

3.1 Amount of Four-Car Train Service

Various options were investigated regarding how to provide four-car train service. Options included:

- adding two four-car trains during peak service,
- alternating three- and four-car trains, and
- providing a full complement of four-car trains running every three minutes across the entire LRT network.

It was decided that the traction power system needs to be upgraded to be able to provide a full complement of four-car trains every three minutes. This will allow for the full operational flexibility to provide the level of service needed for daily ridership and special event conditions. Providing a full complement of four-car trains has the following benefits:

- Maximizes the amount of passengers that we can move, allowing for increased numbers of customers.
- Predictable loading for our customers – Consistency on the location of the beginning and end of the train will help customers spread out across the four cars. Without this predictability, customers may avoid standing by the location of the last car or be forced into bunching into the last door of a three-car train.
- Special events – The possibility of consistent four-car service allows for better performance around the spikes in demand during off peak hours. such as the end of a special event (e.g. concerts, sporting events, Stampede).
- Efficient use of overall LRT system by using existing investments in track, right of way and structures.
- Simplicity of dispatching and scheduling trains.
- Efficiency in yard maintenance – All trains can be stored as four-car trains. This eliminates the need to couple and uncouple trains that are in service.

The decision to include some four-car service on the 202-Blue Line was made for the following reasons:

- A major LRT storage and maintenance facility (Oliver Bowen Maintenance Facility) is located on the 202-Blue Line. Currently trains for both lines are dispatched from this facility. The ability to continue to do this dispatching with four-car trains allows for improved flexibility and resiliency in transit operations.
- The ability to provide four-car service as 202-Blue Line ridership increases, as well as during special events (Stampede Parade, Zoo events).

3.2 Ridership Analysis

The customer experience of riding the LRT is important to the long-term attractiveness of the choice to use the LRT as part of a journey. At 70 per cent of capacity (200 persons per car), the train is perceived as busy by transit customers. At 85 per cent of capacity the train is perceived as full. The following four tables show the current capacity and use of the LRT based on the recent Spring 2014 LRT ridership study.

Table 1: 201 - Northwest Leg

Time Period	Passengers	# Cars	# Three-Car Trains	Capacity	Passengers / Capacity (%)
AM Peak 15 Minutes	1,700	12	4	2,400	71%
PM Peak 15 Minutes	2,020	15	5	3,000	67%

Table 2: 201 - South Leg

Time Period	Passengers	# Cars	# Three-Car Trains	Capacity	Passengers / Capacity (%)
AM Peak 15 Minutes	2,760	15	5	3,000	92%
PM Peak 15 Minutes	2,440	12	4	2,400	102%

Table 3: 202 - Northeast Leg

Time Period	Passengers	# Cars	# Three-Car Trains	Capacity	Passengers / Capacity (%)
AM Peak 15 Minutes	1,620	9	3	1,800	90%
PM Peak 15 Minutes	1,460	9	3	1,800	81%

Table 4: 202 - West Leg

Time Period	Passengers	# Cars	# Three-Car Trains	Capacity	Passengers / Capacity (%)
AM Peak 15 Minutes	1,420	12	4	2,400	59%
PM Peak 15 Minutes	1,160	9	3	1,800	64%

The four tables above indicate a current need to provide four-car services on the South 201-Red Line and Northeast 202-Blue Line, due to overcrowding during the morning and afternoon peaks. With the Tuscany/Rocky Ridge LRT station opening in August 2014, it is anticipated that ridership will increase during peak periods on the Northwest, suggesting four-car service benefits for riders along the entire length of the 201-Red Line.

While the West LRT leg currently has the lowest number of riders, it forms an integral part of the 202-Blue Line, so must practically receive similar levels of service as the Northeast leg.

4. Traction Power Upgrades - Project Progress

The program was developed and divided into 3 phases:

- Phase 1: New Traction Power Substations
- Phase 2: Existing Substation Upgrades
- Phase 3: Distribution System Upgrades.

The first two phases of the program have been substantially completed. All thirteen (13) prefabricated substations for the 201-Red Line have been procured and delivered. Seven of the substations have been installed and will be energized by the end of 2014. The required upgrades to existing substations on the 201-Red Line have also been completed.

The remaining six substations require further electrical load-flow modeling and analysis before insertion into the LRT system to ensure maximum benefits and long-term efficiencies. Calgary Transit is projecting a completion of the original program by the end of 2015 in keeping with the four-car train Service Implementation Plan.

