



STAFF REPORT ACTION REQUIRED

Procurement Authorization Amendment To Modify Four Toronto Rocket Train Sets for Service on Line 4 (Purchase Order No. C31PD05761)

Date:	June 22, 2015
To:	TTC Board
From:	Chief Executive Officer

Summary

The Automatic Train Control (ATC) System is planned to be in full service on Line 1 in 2020; as such, all vehicles operating on Line 1 must be compatible with the ATC system. This affects the service on Line 4, since Line 4 trains (legacy T1 subway trains) are transferred to and from the subway yards via Line 1. Therefore, the trains that service Line 4 must also be ATC-equipped. This report recommends the modification of the final four TR trains for service on Line 4, in place of the existing T1 trains, as the TR trains are delivered with ATC equipment installed. The recommendation overcomes the major operational setbacks associated with operating T1 trains on Line 4, which would disrupt the ATC System on Line 1 during vehicle movements to and from the yards.

Also, the use of TR trains on Line 4 will require that the One Person Train Operation (OPTO) pilot program is fitted to TR trains rather than T1 trains. With the pilot program planned for Line 4, the TTC will benefit from the efficiencies of designing and testing the OPTO modifications on TR trains, which can be immediately implemented on Line 1 service trains. Therefore, the recommendation of this report also capitalizes on cost and schedule benefits by avoiding the early modification of legacy T1 trains with OPTO equipment.

Finally, the 2015 Subway Fleet Plan identified a forecasted shortage of trains available for service on Line 2. Since the recommendation of this report displaces the T1 trains from Line 4, the trains become available for service on Line 2 and eliminate the deferral of ridership growth trains into future years.

Recommendations

It is recommended that the Board authorize:

1. TTC staff to proceed with a Purchase Authorization Amendment to the TR Subway Train Contract with Bombardier Transportation Canada Inc. (Bombardier) no later than June 22, 2015. The amendment is for the modification of four TR 6-car train sets into six 4-car train sets for service on Line 4. The amendment is in the amount of \$25,810,282.54 CDN, inclusive of all applicable taxes.
2. The expenditure of funds up to a total allowance amount of \$12,500,000 CDN inclusive of all applicable taxes, with respect to the modification of 4 train sets, for inflationary escalation adjustments, contract security to cover the relaxed delivery schedule, allowance for a one time foreign exchange adjustment at Notice to Proceed, potential additional capital spares and special tools and test equipment, and contingency allowance for project changes, resulting in a total authorized expenditure of up to \$38,310,282.54 CDN. Net project costs will include tax recoveries under HST from this contract authorized amount. Refer to Appendix 1 for further information.
3. Delegation of its authority to the Chief Executive Officer for the total allowance amount set out in recommendation 2 above.

Financial Summary

Sufficient funds are included under the contingency allowance of Project 4.12 – Purchase of 60 New Subway Cars (Ridership Growth and ATC), which has a budgeted estimated final cost of \$227.2 million, as set out on pages 713 to 714, in the “State of Good Repair & Safety” category of the TTC’s 2015-2024 Capital Budget and Plan, which was approved by the City of Toronto Council on March 10/11, 2015.

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

Accessibility/Equity Matters

The TR train design introduces various accessibility enhancements over the T1 design. Although the recommendations of this report are not primarily driven by accessibility concerns, active consultations with the Advisory Committee on Accessible Transit (ACAT) are ongoing.

Decision History

In 2006, the Board approved the award of a contract to Bombardier for the purchase of 39 TR train sets to replace the existing H4 and H5 subway vehicles that were approaching the end of their service life. Minutes of the meeting are available on the TTC website. Refer to agenda item 4 in the following link:

[http://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2006/Sept 20 2006/Minutes/index.jsp](http://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2006/Sept_20_2006/Minutes/index.jsp)

In 2010, the Board approved the execution of Option 1(B) in the contract for the purchase of 21 TR train sets to replace the H6 subway vehicles, which were also approaching the end of their service life, and Option 1(A) for the purchase of 10 TR train sets to support the Toronto York Spadina Subway Extension (TYSSE) program. Minutes of the meeting are available on the TTC website. Refer to agenda item 5b in the following link:

[http://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2010/June 2 2010/Minutes/index.jsp](http://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2010/June_2_2010/Minutes/index.jsp)

In 2014, the Board approved the execution of Option 1(C) for the purchase of 10 TR train sets to address revised forecasts of future ridership levels, as well as the increased levels of service that will be achievable with ATC. Minutes of the meeting are available on the TTC website. Refer to agenda item 5a in the following link:

[http://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2014/March 26/Agenda/index1.jsp](http://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2014/March_26/Agenda/index1.jsp)

Finally, in March 2015, the Board authorized a change directive to Bombardier in the amount of \$2,734,822.98, including taxes, for the engineering design to facilitate the modifications of TR trains for a Train Door Monitoring (TDM) system as part of OPTO. The report describes the conversion of 6-car TR trains to 4-car trains that would be the subject of a future Board Report. Minutes of the meeting are available on the TTC website. Refer to agenda item 5a in the following link:

[http://www.ttc.ca/About the TTC/Commission reports and information/Commission meetings/2015/March 26/Agenda/index.jsp](http://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2015/March_26/Agenda/index.jsp)

This resulted in the purchase of a total of 80 TR train sets from Bombardier under the existing contract. Table A outlines the Board approved authority for these train orders.

Table A

Item		Vehicle Cost	Allowances	Total Authorization
Original Contract	Base Order (39 Train Sets – H4/H5 Replacement)	\$ 624,567,602.52	\$ 50,220,000.00	\$ 674,787,602.52
Previous Amendments	Option 1(A) (10 Train Sets - TYSSE)	\$128,551,071.30	\$34,157,000	\$162,708,071.30
	Option 1(B) (21 Train Sets – H6 Replacement)	\$ 269,957,249.73	\$ 47,255,000.00	\$ 317,212,249.73
	Option 1(C) (10 Train Sets – ATC/Forecast Growth)	\$ 176,567,020.00	\$ 40,221,850.00	\$ 216,788,870.00
	ATC Integration (70 Train Sets)	\$ 31,517,892.92	\$ 3,266,971.00	\$ 34,784,863.92
	ATC DTO Mod (80 Train Sets)	1,176,072.96	NIL	\$ 1,176,072.96
	Spares, Special Tools and Test Equipment (Option 1(A) and 1(B) Train Sets)	\$ 27,242,504.43	\$ 757,495.57	\$ 28,000,000.00
	All Other Amendments (Design changes, etc.)	\$ 34,447,823.41	NIL	\$ 34,447,823.41
	Engineering for TDM System Modification	\$ 2,734,822.98	NIL	\$ 2,734,822.98
Current Amendment	Modify 4 Train Sets for Service on Line 4	\$ 25,810,282.54	\$ 12,500,000.00	\$ 38,310,282.54
Total Authorization Amount		\$ 1,322,572,342.79	\$ 188,378,316.57	\$ 1,510,950,659.36

Exclusive of the base order vehicle price, all other vehicle pricing is prior to a one-time adjustment for foreign currency exchange rate variance and net project costs will include tax recoveries under HST from the contract authorized amounts.

