

# TORONTO TRANSIT COMMISSION REPORT NO.

**MEETING DATE:** March 26, 2014

**SUBJECT:** PROCUREMENT AUTHORIZATION AMENDMENT TO  
PURCHASE 10 ADDITIONAL TORONTO ROCKET TRAIN SETS  
PURCHASE ORDER NO. C31PD05761

## **ACTION ITEM**

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### **RECOMMENDATION**

It is recommended that the Board authorize:

- 1) Staff to proceed with a Purchase Order Amendment to the Toronto Rocket (TR) Subway Train Contract with Bombardier Transportation Canada Inc. (Bombardier) no later than April 1, 2014; the Amendment is for the purchase of 10 additional six-car subway train sets in the amount of \$ 176,567,020.00 CDN, inclusive of all applicable taxes.
- 2) The expenditure of funds up to a total allowance amount of \$ 40,221,850.00 CDN, inclusive of all applicable taxes, with respect to the 10 train sets, for Inflationary Escalation Adjustment, Contract Security, Foreign Exchange Adjustment, and Potential Contract Changes, resulting in a total authorized expenditure of up to \$ 216,788,870.00 CDN. Net project costs will include tax recoveries under HST from this contract authorized amount. Refer to Appendix 1 for further information.

### **FUNDING**

Sufficient funds are included under Project 4.12 – Purchase of 60 New Subway Cars (Ridership Growth and ATC) as set out on pages 725 to 726, in the “State of Good Repair & Safety” category of the TTC 2014-2018 Capital Budget as approved by City of Toronto Council on January 29/30, 2014.

### **BACKGROUND**

In 2006, the TTC awarded 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%20the%20TTC/Commission%20reports%20and%20information/Commission%20meetings/2006/Sept%2020%202006/Minutes/index.jsp)

Subsequently, the TTC accepted 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)

This resulted in the purchase of a total of 70 TR train sets from Bombardier under the existing contract; Table A shows the Board approved authority for these train orders.

**Table A**

	<b>Item</b>	<b>Vehicle Cost</b>	<b>Allowances</b>	<b>Total Authorization</b>
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	\$ 34,157,000.00	\$ 162,708,071.30
	Option 1(B) (21 Train Sets – H6 Replacement)	\$ 269,957,249.73	\$ 47,255,000.00	\$ 317,212,249.73
	ATC Integration (70 Train Sets)	\$ 31,517,892.92	\$ 3,266,971.00	\$ 34,784,863.92
	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.)	\$ 19,831,897.69	NIL	\$ 19,831,897.69
Current Amendment	Additional 10 Train Sets	\$ 176,567,020.00	\$ 40,221,850.00	\$ 216,788,870.00
<b>Total Authorization Amount</b>		<b>\$ 1,278,235,238.59</b>	<b>\$ 175,878,316.57</b>	<b>\$1,454,113,555.16</b>

The amounts above include all applicable taxes. Exclusive of base order vehicle price, all other vehicle pricing is prior to a one-time adjustment for Foreign Currency Exchange Rate Variance. Net project costs will include tax recoveries under HST from the contact authorized amounts.

The next significant fleet replacement of subway train sets is not planned until 2025, when the existing T1 train sets reach the end of their service life.

**DISCUSSION**

Design of the Automatic Train Control (ATC) System is underway for the YUS Subway Line. The system will allow the headways between train sets to be safely reduced. To meet existing service standards for ridership and reduce crowding on the YUS Line, it is recommended that 5 TR train sets be added to service on the YUS Line upon completion of the ATC Project.

In order to meet future ridership growth on the YUS Line until the next subway train set purchase in 2025, it is recommended that an additional 5 TR train sets be purchased, for a total of 10 additional train sets.

A new competitive procurement for the supply of 10 new subway train sets similar to the TR specifications is not recommended. The small quantity of train sets would make it difficult for subway vehicle suppliers to compete as the cost per train set would be at an unacceptable level. Furthermore, a design for these 10 train sets that is different from the existing TR fleet would increase on-going maintenance costs.

The original TR contract was awarded to Bombardier after successful negotiations on a sole source basis as detailed in the previously referenced Board Reports. This recommendation is for an additional 10 TR train sets to be added to the existing contract with Bombardier, which would increase the contract order from 70 to 80 train sets, on the basis of a sole source contract amendment.

