FINAL REPORT

Independent Peer Review of the California High-Speed Rail Ridership and Revenue Forecasting Process

Findings and Recommendations from the January-April 2012 Review Period

May 29, 2012

The peer review panel met in person in San Francisco on January 9-10, 2012, by teleconference on February 2 & 6, and in person in Irvine on March 12-13. This report summarizes the principal discussions that occurred during these meetings, as well as key findings and recommendations. The topics covered during this period concerned (1) a detailed review of the model used to assess the 2012 Business Plan, key assumptions used with it and the reported ridership; (2) identification of preferred procedure making adjustments to account for choice based sampling; and (3) recommendations to guide the development of a new version of the modeling system, which we call Version 2. These issues are described in this report.

1 Evaluation of the 2012 Business Plan Forecasts

A number of alternative system configurations were evaluated during the preparation of the 2012 Business Plan. Thierry Prate from PB presented the scenarios tested and the results of the model runs. The Panel judged that the differences in ridership between scenarios were intuitively sensible. The Panel examined the definition of each scenario and its outcome with primary attention on some of the major inputs and assumptions used in the forecasts. The major items of discussion included the auto operating cost assumptions and the modal constants, which affect the mode choice and access and egress models. Thus, they apply to all scenarios tested. The Panel also examined how a mixed system of dedicated buses coupled with HSR between the San Francisco Bay and Los Angeles Basin should be represented in the model.

1.1 Auto Operating Cost Assumptions

Respondents in the SP survey used in mode choice model estimation were asked how their choices might change in response to changes in fuel prices and fuel cost per mile. This approach is somewhat different than asking them to consider vehicle operating cost (VOC), which is composed of both fuel and non-fuel cost components. In the version of the model used up to and including the draft 2012 Business Plan, these non-fuel VOCs (NF-VOC) are omitted during estimation (therefore they are accounted for by the alternative specific constants), but included during forecasting. A technical memorandum from Cambridge Systematics on this topic that was shared with the Panel can be found in the Appendix.

The Panel examined two issues relating to this topic. The first, concerning assumptions about future fuel costs used in forecasting, is discussed in Section 1.1.1. The second, concerning the omission of non-fuel VOCs in estimation but their inclusion during model application, is discussed in Section 1.1.2.

1.1.1 Fuel Costs Per Mile

The initial forecasts for the revised Business Plan included sensitivity analyses to fuel costs in the range of $0.21-0.25/mile in 2005 dollars, thereby taking into account fuel prices and fuel efficiency. A value of $0.17/mile, again in 2005 dollars, was subsequently suggested as a more realistic lower bound given expected increases in fuel efficiency through advancing vehicular technologies. This change in the lower bound would bring the implied fuel cost in line with U.S. Energy Information Administration (EIA) projections. The consensus of the Panel was that it is extremely unlikely that fuel prices will drop to a value such that fuel costs are reduced to $0.17/mile, but that this value should be tested to establish a lower bound that is more conservative with respect to HSR ridership. Subsequently, CS ran scenarios using this value as part of the “low” scenario which was used in the final Business Plan.

CS also presented results showing that HSR ridership is only moderately sensitive to vehicle operating cost (VOC) of automobiles. The log and arc elasticity of HSR ridership with respect to VOC, computed from model runs, is about 0.6 (that is, an increase or decrease in HSR ridership of 0.6% would be expected for each 1% increase or decrease in automobile VOC). The Panel believes this is a reasonable estimate. Intra-regional trips were found to be much less elastic with respect to fuel cost changes, and among inter-regional trips, non-business inter-regional travel is more sensitive to VOC than business trips. Both findings are intuitively sensible and are similar to findings in other models.