The next significant fleet replacement of subway train sets is not planned until 2026 when the existing T1 train sets reach the end of their service life.

Comments

Assessment of Alternatives

Since the ATC system is planned to be in full service on Line 1 in 2020, all vehicles operating on Line 1 must be ATC-compatible. This also applies to Line 4, as those trains are transferred to and from the subway yards via Line 1. Via a business case analysis, TTC staff assessed a number of alternatives and identified the only viable approach to meet the ATC requirement. The alternatives are discussed below.

Option 1 – Modify four TR 6-car Trains into six 4-car Trains for Service on Line 4

This option is based on modifying four 6-car TR train sets into six 4-car train sets, as illustrated in Figure 1. Four ‘C’-cars are modified into ‘A’-cars (cab-equipped cars) while the remaining cars remain the same.

This approach immediately solves the ATC-related concerns by populating Line 4 with ATC-equipped trains. It is also the only option that ensures the timely implementation of OPTO on Line 1, as the pilot program will develop a solution that is fitted to TR trains rather than T1 trains. This allows TTC staff to capitalize on cost and schedule benefits by avoiding the early modification of legacy T1 trains with OPTO equipment. Finally, this approach displaces the T1 trains from Line 4 to Line 2, where they will be used to meet the forecasted ridership growth.

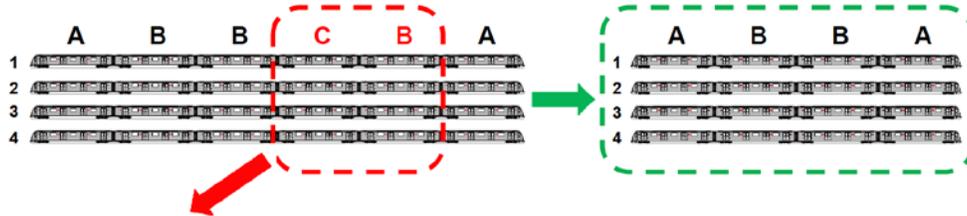
The modification affects four TR train sets. As noted in the 2015 Fleet Plan (page 3, Table 2A), Line 1 has two contingency trains in 2025, at which time the next vehicle procurement will begin to increase the quantity of service trains. Further, TTC staff have a high degree of confidence in the improved reliability of the TR fleet (as compared to T1 trains), as well as the Line Replaceable Unit (LRU) design of the TR train (this is an operational feature that can be exploited to reduce downtime due to overhaul programs). The result is an anticipated reduction in the maintenance spares ratio from 15% to 10%, which will net two additional trains. When combined with the contingency trains, this yields the four trains required to support the conversion of Line 4 to ATC-equipped TR train sets.

Figure 1: Conversion of 4 TR Train Sets into 4-car Train Sets for Line 4

CURRENT TR 6-car train set



MODIFY four (4) TR train sets



'B' cars remain, 'C' cars converted to 'A' cars



RESULT Six (6) 4-car TR train sets

REVISED 4-car configuration for Line 4



In addition to addressing the ATC-related concerns, this option also creates numerous other collateral benefits, as follows:

- The TR design (open gangway, intelligent fire safety, and the door control system) is better suited to facilitate a pilot program for OPTO on Line 4,
- The TR design offers an automatic customer capacity increase (versus T1),
- There are operational benefits of maintaining a single fleet type for Lines 1 and 4 that align with ongoing modifications to the Wilson and Davisville Carhouses,
- There are simplifications in the material handling requirements at the Davisville Complex, and
- There will be common training and operating protocols for Lines 1 and 4.

TTC staff recommends that the Board approve the implementation of Option 1.

Option 2 – Leave T1 trains on Line 4 and Modify them as Required

This option is based on using the legacy T1 fleet to supply service on Line 4 (as is currently done). The approach requires the modification of a subset of T1 trains to accept ATC and OPTO-related equipment (TDM system).

This option introduces significant risk as it involves the design of a T1 vehicle modification for ATC, which currently does not exist. Although technically feasible, the initiative would require significant time to engineer a viable solution, with excessive up-front costs (on the same order of magnitude as the modification in Option 1). Also, the development of an OPTO system on T1 vehicles would not be directly transferable to the TR fleet; this would introduce additional schedule delays to the implementation of OPTO on Line 1, as a separate pilot program would be required. Further, this approach does not alleviate the forecasted shortage of service trains on Line 2. Finally, this option does not introduce any of the collateral benefits germane to the design of the TR train (as described in Option 1 above). For these reasons, this option is not recommended.

Option 3 – Modify Line 4 to Accept 6-car TR Train Sets

The business case analysis also considered the feasibility of modifying the Line 4 infrastructure to accept 6-car TR train sets. This option would allow the TTC to populate Line 4 with TR trains without any modifications.

The analysis revealed that the estimated costs associated with wayside, platform and station modifications far exceed the costs of converting 6-car trains to 4-car trains (the estimated cost of this option is on the order of hundreds of millions). In addition, the modifications would require significant service disruptions to Line 4 resulting in closures and alternative bus supplementary service. Lastly, the modifications would also require detailed project planning and would not be realized in time. For these reasons, this option is not recommended.

Proposed Manufacturing Details for Option 1

Bombardier was requested to submit a proposal for the vehicle modifications. Their proposal is based on two production scenarios, as follows:

Scenario A: Production Continuity (valid until June 22, 2015) - Bombardier maintains a continuous delivery schedule; the modified train sets would be produced once the existing train orders are filled. The delivery of the first 4-car train would be on March 23, 2016, with a final delivery of the sixth 4-car train on June 3, 2016. As a risk mitigation measure to prove the technical feasibility of modifying the 6-car TR trains into 4-car consists, TTC staff and the car builder are currently conducting a prototype exercise on train

number ten (TS10) to physically convert it from a 6-car TR train into a 4-car consist. This will allow TS10 to be available in time for integration testing for TDM and to be safety certified for OPTO by the end of 2015. Once all six 4-car trains are safety certified and approved for OPTO, TS10 will be converted back to its original 6-car configuration.

