



**SOUND TRANSIT**  
**HCT Planning**

**Sound Transit Phase 2 HCT Planning**  
**LINK Operating and Maintenance Cost Model**

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## Introduction

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This report describes the operating and maintenance (O&M) cost model for Sound Transit's Central Link light rail system. The model will be used to estimate costs for extensions to the initial system approved in *Sound Move*; those extensions are being studied as part of the Sound Transit 2 (ST2) planning process.

The model has been calibrated for the initial segment of the Central Link system. The 14-mile line will run from Westlake Station in downtown Seattle to the Tukwila International Boulevard Station, with twelve stations. The initial operating plan calls for two-car trains running every six minutes during peak periods, and every ten minutes offpeak. The initial fleet will have 31 cars, including five spares.

Sound Transit intends to contract with King County Metro (KCM) for operation of the Central Link system. The calibration process has used the budget proposed by King County Metro in 2005 for the initial system. Additional cost items are based on information provided by Sound Transit staff. Using these calibration assumptions as a baseline, the model can be used to estimate the annual O&M cost of any future light rail alternative.

## Model Structure

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The structure of the model is resource build-up model, which conforms to Federal Transit Administration guidelines for Alternatives Analysis. The cost model consists of five Excel worksheets:

- *System and Service Statistics,*
- *Traction Power,*
- *Line Item Detail,*
- *Cost Summary, and*
- *Comparison of Alternatives.*

### 1. System and Service Statistics

Every modeled expense is linked, directly or indirectly, with one or more of the inputs that describe a Link alternative. Model inputs are also called "driving variables" or "drivers". The Link O&M model requires the following input statistics:

Peak Cars – The maximum number of light rail vehicles operating simultaneously in scheduled service.

Annual Revenue Car-Miles – Total miles operated by all rail cars in scheduled service, excluding deadhead mileage.

Annual Revenue Train-Hours – Total hours operated by all trains in revenue service, excluding report and deadhead time.

Subway, Elevated, At-Grade Stations – The number of each type of passenger station in the light rail system.

Directional Route Miles – The miles of revenue track, excluding yard and tail track (e.g., one mile of double track equals two directional route miles).

Maintenance Facilities – The number of light rail maintenance and storage yards.

Joint Operation in DSTT (Downtown Seattle Transit Tunnel) – Yes or no.

In addition to the driving variables, the input sheet also provides for an inflation adjustment, if desired. The model has been developed using 2005 dollars. The results can be adjusted to any future year by inputting an inflation adjustment relative to 2005. The same adjustment factor is applied to all line items.

The following table shows the input worksheet for a model run of the calibration system itself. For a model run of a different alternative, the “input” column would contain a new set of statistics.

### Light Rail O&M Cost Model System and Service Statistics

Variable	Code	Input	DO NOT CHANGE
		14-mi Central Link Calibration	14-mi Central Link Calibration
Peak Cars	PKCAR	26	26
Revenue Car-Miles	CARM	2,606,000	2,606,000
Revenue Train-Hours	TRNHR	62,000	62,000
Subway Stations	SUBSTA	5	5
Elevated Stations	ELEVSTA	2	2
At-Grade Stations	GRADESTA	5	5
Directional Route Miles	RTMILE	27.8	27.8
Maintenance Facilities	YARD	1.0	1.0
Joint operation in DSTT?	yes=1, no=0	1	1
Alternative Name	NAME	Calibration	Calibration

**NOTES:**

1. Calibration statistics provided by Sound Transit, August 2005.
2. Costs estimated in \$2005 using a factor of:

INFLATE      1.000

## 2. Traction Power

The annual cost to power a single car varies among light rail systems in the United States, but for each operator traction power is a significant line item expense. The following table is the model's traction power worksheet for the Central Link's calibration system. The table incorporates the rate structure used by Seattle City Light (e.g., seasonal energy and demand charges, electrical rates) with the consumption experience of other light rail systems.

The five notes at the end of the table explain in some detail the series of assumptions used to generate a traction power cost estimate for the Central Link. Each time the model is run, the traction power cost estimate is imported to the model's Line Item Detail.