1.1.2 Non-Fuel VOCs and Modal Constants in Estimation and Calibration

The panel considered the question of whether non-fuel operating costs should be included in the auto mode when using the model for forecasts. The panel concluded that it would have been preferable to have added them into the cost variable used in model estimation, so that "cost" has the same interpretation in estimation as it is given in the forecasting phase. Thus, it examined what harm, if any, was done because this procedure was not followed. The panel concluded that this approach causes the results to have less precision in forecasting, but not necessarily to be biased for or against HSR because the modal constants were adjusted during model calibration to match observed modal shares.

This led to a further discussion of how that adjustment to modal constants was done, especially how the modal constant for high-speed rail (HSR) was adjusted relative to that for auto. The panel found the original documentation for this in a CS report on model calibration (titled "Statewide Model Validation," dated July 2007) to be inadequate, and asked CS for clarification. This was received in a February 3, 2012 memorandum, "Analysis of Modal Constants in the CA High Speed Rail Model." The panel concluded that the process of adjusting the HSR constant in the calibration stage, while not very precise, was not biased for or against HSR ridership. In particular, the HSR constant was appropriately adjusted in relation to the constants for the two most similar competitors for HSR, namely conventional rail and air. Therefore, the panel concludes that no systematic bias was introduced into the forecasts by omitting non-fuel VOC from model estimation and then using it during model forecast.

1.2 Bus Transfer and Access

Some of the scenarios considered in the Business Plan were specifically designed to assess ridership in the Initial Operating Segment (IOS) of Phase 1 of HSR development. These scenarios included dedicated bus connections into and from the Los Angeles Basin and the San Francisco Bay Area. In these scenarios a reduced HSR system, with termini at the edges of the Bay and Basin, was evaluated. The Panel examined how bus access was included in these scenarios and its likely effect on travel choices.

Transfer penalties reflect the perceived reliability of the service connections. In urban areas there is considerable variation in these penalties, reflecting the differences in services. When transferring from rail to bus the penalties are often small or zero, for example, in cases where departing buses wait until train arrival so that passengers have time to transfer between rail and bus even if the train is late. The penalties may be larger for the reverse movement, as buses are less reliable and trains may depart before all busses arrive to accommodate the majority of connecting passengers. In the CS forecasting work, these transfers were given the same rather large penalty as transfers between rail and bus for typical intra-urban trips. The panel assessed these penalties as

conservative with respect to HSR ridership because the coordination between train and connecting bus should make it an easier and better timed transfer than the typical intra-urban transfer. It was noted that a high percentage of riders on current Amtrak services in California connect by bus, suggesting that the impedance for that transfer is not great.

1.3 Station-Specific Flows in Initial Operating System (IOS) Forecasts

Initial results in the draft business plan showed some results that have puzzled the panel, as well as various commentators. Specifically, the forecasts for the IOS North (with connecting service between Merced and the San Francisco Bay Area) showed a large number of train boardings at Merced. They also showed a higher number of internal trips within the California Central Valley than the more fully built out system called Phase 1.

The panel looked carefully at these numbers, but concluded that they are reasonable. The high number of forecast boardings at Merced occurs not because Merced itself is generating a lot of ridership, but because it is a transfer point at which many riders taking the connecting service first get on the train. Furthermore, in order to accommodate the trips connecting through to the Bay Area, the assumed frequency of HSR service through Merced is higher than in the Phase 1 scenario (since those trips bypass Merced in Phase 1, traveling directly from Fresno into the Bay Area). This is why the HSR was forecast to carry somewhat more trips within the Central Valley in the IOS scenario than in the Phase 1 scenario.

2 Appropriate Adjustments for Choice-Based Sampling

The panel considered further the issue of appropriate adjustments for choice-based sampling in the estimation of the main mode choice model used by CS. This issue was identified as a flaw in the Version 1 model in a critique published by Brownstone et al (2010). The conventional adjustment method used in the model is standard in the industry. However, as was raised in our first report as well as in an earlier review, that method was shown in a recent research paper by Bierlaire et al (2008), hereinafter BBM, to lack a desirable property sometimes called asymptotic unbiasedness, which means that the estimator gets closer to the true value as the sample size increases. Specifically, the conventional procedure may produce parameter estimates that do not get closer to the true parameter values as sample size is increased, even if they are reasonably close in the sample being used.

