TTC'S NEW STREETCAR PROCUREMENT PROCESS AND LESSONS LEARNED

TRANSPORTATION RESEARCH BOARD

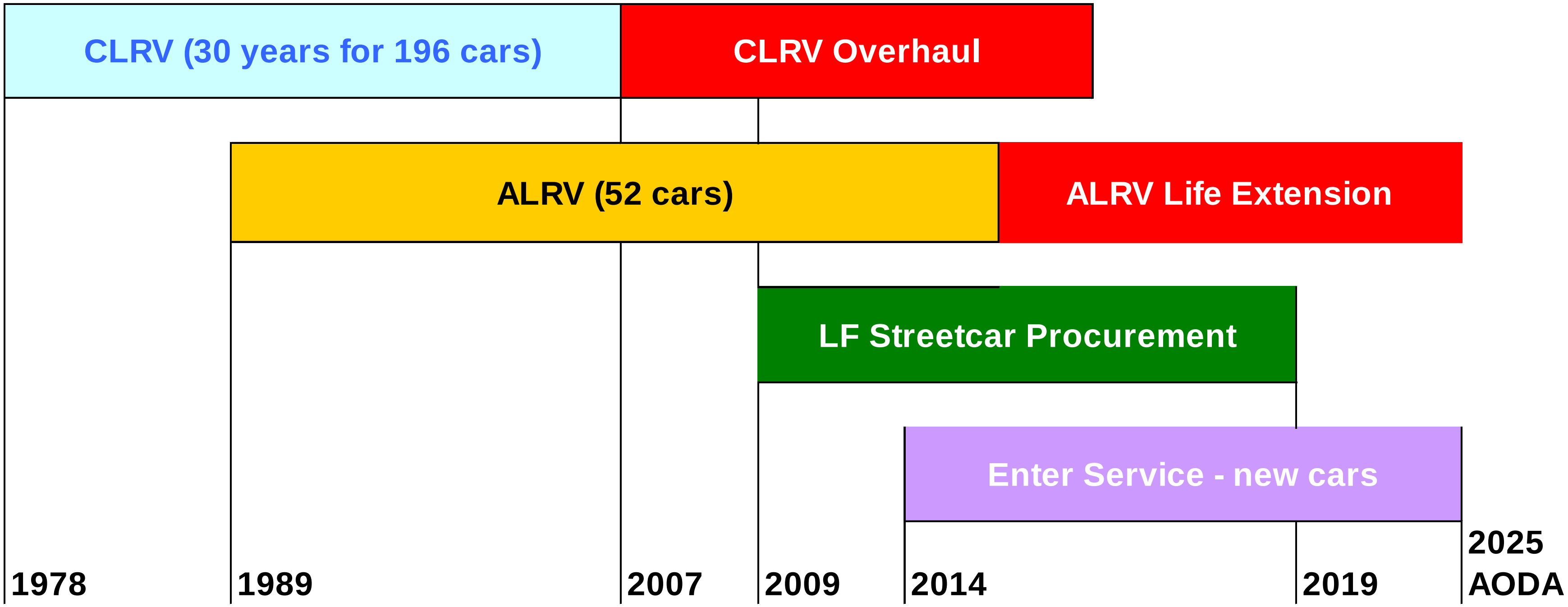
January 12, 2016

Stephen Lam, P.Eng.
Head of Streetcar Department
TORONTO TRANSIT COMMISSION

TRB TRANSPORTATION RESEARCH BOARD

CONTENTS

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**

CONTENTS

TTC STREETCAR HISTORY

Peter Witt

1921 – 1963

PCC

1938 – 1995

CLRV

1978 – Present

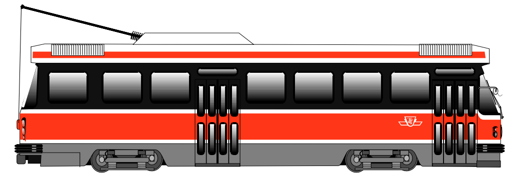
ALRV

1987 – Present

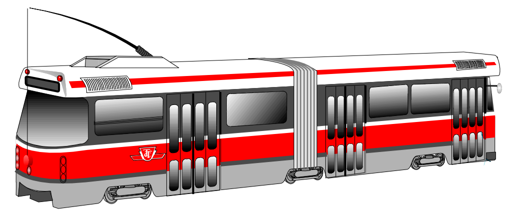
The new streetcar would be the fourth generation of streetcar built for the TTC in the last 93 years, following the Peter Witt, the PCC, the CLRV and the ALRV

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**

STREETCAR FACTS – CURRENT SYSTEM

- **Annual Streetcar Passenger-trips**

  ~ 87 million

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

TTC Annual Ridership ~ 545 million in 2015
Highest Single-day Ridership ~ 1.875 million

UNIQUE TTC OPERATING ENVIRONMENT (1)

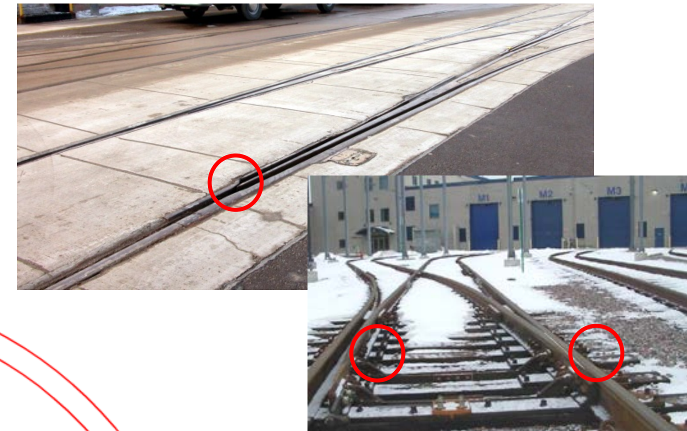
Unique TTC Environment
vs.
Standard LRT

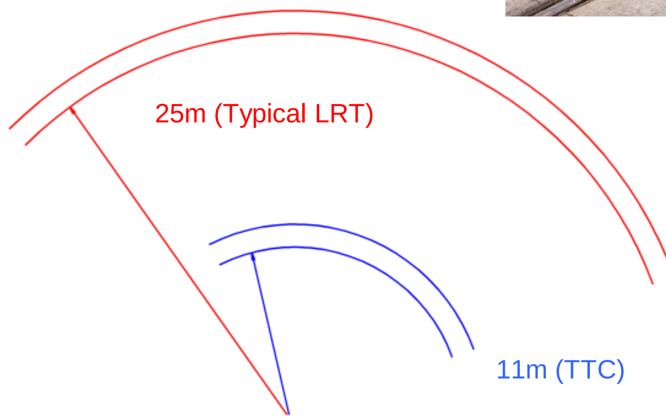
1. Track Switch
   (Single vs. Double-Point)

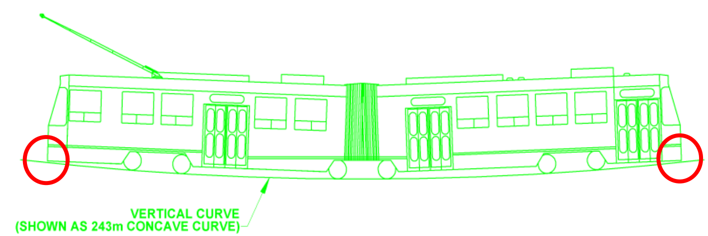
2. Tight Loop and Curve Radius
   (11m vs. 25m)

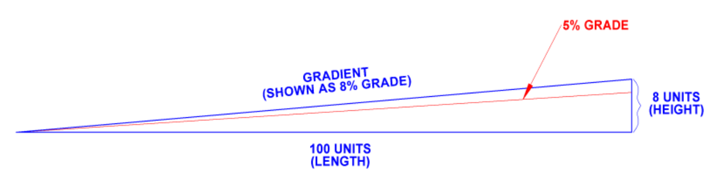
3. Gradeability Requirements
   (8% vs. 5%)

