

Toronto's New Subway Cars

1



**Raffaele Trentadue - Head of Rail Cars and Shop
Subway Operations, Toronto Transit Commission**



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Overview

- **Background**
- **Design and Outcome**
 - **Operational impact**
 - **Vehicle & Infrastructure Interface**
 - **Maintenance Impact**
 - **Maintenance and Storage Facility (MSF) Impact**
 - **Brownfield vs Greenfield**
- **Line 2 BD Modernization Lessons Learned**



Background

Toronto Rocket (TR) Fleet

- 54** Peak Trains Required for Service
- 76** 6 car Consist Trains Available for Service
- 6** 4 car consist trains for Line 4 Sheppard

Peak Headways

- AM **2 min 21 sec** (4 min 42 sec between Downsview & Glencairn)
- PM **2 min 31 sec**

Subway Length 30.2 km

Additional 8.6 km upon opening of TYSSE in December 2017

980 Estimated Automobiles a TR replaces during AM Peak Service

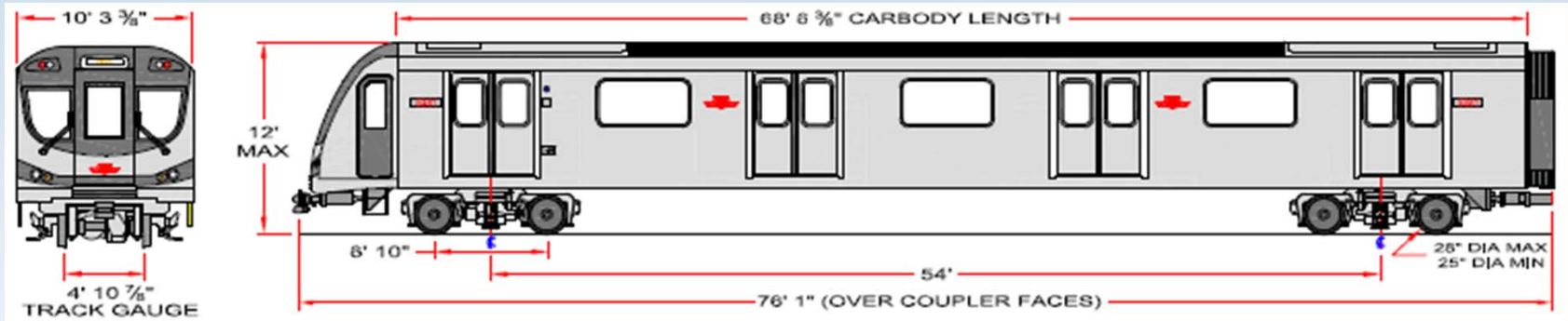
All Subway Lines

- Passengers **221.6 M**
- KM Operated **83.0 M**

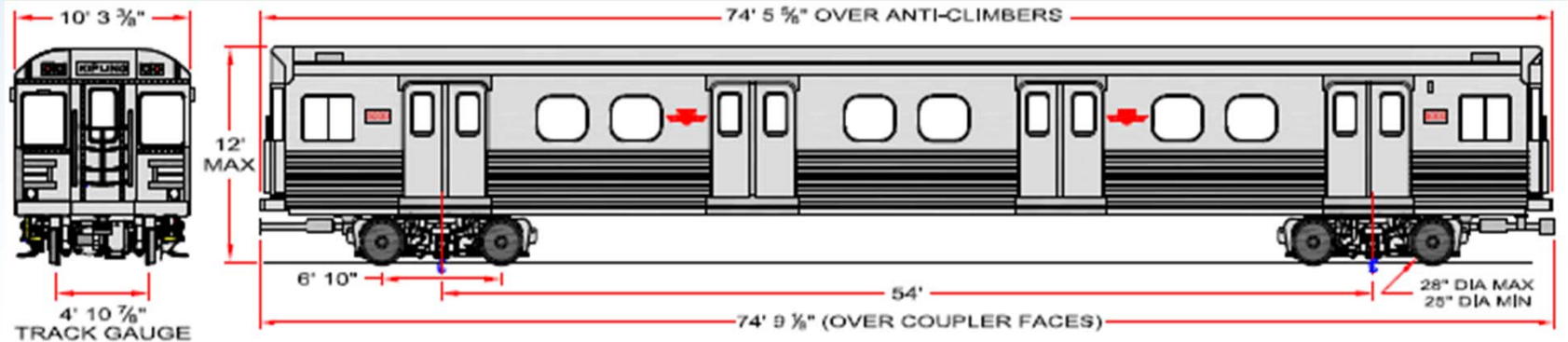


Background

TR



T1



Background

2006 – Contract Award	Replace H4/H5 series vehicles with 39 New TR train-sets	End of service life	39 Trains
2010 - Option B	Replace 21 H6 series Train-sets with 21 new TR train sets	25 Year overhaul Program cancelled Advanced retirement of H6	60 Trains
2010 – Option A	Purchase of 10 New TR train-sets	Toronto York Spadina Subway Expansion TYSSE	70 Trains
2014 - Option C	Purchase of 10 New Train-sets	Service forecast growth and ATC Headway	80 Trains
2015 – CVO	Conversion of the last for 6 car consists to six 4car consists	One Person Train Operation – OPTO readiness	76 – six car consist Trains 6 – four Car consist Trains