Bombardier was requested to submit a proposal to add an additional 10 train sets to the existing contract. Their proposal is based on two production scenarios:

- **Scenario A: Production Continuity** (valid until April 1, 2014) - Bombardier maintain a continuous delivery schedule; the 10 additional train sets would be produced once the existing order is filled. Delivery would commence on March 12, 2015 and would be completed on September 1, 2015.
- **Scenario B: Production Interruption** (valid for 5 months) – TR production at the Thunder Bay facility would halt once the existing order is filled; production 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 April 1, 2014. The costs per train set for the existing contract, as well as the two scenarios in the proposal, are summarized in Table B. To date, 49 of 70 train sets have been accepted.

**Table B**

<b>Order</b>	<b>Train Sets</b>	<b>Requirement</b>	<b>Cost per Train Set</b>
Base Order	39	H4/H5 replacement	\$12,857,645.96 <sup>(1)</sup>
Option 1(B)	21	H6 replacement	\$ 11,059,182.68 <sup>(1)</sup>
Option 1(A)	10	TYSSE support	\$ 11,059,182.68 <sup>(1)</sup>
<b>Proposal Scenario A</b>	<b>10</b>	<b>ATC and Ridership Growth</b>	<b>\$ 15,625,400.00 <sup>(1)(2)</sup></b>
Proposal Scenario B	10	ATC and Ridership Growth	\$ 17,990,300.00 <sup>(1)(2)</sup>

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 offer reduced vehicle pricing in Scenario A as compared to Scenario B.

Scenario B: Production Interruption is an unacceptable alternative. It is extremely cost prohibitive due to the additional \$23.6M investment (before taxes) without any added value. It introduces uncertainty as contracts with suppliers expire, potentially forcing the car builder to procure alternate parts. Any introduction of alternative equipment further amplifies the risks associated with new manufacturing issues, Quality Control, and vehicle reliability. There is no guarantee that the train sets would be delivered on a mutually agreeable schedule. TTC Staff do not recommend the procurement of 10 additional TR train sets as per Scenario B.

In an attempt to rationalize the proposed pricing of Scenario A, TTC representatives performed a Commercial Analysis to quantify the price adjustments for all design changes approved and incorporated to date, as well as escalation adjustments from November 2006 to March 2014. The result is summarized in Table C.

<sup>(1)</sup> The amount is exclusive of taxes, escalation, Contract Security, Spares and Special Tools.

<sup>(2)</sup> The proposal pricing is subject to adjustment for foreign exchange rate variance in accordance with the terms stated in the contract documents.

**Table C**

<b>Scenario</b>	<b>Cost per Train Set</b>
Proposal Scenario A	\$ 15,625,400.00
Calculated Price as per Commercial Analysis	\$ 13,312,277.40
<b>Variance</b>	<b>\$ 2,313,122.60</b>

Bombardier was challenged to justify the variance amount; they stated that the price increase was due to the following factors:

- Increased costs in bill of materials (63% increase from original contract)
- Increased production hours (32% increase from original contract)
- Increased labour and transportation costs (7% increase from original contract)

The TTC secured a third party auditor (CH2MHill) to review the validity of these claimed increases. The audit scope included a review of the discrepancies in the material costs between Bombardier’s current proposal and the Options orders, along with a review of the production labour hours stated in both scenarios (including detailed comparisons at each stage of the production process). The audit was successfully carried out at the manufacturing plant in Thunder Bay, a copy of which is attached to this report.

The audit revealed that Bombardier’s increased labour costs are directly attributable to their underestimation of the effort required to manufacture the TR subway train. The largest percentage of the labour escalation is due to increased production hours. Bombardier showed that they have expended significantly more production hours than were estimated for the Option 1(A) train sets.

To mitigate escalating costs, Bombardier conducted an extensive study to identify production efficiencies and reduce the labour hours in all cost centres. The study revealed that even if all planned production efficiencies are achieved the optimized production hours are still greater than the hours budgeted in their initial proposal (circa 2006).

Bombardier’s proposed production hours for the new 10-train set order are based on the results of the efficiency study. The quantity of hours is still less than the actual time that it is currently taking to manufacture the TR train sets. In summary, Bombardier underestimated the manufacturing resources for the Toronto Rocket.

The audit reviewed the revised costs of the materials used to manufacture the TR. The audit team focused on the five vehicle systems that incurred material cost increases in excess of 5% above the current costs. The findings confirm that some suppliers have significantly increased their pricing to account for external factors such as raw material cost escalations, design changes, currency exchange rate changes, etc. The audit also verified that Bombardier had accurately

applied the contractually allowable escalations for items such as general administration, procurement and logistics, and margin on sales.

