FINAL REPORT

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

Findings and Recommendations from the August-October 2013 Review Period

December 29, 2013

The Peer Review Panel held its tenth formal meeting on September 25-27, 2013 at the California High-Speed Rail Authority's offices in Sacramento. The Panel also conducted discussions via electronic mail, teleconference, and videoconferencing both before and after this meeting. This report covers their activities and deliberations from August through October 2013. The panelists include:

- 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)
- Eric Miller, PhD, Professor, Department of Civil Engineering, University of Toronto
- David Ory, PhD, Principal Planner/Analyst, Metropolitan Transportation Commission
- Kenneth A. Small, PhD, Professor Emeritus, Department of Economics, University of California-Irvine

All panelists were present in person for the meeting except for Dr. Axhausen, who attended for part of the time via videoconferencing. Rick Donnelly, PhD, of Parsons Brinckerhoff (PB) served as facilitator and recorder for the Panel. Thierry Prate of PB was invited to attend the meeting as a representative of the program management team. Jeff Morales, executive director of the Authority, briefed the Panel and received input from them on the final morning of the meeting. The meeting was otherwise closed to non-members.

The Panel briefed CS by teleconference on the findings summarized in the next section at the end of the meeting. Their feedback is incorporated below as deemed appropriate by the Panel. In other cases their responses clarified issues raised by the Panel or obviated the need for further discussion.

1 Review of Version 2 Model Development

The Panel reviewed a number of interim reports prior to and during the meeting that described the work to date on the Version 2 model system. The work reviewed was of commendably high quality, and provided evidence that a great deal of work has been accomplished in the three months since the Panel last met. It is acknowledged that the documentation will lag behind the actual model development work. When this work is complete a report describing the entire Version 2 model development should be prepared by the contractor and reviewed by the Panel. The Panel would like to see a discussion that links the key activities of calibration, validation, and sensitivity testing. Insight into how the estimation results were interpreted is needed, as well as the rationale for the model design choices that were made. Such decisions can be inferred in some cases, but not in others. In short, a document telling the "model development and testing story" is desired.

When reviewing discrete choice model estimation results in the future the rho-squared statistic with respect to zero should be reported in addition to the same with respect to constants. T-statistics should be reported for all variables.

1.1 Comparison of Version 2 model and peer review recommendations

CS prepared a memo on September 11, 2013, describing the high-level design of the Version 2 modeling system, and how that differs from the recommendations of the Panel. The memo provided a highly informative and well-written summary of their progress to date. Several questions from the Panel's first reading of it were discussed with CS staff. The Panel expects CS to incorporate a revised version of that memo into their final Version 2 model development report.

1.2 Processing of CHTS data for model calibration and validation

A separate memo was provided that described how the data from the 2012-13 California Household Travel Survey (CHTS) of 42,000 households across the state were used in several parts of model development. CS used preliminary results from the CHTS for earlier work, as reported in previous reports by the Panel. The recent work reviewed in this paper is based upon the final survey data. The Panel found the report informative and well written. A discussion about how calibration targets will be derived from these analyses was expected, and hopefully will be provided in due course.

The Panel noted some inconsistencies in the various data used in model estimation that were discussed in this report. Significant differences between the key indicators from the three major sources of data – the CHTS, the 2011 Harris Interactive Poll, and the 2005 stated preference (SP) survey – were noted. It appears that CS used the CHTS as the definitive source, and data from the other two surveys to fill gaps in the CHTS. The Panel believes that this is the most appropriate approach. It was also noted that the air passenger volumes obtained by expanding the CHTS did not compare well with counts from the various California airports. This is due in part to the inability to isolate trips made by California residents in the air passenger data, as well as limitations in the CHTS imposed by sample sizes and possible sampling error. The choice of targets to be used (e.g., the expanded survey or counts) should be clarified, along with the rationale for the choice and process used to reconcile them.

1.3 Trip frequency model

The Panel reviewed the results of the trip frequency model estimation. This work represents a substantial revision of the Version 1 models, made possible by the addition of newer data from a number of sources including the CHTS. Comparisons were made between the results obtained using the CHTS and previous data collected in 2012 Harris Interactive Poll. The differences are large in some cases. The Panel endorses the CS approach of using the CHTS as the definitive source upon which to build the models. The topic of calibration will be reviewed separately, but the estimation results appear reasonable.

1.4 Destination choice model estimation results

The re-development of the destination choice model was described in a September 18th memo to the Panel from CS. The memo is clear and well written. The Panel appreciates the more parsimonious model specification, which is in line with their previous recommendations on the topic. The fact that the aggregate changes in modeled origin-destination patterns were small compared to the Version 1.1 model calibration results was noted, adding confidence to the estimation results. The new model estimation results appear reasonable, and the efficiency of the models is appreciated.

The final model form adopted by CS included several constants. It is unclear how far off the results were that motivated the addition of these constants. Understanding their contribution to the overall level of fit is essential, and should be included in the final Version 2 model development report. A discussion about calibration targets is also needed. The memo does an excellent job of describing the model estimation process and results, but stops short of describing the calibration targets gleaned from this work.