Scenario B: Production Interruption – Current schedule for 6-car TR production at the Thunder Bay facility would be interrupted and a start-up of 4-car production in an effort to align with OPTO schedule. Production of 6-car train sets would begin again at a later, mutually agreeable, date.

Both scenarios include a modified, slower, delivery schedule for the remainder of the existing order. The proposal assumes that Bombardier will receive a Notice to Proceed (NTP) no later than June 22, 2015.

Scenario A: Production Continuity is preferred for many reasons. The continuous production of train sets allows Bombardier to apply manufacturing lessons learned to date while benefitting from their quality assurance and quality control experience. The production facility already exists and the workforce maintains continuous production levels without the introduction of new manufacturing issues. Further, Bombardier already has subcontracts in place with their suppliers, allowing them to extend existing orders and capitalize on the known and stable reliability of the current vehicle design. The sum of these advantages allows Bombardier to quote pricing in Scenario A but not in Scenario B.

Scenario B: Production Interruption does present a slight possibility of an improved schedule for 4-Car TR train delivery. However, it is extremely cost prohibitive due to unrecoverable up-front supplier retention fees that do not add any value, as well as causing disruption to production stations; as such, the car builder was uninterested in providing official cost estimates for Scenario B other than to indicate it would be almost double the cost of scenario A. There is still no guarantee that the train sets would be delivered on a mutually agreeable schedule acceptable to the TTC and we do not have the full funding to support this option. TTC staff do not recommend the modification of train sets as per Scenario B.

Financial Analysis of Option 1

Bombardier submitted a proposal for the modification of four TR 6-car Train-sets into six 4-car TR train sets in accordance with Scenario A in the amount of \$25,810,282.54 CDN, inclusive of all applicable taxes.

The TTC secured a third party auditor (CH2M HILL) to review the proposed pricing submitted by Bombardier for the conversion of the 6-car train sets into 4-car train sets. The audit scope included a review of any discrepancies in the material costs between Bombardier's current proposal and the last order under Option 1(c), along with a review

of the labour hours. The audit was carried out at the manufacturing plant in Thunder Bay, a copy of which is attached to this report.

Bombardier demonstrated their approach to address engineering, procurement, production and management costs associated with the modifications. A total of seven project areas were reviewed. The auditors identified the main contributing factor to be the engineering hours needed to deliver the modified train sets as per TTC's schedule.

As the modification represents a major technical change to the train design (with completely different operating characteristics), significant engineering effort is required to complete the proper due process in delivering a safe and reliable train. The audit revealed that Bombardier's design team must overcome the following obstacles:

- the necessity for a safety certification for a new 4-car train consist,
- the impact of the change on the train's crash energy management system (fewer gangways),
- the impact on tractive power and braking effort required to balance the change in powered axles (including the impact on the coupling capabilities of 4-car trains),
- the re-design of structural elements under one of the 'B'-cars to incorporate necessary equipment from the cars that are eliminated, and
- the re-configuration of multiple software packages to align them with the revised 4-car train consist.

When considering the impact of material cost escalations, the audit revealed that the increases are based on selective components that must be procured from specific suppliers. The nature of the components and the delivery requirements (to meet the TTC's schedule) confine Bombardier into a commercial situation where they appear to have little leverage to negotiate down the suggested price increases. As such, the auditor compared the magnitude of the increases to industry standards and determined that they were comparable. A major contributing factor to the increased cost is the loss of volume purchase incentives, as additional components are required in much smaller quantities to support the modification for 4-car train sets.

Further, the audit revealed that many of the engineering obstacles described above have subsequent natural consequences in other facets of the operation, including methods and production controls (for adapted manufacturing processes) and product integration (for on-site testing of a newly-configured train set on Line 4). Therefore, many of the costs in these areas are tied to the design details associated with the implementation of this type of modification.

The auditor concluded that the pricing proposal from Bombardier is justifiable. TTC staff recommends proceeding with the Purchase Authorization Amendment for the subject modifications to six TR train sets.

Contact

Raffaele Trentadue
Head of Rail Cars & Shops Department, Operations Group
Telephone: (416) 393-4126
Mobile phone: (416) 991-8331
raffaele.trentadue@ttc.ca

Attachments

1. Appendix 1 – Calculation of Allowances
2. 2015 Subway Fleet Plan
3. CH2M HILL Audit Report

APPENDIX 1

CALCULATION OF ALLOWANCES *

Category	Total	Notes
Escalation	\$565,000	An estimated inflation rate of 2% per annum is used in the cash flow calculations. The actual escalation is based on published indices and catalogues from Statistics Canada according to the formula specified in the contract clause.
Contract Security (LOC)	\$565,000	This amount is an estimation of additional LOC increases; the alternatives to the current LOC are currently in review with the car builder.
Spares and STTE	\$8,823,858	This is an upset limit amount; the exact quantities of parts will be determined at a later date and may result in fewer actual expenses.
Foreign Exchange Adjustment	\$847,500	This amount is a one-time adjustment at Notice of Award (NOA). It is an estimation based on a forecasted exchange rate of 1 CAD = 0.81739 USD on April 21, 2015, and is subject to change.
Current PCR's	\$565,000	This includes approved contract amendments to date.
Pending PCR's	\$565,000	This includes planned contract amendments that still require approval.
Contract Contingency	\$568,642	Contract contingency is the remainder of the project authority that is available to cover shortfalls (such as fluctuations in escalation and foreign exchange rates) within the base order and the current proposal. The figures will be re-aligned in the next budget cycle.
Total Allowances	\$12,500,000	This pricing reflects contract costs and includes HST; net project costs are subject to HST tax recoveries.

Acronyms:

LOC - Letter of Credit
 STTE - Special Tools and Test Equipment
 NOA - Notice of Award
 PCR - Project Change Request
 ATC - Automated Train Control

*** NOTE: Contract allowances are subject to change with CEO approval; actual costs may be distributed within allowance categories without exceeding the total authorized allowance amount.**

SUBWAY FLEET PLAN 2015

2015 - 2024 Capital Program



Executive Summary

In order to provide the people of Toronto and surrounding areas with reliable public transit service and meet future ridership forecasts, it is essential to maintain the existing subway fleet in a state of good repair, provide for timely replacement, and allow for additional fleet requirements based on ridership growth between procurements. The Subway Fleet Plan as outlined below is the basis for two sections of the TTC's Capital Program: Program 4.12 – Subway Car Purchases; and Program 4.16 – Subway Car Overhaul.

New Subway Car Purchases

The 2015-2024 Capital Program includes the purchase of a fleet of 80 trains, designated as the Toronto Rocket (TR).

