

# *Red Line/Blue Line Connector Project*

Boston,  
Massachusetts

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Massachusetts Department of Transportation  
Boston, Massachusetts



March 2010



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## **1.1 Introduction**

This technical memorandum documents the operating and maintenance (O&M) cost methodology and estimates related to the Red Line/Blue Line Connector Project for the two alternatives being considered:

- Alternative 1: Blue Line extension to Charles/MGH Station with the elimination of the Bowdoin Station; and
- Alternative 2: Blue Line extension to Charles/MGH Station with the relocation of the Bowdoin Station.

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## **1.2 O&M Cost Estimate Methodology**

The extension of the Blue Line under Cambridge Street to the Charles/MGH Station on the Red Line will result in increases to annual operating and maintenance costs as trains will run farther in distance and, depending on the alternative, trains would stop at Bowdoin Station, and additional trains are required to maintain existing peak headways.

This has cascading effects on the costs of providing service in terms of the following functions:

- Vehicle Operations; and
- Vehicle Maintenance and Propulsion Power.

To estimate the incremental operations and maintenance costs associated with the two alternatives, a resource build-up O&M cost model was developed to calculate the additional costs associated with these changes in service.

A resource build-up cost model functions by estimating actual quantities of items, such as labor and materials required to provide the projected service levels. These quantities are multiplied unit costs. The following sections describe the components used to develop the O&M cost model.

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**1.2.1 Cost Categories**

The cost categories for the O&M cost model that were used to estimate the incremental operating and maintenance costs for the alternatives include:

- Vehicle operations. Annual costs associated with vehicle operations such as motor person, train starter (and for Alternative 2 only, other car house employee) wages and fringe benefits, as well as station and vehicle cleaning materials and supplies; and
- Vehicle maintenance. Annual costs associated with propulsion power (e.g., electricity) and costs associated elevator and escalator maintenance.

MBTA contracts the maintenance of its stations and their components (such as escalators and elevators) with a separate, private company. The O&M cost data was derived from the MBTA Blue Line Transportation and Maintenance Departments FY 2010 Operating Budget as well as further inquiries with MBTA staff. This data was used to develop an O&M cost model. The model was used to estimate the incremental operating and maintenance costs associated with any increases to Blue Line service related to the two alternatives.

The cost categories and their associated cost items are shown in Table 1.

**Table 1: O&M Cost Categories and Associated Cost Items**

<b>Cost category</b>	<b>Cost item</b>
Vehicle Operations	Salary and Fringe Station Cleaning Materials and Supplies Vehicle Cleaning Materials and Supplies Elevator and Escalator Maintenance
Vehicle Maintenance	Propulsion Power Costs Vehicle Maintenance Materials and Supplies

## 1.2.2 O&M Cost Items and Unit of Service

For each of the O&M cost items, a unit of service (i.e., service variable) was assigned as shown in Table 2.

**Table 2: O&M Cost Items and Units of Service**

Cost item	Units of Service
<b>Vehicle Operations</b>	
Salary and Fringe	Annual Revenue Train Hours
Station Cleaning Materials and Supplies	Stations
Vehicle Cleaning Materials and Supplies <sup>1</sup>	Annual Revenue Car Miles
Elevator and Escalator Maintenance	Stations
<b>Vehicle Maintenance</b>	
Propulsion Power Cost <sup>2</sup>	Annual Revenue Car Miles
Materials and Supplies	Annual Revenue Car Miles

## 1.2.3 Blue Line Annual O&M Unit Costs

Unit costs represent labor wages and benefits as well costs of materials. Unit costs were developed using data provided by MBTA including:

- MBTA Blue Line Transportation and Maintenance Departments FY 2010 Operating Budget;
- Operating statistics for the existing Blue Line from the September 5, 2009 version of the Blue Line Headway Report.

The following calculations were used to develop unit costs based on Blue Line operating costs and operating statistics.

