METROPOLITAN
TRANSPORTATION
COMMISSION

Joseph P. Bort MetroCenter
101 Eighth Street
Oakland, CA 94607-4700
TEL 510.817.5700
TDD/TTY 510.817.5769
FAX 510.817.5848
E-MAIL info@mtc.ca.gov
WEB www.mtc.ca.gov

Memorandum

TO: FILE DATE: October 2, 2013

FR: David Ory, David Vautin, Rupinder Singh

RE: Year 2010 Validation of *Travel Model One*

The purpose of this memorandum is to demonstrate *Travel Model One's (v 0.3)*[1] ability to replicate, with a reasonable degree of accuracy, transportation conditions observed in year 2010. A companion slide deck is available on the *MTC/ABAG Analytical Modeling Wiki*. Prior calibration (using year 2000 information) and validation (for years 2000 and 2005) documentation is available via a written report and a slide deck.

Validation summaries are presented for the following four broad categories of information:

- Automobile ownership;
- Means of transportation to work;
- Roadway usage; and,
- Transit usage.

Automobile Ownership

American Community Survey (ACS) table B08203 reports the number of workers in households by vehicles available. As automobile ownership prediction is a key component of the *Travel Model One* system and so-called automobile sufficiency (i.e. the relationship between the quantities of workers and automobiles in each household) is a key segmentation variable used in *Travel Model One*, comparison of the year 2010 predictions to this data source is useful. For the present comparison, we use the year 2007 to year 2011 five-year ACS estimates as an estimate of year 2010 observed conditions.

Table 1 compares the observed and estimated number of households by automobile sufficiency category for the nine county Bay Area. Figure 1 presents the share graphically. The slide deck provides county-specific charts.

[1] Simulated results are from model run 2010_03_YYY.

Table 1: Household by Automobile Sufficiency Category

Category	ACS 2007 – 2011				Predicted	
	Mean	Low	High	Share	Estimate	*Share*
Zero automobiles	248,007	232,558	263,456	9.6%	255,243	9.3%
Automobiles < Workers	151,118	138,224	164,012	5.9%	149,708	5.5%
Automobiles >= Workers	2,178,355	2,090,197	2,266,513	84.5%	2,327,771	85.2%

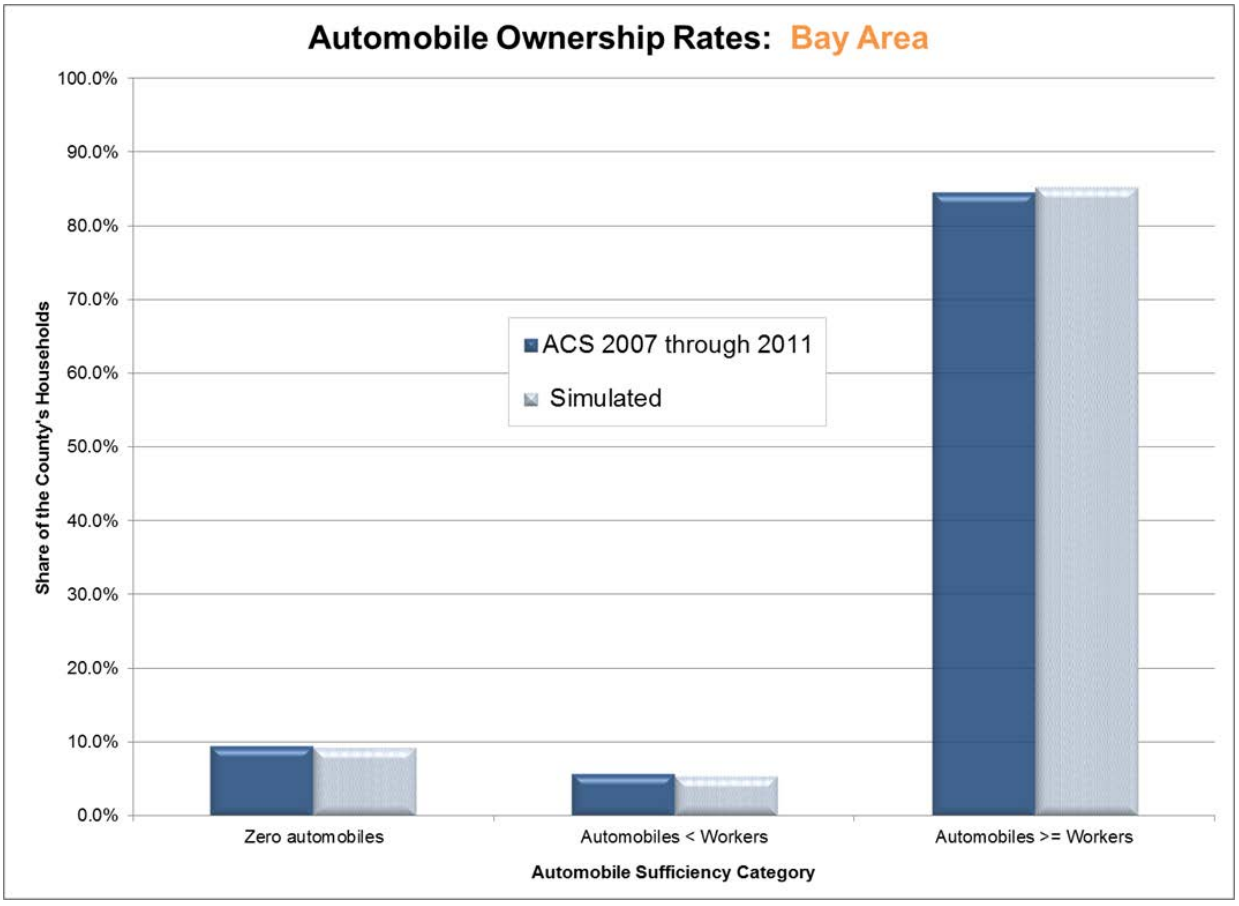

Figure 1: Share of Households by Automobile Sufficiency Category

Means of Transportation to Work

The ACS offers several interesting tables regarding the means by which commuters get to work. Here we summarize results from table B08101: Means of Transportation to Work by Age;

B08406: Sex of Workers by Means of Transportation to Work for Workplace Geography; and, B08130: Means of Transportation to Work by Place of Work. As with the automobile ownership, the year 2007 to year 2011 five-year ACS information is used as an estimate of year 2010 observed conditions.

The ACS questionnaire collects information on commute mode via the question: "How did this person usually get to work LAST WEEK? If this person usually used more than one method of transportation during the trip, mark (X) the box of the one used for most of the distance." And then: "How many people, including this person, usually rode to work in the car, truck, or van LAST WEEK?". Consider, for example, someone who drops their child off at daycare on the way to work in a personal vehicle. It's not clear how someone would answer the second question, as the child traveled with the person for only a portion of their trip to work.

The vague identification of travel mode in the ACS survey makes direct comparisons to the *Travel Model One* simulation results impossible; approximate, indirect comparisons are both possible and useful. A further inconsistency is the number of people who report traveling to work (which could occur outside the Bay Area if a Bay Area resident were in, say, Los Angeles for work on the survey week) in the previous week from 2007 to 2011 (captured by the ACS data) versus those traveling to work in the Bay Area on a typical weekday in 2010 (the subject of the travel model) – the former estimate should be higher. In Table 2, a summary of the means of travel to work for Bay Area residents is presented along with the simulated share of travel by mode for work *tours* and for *trips* made as part of work tours. Extending the example above, if a worker dropped his child off at daycare on his inbound journey to work and returned home directly after work (say his spouse picked the child up at daycare), this traveler would have made one work tour with a shared ride 2 tour mode, and three trips (home to daycare, daycare to work, work to home) on his work tour, two with a drive alone mode (daycare to work, work to home) and one with a shared ride 2 mode (home to daycare).

Figure 2 presents the information in Table 2 graphically. County-specific charts are available in the slide deck.

Table 2: Means of Transportation to Work for Bay Area Residents

Travel Mode	ACS 2007 – 2011				Predicted Work Tours		Predicted Work Trips	
	Mean	Low	High	Share	Estimate	*Share*	Estimate	*Share*
All	3,374,889	3,353,234	3,396,544	100.0%	2,554,680	100.0%	6,924,288	100.0%
Drive alone	2,273,997	2,250,576	2,297,418	67.4%	1,466,153	57.4%	4,867,229	70.3%
Carpool/shared ride	354,625	339,673	369,577	10.5%	625,610	24.5%	920,387	13.3%
Transit	340,383	329,764	351,002	10.1%	347,131	13.6%	673,402	9.7%
Walk	122,629	114,133	131,125	3.6%	70,378	2.8%	361,811	5.2%

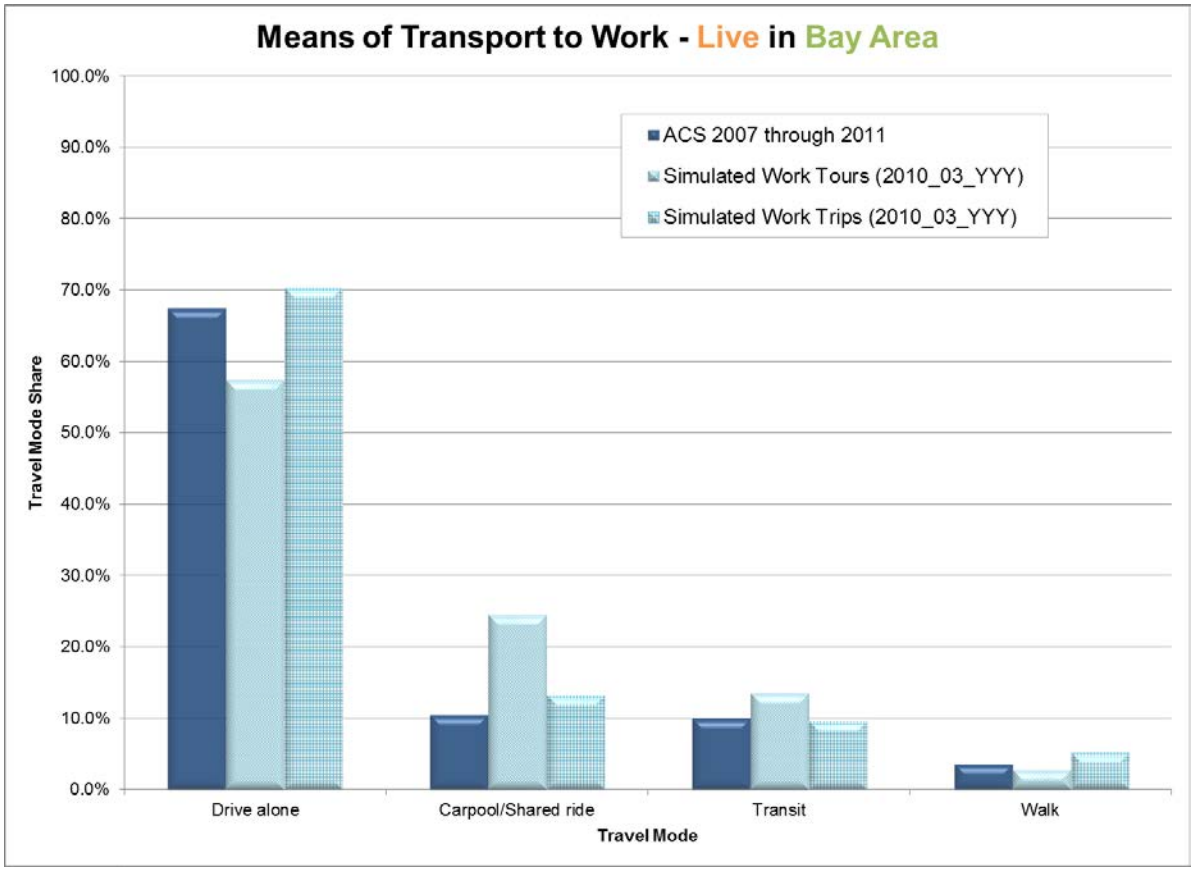

Figure 2: Means of Transportation to Work for Bay Area Residents

Companion data to the information presented above is available for those who work (as opposed to live) in the Bay Area in Table 3 and Figure 3 below. *Travel Model One* makes two important simplifications that are relevant here, as follows: (i) it assumes that each simulated resident of the Bay Area also works in the Bay Area; and, (ii) it does not separate commute travel from all the travel that occurs between the Bay Area and our neighboring counties (i.e., all interactions are simulated, but the interactions are not described by travel purpose). As follows, the simulated data in Table 3 and Figure 3 is the same as that in Table 2 and Figure 2. County-specific charts are available in the slide deck.

Table 3: Means of Transportation to Work for Bay Area Workers

Travel Mode	ACS 2007 – 2011				Predicted Work Tours		Predicted Work Trips	
	Mean	Low	High	Share	Estimate	*Share*	Estimate	*Share*
All	3,493,190	3,461,865	3,524,515	100.0%	2,554,680	100.0%	6,924,288	100.0%
Drive alone	2,361,950	2,332,908	2,390,992	67.6%	1,466,153	57.4%	4,867,229	70.3%
Shared ride 2	285,919	273,127	298,711	8.2%	386,743	15.1%	630,568	9.1%
Shared ride 3+	92,206	81,472	102,940	2.6%	238,867	9.4%	289,819	4.2%
Transit	344,064	334,122	354,006	9.8%	347,131	13.6%	673,402	9.7%
Walk	121,978	113,605	130,351	3.5%	70,378	2.8%	361,811	5.2%
Bicycle	50,759	45,794	55,724	1.5%	45,408	1.8%	101,459	1.5%
Other	236,314	222,188	250,440	6.8%	0	0.0%	0	0.0%

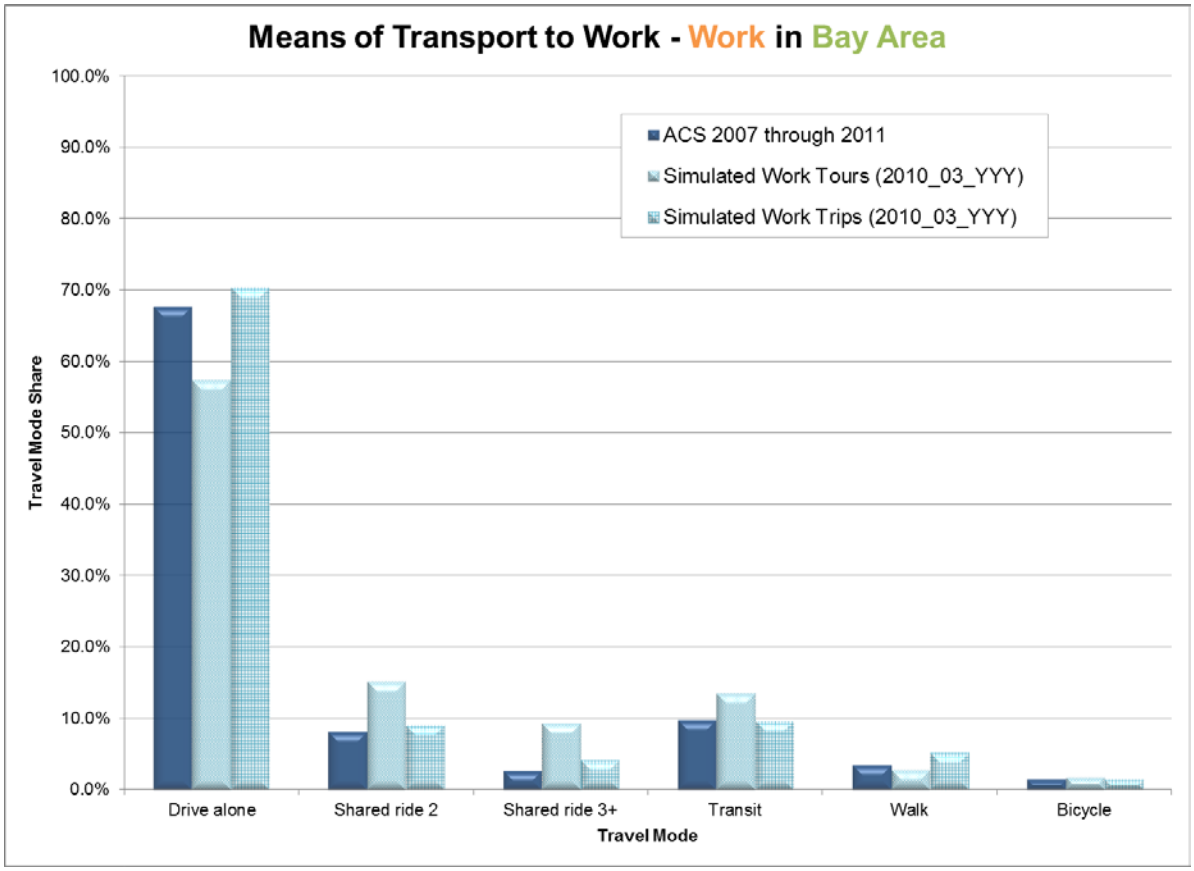

Figure 3: Means of Transportation to Work for Bay Area Workers

The ACS also provides information on the travel mode for those who both live and work within a single Bay Area county. This data allows for two types of comparisons: (i) examining the travel model's workplace location predictions (at the spatial fidelity of the county) and (ii) examining the travel model's mode choice predictions for those who live and work in the same Bay Area county.

