FINAL REPORT

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

Findings and Recommendations from April-July 2011 Review Period

August 1, 2011

1 Introduction

The peer review panel held its second formal meeting on May 2-3 at the offices of the San Francisco County Transportation Authority. All members were present except for the recorder, who attended via videoconferencing:

- Frank S. Koppelman, PhD, Professor Emeritus of Civil Engineering, Northwestern University (chair)
- Kay W. Axhausen, Dr.Ing., Professor, Institute for Transport Planning and Systems, ETH Zurich (Swiss Federal Institute of Technology Zurich)
- Billy Charlton, San Francisco County Transportation Authority
- Eric Miller, PhD, Professor, Department of Civil Engineering and Director, Cities Centre, University of Toronto
- Kenneth A. Small, PhD, Professor Emeritus, Department of Economics, University of California-Irvine

Rick Donnelly, PhD, AICP of Parsons Brinckerhoff served as facilitator and recorder for the panel. In this capacity he serves at the convenience of the chair rather than as a representative of the project management team.

The panel invited several others to attend some portions of the meeting. They included Nick Brand from Parsons Brinckerhoff (representing the project management team) and Jeff Buxbaum, David Kurth, and Kimon Proussaloglou from Cambridge Systematics (CS). During the meeting the following broad topics were discussed:

- Briefing on ridership forecasting milestones in the near future (all in attendance)
- Discussion of the proposed Cambridge Systematics work plan for model enhancements (all in attendance)
- Review of CS responses to issues of concern identified in previous peer review panel findings (closed meeting among panelists)
- Discussion of panel assessment of CS responses (all in attendance)
- Identification of topics for further discussion and wrap-up (all in attendance)

Several topics discussed in the meeting were left unresolved, pending further investigation by the CS team. In such instances one or more panelists identified issues or questions during the meeting that could not be answered without further research or model summaries. The panel subsequently met with the CS staff identified above in videoconferences on May 27th and June 14th, 2011 to receive and discuss their responses. This report documents the findings over the panel from all three meetings, as well as teleconferences and email exchanges during that time.

2 Review of Supplemental Documentation

We identified two areas of concern about documentation in Section 3 of our first report. In some instances documentation was incomplete or missing. In other cases key information needed to interpret previous model validation work was not found. CS resolved both issues over the past three months. In addition, CS has re-validated the current model using more recent socioeconomic, travel survey, and traffic count data. The review of this newer data has largely alleviated our concerns with previous gaps of documentation on this subject.

2.1 Documentation Addenda

Following our initial meeting in January, we identified a number of missing, incomplete, or confusing aspects in the documentation. There was no evidence that these issues pointed to problems with the model, but rather that a thorough review of the model could not be completed without this additional information. CS developed a 43-page memo (Cambridge Systematics 2011) summarizing their responses to the information we requested, shown in Table 1. While their responses were limited to information about inter-regional travel[1], we felt that this was highly responsive to their needs, and permitted us to make well-informed impressions of the current model.

Table 1: Incomplete documentation identified in first peer review panel report

Further information about inputs to model application were sought in the following areas:

- Fare levels and structures
- Levels of highway and airport congestion
- Levels of service (train frequency)
- Levels of ridership and service on competing intercity bus services
- Fuel prices
- Induced effects
- Competitive responses from other modes
- Socioeconomic and land use forecast inputs

Further documentation of the model validation results were sought, to include:

For the calibration year only

- Maps, graphs, and tabular summaries of statistical measures of the deviation between assignment results and observed modal flows (road, air, rail)
- Tabular summaries of comparisons of assigned versus screenline volumes

For both calibration and forecast years

- Overall mode shares by origin-destination distance
- Mode shares by income
- Tables and maps of long distance trips per day by person type and trip purpose
- Summary of income elasticities by mode

For forecast years only

- Mode shares by network distance from HSR stations
- Tables of own- and cross-elasticities by model for the time and cost variables across the state, by OD distance or intra-regional pairs, by income group and distance band from HSR stations
- A brief assessment of access and egress mode shares by HSR station
- Analysis of the effects of forecasts of expert judgments that were made to override estimated model coefficients

[1] As part of their model design CS defined regions of the state that are aggregations of counties. Inter-regional trips are those with trip ends in different regions, irrespective of the distance traveled, while intra-regional trips have both trip ends within the same region. A map of the regions can be found in Cambridge Systematics (2006).