### Alternative 1 only

Under Alternative 1, it is assumed that only labor costs associated with motor persons and train starters would be affected by the extension. The labor levels and costs associated with supervision and administration would remain unchanged with the extension of the Blue Line.

<sup>1</sup> Only eight stations on the Blue Line have elevators or escalators.

<sup>2</sup> Propulsion power is provided under a contract with Florida Power and Energy. The unit cost is based on FY 2009 NTD Form 402 provided by MBTA.

*Salary and Fringe = (sum of annual operator salary and fringe / annual revenue train hours)*

Salary and Fringe = (\$3,699,454 / 49,352)

Salary and Fringe = \$74.96 / annual revenue train hour

**Alternative 2 only**

Under Alternative 2, it is assumed that only labor costs associated with motor persons, train starters and other car house employees would be affected by the extension because one additional train would be required to maintain the 4.5 minute headways during the AM peak rush. .

*Salary and Fringe = (sum of annual operator and other car house employee salary and fringe / annual revenue train hours)*

Salary and Fringe = (\$5,085,850 / 49,352)

Salary and Fringe = \$103.05 / annual revenue train hour

**Vehicle Operations - Station Cleaning Materials and Supplies**

*Station Cleaning Materials and Supplies = (annual sum of station materials and supplies / number of stations on the Blue Line)*

Station Cleaning Materials and Supplies = (\$1,538,264 / 12)

Station Cleaning Materials and Supplies = \$128,189 / station



**Vehicle Operations - Vehicle Cleaning Materials and Supplies**

*Vehicle Cleaning Materials and Supplies = (annual sum of vehicle cleaning materials and supplies / annual revenue car miles)*

Vehicle Cleaning Materials and Supplies = (\$316,992 / 4,127,220)

Vehicle Cleaning Materials and Supplies = \$0.08 / annual revenue car mile

**Vehicle Operations - Elevator and Escalator Maintenance**

Elevator and Escalator Maintenance services are contracted with a private company, KONE. Based on information provided by MBTA, the total system wide cost for maintenance services was \$5,652,000 per year. There are 60 stations on the Red, Blue, Orange, Silver and Green Lines.

*Elevator and Escalator Maintenance = (annual system wide elevator and escalator cost / number of stations on the MBTA subway system with elevators and escalators)*

Elevator and Escalator Maintenance = (\$5,652,000 / 60)

Elevator and Escalator Maintenance = \$94,200 / station

**Vehicle Maintenance - Propulsion Power**

Traction and non-traction power on the Blue line is provided under contract with Florida Power and Energy. The propulsion power cost and annual revenue car-miles are based on FY 2009 NTD Form 402 provided by MBTA.

*Propulsion Power = (annual propulsion cost / annual revenue car miles)*

Propulsion Power = (\$3,313, 757 / 3,520,510)

Propulsion Power = \$0.94 / annual revenue car mile

**Vehicle Maintenance – Materials and Supplies**

*Materials and Supplies = (annual sum of vehicle maintenance materials and supplies / annual revenue car miles)*

Materials and Supplies = (\$394,421 / 4,127,220)

Materials and Supplies = \$0.10 / annual revenue car mile

Table 3 displays the unit costs calculated for the existing MBTA Blue Line.

**Table 3: Existing Blue Line FY 2010 Operating Budget Unit Costs**

<b>Cost category</b>	<b>Unit cost</b>
<b>Vehicle Operations</b>	
Salary and Fringe (Alternative 1)	\$74.96 / annual revenue train hour
Salary and Fringe (Alternative 2)	\$103.05 / annual revenue train hour
Station Cleaning Materials and Supplies	\$128,189 / station
Vehicle Cleaning Materials and Supplies	\$0.08 / annual revenue car mile
Elevator and Escalator Maintenance	\$94,200 / station
<b>Vehicle Maintenance</b>	
Propulsion Power	\$0.94 /annual revenue car mile
Materials and Supplies	\$0.10 / annual revenue car mile

Table 4 displays the annual O&M cost for the entire, existing Blue Line.