Table 4 summarizes observed and predicted within-county movements. This information is presented graphically in Figure 4. Please see the slide deck for county- and travel mode-specific results.

Table 4: Share of Residents who make Work Tours in the Same County

County of Residence	County of Workplace	ACS 2007 – 2011				Predicted Work Tours	
		Mean	Low	High	Share	Estimate	*Share*
Alameda	All	688,958	682,061	695,675	100.0%	550,420	100.0%
Alameda	Alameda	463,389	459,654	466,944	67.3%	331,374	60.2%
Contra Costa	All	468,264	462,660	473,332	100.0%	366,870	100.0%
Contra Costa	Contra Costa	279,651	276,506	282,260	59.7%	187,835	51.2%
Marin	All	120,272	117,276	123,191	100.0%	86,098	100.0%
Marin	Marin	79,071	77,495	80,570	65.7%	43,912	51.0%
Napa	All	63,257	61,295	65,126	100.0%	46,846	100.0%
Napa	Napa	48,685	47,458	49,819	77.0%	26,266	56.1%
San Francisco	All	434,545	429,323	439,302	100.0%	321,211	100.0%
San Francisco	San Francisco	334,949	331,852	337,581	77.1%	248,488	77.4%
San Mateo	All	351,658	346,796	356,446	100.0%	258,090	100.0%
San Mateo	San Mateo	205,753	203,207	208,225	58.5%	130,958	50.7%
Santa Clara	All	824,624	818,079	830,794	100.0%	608,426	100.0%
Santa Clara	Santa Clara	718,360	714,230	722,115	87.1%	518,382	85.2%
Solano	All	183,948	179,854	187,731	100.0%	145,890	100.0%
Solano	Solano	110,576	108,292	112,549	60.1%	92,867	63.7%
Sonoma	All	225,706	222,080	229,078	100.0%	170,676	100.0%
Sonoma	Sonoma	188,588	186,308	190,614	83.6%	126,024	73.8%

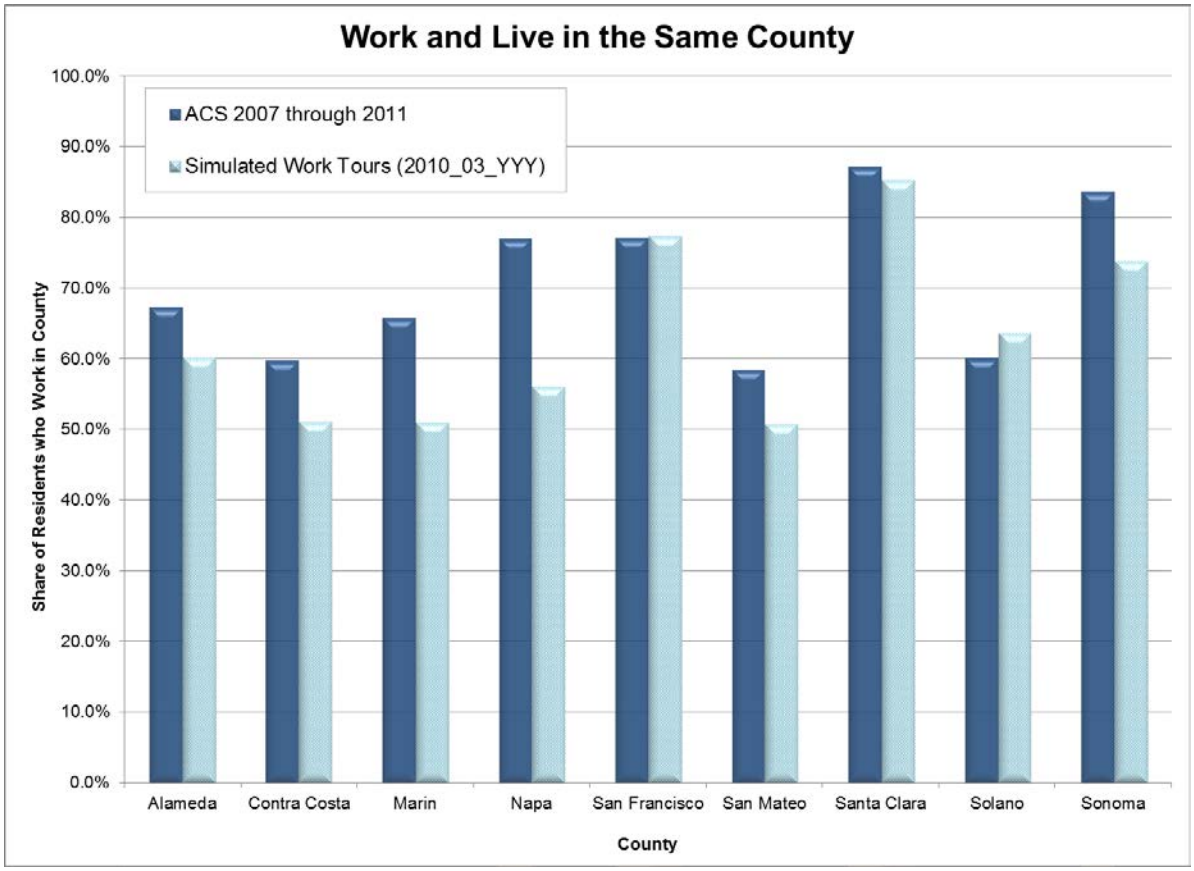

Figure 4: Share of Residents who make Work Tours in the Same County

Roadway Usage

Observed traffic volume estimates are obtained directly from Caltrans and via the Caltrans Performance Monitoring System (PeMS). Counts for typical weekdays, defined here as Tuesdays, Wednesdays, and Thursdays in March, April, May, September, October, and November, are extracted and compared to the model estimates.

Figure 5 presents a measure of difference between the observed counts and simulated estimates known as the percent root mean square error. Separate statistics are computed for different facility types and time periods.

Figure 6, Figure 7, Figure 8, and Figure 9 plot observed and simulated volumes and present a measure of similarity between the two data series, which ranges from 0 to 1.0, known as "r-squared" (R^2). The plots compare daily, morning commute, midday, and evening commute data, respectively.