The purchase of 39 trains was approved in the 2006-2010 Capital Program and replaces the H-4 and H-5 fleets while providing for limited growth. The current total estimated final project cost (EFC) is \$649.8 million (refer to Table 1A below; quantity and total cost of the new subway cars is based on a 6-Car train set design).

Table 1A: Subway Car Purchases - H4 and H5 Replacement plus growth (234 cars)

W.O. 6231 (Millions)	to 2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Post 2024	EFC
2014 - 2023 Budget	639.1	6.9	3.8											649.8
2015 - 2024 Proposed	626.9	15.1	7.8											649.8
Variance	(12.2)	8.2	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The purchase of 21 TR trains to replace the H6 fleet has been advanced from 2017 - 2019 to 2012 - 2013 due to significant cost savings (both NPV & EFC) resulting from exercising an option in the current contract. Replacing H6 trains with TR trains will also provide increased capacity, increased customer service and safety, and reduce energy consumption. The current



**Subway Fleet Plan
2015-2024 Capital Program**

total estimated final project cost (EFC) is \$295 million (refer to Table 1B below; quantity and total cost of the new subway cars is based on a 6-Car train set design).

Table 1B: Subway Car Purchases - H6 Replacement (126 cars)

W.O. 6002 (Millions)	to	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Post 2024	EFC
2014 - 2023 Budget		273.4	11.0	4.1	6.4										295.0
2015 - 2024 Proposed		234.5	46.0	6.3	8.1										295.0
Variance		(38.9)	35.0	2.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The purchase of 10 TR trains to accommodate the Toronto York Subway Extension (TYSSE) was approved by the Commission on May 6, 2010. Funds for this purchase have been budgeted under Project 568X-TYSSE. The project commitment requirement for vehicles is \$152.5 million, as shown in Table 1C below.

Table 1C: Subway Car Purchases – TYSSE Support (60 cars)

W.O. 568X (Millions)	to	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Post 2024	EFC
2014 - 2023 Budget		71.9	75.7	1.7	3.1	0.0									152.5
2015 - 2024 Proposed		66.2	60.0	23.1	0.4	2.9									152.5
Variance		(5.7)	(15.7)	21.4	(2.8)	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The purchase of 10 TR trains to support forecast growth enabled by Automatic Train Control (ATC) on Line 1 (YUS), from 2019 to the next procurement cycle in 2025, was approved by the Commission on March 26, 2014. The project commitment requirement for the 10 additional TR trains is estimated at \$227.2 million, as shown in Table 1D below.

Table 1D: Subway Car Purchases – Support for ATC and Forecasted Growth (60 cars)

W.O. 6278 (Millions)	to	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Post 2024	EFC
2014 - 2023 Budget			38.5	166.1	2.2	22.9	0.0								229.8
2015 - 2024 Proposed			64.8	137.0	15.0	10.4	0.0								227.2
Variance		0.0	26.3	(29.1)	12.8	(12.5)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(2.6)

The Estimated Final Cost shown above is based on a continuation of the contract with the current car builder, with a reduced delivery rate on the current schedule starting at the end of the first quarter of 2014.

Wilson Facility Implications

In order to accommodate the TR train sets, upgrades to existing maintenance facilities and additional storage capacity are required at Wilson complex. Immediate requirements are being addressed as EC&E Branch projects. Further facility/yard expansion is required; future infrastructure improvements will be governed by the results of the EC&E Rail Amalgamation Study.



T1 Fleet Replacement

Replacement of the T1 fleet will be required commencing in 2025. The project is estimated at \$1,737.1 million with a contract award in 2022 (refer to Table 1E below).

Table 1E: Subway Car Purchases – T1 Replacement (62 trains)

The replacement costs shown in Table 1E do not account for any forecast growth in ridership beyond 2030. Extensive infrastructure funds are required for the expansion and modification of the Greenwood Complex in order to accommodate additional growth.

Subway Fleet Plan

The Subway Fleet Plan for Lines 1, 2 and 4 are provided in Table 2. It envisions one car type per line: TR's on Line 1 and T1's on Lines 2 and 4.

Additional train procurement is required to meet currently identified Service Planning growth forecast on Line 1 beyond 2028 as outlined in Table 2A.

Table 2A: Line 1 (YUS) Fleet Plan

Year End	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Trains Required																					
Short Turn - (Glencairn AM ONLY)					2																
Forecast Growth (ATC Required)						5	1	7	1	1		1		1	1	1		1		1	
Spadina Ext/Short Turn at Wilson				2	5																
AM Peak Short Turn at Wilson					1																
Total Peak Service	49	49	49	51	52	58	58	65	66	67	67	68	68	69	70	71	71	72	72	73	
Maintenance Spares	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Total Trains Required	57	57	57	59	60	67	67	74	75	76	76	77	77	78	79	80	80	81	81	82	
Trains Available																					
H5 (Retirements)		(14)	(8)																		
T1 (Transfer to Line 1)	(7)	(2)	(11)	(18)																	
TR Procurement	11	17	18	18	16																
Total Trains Available	64	65	64	64	80	80	80														
Contingency	7	8	7	5	20	13	13	13	6	5	4	4	3	3	2	1	0	0	(1)	(1)	(2)

Peak service in these years is based on a P.M. peak of 49 trains.

Line 1 (YUS)

- Two additional 'service resilience' trains in 2014 (2 short turns advanced from 2016).
- Two additional trains in 2015 to allow for the Glencairn short-turn to be extended.
- Six additional trains in 2016 with the expansion of Line 1 to Vaughan (TYSSE).
- Forecast growth beyond 2016 is currently capacity constrained. Full implementation of automatic train control will enable higher capacity; however, yard operations must be optimized to support the increased quantity of trains.

W.O. TBD	Subway Fleet Plan - 2015 Revision 3.2	(Millions)	2013	2014	2015	2016	2017	2018	2019
2014 - 2023 Budget									
2015 - 2024 Proposed									0.2 0.5
Variance			0.0	0.0	0.0	0.0	0.0	0.2	0.5



**Subway Fleet Plan
2015-2024 Capital Program**

Table 2B: Line 2 (BD) Fleet Plan (including Line 4 – Sheppard)

Year End	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Trains Required																					
Forecast Growth				2												4	1	1	1		1
Line 2 Extension (Scarborough)													6								
Total Peak Service (T1)	43	43	43	45	51	51	51	55	56	57	58	58	59								
Sheppard Line				3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
15% Maintenance Spares	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	9	9	9	9	9	9
Total Trains Required	50	50	50	55	61	61	61	67	68	69	70	70	71								
Trains Available																					
H4 (Retirement)	(7)																				
H6 (Retirement)		(1)	(11)	(9)																	
T1 (Transfers from Line 1)	8	2	11	17																	
T1 Asset converted to Workcar					(1)																
T1 Retirement (End of Life)																(4)	(10)	(15)	(15)	(13)	(5)
Next Procurement																13	15	15	15	11	
Total Trains Available	53	54	54	62	61	70	75	75	75	73	68										
Contingency	3	4	4	7	6	0	0	0	3	7	6	5	3	(3)							

Maintenance spares reduced in these years to offset loss of contingency trains; dependent upon timing of next vehicle procurement.