Background

Customer	Improved Comfort	<ul style="list-style-type: none"> • Open concept • Free movement between cars • HVAC Circulation • Mobility friendly
Capacity	10% Increase	<ul style="list-style-type: none"> • Increase in Standing area • Addresses maximum growth on Line 1 YUS
Reliability	Decrease in delay Incidents and Minutes	<ul style="list-style-type: none"> • Projected decrease in delay minutes by 60%
Safety	Improved Safety Design Features	<ul style="list-style-type: none"> • Crash Safety Worthiness • Smoke Detection • Car Structure (steel) • Improved Fire retardant material • CCTV Camera • Faster egress for Evacuation (deployable ramp)
Infrastructure	\$50M	<ul style="list-style-type: none"> • Estimated Modifications to accommodate 6 Car Consist



Design and Outcome Operational Impact



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Design & Outcome – Operational Impact



Six car permanent consist with articulated gangways



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Design & Outcome – Operational Impact



Accessibility for mobility seating



Blue Priority Seating



Perch Seating for increased standing room



Design & Outcome – Operational Impact

10

CCTV Dome Camera



PAI



Operator Cab



- Improved Security for Operator (isolated cab)
- Improved Security for Passengers
- Improved passenger assistance and intercom



Design & Outcome – Operational Impact



Can evacuate
1500 people
within 30 minutes

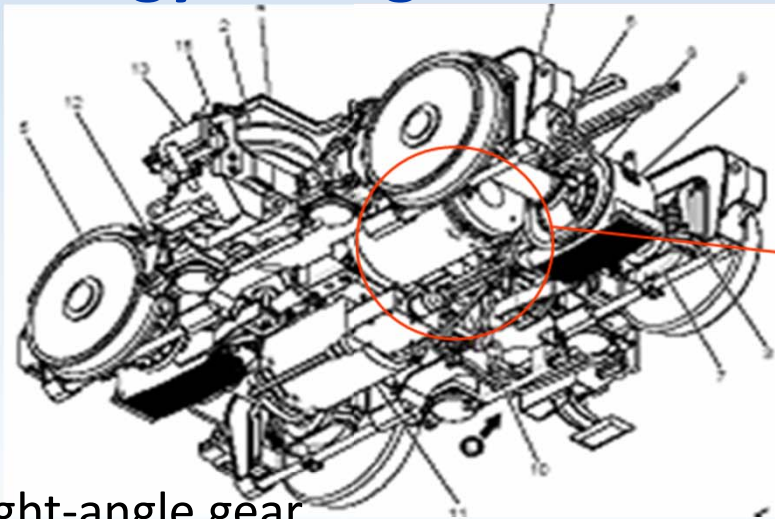


- **Open Gangway Concept allows for Improved Mobility**
- **Emergency Egress rate reduced by 50%**

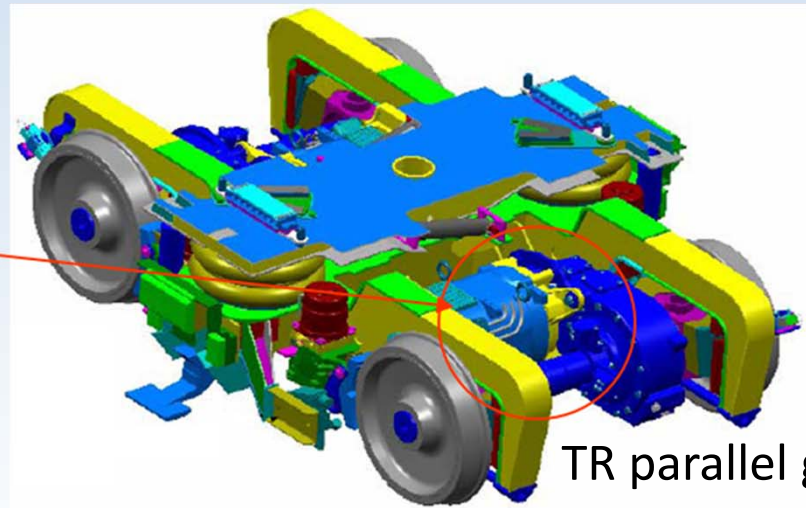


Design & Outcome – Operational Impact

Energy Savings



T1 right-angle gear



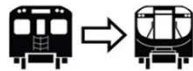
TR parallel gear

Produces annual traction energy saving, i.e. 82 TR trains will save:

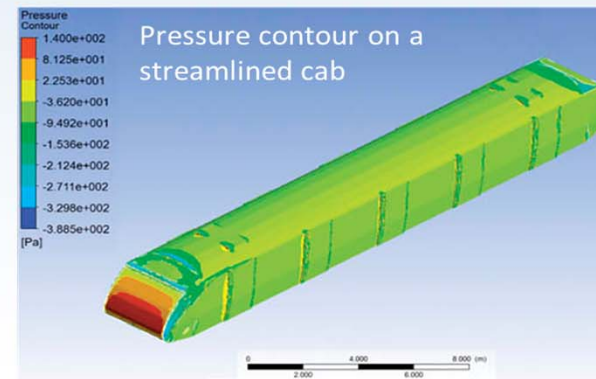
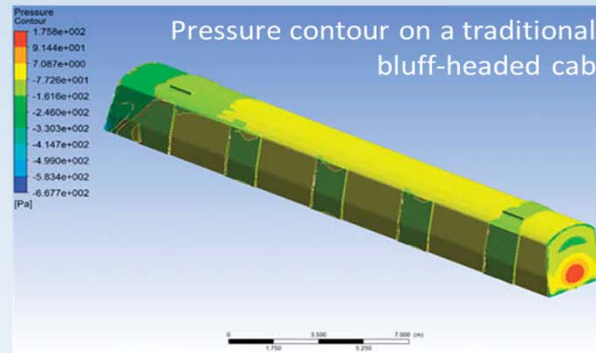
$P \cong 10,000,000$ kW