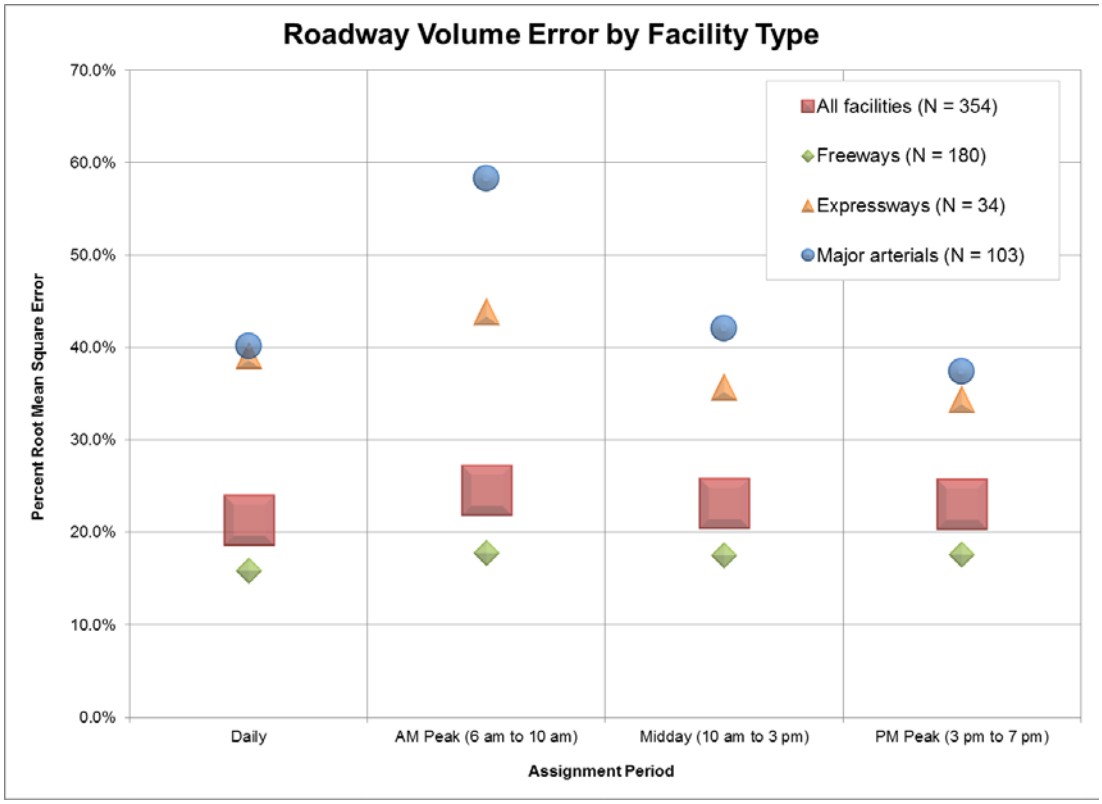

Figure 5: Roadway Volume Percent Root Mean Square Error

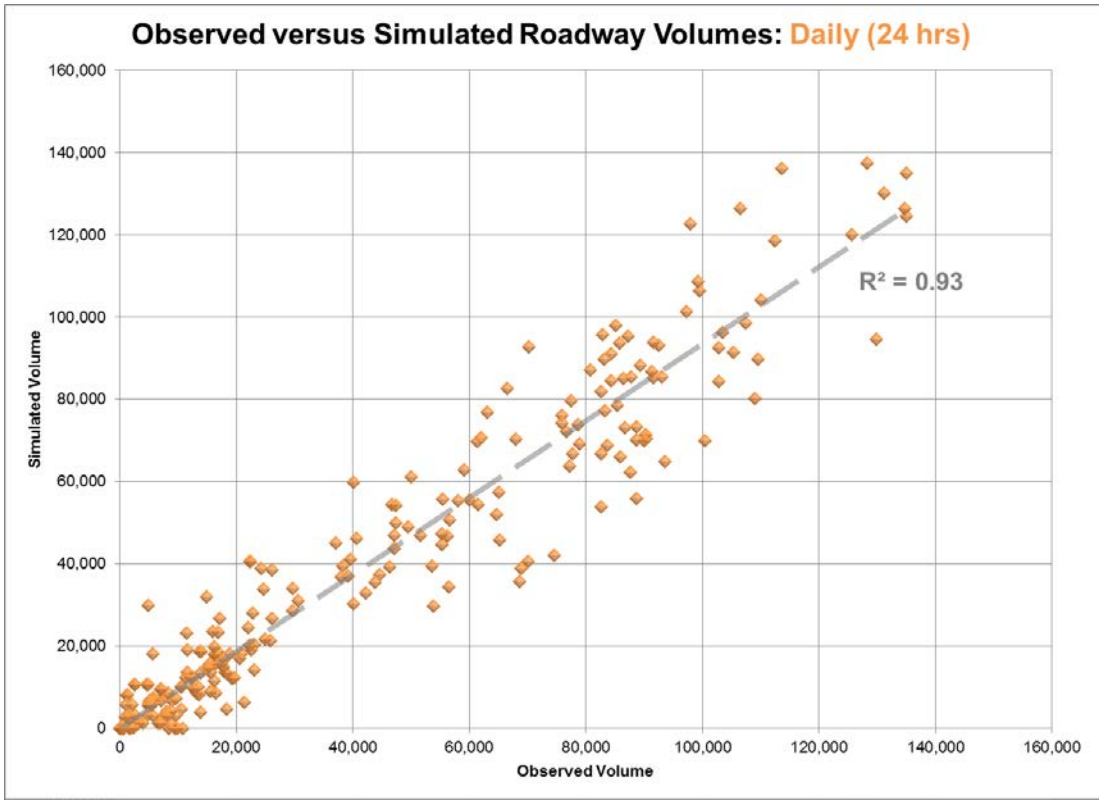

Figure 6: Observed and Simulated Daily Volumes

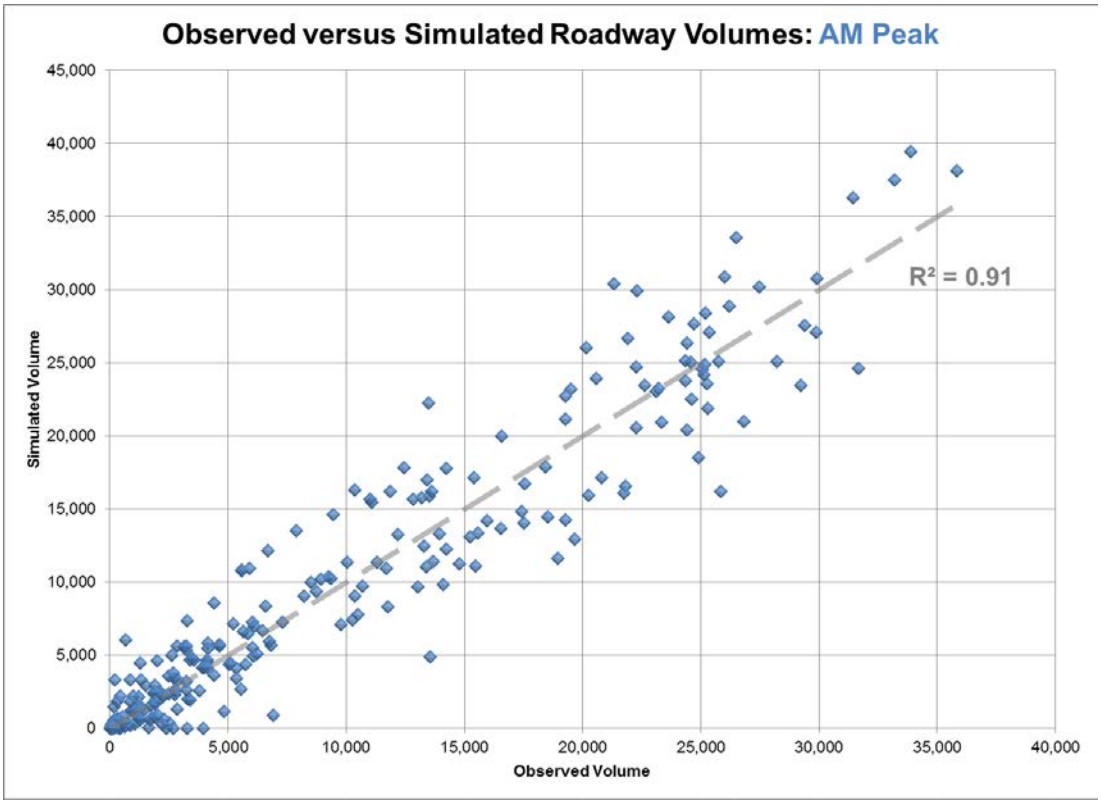

Figure 7: Observed and Simulated Morning Peak (6 am to 10 am) Volumes

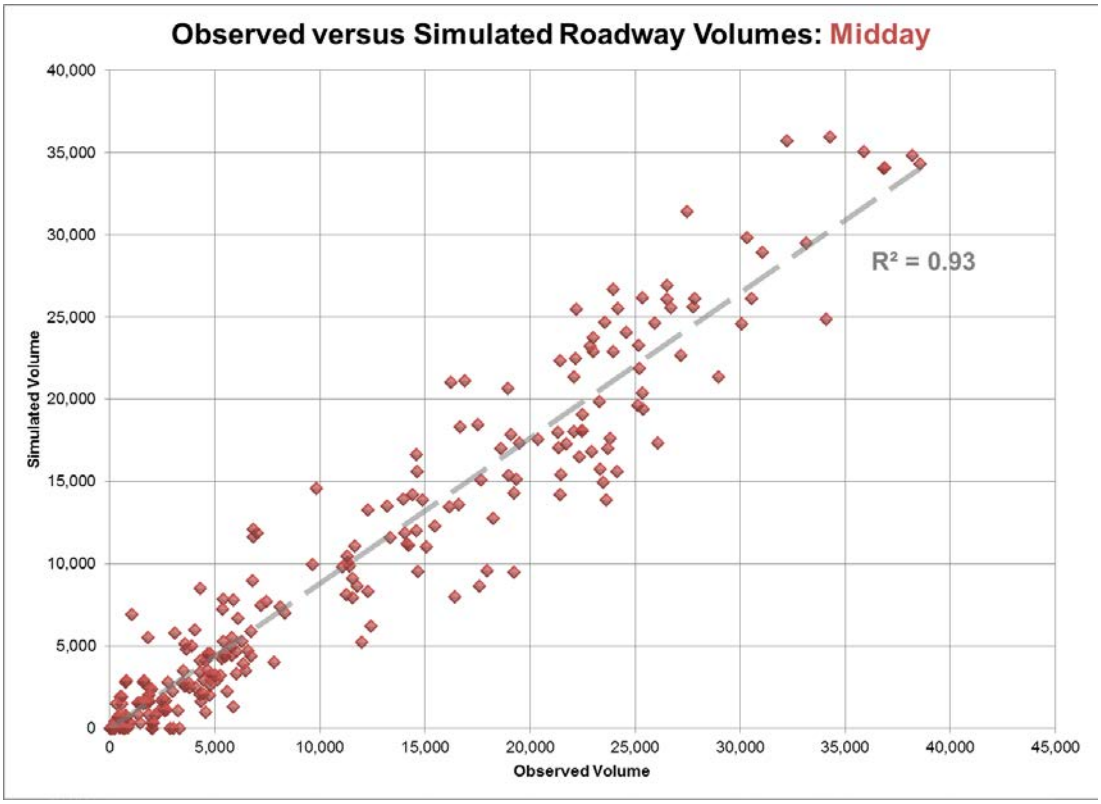

Figure 8: Observed and Simulated Midday (10 am to 3 pm) Volumes

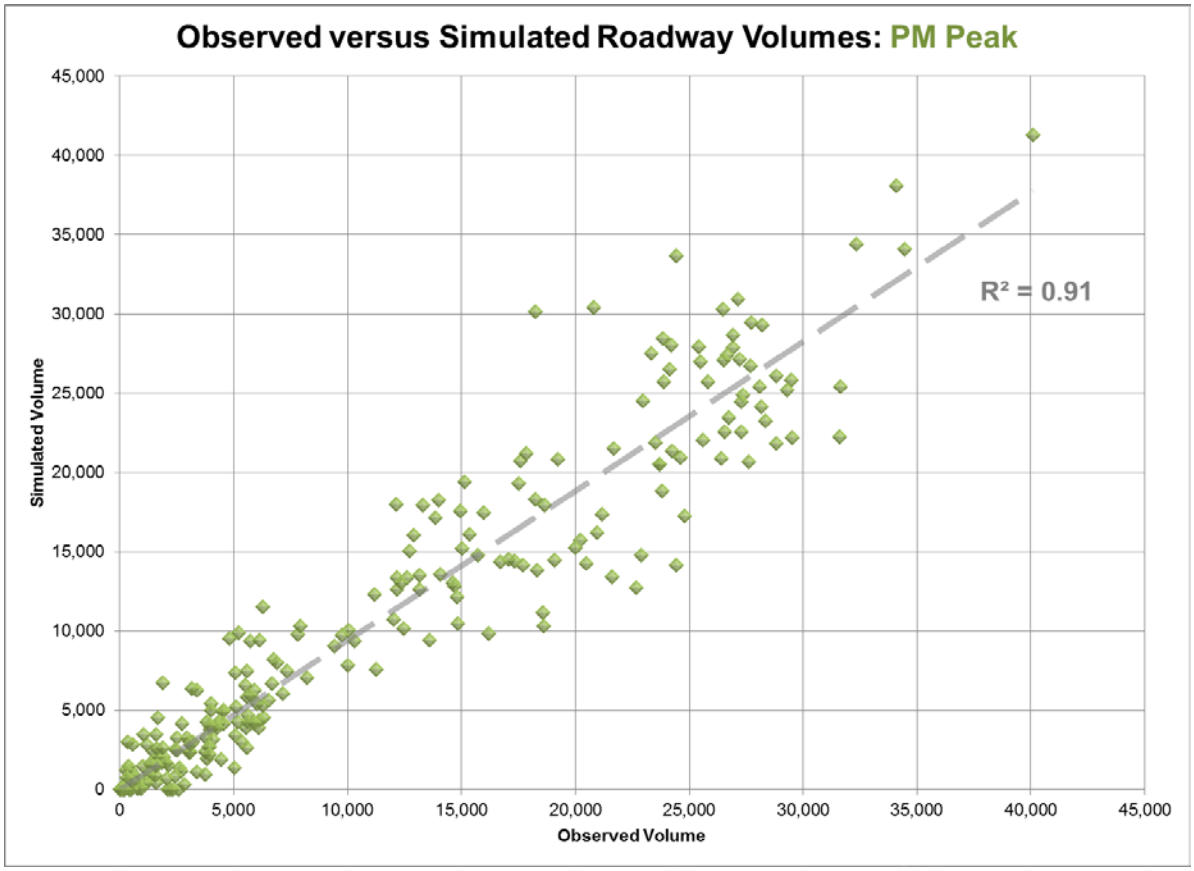

Figure 9: Observed and Simulated Evening Peak (3 pm to 7 pm) Volumes

Table 5 presents daily assignment results at key locations – county lines and bridges. Table 6 presents the same information for the morning peak period and Table 7 for the evening peak period. The slide deck contains dozens of location-specific comparisons (between simulation results and the PeMS data) by time of day similar to the chart (for the San Francisco/Oakland Bay Bridge) shown in Figure 10.

Table 5: Observed and Simulated Daily Volumes at Key Locations

Category / Location (both directions unless otherwise noted)	Typical Weekday Daily Traffic			
	Observed	Simulated	Abs Diff	Pct Diff
Bridges				
US 101, Golden Gate Bridge (SB)	105,000	123,895	18,895	18.0%
I-80, SF/Oakland Bay Bridge	242,050	254,046	11,996	5.0%
CA 84, Dumbarton Bridge (NB)	98,038	98,545	507	0.5%
I-580, Richmond/San Rafael Bridge (EB)	75,032	78,888	3,856	5.1%
I-80, Carquinez Bridge (EB)	55,632	34,873	-20,759	-37.3%
I-680, Benicia/Martinez Bridge	64,385	78,129	13,744	21.4%
CA 92, San Mateo Bridge	101,554	123,903	22,349	22.0%
CA 160, Antioch Bridge	10,100	13,460	3,360	33.3%
San Francisco/San Mateo County Line				
US 101, Bayshore Freeway (NB)	213,226	176,341	-36,885	-17.3%
CA 1, Junipero Serra Blvd (NB)	112,000	135,010	23,010	20.5%
I-280, Foran Freeway	109,000	63,495	-45,505	-41.8%
Sub-total	*434,226*	*374,846*	*-59,380*	*-13.7%*
San Mateo/Santa Clara County Line				
CA 82, El Camino Real (NB)	30,000	28,811	-1,189	-4.0%
US 101, Bayshore Freeway (NB)	217,921	184,515	-33,406	-15.3%
I-280, Serra Freeway (NB)	97,000	80,725	-16,275	-16.8%
Sub-total	*344,921*	*294,051*	*-50,870*	*-14.8%*
Santa Clara/Alameda County Line				
I-680, at Scott Creek Road (NB)	108,924	89,064	-19,860	-18.2%
I-880, Nimitz Freeway (NB)	194,500	232,964	38,464	19.8%
Sub-total	*303,424*	*322,028*	*18,604*	*6.3%*
Alameda/Contra Costa County Line				
I-580, Knox Freeway	82,256	96,330	14,074	17.1%
I-80, Eastshore Freeway	144,853	150,936	6,082	4.2%
CA 24, Caldecott Tunnel (EB)	161,918	189,317	27,399	16.9%
I-680, in Dublin/San Ramon	153,031	149,123	-3,908	-2.6%
Sub-total	*542,058*	*585,706*	*43,648*	*8.1%*
Solano/Napa County Line				
Route 29, Napa-Vallejo Highway (NB)	29,604	36,876	7,272	24.6%
Solano/Sonoma County Line				
Route 37, Sears Point Road	33,539	35,042	1,503	4.5%
Napa/Sonoma County Line				
Route 121, Carneros Highway (NB)	25,000	30,564	5,564	22.3%
Route 128, Calistoga-Healdsburg Road	2,650	2,056	-594	-22.4%
Sub-total	*27,650*	*32,620*	*4,970*	*18.0%*
Sonoma/Marin County Line				
US 101, Redwood Highway (NB)	83,103	80,040	-3,064	-3.7%

Table 6: Observed and Simulated Morning Peak (6 am to 10 am) Volumes at Key Locations

Category / Location (both directions unless otherwise noted)	Typical Weekday Daily Traffic			
	Observed	Simulated	Abs Diff	Pct Diff
Bridges				
US 101, Golden Gate Bridge (SB)	-	-	-	-
I-80, SF/Oakland Bay Bridge	13,377	16,821	3,445	25.8%
CA 84, Dumbarton Bridge (NB)	6,368	7,761	1,393	21.9%
I-580, Richmond/San Rafael Bridge (EB)	5,247	6,007	760	14.5%
I-80, Carquinez Bridge (EB)	3,952	4,664	712	18.0%
I-680, Benicia/Martinez Bridge	4,095	5,383	1,288	31.5%
CA 92, San Mateo Bridge	6,690	8,804	2,114	31.6%
CA 160, Antioch Bridge	-	-	-	-
San Francisco/San Mateo County Line				
US 101, Bayshore Freeway (NB)	13,024	11,000	-2,024	-15.5%
CA 1, Junipero Serra Blvd (NB)	-	-	-	-
I-280, Foran Freeway	-	-	-	-
Sub-total	13,024	11,000	-2,024	-15.5%
San Mateo/Santa Clara County Line				
CA 82, El Camino Real (NB)	-	-	-	-
US 101, Bayshore Freeway (NB)	12,853	11,273	-1,580	-12.3%
I-280, Serra Freeway (NB)	-	-	-	-
Sub-total	12,853	11,273	-1,580	-12.3%
Santa Clara/Alameda County Line				
I-680, at Scott Creek Road (NB)	7,939	8,264	325	4.1%
I-880, Nimitz Freeway (NB)	11,462	15,881	4,419	38.6%
Sub-total	19,401	24,145	4,744	24.5%
Alameda/Contra Costa County Line				
I-580, Knox Freeway	5,089	5,963	874	17.2%
I-80, Eastshore Freeway	7,949	7,352	-596.185	-7.5%
CA 24, Caldecott Tunnel (EB)	10,456	12,825	2,368	22.7%
I-680, in Dublin/San Ramon	9,782	10,397	614	6.3%
Sub-total	33,276	36,537	3,261	9.8%
Solano/Napa County Line				
Route 29, Napa-Vallejo Highway (NB)	1,830	1,990	161	8.8%
Solano/Sonoma County Line				
Route 37, Sears Point Road	2,191	2,753	563	25.7%
Napa/Sonoma County Line				
Route 121, Carneros Highway (NB)	-	-	-	-
Route 128, Calistoga-Healdsburg Road	-	-	-	-
Sub-total	-	-	-	
Sonoma/Marin County Line				
US 101, Redwood Highway (NB)	4,921	5,799	878	17.8%

Table 7: Observed and Simulated Evening Peak (3 pm to 6 pm) Volumes at Key Locations

Category / Location (both directions unless otherwise noted)	Typical Weekday Daily Traffic			
	Observed	Simulated	Abs Diff	Pct Diff
Bridges				
US 101, Golden Gate Bridge (SB)	-	-	-	-
I-80, SF/Oakland Bay Bridge	14,974	16,557	1,583	10.6%
CA 84, Dumbarton Bridge (NB)	6,722	7,657	935	13.9%
I-580, Richmond/San Rafael Bridge (EB)	5,806	6,170	364	6.3%
I-80, Carquinez Bridge (EB)	2,829	3,010	181	6.4%
I-680, Benicia/Martinez Bridge	4,333	5,349	1,016	23.5%
CA 92, San Mateo Bridge	7,322	9,219	1,897	25.9%
CA 160, Antioch Bridge	-	-	-	-
San Francisco/San Mateo County Line				
US 101, Bayshore Freeway (NB)	13,132	11,434	-1,697	-12.9%
CA 1, Junipero Serra Blvd (NB)	-	-	-	-
I-280, Foran Freeway	-	-	-	-
Sub-total	13,132	11,434	-1,697	-12.9%
San Mateo/Santa Clara County Line				
CA 82, El Camino Real (NB)	-	-	-	-
US 101, Bayshore Freeway (NB)	13,209	11,825	-1,384	-10.5%
I-280, Serra Freeway (NB)	-	-	-	-
Sub-total	13,209	11,825	-1,384	-10.5%
Santa Clara/Alameda County Line				
I-680, at Scott Creek Road (NB)	7,671	7,763	92	1.2%
I-880, Nimitz Freeway (NB)	12,983	15,077	2,094	16.1%
Sub-total	20,654	22,840	2,186	10.6%
Alameda/Contra Costa County Line				
I-580, Knox Freeway	5,497	6,872	1,375	25.0%
I-80, Eastshore Freeway	8,311	11,759	3447.69	41.5%
CA 24, Caldecott Tunnel (EB)	11,203	12,886	1,683	15.0%
I-680, in Dublin/San Ramon	10,917	10,525	-393	-3.6%
Sub-total	35,928	42,041	6,113	
Solano/Napa County Line				
Route 29, Napa-Vallejo Highway (NB)	2,016	2,842	826	41.0%
Solano/Sonoma County Line				
Route 37, Sears Point Road	2,287	2,597	310	13.6%
Napa/Sonoma County Line				
Route 121, Carneros Highway (NB)	-	-	-	-
Route 128, Calistoga-Healdsburg Road	-	-	-	-
Sub-total		-	-	-
Sonoma/Marin County Line				
US 101, Redwood Highway (NB)	5,552	5,444	-108	-2.0%

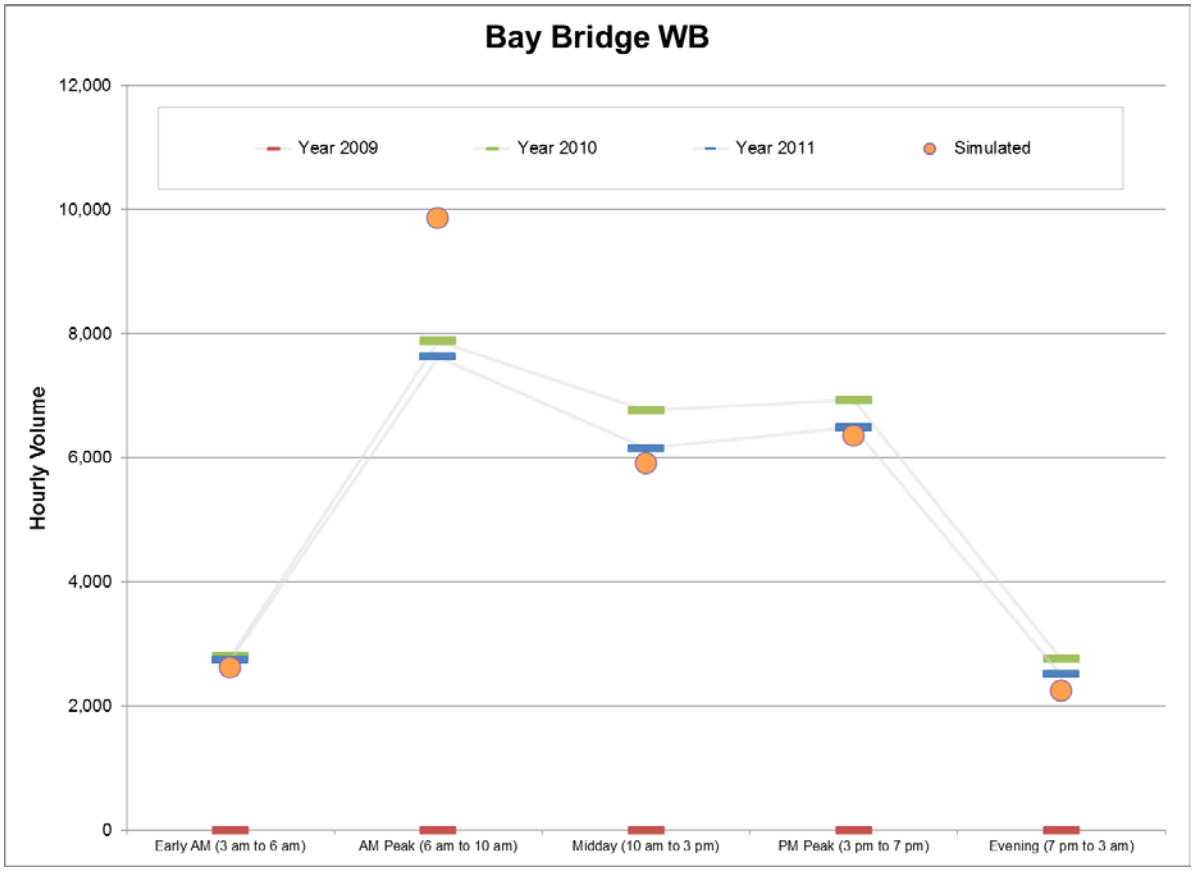

Figure 10: Observed and Simulated Bay Bridge Volume Estimates by Time of Day

Transit Usage

Observed transit ridership information is obtained directly from the Bay Area's numerous transit operators. In a handful of cases, the year 2010 data was not available, but data for another year, e.g., 2012, was available. In these cases, adjustments were made to the provided data using information from the Federal Transit Administration's National Transit Database to scale the provided data to represent year 2010 conditions.