### Sound Transit Light Rail O&M Cost Model Traction Power Worksheet

Charges	Units	Estimated Cost (\$2005)	
		Monthly	Annually
<b>1. Energy</b>	9.05	<i>kWh per revenue car-mile</i>	
Summer, peak	\$0.0619	\$119,303	\$715,820
Summer, off-peak	\$0.0543		
Winter, peak	\$0.0619	\$119,303	\$715,820
Winter, off-peak	\$0.0543		
<b>2. Demand</b>	157.5	<i>kW per peak car</i>	
Summer, peak	\$0.84	\$3,440	\$20,639
Summer, off-peak	n/a		[no demand exceeds peak]
Winter, peak	\$0.84	\$3,440	\$20,639
Winter, off-peak	n/a		[no demand exceeds peak]
<b>Total Annual Traction Power Cost</b>			<b>\$1,472,918</b>

**Modeled with statistics for:** 14-mi Central Link  
Revenue car-miles 2,606,000  
Peak Cars 26

#### NOTES

- Unit costs from Seattle City Light electrical rates and provisions, printed May 4, 2005, for Schedule LGD (Large General Service, with monthly demand between 1,000 and 10,000 kW).
- Summer rates apply in April through September; winter rates apply from October through March.
- Peak usage means between 6:00 AM and 10:00 PM, Monday through Saturday.  
Off-peak usage refers to the remaining (late night and early morning) weekday and Saturday hours, Sundays and holidays. Distribution of revenue car-miles assumed to be 84% peak and 16% off-peak, based on LINK Light Rail System, Phase I (Option B) operating plan, prepared by Manuel Padron & Associates on 26 March 1998.
- Kilowatt hours per revenue car-mile is the average for seven light rail systems (in San Diego, St. Louis, Denver, San Jose, Portland, Sacramento, and Los Angeles).
- Demand consumption rate is based on Sacramento experience (approx. 150 kW per peak car).  
Rate factored by 1.05 to reflect deadhead and yard consumption.

### 3. *Line Item Detail*

This worksheet simulates an annual operating budget where Sound Transit and KCM expenses are mutually exclusive. Generally, the model's rows are structured in "departments", with line item expenses in King County Metro's proposal listed first. Departments assumed are:

- *Vehicle Operations*
- *Vehicle Maintenance*
- *Facilities Maintenance*
- *Administration & Support*

Besides cost item and department, other columns in the Line Item Detail include:

Cost Type – Categories are labor, service, material/supplies, insurance, fuel (lube), utilities and miscellaneous.

Annual Earnings – KCM estimated salaries and wages for the specific positions they identified for the Central Link project.

Productivity – For the most part, these factors are based on KCM's projections for the start-up system and MPA's adjustments for future system growth based on the experience of existing light rail systems.

Driver – For each line item, this column displays the driving variable selected as the most influential for projecting incremental changes to future costs of a different-sized system. Some examples of direct driving variables are: train-hours for rail operators and car-miles for repair parts. An example of an indirect driver is total KCM cost as the basis for estimating the level of Sound Transit's administration and support.

The model also recognizes the reality of a few expenses that will neither increase nor decrease with changes in system size. Examples of fixed costs in this model are: KCM department heads and a portion of Sound Transit's security and staff expenses.

Full-time Equivalent – The estimated staffing level for each labor position.

Annual Cost – Because the model implicitly assumes that baseline (calibration) rates of consumption and labor productivity will continue into the future, expenses are calculated as a function of the base year cost and the base and future (or alternative) values of the driving variables. This column is where the model's cost equations reside. The equations are generally of the form:

$$\text{Estimated Annual Cost} = \text{Base Year Cost} / \text{Driver Value for Base Year} * \text{Driver Value for Future Year}$$

Following are pages that show the Line Item Detail for the calibration system model run.