After extensive discussion, the panel concluded that it is unlikely that this issue causes important errors in the forecasts, and therefore re-estimating the models using the BBM procedure is of low priority. Furthermore, it is not certain that using the BBM procedure would improve the model's performance, and we do not recommend using it for forecasts without extensive prior research to validate the procedure as it applies to this model.

We base these judgments on several considerations. First, the BBM procedure has had no practical use in any production models as far as we can ascertain (using a literature search, a citation search, and contacting the lead author of the BBM paper), and therefore there is too little experience to verify how well it performs in practice. Second, it is entirely possible for an estimator that is asymptotically unbiased to give worse results than one that is asymptotically biased because of lower precision, making prior experience essential to have full confidence in it. Third, our experience leads us to believe that often simple models perform nearly as well as, or even better than, more complex models even when the latter have theoretical advantages, because the

extra complexity may have unanticipated and undesirable effects on model accuracy. Fourth, the impact of any changes in the estimated parameters on model performance would be at least partially offset by changes in the constants when the model is calibrated to match observed modal shares from external data.

To summarize, we do not expect BBM to make a big difference and therefore its non-use in the Version 1 model is not an important defect. But like many other issues we have identified in the past, we think this one is worth investigating in the work leading to an enhanced model. At that time it would be desirable to test our expectation by estimating the main mode choice model with and without BBM and, if differences arise, to perform further tests to see which estimation procedure is producing greater accuracy.

3 Priorities for the Version 2.0 Modeling System

In its initial report, and in all subsequent deliberations, the Panel has anticipated the development of a thoroughly revised modeling system, which it has proposed be designated Version 2. It will build upon the lessons learned during the development and application of the Version 1 system. While the Version 1 system (as reported earlier in Cambridge Systematics' Final Report, 2007) was deemed satisfactory for conducting the analyses required to date, it may not support the more detailed design and investment decisions that are expected in the future. Professional best practices dictate the continual evolution of ridership forecasting models in order to incorporate new data, methodologies, assumptions, and software. In this case a second-generation model will address the remaining unresolved issues identified by the Panel in their first report, and will bolster professional and public credibility in the modeling process. Further, the next model will provide more accuracy at the increased levels of socio-economic, spatial, and temporal detail required for the detailed planning and impact analyses to be undertaken next by the Authority.

An evolutionary approach is recommended for the transition from Version 1 to 2. Such an approach will retain the structure and many parts of the existing model, enabling changes to be incorporated as soon as they are tested and validated, rather than waiting for an entirely new modeling system to be made operational. The recommendations presented in this section are predicated upon such an evolutionary approach.

3.1 Data Requirements

The Version 1 model was based exclusively on a set of stated preference (SP) surveys conducted in 2005. Adjustments were made for the Business Plan "Low" forecasts in part using travel data from the Harris Interactive Poll obtained in the summer of 2011.

The Version 1.1 model should initially be enhanced by:

1. Insofar as possible, incorporating RP data from the same data set as the SP data used in the Version 1 Model. Also, RP-SP estimation should take account of auto-correlation among SP responses by each respondent.
2. Maximizing its use of the recently completed Caltrans statewide travel survey as a complementary data set for short trips that can be incorporated using the existing zonal data, to the extent that such preliminary data are available
3. Using the updated land use and socioeconomic data at the zonal level compiled as part of the parallel Caltrans-UC Davis statewide modeling work. Updated socioeconomic fore-

casts that capture current thinking about likely trajectories of the California economy over the coming two decades should also be included.