Table 8 compares observed and estimated transit boardings by technology (also referred to as "line-haul mode"). Table 9 compares observed and estimated boardings by operator. Companion graphics are available in Figure 10 and Figure 11. Table 10 provides a full reporting of observed and estimated boardings by operator and technology combinations.

Table 8: Observed and Simulated Ridership by Technology

Technology	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
Local Bus	886,992	951,879	64,887	7%
Cable Car	27,053	5,112	-21,941	-81%
Express Bus	44,763	47,592	2,829	6%
Ferry	10,862	12,136	1,275	12%
Light Rail	193,762	205,690	11,928	6%
Heavy Rail (BART)	348,991	341,516	-7,475	-2%
Commuter Rail	41,558	16,854	-24,704	-59%
All Modes	*1,553,981*	*1,580,779*	*26,798*	*2%*

Table 9: Observed and Simulated Ridership by Opeartor

Operator	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
Muni	703,894	534,497	-169,397	-24%
BART	348,991	341,516	-7,475	-2%
AC Transit	174,888	248,998	74,110	42%
VTA	133,912	256,812	122,900	92%
SamTrans	42,304	61,448	19,144	45%
Caltrain	37,779	16,619	-21,160	-56%
Golden Gate	18,253	21,599	3,346	18%
Other	93,960	99,290	5,330	6%
All Operators	*1,553,981*	*1,580,779*	*26,798*	*2%*

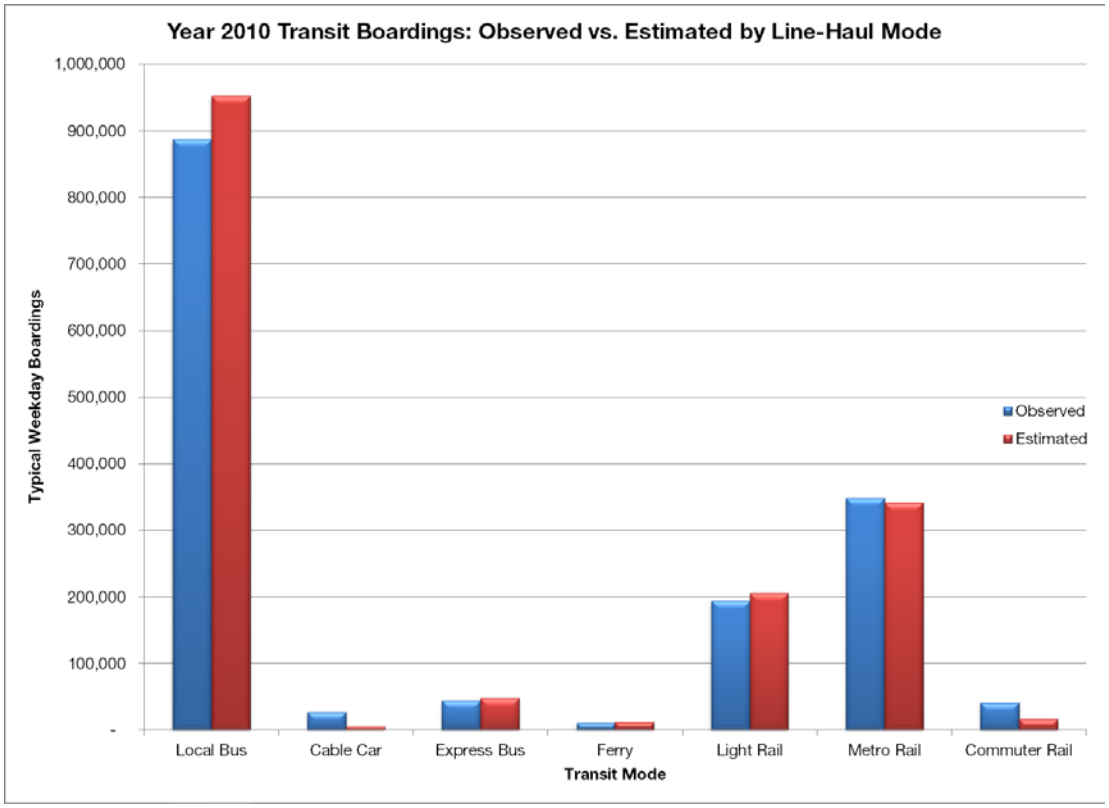

Figure 11: Observed and Simulated Transit Boardings by Technology

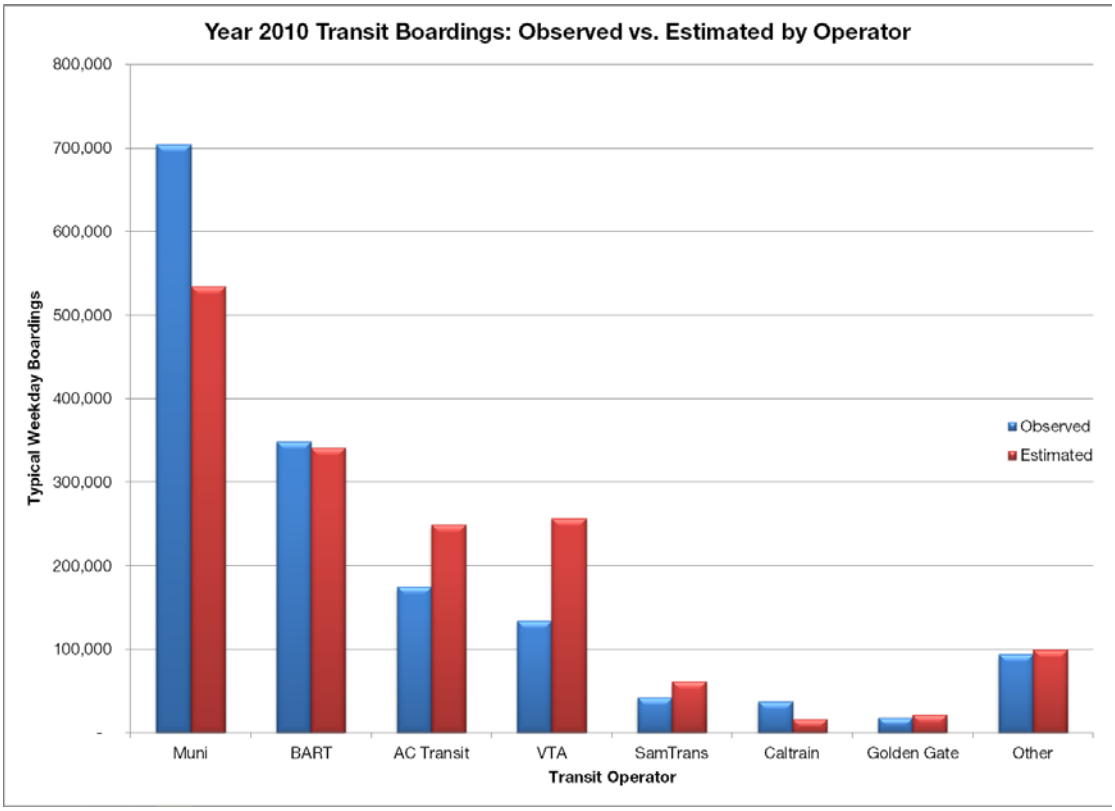

Figure 12: Observed and Estimated Transit Boardings by Operator

Table 10: Observed and Simulated Boardings by Operator and Technology

Operator	Tech Category	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
Muni	Local Bus	514,817	398,454	-116,363	-23%
AC Transit	Local Bus	160,184	229,560	69,376	43%
Santa Clara VTA	Local Bus	90,648	178,534	87,886	97%
SamTrans	Local Bus	40,823	61,279	20,456	50%
Marin Transit	Local Bus	10,617	4,914	-5,703	-54%
Santa Rosa City Bus	Local Bus	9,986	10,722	736	7%
County Connection	Local Bus	9,302	12,434	3,132	34%
Tri-Delta Transit	Local Bus	8,257	12,071	3,814	46%
WHEELS	Local Bus	6,093	5,338	-755	-12%
Emery Go Round	Local Bus	4,790	4,710	-80	-2%
Sonoma County Transit	Local Bus	4,459	3,540	-919	-21%
Stanford Shuttles	Local Bus	4,167	8,770	4,603	110%
WestCAT	Local Bus	3,652	4,588	936	26%
Caltrain Shuttles	Local Bus	2,953	3,430	477	16%
Vallejo Transit	Local Bus	2,626	3,205	579	22%
Fairfield & Suisun Transit	Local Bus	1,955	3,579	1,624	83%
Broadway Shuttle	Local Bus	1,938	90	-1,848	-95%
AirBART	Local Bus	1,800	126	-1,674	-93%
Union City Transit	Local Bus	1,696	3,175	1,479	87%
Vacaville City Coach	Local Bus	1,212	147	-1,065	-88%
Santa Clara VTA Shuttles	Local Bus	1,908	765	-1,143	-60%
Petaluma Transit	Local Bus	673	622	-51	-8%
San Leandro Links	Local Bus	658	763	105	16%
VINE	Local Bus	628	124	-504	-80%
Palo Alto/Menlo Park Shuttles	Local Bus	611	913	302	49%
West Berkeley Shuttle	Local Bus	394	-	-394	-100%
American Canyon Transit	Local Bus	90	-	-90	-100%
Benecia Breeze	Local Bus	56	26	-30	-53%
Muni	Cable Car	27,053	5,112	-21,941	-81%

Operator	Tech Category	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
AC Transit (Transbay)	Express Bus	14,704	19,438	4,734	32%
Golden Gate Transit (To SF)	Express Bus	10,990	12,341	1,351	12%
Santa Clara VTA	Express Bus	9,617	2,754	-6,863	-71%
Vallejo Transit	Express Bus	2,714	2,449	-265	-10%
SamTrans	Express Bus	1,481	169	-1,312	-89%
County Connection	Express Bus	1,322	1,747	425	32%
Fairfield & Suisun Tran.	Express Bus	1,320	702	-618	-47%
Dumbarton Express	Express Bus	1,118	3,534	2,416	216%
Golden Gate Transit (To Richmond)	Express Bus	816	584	-232	-28%
WestCAT	Express Bus	599	3,874	3,275	547%
VINE	Express Bus	83	-	-83	-100%
Golden Gate Ferry (Larkspur)	Ferry	4,817	8,454	3,637	76%
East Bay Ferries	Ferry	1,853	2,690	838	45%
Vallejo Baylink Ferry	Ferry	1,737	711	-1,026	-59%
Golden Gate Ferry (Sausalito)	Ferry	1,630	220	-1,410	-87%
Tiburon Ferry	Ferry	825	61	-764	-93%
Muni	Light Rail	162,023	130,931	-31,092	-19%
Santa Clara VTA	Light Rail	31,739	74,759	43,020	136%
BART	Heavy Rail	348,991	341,516	-7,475	-2%
Caltrain	Commuter Rail	37,779	16,619	-21,160	-56%
ACE	Commuter Rail	2,025	50	-1,975	-98%
Amtrak Capitol Corridor	Commuter Rail	1,666	185	-1,481	-89%
Amtrak San Joaquin	Commuter Rail	88	-	-88	-100%
All	*All*	*1,553,981*	*1,580,779*	*26,798*	*2%*

A thorough examination of the region's three largest bus operators – Muni, AC Transit, and VTA – and four largest rail operators – BART, Muni, Caltrain, and VTA – was performed to assess how well the model predicts ridership patterns.

San Francisco Muni

Table 11 compares observed and simulated boardings by Muni line. Figure 12 plots this information and fits a linear regression. The regression results reveal an R^2 value of 0.79 (i.e., the travel model estimates explain 79 percent of the variation in the observed boardings), which suggests the model has a fairly good understanding of the spatial patterns of transit ridership in

San Francisco County. The regression falls below the 45-degree line, which reveals, as does Table 11, the model's general underestimation of Muni ridership.

Table 11: Observed and Simulated Muni Boardings by Route and Technology

Route	Technology	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
1	Local Bus	25,475	21,405	-4,070	-16%
1AX	Local Bus	1,033	427	-606	-59%
1BX	Local Bus	1,533	861	-672	-44%
2	Local Bus	5,988	1,153	-4,835	-81%
3	Local Bus	4,742	820	-3,922	-83%
5	Local Bus	19,845	10,103	-9,742	-49%
6	Local Bus	8,656	9,659	1,003	12%
8AX	Local Bus	4,225	4,448	223	5%
8BX	Local Bus	6,124	4,530	-1,594	-26%
8X	Local Bus	23,076	16,711	-6,365	-28%
9	Local Bus	12,374	9,745	-2,629	-21%
9L	Local Bus	6,237	4,395	-1,842	-30%
10	Local Bus	5,293	1,651	-3,642	-69%
12	Local Bus	4,851	1,128	-3,723	-77%
14	Local Bus	30,365	25,980	-4,385	-14%
14L	Local Bus	16,201	10,742	-5,459	-34%
14X	Local Bus	3,055	4,607	1,552	51%
16X	Local Bus	1,650	487	-1,163	-70%
17	Local Bus	2,469	218	-2,251	-91%
18	Local Bus	3,893	1,069	-2,824	-73%
19	Local Bus	8,709	7,132	-1,577	-18%
21	Local Bus	7,784	1,938	-5,846	-75%
22	Local Bus	19,443	14,397	-5,046	-26%
23	Local Bus	3,917	1,555	-2,362	-60%
24	Local Bus	12,484	9,381	-3,103	-25%
27	Local Bus	7,049	3,899	-3,150	-45%
28	Local Bus	14,167	9,432	-4,735	-33%

Route	Technology	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
28L	Local Bus	2,585	4,852	2,267	88%
29	Local Bus	18,827	11,134	-7,693	-41%
30	Local Bus	28,797	25,014	-3,783	-13%
30X	Local Bus	2,606	2,750	144	6%
31	Local Bus	10,021	3,095	-6,926	-69%
31AX	Local Bus	992	410	-582	-59%
31BX	Local Bus	900	1,160	260	29%
33	Local Bus	6,967	2,397	-4,570	-66%
35	Local Bus	744	36	-708	-95%
36	Local Bus	1,395	226	-1,169	-84%
37	Local Bus	1,993	2,131	138	7%
38	Local Bus	26,504	20,855	-5,649	-21%
38L	Local Bus	26,413	30,484	4,071	15%
38AX	Local Bus	907	163	-744	-82%
38BX	Local Bus	1,029	289	-740	-72%
39	Local Bus	798	124	-674	-84%
41	Local Bus	3,368	5,827	2,459	73%
43	Local Bus	14,705	11,121	-3,584	-24%
44	Local Bus	14,595	8,598	-5,997	-41%
45	Local Bus	12,367	10,716	-1,651	-13%
47	Local Bus	13,226	10,312	-2,914	-22%
48	Local Bus	8,888	7,367	-1,521	-17%
49	Local Bus	25,806	19,824	-5,982	-23%
52	Local Bus	2,188	535	-1,653	-76%
54	Local Bus	6,474	1,065	-5,409	-84%
56	Local Bus	245	10	-235	-96%
66	Local Bus	821	168	-653	-80%
67	Local Bus	1,482	18	-1,464	-99%
71	Local Bus	10,342	29,942	19,600	190%
71L	Local Bus	2,119	4,067	1,948	92%

Route	Technology	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
80X	Local Bus	14	1	-13	-93%
81X	Local Bus	246	163	-83	-34%
82X	Local Bus	969	294	-675	-70%
88	Local Bus	405	103	-302	-75%
90	Local Bus	320	1,280	960	300%
91	Local Bus	629	2,746	2,117	337%
108	Local Bus	3,492	1,304	-2,188	-63%
C	Cable Car	6,324	915	-5,409	-86%
PH	Cable Car	10,690	2,139	-8,551	-80%
PM	Cable Car	10,040	2,058	-7,982	-80%
F	Light Rail	17,371	7,837	-9,534	-55%
J	Light Rail	13,307	15,365	2,058	15%
K	Light Rail	16,763	8,275	-8,488	-51%
L	Light Rail	27,145	16,219	-10,926	-40%
M	Light Rail	28,381	20,372	-8,009	-28%
N	Light Rail	43,637	36,419	-7,218	-17%
S	Light Rail	-	870	870	n/a
T	Light Rail	15,419	25,574	10,155	66%
All	*All*	*703,894*	*534,497*	*-169,397*	*-24%*