We reviewed this memo and its predecessors in great detail, and several hours were spent discussing the information presented. We were very pleased with content, quality, and quantity of the information. Only a few items left us with lingering concerns. We continue to struggle with the arbitrary distinction between intra-regional and inter-regional trips, although we understand the practical rationale for it. We would like a more clearly defined demarcation of geographic travel segments in future work, if the distinction is maintained at all.

We have been concerned about the possibility of discontinuity in mode choice at the 100-mile demarcation between local (less than 100 miles) and long-distance (greater than or equal to 100 mile) travel markets. CS presented evidence that indeed such a discontinuity does occur, but the effect was shown to be small. If the long versus short distance segmentation is retained in the model structure, clear and conclusive evidence should be produced to demonstrate that any remaining discontinuity is small enough to have little to no impact on model forecasts. CS is currently undertaking an exploration of the effect of combining the long and short distance models into a single model that takes account of distance in the model specification. The initial results of such work will be presented to the panel at the planned August 10th and 11th meeting.

We also noted that the reported elasticities for total auto trips with respect to auto travel times have unexpected signs in Table 12 of the CS memo (Cambridge Systematics 2011, but also that they were very small in magnitude and not statistically significant. The panel believes that this anomaly is of negligible importance and is adequately explained by location-specific differences in trip generation effects (as suggested in the CS memo), and is therefore satisfied that no further action is needed with respect to this particular finding.

We are satisfied with the documentation presented in Cambridge Systematics (2011), and conclude that it demonstrates that the model produces results that are reasonable and within expected ranges for the current environmental planning and Business Plan applications of the model.

The longer-term issues mentioned in Section 5 of our report from January, 2011 remain unaddressed. We continue to view these as critical to a full assessment of the credibility of model forecasts for future applications. These were examined in the panel's August meeting and our conclusions will be reported shortly.

2.2 Expanded Validation Efforts

This section considers the work being done by CS to validate and, if necessary, adjust the model to reflect changes in socioeconomic conditions and travel patterns since the years 2000 and 2005, which were the sources of the data used in model development. CS has developed a proposed work plan for enhancement of the current model to address expected future needs of the Agency and our recommendations. We reviewed their fourth draft of the proposal, dated April 20, 2011, in preparation for the May 2-3 meeting. We discussed the proposal at length, and compared it to both the short and long-term recommendations they made after their January, 2011 meeting.

Jeff Buxbaum of CS summarized the anticipated uses of the current model. Owing to the business plan deadline the CS team plans several short-term actions:

- Collection of data for re-validating the model to observed 2008-09 flows. This was scheduled for completion in May and June.

- Changes to the model based on the re-validation work, schedule for completion in June, resulting in an interim model to be used until the next generation model is complete.
- Continued to work on ridership and revenue forecasting with the existing model to evaluate different configurations of initial operating segments (IOS), Phase 1, and the full system, scheduled for completion in July.

In parallel to these efforts, CS staff is also planning to carry out enhancements that will be incorporated into the interim model after the business plan forecasts are complete. These enhancements are discussed in Section 4. We discussed the relationship between the current, interim, and possibly a model to be developed in the future, both during the May 2nd meeting and in subsequent internal discussions. We emphasized that any model development work beyond that needed for the IOS and 2011 business plan should be directed towards addressing the long-term issues previously identified in addition to meeting the schedules and capabilities required by the Authority. How exactly that can be done was discussed at length, as summarized in the remainder of this section.

Two important inputs identified for the re-validation work were analyses of the 10 percent sample of air passenger tickets and an Internet panel survey of long distance journeys. The former is being processed by Geoffrey Gosling as part of his work, while the latter will be performed by Harris Interactive to specifications developed by the CS team.

CS plans to use the Harris Interactive data to learn more about long distance journeys in relation to traveler and household attributes (e.g., income, household size, number of workers, auto availability). Harris has a pre-selected and verified a panel of respondents, from which they can deliver responses for a wide variety of desired sample frames. We discussed the representativeness of a pre-selected panel for intercity travel market analysis. While a specially-drawn random sample might in principle offer advantages, time and budget constraints precluded this possibility and the use of the Harris poll clearly represents the most cost-effective way to quickly obtain data needed for short-term improvements to the model.

Two other sources of data – retrospective travel surveys and an upcoming California Department of Transportation (Caltrans) statewide travel survey – represent other possible sources of information to support model development. Again, undertaking a retrospective survey simply is not feasible within the scope of the current work, while the Authority does not appear to be able to influence the design, sampling frame, or other details of the Caltrans survey. While the Harris poll data will provide very useful immediate input to the model upgrade, comparison to the results of the Caltrans statewide travel survey, as soon as it becomes available, will provide additional useful information for the modeling work as well as an additional check on the Harris poll results.