**Table 4: Existing Blue Line FY 2010 Operating Budget**

<b>Cost Item</b>	<b>Unit Of Service</b>	<b>Type</b>	<b>Unit Cost</b>	<b>Annual Cost</b>
<b>Vehicle Operations</b>				
Salary and Fringe	49,352 Annual Revenue Train Hours	L	\$147.80 /revenue train hour	\$7,294,467
Station Cleaning Materials and Supplies	12 Stations	M	\$128,189 /station	\$1,538,264
Vehicle Cleaning Materials and Supplies	4,127,220 Annual Revenue Car Miles	M	\$0.08 /revenue car mile	\$316,992
Elevator and Escalator Maintenance <sup>1</sup>	8 Stations	-	\$94,200 /station	\$753,600
	<b>Subtotal</b>			<b>\$9,903,323</b>
<b>Vehicle Maintenance and Propulsion Power</b>				
Propulsion Power <sup>2</sup>	4,127,220 Annual Revenue Car Miles	U	\$0.94 /revenue car mile	\$3,884,836
Materials and Supplies	4,127,220 Annual Revenue Car Miles	M	\$0.10 /revenue car mile	\$394,421
	<b>Subtotal</b>			<b>\$4,279,257</b>
	<b>Grand Total</b>			<b>\$14,182,580</b>

L = Labor M = Material U=Utilities

<sup>1</sup> Only 8 stations in the Blue Line have elevators or escalators. Unit cost assumes \$5,652,000 systemwide annual cost divided by 60 MBTA subway stations with elevators and/or escalators (red, blue, orange, silver and green lines)

<sup>2</sup> Propulsion power is provided under a contract with Florida Power and Energy. The unit cost is based on FY 2009 NTD Form 402 provided by MBTA

### 1.3 Blue Line Extension Operating Statistics

For the purpose of developing the incremental operations and maintenance cost estimates, a simplified plan of operations was assumed. It was assumed that the existing service levels for Weekdays, Saturdays, and Sundays would be extended to/from Wonderland over the new extension, on a train-for-train basis, as they appear on the September 5, 2009 version of the Blue Line Headway Report.

The operating service plan defined the proposed alternatives in terms of alignment, station stops, and headways. The calculation of additional revenue train hours takes into account the additional running time generated by the extension of Blue Line service to MGH/Charles under both alternatives, stopping at Bowdoin Station under Alternative 2, a four minute layover at Charles/MGH, and an eight minute layover at Wonderland, as discussed with MBTA Scheduling Department

Several products derived from the operating service plan were needed to develop the incremental O&M costs. These products include:

- Additional annual revenue train miles
- Additional annual revenue car miles
- Additional number of stations
- Additional annual revenue train hours

The Table 5 displays the operating statistics that were calculated based on the operating service plan developed specifically for this study.

**Table 5: Alternative Specific Operating Statistics**

Alternative	Overall Station-to- Station Distance (feet)	Additional Number of Stations	Additional - Round Trip Run Time (minutes)	Peak Trains	Avg Peak Headway (minutes)	Weekday Round Train Trips (both ways)	Saturday Train Trips (both ways)	Sunday Train Trips (both ways)	Additional Annual Train Mileage	Additional Annual Car Mileage	Additional Annual Train Hours
1	2,000	0	2.48	13	4.5	174	126	113	21,713	130,278	11,088
2	2,000	1	4.13	14	4.5	174	126	113	21,713	130,278	16,835

## 1.4 Operations and Maintenance Cost Estimate Results

The alternative specific operating statistics (annual revenue train-hours, annual revenue car-miles, and stations) were multiplied by the unit costs to produce O&M costs for each line item and the total O&M cost for each alternative for the Blue Line Extension.

Under Alternative 1, the incremental increase in annual O&M costs is \$976,232.

Under Alternative 2, the incremental increase in annual O&M costs is \$2,102,315.