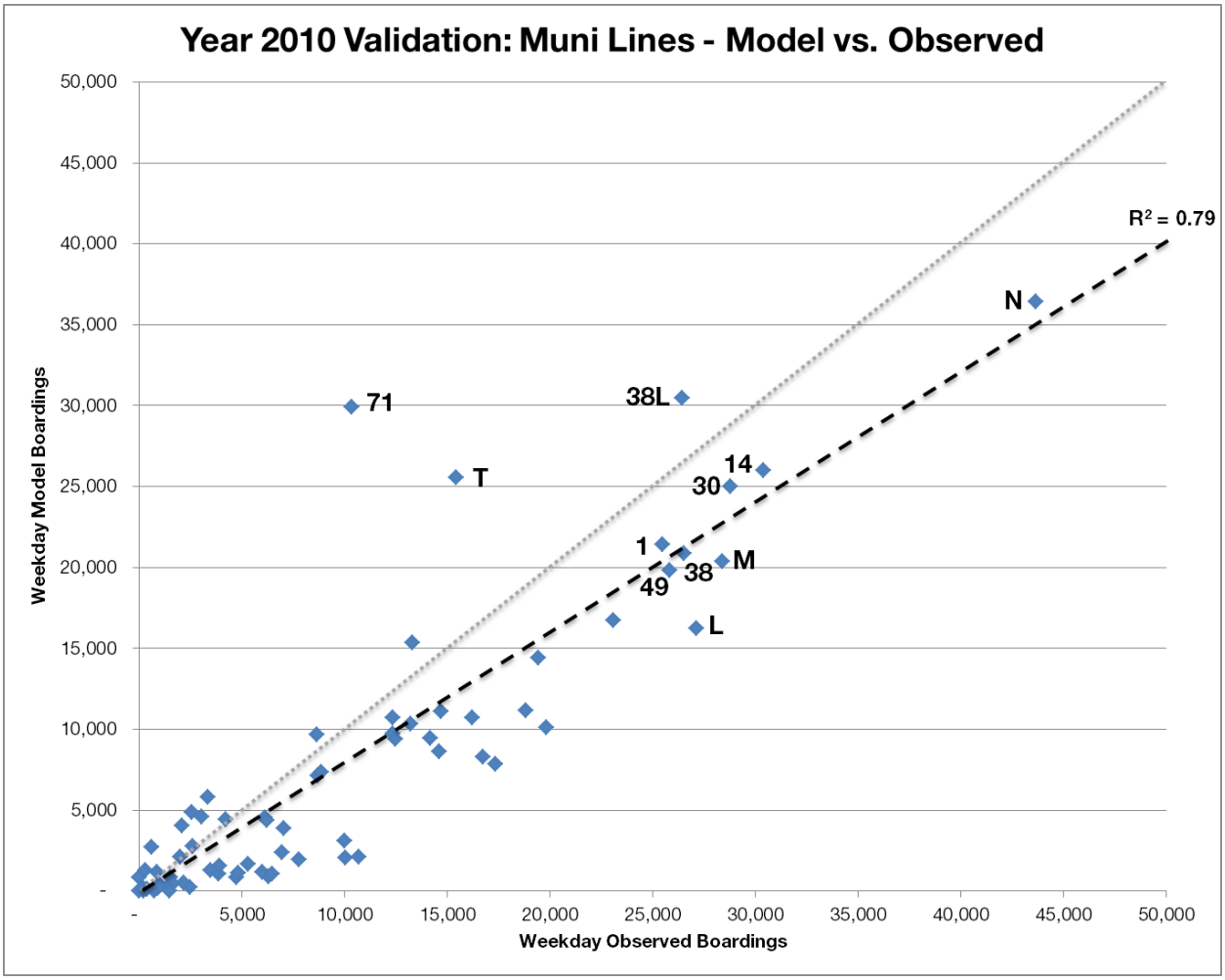

Figure 13: Observed and Simulated Muni Boardings by Route with 45-degree and Regression

AC Transit

Table 12 compares observed and simulated boardings by AC Transit line. Figure 12 plots this information and fits a linear regression. The regression results reveal an R^2 value of 0.84, which suggests the model has a good understanding of the spatial patterns of transit ridership in AC Transit's service area. The regression falls above the 45-degree line, which reveals, as does Table 12, the model's general over-estimation of AC Transit ridership.

Table 12: Observed and Simulated AC Transit Boardings by Route and Technology

Route	Technology	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
1	Local Bus	10,762	21,604	10,842	101%
1R	Local Bus	12,696	20,655	7,959	63%
7	Local Bus	792	754	(38)	-5%
11	Local Bus	1,901	1,672	(229)	-12%
12	Local Bus	2,116	3,270	1,154	55%
14	Local Bus	3,318	9,221	5,903	178%

Route	Technology	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
18	Local Bus	7,162	23,034	15,872	222%
20	Local Bus	2,843	3,612	769	27%
21	Local Bus	2,064	2,502	438	21%
22	Local Bus	2,356	2,775	419	18%
25	Local Bus	1,229	281	(948)	-77%
26	Local Bus	1,842	863	(979)	-53%
31	Local Bus	1,700	1,509	(191)	-11%
32	Local Bus	1,112	1,756	644	58%
37	Local Bus	584	724	140	24%
39	Local Bus	476	111	(365)	-77%
40	Local Bus	9,178	9,702	524	6%
45	Local Bus	2,503	764	(1,739)	-69%
46	Local Bus	602	47	(555)	-92%
47	Local Bus	148	-	(148)	-100%
48	Local Bus	435	909	474	109%
49	Local Bus	2,367	935	(1,432)	-60%
51A	Local Bus	11,445	16,507	5,062	44%
51B	Local Bus	10,581	16,979	6,398	60%
52	Local Bus	2,657	5,603	2,947	111%
54	Local Bus	2,478	3,043	565	23%
57	Local Bus	7,603	5,540	(2,063)	-27%
58L	Local Bus	1,001	2,119	1,118	112%
60	Local Bus	968	635	(333)	-34%
61	Local Bus	150	-	(150)	-100%
62	Local Bus	3,388	996	(2,392)	-71%
65	Local Bus	816	1,149	333	41%
67	Local Bus	307	519	212	69%
68	Local Bus	375	258	(117)	-31%
70	Local Bus	909	799	(110)	-12%
71	Local Bus	1,424	1,548	124	9%

Route	Technology	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
72	Local Bus	3,886	6,758	2,872	74%
72M	Local Bus	3,768	5,658	1,890	50%
72R	Local Bus	6,927	9,853	2,926	42%
73	Local Bus	2,837	2,550	(287)	-10%
74	Local Bus	1,351	2,104	753	56%
75	Local Bus	587	306	(281)	-48%
76	Local Bus	1,635	1,972	337	21%
83	Local Bus	562	288	(274)	-49%
85	Local Bus	813	504	(309)	-38%
86	Local Bus	946	554	(392)	-41%
88	Local Bus	2,374	1,602	(772)	-33%
89	Local Bus	1,232	3,314	2,082	169%
93	Local Bus	696	1,357	661	95%
94	Local Bus	191	423	232	121%
95	Local Bus	336	194	(142)	-42%
97	Local Bus	5,443	8,234	2,791	51%
98	Local Bus	1,455	1,425	(30)	-2%
99	Local Bus	3,389	3,785	396	12%
210	Local Bus	1,839	2,769	930	51%
212	Local Bus	918	1,822	904	99%
215	Local Bus	251	159	(92)	-37%
216	Local Bus	411	528	117	29%
217	Local Bus	1,658	3,154	1,496	90%
232	Local Bus	516	762	246	48%
239	Local Bus	461	921	460	100%
242	Local Bus	893	1,438	546	61%
251	Local Bus	1,028	1,286	258	25%
264	Local Bus	782	843	61	8%
275	Local Bus	266	692	426	160%
802	Local Bus	97	311	214	219%

Route	Technology	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
805	Local Bus	135	151	16	12%
840	Local Bus	125	147	22	18%
851	Local Bus	93	1,301	1,208	1292%
B	Transbay Bus	201	60	(141)	-70%
C	Transbay Bus	148	113	(35)	-24%
CB	Transbay Bus	153	56	(97)	-63%
DA	Transbay Bus	35	-	(35)	-100%
E	Transbay Bus	182	1	(181)	-99%
F	Transbay Bus	1,856	2,706	850	46%
FS	Transbay Bus	182	109	(73)	-40%
G	Transbay Bus	265	71	(194)	-73%
H	Transbay Bus	433	863	430	99%
J	Transbay Bus	269	324	55	21%
L	Transbay Bus	566	1,391	825	146%
LA	Transbay Bus	607	1,830	1,223	201%
LC	Transbay Bus	16	1,017	1,001	6357%
M	Transbay Bus	491	1,094	603	123%
NL	Transbay Bus	2,320	5,494	3,174	137%
NX	Transbay Bus	200	508	309	155%
NX1	Transbay Bus	232	164	(68)	-29%
NX2	Transbay Bus	279	119	(160)	-57%
NX3	Transbay Bus	309	107	(202)	-65%
NX4	Transbay Bus	282	278	(4)	-2%
NXC	Transbay Bus	15	39	24	165%
O	Transbay Bus	1,730	574	(1,156)	-67%
OX	Transbay Bus	662	297	(365)	-55%
P	Transbay Bus	525	182	(343)	-65%
S	Transbay Bus	260	87	(173)	-67%
SB	Transbay Bus	508	494	(14)	-3%
U	Transbay Bus	542	557	15	3%

Route	Technology	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
V	Transbay Bus	582	564	(18)	-3%
W	Transbay Bus	522	286	(236)	-45%
Z	Transbay Bus	69	45	(24)	-35%
800	Transbay Bus	264	8	(256)	-97%
All	*All*	*174,888*	*248,998*	*74,110*	*42%*

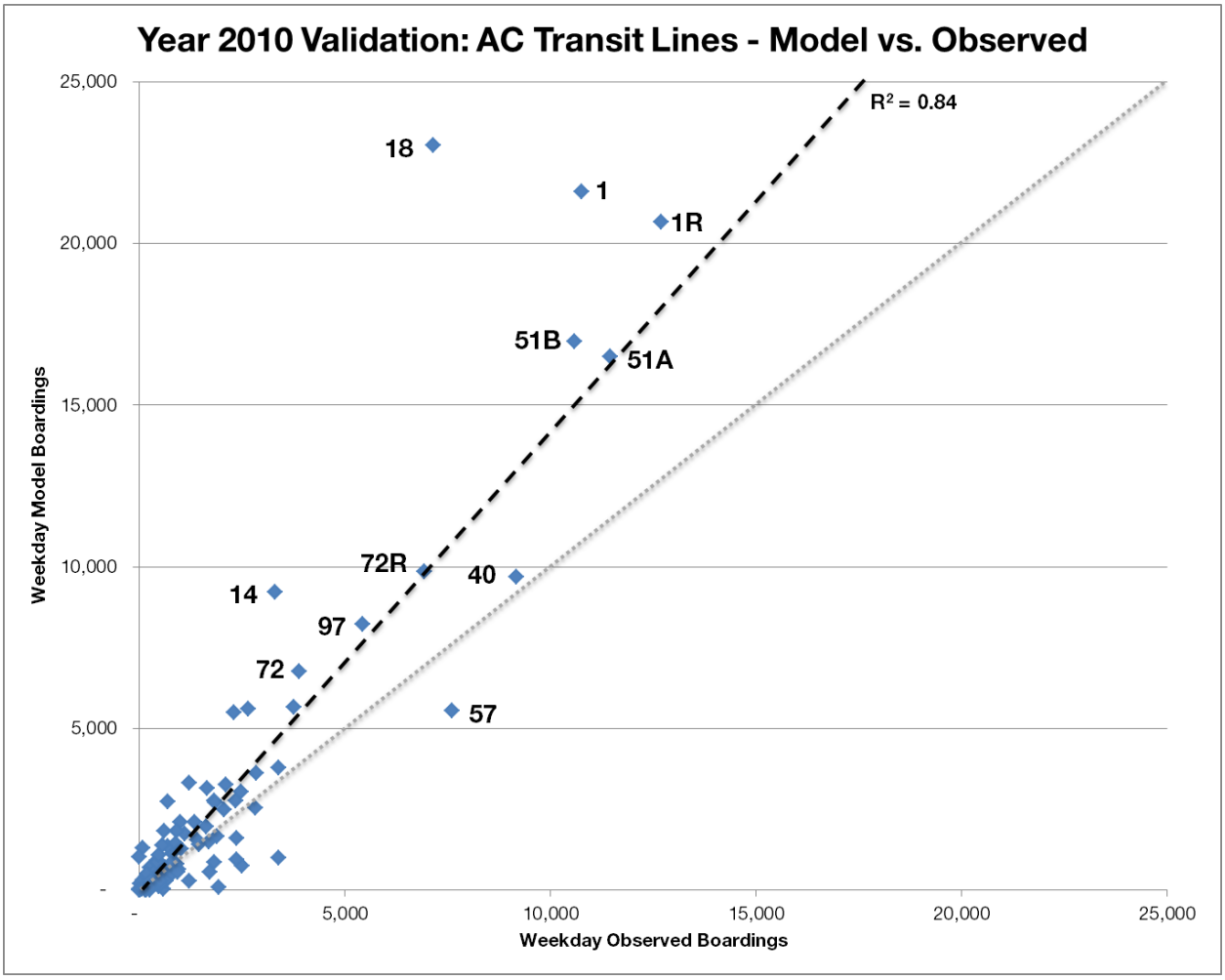

Figure 14: Observed and Simulated AC Transit Boardings with 45-degree line and Regression

Santa Clara VTA

Table 13 compares observed and simulated boardings by Santa Clara VTA line. Figure 15 plots this information and fits a linear regression. The regression results reveal an R^2 value of 0.94, which suggests the model has a good understanding of the spatial patterns of transit ridership in Santa Clara County. The regression falls above the 45-degree line, which reveals, as does Table 13, the model's general over-estimation of VTA ridership.

Table 13: Observed and Simulated VTA Boardings by Route and Technology

Route	Technology	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
11	Local Bus	128	120	(8)	-6%
13	Local Bus	188	80	(108)	-57%
14	Local Bus	175	-	(175)	-100%
16	Local Bus	188	189	1	1%
17	Local Bus	70	181	111	158%
18	Local Bus	173	-	(173)	-100%
19	Local Bus	210	135	(75)	-36%
22	Local Bus	15,078	34,891	19,813	131%
23	Local Bus	8,320	21,374	13,054	157%
25	Local Bus	6,890	12,088	5,198	75%
26	Local Bus	3,756	5,645	1,889	50%
27	Local Bus	820	1,235	415	51%
31	Local Bus	753	986	233	31%
32	Local Bus	893	1,807	914	102%
34	Local Bus	84	42	(42)	-50%
35	Local Bus	1,203	1,328	125	10%
37	Local Bus	653	1,722	1,069	164%
39	Local Bus	398	446	48	12%
40	Local Bus	1,193	654	(539)	-45%
42	Local Bus	266	92	(174)	-65%
45	Local Bus	172	67	(105)	-61%
46	Local Bus	775	897	122	16%
47	Local Bus	795	2,104	1,309	165%
48	Local Bus	353	410	57	16%
49	Local Bus	291	418	127	44%
51	Local Bus	935	1,099	164	18%
52	Local Bus	448	587	139	31%

Route	Technology	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
53	Local Bus	773	618	(155)	-20%
54	Local Bus	1,035	1,848	813	78%
55	Local Bus	2,806	3,767	961	34%
57	Local Bus	1,560	4,804	3,244	208%
58	Local Bus	693	3,330	2,637	381%
60	Local Bus	2,331	4,097	1,766	76%
61	Local Bus	1,720	4,341	2,621	152%
62	Local Bus	1,738	4,266	2,528	145%
63	Local Bus	797	2,419	1,622	204%
64	Local Bus	3,089	6,212	3,123	101%
65	Local Bus	357	291	(66)	-19%
66	Local Bus	5,877	13,388	7,511	128%
68	Local Bus	5,332	8,832	3,500	66%
70	Local Bus	5,148	7,781	2,633	51%
71	Local Bus	1,986	4,845	2,859	144%
72	Local Bus	2,276	7,847	5,571	245%
73	Local Bus	2,619	4,276	1,657	63%
77	Local Bus	1,981	1,944	(37)	-2%
81	Local Bus	1,021	1,774	753	74%
82	Local Bus	1,503	1,453	(50)	-3%
88	Local Bus	298	110	(188)	-63%
89	Local Bus	135	261	126	94%
10	Shuttle	1,096	492	(604)	-55%
201	Shuttle	813	216	(597)	-73%
101	Express Bus	34	-	(34)	-100%
102	Express Bus	152	2	(150)	-99%
103	Express Bus	141	12	(129)	-91%
104	Express Bus	75	4	(71)	-95%
120	Express Bus	167	5	(162)	-97%
121	Express Bus	250	19	(231)	-92%