The Panel has previously identified a number of long-term issues that can only be overcome with the collection and analysis of new survey data. These data will support easier re-estimation of model coefficients and obviate the need for adjustments currently required to update demographic and socioeconomic base. The RP portion of the data set should be designed and coded in a form to facilitate estimation using revealed preference (RP) and stated preference (SP) responses simultaneously, as is now common practice in travel demand modeling.

We strongly recommend that this survey include preferential sampling in conventional rail corridors (Amtrak and Caltrain) and that special attention be paid to SP responses from these individuals concerning use of high-speed rail, in order to instill greater confidence in the estimation of HSR modal constants in the modal choice portion of the model system. Furthermore, including RP data from people in these corridors will offer an opportunity for consistency checks to see if the modeled response to HSR service is similar to the modeled response to comparable hypothetical improvements in conventional rail.

3.2 Model Requirements

The following discussion of model development is set forth as a first cut to provide a basis for discussion with CS. This discussion should be considered recommendations to CS and HSRA which will be refined based on information and ideas provide by CS. Components may be assigned to different model versions and the time schedule will be developed.

The initial development of Version 1.1 will use existing data as described above. Continuing development with the new data to be collected will start as soon as that data has been collected and processed so that it is suitable for model estimation use. The Panel anticipates significant refinements to each of several components, to include:

- Line-haul mode choice
- Access and egress mode choice
- Peak versus off-peak time differentiation with different levels of service
- Access and egress station choice
- Trip generation (expanded to include non-resident travel)
- Destination choice

Each component will be updated in cycles, as most depend upon parallel enhancements made to other components. When made in a small number of increments these cycles will reduce the amount of validation work to be performed and isolate the effects of each set of changes on model performance and accuracy. Refinement of specific components is assigned to different model versions for further discussion with CS.

The inclusion of the urban models from the Southern California Association of Governments (SCAG) and Metropolitan Transportation Commission (MTC) in the LA Basin and Bay Areas, respectively, appears to contribute a substantial amount of complexity to the overall modeling system. The Panel believes that the benefits associated with these efforts are not worth the additional cost and complexity. A generic model with consistent structure and level of detail appropriate for intercity high-speed rail analyses is recommended.

The Panel considered several approaches to staging the model enhancements, settling on three model versions beyond the current Version 1 model. Version 1.1, is expected to occur over the next 12 months (July 2012 through June 2013); and Version 1.2 over the following year. Further development will be scheduled if considered necessary at that time. Both of these model updates will be carried out using existing data as described above. Thus, the Versions 1.1 and 1,2 will take place in parallel with new data collection and processing. Continuing development with the new data will start as soon as that data has been collected and processed so that it is suitable for model estimation use.

No time frame is proposed for Version 2, as the specification and development of its components will depend upon the timing and results of several data collection efforts, the most important being the work described in Section 3.1.

The model refinements proposed for each stage within each component are summarized in Table 1. It is anticipated that assembly of new zonal and network data from the California statewide model will precede the final development activities for Version 1.1. This will include coding of the HSR network and stations, which are not included in the statewide network. Moreover, the new combined RP-SP survey results will be required to fully complete the work leading to Version 1.1, although some new model formulations and utility expressions can be tested using existing data; indeed such testing has already begun as documented in Sections 3 and 4 of our second report.

3.3 Software Implementation

The current implementation of the model is unwieldy and complex, with long run times. Recent model runs have reportedly taken 48 hours to complete, and their preparation and interpretation has frequently taken weeks of time in addition. Indeed, some of the analyses completed recently were based on post-processing of earlier model runs because new runs could not be completed within the time constraints imposed by the Authority. These heavy computational and labor requirements have sometimes impeded the Panel's and the Authority's desires for sensitivity analyses and analysis of alternative specifications.

Sensitivity testing of estimated parameters and calibration results, as well as the effect of various exogenous assumptions, will be required as part of investment analyses likely to be undertaken in the future. The Panel recommends the addition of a software development team with experience in high-performance scientific and engineering computing that can assist in achieving improved runtime performance and incorporate some of the staff based pre- and post-processing within the model framework.

