TTC’S NEW STREETCAR PROCUREMENT PROCESS AND LESSONS LEARNED

TRANSPORTATION RESEARCH BOARD

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STREETCAR FLEET PLAN

Notes: 1. Accessibility for Ontarians with Disability Act – full accessibility by January 1, 2025
2. CLRV overhaul was scaled down on anticipation of LFLRV deliveries
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- Testing, Commissioning and Revenue Service Launch
The new streetcar would be the fourth generation of streetcar built for the TTC in the last 93 years, following the Peter Witt, the PCC, the CLRV and the ALRV.
STREETCAR FACTS – CURRENT SYSTEM

Vehicles:
• 196 Canadian Light Rail Vehicles (1st CLRV – 1977)
• 52 Articulated Light Rail Vehicles (1st ALRV – 1987)

Tracks:
• 85 double track km
• 89 special trackwork

Service Routes:
• 11 Routes total >300 route-km or 186 route-miles
• 3 Semi-Right-of-Way
• Annual Streetcar Passenger-trips
  ~ 87 million

• Busies 3 streetcar routes in TTC system:
  o 504 King = 57,000/day
  o 510 Spadina/Harbourfront = 55,000/day
  o 501 Queen = 52,000/day

TTC Annual Ridership ~ 545 million in 2015
Highest Single-day Ridership ~ 1.875 million
Unique TTC Environment vs. Standard LRT

1. Track Switch (Single vs. Double-Point)
2. Tight Loop and Curve Radius (11m vs. 25m)
3. Gradeability Requirements (8% vs. 5%)
4. Ground-borne Vibration
UNIQUE TTC OPERATING ENVIRONMENT (2)

TTC STREETCAR NETWORK

SAMPLE OF TIGHT RADIUS CURVES AND STEEP GRADES

- Gunn’s Loop - 13.7 m (45’)
- St. Clair W. Stn. - 12.8 m (42’), 7% grade
- Dundas West Stn. - 12.2 m (40’)
- Bathurst St. – 8% grade
- Roncesvalles Carhouse - 11.3 m (37’)
- Bathurst Stn. – 12.8 m (42’)
- McCaul Loop – 13.7 m (45’)
- Bingham Loop – 11.9 m (39’)
- Union Stn. – 14.5 m (47.5’), 7% grade
- Neville Park Loop – 13.7 m (45’)
- Woodbine Loop – 11.2 m (36.6’)
- Russell Carhouse – 11.3 m (37’)

- Curve or Loop under 12.2 m (40’) radius
- Curve or Loop between 12.2 and 14.6 m (40’1” and 48’)
- Grade steeper than 7%
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Infrastructure Upgrades

Testing, Commissioning and Revenue Service Launch
Base 204 LF LRVs will:

– Replace aging fleet, relieve congestion & accommodate natural ridership growth
– Provide accessible, safe and customer-friendly vehicles; attract ridership
– Improve fleet reliability, availability & maintainability
– Form base design for adaptation for Transit Expansion LRVs for improved reliability, maintenance efficiency and reduced spare parts ratio
• Customized from “typical” proven low floor LRVs
• Stainless steel carbody structures
• 2.54 metre carbody width
• Length similarity between carbody modules
• Composite sub-floor
• Drawbar and coupler for inter-fleet coupling capability
• CLRV/ALRV crashworthiness
• All bogies powered for gradeability
• Super-resilient wheels for Noise & GBV
• Trolley pole and pantograph
• Auxiliary power system with partial redundancy
• 36 V DC/DC converter
• Nickel-Cadmium batteries
• Customized geo-location logic
• Onboard electronic fare collection
• Communication system integration
• Trackswitch control integration
• Technology Research and RFI
  • Investigated technology feasibility for Toronto
    o Tight horizontal curves (11 metres vs. 25 metres)
    o Track switches (single point vs. double point)
    o Steep hills (8% vs. 5%)
    o Current collection (trolley pole vs. pantograph)
    o Weather
    o Mixed-traffic and platform operation

• Carbuilders

• Equipment Suppliers
1. Analyzed technical risks & identified best practices

2. August 15, 2006 - Advertised & issued Request for Information (RFI) to known carbuilders – 7 responded

3. Summer 2007 - Public consultation

4. On-going discussions with industry and internal stakeholders

5. TTC and its consultants conducted:
   a) 3-D track geometry mapping to ensure compatibility of LRV with TTC infrastructure – data subsequently included in RFP
   b) Simulated LFLRV behaviour – ground-borne vibration, overhead power capacity

6. May to June 2007 - In-depth technical discussions with various interested carbuilders
• NO COMPLIANT BID AGAINST RFP-1
• STRUCTURED MULTI-PHASE BID PROCESS INITIATED