Route	Technology	Observed Boardings	Simulated Boardings	Abs Diff	Pct Diff
122	Express Bus	32	-	(32)	-100%
140	Express Bus	114	9	(105)	-92%
168	Express Bus	216	2	(214)	-99%
180	Express Bus	638	199	(439)	-69%
181	Express Bus	1,617	1,134	(483)	-30%
182	Express Bus	64	-	(64)	-100%
304	Express Bus	166	1,039	873	527%
321	Express Bus	15	2	(13)	-87%
328	Express Bus	28	24	(4)	-13%
330	Express Bus	157	368	211	135%
522	Express Bus	6,117	1,368	(4,749)	-78%
900	Light Rail	1,000	759	(241)	-24%
901	Light Rail	18,585	46,938	28,353	153%
902	Light Rail	12,154	27,062	14,908	123%
All	*All*	*133,912*		*122,900*	*92%*

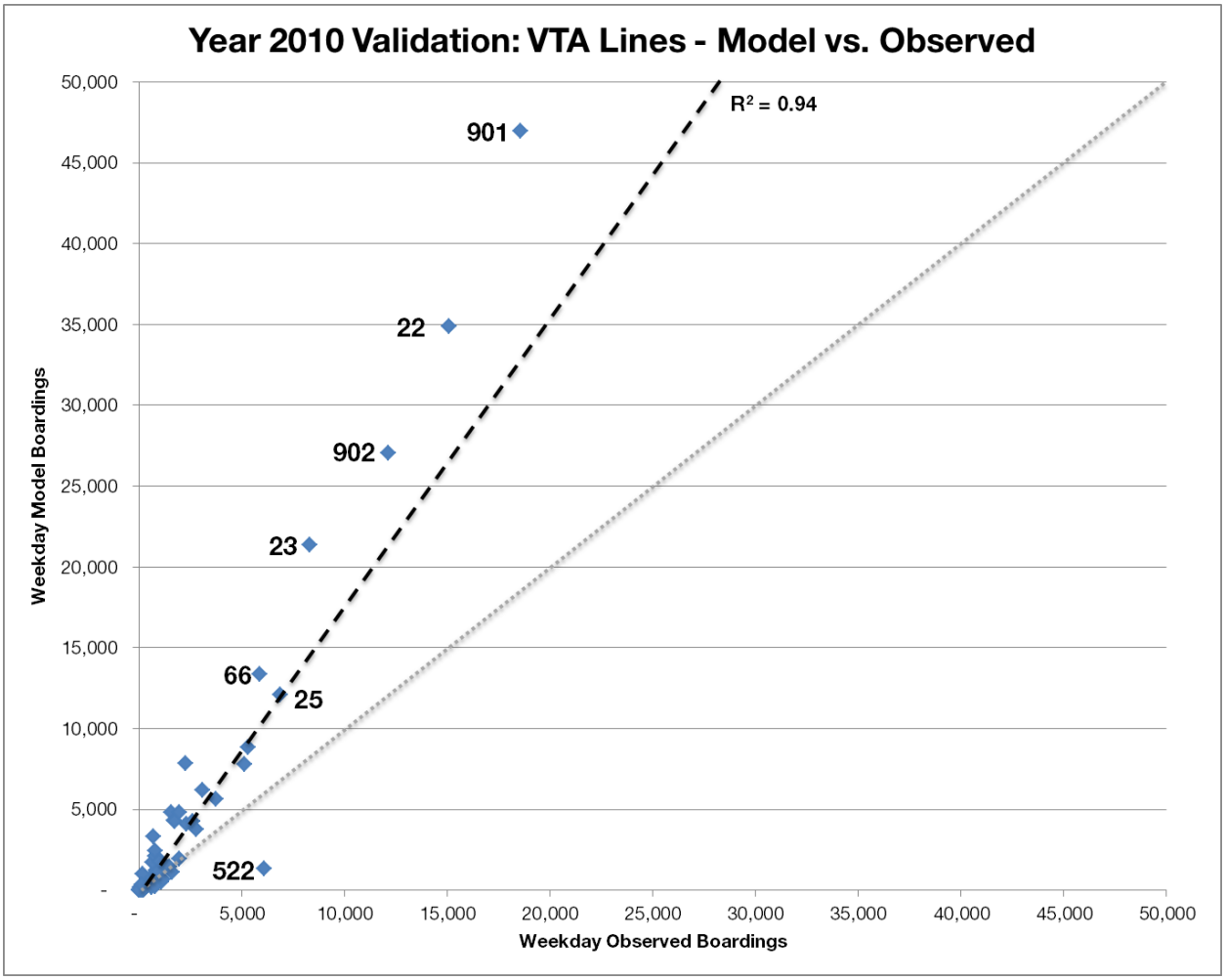

Figure 15: Observed and Simulated VTA Boardings by Route with 45-degree line and Regression

BART

Figure 16 and Figure 17 summarize the difference between observed and simulated BART boardings by station and by sub-region. Figure 18 through Figure 27 present the observed and simulated loading pattern for each BART line by direction.

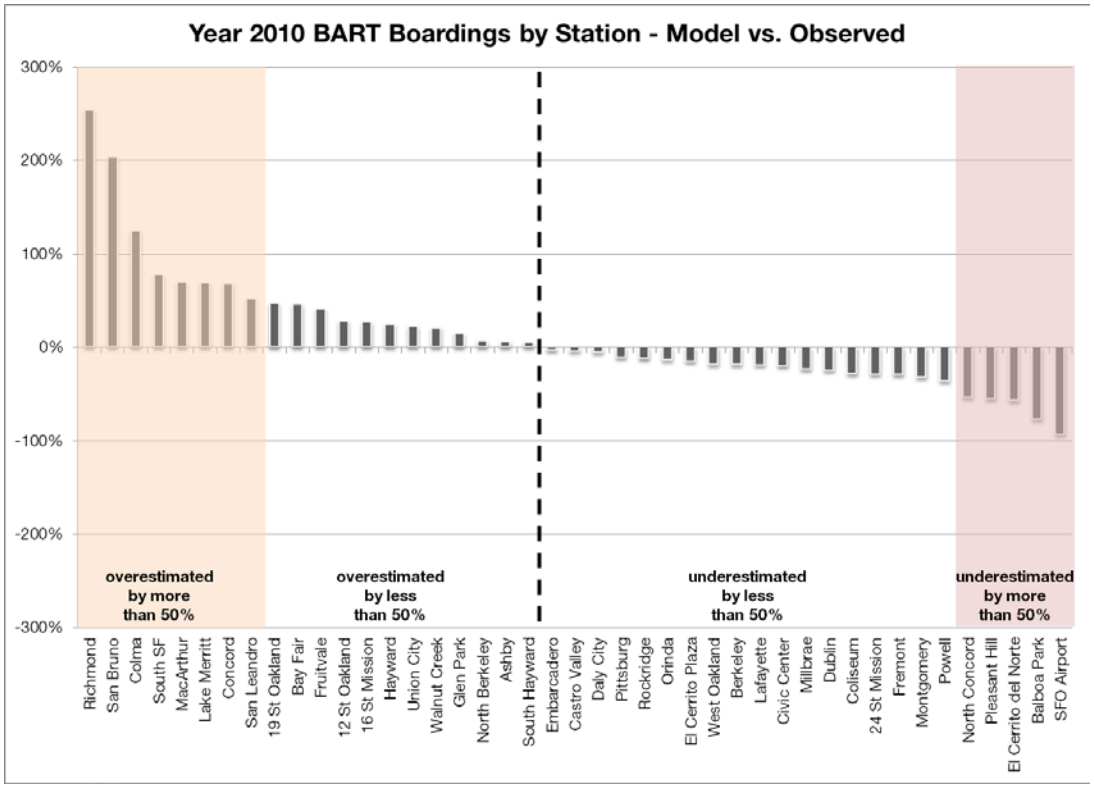

Figure 16: Comparison of Observed and Simulated BART Boardings by Station

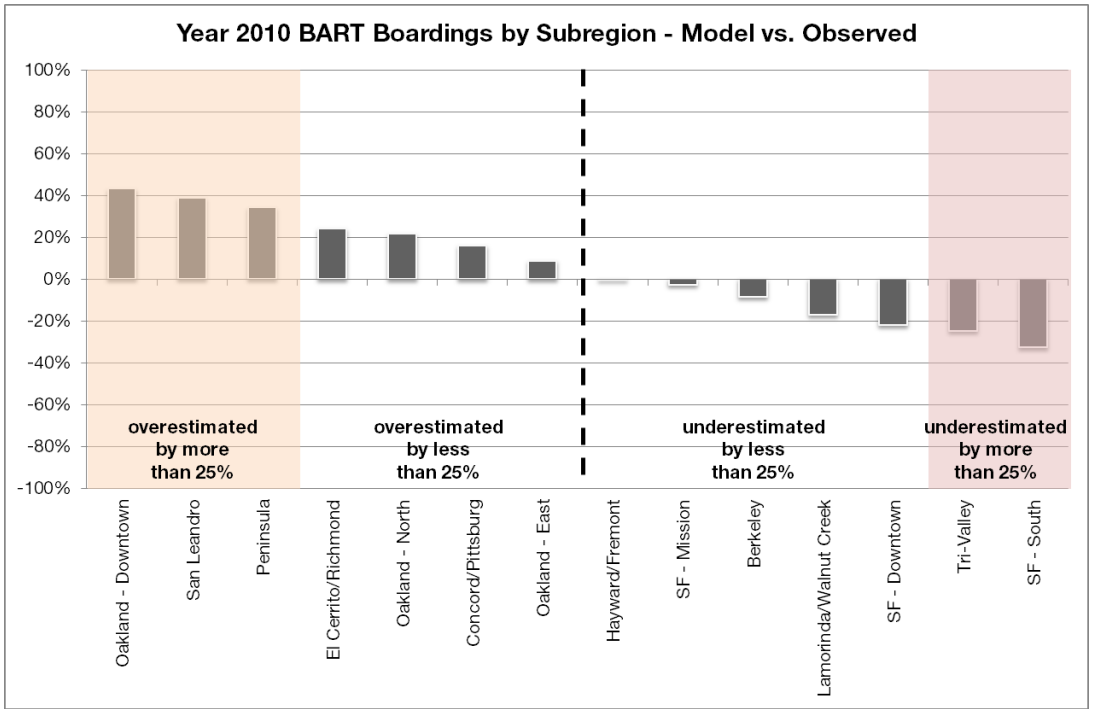

Figure 17: Comparison of Observed and Simulated BART Boardings by Sub-Region

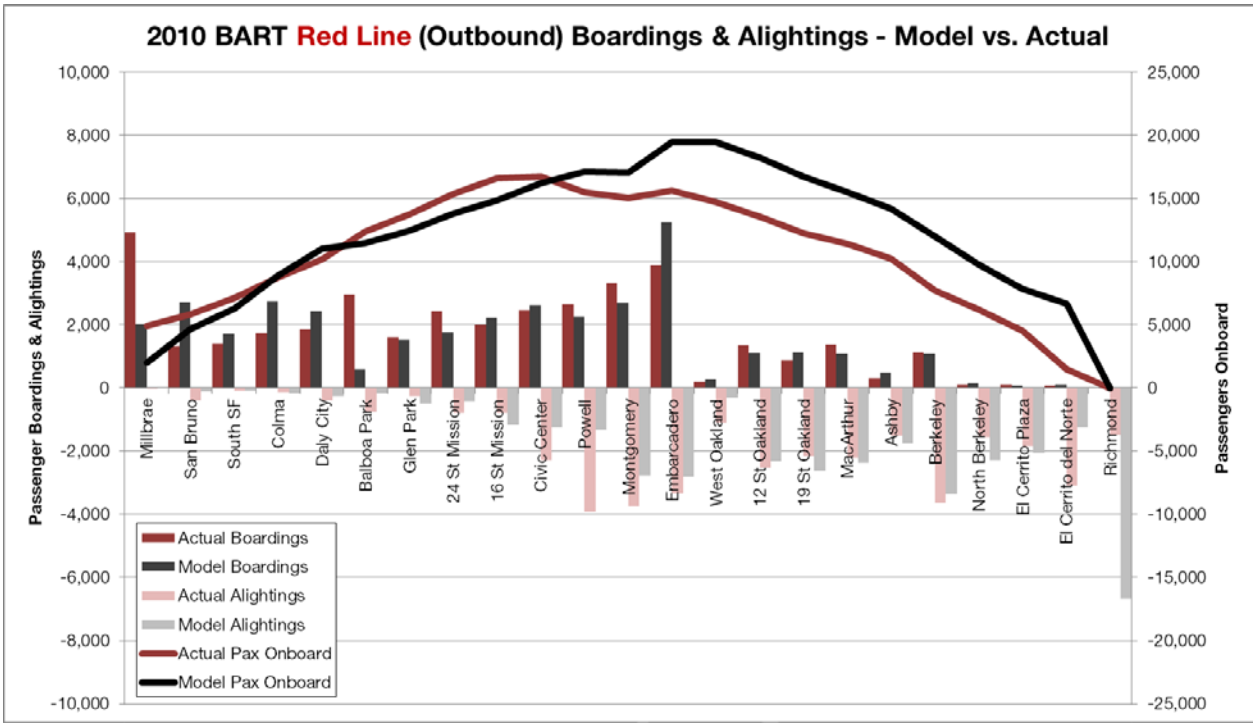

Figure 18: Observed and Simulated Loading Pattern on BART Red Line Outbound

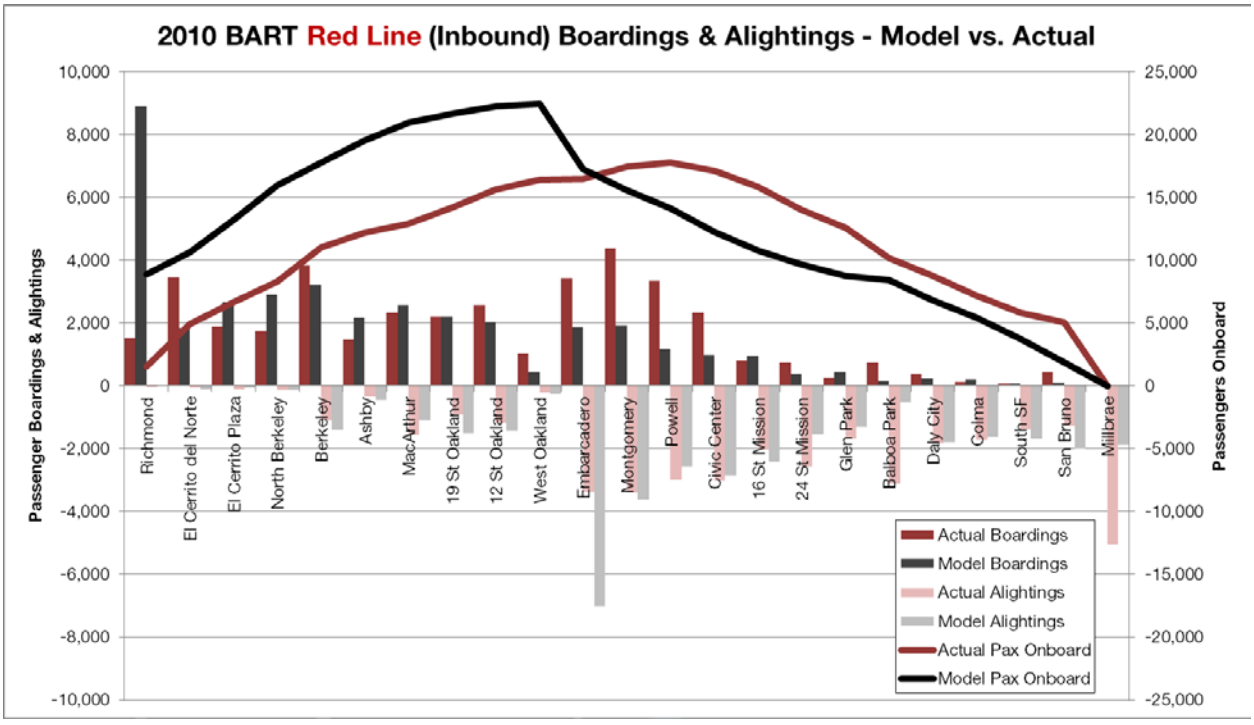

Figure 19: Observed and Simulated Loading Pattern on BART Red Line (Inbound)