Sound Transit  
 Light Rail O&M Cost Model  
 Line Item Detail  
 Calibration

Cost Item	Dept.	Type	Annual Earnings	Productivity Factor	Driver	FTEs	Annual Cost (2005 dollars)	Assumptions
<b>Vehicle Operations - KCM</b>								
Rail Operations Supervisor	100	LABOR	\$88,132	1.0	Fixed	1.0	\$88,132	KCM, 2005
Rail Operations Chief	100	LABOR	\$80,156	3.0	Fixed	3.0	\$240,469	KCM, 2005
Rail Supervisor	100	LABOR	\$69,637	5.3	PKCAR	5.3	\$369,075	1 on duty at all times for Rail Control (MPA: adjust for sys growth)
Rail Supervisor	100	LABOR	\$69,637	1.20	Total Stations-4 (DSTT stations)	9.6	\$668,513	
Rail Supervisor	100	LABOR	\$69,637		Joint operations in DSTT	5.2	\$362,111	FTEs=5.2 if joint oper in DSTT (6.9 to KCM bus); 12.1 otherwise
Rail Operator	100	LABOR	\$54,866	0.00074	TRNHR	46.0	\$2,523,825	KCM, 2005; (MPA: 1,348 rev. hrs./operator)
Rail Operator - PT	100	LABOR	\$49,088	0.07	# FT operators	3.0	\$147,264	KCM, 2005; (MPA: 1/15 full-time operators)
Administrative	100	LABOR	\$41,261	1.0	YARD	1.0	\$41,261	KCM, 2005
Fringe Benefits	100	LABOR		34.2%	Dept. earnings		\$1,519,783	KCM, 2005
Workers Compensation	100	LABOR		6.0%	Dept. earnings		\$268,490	KCM, 2005; Exhibit N3-A
Security Services	100	SERV		\$67,141	Non-Tunnel Stations, weighted		\$872,837	KCM, 2005; Exhibit N5; (MPA weights: grade=1, elev=2, subway=4)
KCM Scheduling Support	100	SERV		\$464	PKCAR		\$12,067	KCM, 2005; Exhibit N6
Other Contract Services	100	SERV		\$431	# operators		\$21,121	KCM, 2005; Exhibit N5
Other Contract Services	100	SERV		\$305	# other dept. empl.		\$7,645	KCM, 2005; Exhibit N5
Materials & Supplies	100	MATL		\$342	Total dept. empl.		\$25,313	KCM, 2005; Exhibit N5
DSTT Security	100	MISC			Joint operations in DSTT		\$1,482,853	ST, 09/21/05
Travel, Training, Conferences	100	MISC		\$183	Total dept. empl.		\$13,526	KCM, 2005; Exhibit N5
KCM Bus Bridging, 1000 hours	100	MISC		\$4,112	RTMILE		\$114,303	KCM, 2005; Exhibit N6
Claims Processing & Defense	100	INSUR		\$0.12	CARMI		\$315,100	KCM, 2005; Exhibit N5
Subtotal						74.1	\$9,093,689	

Train-Hours/Operations Employee	836.7
Operations Non-Labor Cost/Train-Hour	\$46.21

<b>Vehicle Maintenance - KCM</b>								
LRV Supervisor	200	LABOR	\$88,132	1.0	Fixed	1.0	\$88,132	KCM, 2005
LRV Chief	200	LABOR	\$80,156	4.0	Fixed	4.0	\$320,624	KCM, 2005
LRV Tech	200	LABOR	\$57,447	0.05	10,000 CARM	15.0	\$861,700	KCM, 2005; 1 for every 173,733 rev car miles
Miscellaneous Staff	200	LABOR	\$50,247	0.01	10,000 CARM	3.0	\$150,742	KCM, 2005; 1 for every 868,667 rev car miles
Clerk	200	LABOR	\$44,924	1.0	YARD	1.0	\$44,924	KCM, 2005
Administrative	200	LABOR	\$41,261	1.0	YARD	1.0	\$41,261	KCM, 2005
Car Cleaner	200	LABOR	\$38,836	0.19	PKCAR	5.0	\$194,182	KCM, 2005; 1 for every 5.2 peak cars
Fringe Benefits	200	LABOR		30.1%	Dept. earnings		\$512,603	KCM, 2005; Exhibit N4
Workers Compensation	200	LABOR		7.9%	Dept. earnings		\$135,128	KCM, 2005; Exhibit N3-A
Contract Services	200	SERV		\$0.09	CARM		\$244,804	KCM, 2005; Exhibit N5
KCM Work Order System Support	200	SERV		\$0.04	CARM		\$98,052	KCM, 2005; Exhibit N6
Repair Parts	200	MATL		\$0.03	CARM		\$78,151	KCM, 2005; Exhibit N5; see also under ST costs
Other Materials & Supplies	200	MATL		\$162,006	YARD		\$162,006	KCM, 2005; Exhibit N5
Miscellaneous	200	MISC		\$352	Dept. employee		\$10,562	KCM, 2005; Exhibit N5
Fuel & Lube	200	FUEL		\$731	PKCAR		\$19,010	KCM, 2005; Exhibit N5
Subtotal						30.0	\$2,961,881	