Further, the audit team reviewed the August 23, 2006 report titled "Price Analysis of the New Subway Trains", authored by Booz Allen Hamilton. The report showed that the escalated cost of the T1 subway cars (in 2006 dollars) would equate to approximately \$2.97M per car. The team compared this amount to Bombardier's proposal of \$2.60M per car (in 2014 dollars), revealing that the proposed cost is, in fact, less than the original price paid for the T1 subway car escalated to 2006 dollars.

In conclusion, the audit confirmed that the escalated material costs and increased labour hours claimed by Bombardier were accurate reflections of the costs incurred by the car builder.

**CONCLUSION**

TTC Staff recommend the procurement of 10 additional TR train sets to ensure sufficient trains are available to fully realize the benefits of the ATC Project and accommodate future ridership growth. The purchase of additional trains from the same car builder ensures technological consistency across the fleet without introducing operational complications. The proposed contract amendment is based on an increased train price that is deemed reasonable.

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Attachments: Appendix 1  
CH2MHill Audit Report

# APPENDIX 1

## CALCULATION OF ALLOWANCES

Category	Cost	HST	Total	Notes
Escalation	\$3,176,478.00	\$412,942.00	\$3,589,420.00	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)	\$1,018,678.00	\$132,428.00	\$1,151,106.00	This amount is identified in Bombardier's proposal.
Spares, Special Tools and Equipment (STTE)	\$6,581,626.00	\$855,611.00	\$7,437,237.00	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	\$9,117,776.00	\$1,185,311.00	\$10,303,087.00	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 = 0.880 USD on April 1, 2014, and is subject to change.
Project Change Requests (PCR)	\$11,700,000.00	\$1,521,000.00	\$13,221,000.00	This includes approved contract amendments (to date) and planned contract amendments. Examples include ATC Equipment, De-Icing Equipment, Work Area Warning Alarm, Reverse Alarm, etc.
Contract Contingency	\$4,000,000.00	\$520,000.00	\$4,520,000.00	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.
<b>Total Allowances</b>	<b>\$35,594,558.00</b>	<b>\$4,627,292.00</b>	<b>\$40,221,850.00</b>	

### Acronyms:

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



**TTC  
Toronto Rocket  
Potential Additional Trains Order**



**Labour & Material Cost  
Escalation Audit**





### Revision Log

Revision	Date (yyyy.mm.dd)	Description of Change
IR	2014.02.06	Initial release.
A	2014.02.06	Final edits to reflect confidentiality review
B	2014.02.06	Revised referenced year in section 9
C	2014.02.06	Correction made to the base contract award price

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## 1. Introduction

In 2006, the Toronto Transit Commission (TTC) awarded Bombardier a sole source contract for thirty-nine (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 ten and twenty-one additional train sets, referred to as Option 1A and Option 1B respectively. Both options were executed by the TTC in 2010. The TTC is considering placing an additional order for ten (10) additional train sets to support revenue service demands.

CH2M HILL Canada Limited (CH2M HILL) 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 an Additional Ten Train sets Order (ATTO) of the Toronto Rocket (TR) subway cars. The CH2M HILL team conducted the audit at Bombardier's Thunder Bay facility from January 29th through 31st, 2014.

The approach used by the audit team was in accordance with the agreed upon audit plan by the parties impacted by the activities (TTC, Bombardier and CH2M HILL). The audit plan consisted of reviewing specific documents provided by Bombardier and interviews with Bombardier key project team members including Program Management, Engineering, Finance, Methods, Production, Quality Assurance (QA)/Quality Control (QC), Supply Chain/Management. A cursory site tour of the Toronto Rocket production Line was also conducted. Field audit activities ended with an exit meeting which took place on January 31<sup>st</sup>, 2014, during which CH2M HILL summarized their findings to Bombardier and TTC. This report summarizes how the audit was conducted and the findings that were identified during the audit process.