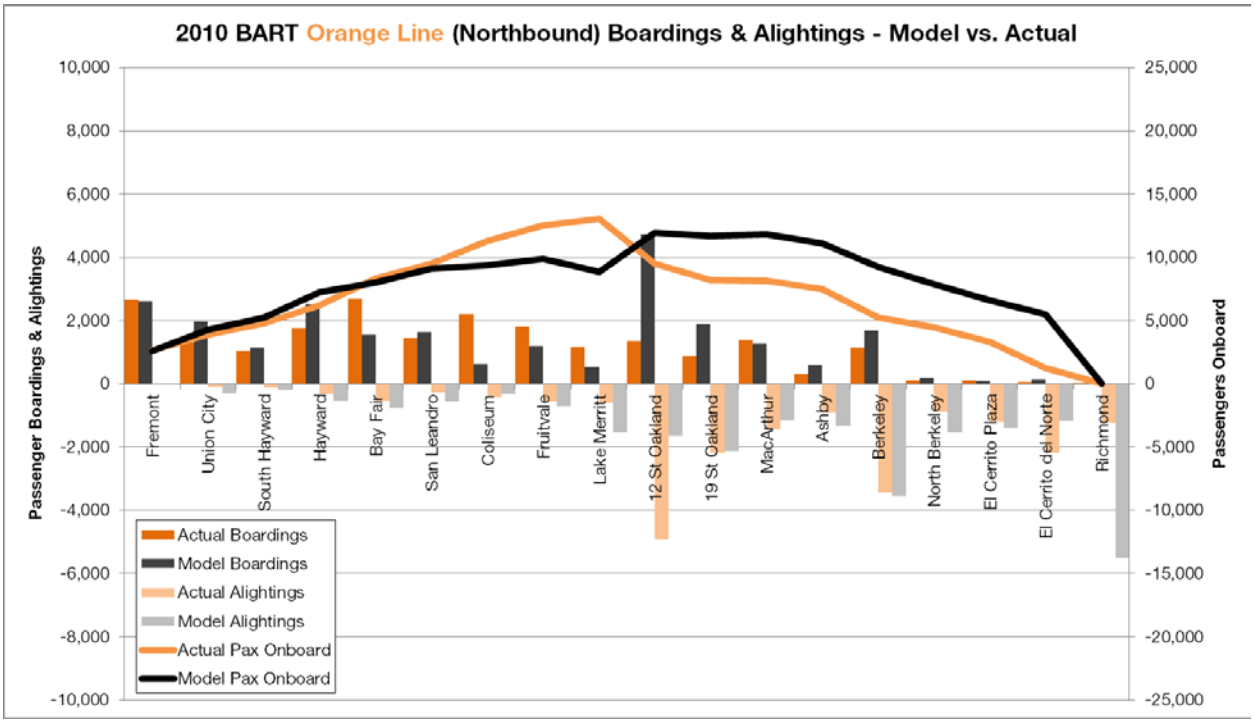

Figure 20: Observed and Simulated Loading Pattern on BART Orange Line (Northbound)

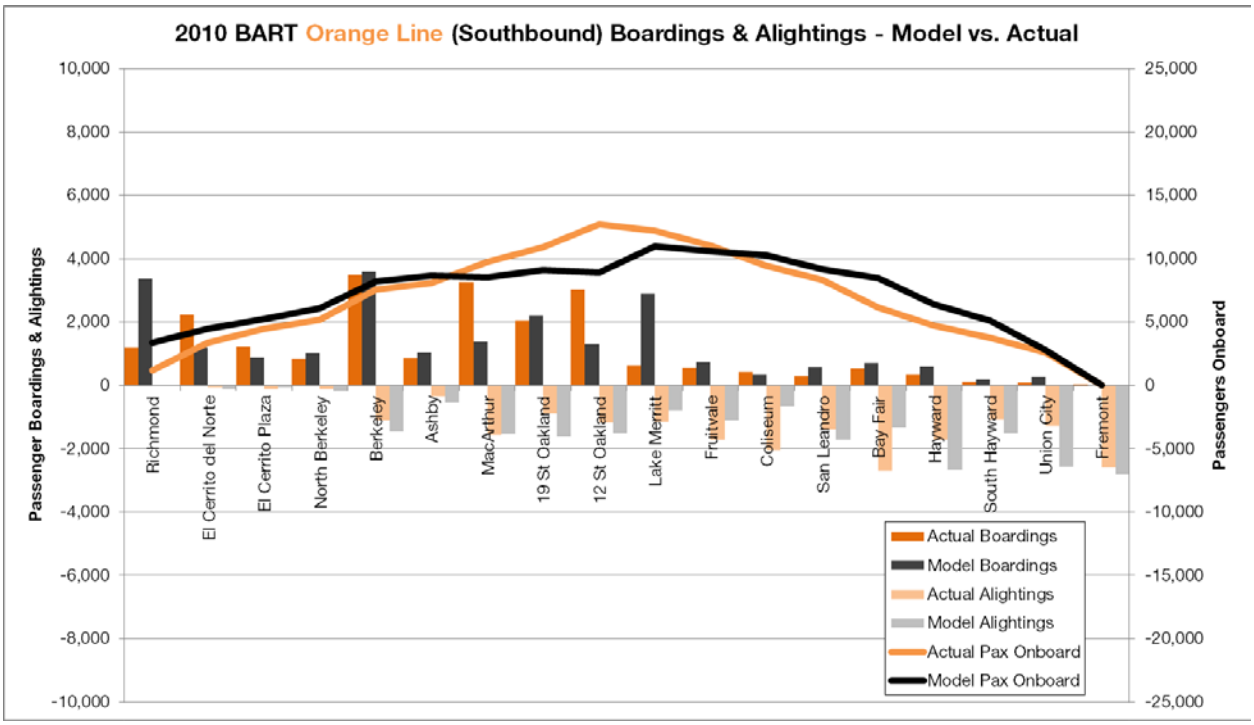

Figure 21: Observed and Simulated Loading Pattern on BART Orange Line (Southbound)

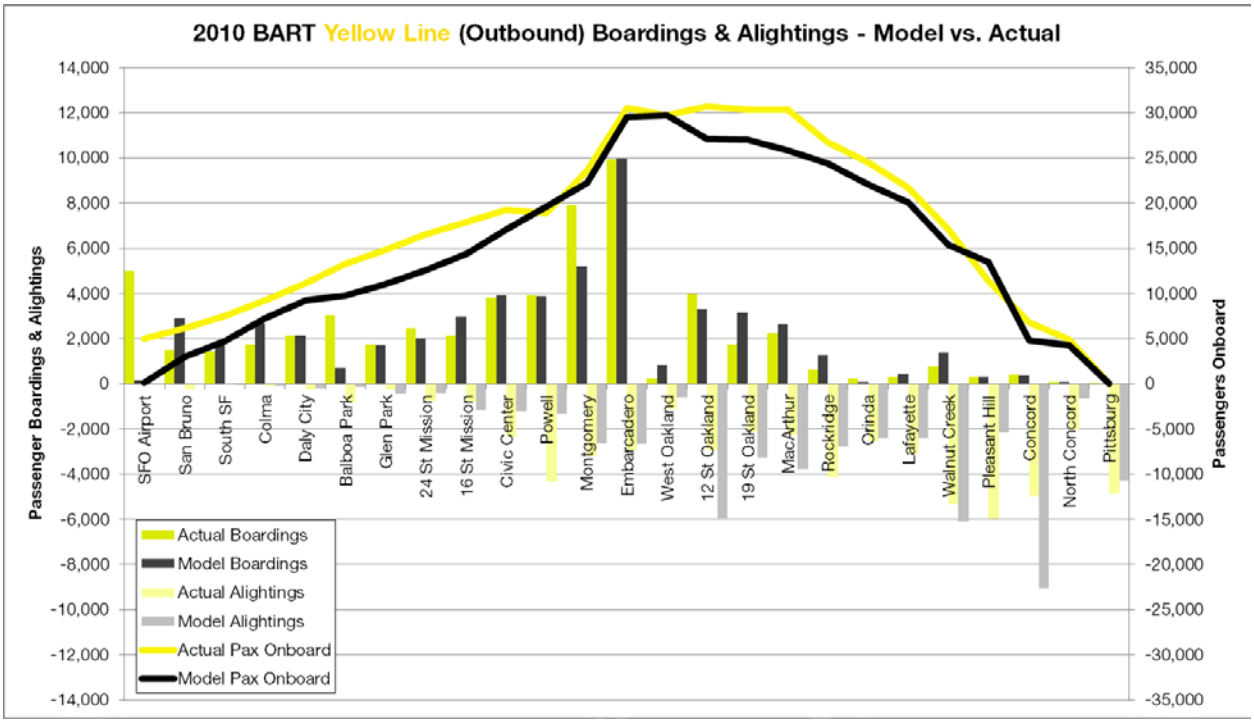

Figure 22: Observed and Simulated Loading Pattern on BART Yellow Line (outbound)

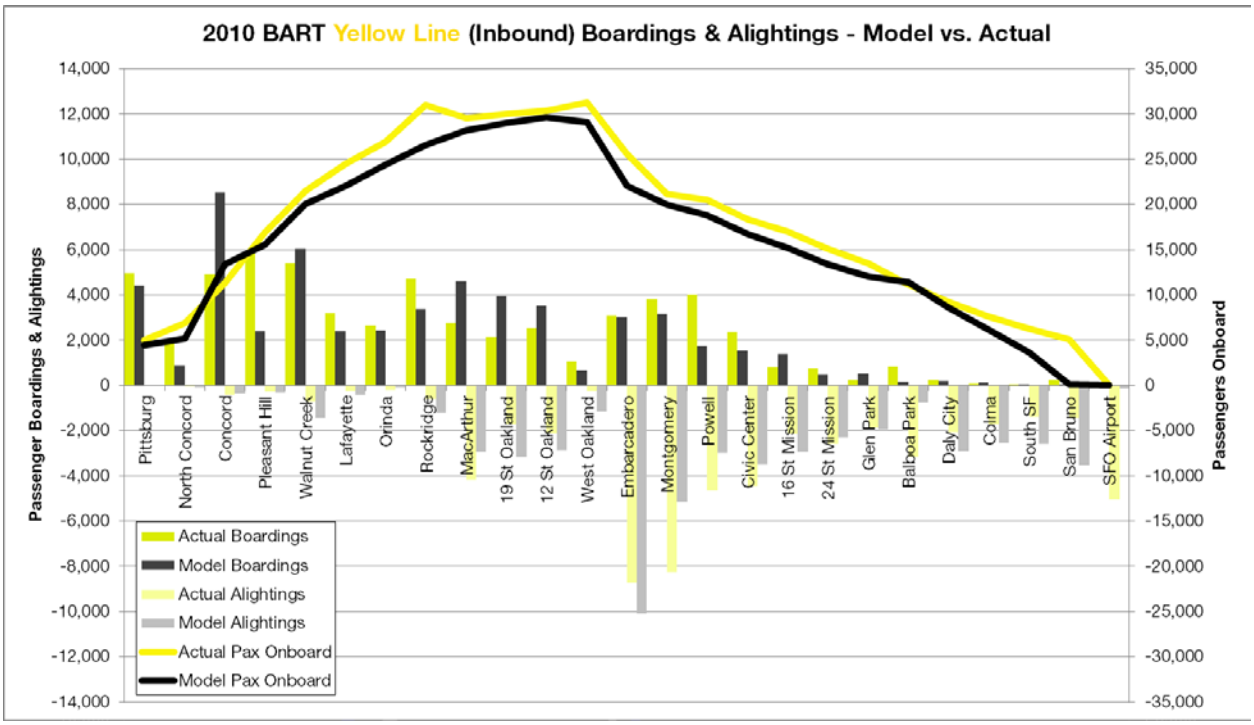

Figure 23: Observed and Simulated Loading Pattern on BART Yellow Line (Inbound)

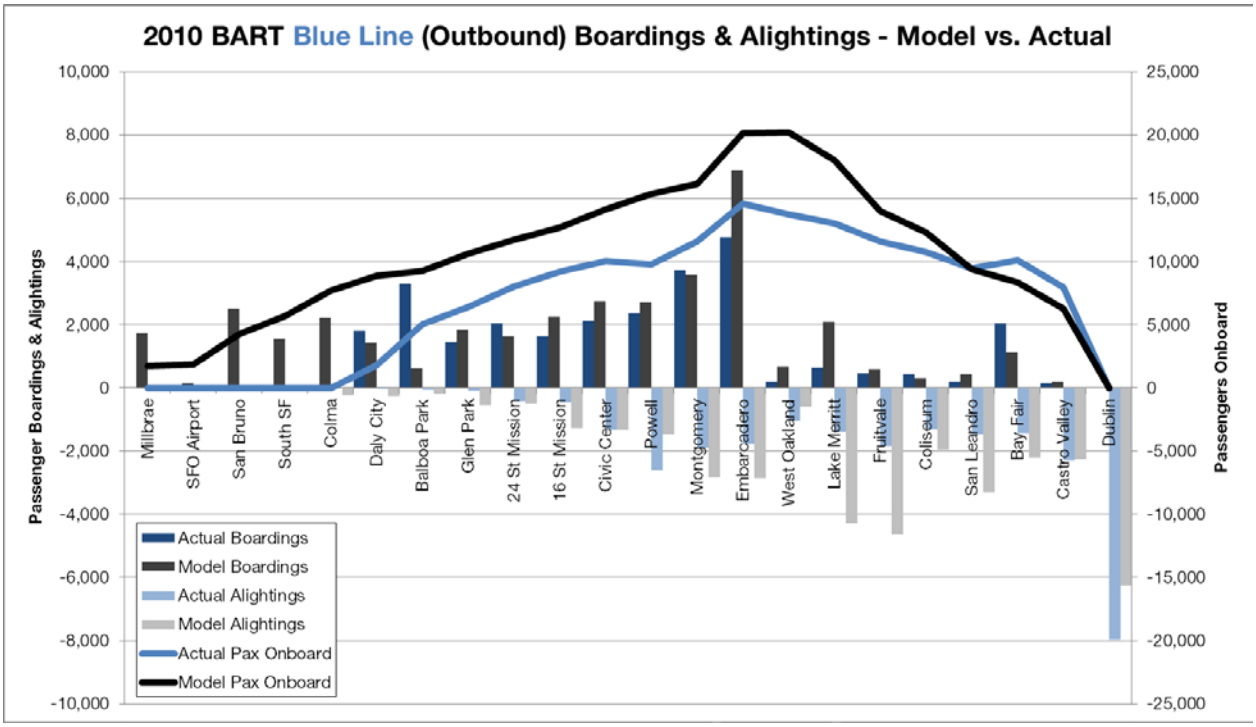

Figure 24: Observed and Simulated Loading Pattern on BART Blue Line (Outbound)

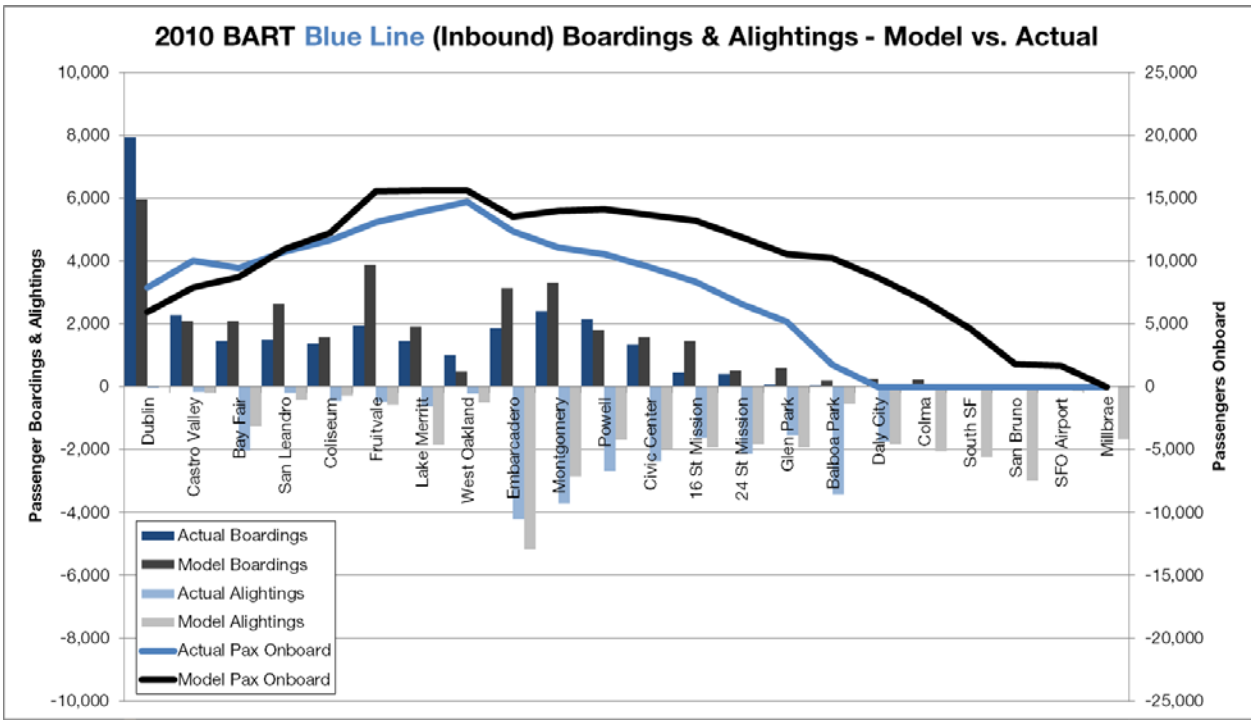

Figure 25: Observed and Simulated Loading Pattern on BART Blue Line (Inbound)