References

Bierlaire, M., Bolduc, D. & McFadden, D. (2008), "The estimation of generalized extreme value models from choice-based samples", *Transportation Research Part B*, 42(4), 381-394.

Brownstone, D., Hansen, M. & Madanat, S. (2010), Review of "Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study", Research Report UCB-ITS-RR-2010-1, Institute of Transportation Studies, University of California-Berkeley.

Table 1: Staging of recommended model improvements

Component	Enhancement(s)
Data collection and processing (Months 1 to 6)	
New zone and network data	1. Assembly of data developed for new Caltrans statewide model 2. Coding of HSR network and stations (not included in statewide model) 3. Replace SCAG and MTC intra-regional models with a simplified, generic version
New HSR RP-SP data collection	4. Data collection of new RP-SP data 5. Re-estimation of all Version 1 models with new data and pooled old+new data, accounting for inflation
Version 1.1 (Months 1 to 12)	
Mode choice	6. Travel time entered non-linearly (options include natural log, Box-Cox, and Mackie transform; preliminary estimation favored natural log, but since Box-Cox includes natural log as special case kept in consideration) 7. Auto operating cost variable to include estimate of non-fuel costs
Access/egress	8. Distinction between coefficients on in- and out-of-vehicle travel times 9. Consider the nature of possible constraints (equality, ratio) between coefficients of main mode in-vehicle and access mode in-vehicle travel time in the main mode and access mode choice components 10. Relax equality constraint for access and egress logsums
Trip generation	11. Employment to be included (so that projected future changes in employment/ population ratio can have appropriate effect)
Destination choice	12. Use many fewer constraints and find better specification of attraction variables 13. Look at the Caltrans-UC Davis statewide destination choice model for lessons learned about optimal model structure
All components	14. Recalibrate to 2008 without post-processing, for any versions using existing data 15. Joint RP-SP estimation with new HSR survey (weight RP versus SP appropriately), possibly in combination with existing SP survey data
Version 1.2 (Months 13 to 24)	
Mode choice	16. Elimination of "cliff effects" insofar as possible, by eliminating distinction between intra- and inter-regional trips and replacing with functional forms that make extreme values particularly unattractive
Access/egress	17. Consider replacing production-attraction structure with origin-destination format (to facilitate handling return trips) 18. Consider dividing measure of "access impedance" (e.g., in- or out-of-vehicle time) by the log of total distance
Destination choice	19. Investigate placing destination choice above access mode in nesting structure 20. Consider simultaneous estimation of station choice with mode choice and access/egress 21. Incorporate parking capacity and costs (free or charged?) at stations 22. Conduct station search among two best choices based upon a simplified criterion
Time of day	23. Disaggregate level of service by peak and off-peak. Allocate business and other trips separately to peak and off-peak using choice model or historic share. LOS will be based on start time of each trip.
All components	24. Eliminate distinction between short and long-distance trips
Version 2	
Access/egress	25. Simultaneously estimate access/egress and line-haul mode choice (joint estimation) 26. Determine whether trip duration influences station choice (e.g., access time/HSR distance)
Trip generation	27. Include non-resident trips

Appendix:

Range of forecasts of gasoline prices and fuel efficiency for use in 2012 Business Plan Model Runs and Forecasts (6 pages)

Memorandum

TO: California High Speed Rail Ridership and Revenue Peer Review Panel

FROM: Cambridge Systematics

DATE: March 9, 2012 (REVISED)

RE: Range of forecasts of gasoline prices and fuel efficiency for use in 2012 Business Plan Model Runs and Forecasts

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This memo summarizes a range of forecasts of gasoline prices and fuel efficiency as well as recommendations for combining these factors into auto operating costs for use in forecasting ridership and revenue for the California High Speed Rail (CHSR) project.