Car-Miles/Vehicle Maint. Employee	86,867
Veh. Maint. Non-Labor Cost/Car-Mile	\$0.24

Sound Transit  
 Light Rail O&M Cost Model  
 Line Item Detail  
 Calibration

Cost Item	Dept.	Type	Annual Earnings	Productivity Factor	Driver	FTEs	Annual Cost (2005 dollars)	Assumptions
<b>Facilities Maintenance - KCM</b>								
Link P&F Supervisor	300	LABOR	\$88,132	1.00	Fixed	1.0	\$88,132	KCM, 2005
Link Maintenance Chief	300	LABOR	\$80,156	3.00	Fixed	3.0	\$240,468	KCM, 2005
SCADA/Comm. Sys. Maintainer	300	LABOR	\$76,545	2.00	Fixed	2.0	\$153,090	KCM, 2005
TPSS Electrician	300	LABOR	\$70,355	0.11	RTMILE	3.0	\$211,065	KCM, 2005; (MPA: 1 for every 9.27 rt-miles, min. of 1)
OCS Line Crew	300	LABOR	\$70,357	0.14	RTMILE	4.0	\$281,427	KCM, 2005; (MPA: 1 for every 6.95 rt-miles, min. of 1)
Signals Tech	300	LABOR	\$60,876	0.14	RTMILE	4.0	\$243,504	KCM, 2005; (MPA: 1 for every 6.95 rt-miles, min. of 1)
Communications Tech	300	LABOR	\$60,669	0.11	RTMILE	3.0	\$182,007	KCM, 2005; (MPA: 1 for every 9.27 rt-miles; min. of 1)
System Electrician	300	LABOR	\$59,126	0.07	RTMILE	2.0	\$118,252	KCM, 2005; (MPA: 1 for every 13.9 rt-miles; min. of 1)
Track & ROW Maintainer	300	LABOR	\$55,748	0.22	RTMILE	6.0	\$334,486	KCM, 2005; 1 for every 4.3 track-miles
MMIS Support	300	LABOR	\$55,006	1.00	Fixed	1.0	\$55,006	KCM, 2005
Facilities Maintainer	300	LABOR	\$56,920	0.14	Total Stations, weighted	4.0	\$227,680	"; (MPA weights: grade=1, elev=2, subway=4)
Parts Specialist	300	LABOR	\$51,024	1.00	YARD	1.0	\$51,024	KCM, 2005
Landscape	300	LABOR	\$49,818	0.43	Elevated and At-Grade Stations	3.0	\$149,454	KCM, 2005
Custodian	300	LABOR	\$42,121	0.31	Total Stations, weighted	9.0	\$379,093	"; (MPA weights: grade=1, elev=2, subway=4)
Custodian	300	LABOR	\$42,121	3.00	YARD	3.0	\$126,364	KCM, 2005
Administrative	300	LABOR	\$43,382	1.00	YARD	1.0	\$43,382	KCM, 2005
Fringe Benefits	300	LABOR		29.0%	Dept. earnings		\$836,738	KCM, 2005
Workers Compensation	300	LABOR		3.4%	Dept. earnings		\$96,977	KCM, 2005; Exhibit N3-A
Non-Tunnel Elev/Escal Maint.	300	SERV		\$8,462	Non-Tunnel Stations, weighted		\$110,000	KCM, 2005 \$503,601, split X 3. MPA: Subway elev/esc maint=50k, aerial=
Trackwork & Custodial Services	300	SERV		\$7,079	RTMILE		\$196,801	(MPA: assumed 50% rtmile, 50% station)
Trackwork & Custodial Services	300	SERV		\$6,786	Total Stations, weighted		\$196,801	(MPA weights: grade=1, elev=2, subway=4)
KCM Enviro & Hazmat Support	300	SERV		\$88,549	YARD		\$88,549	KCM, 2005; includes compliance, training, certifications
<b>Materials &amp; Supplies</b>								
Track/Way	300	MATL		\$1,861	RTMILE		\$51,749	KCM, 2005 (MPA: 40% track, 30% station, 30% yard)
Stations	300	MATL		\$1,338	Total Stations, weighted		\$38,812	"; (MPA weights: grade=1, elev=2, subway=4)
Yard/Shop/Central Control	300	MATL		\$38,812	YARD		\$38,812	KCM, 2005 (MPA: 40% track, 30% station, 30% yard)
Station Power	300	UTIL		\$5,827	Total Stations, weighted		\$168,976	KCM, 2005, Exhibit N5
<b>Other Utilities</b>								
Tunnel	300	UTIL		\$91,802	Fixed		\$91,802	KCM, 2005 (MPA: 15% tunnel/fixd, 85% yard)
Yard	300	UTIL		\$520,209	YARD		\$520,209	KCM, 2005 (MPA: 15% subway stations, 85% yard)
DSTT Maintenance	300	MISC			Joint operations in DSTT		\$1,459,190	ST. 09/21/05; includes escalator/elevator maint.
Miscellaneous	300	MISC		\$1,142	Dept. Employee		\$57,094	KCM, 2005, Exhibit N5
<b>Subtotal</b>						<b>50.0</b>	<b>\$6,836,942</b>	