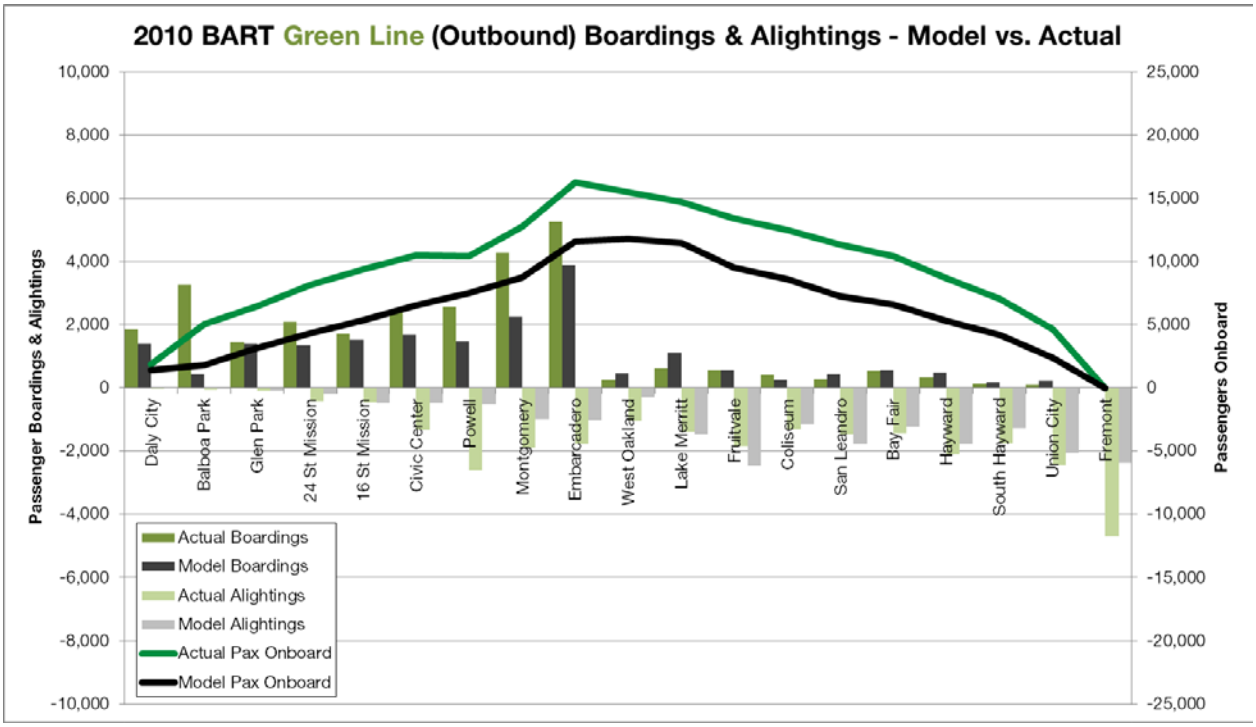

Figure 26: Observed and Simulated Loading Pattern on BART Green Line (Outbound)

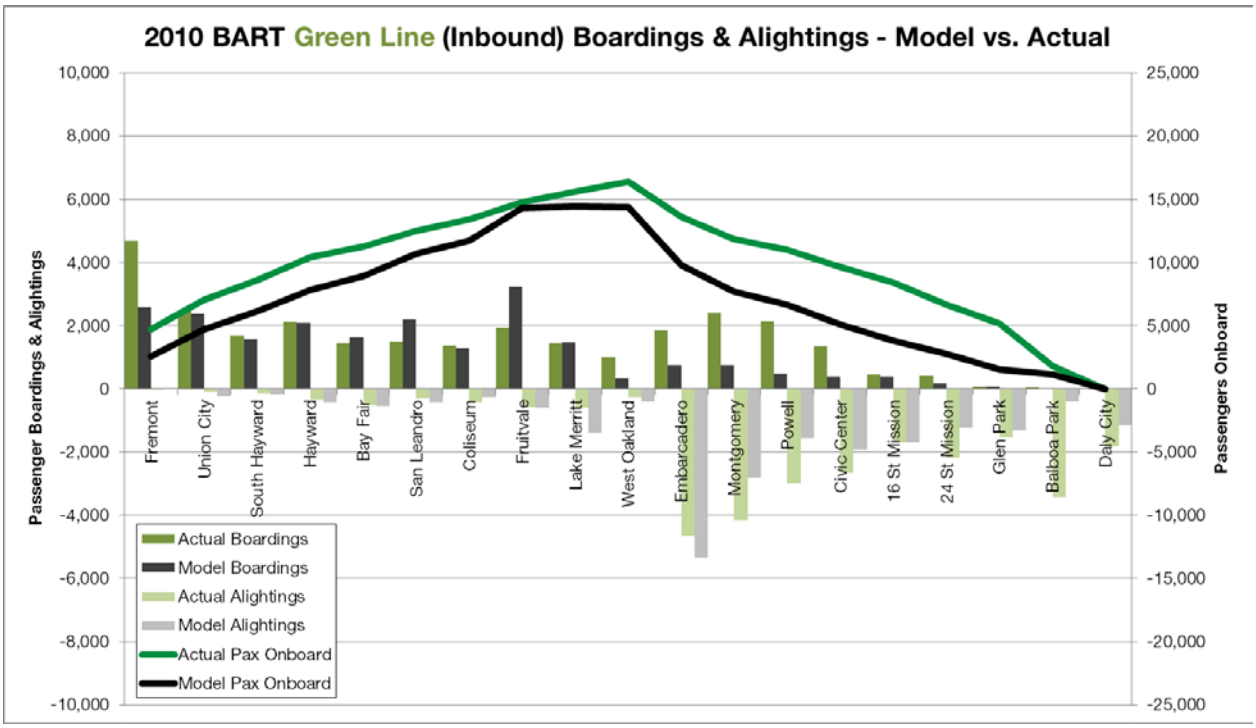

Figure 27: Observed and Simulated Loading Pattern on BART Green Line (Inbound)

Caltrain

Similar to the information presented for BART, the observed and simulated Caltrain results are presented two ways as follows: (i) as differences between boardings by station (see Figure 28) and (ii) by comparing the loading pattern (see Figure 29 and Figure 30). As in the 2005 validation, Caltrain ridership is underestimated and the model appears to not understand the impact the "baby bullet" service has in shaping demand.

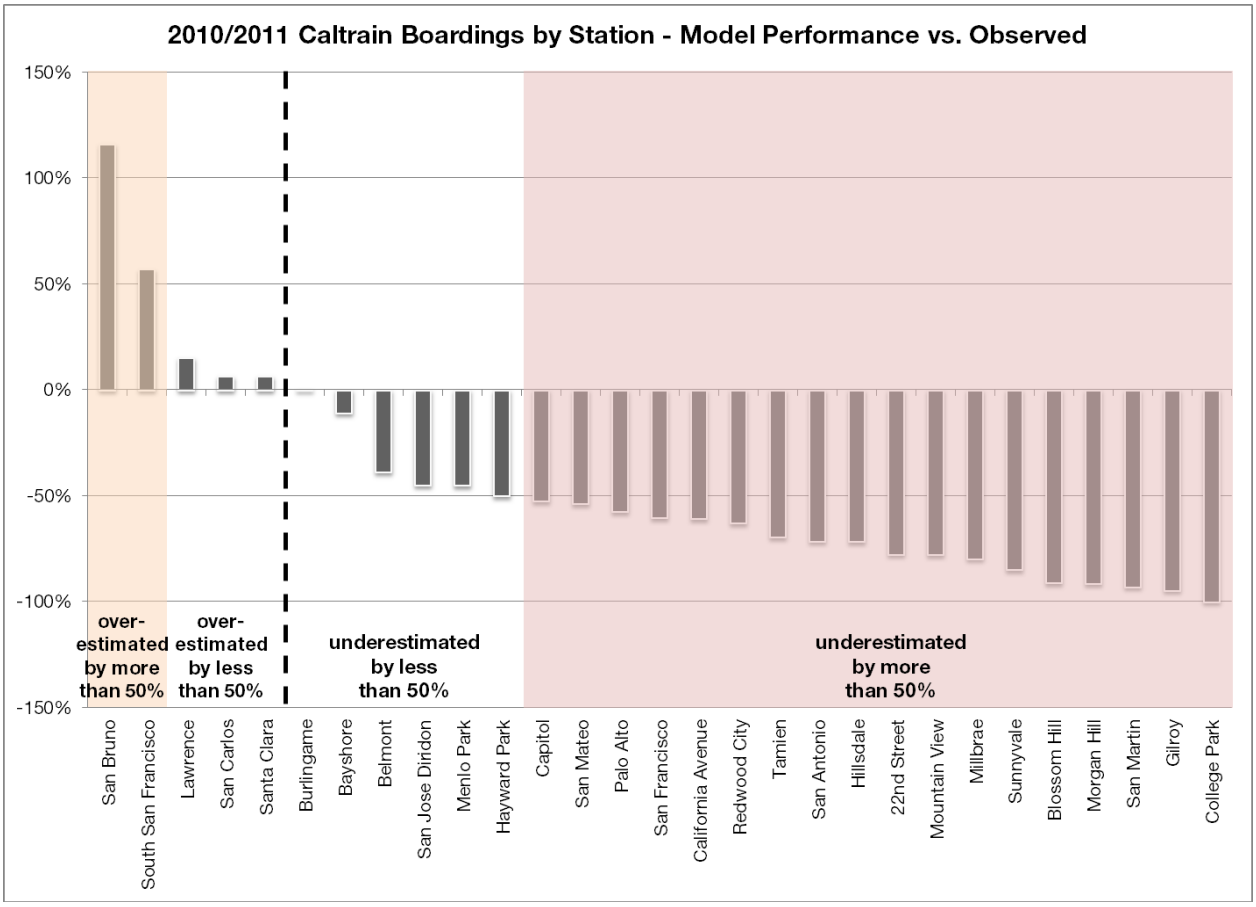

Figure 28: Observed and Simulated Caltrain Boardings by Station

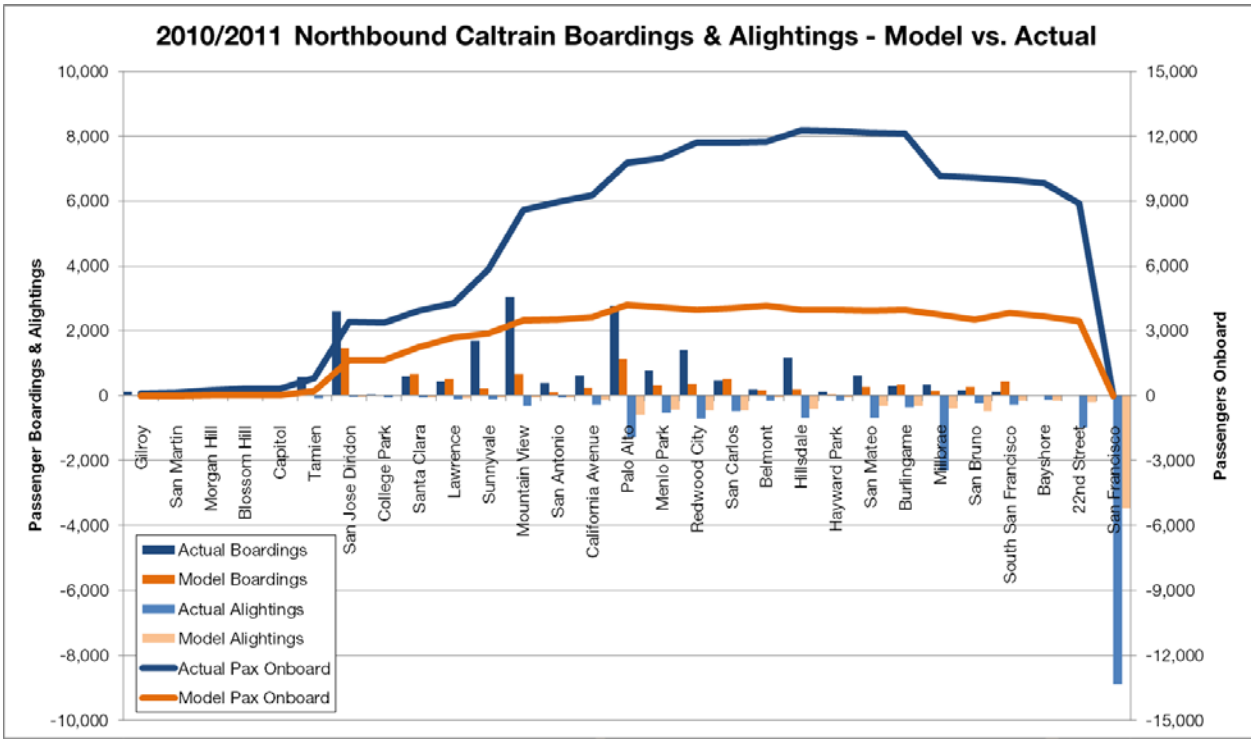

Figure 29: Observed and Simulated Caltrain Loading Pattern (Northbound)

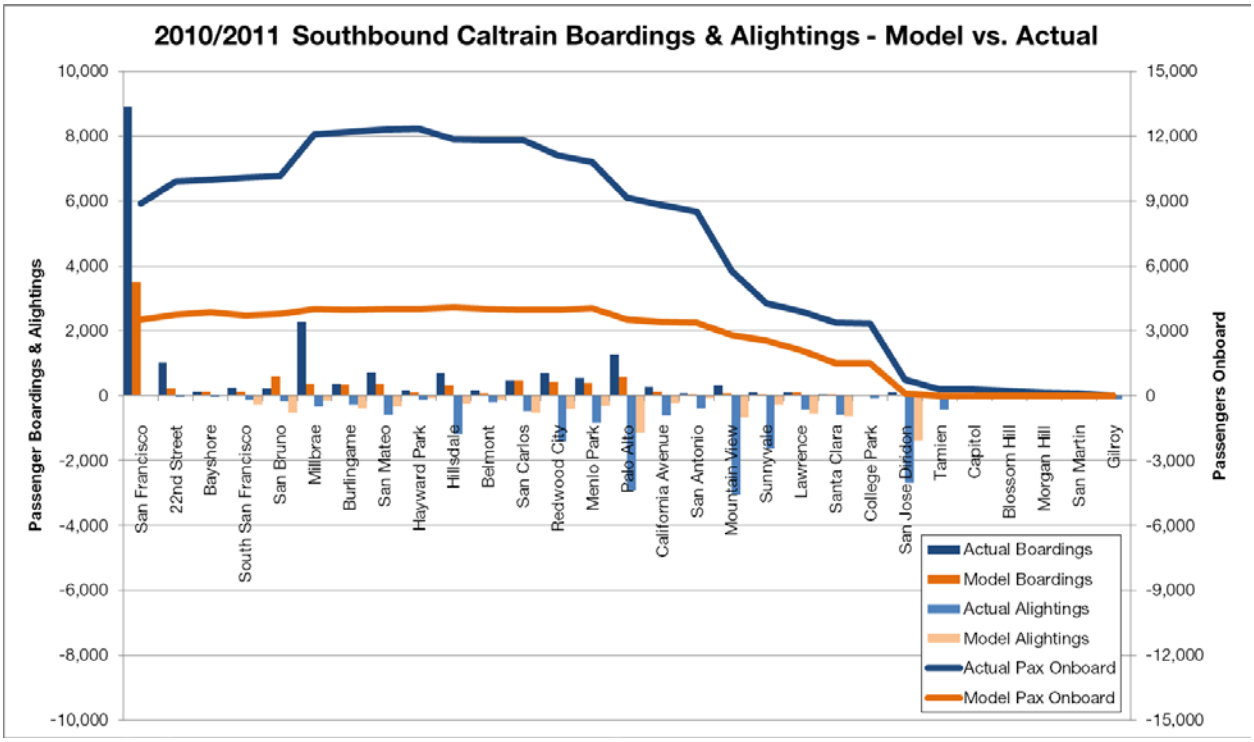

Figure 30: Observed and Simulated Caltrain Loading Pattern (Southbound)