Benefits:
• Process structured & competitive
• 3 proven carbuilders - 100% Low Floor LRV
• Bidders engaged throughout process
• Address questions/concerns (Tech/Commercial)
• Encourage participation/competitive bids
• Formal process: pricing & Canadian Content
• More likely to result in compliant bids
Structured Multi-Phase Bid Process:

• Phase 1 - Introduction
  – Invite Alstom, Bombardier and Siemens to participate based on proven experience in manufacturing 100% LF LRVs
  – Develop preliminary timeline
  – Commitment to participate

• Phase 2 - Technical
  – Carbuilders to demonstrate ability to meet Pass/Fail requirements
  – Carbuilders to demonstrate ability to meet other technical requirements
Structured Multi-Phase Bid Process:

• Phase 3 - Commercial
  – Negotiate acceptable commercial conditions

• Phase 4 – Competitive Bidding
  – Formal process for submitting pricing and Canadian Content plan

• Phase 5 – Commission Approval / Award
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Multi-Site Operation

- **Thunder Bay, Ontario** – Project Management, Final Assembly
- **St. Bruno, Quebec** – Systems Engineering, RAMS
- **Toronto, Ontario** – Product Introduction
- **Sahagun, Mexico** – Fabrication, Module Assembly
- **Vienna, Austria** – LRV Engineering
- **Winterthur, Switzerland** – Bogie Engineering
- **Mannheim, Germany** – Propulsion, TCMS Engineering
Bombardier Flexity LRV Evolution

- Valencia & Alicante 2005 (30)
- Palermo 2006 (17)
- Innsbruck 2005 (16+6) 2006 (10)
- Marseille 2004 (26)
- Brussels 2003 (27+19) 2005 (22) 2008 (87+15)
- Geneva 2002 (21) 2008 (18)
- Eskisehir 2001 (18) 2006 (5)
- Lodz 2000 (15)
- Graz 1998 (12)
- Linz 3 2009 (23)
- Toronto 2009 (204)
- Krefeld 2007 (19)
- Pöstlingberg-bahn 2007 (3)
- Augsburg 2007(10) 2008 (14)
- Blackpool 2010 (16)
• 27m – 30m long (CLRV = 15.4m; ALRV = 23.2m)

• 100% Low Floor

• Single ended, 4 doors, air-conditioned

• ~ 260 passenger crush load (CLRV = 132; ALRV = 205)

• Customer input driven design

• Accessible – 2 wheelchair positions, bike rack, audio/visual stop announcement

• Secure – cameras, advance warning to motorists about impending stops

• Safe – performance, crash energy management, outward visibility, meet System Safety Plan
• Enclosed cab, no fare collection
• Ticket vending & validation machines
• Go anywhere – steep grades, tight curves, extended tunnel operation
• High reliability and maintainability
• High energy efficiency – regenerative braking, LED ext lighting, glazing, insulation
• Aggressive weight and end-of-life recyclable material management
• Easy adaptation for Transit City vehicles
• 70 seats including some extra-wide seats
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CONSULTATION PROCESS

• Interactive website
• Input at public open house presentations and meetings
• Feedback from internal and external stakeholders
• Consultations with Advisory Committee on Accessible Transit (ACAT)
• Guidance from community and City’s artistic leaders in vehicle design
• Mock-up and prototype demonstrations
CONSULTATION PROCESS

Conceptual Design:
- Incorporating historical TTC streetcar elements
- Contemporary, modern, dynamic, iconic, timeless
Consultation and community guidance to design maturity
• Improved driving environment and security
VEHICLE MOCK-UP & PUBLIC CONSULTATION
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DO NOT PASS OPEN DOORS
Decal text wording is under review
OPERATING SCENARIO: STREET-LEVEL

- Pictogram and 4 new red flashing lights to pre-warn motorists
- Door edge LEDs are on during door opening and when opened
PROOF-OF-PAYMENT FARES

- Boarding and alighting from all doorways
- Ticket validators at all doors
- On-board vending machines at 2\textsuperscript{nd} & 4\textsuperscript{th} modules
• Designated wheelchair boarding at second doorway
- 1 Stop Request Push Button is located at the centre of each circle, for a total of 17 buttons
- Minimum of 1 PB within 1.5m of the centre of any fixed seat
- Minimum of 1 PB within 1.0m of the centre of each doorway
OPERATING SCENARIO: STREET-LEVEL

Watch Right for Traffic:
- Audio announcement
- LED display
- Decals on door headers
- Education campaign
RAMP CARTRIDGE GEOMETRY

Stage 1 – At Platforms (150+/−10 mm)

Stage 2 – On Street
Prototype door threshold interface requires significant boarding and alighting effort by manual wheelchair customers.