Design & Outcome – Operational Impact



Drag Forces (Newton)	Bluff Head	Streamlined Head
Drag due to head shape	1484	506
Skin friction	140	182
Total	1624	688



Energy Savings

Modelling demonstrates potential Energy Savings due to increase of aerodynamic efficiency from cab design



Design & Outcome – Operational Impact



Improved fire rating standard

- TR floor is tested to ASTM E119 (fire resistance) for 30 minutes
- T1 Specification called for ASTM E119 but only 15 minutes rating which was in alignment with the FRA guidelines* at that time.

** Federal Railroad Administration, Rail Passenger Equipment; Reissuance of Guidelines for Selecting Materials to Improve Their Fire Safety Characteristics, Federal Register, Vol. 54, NO. 10, 1837-1840 (1989)*



Design and Outcome Vehicle/Infrastructure Interface



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Design & Outcome Vehicle/Infrastructure Interface¹⁶



**Excessive Grease Picked up by
Wheels and Transferred over
on Brake Shoes**



**Track Lubricators
(Fine Tuning the Lubrication
Rates)**

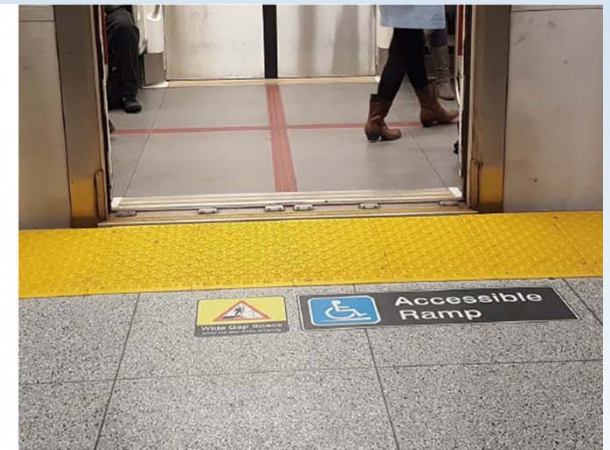


Design & Outcome Vehicle/Infrastructure Interface

Car Floor level with platforms



Before



After

Cars ToFF had been set within tight guidelines for fleet consistency and deficient areas within the network were addressed



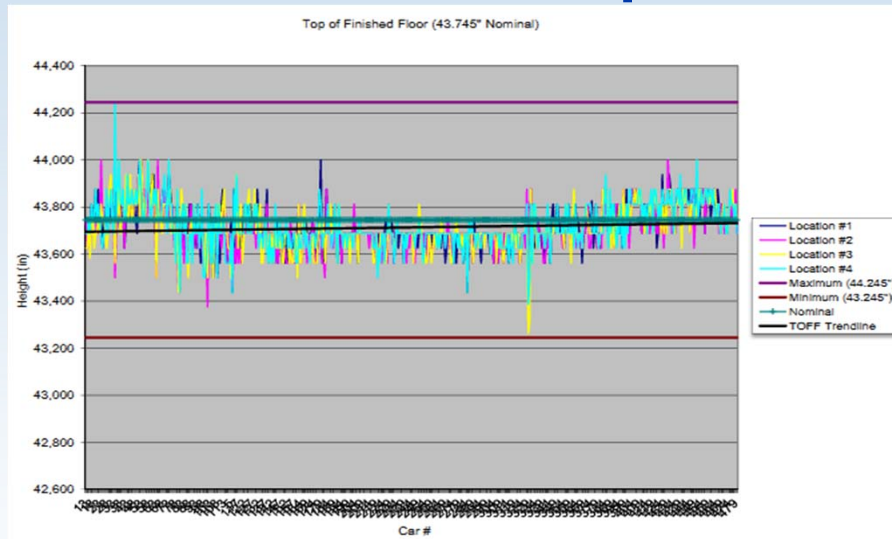
RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Design & Outcome Vehicle/Infrastructure Interface

Car Floor level with platforms



Tight control during production was implemented in order to ensure that acceptable level of consistency in cars floor height tolerance was achieved $\pm 0.5''$