4. Ground-borne Vibration

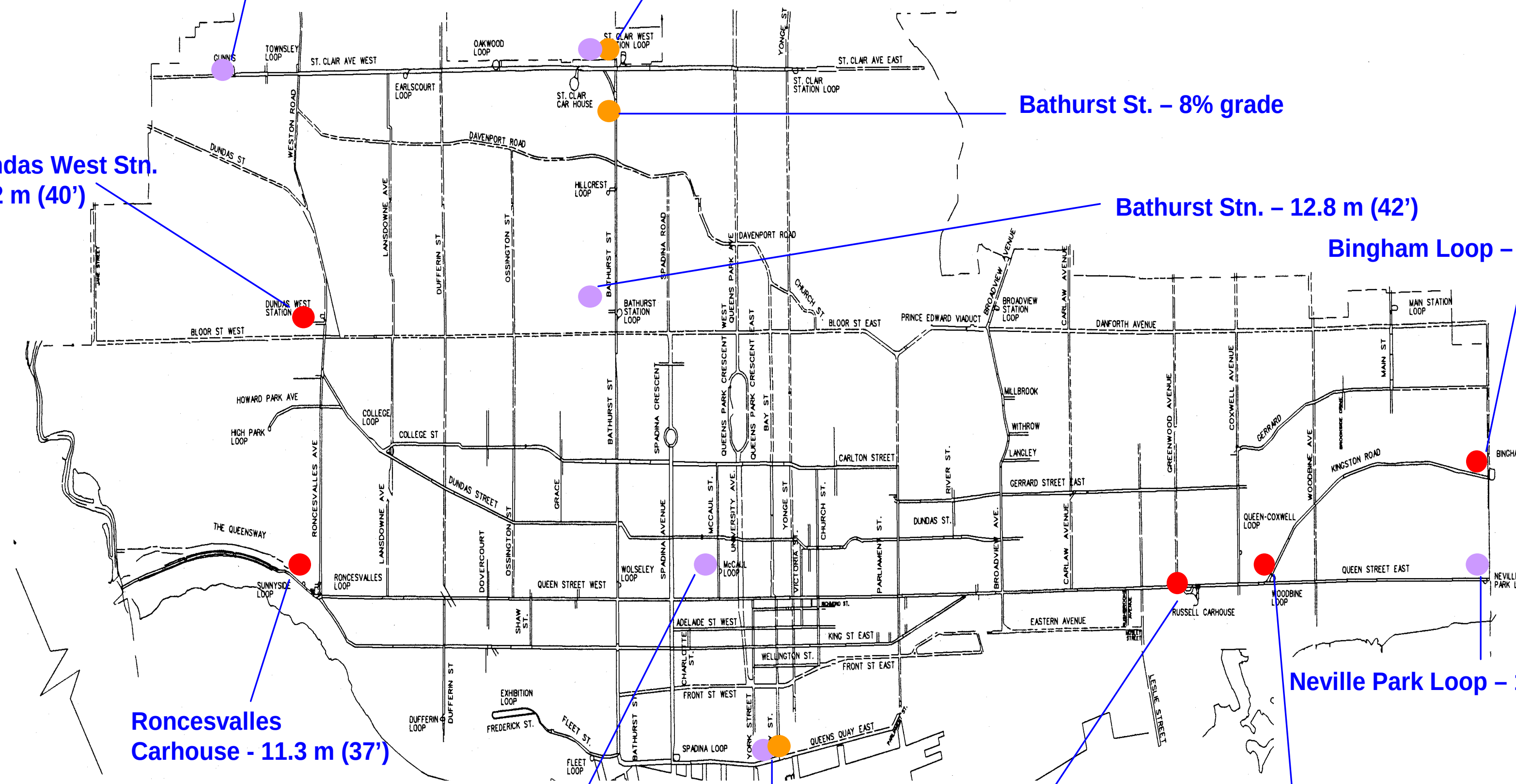








UNIQUE TTC OPERATING ENVIRONMENT (2)



TTC STREETCAR NETWORK

SAMPLE OF TIGHT RADIUS CURVES AND STEEP GRADES

CONTENTS

MAIN PROJECT OBJECTIVES

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**

TORONTO-SPECIFIC DESIGN (1)

- 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

TORONTO-SPECIFIC DESIGN (2)

- 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
  - Tight horizontal curves (11 metres vs. 25 metres)
  - Track switches (single point vs. double point)
  - Steep hills (8% vs. 5%)
  - Current collection (trolley pole vs. pantograph)
  - Weather
  - Mixed-traffic and platform operation
- Carbuilders
- Equipment Suppliers

TTC'S PROCUREMENT PROCESS (1)

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

TTC'S PROCUREMENT PROCESS (2)

- **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**

TTC'S PROCUREMENT PROCESS (3)

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

TTC'S PROCUREMENT PROCESS (4)

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**

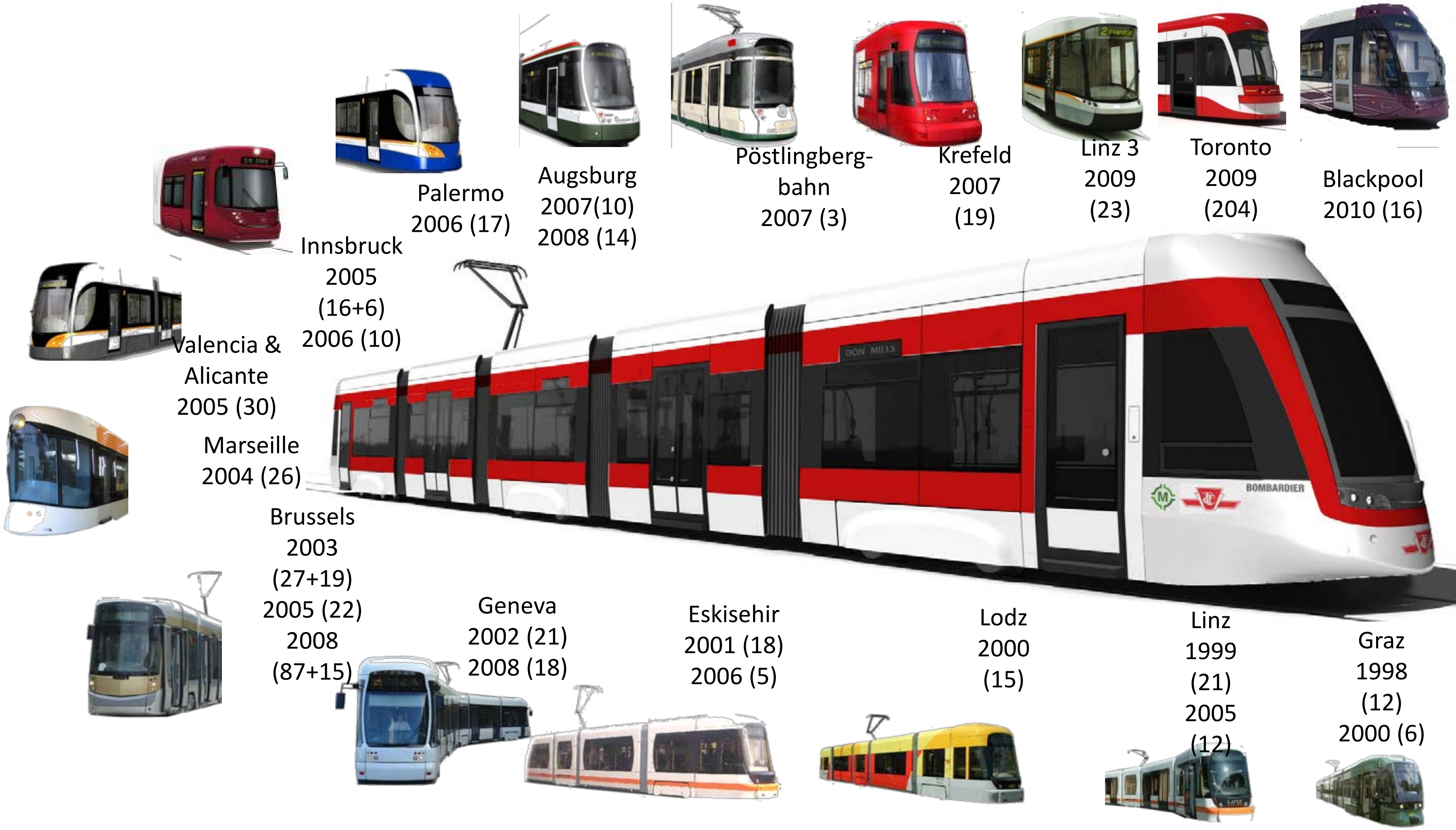
CONTENTS

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



TTC STREETCAR FUTURE

REAR

FRONT

LF LRV MAIN FEATURES (1)