Line 2 (BD)

1. Two additional 'service resilience' trains in 2014 (2 growth trains advanced).
2. Six additional trains in 2023 with the expansion of Line 2 to Scarborough (BD Expansion).
3. Four Forecast Growth trains moved to 2026 to align with next vehicle procurement.

The next vehicle procurement (T1 replacement vehicles) primarily addresses the end of the asset life cycle. In addition, the timing and procurement quantities must align with forecasted service requirements and potential service expansion, such as the Downtown Relief Line, the Yonge North Expansion, and any potential headway savings (due to ATC) that result in increased service levels.

Subway Car Overhaul

A comprehensive maintenance program is required to maintain the subway vehicle fleet in a state of good repair. This program is based on scheduled maintenance at regular intervals and incorporates work recommended by the manufacturer together with information gathered through fault trend analysis. It includes the overhaul of major car components at 5-year intervals on T1 cars until retirement at 30 years. Table 3 illustrates the scope of work scheduled at each interval. Tables 4A, 4B and 4C show the overhaul cash flows estimated at a total of \$193.8 million.



**Subway Fleet Plan
2015-2024 Capital Program**

Table 3: T1 Overhaul Scope

COMPONENT	OVERHAUL CYCLE					COMPONENT	OVERHAUL CYCLE				
	5 YR	10 YR	15 YR	20 YR	25 YR		5 YR	10 YR	15 YR	20 YR	25 YR
Air Compressor	✓	✓	✓	✓	✓	Door Systems					
Master Controller	✓	✓	✓	✓	✓	Door Leafs			✓		
Coupler						Door Rollers/Belts/Pulleys		✓		✓	
Electrical Pin Boxes			✓			Door Isolation Switches/Valves			✓		
Single & Double Check Valves	✓	✓	✓	✓	✓	Door Cylinders		✓		✓	
Mechanical Rebuild (all couplers)			✓			Door Lock Assemblies		✓		✓	
Batteries						Door Control/Relay Panels		✓		✓	
Electronic Memory Boxes	✓	✓	✓	✓	✓	Propulsion					
Main Car Batteries (36V)		✓				Static Converters		✓	✓	✓	✓
Trucks						LEDs		✓	✓	✓	✓
Traction Motors (on condition)	✓	✓	✓	✓	✓	Line Contactors (LC/LCC)			✓	✓	✓
Trip Switch	✓	✓	✓	✓	✓	Traction Resistors			✓	✓	✓
Levelling Valve	✓	✓	✓	✓	✓	Con-A and Con-D Contactors			✓	✓	✓
NDT Inspection (full sampling)		✓	✓	✓	✓	Braking system					
NDT Inspection (critical areas)		✓	✓	✓	✓	Valves	✓	✓	✓	✓	✓
Gearboxes (on condition)		✓	✓	✓	✓	Brake Cylinders (on condition)		✓	✓	✓	✓
Axle Re-Wheel (on condition)			✓	✓	✓	Car Body		✓	✓		
Undercar Air Hoses			✓			Monitoring Terminal Units			✓		
						Static & Dynamic Tests	✓	✓	✓	✓	✓

IGBT retrofit not included at this time.

Table 4A: Subway Car Overhaul Cash Flows - T1 15 Year Overhaul

W.O. 6070 (Millions)	to 2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Post 2024	EFC
2014 - 2023 Budget	34.8	27.9	23.7	22.0	11.4									119.7
2015 - 2024 Proposed	22.1	20.8	25.4	25.3	26.1									119.7
Variance	(12.7)	(7.1)	1.7	3.3	14.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(0.0)

Table 4B: Subway Car Overhaul Cash Flows - T1 20 Year Overhaul

W.O. TBD (Millions)	to 2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Post 2024	EFC
2014 - 2023 Budget				0.3	4.7	9.8	10.1	10.3	10.6	5.3				51.1
2015 - 2024 Proposed			0.5	0.3	4.2	9.8	10.1	10.3	10.6	5.3				51.1
Variance	0.0	0.0	0.5	0.0	(0.5)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(0.0)

Table 4C: Subway Car Overhaul Cash Flows - T1 25 Year Overhaul

W.O. TBD (Millions)	to 2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Post 2024	EFC
2014 - 2023 Budget										2.3	4.4	4.5	11.7	22.9
2015 - 2024 Proposed										2.3	4.4	4.5	11.7	22.9
Variance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The detailed scope for the Toronto Rocket has been scheduled at a five- and seven-year interval based on manufacturer recommendations (based on component exchanges as line-replaceable units – LRU). Table 5 illustrates the scope of work scheduled at each interval. Tables 6A and 6B show the overhaul cash flows estimated at a total of \$112.1 million. The EC&E Rail Amalgamation Study will determine the best infrastructure option to facilitate the execution of various overhaul functions.



**Subway Fleet Plan
2015-2024 Capital Program**

Table 5: TR Overhaul Scope

COMPONENT	OVERHAUL CYCLE					COMPONENT	OVERHAUL CYCLE				
	5 YR	10 YR	15 YR	20 YR	25 YR		5 YR	10 YR	15 YR	20 YR	25 YR
Air Supply Unit	✓	✓	✓	✓	✓	Door Systems					
Traction Brake Controller	✓	✓	✓	✓	✓	Door Leafs			✓		
Coupler						Door Switches		✓		✓	
Permanent		✓		✓		Door Cylinders		✓		✓	
Semi permanent		✓		✓		Door Lock Assemblies		✓		✓	
Batteries						DMS/DECU/Controls			✓		
Main Car Batteries	✓	✓	✓	✓	✓	Propulsion					
Small Electronics Batteries	✓	✓	✓	✓	✓	Contactors (on cond.)			✓		
Braking system						Auxiliary Power Supply					
Valves / TCUs	✓	✓	✓	✓	✓	Contactors (on cond.)			✓		
Brake Cylinders	✓	✓	✓	✓	✓	Communication Systems					
ATC System			✓			Multimedia / Displays	✓	✓	✓	✓	✓
Static and Dynamic Tests	✓	✓	✓	✓	✓	Car Body					
						Cab Door		✓		✓	
						EDD Door		✓		✓	
						Inter Car Gangways		✓		✓	