Other potential sources of travel behavior data discussed included the 2009 National Household Travel Survey (NHTS) and Amtrak passenger surveys. The number of intercity trips in the NHTS is very small, greatly reducing its utility for use in this work. California was not one of the states that purchased additional sampling to increase the number of observations using rural and intercity travel. Amtrak historically has not shared data, but CS agreed to renew attempts to identify and obtain relevant data from them. The panel felt that this information would be particularly

useful for the analysis of IOS alternatives in the Central Valley, where Amtrak will be a larger competitor to HSR than air service.
The CS team is also planning to adopt the networks and zone system being used by the statewide travel model under development by the University of California at Davis (UCD). The zone systems of that and the current model are slightly different, but this is not expected to create significant difficulties.

Furthermore, 2030 socioeconomic forecasts are not yet available for the UCD zone system. Jeff Buxbaum reported that new economic data from economy.com will be purchased as a placeholder until an independent economist can be contracted to provide an alternative to the forecasts presently used. We endorses this approach, believing that the testing of alternative economic futures will enhance the credibility of the model with policy-makers and potential investors and enable them to better gauge the risk associated with such assumptions in the forecasts.

3 Short-Term Issues Resolved

We found that significant progress has been made in the resolution of many short-term issues identified in Section 4 of our January 2011 report.

3.1 Representation of Distance Effects in the Model

In Section 4.1 of our first report, we expressed concern about the representation of distance in the destination and mode choice models. In response to our comments, CS conducted tests demonstrating that the discontinuity between the short and long-distance models at 100 miles is present but not quantitatively significant. The evidence from their testing suggests that the number of trips affected is very small, leading us to conclude that further work on this issue – which would likely take the form of joint models of short and long-distance travel – can be deferred and dealt with as part of developing an updated version of the model.

3.2 Observed Heterogeneity

In Section 4.2 of our first report, we outlined concerns that observed heterogeneity was not adequately treated in the current model. At the time, we found no evidence that the forecast results were biased in aggregate, but that an improvement in this area (i.e., characterizing some parameters as functions of distance or household characteristics) was a candidate for quick resolution. CS conducted exploratory estimations of alternative mode choice models that explored the influence of income and its interaction with other variables. This led us to conclude that the effects were significant, which is in line with typical findings from both urban and statewide models, and should be included in an enhanced model structure when possible. However, we found no evidence that the current treatment of income biases model results toward more or less optimistic forecasts.

3.3 Examination of Level-of-Service Variables

In Section 4.3 of our first report we criticized the lack of sensitivity testing of key service variables. CS conducted a large number of sensitivity tests over the past few months that are documented in Cambridge Systematics (2011). We are satisfied that the model is appropriately sensitive across the range of values tested, leading us to conclude that this issue has largely been resolved, apart from station access.

3.4 Constraint on HSR Vehicle Headways

In Section 4.4 we expressed concern with the original model's constraining of the coefficient on headway to equal that of travel time, for the HSR mode. This was in response to several problems, as described in the original CS final report (Cambridge Systematics 2006) and the Authority's response on this issue (CHSRA 2010). We continue to believe that a better solution would have been to fully re-estimate the model in ways described in our first report. However, the schedule for producing the 2011 business plan and other deadlines beyond the control of the Authority precluded delaying the project for the four to six months that such work would have required. We also recognize that a viable model sometimes needs professional judgment to overrule statistically estimated parameters, and any of us might also have made such a decision in similar circumstances.

We have examined in detail the question of how the model performs with respect to headway. It is important to note that the portion of waiting time that is independent of headway (e.g. walking time from a station entrance to a platform) is presumed to be included in the mode-specific constants of the model. Thus, the constrained coefficient truly reflects only the effect of headway in mode choice, and cannot be expected to equal the ratio of out-of-vehicle to in-vehicle travel times.