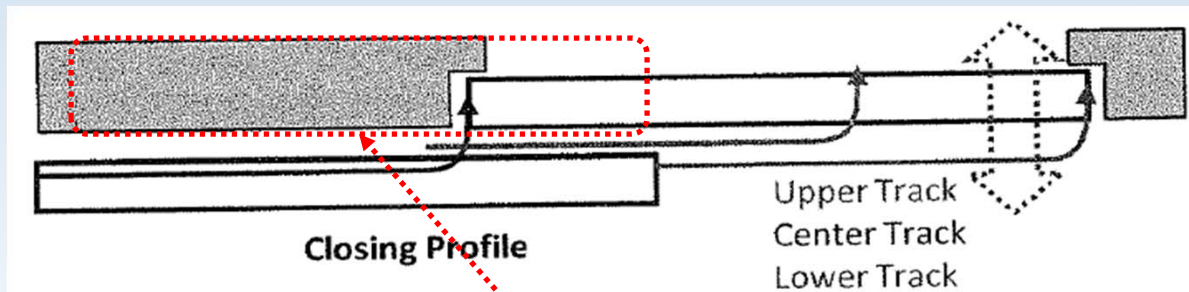
Total Average	1.191532258	1.236607143	1.315104167	1.239583333
Standard Dev. (all stations)	0.582052646	0.556515787	0.573260355	0.663403472
Average of Accessible Stations	1.1171875	1.153846154	1.266666667	1.159090909
Standard Dev. (accessible stations)	0.589844612	0.473742354	0.604186402	0.576748549

- **Managing platform and vehicle interface within AODA framework.**
- **Documented the differences in height of platforms vehicle during train test runs**

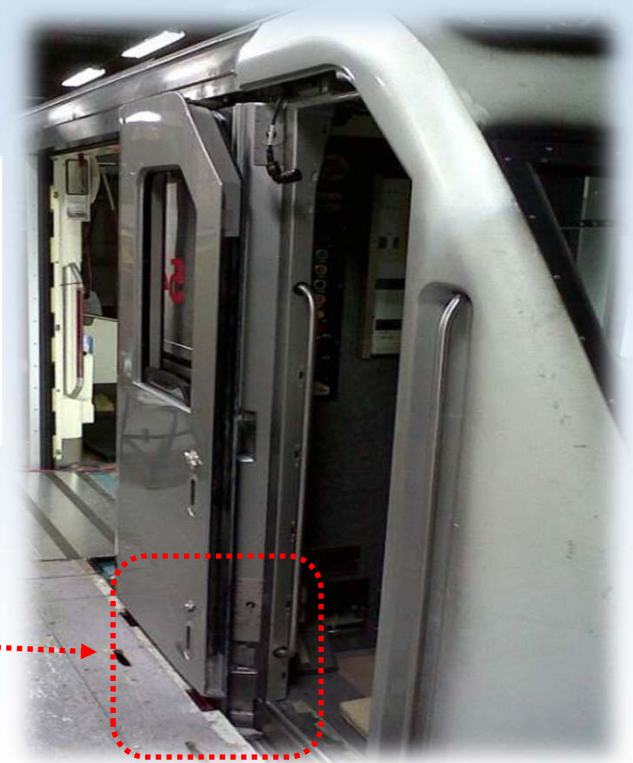


Design & Outcome Vehicle/Infrastructure Interface

Cab door dynamic envelope



Inconsistent structural tolerance clearance infringed on Cab Door "Open Position"



Design and Outcome Maintenance Impact



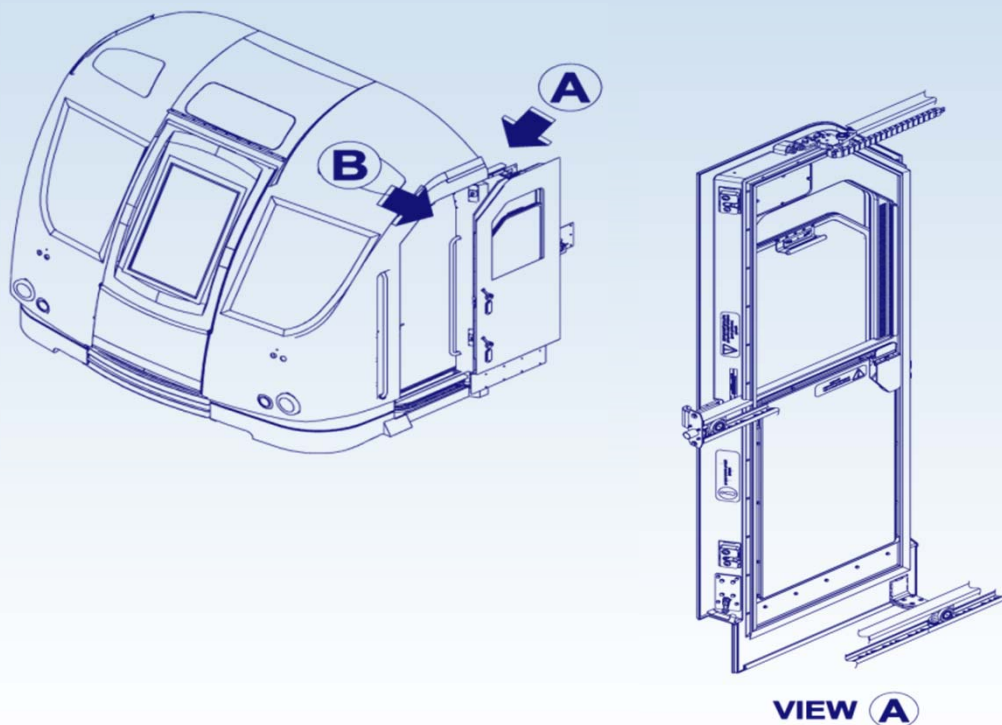
RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Design & Outcome – Maintenance Impact