COMPONENT	OVERHAUL CYCLE			
	7 YR	14 YR	21 YR	28 YR
Trucks				
Traction Motors	✓	✓	✓	✓
Trip Switch	✓	✓	✓	✓
Truck-Mounted Valves	✓	✓	✓	✓
NDT Inspection	✓	✓	✓	✓
Gearboxes	✓	✓	✓	✓
Axle Re-Wheel (on condition)	✓	✓	✓	✓
HVAC System				
Complete System		✓		✓
Seals / Wear Components	✓	✓	✓	✓

Notes:

Propulsion and Aux. Power contactors do not have a defined interval (T1 interval assumed).
 Cab Door does not have a defined interval; initial estimate is 10 years.
 ATC System does not have a defined interval; initial estimate is 15 yrs.
 The Truck overhaul cycle will be impacted by wheel size constraints.

Table 6A: Subway Car Overhaul Cash Flows - TR Overhaul Cycle #1

W.O. TBD (Millions)	to 2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Post 2024	EFC
2014 - 2023 Budget		0.0	0.0	1.4	4.0	3.9	3.9	4.0	4.0	4.1				25.3
2015 - 2024 Proposed		0.3	0.5	1.3	1.9	5.1	7.0	6.7	5.9	4.2				32.9
Variance		0.0	0.3	0.5	(0.1)	(2.1)	1.3	3.1	2.7	1.8	0.1	0.0	0.0	7.6

Table 6B: Subway Car Overhaul Cash Flows - TR Overhaul Cycle #2

W.O. TBD (Millions)	to 2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Post 2024	EFC
2013 - 2017 Budget										0.7	7.7	37.8		46.2
2014 - 2018 Proposed										0.7	7.7	7.9	63.0	79.2
Variance		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(30.0)	63.0	33.0



FINAL REPORT

Potential Order of 4-Car Toronto Rocket Train: Costing of Material and Labour Audit

Prepared for

Toronto Transit
Commission

June 02, 2015



CH2M HILL Canada Limited (CH2M)



Revision Log

Revision	Date (yyyy.mm.dd)	Description of Change	Prepared by	Checked
0	2015.05.29	Draft release.	Peter Doggett	Jeffrey Rankin
1	2015.05.29	Internal review.	Peter Doggett	
2	2015.06.01	Final report release.	Peter Doggett	Jeffrey Rankin
2.1	2015.06.02	Final report – update to material costs text	Peter Doggett	Gene Sansone

Contents

Section	Page
1. Introduction	1
2. Audit Conclusion	1
3. Audit Limitations	2
4. Approach.....	2
5. Documentation Review	3
6. List of Attendees	4
7. Engineering.....	4
8. Material Escalation	5
8.1 Material Costs	5
8.2 Material Delivery	5
9. Product Introduction/Customer Service.....	6
10. Project Management	6
11. Methods and Production.....	6
12. Quality and Testing	7
13. Limitations.....	7

Potential Order of 4-Car Toronto Rocket Train: Costing of Material and Labour Audit

1. Introduction

In 2006, the Toronto Transit Commission (TTC) awarded Bombardier Transportation Americas (BTAME) a sole source contract for 39, 6-car subway trains at a cost of \$624,567,602 referred to as the Toronto Rocket (TR). As part of the original contract, the TTC had two options for 10 and 21 additional train sets, referred to as Option 1A and Option 1B, respectively. Both options were executed by the TTC in 2010. The TTC placed an additional order for ten (10) additional train sets to support increased revenue service demands. The TTC is now considering placing a Change Directive order to modify their requirement for the final four (4) x six (6) car train sets to six (6) x four (4) car train sets.

CH2M HILL Canada Limited (CH2M) was contracted by the TTC to perform a high level audit on the escalated material and labour costs associated with Bombardier's proposal to provide six 4-car train sets. The CH2M team conducted an audit at Bombardier's Thunder Bay facility from May 25 through 27, 2015.

The approach used by the audit team was in accordance with the agreed upon audit plan by the parties impacted by the activities (TTC, BTAME, and CH2M). The audit plan consisted of reviewing specific documents provided by BTAME and meetings with BTAME key project team members including Program Management, Engineering, Finance, Methods, Production, Quality Assurance (QA)/Quality Control (QC), Supply Chain Management and Product Introduction/Customer Service. A site tour of the Toronto Rocket production Line was also conducted. Field audit activities ended with an exit meeting which took place on May 26, 2015, during which CH2M summarized their findings to Bombardier, later the meeting was joined by a TTC representative who reviewed the Audit Findings documentation and signed these documents to indicate the TTC had reviewed and received a copy of the documents. This report details how the audit was conducted, the findings, concerns identified and formed during the audit process and the CH2M audit team's opinion of the justification provided by BTAME for changes to the costs of the train sets.

2. Audit Conclusion

The main driver identified for increases in production hours and material costs were the Engineering hours needed to meet the TTC outcome in their requested change from six-Car trainsets to four-Car trainsets. Due to the 6-car unified trainset design of the Toronto Rocket, this variation order from a six-car to a four-car consist configuration represents a major technical change order requiring a significant increase in engineering hours. A change order of this nature and magnitude is the main cost driver to the project. The change is complex and impacts on both the budget and time schedule.

The change directive requires that several areas of the consist be modified by BTAME. The effective technical requirements for a change of this size to a fixed car train set are considerable and this has an effect on the level of effort required to complete the proper due process in delivering a safe and reliable train.

The CH2M Audit Team conclude that increases are justifiable.

3. Audit Limitations

The relatively brief time frame allocated to perform the actual audit and BTAME's requirement to have a signed Non Discloser Agreement (NDA) in place before the release of any 'confidential information' added constraints and delays to the audit process. The delayed start to the audit was resolved once agreement with Bombardier on the contents of the NDA were agreed and signed. The following are some limitations encountered by the CH2M Audit team:

The audit focused on the material cost escalation and increased labour hours (known as the 'Delta') BTAME stated they will incur to manufacture the 4-car train when compared to those of the extension order for 10 additional 6-car trains.

The information presented by BTAME was accepted at face value with inquiries limited to open meeting discussions with BTAME's key staff on the TR Project. High level supporting information was presented by the BTAME project team. For example, a review of employee daily task records was not provided to verify BTAME's claims of increased hours for Project Management resources planned for the Change Directive to the 4-car train.