On the 202-Blue Line, initial load-flow modeling showed a total of four new substations would be required and seven existing substations would require upgrades, all in the inner Northeast leg. No work has yet been completed on the northeast section of the 202-Blue Line, except for the work along the 7th Avenue LRT Corridor. Further refinement of load-flow modelling is on-going and is required in order to refine the necessary improvements along the inner Northeast line. This work is expected to be completed by December 2016, in keeping with the four-car train Service Implementation Plan.

5. Budget Change History for Traction Power

The following table is a summary of the major changes in the Traction Power Upgrade project budget and Estimate-at-Completion (EAC) costs:

Date	Approved Budget (millions)	Required Budget (millions)	Class of Estimate (CPMF)	Notes	Scope Summary
May 2009	\$30	\$30	5 (-50%/+100%)	Original project scope was to enable some limited four-car service on the 201-Red Line. Would be accomplished with the purchase and installation of 13 new prefabricated substations and upgrades to an additional seven existing substations.	201-Red Line – Occasional Peak Trains 202-Blue Line - None
Aug 2011	\$30	\$40.4	4 (-40%/+75%)	As the project progressed, a more accurate cost estimate was developed and an additional \$10 million in costs were identified.	201-Red Line – Occasional Peak Trains 202-Blue Line - None
April 2012	\$37.6	\$42.6	4 (-40%/+75%)	An additional \$10 million was transferred from the four-car platform project and a \$2.4 million reduction in unused ISF was applied.	201-Red Line – Alternating three-car and four-car by 2015 202-Blue Line – None
Nov 2012	\$38.6	\$42.6	4 (-40%/+75%)	TIIPS funding for 2012 and 2013 (\$500,000/year) was added to the approved budget.	201-Red Line – Alternating three-car and four-car trains by 2015 202-Blue Line – None
April 2014	\$38.6	\$47.6	4 (-40%/+75%)	Increased the project scope to include the capability to run all 201-Red Line trains as four-car while still maintaining current headways (\$9 million shortfall), starting by Q4 2015.	201-Red Line - All 30 trains as 4-car 202-Blue Line – None
June 2014	\$38.6	\$68.6	3 (-30%/+50%)	An additional \$21 million (Class 3 estimate) is needed to cover the increased scope for the 201-Red and 202-Blue lines.	201-Red Line - All 201 trains as four-car, every three minutes. 202-Blue Line – All 202 trains as four-car, every three minutes.

As noted above, the current funding gap is \$30 million. This additional funding, identified for the 2015-2018 period as part of the Action Plan's Investing in Mobility, would be used for:

- the completion of analysis using advanced modelling techniques,
- the execution of traction power upgrading activities to allow four-car, three minute service on both the 201-Red Line and the 202-Blue Line, and
- the incorporation of the efficiencies found in the on-going phasing out of the U2 fleet to validate the 2015-2018 Traction Power Upgrade Program.

5.1 Operating Budget Implications

With the addition of up to ten new substations, maintenance costs are expected to increase by \$250,000 annually. Electrical energy costs are expected to increase by approximately \$1.35 million upon full deployment of the current four-car train Service Implementation Plan.

Additional passes of the fourth car will increase the rate of wear on the OCS and rail plant, due to a 33 per cent increase in pantograph and axle passes. Increased lifecycle replacement cost for this LRT infrastructure will be included in the 2015-2018 Action Plan Operating Budget submission for Calgary Transit.

6. Four-Car Trains – Technical Considerations

Providing four-car train service is a technically challenging endeavour which must be carefully engineered to match real-world service demands if unplanned outages are to be avoided. As expected, numerous technical challenges have arisen, been analyzed and solved in the course of this program:

- Differing tractive effort curves in the U2, SD160 (Series 5, 6, 7, 8), and new S200 LRV have required adjustment to the electrical distribution modelling and planning. The decision was made to not create four-car trains comprised of U2 vehicles, on account of the disproportionate increase in expensive copper plant required to support the operation of a "sunset" vehicle.
- New electrical modeling software needed to be purchased to allow load-flow modelling to occur in-house in place of reliance on contractors. This has greatly enhanced Calgary Transit's ability to perform cost-effective "what-if" service delivery analysis to review projected LRT schedules against required electrical infrastructure investments.
- Intense Factory Acceptance Testing and Site-Acceptance Testing of prefabricated substation based on initial quality concerns from the substations installed in Phases 1 and 2 of the program.
- Additional design work and some delay in the receipt of prefabricated substations has been overcome as the supplier works to meet Calgary Transit's stringent performance criteria.