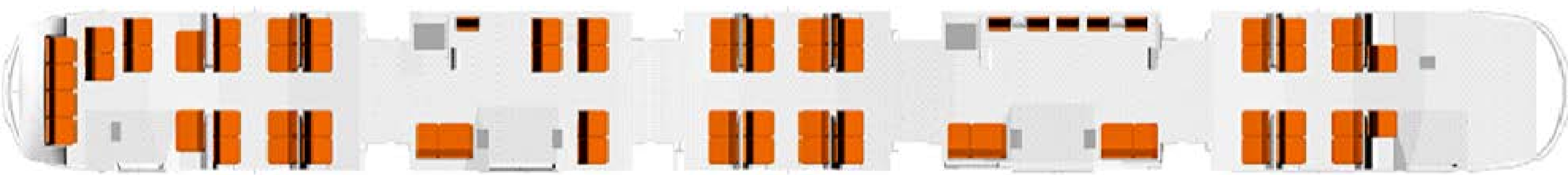
- **27m – 30m long (CLRV = 15.4m; ALRV = 23.2m)**
- **100% Low Floor**
- **Single ended, 4 doors, air-conditioned**
- **~ 260 passenger crush load (CLRV = 132; ALRV = 205)**
- **Customer input driven design**
- **Accessible – 2 wheelchair positions, bike rack, audio/visual stop announcement**
- **Secure – cameras, advance warning to motorists about impending stops**
- **Safe – performance, crash energy management, outward visibility, meet System Safety Plan**

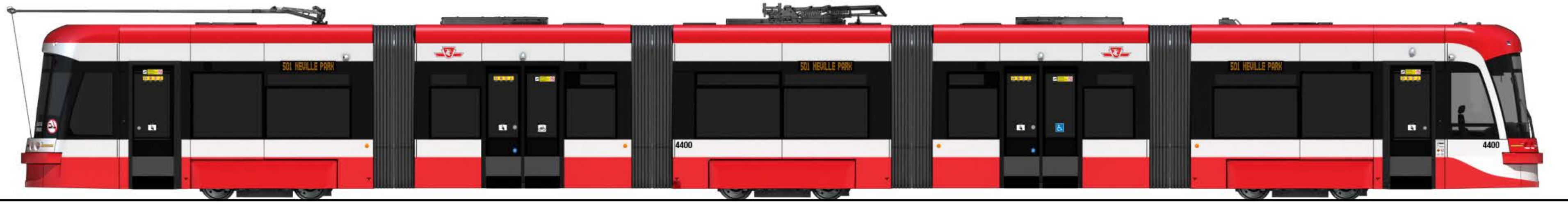
LF LRV MAIN FEATURES (2)

- 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

SEATING ARRANGEMENT

- 70 seats including some extra-wide seats





CONTENTS

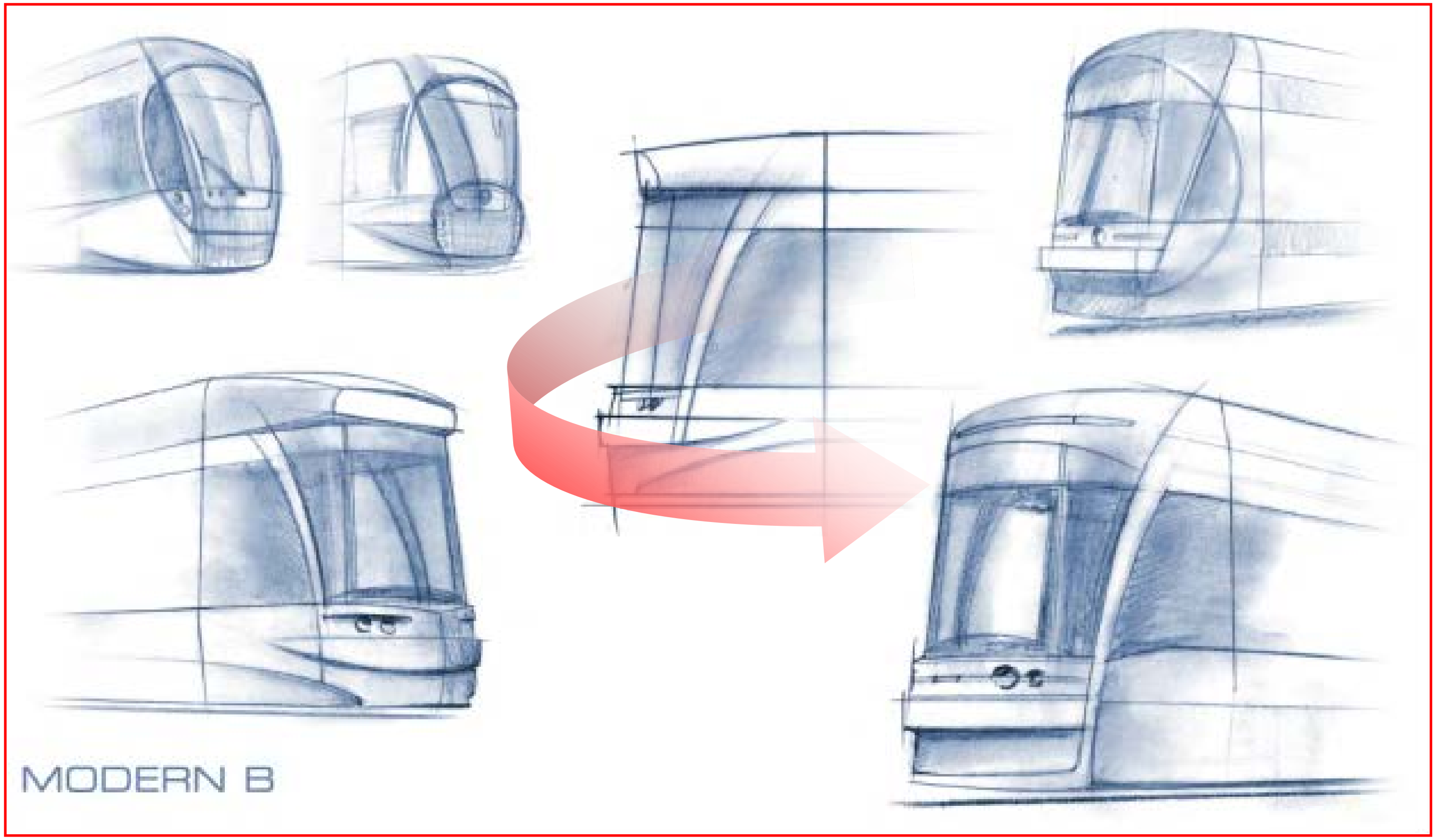
CONSULTATION PROCESS

- 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

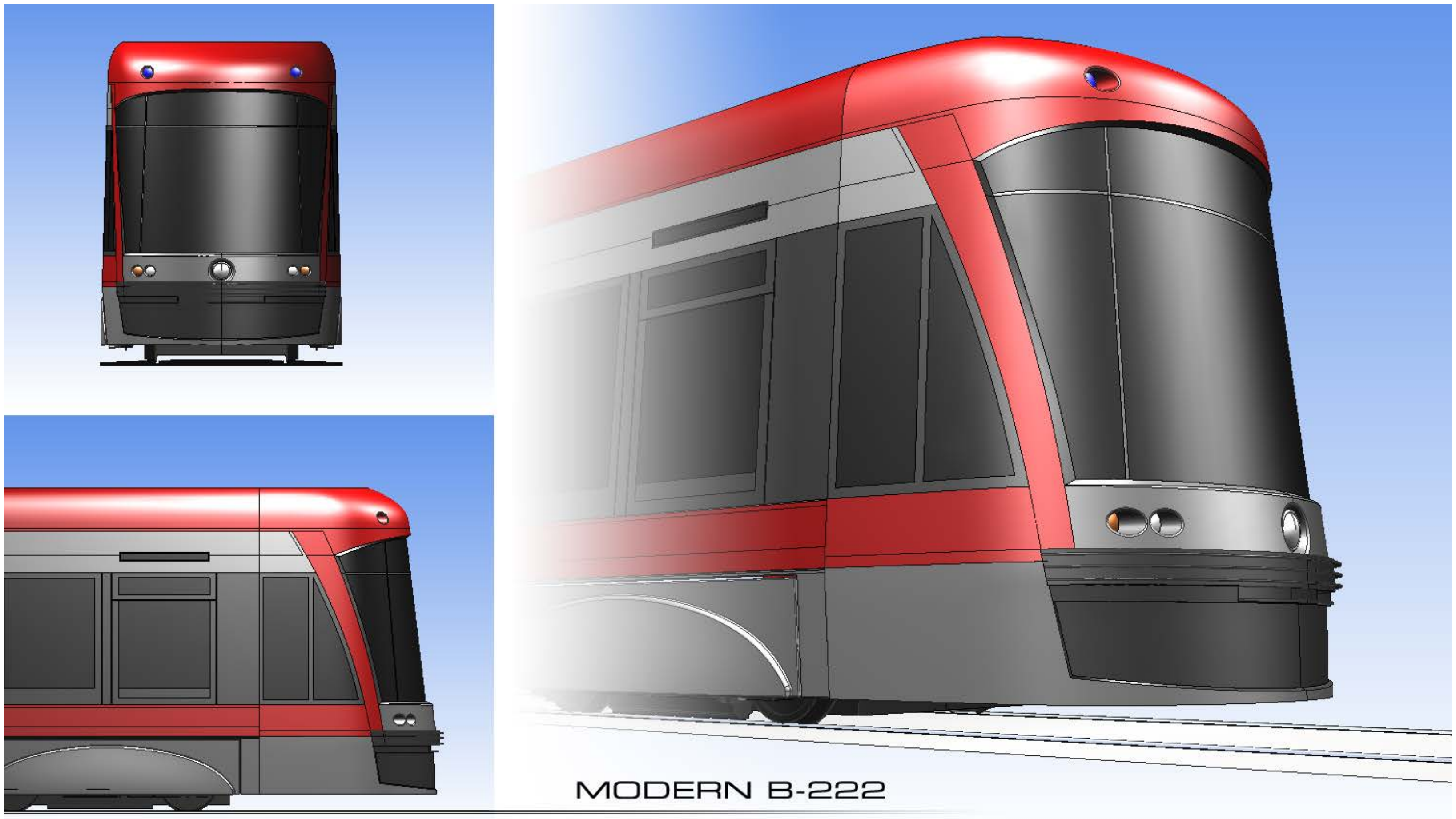
Conceptual Design:

- **Incorporating historical TTC streetcar elements**
- **Contemporary, modern, dynamic, iconic, timeless**



CONSULTATION PROCESS

Consultation and community guidance to design maturity



SEPARATED OPERATOR’S CAB

- Improved driving environment and security

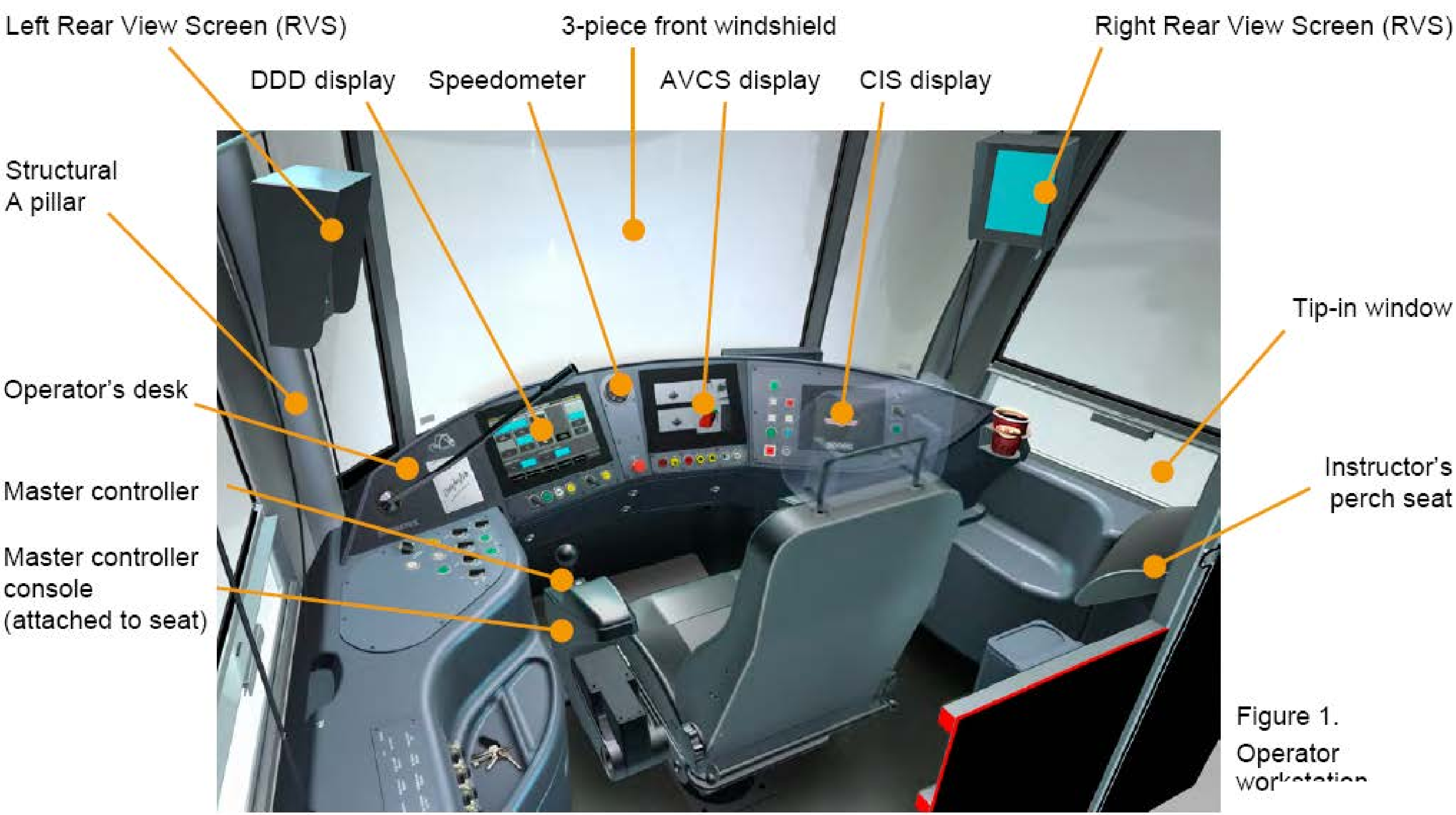


Figure 1. Operator workstation

VEHICLE MOCK-UP & PUBLIC CONSULTATION

CONTENTS

OPERATING SCENARIO: STREET-LEVEL

DO NOT PASS OPEN DOORS

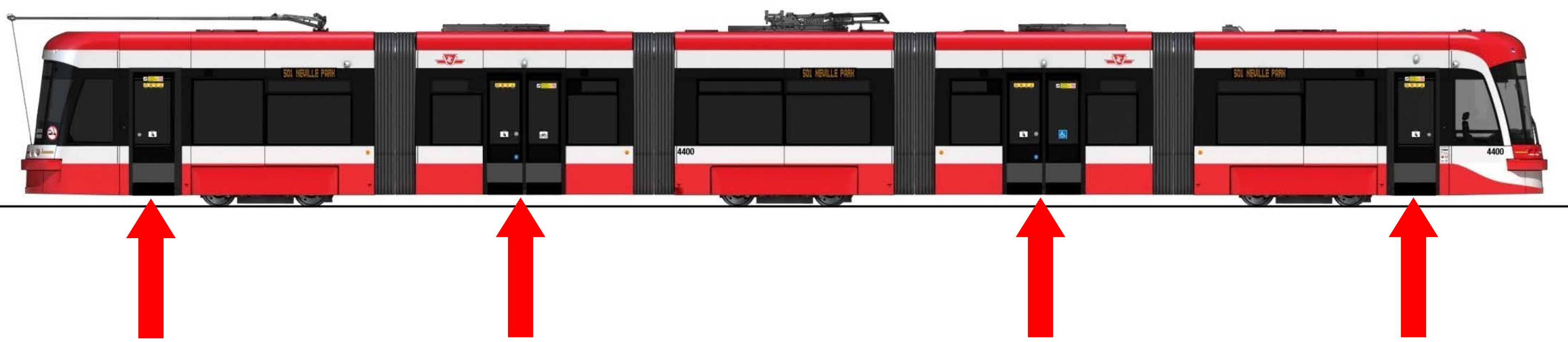
Decal text wording is under review

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 2nd & 4th modules

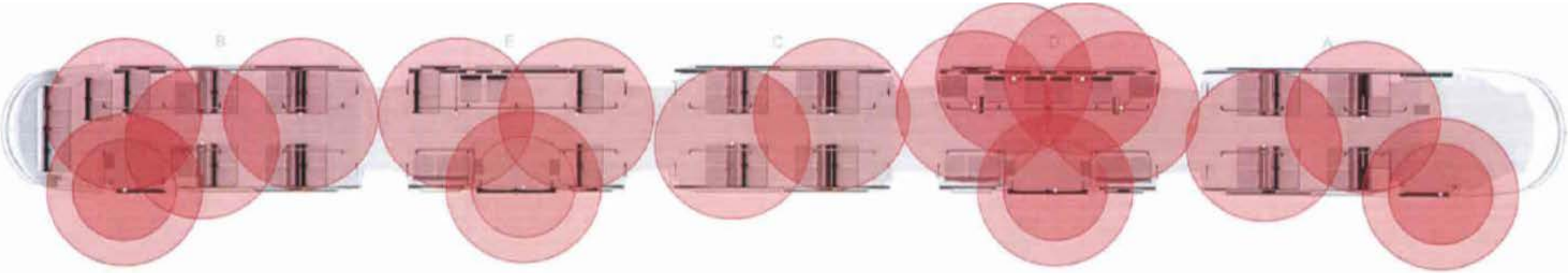