To assess the material cost, a review was performed on a sample of two purchase orders (POs) issued by BTAME to their suppliers for key components required for the 4-car train. Using the information provided by BTAME, the quoted prices for these items had increased and the lead time to delivery was considered lengthy. Due to time constraints to complete the audit, CH2M only sampled two (2) items identified as, 'long lead time' items and their delta costs from the 6-car train. No effort was made to verify component and car system prices against industry averages since this was not included in the scope of this audit.

CH2M was not provided with a copy of the entire offer documents for the 10 train extension and findings are strictly based on the information provided by the TTC and BTAME as it pertains to Material and Labour costs. A list of the information presented to for the CH2M audit team to review and conduct the audit is provided in Section 4 below.

BTAME's estimated standard times to budget production hours for the Rocket Project were not verified via industrial engineering activities or compared to typical industry production standards.

The BTAME team was professional, cooperative and willing to assist the audit team understand their reasons for the delta in costs. At BTAME's request and as per the signed NDA, the detailed information shown to the audit team is considered by BTAME as 'confidential information' and is not presented in this report and therefore the report is limited to generalities and our professional opinions.

4. Approach

The approach used in this audit was a high level review of the prices provided in BTAME's commercial offer dated May 7, 2015. This offer was made in response to TTC's request for the train configuration change from a six-car trainset to a 4-car trainset. This offer document was reviewed as it proposed the estimated delta in the Manufacture, Engineering Hours and Product Introduction costs and the delta in the costs of the additional materials required to supply the 4-car trainsets.

To understand the delta in the costs to supply the 4-car trains the audit team reviewed the workforce hours estimated by BTAME. The audit team reviewed a random sample of BTAME's supplied information indicating the delta in component costs and the lead times required for components.

CH2M audit team was provided a meeting room in BTAME's Thunder Bay facility where discussions and presentations were held. The CH2M audit team extends their appreciation to BTAME for the use of this facility and the time and cooperation of their project team. During the audit key members of the TR project in Thunder Bay provided slide presentations and supporting spreadsheets on their development of the delta in the hours and costs required to meet the requested 4-car train sets variation. The audit team proposed questions regarding the development of the delta and evidence was provided by BTAME in the form of documents and spreadsheets that are considered confidential and will therefore not be presented in the audit team's report.

In view of time limitations, only a sample of the information pertaining to long lead time items were requested to be seen by the auditors. These items were demonstrated by BTAME as email replies to BTAME's enquires for the components. The information supplied by BTAME was taken at face value and was not challenged to be supported with other evidence or forms of support for the hours or costs presented.

5. Documentation Review

The following documentation was provided by the TTC and BTAME to conduct the audit:

- BT-4cars-1.0 - Audit Plan and background – 4-Cars Trainset Variation Order TTC Audit
- BT-4cars-2.0 - Material – 4-Cars Trainset Variation Order TTC Audit
- BT-4cars-2.1-3 - Spreadsheets identifying estimated pricing and lead times
- BT-4cars-2.4 - Letter from Supplier (Voith) with quoted price and lead time
- BT-4cars-3.0 - Production Labor hours – 4-Cars Trainset Variation Order TTC Audit
- BT-4cars-4.0 - Direct Labour hours (Engineering, Quality, Methods, Customer Service & Program Mgm) – 4-Cars Trainset Variation Order TTC Audit
- BT-4cars-4.1 - Product Introduction - Direct L1 INPUT (Heads & \$) [Filename: 19011 Budget 2014 datacapture CS 4-cars consist rev4.xlsx]
- BT-4cars-4.2 - Project Management - Direct L1 INPUT (Heads & \$) [Filename: 19011 PM 4-car trainset costing rev4.xlsx]
- BT-4cars-4.3 - QA (Heads & \$) [Filename: 19011 Budget 2016 datacapture Tbay QA and TEST 4-Car VO Backup rev1.xlsx]
- BT-4cars-4.4 - Costing for 19011 Rocket-4-car consist [Filename: PCR 669 4-car consist Rev 6 for audit auditor hand out rev2.xlsx]
- BT-4cars-4.5 - Methods Hours to Support 4-Car TS Variation Order [Filename: Met 4-Car Consist Production Support Costing.xlsx]
- BT-4cars-4.6 - 4-Car VOR Engineering Labour and \$ODC package
- BT-4cars-4.7 - 4-Car Trainset – TTC-TR Technical Proposal (Prototype Analysis Phase)
- BT-4cars-5.0 - BT-GC-1432 Clarification to Commercial Offer for 4-Car Consist

6. List of Attendees

The following attendees participated during the audit over the three-day period:

Name	Title	Company
Wenceslao Torres	Project Director	Bombardier
Pablo Vieira	Finance Director	Bombardier
Carolyne Leroux	Portfolio Director	Bombardier
Lindsay Menard	Contract Manager	Bombardier
Mike Colaneri	Material - Supply Management	Bombardier
Marc Leschuk	Labour – Engineering Manager	Bombardier
Alexandre Bazinet	Labour – Engineering	Bombardier
Filip Luczak	Labour – Quality and Testing	Bombardier
Murad Jafari	Labour – Methods/Production	Bombardier
Wenceslao Torres	Labour – Project Management	Bombardier
Pat Sabino	Labour – Customer Services	Bombardier
Peter Doggett	Lead Auditor	CH2M HILL
Gene Sansone	Senior Audit Advisor	CH2M HILL
Zachary Kuzmicz	Auditor	CH2M HILL

7. Engineering

This change order from a six-car to a four-car TR train consist configuration represents a major technical change order with a significant increase in engineering hours. A change order of this nature and magnitude is the main cost driver to the project. The change is complex and impacts on both the budget and time schedule.

A ‘proof of concept’ project is being carried out on Train Set 10 (a six-car train) which has been modified to a four-car train to demonstrate that the train can be converted. This train set is to be reverted back to a six car train following the proof of concept project to form part of the contracted delivery to the TTC. The Engineering hours required to perform this project have been included in the pricing for the 4-Car consists.

At first, CH2M checked the 6-car technical specification to assure that there was not any reference to a 4-car train potential operation on the TTC Sheppard Line. Not only does running on the Sheppard Line require a different train consist operation but the safety certification must be provided by BTAME to TTC before passenger service is authorized to commence. The ‘top down’ estimation of the Engineering hours required to develop an agreed technical specification was produced by identifying the estimated hours each of the BTAME engineering functions would require. This ‘top down’ approach also had an allowance for some level of risk that the BTAME commercial offer would be agreed with the exceptions from the 6-car train contract terms and conditions.