21



New Cab Configuration and Cab Door Design

- introduced unexpected delays related mechanical latching and electrical door train-line
- Extension of warranty, several design revisions



Design & Outcome – Maintenance Impact

22



REV. E CAB DOOR

- Manual local isolation device allows trains to stay in service
- Ease of adjustment / maintenance
- Modified external handles to prevent stuck key
- Modified exterior seal & bulb seal to improve air & sound infiltration
- Modified window seal to minimize friction



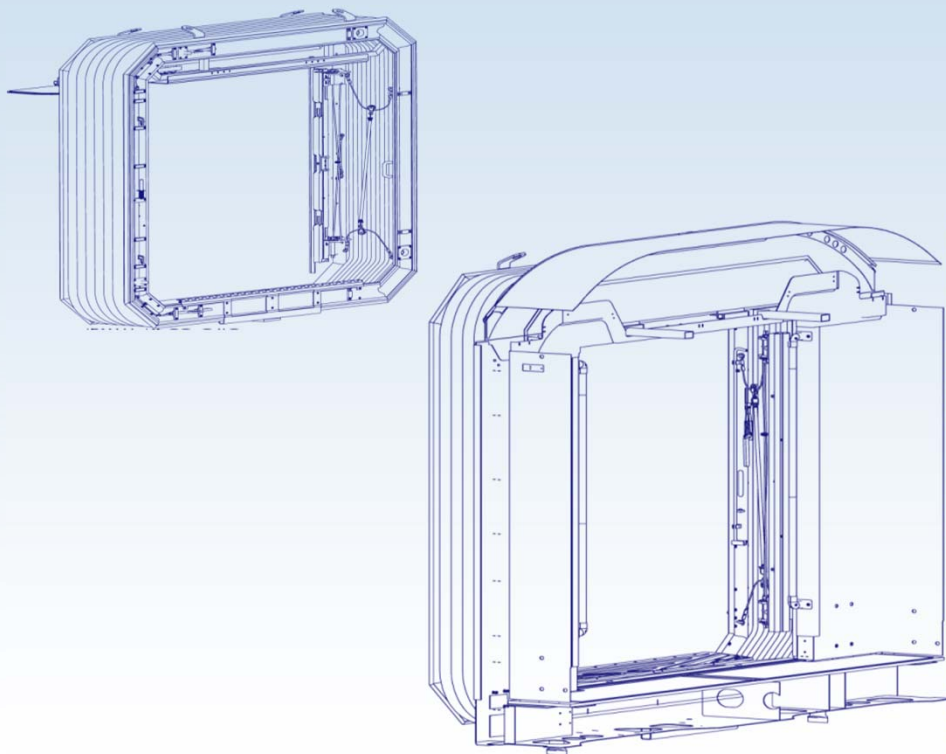
RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Design & Outcome – Maintenance Impact

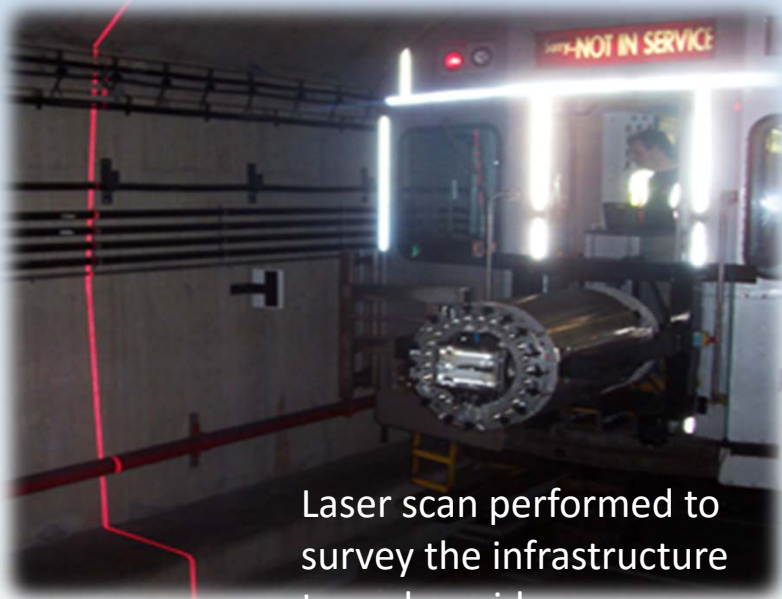
23



- Interior Gangways require much more attention to detail for maintenance
- Both from a cleanliness and mechanical interface perspective
- Early issues with panels cracking and shifting