1.5 Revised forecasts of gasoline prices and fuel efficiency

CS provided a memo to the Panel on September 23, 2013 that described the development of revised forecasts of gasoline prices and fuel efficiency. These parameters will be used in the 2014 Business Plan model runs and forecasts. The memo is clear and well written. The Panel was pleased to find that CS has adopted the "extended policy," as it is likely to track the expected Corporate Average Fuel Economy (CAFE) changes.

The Panel's comments on this memo were minor. CS asserts that, "…high fuel prices will drive the demand for better fuel economy" in the future. This is probably not an unreasonable assumption, but should be supported by appropriate citations. The consumer price index (CPI) was used in the memo to adjust cost for the effects of inflation. The source of the CPI series used in the memo should likewise be attributed in the final Version 2 model development report.

1.6 Main mode choice and access-egress model estimation results

The estimation of the mode choice models was described in a memo from CS to the Panel on September 10, 2013. A joint estimation of the main mode choice and access-egress choice models was undertaken. The Panel is pleased with this approach, for it implements one of their long-standing recommendations. While similar formulations were attempted during the Version 1.1 model update the results were unsatisfactory. The addition of more recent data appears to have facilitated the development of robust joint models that appear to be well suited for model application.

The memo was clear and well written. Given the depth and complexity of this model the Panel spent a considerable amount of time reviewing and discussing it. In general the results are encouraging, and it is recognized that further refinement of the model will take place during model calibration. It was noted that some of the constants in the model are large. It is unsettling that the model still requires large constants, although it is recognized that they might be reduced during further estimation or calibration. While the report is generally well written some questions remain; in particular, it is unclear how the out-of-vehicle travel time (OVTT) was defined in the model, a definition that must be addressed in the final report.

The Panel remains concerned about some structural aspects of the model. It was noted that CS tested the nesting of transit and walk as non-auto choices in access-egress choice and concluded that such was not useful. A flat nesting structure was used instead. It is unclear whether other nesting structures were evaluated (e.g., was an auto nest similarly not useful?). The decision to nest HSR under rail in the main mode choice model is similarly questioned. It may be that for certain interchanges, such as Los Angeles to San Francisco, a reduction in HSR service may be expected to have a larger impact on air travel than conventional rail travel. If this nesting structure is maintained, the model's response in the longer-haul corridors should be closely examined during the testing phase.

The ratio of in-vehicle travel time (IVTT) to out-of-vehicle travel time (OVTT) was asserted in the results reviewed instead of formally estimated. The Panel paid particular attention to this issue, given the amount of controversy over the values asserted in the Version 1 model. In the Version 1 model the coefficient on frequency of service was constrained to be equal to the coefficient on travel time in the main mode choice model. This constraint was removed in the Version 2 model, where frequency of service is represented as a non-linear variable. The asserted OVTT/IVTT ratios – 2.5 for business/commute travel and 2.0 for recreation/other – are based upon their common use in urban models. It is felt that such an assumption is reasonable in this case, even though both urban and intercity mode choice is being modeled, as these ratios primarily affect the access and egress modes. It is expected that urban residents will make the majority of such modeled choices.

The Panel discussed the assertion of the HSR constant at length, both among themselves and with CS staff. A consensus was reached on the following points:

1. The inertia coefficients in the SP estimation should be omitted from the model application, as they represent the bias in SP response that results from self-justification of the reported travel mode.
2. The calibrated air passenger alternative-specific constants are constructed via a two-by-two matrix by airport type (from major to major, from major to minor, from minor to major, from minor to minor) using three coefficients (start at major, end at major, reference). A fourth constant representing the interaction of departure and arrival airports could be included to fully specify a constant for the possible combinations. A final decision to use three or four constants should be based upon re-estimation using the 2005 and 2013 (when available) RP-SP data, followed by discussion of the results.
3. The air passenger and conventional rail SP constants are used, in combination with the calibrated constants, to infer a HSR constant for forecasting. This calculation should consider that there are four calibrated air passenger constants. The current approach considers only the "minor to minor" air passenger interchange, which is likely not representative of the SP respondents. Two alternative approaches were discussed. The first is to use a weighted average (the weight being passenger counts) of the four air passenger constants in the calculation of the HSR constant. The latter would be defined by the midpoint between the mean air passenger and the conventional rail (CVR) constants. The second approach is to calculate the difference between the calibrated and SP values for the four air passenger constants and the single CVR constant. This would require re-estimation of the SP model to obtain the four values of the air passenger constant. A single composite or four separate HSR constants would then be calculated. In the latter case, the same definitions of airport types noted above (major and minor) would hold for the HSR constant application.

Given the pivotal importance of this parameter the Panel would like to review final recommendations from CS before the model is used for forecasting.