## 2. Audit Limitations

The relatively brief time frame allocated to perform the actual audit and Bombardier's firm stand to provide only the information agreed in the audit plan added significant constraints to identifying specific findings and receiving agreement with Bombardier. The following are some limitations encountered by the CH2M HILL team:

- The audit focused strictly on the material cost escalation and increased labour hours Bombardier stated they will incur to manufacture the ATTO when compared to those for Option 1A Order contract.
- The information presented by Bombardier was accepted at face value with inquires limited to discussions with key staff and top level supporting information presented. For example, a review of employee records was not conducted to verify Bombardier's claims of increased hours to complete assigned tasks.
- To assess the material cost, a review was performed on the purchase orders (POs) issued by Bombardier to their suppliers for the Option 1A Order and the quoted prices for these systems for the ATTO. Again due to time constraints, CH2M HILL only verified those material costs that had escalated in excess of 5% from the Option 1A Order. Furthermore, no effort was made to verify component and car system prices against industry averages since this was not included in the scope.
- CH2M HILL was not provided with a copy of the entire bid document and findings are strictly based on the information provided by the TTC and Bombardier as it pertains to Material and



Labour costs. A list of the information presented to conduct the audit is provided in section 4 below.

- Bombardier'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.
- While Bombardier team was professional and cooperative, valuable productive time was used in assuring strict compliance to details spelled out in the official audit plan. Due to the confidential nature of the information provided by Bombardier the information presented in the report is limited to generalities.

### **3. Approach**

The approach used to audit the escalated labour costs consisted of comparing Bombardier's estimated hours to manufacture the Option 1A Order (originally based on previously manufactured cars) compared to actual hours compared to the ATTO proposal. In order to accomplish this, the audit team met with key staffs and reviewed supporting documents associated with the six cost centres responsible for creating the labour cost estimates for the ATTO. These six centres are: Production, Quality Assurance (includes Quality Control activities), Methods, Product Introduction (also called Customer Service responsible for car commissioning), Program Management and Engineering. The main root causes identified for significant increases in production hours were discussed in terms of impact and responsibility i.e. plant logistics, manufacturing, design, and supply chain issues contributing to poor quality, disruptions, late delivery, etc.

The approach used to audit the escalated material costs consisted of a review of the following documents presented by Bombardier:

- summary of the material costs utilized for the base order,
- summary of current material prices for Option 1A Order and
- quotations for ATTO.

In view of time limitations, only those material costs exceeding 5% from the Option 1A Order were verified. The CH2M HILL team also verified that that Bombardier had accurately applied freight costs and U.S. dollar to Canadian dollar conversion rates and the contractually allowable mark-ups for General Administration, Procurement and Logistics, and Margin on Sales.

### **4. Documentation Review**

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

- Appendix 3 079 – 10 Train Sets Proposal - Recommended List of Spare Parts
- Excerpt from General Condition revised under Contract Amendment No. 29 on February 2012 Section 43 - Contract Security
- Excerpt from General Condition revised under Contract Amendment No. 29 on February 2012 Section 58 - Escalation
- Summary of Bombardier's Additional Ten Train set order proposal
- BT-01 Potential Additional Trains Order
- BT-02 Price Increase to TTC for the new 10 Train Sets
- BT-03 Manufacturing Hours Forecast

- BT-04 TTCR Manufacturing Hours
- BT-05 Rocket Train set projection
- BT-06 Contract Summary
- BT-07 Section 43- Truck Weldment
- BT-08 "Untitled" – Workstations Flow Chart (Plant Tour was provided)
- BT-09 Truck Recovery and Spares Delivery Plan
- BT-10 TB Production Hours Reconciliation
- BT-11 Potential Additional Trains Order – Bill of Material
- BT-12 "Untitled" – Supplier Price Increases
- BT-13 Price Increase to TTC for New 10 Train set Bid vs Option 1A
- BT-14 Variance Actual Hours and 10 Train set Bid vs. Option 1A
- BT-15 Contract Summary Monthly Period 12.2013
- BT-16 Actual Hours Compared to Target Contract 079 dated 01/29/2014
- BT-17 TTC Allocated Hours per Car Rev.9 October 11, 2013
- BT-18 Material Summary Option Costing Rev. 5 Feb/10
- BT-19 Potential Additional Trains Order - Quality Assurance Build Up of Hours
- Booz Allen Hamilton Report Price Analysis of New Subway Trains

## 5. List of Attendees

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

<u>Name</u>	<u>Title</u>	<u>Company</u>
Kam T. Kwok *	Manager – Subway Vehicle Engineering	TTC
Sean Meadows	Lead Auditor	CH2M HILL
Gene Sansone	Senior Audit Advisor	CH2M HILL
Damon Quan	Auditor	CH2M HILL
Carolyne Leroux	Project Director	Bombardier
Pablo Vieira	Finance Director	Bombardier
Lindsay Menard	Contract Manager	Bombardier
Jochen Knorr	Project Controller	Bombardier
Harald Braun	Material - Supply Chain Lead	Bombardier
Crystal Culbert	Material – Supply Management	Bombardier
Wanda Major	Material – Finance (On-call)	Bombardier
James Van Acker	Labour – GM	Bombardier
Carlos Barcena	Labour – Production Line	Bombardier
Kris Kardal	Labour – Production PP/Trucks	Bombardier
Corey Rabachuk	Labour – Methods	Bombardier
Andrea Middleton	Labour – Finance (On-Call)	Bombardier
Julie Pronovost	Quality Assurance Director (On-Call)	Bombardier
Marc Leschuk	Engineering – Manager (On call)	Bombardier