Design & Outcome – Maintenance Impact



Laser scan performed to survey the infrastructure tunnel corridor

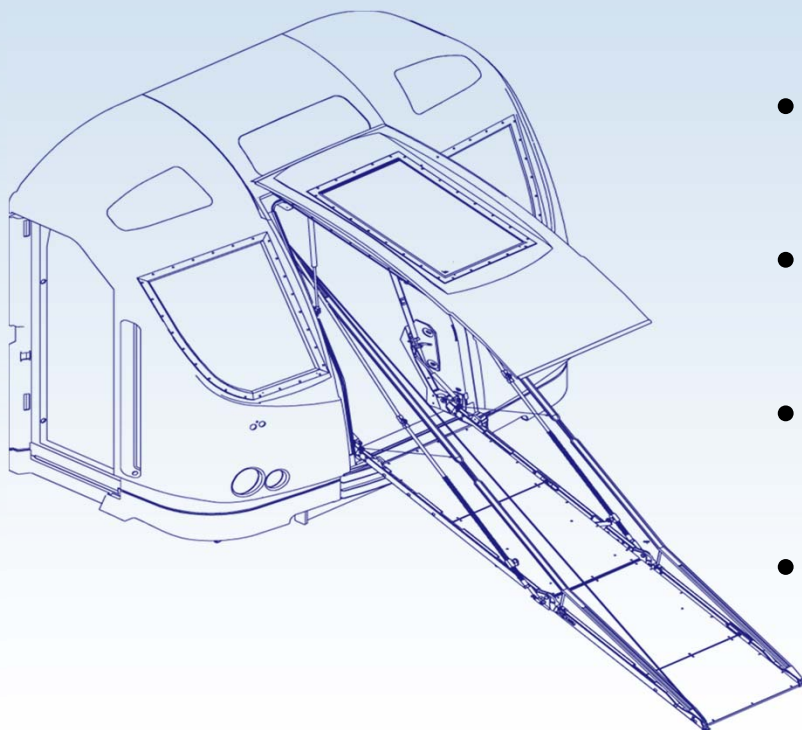


Cracked side wall – Supplier attempted to blame unregistered tight curve but unsupported by the laser scan data obtained during design stage



Design & Outcome – Maintenance Impact

25



- Early issues with seal retention (water and air ingress) in cab area
- Design issues with door detrainment ramp
- Deploys easy but requires ratcheting tool to recovery ramp
- Long recovery time to restore ramp



Design & Outcome – Maintenance Impact

26



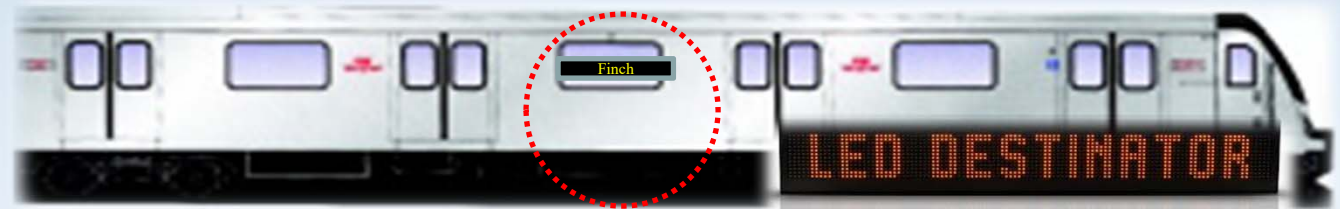
- **Networking Control and Train-lines have less electrical contacts between coupler interface - eliminates Door, EB train-line intermittent type failures and less maintenance.**



Design & Outcome – Maintenance Impact

AODA and customer enhancements modifications cut-in

Pre-boarding and external audio



Low Ceiling Hand Hold



External Speakers



Priority Seating



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Design & Outcome – Maintenance Impact



Automatic Train Control (ATC) cut – in

Retrofitting the radio antenna onto the 1st prototype train at Thunder Bay

- Upon “execution” of ATO implementation, 6 to 7 months of software development incurred before proceeding to integration tests of the complete train-borne network exposing high risk to production.



Design & Outcome – Maintenance Impact

Train Door Monitoring System (TDMS) Requirements for One Person Train Operation (OPTO) Cut-in



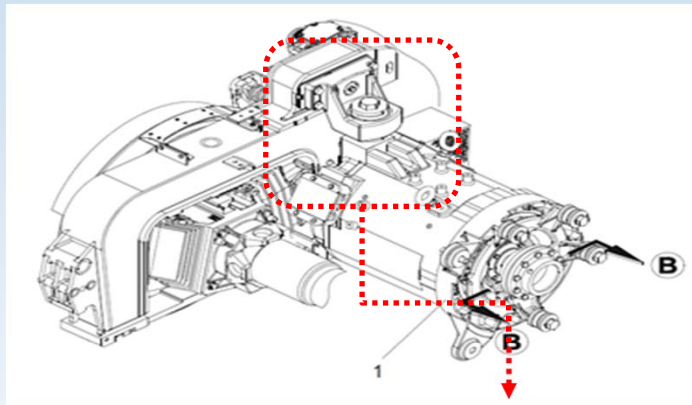
- Train borne wireless receiver & TDM screen
- Cab Console Door Master Switch Panel (CDMSP)



- The main purpose of the TDM system is to display view of passenger train doors in cab console via Way side CCTV camera & wireless transmitter



Design & Outcome – Maintenance Impact



Broken Torque Seal – Loosened
NDE Bolt



Traction Motor
(Non-Drive End)
Bolt Failures

Rapid Breakage
by Shear Forces



Insufficient Clamp Loads
due to Sub-Quality Blind
Thread Hole of the Motor
Casting Case



Design & Outcome – Performance

LINE 1 YUS

TR MEAN KILOMETRES BETWEEN EQUIPMENT DELAYS (MKBD)
(GREATER THAN OR EQUAL TO FIVE MINUTES)

YEAR END REVIEW 2013 to 2017 (YTD)*



*YTD as of April 29, 2017

With 2017 projected targets



Design and Outcome Maintenance and Storage Facility (MSF) Impact



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Design and Outcome – MSF Impact