2 Methodology for developing and using a risk analysis model

The Authority has identified a formal assessment of the risk and uncertainty associated with the forecasts as a high priority test of the modeling system. CS initially developed a method for

assessing these issues as part of the 2012 Business Plan work. They provided an updated memo on this topic to the Panel on September 17, 2013, for use in the 2014 Business Plan. It provided a clear description of the process, and was viewed as an improvement over the previous memo on this subject. Then, and now, the process involves measuring the change in HSR ridership resulting from varying one parameter of interest (risk factor) in isolation. Scores of similar model runs are made while varying other parameters of interest. A simulation model is run to test several thousand combinatorial effects in order to estimate the parameters of a linear regression model that relates total ridership to changes in one or more key variables. In this case CS has defined those key variables as:

- A socio-economic and land use factor that varies the magnitude and distribution of households, employment, and income throughout the state;
- Auto operating cost;
- Airline fares and frequencies;
- HSR main mode choice constant; and
- Trip frequency model constant for each trip purpose.

If robust, this process will enable a very large number of scenarios to be tested without having to code, run, and interpret each individually. It will also allow the sensitivity of major parameters and assumptions to be quantified, enabling decision-makers to assess the vulnerability of projected ridership due to changes in these important variables. However, the utility of this method depends upon the effects being independent and additive. This is unknown, for combinations of variable changes are only approximated via the regression, but not tested using the model. However, it seems likely that the combinatorial effects will involve complex and subtle interactions of these variables that might result in different outcomes than those obtained through the approach described by CS. It should be relatively easy to test whether this is the case or not, for running a few "edge case" scenarios and comparing the projected ridership to the values obtained in the regression model will help dispel concerns about potential interaction effects and help represent a compelling validation of the process.

Non-linear formulations of the regression model should be investigated as well. It is important that this be formally tested, not merely considered. This is especially true if an adjusted R^2 statistic of less than 0.8 for the linear model is obtained, which would undermine the confidence placed in the risk analyses using it. Likewise, a finding of co-linearity between two or more variables will reduce the attractiveness of this approach.

The construction of the first set of risk factors – state growth and fiscal changes – is likely to be tricky. Collapsing several vectors of population and employment into a single factor will be challenging. The sensitivity of the overall process to different definitions should be assessed as part of the development and testing of the process.

3 Version 3 design requirements

The Panel continued to consider requirements that will not likely be met with the Version 2 modeling system. These requirements are based on the Authority's current and anticipated forecasting needs. These have been gleaned through conversations with Thierry Prate from PB

and Jeff Morales, the Executive Director of the Authority, and prior Panel deliberations. Key components that are seen as necessary additions to the modeling system in light of the more detailed planning, design, operational, and investment decisions that it must soon inform include:

- Station access model
- True access and egress by origin and destination (move away from production-attraction formulation)
- Time-of-day model
- Trip chaining or tour generation model
- Trip duration model (capable of modeling the trip start time)
- Non-resident/visitors model
- Fare class model
- Explicit representation of seasonality

These and other requirements should be implemented within a microsimulation architecture that maximizes the reuse of existing resident travel models as well as development of new components and capabilities. Moreover, the framework should include dynamic elements that take into account differing levels of service and competition by hour of the day. This is not to suggest that dynamic network models are required, but rather that a finer grain of temporal resolution is needed in order to capture the time-dependent effects of congestion, crowding, and peak pricing opportunities.

The challenge in moving towards the Version 3 design is to do so in a way that complements rather than disrupts the current work on Version 2 and its applications. It is anticipated that a large number of runs will be made with it in support of the 2014 Business Plan and related analyses. It is believed that progress can best be maintained through the introduction of a second team that will handle the overall software architecture and concurrent development of the visitor model. Once the software architecture and supporting data systems are in place both teams can implement the respective models within it, with a goal of a fully operational and validated system in time for use with the 2016 Business Plan forecasts and subsequent detailed system planning, financing, and implementation. The Panel acknowledges that the high level of expertise required for such an undertaking is quite limited, but believes that it is within reach given the magnitude and importance of this project, both in California and within the wider transportation planning professional community.

4 Conclusions

The work on the estimation of the Version 2 modeling system appears robust, and the timeliness and quality of the documentation are commendable. Considerable work remains to be done in the calibration and validation of the modeling system before it can be used for the 2014 Business Plan and other planning purposes. However, CS appears to be on track to meet the aggressive deadlines required for doing so. Interim reviews of the calibration and validation work by the Panel is anticipated, as its next formal meeting will be after the forecasts are completed.

Looking past the expected success of the Version 2 development the Panel is anxious to see work begin on the Version 3 modeling system. The long development cycle required to build it makes it imperative to begin work on this immediately so that it can support the Authority's forecasting needs, beginning with those needed for the 2016 Business Plan. It is expected that the Version 2 models will continue to be used to represent travel by California residents with minimal changes to model structure. It should be coupled with parallel development of a visitor travel model and updated software architecture for both components. The design of a framework for doing so should be completed in time for the Panel's review at their next scheduled meeting in January 2014. Budgeting and task scheduling will have to be modified to allow this parallel work effort to take place and thereby ensure that the Version 3 model system will be ready for use in preparation of Business Plan 2016.