The total Blue Line O&M costs and the incremental change in O&M costs by alternative is shown in Table 6.

**Table 6: Summary of Annual Operating and Maintenance Costs by Alternative (\$2009)**

Cost Item	Existing Blue Line Annual Cost	Blue Line Annual O&M Cost inc. Alternative 1	Blue Line Annual O&M Cost inc. Alternative 2
<b>Vehicle Operations</b>			
Salary and Fringe	\$7,294,467	\$8,125,615	\$9,029,309
Station Cleaning Materials and Supplies	\$1,538,264	\$1,538,264	\$1,666,453
Vehicle Cleaning Materials and Supplies	\$316,992	\$326,998	\$326,998
Elevator and Escalator Maintenance	\$753,600	\$753,600	\$847,800
<b>Vehicle Maintenance and Propulsion Power</b>			
Propulsion Power	\$3,884,836	\$4,007,463	\$4,007,463
Materials and Supplies	\$394,421	\$406,871	\$406,871
<b>Total</b>	<b>\$14,182,580</b>	<b>\$15,158,812</b>	<b>\$16,284,895</b>
<b>Incremental Change in Cost</b>	<b>-</b>	<b>\$976,232</b>	<b>\$2,102,315</b>

Tables 7 and 8 display the incremental change in annual O&M costs for each alternative by cost item.

**Table 7: Incremental Change in Annual Operating and Maintenance Costs for Alternative 1 (\$2009)**

Cost Item	Unit Of Service	Type	Unit Cost	Annual Cost
<b>Vehicle Operations</b>				
Salary and Fringe	11,088 Additional Annual Revenue Train Hours	L	\$74.96 /revenue train hour	\$831,148
Station Cleaning Materials and Supplies	0 Additional Station (Net)	M	\$128,189 /station	\$0
Vehicle Cleaning Materials and Supplies	130,278 Additional Annual Revenue Car Miles	M	\$0.08 /revenue car mile	\$10,006
Elevator and Escalator Maintenance	0 Additional Station (Net)	-	\$94,200 /station	\$0
<b>Subtotal</b>				<b>\$841,154</b>
<b>Vehicle Maintenance and Propulsion Power</b>				
Propulsion Power	130,278 Additional Annual Revenue Car Miles	U	\$0.94 /revenue car mile	\$122,627
Materials and Supplies	130,278 Additional Annual Revenue Car Miles	M	\$0.10 /revenue car mile	\$12,450
<b>Subtotal</b>				<b>\$135,078</b>
<b>Blue Line Operations and Maintenance Cost Estimation</b>				<b>2/13,978,032</b>

**Table 8: Incremental Change in Annual Operating and Maintenance Costs for  
Alternative 2 (\$2009)**

<b>Cost Item</b>	<b>Unit Of Service</b>	<b>Type</b>	<b>Unit Cost</b>	<b>Annual Cost</b>
<b>Vehicle Operations</b>				
Salary and Fringe	16,835 Additional Annual Revenue Train Hours	L	\$103.05 /revenue train hour	\$1,734,842
Station Cleaning Materials and Supplies	1 Additional Station (Net)	M	\$128,189 /station	\$128,189
Vehicle Cleaning Materials and Supplies	130,278 Additional Annual Revenue Car Miles	M	\$0.08 /revenue car mile	\$10,006
Elevator and Escalator Maintenance	1 Additional Station (Net)	-	\$94,200 /station	\$94,200
	<b>Subtotal</b>			<b>\$1,967,237</b>
<b>Vehicle Maintenance and Propulsion Power</b>				
Propulsion Power	130,278 Additional Annual Revenue Car Miles	U	\$0.94 /revenue car mile	\$122,627
Materials and Supplies	130,278 Additional Annual Revenue Car Miles	M	\$0.10 /revenue car mile	\$12,450
	<b>Subtotal</b>			<b>\$135,078</b>
	<b>Grand Total</b>			<b>\$2,102,315</b>

L = Labor M = Material U=Utilities