CS calculated the elasticity of total HSR ridership with respect to HSR headway at approximately -0.30 (see last two rows of Table 14 in Cambridge Systematics (2011). This elasticity is about the same size that the panel would expect, based on experience with urban transit and accounting for the expectation that headway is likely to be less important in intercity than in urban transit. It also compares well to elasticities found in a national survey in Switzerland, covering trips 10-300 km in length, whose values are shown in Table 2. Furthermore, the panel feels that if the original model had kept the estimated coefficient (which was approximately one-

Table 2: Swiss elasticities for long distance travel (Source: Vrtic & Axhausen 2003)

Demand elasticities shown for distances greater than 10 kilometers
(SP parameters at the mean values of the underlying RP trips)

Parameter(s)	Mode	All	Commute	Business	Shopping	Leisure/ Vacation
Travel time car	Car	-0.425	-0.665	-0.68	-0.545	-0.53
	Train/transit	0.671	0.776	1.531	1.008	0.937
Cost car	Car	-0.121	-0.312	-0.076	-0.156	-0.174
	Train/transit	0.191	0.365	0.171	0.288	0.308
In-vehicle-time train/transit	Car	0.365	0.48	0.615	0.46	0.456
	Train/transit	-0.575	-0.56	-1.386	-0.85	-0.805
Fare train/transit	Car	0.157	0.435	0.092	0.223	0.217
	Train/transit	-0.247	-0.508	-0.206	-0.512	-0.373
Access/egress train/transit	Car	0.172	0.272	0.111	0.279	0.127
	Train/transit	-0.272	-0.318	-0.249	-0.515	-0.224
Headway	Car	0.144	0.32	0.154	0.121	0.116
	Train/transit	-0.277	-0.374	-0.346	-0.224	-0.205
Number of travelers	Car	0.115	0.133	0.151	0.101	0.134
	Train/transit	-0.181	-0.156	-0.339	-0.186	-0.237

fifth as large as the value they constrained it to), the resulting elasticity would have been too low to be plausible. Therefore, we conclude that in the end, this problem with the model did not misrepresent traveler behavior in important ways.

3.5 Excessive Use of Constants

In Section 4.5 of our first report we criticized the excessive use of alternative-specific constants. The fear was that this would cause the model to be unrealistically unresponsive to changes, or to display paradoxical responses to changes in conditions. The extensive documentation provided to us by CS, in response to our first report, does not reveal such unrealism or paradoxical behavior. Therefore, this originally perceived problem with the model does not seem to be adversely affecting its behavior. In particular, we now think that the magnitude of alternative specific constants is neither an indication of poor model fit nor of inadequate representation of the impact of operational or travelers variables on behavior. That said, we still believe that every effort should be made to eliminate the use of such a large set of constants in future versions of the model. They represent current travel patterns that may not hold true under future conditions.

4 Initial Investigations into Mode Choice Model Improvements

In parallel with addressing the short-term issues described above, CS invested considerable effort exploring alternative mode choice model formulations, both to inform future model development work and to investigate the robustness of their current model to changes in specification. The bulk of this work has focused upon the re-estimation of the line haul mode choice models. We anticipate that this work will be incorporated into a new version of the modeling system that will be available for use sometime in 2012.

4.1 Long Distance Mode Choice Model for Business Trips

The panel previously expressed reservations about the omission of income from the current line haul mode choice model. Several model formulations designed to incorporate this effect and others were presented, all with encouraging estimation results. The panel offered several observations and interpretations of the findings, all of which were agreed with by CS:

- The model was tested using both three and seven groupings of income. The panel agreed that three income levels, as suggested by CS, appeared to perform as well as seven, and this smaller number of categories is easier to forecast and implement. These income categories, plus one for missing income information, substantially improve the model and give sensible results when interacted with the cost variable. We maintain our longer-term recommendation that estimation of imputed income be undertaken to (1) obtain continuous values of household income to replace the current categorical variables, and (2) provide income estimates for households for which no income response was given.
- With respect to mode-specific dummy variables for income categories, it appears that interacting cost and performance variables with all income categories would be over-fitting. We recommend retaining only the high-income category for this purpose. We continue to recommend that over the longer term, a variable defined as cost adjusted by a function of income be explored when additional choice data (revealed or stated preference) becomes available.
- Reliability was found to be statistically insignificant for business trips. This was not entirely unexpected, as some panel members suspect that the effects of reliability are

embedded in the constants due to an inability of SP data questions to fully capture reliability as viewed by the user. New data collection should consider representing reliability in terms of the distribution of possible travel times, so that a variable could be constructed representing the time difference between the median and 80th (or 90th) percentile of the time distribution. Small, Brownstone, and colleagues, who have devoted substantial efforts to studying the usefulness of alternative measures of reliability, has adopted this formulation. It was also felt that reliability might become a more significant determinant of behavior as highway congestion increases. In principle, reliability is a relevant policy variable for designing a rail system because it can help guide operational decision-making. In practice, however, reliability cannot be forecasted accurately enough at this time for it to be a useful part of the demand model for its short- and medium-term uses. Rather, it would be desirable to include this variable as an enhancement of models to be estimated for longer-term future uses.