Gasoline Prices

The U.S. Energy Information Administration (EIA) provides the most current motor gasoline forecasts out to year 2035 for three different scenarios in its 2011 Annual Energy Outlook (AEO): reference, low, and high. Table 1 shows the EIA 2011 motor gasoline forecasts from 2015 to 2035 in 2009 dollars. The CHSR ridership and revenue model runs are at 2030 levels. The spread between the low and high forecast for 2030 is considerable—from $2.24 at the low to $5.26 at the high—a spread of over three dollars. This spread is greater than developed by other sources, such as those by the California Energy Commission that forecast a range of about $3.10 to $4.80 in 2008$.[1]

Table 1: Forecast U.S. Transportation Motor Gasoline Prices
2015-2035, in 2009$[1]

Year	Low	Reference	High
2015	$2.17	$3.13	$4.27
2020	$2.30	$3.38	$4.85
2025	$2.12	$3.54	$5.12
2030	**$2.24**	**$3.64**	**$5.26**
2035	$2.12	$3.71	$5.36

Source: Annual Energy Outlook 2011
(1)Sales weighted-average price for all grades. Includes Federal, State and Local taxes.

[1] California Energy Commission, Transportation Energy Froecasts and Analyses for the 2009 Integrated Energy Policy Report, Final Staff Report, May 2010

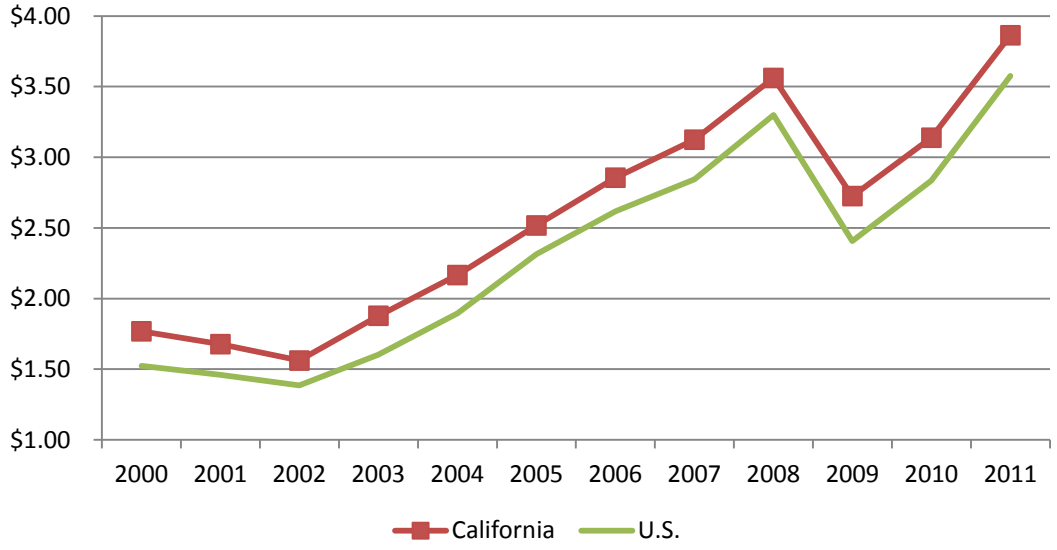
Historically, California retail gasoline prices have been an average of 12 percent higher than the U.S. average (Figure 1.) CS developed a forecast of California gasoline prices by taking the 2030 forecasts from EIA (from Table 1) and increasing by 12 percent (Table 2.) Table 2 shows the prices expressed in:

- 2009$ - consistent with EIA
- 2005$ - consistent with what is used in the travel demand model
- 2010$ - consistent with the Draft Business Plan
- 2011$ - consistent with other dollar amounts in the 2012 Business Plan

The currency conversions use the California consumer price index (CPI) values of:

- 202.6 for 2005
- 224.110 for 2009
- 226.919 for 2010
- 232.931 for 2011

Figure 1: Annual Retail Gasoline Prices (dollars per gallon) 2000-2011, nominal dollars