\* **Attendee only participated on the third day of the audit when the audit findings were presented and discussed.**



## **6. Labour Escalation**

To evaluate the escalated labour costs Bombardier has stated that they will incur to build the additional ten train sets (ATTO), an understanding of their initial labour estimates and the labour effort currently being expended is required.

When developing their base order proposal to build the TR, Bombardier utilized data from previous subway car builds for the Canadian market to develop their labour estimate. The TR has presented several engineering and manufacturing challenges that Bombardier did not anticipate during the bid development phase, which has resulted in a significant labour effort above their initial assumptions.

Due to the structure of the contract between the TTC and the car-builder, Bombardier was not entitled to increase the cost of labour or material to produce the vehicle when the proposal for Option 1A Order was submitted. Additionally, at the time the Option Order was awarded, Bombardier had yet to begin their production run of the TR train sets and actual costs were not realized.

It should be noted, that Bombardier stated under the "delta justification" heading on the bid proposal summary for the ATTO, that the labour escalation is associated with "production hours", during the audit this was clarified by the car-builder that labour increase was associated with all cost centres which encompasses Manufacturing, Quality Assurance, Methods, Product Introduction, Program Management and Engineering. Each of these categories were reviewed independently as part of the audit and the findings presented in the sections below.

### **6.1 Manufacturing**

Bombardier defines manufacturing as the efforts associated with production, tooling and testing. Production activities represent the greatest percentage of labour hours that exceed the Option 1A Order estimates. To mitigate the production hour overruns, Bombardier is implementing production efficiencies to significantly reduce production time. These efficiencies include; improved production processes, Quality Assurance (QA) support and Supply Chain Management. If all of the planned efficiencies are achieved, the actual production hours required to manufacture the TR will still be in excess of the hours budgeted in their proposal for the Option 1A Order. The production hours identified in Bombardier's proposal for the ATTO is in accordance with their planned production efficiencies.

No increase was identified or observed by the Audit team associated with tooling or testing efforts.

### **6.2 Quality Assurance**

Bombardier's QA efforts includes Quality Control (QC) of production activities at all manufacturing sites (Mexico, La Pocatiere and Thunder Bay), QA / QC at customer delivery sites, QA of suppliers and supplier testing activities. QA efforts are directly proportional to the amount of production hours required to manufacture a subway car. Therefore, as the production hours increased from the Option 1A Order, the amount of QA effort will increase. The audit team verified that the same ratio of QA support was applied to the Option 1A Order contract as is being applied to the ATTO proposal.



### **6.3 Methods**

Methods department coordinates with engineering, production, quality assurance departments to develop production documents, assists in Non-Conformance Reports (NCR), chair's the Materials Review Board (MRB), authoring field modification instructions (FMI), etc.

Through the production efficiencies and improved supply chain management, Bombardier anticipates a reduction in NCRs, MRBs and no additional FMIs for the ATTO. If efficiencies are realized, the estimated Methods hours for the ATTO are greater than those estimated in Option 1A Order.

### **6.4 Product Introduction**

Bombardier Product Introduction (PI) team is based at the client delivery sites to support validation testing, commissioning activities, implementation of modifications and provide warranty support. Currently the PI team is streamlining the commissioning process and anticipate to be at optimum efficiency for ATTO. Additionally, all field modifications should be completed prior to the ATTO contract. The streamlined commissioning process and the elimination of field modifications will result in a significant reduction in effort for PI from the Option 1A Order vehicles. The reduced effort was reflected in Bombardier's ATTO proposal.

### **6.5 Program Management**

No significant change in Program Management effort was noted between the Option 1A Order and the ATTO proposal.

### **6.6 Engineering**

Bombardier's engineering support for the Option 1A Order vehicle consists of Vehicle Structures, Trucks, Vehicle Systems, Vehicle Doors, Software (vehicle and support systems), Reliability/ Availability / Maintainability / Safety (RAMS) and Production. To date, Bombardier has expended engineering effort in excess of what was budgeted in their Option 1A Order bid to design the TR and meet the TTC's Mean Distance Between Relevant Failure (MDBRF) requirements.