Track-Miles/Facil. Maint. Employee	0.56
Facil. Maint. Non-Labor Cost/Track-Mile	\$87,289

Sound Transit  
 Light Rail O&M Cost Model  
 Line Item Detail  
 Calibration

Cost Item	Dept.	Type	Annual Earnings	Productivity Factor	Driver	FTEs	Annual Cost (2005 dollars)	Assumptions
<b>Administration &amp; Support - KCM</b>								
KCM Central Link Manager	400	LABOR	\$111,722	1.0	Fixed	1.0	\$111,722	KCM, 2005
KCM Administrator	400	LABOR	\$48,712		PKCAR	1.0	\$48,712	KCM, 2005 (MPA: add 1 if peak cars > 100)
KCM Analyst	400	LABOR	\$67,894		PKCAR	1.0	\$67,894	KCM, 2005 (MPA: add 1 if peak cars > 100)
Fringe Benefits, KCM	400	LABOR		23.7%	Dept. KCM earnings		\$54,012	KCM, 2005
Workers Compensation	400	LABOR		0.3%	Dept. KCM earnings		\$596	KCM, 2005; Exhibit N3-A
Bus System, Centralized Support	400	SERV		6.96%	Cost of VO + VM + FM		\$1,315,318	KCM, 2005, Exhibit N6
KCM Equipment Lease/Rental	400	SERV			Fixed		\$11,617	KCM, 2005, Exhibit N5
KCM Office Supplies	400	MATL		\$59	Total o&m empl.		\$9,098	KCM, 2005, Exhibit N5
KCM Travel/Training/Conf.	400	MISC		\$4,224	KCM Dept. empl.		\$12,673	KCM, 2005, Exhibit N5
						3.0	\$1,631,641	
<b>TOTAL KCM EMPLOYEES AND COST</b>						<b>157.1</b>	<b>\$20,524,153</b>	
<b>Vehicle Operations - ST</b>								
Security, Yard	101	SERV	\$120,000		YARD		\$120,000	\$1.2M = total ST security estimate; 10% is MPA alloc.
Security, Fare Inspection	101	SERV	\$15.48		TRNHR		\$960,000	\$1.2M = total ST security estimate; 80% is MPA alloc.
Security, Other	101	SERV			Fixed		\$120,000	\$1.2M = total ST security estimate; 10% is MPA alloc.
Traction Power	101	UTIL			ref: Traction Power Worksheet		\$1,472,918	
<b>Vehicle Maintenance - ST</b>								
Materials & Supplies	201	MATL	\$0.54		CARMI		\$1,407,269	Unit cost from FY03 NTD rpts for 9 LRT systems, less minor parts by KCM
<b>Facilities Maintenance - ST</b>								
Fare Equip Maintenance	301	SERV	\$71,890		Total Stations		\$862,680	Unit cost based on Sounder, \$15,800 per tvrm (May 2005) ST, 02/05 est 91 tvrms, 20 sta or avg. 4.55 tvrms/station
<b>Administration &amp; Support - ST</b>								
Link LR Staff	500	LABOR	\$375,000		Fixed		\$375,000	\$750K = ST estimate (MPA: 50% fixed, 50% system size)
Link LR Staff	500	LABOR	\$14,423		PKCAR		\$375,000	\$750K = ST estimate (MPA: 50% fixed, 50% system size)
Casualty/Liability	500	INSUR	\$8,769		PKCAR		\$228,000	Total insurance estimate (\$855,000) allocated per ST to rtmiles, vehicles
Casualty/Liability	500	INSUR	\$22,554		RTMILE		\$627,000	"
Agency Allocated Costs	500	OTHER		6.82%	Total KCM cost		\$1,400,000	ST, 05/05, \$1.4M
<b>TOTAL SOUND TRANSIT COST</b>							<b>\$7,947,867</b>	
<b>TOTAL ANNUAL O&amp;M COST</b>							<b>\$28,472,020</b>	