Source: U.S. Energy Information Administration: Annual All Grades All Formulations Retail Gasoline Prices

Table 2: Forecast 2030 Motor Gasoline Price in California Expressed in 2005, 2010 and 2011 dollars

Currency Year	Description	Low	Reference	High
2009$	*Based on EIA, increased by 12% for California*	*$2.51*	*$4.07*	*$5.88*
2005$	Used in travel demand model	$2.26	$3.68	$5.32
2010$	As expressed in Draft Business Plan	$2.54	$4.12	$5.96
2011$	2012 Business Plan	$2.60	$4.23	$6.11

Source: CS analysis of Annual Energy Outlook 2011

Vehicle Fuel Economy Forecast

The U.S. Energy Information Administration also provides projections on fuel economy (mpg) for light-duty vehicles through year 2035 for three cases:

- **Reference Case –** In 2007 the Energy Independence and Security Act (EISA) was signed into law to tighten the Corporate Average Fuel Economy (CAFE) Standards. The law established a target of 35 miles per gallon for the combined fleet of new cars and light trucks by model year 2020 starting with model year 2011. In 2009 the President implemented a new national policy (a.k.a. National Program) and set stringent CAFE standards to increase fuel efficiency and reduce greenhouse gas emissions for all new cars and trucks sold in the United States beginning in 2012. The new CAFE standards apply to model years 2012-2016 for all passenger vehicles, including cars, light trucks and SUVs. Significant improvements in fuel efficiency are required on all new vehicles in 2012 model, with yearly gains of 5 percent or more in subsequent years. In 2010 California accepted compliance with these federal GHG standards as meeting similar state standards and incorporated the national standards into their motor vehicle emissions program.[2,3] We interpret this to mean that in the future, national and California standards will be the same, even though in the past, California standards have been more stringent.

  The *AEO2011 Reference case* includes the attribute-based CAFE standards for light-duty vehicles (LDV) for model year (MY) 2011 signed originally in 2007 and the 2009 CAFE standards for MY 2012 to MY 2016. The reference case results in fleet fuel economy for new cars of 35.8 miles per gallon by 2030.

- **CAFE 3% Growth –**Per a Presidential memorandum submitted in 2010 to NHTSA and EPA,

[2] EPA (http://yosemite.epa.gov/opa/admpress.nsf/1e5ab1124055f3b28525781f0042ed40/6f34c8d6f2b11e5885257822006f60c0!OpenDocument)

[3] California Air Resources Board, Statement of the California Air Resource Board Regarding Future Passenger Vehicle Greenhouse Gas Emission Standards, May 21, 2010.

a new proposal to further reduce GHG and improve fuel economy for model years 2017-2025 is under way. These federal agencies, along with the California Air Resources Board (CARB), are collaborating on the second phase of the program and are developing new standards for the new generation of clean vehicles. In 2011 the NHTSA and EPA issued a Supplemental Notice of Intent (NOI) outlining the agencies' plans for proposing the model years 2017-2025 standards. The State of California provided letters of support for the program.

EIA provide forecasts that approximate the effects of the second phase of the National Program. The CAFE 3% Growth (CAFE3) case is a modified Reference case that assumes a 3-percent annual increase in fuel economy standards for MY 2017 through MY 2025 LDVs, starting from the levels for MY 2016 LDVs, with the subsequent post-MY 2025 standards held constant. By 2030, this would result in fleet fuel economy for new cars of 46.3 miles per gallon.

- **CAFE 6% Growth –** The CAFE 6% Growth (CAFE6) case assumes a 6-percent annual increase in fuel economy standards for new LDVs from MY 2016 levels for MY 2017 through MY 2025, with the subsequent standards held constant. The fleet fuel economy for new cars by 2030 would be 59.5 miles per gallon under this scenario.