- Including non-linear distance interaction effects led to a significant improvement in model fit without major changes in time, cost, or other coefficients. We agree with the CS proposal to include it as in Interim Models 2A and 2B in Table 4 of Cambridge Systematics (2011). Additional refinements for the longer term that are worth exploring are: (1) replacing the distance interaction with use of non-linear transforms of the base variables (e.g., powers of line haul travel time); and (2) differentiating non-linear distance interaction effects or non-linear transforms of base variables by time of day.

Overall we were satisfied with the estimation results, and strongly endorse their inclusion in the next version of the modeling system.

4.2 Long Distance Mode Choice Model for Non-Business Trips

CS has tested several alternative formulations of the model of non-business and non-commuting trips over the past several months. The most promising ones were shared with us during the May 2-3 meeting in San Francisco and in subsequent videoconferences. In this model, unlike the model of business trips, the inclusion of income led to unsatisfactory results, leading us to recommend removing income from this portion of the model until further investigation with new data can take place.

Paradoxically, reliability proved to be a reasonably strong factor in this model, whereas it was not for the business long distance travel. Because of that paradox, we recommended that reliability be excluded from this model, as well as the model for business trips, for the reasons outlined in Section 4.1.

The specification and interpretation of the headway coefficient were discussed at length, as in the case of the model of business trips. As before, one cannot choose between competing specifications solely based on estimation results. We were concerned that the SP experiment described to survey respondents included frequencies between one and two trains per hour, but that the application range is much larger. As a result, any tapering effect at higher frequencies, which is likely a priori and might be important to forecasts, would not be detected within the bounds of the SP survey. In this case, the difference between using frequency versus logarithm of frequency as a variable would be important. Insofar as it is feasible and fits well, we recommends that the same specification be used in both the business and non-business long distance models.

We make the same recommendations with respect to the distance coefficient in this model as it does for the model of long-distance business trips. Overall, we are satisfied with the estimation results, view the resulting model as superior to the current formulation, and recommend that this enhanced model be implemented as quickly as possible. Future analyses should examine a non-linear transformation of several variables in place of interactions with distance.

4.3 Models of Short-Distance and of Pooled Short and Long-Distance Trips

The CS team briefly presented three short distance models. They covered business, commuting, and non-business travel. In addition, the team presented a combined model of mode choice that includes both short and long-distance trips. These models each had some advantages and disadvantages, leading us to recommend further model development. It noted that when the in-vehicle time, cost, and service frequency variables were differentiated between commuting versus business travel, the resulting coefficients were significantly different, suggesting the need for separating these two purposes.

4.4 Restructuring the Segmentation of Trips by Purpose Rather than Distance

CS estimated models that differentiated between commuting and business travel. Several interesting results were obtained, including a reduction in the magnitudes of the in-vehicle time coefficients relative to the current model, smaller egress logsum coefficients, and reasonable implied values of time by income segment. However, the nesting coefficients were slightly higher than 1.0 (although perhaps not significantly so), and model fit was better for business-only travel versus pooled commuting and business purposes. When the in-vehicle time, cost, and service frequency variables were differentiated between commuting versus business travel, the resulting coefficients were significantly different, suggesting the need for separating these two purposes.

5 Conclusions

The work completed by CS since the first meeting of the panel has greatly improved our confidence in the existing model. We were encouraged by the depth and extent to which CS addressed the short-term issues we identified in January. Further, we support the work that CS has undertaken to date for model improvement. This conclusion is based upon the work they have done to address those issues identified by ourselves and critics as potentially critical shortcomings of the model. In addition, our examination of additional data and analyses provided to us by CS, has led us to determine that these issues are not critical to current applications of the model.

We also find that the strategy being used by CS to go forward, namely building a substantially improved model for future work, is paying off very well. Key to this strategy are improvements to the mode choice model, which have in part now been completed as described in Section 4 of this report, and we believe this component of the model will provide a sound basis for the further demands on the model called for by future forecasting needs.

References

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The CHSRA and Cambridge Systematics references are available online at http://www.cahighspeedrail.ca.gov/Ridership_and_Revenue_Forecasting_Study.aspx