## 4. Cost Summary

The fourth worksheet in the model simply summarizes a model run's cost estimate by department and agency. Including the input statistics gives a point of reference for the cost estimate.

**Sound Transit  
Light Rail O&M Cost Model  
Cost Summary by Function & Agency**

Alternative: Calibration      14-mi Central Link

**Model Run Inputs:**

Variable	14-mi Central Link Calibration
Peak Cars	26
Revenue Car-Miles	2,606,000
Revenue Train-Hours	62,000
Subway Stations	5
Elevated Stations	2
At-Grade Stations	5
Directional Route Miles	27.8
Maintenance Facilities	1.0
Joint operation in DSTT? 1=yes, 2=no	1

**Estimated Annual Costs:**

	King County Metro	Sound Transit	Total
Vehicle Ops	\$9,093,689	\$2,672,918	\$11,766,607
Vehicle Maint	\$2,961,881	\$1,407,269	\$4,369,150
Facil Maint	\$6,836,942	\$862,680	\$7,699,622
Admin/Support	\$1,631,641	\$3,005,000	\$4,636,641
<b>Total</b>	<b>\$20,524,153</b>	<b>\$7,947,867</b>	<b>\$28,472,020</b>

## 5. Comparison of Alternatives

The last worksheet in the model allows for the input statistics and results for multiple alternatives to be displayed side-by-side. An example is shown in the last section of this report where an extended Link system is modeled.

## Additional Assumptions

Assumptions are inherent in simulation models and the Link O&M cost model is no exception. This report has already noted the assumptions used for estimating traction power costs, and the sample Line Item Detail includes some explanations in the last column of the worksheet. Highlighted here are some additional assumptions, unique to the Link model. Most of these deal with cost items that are not included, or only partially included, in the KCM proposal.

**Station Maintenance and Security** – These costs are based on station type, assuming that subway stations with their elevators, escalators and mezzanines are the most complex/expensive to maintain and secure; at-grade stations are the least expensive; and aerial stations (which have vertical circulation but not mezzanine levels) are somewhere in-between. For applicable expenses, the model “weights” an aerial station as twice that of an at-grade station, and a subway station as four times an at-grade station.

**Fare Equipment Maintenance** – In 2004, staff for Sounder projected an annual maintenance cost of \$15,800 per ticket vending machine (TVM). This cost estimate is

fully allocated for TVM operations and maintenance. About 80% of the cost is for the actual equipment maintenance contract. The remainder includes annual expenses such as the collections contract, foreign language service and card stock. As to the number of units, Sound Transit projects the need for 91 TVMs for a system with 20 stations. In applying Sounder's TVM maintenance projections to the Link system, it was noted that Link stations' closer spacing might eliminate some of the travel time required to service equipment and thus provide some unit cost savings. However, it was also noted that Link TVMs would likely receive heavier use and thus require more frequent maintenance. The model assumes that these factors would balance each other out and therefore uses an average of 4.55 TVMs per station at an annual maintenance cost of \$15,800 per TVM.