As BTAME explained, original performance parameters including operational (car availability), reliability (Mean Distance Between Failure-MDBF), maintainability (Mean Time to Repair-MTTR) will represent a

challenge to be met in view of the new configuration. The removal of two cars with their associated equipment will result in the reduction of some redundant components and potential degradation in the dynamic performance which can impact MDBF. The fact that some components will have to be relocated could impact the performance of future car maintenance in terms of MTTR. Because the new 4-car fleet will be a smaller population of a total 24 cars, car availability will also be impacted (larger rolling stock fleets can afford smaller spare ratios).

In addition, BTAME explained that the existing software intended for the 6-car fleet will require significant changes to accommodate the 4-car trains. The existing software must recognize the presence of all six cars for operation to be possible.

BTAME has already started phase 1 (4-car conversion) and phase 2 (preparation of technical specification) with the next two phases coming up soon, phase 3 (design & qualification) starting in July and phase 4 (production conversion) with an October start.

CH2M understands BTAME process in proceeding along this path which is to meet the TTC schedule.

CH2M audit team conclude that the significant Engineering costs are justified but BTAME did not produce documents to demonstrate the extent of the engineering estimated.

8. Material Escalation

BTAME and its suppliers defined the material costs for the TR 10 train extension option which is for six car train sets. Subsequently, BTAME has been requested to make a configuration change to the final 4 train sets, making these as 4-car trains. This Change Directive requires a number of changes to be made to the material requirements for the manufacture and delivery of the train sets.

8.1 Material Costs

CH2M audit team observed that the material cost mentioned by BTAME to perform this change directive were significantly higher costs when compared to the production of the 10 additional 6 car trainsets. BTAME showed specific documents demonstrating this cost increase especially for selective components which must be procured from the same supplier and cannot be substituted by another source. Both the nature of the component and the delivery time requirements confine BTAME into a commercial situation where it appears to have little leverage to negotiate down the suggested price increases.

Component suppliers are fully aware that BTAME can only buy their product from them, that BTAME has a very aggressive schedule for their delivery and are also aware of the 'financial cloud' that is surrounding the Bombardier Company as it moves forward to an announced initial public offering (IPO) of their Transportation Business.

In view of all the above conditions, CH2M verified by checking some specific suppliers' official quotations and found them to be as stated by BTAME. In conclusion, CH2M find that the material cost increase is understandable and predictable in these situations of limited production units and a restricted supply base.

8.2 Material Delivery

CH2M observed that there were significantly long lead items from some specific suppliers to deliver their products. These are considered as critical components which cannot be substituted in view of the time constraints and would require a very expensive effort to qualify alternate sourcing with a very limited probability of success.

CH2M is familiar with some specific products of these suppliers and has encountered similar long lead time and relatively high prices in other projects with other rail transit agencies. Further, material diverted from the 6-car train set production line will be provided to and retained by TTC to be used as capital spare parts for the maintenance of the present 6-car train set fleet. BTAME stated that TTC had not contracted for this provisioning in the original contract.

In view of these facts, CH2M opinion is that the long lead items of some critical components is true as stated and the impact is justifiable.

9. Product Introduction/Customer Service

The two main segments of this function involve commissioning and field support including warranty of the Toronto Rocket (TR) railcars once they are accepted by the TTC. Expenses to perform the commissioning function, which will involve repeating many of the acceptance tests already performed for 6-car TR fleet and the 6-month impact caused by the work extension, justifies the increased costs germane to this activity. Some testing will be done on a new location i.e. the Sheppard Line where the 4-car TR train consist is confined to be operated (civil engineering station platform limitations).

BTAME cited the fact that this field activity faces many uncertainties due to the fact that the TTC cannot guarantee access to the Sheppard Line for testing and non-revenue running and therefore only a limited window of time is available to perform dynamic testing on their system, owing to the many construction activities presently taking place on the entire subway car system.

CH2M is personally aware of this construction activities which are impacting the field operations and believe that this increase in hours of the PI/Customer Service group is justifiable.

10. Project Management

After a first review of increased labor hours costs associated with Project Management staffing, CH2M was of the original opinion that the hours contained in the delta could be overestimated. This was based on some work efficiencies that could have been obtained by the BTAME PM staff as the original project was approaching completion.

BTAME later provided additional verbal and written information showing this potential savings not be the case for this Change Directive. Since efficiencies could not be realized, BTAME had to increase staffing to address additional requirements generated by the Change Directive.

Based on this additional evidence CH2M is of the opinion that the increase is justifiable.

11. Methods and Production

CH2M observed an increase in the number of hours to perform these activities. However, this increase is in line with the revised work scope as estimated by Engineering. The 6-car to 4-car change in configuration is not simply changing the train set configuration from an A-B-B-C-B-A (each car type is identified with an alphabetical letter) to a train with two less cars. The new configuration designated is A1-B2-B5-A6. One of the main complications is due to present arrangement vs. the new arrangement of the semi-permanent coupling between the car types. The new configuration between the 4-car train set requires another (not required on the 6-car train set) female coupler type.

The methods group has estimated the effort required to product the B5 (also known as the B prime car) to require an additional percentage of the average hours need to complete a car. This percentage is based on their estimation and the type of changes required as defined by the Engineering group. As the technical requirements for the 4-car train are not firm, this estimated change has the opportunity to be reduced depending on the changes to the B prime car build.

Given the reasons outlined above, CH2M is of the opinion that the increase is justifiable.

12. Quality and Testing

Before the start of the actual review of labor hours associated with the Quality Assurance (QA), CH2M was expecting a tapering off of QA activities as the 6-car train set program was nearing completion. This scenario would not be the case as BTAME started their presentation on this subject.

At first, BTAME explained that their definition of QA is not the only global oversight of all quality functions but it includes hours associated with Quality Control (QC) i.e. line inspections, testing, calibration activities, etc. Therefore, QA activities will not be tapering off but are in line with the 6-month time extension as scheduled in this Change Directive. QA activities were not only described in BTAME documents but CH2M requested and performed a site visit of the Thunder Bay facility to verify the actual QA performance on the present TR production line.

Based both on verbal communications, written documentation and physical verification, CH2M determines that the Change Directive in QA hours to be in line with the 4-car work scope and extension in time duration of the total program.

CH2M is of the opinion that the increase is justifiable.

13. Limitations

All reports, drawings, specifications, documents, and other deliverables of CH2M HILL, whether in hard copy or in electronic form, are instruments of service for this Project, whether the Project is completed or not. Client agrees to indemnify CH2M HILL and CH2M HILL's directors, officers, employees, subcontractors, and affiliated corporations from all claims, damages, losses, and costs, including, but not limited to, litigation expenses and legal fees arising out of or related to the unauthorized reuse, change or alteration of these Project documents.