Table 4 shows the fuel economy projections for the Reference, CAFE3 and CAFE6 cases, as well as an average between CAFE3 and CAFE6 for the entire fleet of vehicles (not only new vehicles.)

Table 3: Projections of Fuel Economy of Light-Duty Vehicles

	Light-Duty Stock[1] (mpg)			
	Reference	**3% LDV fuel economy growth**	**6% LDV fuel economy growth**	**Average of 3% and 6% Fuel Economy Growth**
2015	22.1	22.1	22.1	22.1
2025	25.7	28.6	30.2	29.4
2030	**27.0**	**31.8**	**35.3**	**33.6**
2035	27.9	34.0	39.4	36.7

Source: Annual Energy Outlook 2011, Transportation Sector Key Indicators and Delivered Energy Consumption
Notes:
(1) Combined "on-the-road" estimate for all cars and light trucks

2030 Auto Operating Cost Estimates

CS estimated a range for auto operating costs (Table 4) incorporating both fuel and non-fuel components.

Fuel Component

While the lowest auto operating cost could be achieved by combining the high fuel efficiency with the low gasoline price, and the highest cost could be achieve by assuming the reverse, it is more reasonable to assume that high prices will coincide with high fuel economy, and low prices with low fuel economy. While fuel economy is not nearly as volatile as fuel prices, it is reasonable to assume that over a long period of time, high prices will drive the demand for better fuel economy. Since we do not know where the CAFE standards will land (at CAFE3 or CAFE6), we used an average of the two for the High HSR case, and the reference standard for the Low HSR case. The average of the low and high fuel efficiency was assumed for the Medium HSR case.[4]

Table 4: 2030 Auto Operating Cost Assumptions for 2012 Business Plan

	Low HSR Scenario			Medium HSR Scenario			High HSR Scenario		
	2005$	**2010$**	**2011$**	**2005$**	**2010$**	**2011$**	**2005$**	**2010$**	**2011$**
Motor Gasoline	$2.26	$2.54	$2.60	$3.68	$4.12	$4.23	$5.32	$5.96	$6.11
Fuel Efficiency (mpg)	27.0	27.0	27.0	30.3	30.3	30.3	33.6	33.6	33.6
Gas Operating Cost ($/mile)	$0.08	$0.09	0.10	$0.12	$0.14	$0.14	$0.16	$0.18	0.18
Non Gasoline Operating Cost ($/mile)	$0.09	$0.10	0.10	$0.09	$0.10	$0.10	$0.09	$0.10	0.10
2030 Auto Operating Cost ($/mile)	**$0.17**	**$0.19**	**$0.20**	**$0.21**	**$0.24**	**$0.24**	**$0.25**	**$0.28**	**$0.28**

Source: CS

Non-Fuel Component

For the original model calibration effort in 2006-2007, non-gasoline operating costs were assumed to be 67 percent of the gasoline costs.[5] For the 2012 Draft Business Plan work, CS used 9 cents per mile in 2005$ as the non-gasoline operating costs for autos (56 percent of the assumed 16 cents per mile gasoline cost). However, the non-gasoline operating costs are likely to be less volatile than fuel prices, so it is reasonable to keep this as a constant amount, modified only by inflation over time. We retain this fixed amount per mile in these calculations, which equates to 10.3 cents per mile in 2011$.

[4] Note that the medium case is not being modeled directly, but is being constructed by PB as the average of the high and low cases.

[5] Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study, Levels-of-Service Assumptions and Forecast Alternatives, prepared for Metropolitan Transportation Commission and California High-Speed Rail Authority, prepared by Cambridge Systematics, Inc., August 2006, Table 2-1, page 2-2.

Total Auto Operating Cost Assumptions for Modeling

Based on the foregoing assumptions, we are assuming a range of auto operating costs from:

- 17 to 25 cents per mile in 2005$
- 19 to 28 cents per mile in 2010$
- 20 to 28 cents per mile in 2011$.

These are used as the relevant low and high inputs into the business plan modeling.