33

MSF (Carhouse) Modifications

- Platform/Track Extensions
- Roof Mounted HVAC Mezzanie
- Underground Walkway Access (Blocked center Isles)
- Tandem Wheel Lathe Installation and relocation
- 6 Car Hoist Installation



Design and Outcome – MSF Impact

34



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Design and Outcome – MSF Impact

Incompatible Lifting Jacks



**Single Car Lifting Jack
(for truck replacement)**



**Partial Seating at the Jacking
Pad (due to different jacking
point locations of older vehicles)**



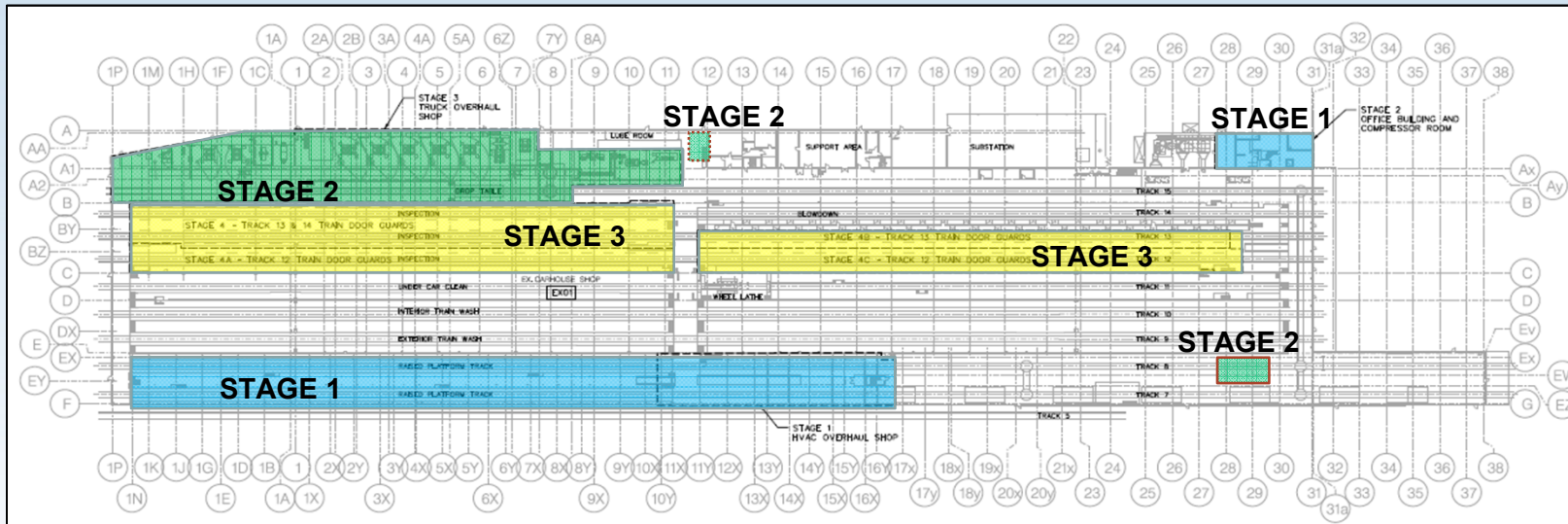
Design and Outcome – MSF Impact



- Ergonomic and functional study
 - Comparing TR Truck Stand and Adjustable Height Hoist
 - Truck Overhaul Maintenance output



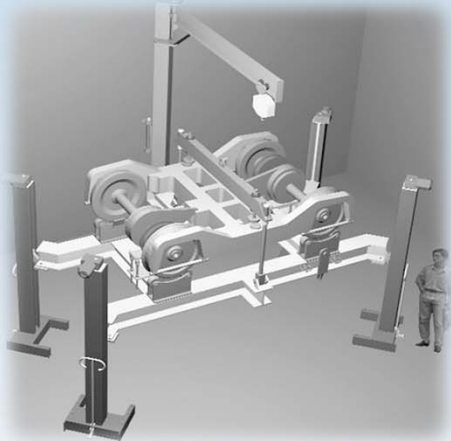
Design and Outcome – MSF Impact



- Stage 1 – Track 7&8 HVAC Overhaul Shop and Mezzanine Ventilation Upgrade and office Building
- Stage 2 – Track 15&16 Truck Overhaul Shop & South Basement Expansion
 - Track Stand Relocation and Additional Track Stand and Crane
- Stage 3 – Train Door Guards and Platforms (Tracks 12, 13 and 14)



Design and Outcome – MSF Impact



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Design and Outcome – MSF Impact

First in North America 6-Car hoist



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Design and Outcome – MSF Impact



6 Car Hoist Configuration problem

Configuration of control of train position sensors was modified to correct the issue



Brownfield vs Greenfield



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Brownfield vs Greenfield

42



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

Brownfield vs Greenfield

Brownfield

- **Comparable Costs for Infrastructure Changes to Greenfield**
- **Impact on Operation & Maintenance during Construction**
- **Susceptible to Scope Creep**
- **Unpredictable Compatibility Issues with Infrastructure**



Brownfield vs Greenfield

Greenfield

- **Purposely Design Build for Compatibility**
- **No disruption to Operation**
- **Improved opportunity to design latest tooling and technology**
- **No limitations/restrictions in design**
- **Able to improve on ergonomics and eliminate high risk hazards**