ACCESSIBLE BOARDING/ALIGHTING

- Designated wheelchair boarding at second doorway

STOP REQUEST PUSHBUTTON LAYOUT

- 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

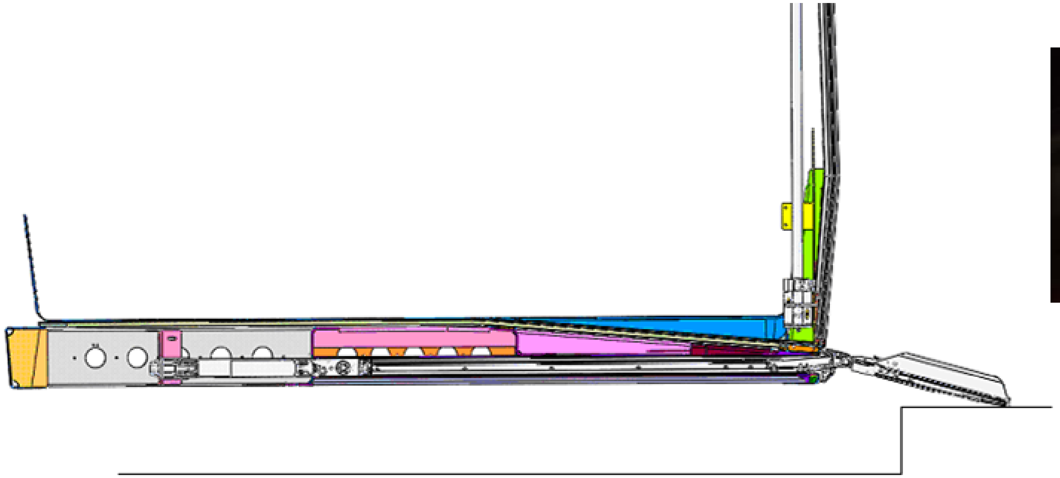


OPERATING SCENARIO: STREET-LEVEL

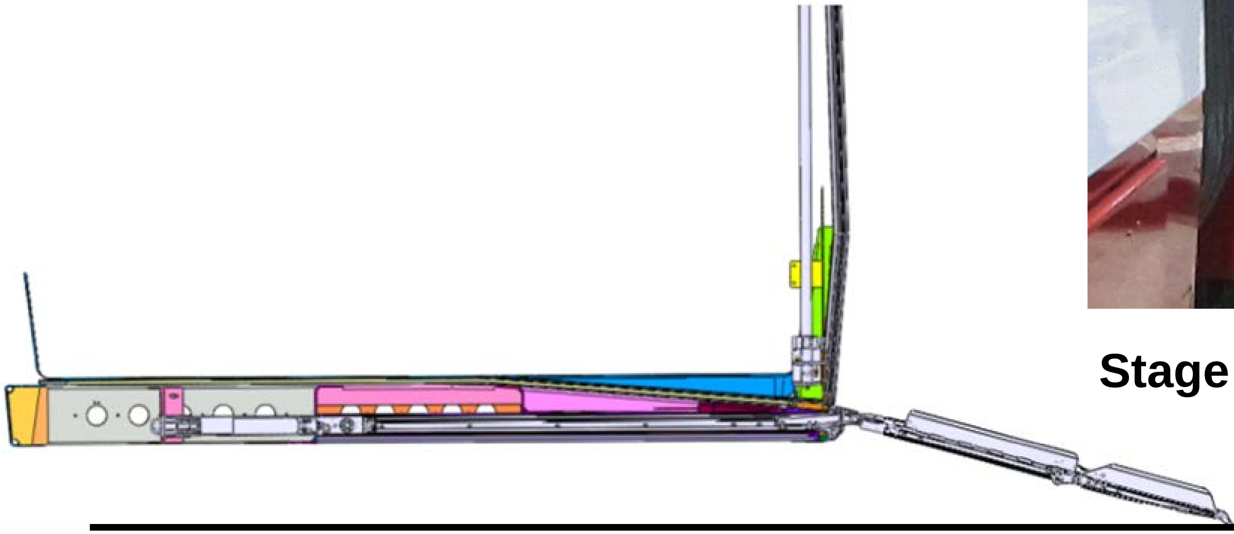
<u>Watch Right for Traffic:</u>

- **Audio announcement**
- **LED display**
- **Decals on door headers**
- **Education campaign**

RAMP CARTRIDGE GEOMETRY



Stage 1 – At Platforms (150+/-10 mm)



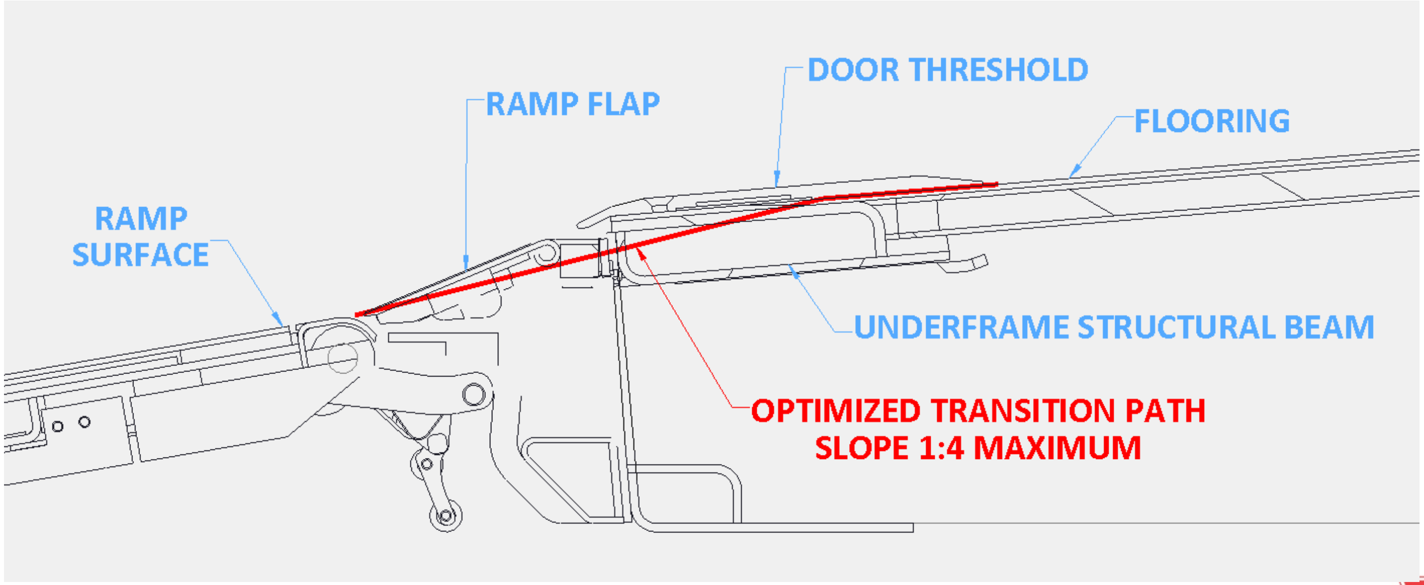
Stage 2 – On Street

REQUIRED MODIFICATIONS TO RAMP

- **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:

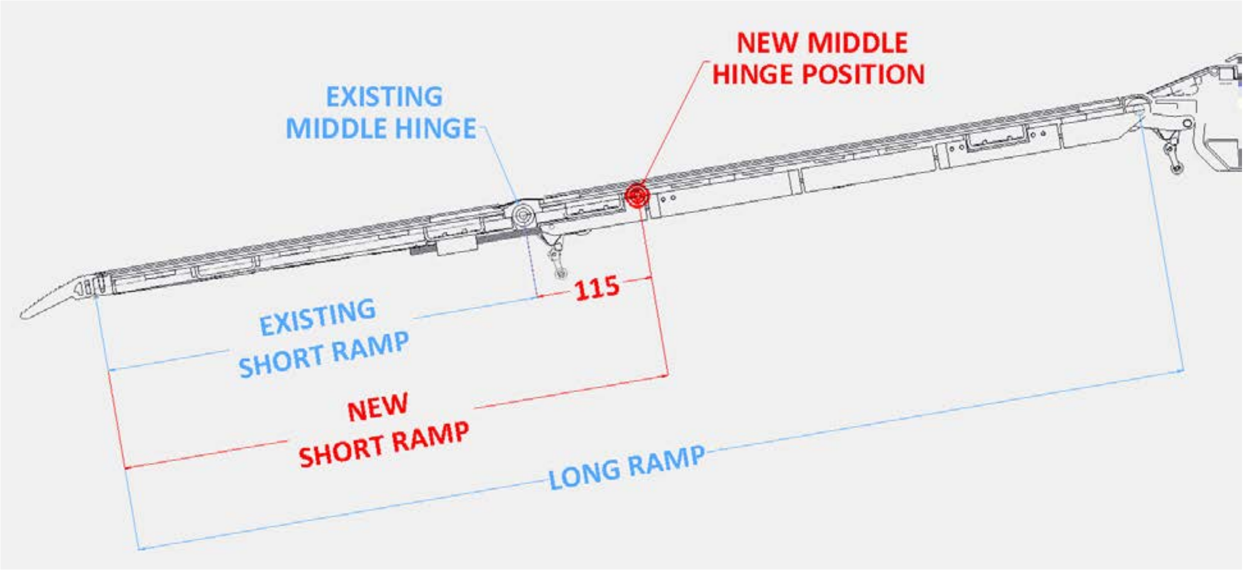
- **Door threshold - Redesign to provide a lower-profile shape**
- **Ramp Flap - Redesign to follow the optimized transition path**

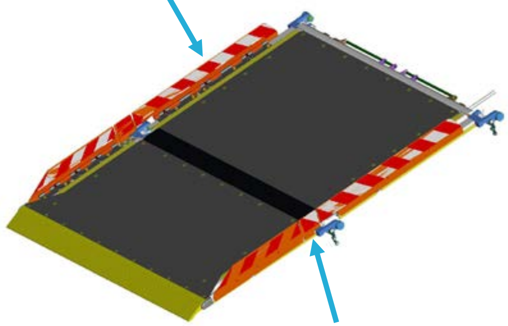


REQUIRED MODIFICATIONS TO RAMP

2. Move Middle Hinge

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



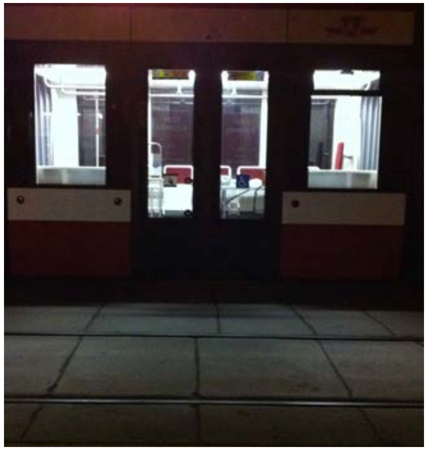


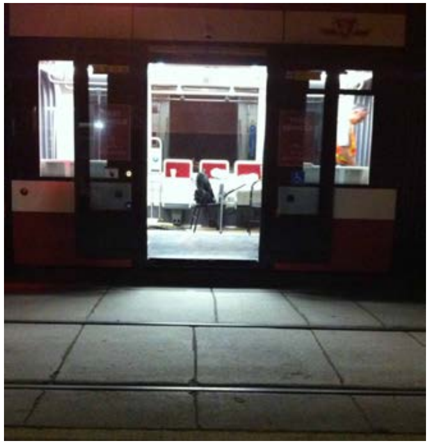
Description of changes

- **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

ACCESSIBLE VEHICLE – EXTERIOR LIGHT

Before modification: Doorway Illumination





Door Closed

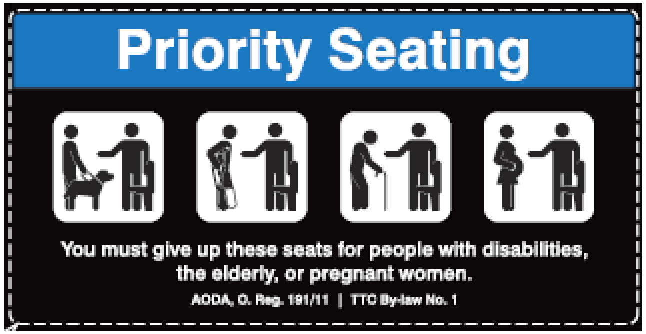
Door Opened

In response to ACAT's suggestion, an exterior light was added to illuminate ramp doorway before the door is opened

ACCESSIBLE VEHICLE – PRIORITY SEATS

Priority Seats are designated by:

1. by-law signs



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

CONTENTS

NOISE & GROUND BORNE VIBRATION

- 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

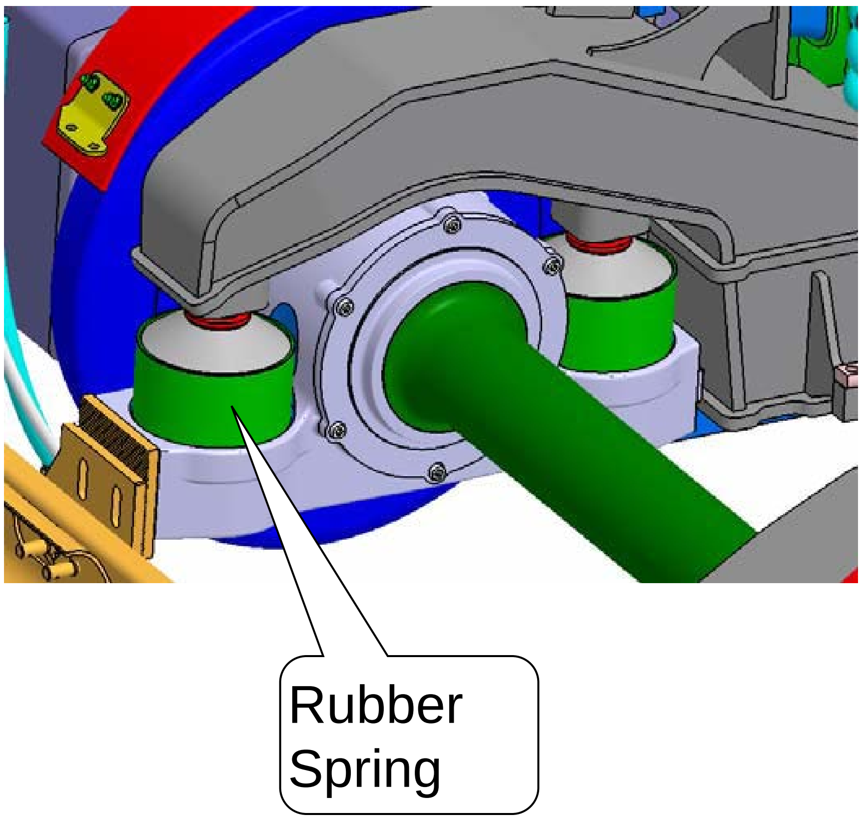
- Wheels
- Unsuspended Mass
- Suspension

Noise Reducing Components

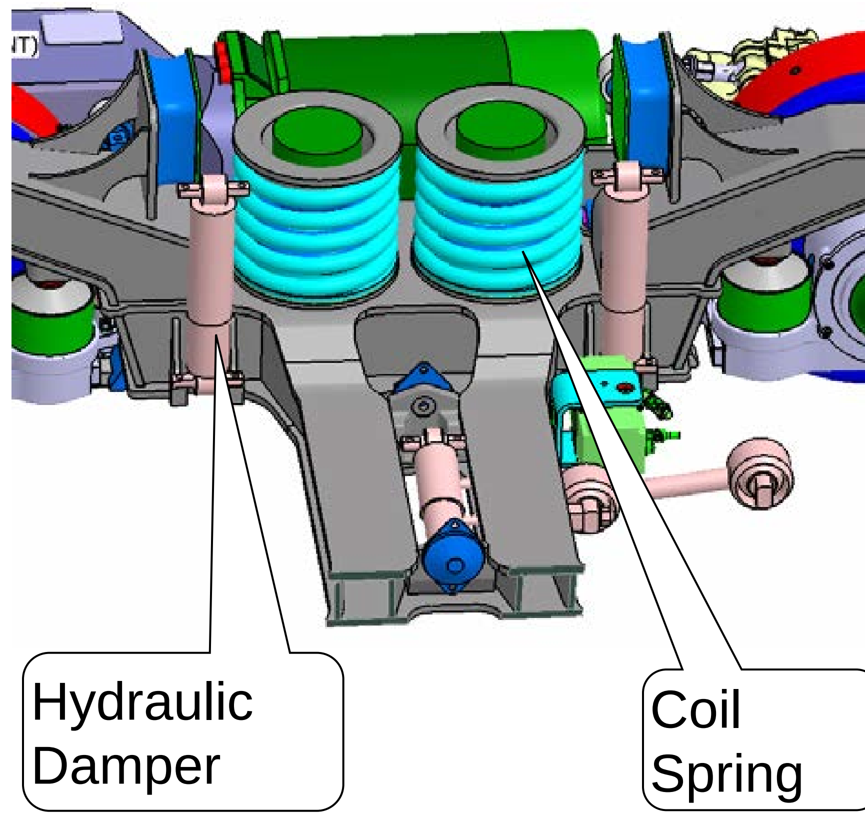
- Bogie Skirts
- Wheel lubrication System

In addition to softer wheels and reduced unsuspended mass, the LRV has two sets of suspension to minimize vibration.