Tests demonstrate the threshold acts negatively as a “speed bump”

Thus, optimize transition:

- Door threshold - Redesign to provide a lower-profile shape
- Ramp Flap - Redesign to follow the optimized transition path
2. **Move Middle Hinge**

- Increase the short ramp effective length 115mm by moving the middle hinge centerline.

**Description of changes**

- **Ramp Structure** - Redesign with new middle hinge position making ramp slope shallower when deployed to platforms.
- **Ramp Leaf Springs** - Modify spring-rates to provide new short ramp rotation range with the same functionality as the current short ramp
- **Ramp Side Guard Assembly** - Modify lengths of guards accordingly
In response to ACAT’s suggestion, an exterior light was added to illuminate ramp doorway before the door is opened.
Priority Seats are designated by:

1. by-law signs

![Priority Seating Sign](image1)

2. blue fabric seat covers (wheel chair ramp module shown, flip-down seats)

![Priority Seating Sign](image2)
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• A comprehensive noise and vibration control plan
• Specified noise and vibration levels to be achieved by careful selection, design, location, and installation of components on the LRV
• Noise and vibration levels predicted with simulation software before the LRVs are built
• The first three LRVs were tested on Toronto streets for 9 months to ensure the established criteria has been achieved.
• Several components of the LRV were designed to minimize noise and vibration. Some examples:

**Vibration Reducing Components**

- Wheels
- Unsuspended Mass
- Suspension

**Noise Reducing Components**

- Bogie Skirts
- Wheel lubrication System
In addition to softer wheels and reduced unsuspended mass, the LRV has two sets of suspension to minimize vibration.

**Primary Suspension**

- Rubber Spring

**Secondary Suspension**

- Hydraulic Damper
- Coil Spring
Most rail vehicles use stiff wheels.
Typical European LRVs use semi-soft wheels.
TTC will use advanced softer wheels on the LRV.
Softer wheels tend to transmit less vibrations into the ground than other wheel types.
Bogie skirts reduce wheel noise while improving safety and aesthetics.

The bogie is the vehicle undercarriage. It uses two motors to drive four wheels on solid axles through gearboxes. It also contains suspension and brake components.
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WHY REBUILD THE OVERHEAD CONTACT SYSTEM (OCS)

• Pantograph system – significantly reduced energy consumption due to improved energy recovery during braking (regenerative power)
• New cars draw over 50% more current than the old cars on acceleration
• Low voltage problems will result in reduced performance (i.e. no A/C in summer)
• New OCS including different hardware and staggered wire arrangement along with pantograph (instead of trolley pole) are required to allow for improved reliability and reduced maintenance
• Leslie Barns Facility Construction
• Construction of a maintenance facility to accommodate 204 low floor light rail vehicles (LFLRVs)
• Construction of a 26,000 sq. m. carhouse:
  ▪ Green roof
  ▪ Maintenance area with 30 bays
  ▪ Offices
  ▪ Cab simulator training room
• Storage Tracks for 100 LFLRVs
• Substation
• Leslie Street Connection Track
Exterior perspective from Lake Shore Boulevard, looking southwest.
LESLIE BARNES – MAIN FUNCTIONS

- Daily Service Bay
  - Sanding System
  - Under Car Clean
  - Car Wash
- Wheel Lathe Bay
  - Vehicle Progression System
  - Body Hoists for Shimming
- Body Repair & Paint Section
  - Paint Booth
  - Portable Vehicle Lifts
- Maintenance Bays Equipped with Mono Rail Lifts
- Yard (Start Up with Manual Operation)
- Offices (Transportation, Maintenance, M&P, Training)
- Material & Procurement, Parts Storage
LESLIE BARNS – INTERIOR LAYOUT

- Partial Facility Handover: June 30th 2015
- Train Washer: November 2015
- CIS Office: August 31 2015
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In addition to TTC network tests, the first prototype vehicle was shipped to the National Research Council in Ottawa for Climate Room Tests on July 23, 2013.

The climate room tests included verification of system operation and performance including HVAC capacity, under specified duty cycles and temperature range.
Network interface, new-old vehicle compatibility and new vehicle performance tests were conducted for approximately 9 months to establish production baseline. FAC requirement includes 600 km fault-free burn-in run.
Meet your new ride, Toronto!
In service, starting August 31.
Pre-service launch demonstration and closure of action items by CEO Andy Byford and project team with the Design Sub-Committee members of Toronto’s Advisory Committee on Accessible Transit
Thank You