Brownfield vs Greenfield

Work Order	Description	EFC \$M
584X	Wilson Complex - Modifications for the Toronto Rocket	\$95.0
6659	Toronto Rocket / T1 Rail Yard Accommodation	
	C1-38 WILSON YARD - EXTEND CARHOUSE NORTH	\$61.3 **
	C1-42 WILSON CARHOUSE - TRACKS 15 AND 16 EXPANSION AND ALTERATIONS	\$59.5 **
	WILSON CARHOUSE - IMPROVE VENTILLATION IN THE MEZZANINE AREA TRACKS 7 & 8	\$4.6
	S5-59 DAVISVILLE CARHOUSE - EXPANSION	\$10.4
	C1-40 WILSON CARHOUSE- ALTERATIONS FOR THE TR VEHICLES	\$1.7
	TBD WILSON CARHOUSE - TR HVAC OVERHAUL REPAIR FACILITY (NEW*)	\$9.5 \$147.0
		<u>\$242.0</u>






Notes:

* New project in 2016-2025 Budget and subject to City Approval.

** Contracts C1-38 and C1-42 are shared with TYSSE and represents total costs shared by both projects.



Design and Outcome

Customer	Improved Comfort	<ul style="list-style-type: none"> • Open concept • Free movement between cars • HVAC Circulation • Mobility friendly 	
Capacity	10% Increase	<ul style="list-style-type: none"> • Increase in Standing area • Addresses maximum growth on Line 1 YUS 	
Reliability	Decrease in delay Incidents and in Minutes	<ul style="list-style-type: none"> • Projected decrease in delay minutes by 60% 	
Safety	Improved Safety Design Features	<ul style="list-style-type: none"> • Crash Safety Worthiness • Smoke Detection • Car Structure (steel) • Improved Fire retardant material • CCTV Camera • Faster egress for Evacuation (deployable ramp) 	
Infrastructure	\$50M 242M	<ul style="list-style-type: none"> • Estimated Modifications to accommodate 6 Car Consist 	



Line 2 Modernization Lessons Learned



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017

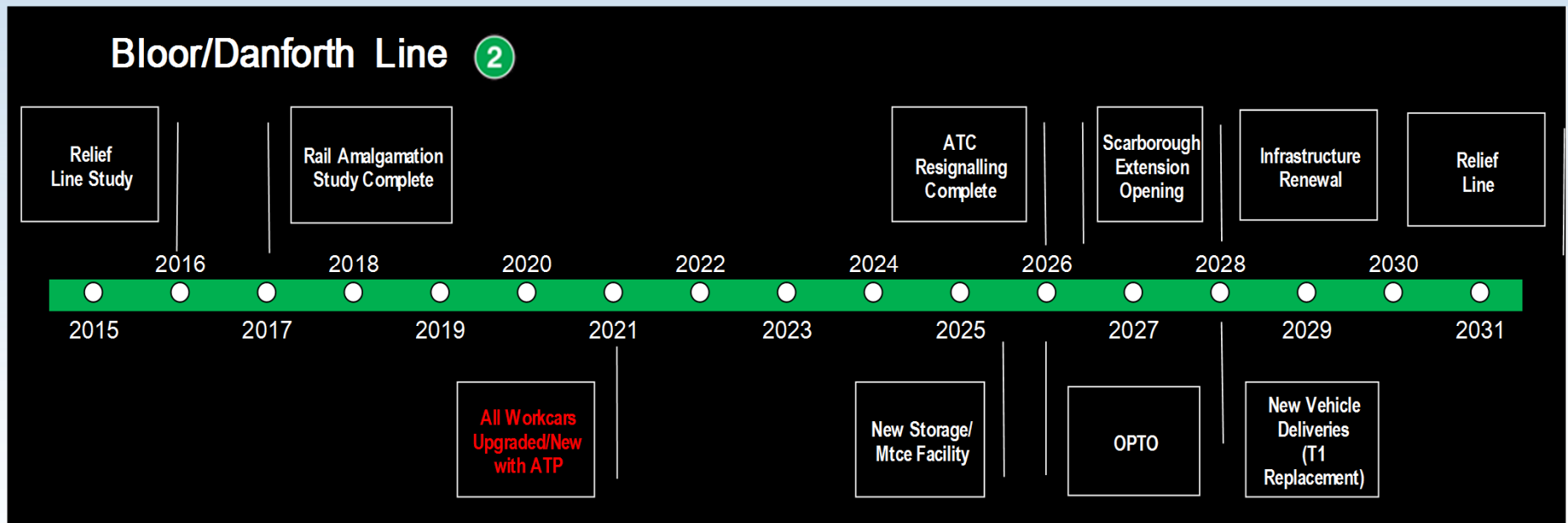
Line 2 Modernization

On the Horizon.....

- Rolling Stock (T1) Replacement
- One Person Train Operation (OPTO)
- Infrastructure Renewal
 - Corridor
 - Stations
- Automatic Train Control
 - ATP Workcars
- New Maintenance and Storage Facility (MSF)
- Line Expansion
 - Scarborough Subway Extension (SSE)
 - North Yonge Extension
 - Relief Line



Line 2 Modernization



Thank You



RAIL TRANSIT SEMINAR • JUNE 5, 2017



WRI 2017