Some of the additional hours required by the engineering team can be attributed to the bankruptcy of the original door manufacture during execution of the base contract, which resulted in Bombardier inheriting a premature design that they were required to finalize. Bombardier engineering now consequently assumes the on-site customer activities (commissioning, FARs, warranty support, etc.) typically the responsibility of their supplier. Specific to the 10 train sets proposal, Bombardier will assume the engineering support typically provided by the door vendor.

A review of Bombardier's ATTO proposal includes three on-site engineers (2 – doors, 1 – RAMS) for the commissioning process that tapers down over the warranty period and five additional engineers to support the other engineering disciplines. The estimated hours Bombardier has allocated in the ATTO proposal is greater than what was in their base proposal but is less than what they are currently expending on the Option 1A Order contract.

## 6.7 Labour Conclusion

Bombardier's increased labour costs are directly attributed to their underestimation of the effort required to manufacture the TR subway car in their Base and Option Order vehicles. The technologically advanced vehicle for the North American market presented Bombardier several engineering and manufacturing challenges that were not anticipated at the time of their bid development. The challenges experienced by Bombardier can be attributed to this being the first time they produced this type of vehicle in North America. The labour hours identified in Bombardier's proposal for the ATTO is greater than their initial proposal, but is still significantly less than what they are currently expending to manufacture the Option 1A Order cars. In summary, Bombardier underestimated the manufacturing requirements of the TR resulting in them exceeding their Option 1A Order budgeted hours. Bombardier's proposal for the ATTO reflects anticipated production efficiencies, which are still greater than what was initially budgeted in their Base and Option Order Proposal.

## 7. Materials

During the development of the base order proposal, Bombardier and its suppliers defined the material costs for the TR contract which included the Option Order vehicles. Subsequently, when the Option 1A Order was executed, Bombardier and their suppliers' material costs were bound to the terms defined in the initial contract. For the ATTO, these terms are no longer applicable which has resulted in some vendors significantly increased their costs to account for raw material cost escalations, redesigns for product improvement, currency exchange rates, change in suppliers and vendors underbidding in the base order.

Suppliers with a cost increase of more than 5% between the ATTO bid and current costs were reviewed in detail. The quotes from these suppliers for the ATTO were reviewed and validated with Bombardier's reported prices. The five largest cost increases were associated with the propulsion system, gangway articulation section, door system suppliers, integrated power systems and coupler systems.

The total material cost increase from Option 1A Order freight and packaging costs along with the conversion from U.S. dollars to Canadian dollars was verified. In addition, it was verified that Bombardier had accurately applied the contractually allowable mark-ups for General Administration, Procurement and Logistics and Margin on Sales that was communicated to us. Bombardier verbally stated that these mark-ups were not applied to any other portion of their proposal.

In summary, Bombardier's material cost escalation documentations was reviewed in detail and validated.

## 8. Audit Conclusion

The escalated material costs and increased labour hours that Bombardier stated they are incurring for the ATTO has been confirmed. The increased labour hours reflected in their proposal are based upon the estimated hours to manufacture a TR if all production efficiencies are realized. While the hours are greater than what was identified in the Option 1A Order estimate they are significantly lower than the current labour that is being expended to manufacture the TR.

Material escalation costs were confirmed through the aforementioned process and with the contractual mark-ups appropriately applied. The escalated material costs can be attributed to raw material cost, redesigns for product improvement, currency exchange rates, change in suppliers and



vendors underbidding in the base order. Additional costs associated with the materials for the TR was found in accordance with Bombardier's stated escalation.

The audit team concludes that the cost escalation identified by Bombardier within their proposal accurately reflects the costs incurred by the car-builder.

## **9. Cost Comparison to T1 Subway Cars**

Our audit was strictly focused on the escalated material and labour costs associated with Bombardier's proposal to provide the ATTO. For reference, the team reviewed the August 23, 2006 report titled "Price Analysis of the New Subway Trains" authored by Booz Allen Hamilton. The authors of the report determined that the escalated cost of the T1 subway cars in 2006 dollars would equate to \$2.971M per car including tooling, computer based training and a cab simulator. Bombardier's December 2013 proposal for the ATTO order equates to \$2.604M per car in 2014 dollars. While this price does not include the additional equipment and training it is still less than what the estimated escalated cost of the T1 subway car in 2006 dollars.