Primary Suspension

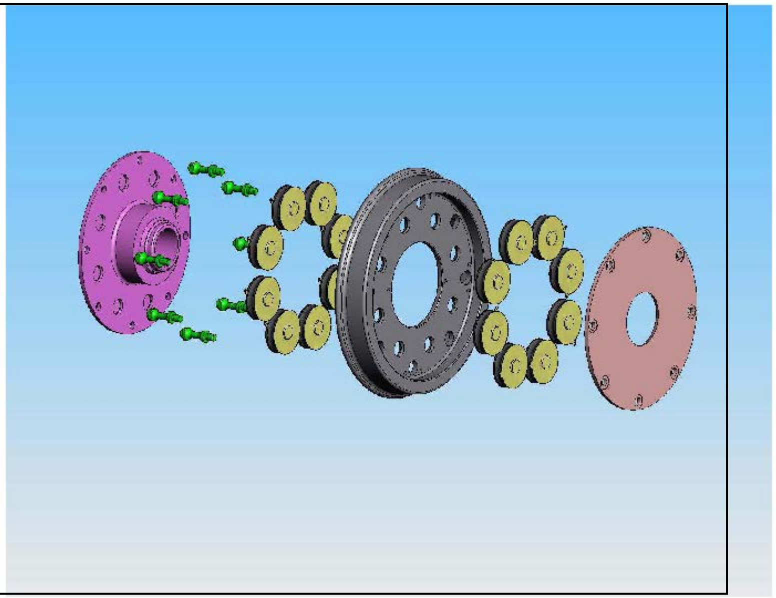


Secondary Suspension



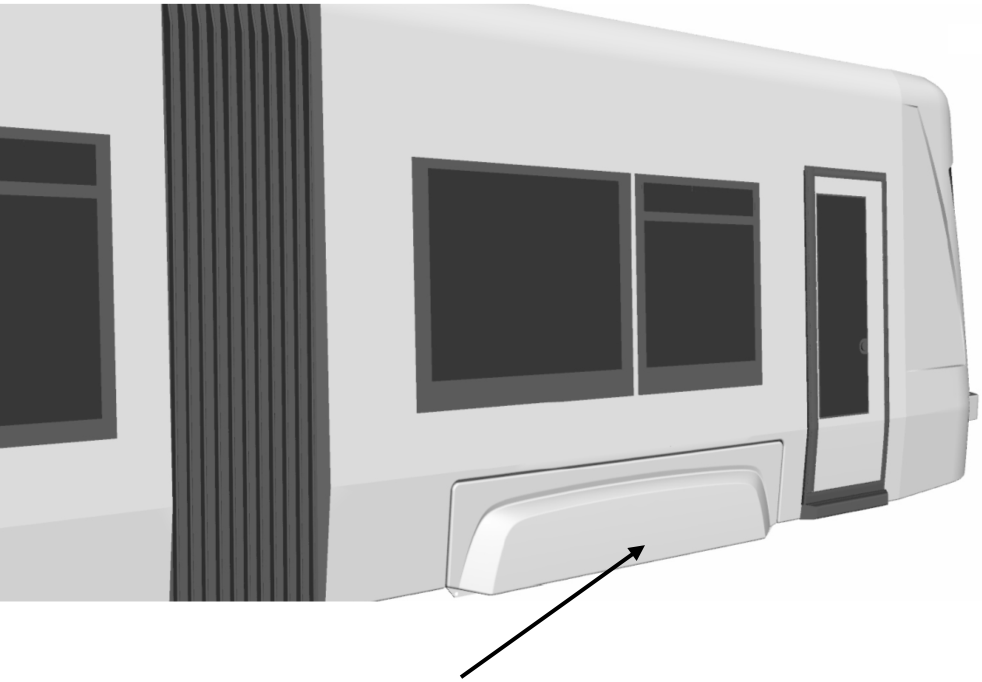
WHEELS

Typical Semi-Soft Wheel **Advanced Softer Wheel**



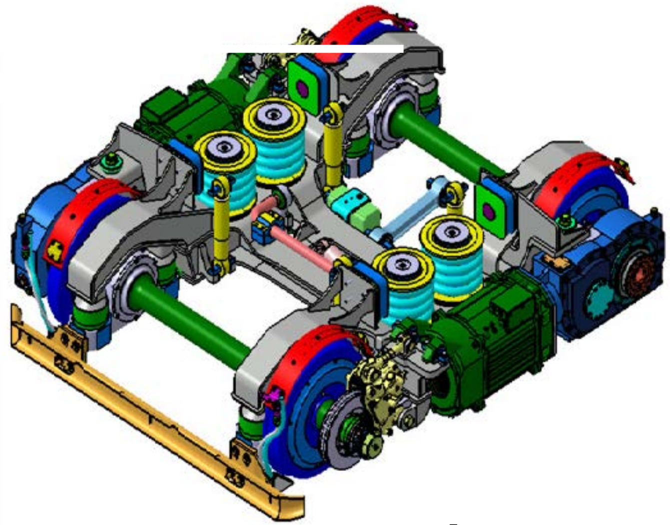
- Most rail vehicles use stiff wheels.
- Typical European LRVs use semi-soft wheels.
- TTC will use advanced softer wheels on the LRV.
- Softer wheels tend to transmit less vibrations into the ground than other wheel types.

BOGIE SKIRTS



Bogie Skirt

Bogie skirts reduce wheel noise while improving safety and aesthetics.



Bogie

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.

CONTENTS

- Introduction
- TTC System Facts
- Project Objectives and Procurement Process
- Contract Award
- Public & Stakeholder Consultation
- Safety & Accessibility Features
- Noise & Ground Borne Vibration
- **Infrastructure Upgrades**
- Testing, Commissioning and Revenue Service Launch