Vehicle Maintenance Parts – KCM projects spending \$76,000 per year for small items, such as windshield wipers for example, which has been modeled as a baseline cost of \$0.03 per car-mile. According to our research in the FY 2002 National Transit Database, nine existing light rail systems reported paying an average of \$0.57 per car-mile for vehicle maintenance materials and supplies. Even the newest LRT system, Salt Lake, paid \$0.54 per car-mile that year. Therefore, the model assumes a total vehicle parts cost of \$0.57 per car-mile, with KCM paying the aforementioned \$0.03 and ST paying the \$0.54 per car-mile difference.

Casualty/Liability – ST provided an insurance broker's estimate of \$1.7 million for premiums related to a 15-mile light rail system, and information that suggested this was a system cap (i.e., a larger system would not automatically pay more just because of its increased size). Based on the idea of an upper limit to annual premiums, the model assumes \$700,000 is fixed (40%), and divides the remainder evenly between heftier premiums due to increases in route miles and car-miles.

DSTT Shared Costs – When Central Link opens for service, the Downtown Seattle Transit Tunnel (DSTT) will have joint operations of light rail and bus service. At some time in the future, as the rail system expands and rail headways become shorter, bus service will be removed from the DSTT. The model includes several line items for costs that would be shared by KCM and Sound Transit while joint operations are in place. These include transportation supervisors, security, and facility maintenance. For example, KCM's proposal includes nine transportation supervisors for the DSTT assuming joint operations. The cost of five of the nine supervisors is allocated to bus service, and the other four to rail service. When joint operations are discontinued in the future, all of the DSTT supervisors would be charged to the rail system. Therefore the cost model includes a variable for whether or not joint operations are in effect for the alternative being tested. The same approach is applied to the security and facility maintenance costs.

Sound Transit Administration & Support – This cost item is based on an estimate of \$1.4 million for the initial 14-mile Central Link. The amount assumes the calibration ratio of Sound Transit administration and support to total KCM cost will continue into the future.

## Sensitivity Testing & Reasonableness Tests

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Several sensitivity runs were conducted as a reasonableness check of the model. Each driving variable was modified, and the resulting change in estimated cost was observed to test the impacts associated with each driving variable. The results are summarized in the following table.

Sensitivity test results:	
+1 Peak Car	\$30K
+1 Car-mile	\$2.04
+1 Train-hr	\$86
+1 Station (grade)	\$384K
+1 Station (aerial)	\$499K
+2 Dir Route-miles	\$104K
+1 Yard	\$1.59M
DSTT Joint Ops=no	\$5.82M

It should be noted that the effect of discontinuing joint operations in the DSTT is quite large. Other things being equal, switching to rail-only operations will increase Sound Transit's costs for the DSTT by about \$5.8 million.

In another test of reasonableness, the calibration system's cost per car-mile was deflated to \$2003 and compared with that of the following nine existing U.S. light rail systems, as reported for that year to the National Transit Database: Baltimore, Dallas, Denver, Los Angeles, Portland, Sacramento, St. Louis, Salt Lake City, and San Jose. Central Link's cost is estimated to be \$10.49 per car-mile. The peer average was \$10.78 per car-mile (ranged from \$5.33 to \$27.68).

Finally, the model was run with system and service statistics representing an extended system, with service from Husky Stadium to the Airport Station. Results are shown in the following comparison table.

**Sound Transit  
Comparison of Light Rail Alternatives**

<b>Alternative</b>	<b>Calibration 14-miles</b>	<b>Husky Stadium to Airport</b>
<i>INPUT STATISTICS</i>		
Peak Cars	26	69
Revenue Car-Miles	2,606,000	5,594,753
Revenue Train-Hours	62,000	85,652
Subway Stations	5	7
Elevated Stations	2	3
At-Grade Stations	5	5
Directional Route Miles	27.8	37.4
Maintenance Facilities	1.0	1.0
Joint operation in DSTT?	0	0
<i>ESTIMATED O&amp;M COSTS</i>		
Vehicle Operations	\$9,093,689	\$11,973,981
Vehicle Maintenance	\$2,961,881	\$5,506,485
Facilities Maintenance	\$6,836,942	\$7,975,081
Admin. & Support - KCM	\$1,631,641	\$2,092,204
Subtotal KCM	\$20,524,153	\$27,547,751
Sound Transit Costs	\$7,947,867	\$13,173,321
Total	\$28,472,020	\$40,721,072