OVERHEAD SYSTEM UPGRADES

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

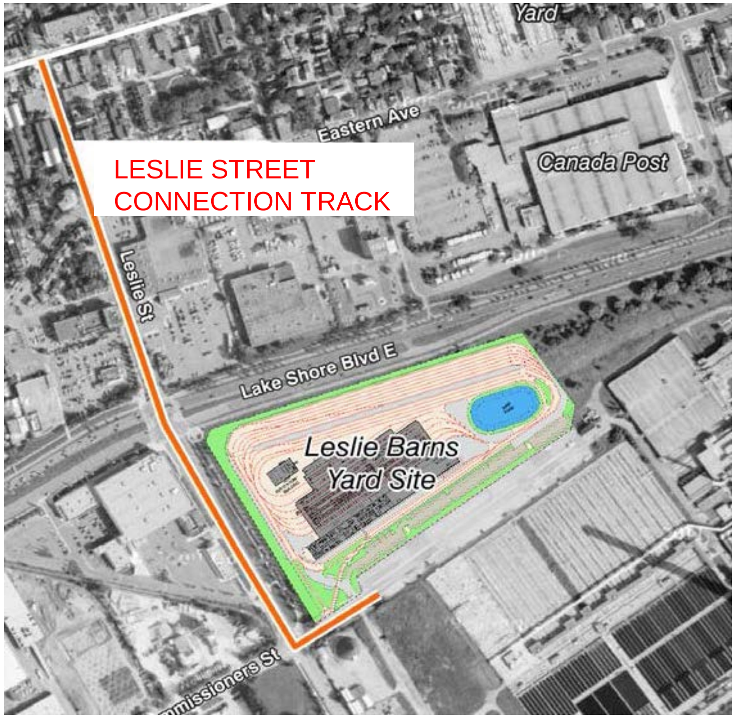
OVERHEAD SYSTEM UPGRADES

OLD OVERHEAD

NEW OVERHEAD

LESLIE BARNS - GENERAL

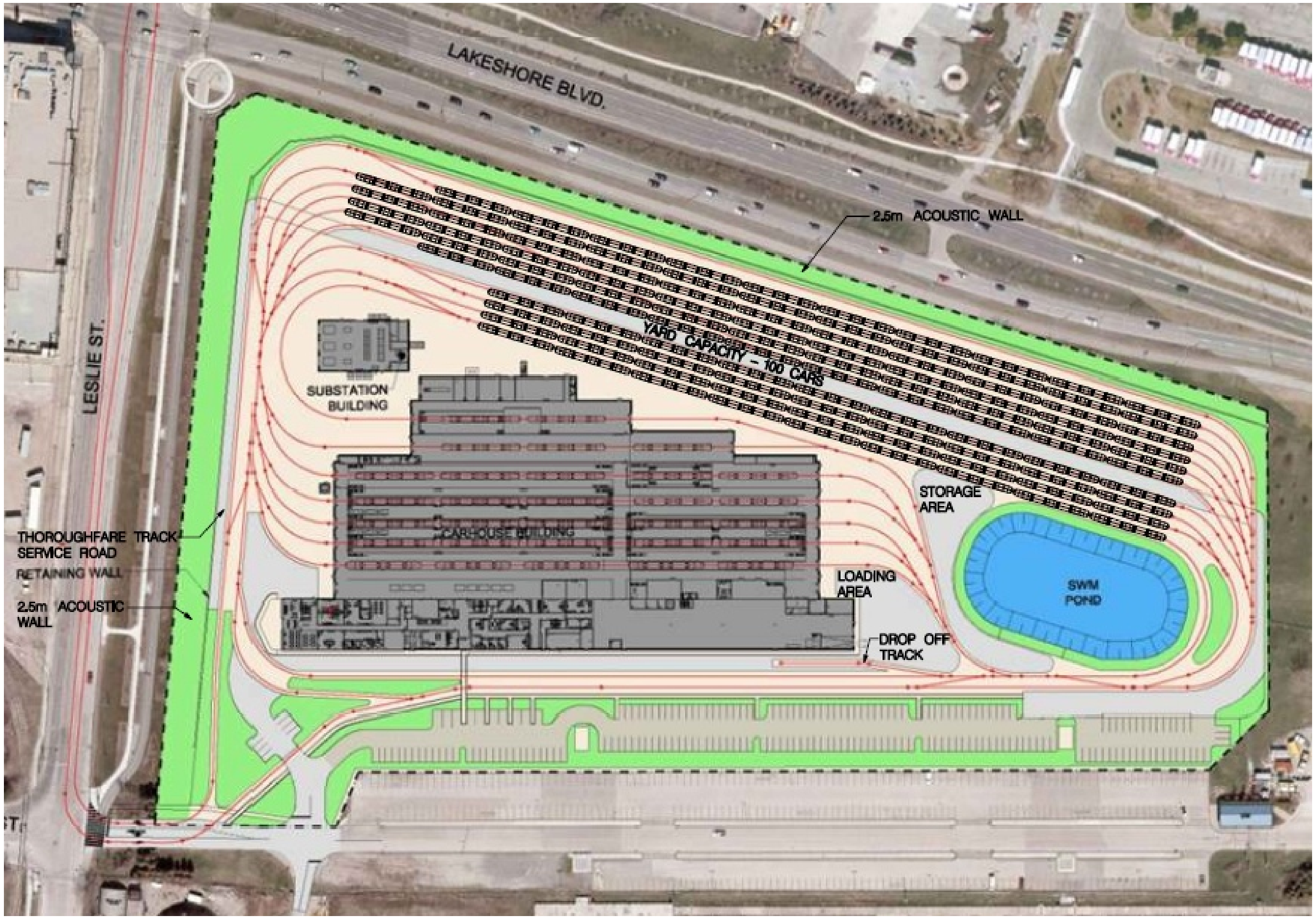
- Leslie Barns Facility Construction
- Construction of a maintenance facility to
- accommodate 204 low floor light rail vehicles (LFLRVs)
- Construction of a 26,000 sq. m. carhouse:
  - Green roof
  - Maintenance area with 30 bays
  - Offices
  - Cab simulator training room
- Storage Tracks for 100 LFLRVs
- Substation
- Leslie Street Connection Track



LESLIE BARNS - EXTERIOR

Exterior perspective from Lake Shore Boulevard, looking southwest.

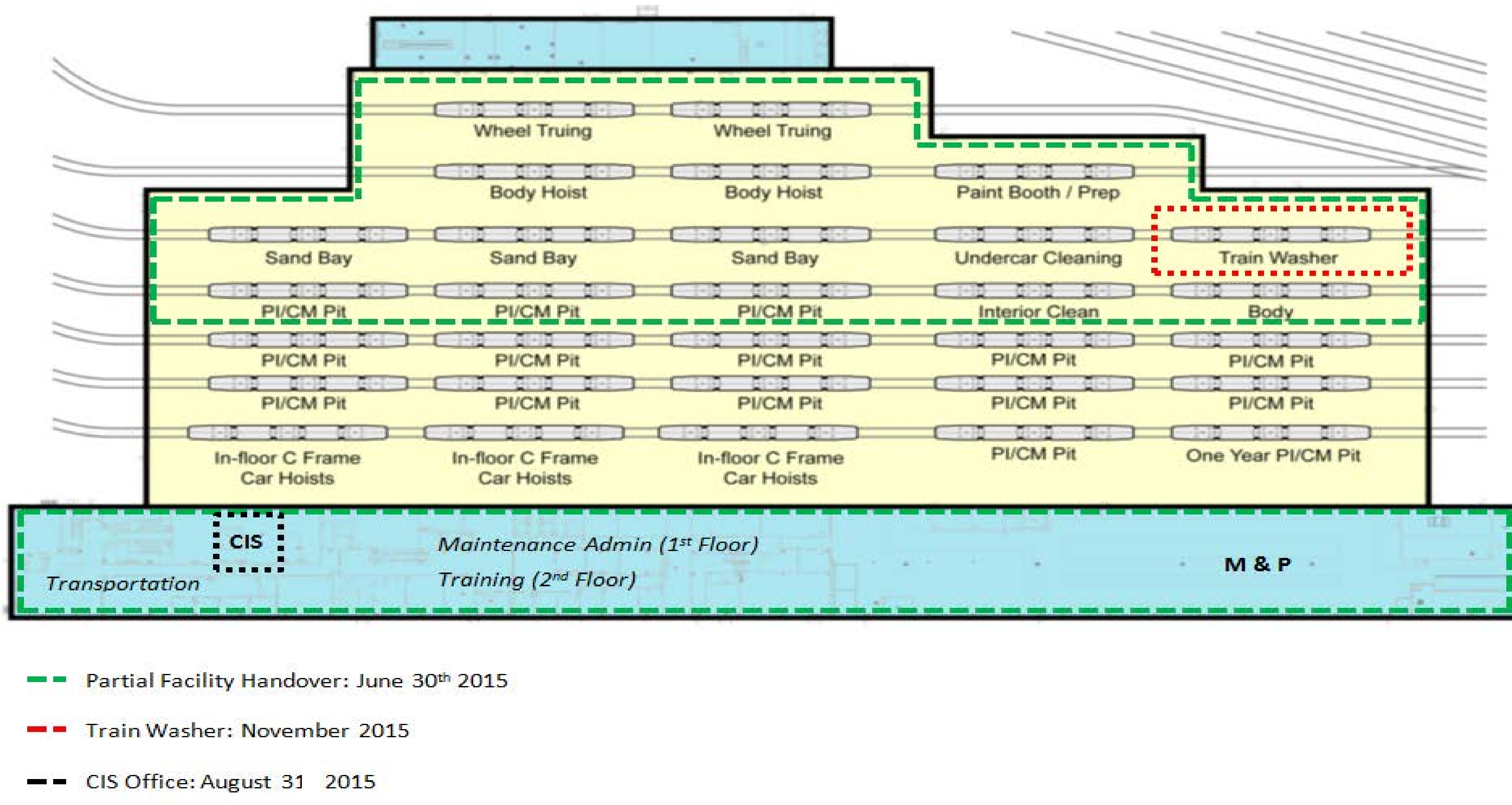
LESLIE BARNS – TRACK LAYOUT



LESLIE BARNS – 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



CONTENTS

TESTS - CLIMATE ROOM

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.

TESTS - NETWORK COMPATIBILITY AND VEHICLE PERFORMANCE

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

TESTS – FREE RIDES

Meet your
new ride, Toronto!
In service, starting
August 31.

PRE-SERVICE LAUNCH MEETING - ACAT

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

SERVICE LAUNCH – AUGUST 31, 2014

SERVICE LAUNCH – AUGUST 31, 2014

Thank You

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